CARIBBEAN FOOD CROPS SOCIETY 44

Forty Fourth Annual Meeting 2008

Miami, Florida, USA

Vol. XLIV – Number 2 Continued

Poster Session Abstracts

With Some Posters Expanded as Full Papers

MEETING HOST:

UF UNIVERSITY of FLORIDA IFAS

ISSN 95-07-0410

Copies of this publication may be obtained from:

Secretariat, CFCS
P.O. Box 40108
San Juan, Puerto Rico, 00940

or from:

CFCS Treasurer
Agricultural Experiment Station
Botanical Garden South
1193 Guayacán Street
San Juan, Puerto Rico 00926-1118

EDITOR'S NOTE ON "NUMBER 2" AND "NUMBER 2 CONTINUED" FOR READERS AND AUTHORS: It was discovered at press-time that Volume XLIV "Number 2" of the Proceedings was too thick for conventional binding in the printed-book format. To solve this production problem, the volume was broken in half. The second "half" (Number 2 Continued) is a direct continuation of the first "half" (Number 2), with the page numbering of the second half picking up directly where the page numbering ended in the first half. Number 2's Roman numeral section ("i, ii, iii") of introductory information ends at "page xi" and the Roman numeral section of Number 2 Continued begins at "page xii."

Number 2's "Arabic numeral" section (i.e. 1, 2, 3 rather than i, ii, iii) ends at page 355, while the Arabic numeral section for Number 2 Continued begins at page 356, after the introductory Roman numeral section. The Roman numeral section of Number 2 Continued includes introductory information such as this page and the Table of Contents. The Table of Contents in Number 2 Continued picks up precisely where the Number 2 Table of Contents ends. The two volumes are thus a paired set. Both "Number 2" and "Number 2 Continued" are listed as "Number 2" on the covers and in the citations for each abstract and paper, to reduce confusion when authors list their citations in CVs and other documents. "Number 2 Continued" consists of "Poster Session Abstracts and Expanded Papers," as some poster authors expanded their poster abstracts into full papers for these Proceedings.

2007-2008 CFCS BOARD OF DIRECTORS AND OFFICERS

BOARD OF DIRECTORS

Chair:	Dr. Héctor Santiago, University of Puerto Rico
Vice Chair:	Dr. Kwame Garcia, University of the Virgin Island
Secretary:	Mr. Wilfredo Colón, Universidad del Este, Puerto Rico
Treasurer:	Dr. Alberto Beale, University of Puerto Rico
President 2007- 2008:	Dr. Jimmy Cheek, University of Florida

REGIONAL REPRESENTATIVES

English:
Mr. Kwame Garcia, UVI, University of the U.S. Virgin Islands
Dr. William F. Brown, University of Florida
Mr. Bruce Lauckner, CARDI, Trinidad and Tobago

Spanish:
Dr. Wilfredo Colón, Universidad del Este, PR
Mr. Jerry Dupuy, Private Sector, Dominican Republic
Dr. Héctor Santiago, University of Puerto Rico

French:
Mr. Marceau Farant, INRA, Guadeloupe
Dr. Jean Louis Diman, INRA, Guadeloupe
Dr. Isabelle Jean-Baptiste, AMADEPA, Association Martiniquaise por le Developpement des Plantes Alimentaires, Martinique

Dutch:
Prof. Robert Tjien Fooh, ADEKUS, Suriname

ADVISORY BOARD

Dr. Altagracia Rivera de Castillo, Dominican Republic, President
Dr. Claude Vuillaume, CIRAD, Guadeloupe
Dr. Harry Ozier Lafontaine, INRA, Guadeloupe
Dr. Arlington Chesney, CARDI, Caribbean Region
Dr. Rafael Perez Duverge, IDIAF, Dominican Republic
Prof. Vivian Carro, UPR, Puerto Rico
Dr. Chelston W. D. Brathwaite, IICA, Costa Rica
Dr. Errol Rhoden, HBCU, USA
Dr. Guy Anais, INRA (retired), St. Martin
Dr. Louis Petersen, DOA, U.S. Virgin Islands
Dr. Cassel Gardner, FAMU, Florida
Dr. Wendel Parham, CARDI, Trinidad and Tobago

Caribbean Food Crops Society
44th Annual Meeting
July 13-17, 2008

Miami Beach Resort and Spa
Miami Beach, Florida, USA

Repositioning Caribbean Agriculture:
Challenges and Opportunities for Sustainability

Reposicionando la Agricultura Caribeña:
Retos y Oportunidades para la Sostenibilidad

Repositionner l'agriculture de la Caraïbe :
Défis et opportunités pour la durabilité

Caribbean Food Crops Society

POSTER SESSION

Poster Session Abstracts with Some Posters Expanded into Full Papers

Poster Session Edition

TABLE OF CONTENTS

PROCEEDINGS OF THE 44th ANNUAL MEETING OF THE CARIBBEAN FOOD CROPS SOCIETY xii

Published by the Caribbean Food Crops Society xiii

2007-2008 CFCS BOARD OF DIRECTORS AND OFFICERS xiv

BOARD OF DIRECTORS xiv

REGIONAL REPRESENTATIVES xiv
English xiv
Spanish xiv
French xiv
Dutch xiv
ADVISORY BOARD xiv

TABLE OF CONTENTS Number 2 Continued ..... xv-xxiii

POSTER PRESENTATIONS 356

NATURAL RESOURCES 356

Impact of Coffee Management Practices on the Soil Ecosystem: Earthworm Community Function, *J. A. Amador, K. Winiarski, and D. Sotomayor-Ramirez* 356

Factores de Transferencia Suelo-Hojas de Metales PesadoS (Co, Cu, Ni, Zn) en *Prunus Persica L.*, *Orihuela, DL., Hernández, J.C., Colón, W., and Bastida, F.* . 365

Caracterización del Transporte de Nutrientes y Sedimentos en Suelos Enmendados con Residuos Orgánicos ve Vaquería, *G. Ardila, D. Sotomayor Ramírez, G. Martínez, y L. Perez Alegría* 379

Tillage Effects on a Crop Rotation of Yam, Eggplant, Bean and Corn in Oxisol, Ultisol and Vertisol Soils in Puerto Rico, *Wanda I. Lugo, Agenol González, Elvin Román, Nydia Rafols and Héctor Lugo* 380

Relationship between Vegetative Covers and Soil Physical Properties of one Mollisol on *Phytophthora cinnamomi* Occurrence in Avocado *Persea americana* Mill. in Puerto Rico, *Beatriz E. Torres Ordóñez, C. Estévez de Jensen, V. Snyder, y M. Vazquez* 387

FRUITS, VEGETABLES, AND SPECIALTY CROPS 388

Respuesta de Líneas de Habichuela (*Phaseolus vulgaris L.*) a Diferentes Niveles de Fertilidad en un Oxisol, *R. Dorcinvil, D. Sotomayor Ramírez, and J. Beaver* 388

Response of Taro var. Lila or Bun Long to Levels of Supplemental Irrigation, *Luis E. Rivera, Carlos E. Ortiz, and John J. Cho* 389

Production of Table Cucumber (*Cucumis sativa*) on Two Trellis Systems in North Florida, *C. S. Gardner, G.L. Queeley, K. T. Grant, B. G. Brown and T. Hylton* 393

Effects of Bulbils Weight Used as Seed on Tuber Yield of Greater Yam Belep *(dioscorea alata l.),* *David Hammouya, Marceau Farant, J. Lator, and J. L. Irep* 398

Performance of a Quality Protein Maize Variety Grown in a Vertisol, *Elvin Román-Paoli, and James Beaver* 399

Effects of Plastic Mulch on Development and Nodulation of Cowpeas, *Steven H. Wysinger, E. G. Rhoden, V. Khan, C. Stevens, and J. R. Bartlett* 400

The Effect of Lime Application on Emergence and Growth of Castor Oil Plants, *Ronald J. Smith, Errol G. Rhoden, Janette R. Bartlett, Victor A. Khan, Crystal Drakes and Prosanto K. Biswas* 401

Mandarina Híbrida Fallglo: Primeros Cuatro Años de Crecimiento en Dos Localidades de Puerto Rico, *Félix M. Román Pérez, Agenol González Vélez, y Raúl Macchiavelli* 408

Yield and Fruit Quality of Rambutan Cultivars Grown at Two Locations in Puerto Rico, *R. Goenaga and A. Marrero* 413

Calibration of SPAD-Meter Readings to Chlorophyll Content in Strawberry, *D.L. Orihuela, W. Colón, J.C. Hernández, and C. Weiland* 414

Growth Rate and Yield of Coffee (C*offea arabica L.*) Grown Under Partial Shade and Full Sunlight after Severe Renovation Pruning, *Carlos A Flores Ortega and Miguel A. Muñoz* 415

Using a Commercial Mixture of Amino Acids and a Commercial Extract of *Ascophyllum* Kelp To Reduce the Time in Nursery of 'Duncan' and 'Marsh' Grapefruits (*Citrus Paradisi* Macf.) in Puerto Rico, *J. Pablo Morales-Payan* .. 416

Evaluation of Alternative Pesticides and Mulching for Organically-Grown Watermelons in Puerto Rico, *Mabel Vega-Almodovar, J. Pablo Morales-Payan, Sonia Martinez-Garrastazu, & Bryan Brunner* 420

Crecimientos Vegetativo y Reproductivo del Aguacate 'Hass' en Varios Climas de Michoacán, México, *J.L. Rocha-Arroyo, S. Salazar-García, I.J.L. González-Durán, y J. Anguiano-Contreras* 425

Corrección de la Deficiencia Crónica de Zinc en Aguacate 'Hass', S. *Salazar-García, L.E. Cossio-Vargas y I.J.L. González-Durán* 426

Papaya Growth in Double-Row Systems Established During the Dry Season, *Thomas W. Zimmerman* 427

SOCIOECONOMICS AND POLICY 437

Agricultural Labor Issues and Immigration in Southwest Florida, *Robert D. Halman* 437

PROCINORTE'S Tropical and Subtropical Fruits Task Force: a Tri-National Effort to Improve Fruit Quality and Trade, *R. Goenaga, S. Salazar-García, G. Doyon, J.A. Osuna-García, I.J.L. González-Durán, and J.A. Landry* 438

Le Programme Régional de Développement Agricole : un outil méthodologique pour la modernisation et l'adaptation de l'agriculture Guadeloupéenne, *Edmond Rubrice* 439

Incubator Farms as a Sustainable Approach for 'Neo Farmers', *Puran Bridgemohan* 440

Policy Implications of the Composite CARICOM Business Environment, *Ronald M. Gordon and John J. VanSickle* 447

An Evaluation of Dairy Farming in Suriname, *Samantha Engeldal* 448

Exploring the Internationalizing of Extension Opportunities: A Partnership with the Antigua 4-H Youth Program, *Norma Samuel* and *Nicole Walker* 449

Environmental Damages Versus Economic Performance, Sustainability of Guadeloupean Banana Cropping Systems in Question: an Emergetic Approach, *Jean-Marc Blazy; Inacio de Barros; Geraldo S Rodrigues; Harry Ozier-Lafontaine* 450

Banana Sector in the French West Indies (FWI) in the 21st Century: Typology of Farmers' Room for Manoeuvre in Adapting their Cropping Systems to Crisis, *Jean-Marc Blazy; Jean-Louis Diman; François Causeret; and Danny Peregrin* 461

Village du Millénaire : Expérience d'Haïti, *Ronald Bien-aimé* 462

FORAGE AND LIVESTOCK 463

Effects of Palm Kernel Cake on Daily Gain and Carcass Yield of Broiler Chicks; Efecto de la Sustitución de Palmiste por Maíz en la Dieta de Pollo Engorde Sobre la Ganancia Diaria y el Rendimiento de Canal, *Neirin Matos, Rosina Polanco, Carlos M. De Jesús, and Rafael A. Vásquez* 463

Evaluacion de Nitrogeno Líquido (ULB-35®) para la Produccion de Forraje en Puerto Rico, *Alexander Recamán-Serna, David Sotomayor Ramírez, Yamil Quijano, y Gilberto Lozada* 473

Tecnicas de Aplicación de Nitrogeno Líquido (ULB-35®) en la Produccion de Forraje en Puerto Rico, *Alexander Recamán-Serna, David Sotomayor-Ramírez, y Gilberto Lozada* 474

Plant Density and Dry Matter Yield of 'Ubon Stylo' (*Stylosanthes guianensis*) in an Oxisol of Puerto Rico, *Jorge Luis Olivares-Lopez, Elide Valencia, and Abner Rodríguez-Carías* 475

Effects of Planting Density and Cut Frequency on Dry Matter Yield of Mulberry (*Morus Alba) and* Guacima *(Guázuma ulmifolia;* Influencia de Diferentes Densidades de Siembra y Frecuencias de Corte sobre el Rendimiento en Biomasa de *Morus alba* y *Guázuma ulmifolia),* *Ramón A. Marte Estévez, Carlos M. de J. Arias, Rafael A. Vásquez Martínez* 481

The Mineral Status of Sheep and Goats with Reference to Swayback in Central Trinidad, *Aphzal Mohammed and Fayez G. Youssef*..... 489

Lamb's Voluntary Intake and Digestibility of Forage Soybean 'Hinson Long-Juvenile (*Glycine max*) and Lablab 'Rongai' [*Lablab purpureus* **(L.) Sweet],** *Rivera-Melendez, F., A. Rodriguez-Carias, and E. Valencia*..... 495

Composición Química de *Stylosanthes guianensis* Fresco o Fermentado en Pacas Cilíndricas durante dos Periodos de Fermentación, *Vázquez, M.S., A.A. Rodríguez, E. Valencia, y P. Randel*..... 500

Liquid Urea Rate Effects on Nutritive Value of 8-Week Regrowth of Guineagrass (*Panicum maximum* Jacq.) Hay, *Almodóvar L. E., E. Valencia, y A. Rodríguez* 501

Fermentation Characteristics and Consumption of Forage Sorghum and Sudax Ensiled in Round Bales, *W. Rodríguez, A.A. Rodríguez, and E. Valencia* 505

Composición Química y Consumo Voluntario de *Calliandra calothyrsus* Deshidratada o Fresca por Ovinos y Caprinos, *Lisa Dillon, Melanie Román Zayas, Abner A. Rodríguez Carías y Elide Valencia*..... 506

The Evaluation of Three Feeding Regimens and Three Anthelmintics in a Meat Goat Production System: a Florida A&M University Research/ Extension Project, *T. E. Peterson, R. Mobley, G. Nurse, F. Okpebholo, C. J. Lyttle-N'guessan, G. Queeley, and T. Kahan*..... 507

Stocking Rate Trial with Boer X Spanish Goats under Thinned Loblolly Pines, *Nadine Gordon-Bradley and O. U. Onokpise*..... 516

Effects of Palm Kernel Cake in the Diet of Dairy Goats on Milk Production and Kid Daily Gain; Efecto del Palmiste (*Elaeis guineensis*) Sobre el Comportamiento Productivo de Cabras Lecheras, *Juan C. Ureña, Marco E. Fernández, Carlos M. De Jesús, Rafael A. Vásquez*..... 522

Development of Small Scale Aquaculture Farms in North Florida, *Uford A. Madden, G. Nurse, J. Beaudouin, A. Bolques, L. Muralles, S. Harris-Thompson, A. Wallamsley, M. May, and F. Chapman* 530

Comparison of Oral Administration of Various Doses of Moxidectin and Ivermectin Pour-On Formulations Against Intestinal Parasites in Meat Goats, *Uford A. Madden, N. Wilson, G. Nurse, and J. Beaudouin* 535

A Comparison of Grass vs. Legume Free Range Small Ruminant Finishing Systems for the Tropics, *S.A. Weiss, R. Ben-Avraham, R.C. Ketring, and R.W. Godfrey* 542

Development and Evaluation of a Ready to Cook Vacuum Packaged Goat Meat Product, *N. Djeri, S. K. Williams, R. Mobley, A. McKenzie-Jakes, K. Sarjeant, and A. Ruiz* 543

Development and Evaluation of Pre-Cooked Vacuum Packaged Goat Meat Products, *N. Djeri, S.K. Williams, R. Mobley, A. McKenzie-Jakes, K. Sarjeant, and A. Ruiz* 544

The Effects of Synchronization Treatments on Estrous Response in Seasonal Does, *Angela McKenzie-Jakes, G. Nurse, and G. Byrant* 545

An Integrated Approach to Increasing Food Safety Awareness at the Farm Level among Small and Limited Resource Goat Producers in Florida, *A. McKenzie-Jakes, R. Mobley, T.E. Peterson, P. Hunter, G. Nurse, J. Beaudouin, G. Bryant, G. Queeley, S. Thompson, N. Tillman, and L. Anderson* 546

CROP PROTECTION AND PEST MANAGEMENT 547

First Report of *Cladosporium tenuissimum* Cooke on Taro in Puerto Rico, *Evelyn Rosa-Márquez and Carlos E. Ortíz* 547

Relación entre las Propiedades Físicas de un Oxisol y Coberturas Vegetales en la Incidencia de *Phytophthora cinnamomi* en Aguacate *Persea americana Mill.*, *Torres Ordóñez B., C. Estévez de Jensen, V. Snyder, y M. Vazquez* 548

Weed Management During and After Rhizoma Perennial Peanut Establishment, *María de L. Lugo-Torres and Teodoro Ruiz* 550

Black Sigatoka IPM in Puerto Rico, *W. Almodóvar and M. Díaz* 553

Crianza Masiva de Mirax Insularis Muesebeck, el Parasitoide Exótico del Minador del Café *Leucoptera coffeella* Guérin-Ménéville (Lepidoptera: Lyonetíidae) en Puerto Rico, *Fernando Gallardo, Evelio Hernández, Marcela Daza, & Jennifer González* 554

Extracts of Native and Non-Native Plant Species for the Control of Cogongrass (*Imperata cylindrica* L), *Lissa D. Reid, Bravo G. Brown, and Oghenekome U.Onokpise* 563

Evaluation of Acibenzolar-S-Methyl, PGPR and Silicon for Their Effects on Growth and TYLCV of Tomato, *Shouan Zhang, Thomas L. White and Waldemar Klassen* 571

Evaluation of Triazole and Strobilurin Fungicides, Alone and in Combination, for Control of *Exserohilum turcicum* on Sweet Corn, *Richard N. Raid* 576

Educational Efforts Enhance Diagnostic Capabilities in the United States and the Caribbean Region, *Amanda Hodges, Greg Hodges, and Russell Duncan* 577

Response of the Melon Thrips, *Thrips palmi* Karny, and the Chilli Thrips, *Scirtothrips dorsalis,* to some Selective Insecticides, *Dakshina R. Seal, Vivek Kumar Jha, Waldemar Klassen, and Catherine M. Sabines* 578

Development of IPM Field Guides for Coffee, Citrus, Plantain and Banana, *Ada N. Alvarado Ortíz* 579

Erythrina Gall Wasp, *Quadrastichus erythrinae* (Hymenoptera: Eulophidae), a Pest of Coral Trees (*Erythrina* spp.) Recently Found in the Western Hemisphere, *Forrest W. Bill Howard* 580

Climate Factor Comparison Analysis for Red Palm Mite, Raoiella Indica, *D. Borchert and D. Fieselmann* 581

Tropical Race 4 of Panama Disease: A Dangerous Threat to Sustainable Production of Banana and Plantain, *Randy C. Ploetz* 582

Distribution and Host Associations of *Proba distanti* (Atkinson) (Hemiptera: Miridae), a Plant Bug Recently Established in Florida, *Thomas T. Dobbs, Thomas J. Henry, and Alfred G. Wheeler, Jr* 583

The Caribbean Pathway Analysis - Evaluation of Pathways for Exotic Plant Pest Movement into and within the Greater Caribbean Region, *Heike E. Meissner, Christie A. Bertone, Lisa M. Ferguson, Andrea V. Lemay, and Kimberly A. Schwartzburg* 584

Population Dynamics of the Red Palm Mite (*Raoiella indica* Hirst) and the Search for Sustainable Management Options in Jamaica, *J. V. Goldsmith, and L. R. Myers* 586

Management of Pink Hibiscus Mealybug (*Maconellicoccus hirsutus* Green) in Jamaica, *Michelle A. Sherwood, L. R. Myers, M. Young, D. Robinson and J. Lawrence* 587

Impact of Organic Mulches on Watermelon Fruit Yield and Purple Nutsedge Tuber Productivity in an Ecological Production System, *J. Pablo Morales-Payan, Pedro Marquez-Mendez, Erin Rosskopf, Yasser Shabana, Raghavan Charudattan & Waldemar Klassen* 588

Effects of Altitude and Harvest Period on Broca (*Hypothenemus hampei Ferrari*) infestations in Coffee (*Coffea arabica L.*) Beans in the Dominican Republic, *Yluminada O. López, Miguel M. Campo, and José B. Nuñez* 593

Disease Management Programs for Basil Downy Mildew, *R. N. Raid, P. Roberts, and P. Harmon* 601

A New Lethal Disease of *Syagrus romanzoffiana* and *Washingtonia robusta* in Florida is Caused by *Fusarium oxysporum,* *Monica L. Elliott[1] and Elizabeth A. Des Jardin* 602

***In Vivo* Study of Cogongrass (*Imperata Cylindrica* L.) Rhizome Production,** *Oghenekome U. Onokpise, James J. Muchovej, and Susan K. Bambo* 608

Natural Spread of Pests within and into the Greater Caribbean Region, *Christie A. Bertone, Heike E. Meissner, and Andrea V. Lemay* 617

Wood Packaging Material as a Pathway for the Movement of Exotic Insect Pests into and within the Greater Caribbean Region, *Heike E. Meissner, Thomas W. Culliney, Andrea V. Lemay, Leslie P. Newton, and Christie A. Bertone* 621

Airline Passenger Baggage as a Pathway for Exotic Plant Pest Movement through the Greater Caribbean Region, *Heike E. Meissner, Andrea V. Lemay, and Kimberly A. Schwartzburg* 628

Likelihood of Hitchhiker Pests Being Moved into and within the Greater Caribbean Region, *Andrea V. Lemay and Heike E. Meissner* 634

Control of Broad Mite, *Polyphagotarsonemus Latus* and the Whitefly, *Bemisia tabaci*, in Open Field Pepper and Eggplant with Predaceous Mites, *José Castillo and Philip A. Stansly* 638

Demonstrating Integrated Pest Management of Hot Peppers, *Jesusa Crisostomo Legaspi, Cassel Gardner, Gilbert Queeley, Norman Leppla, and James Cuda* 639

CIRAD Invasive Species Initiatives in the Caribbean Basin, *Emmanuel Wicker, Catherine Abadie, Jean Heinrich Daugrois, Luc Baudouin, Michel Dollet, Claude Vuillaume and Pierre-Yves Teycheney* 640

FOOD SCIENCE AND POSTHARVEST TECHNOLOGY 641

Biogas Production from Rice Hulls and Straw Treated with Urea, *Amarely Santana, Jerry Gabriel, Pascal Fenelus, Eliezer Louis, Juguette Badette, Carlos Miguel De Jesús Arias* 641

Optimization of a Clarification Process for Guava Puree using Bioguavase Enzyme, *María L. Plaza and Murat Balaban* 651

Relationship between Chlorophyll Fluorescence and Dry Matter Content of 'Hass' Avocado Fruit, *J.A. Osuna-García, G. Doyon, I.J.L González-Durán, S. Salazar-García, and R. Goenaga* 652

Effect of Harvest Time and Ripening Degree on Quality and Shelf Life of 'Hass' Avocado, *J.A. Osuna-García, G. Doyon, I.J.L González-Durán, S. Salazar-García, and R. Goenaga* 653

Influencia del Clima, Riego y Época de Floración Sobre la Composición Nutrimental del Fruto de Aguacate 'Hass' en Michoacán, *S. Salazar-García, M. Gallardo-Valdez, y L.M. Tapia-Vargas* 654

POSTER PRESENTATIONS
Tuesday, July 15, 2008

NATURAL RESOURCES

2008 Proceedings of the Caribbean Food Crops Society. 44(2):356-364. 2008

Poster #1
Impact of Coffee Management Practices on the Soil Ecosystem: Earthworm Community Function

J. A. Amador[1], K. Winiarski[2], and D. Sotomayor-Ramirez[3]. [1]Laboratory of Soil Ecology and Microbiology and [2]Physiological Ecology Laboratory, University of Rhode Island; [3]Dept. of Agronomy and Soils, University of Puerto Rico – Mayagüez. jamador@uri.edu

ABSTRACT.
Coffee (*Coffea arabica* L.) is the most economically important crop in the central mountainous region of Puerto Rico, where it is grown under shade or in full sunlight. The conditions under which coffee is grown may affect the long-term sustainability of this land use through effects on soil physical, chemical and biological properties. As ecosystem engineers, earthworms are known to have a profound effect on abiotic and biotic properties and processes in terrestrial ecosystems. We examined differences in earthworm communities as a function of ecosystem type (sun and shade coffee, forest) and soil order (Oxisols, Ultisols, Inceptisols) as part of a study of the effects of coffee production practices on the structure and function of coffee agroecosystems led by scientists in the Dept. of Agronomy and Soils of the University of Puerto Rico – Mayagüez. Ecosystem type significantly affected earthworm population density (Sun, 281/m^2 > Shade, 125/m^2 > Forest, 37/m^2) and earthworm biomass (Sun, 71 g f.w./m^2 > Shade, 34 g f.w./m^2 > Forest, 12 g f.w./m^2). In contrast, the specific biomass of earthworms was significantly affected only by soil order. In general, earthworm population density and biomass appeared to be a function of soil moisture, leaf litter biomass, and the mineral content of leaf litter. Analyses of ^{15}N and ^{13}C enrichment of earthworm tissues suggest that management practices affect the trophic level they occupy within an ecosystem. Examination of isotopic enrichment of soil and leaf litter is underway to help elucidate the role of earthworms in carbon and nitrogen cycling in these ecosystems.

KEYWORDS: *Coffea arabica*, cultivation practices, stable isotope enrichment

INTRODUCTION

Coffee (*Coffeea arabica*) is an economically important crop in Puerto Rico, where its production accounts for nearly 15% of the annual gross revenue from all crop production (Estado Libre Asociado de Puerto Rico - Departamento de Agricultura, 2004). Although cultivation practices vary considerably, whether to grow coffee under shade

trees – often leguminous, N_2-fixing species (Aranguren et al., 1982) – or in full sunlight is one of the most basic decisions made by coffee growers. This choice has consequences for the structure and function of these ecosystems that may affect their long-term sustainability. Shade coffee is generally regarded as more environmentally benign, supporting greater plant and animal diversity (Perfecto et al., 1996), resulting in lower soil erosion (Smith and Abruña., 1955), and requiring lower inputs of synthetic fertilizers. In contrast, coffee cultivation under full sunlight produces higher yields, but also higher rates of soil and water runoff (Smith and Abruña., 1955) and lower biodiversity (Perfecto et al., 1996).

The long-term sustainability of agricultural production systems is tied to maintenance of soil physical and chemical attributes and elemental cycling that are favorable to crop production and soil quality. Earthworms are widely recognized as ecosystem engineers in a wide range of natural and agricultural ecosystems, where they play important roles in the physical, chemical and biogeochemical properties and processes (Jones et al., 1994). They are important in the translocation of organic forms of C and nutrients across the litter-soil interface and within the soil profile, accelerating their decomposition and increasing the availability of these resources with the soil foodweb (Edwards and Bohlen, 1996). The limited number of field and greenhouse studies on effects of earthworms in tropical agroecosystems suggest that they generally have a positive effect on plant growth and yields (Brown et al., 1999).

We compared the abundance, biomass and specific biomass of earthworms in sites with coffee under partial shade, coffee under full sunlight, and secondary forest in western-central Puerto Rico. We also examined relationships to resource quality and quantity, as well as the role of earthworms in C and N cycling.

MATERIALS AND METHODS

Study area. The experiment was conducted in coffee farms and adjacent forested areas at three different sites in western-central Puerto Rico (Table 1). Within each site three replicate square plots (20 m × 20 m) were established in each of three ecosystem types: (i) coffee grown under partial shade (SHD), (ii) coffee grown under full-sunlight (SUN), and (iii) secondary forest (FOR).

Table 1. Altitude, soil order, and latitude and longitude of study sites for shade (SHD) and sun (SUN) coffee and secondary forest (FOR) ecosystems in Puerto Rico.

Site	Altitude range (m)	Soil order	Ecosys.	Latitude (West)	Longitude (North)
Jayuya	670 – 870	Oxisol	FOR	66°38' 52.21"	18°09' 35.96"
			SHD	66°38' 52.21"	18°09' 35.96"
			SUN	66°37' 47.77"	18°09' 58.35"
Lares	470 – 670	Inceptisol	FOR	66°50' 47.42"	18°11' 54.41"
			SHD	66°50' 47.42"	18°11' 54.41"
			SUN	66°50' 47.42"	18°11' 54.41"
Las Marias	270 – 670	Ultisol	FOR	67°00' 7.42"	18°14' 30.22"
			SHD	67°00' 22.11"	18°14' 32.97"
			SUN	67°00' 22.11"	18°14' 32.97"

Sampling. Sites were sampled between November and December 2007. Within each replicate 20 m × 20 m plot a 30 cm × 30 cm subplot was established for sampling of leaf litter, earthworms and soil. The leaf litter was removed from the subplot and stored in plastic bags. To sample earthworms, soil in the subplot was excavated to a depth of 10 cm, placed on a plastic bag, and earthworms picked out by hand. A subsample of the excavated soil was stored in a sealable plastic bag.

Sample processing and analyses. Leaf litter dry weight was determined after drying at 65°C for 24 h. Dried litter was ground in a Wiley mill and mineral content determined by ashing at 550°C for 4 h. Soil moisture was determined gravimetrically. Soil pH was determined using a 1:5 (wt/vol) mixture of soil and water and a pH meter. Earthworms were weighed after rinsing and drying. They were frozen at -4°C, shipped in dry ice to Kingston, RI by overnight courier, where they were dried using a lyophilizer.

^{13}C and ^{15}N, and total C and N content. Stable isotope content of C and N, and the total C and N content of earthworms, leaf litter and soil were determined using a Carlo-Erba NA 1500 series II elemental analyzer (Thermo Fisher, Waltham, MA) attached to a continuous flow isotope ratio Micromass Optima mass spectrometer (Micromass, Manchester, UK).

Statistical analyses. A two-way analysis of variance (with interaction) with ecosystem and site as the two factors was used to examine differences in earthworm parameters. Tukey's test was used to identify treatment differences. Correlations between earthworm parameters and environmental variables were evaluated using a Pearson correlation analysis. All statistical analyses were evaluated at the $P < 0.05$ level.

RESULTS AND DISCUSSION

Biomass and abundance. There were no significant differences in biomass when data were grouped by site. When data were grouped by ecosystem, mean biomass values for SUN were significantly higher than for FOR and SHD ecosystems (Fig. 1). The earthworm community in the FOR had significantly higher specific biomass than either SHD or SUN ecosystems (Fig. 1). Earthworms abundance was not significantly different when grouped by site. Grouping the data by ecosystem revealed that earthworm abundance in the SUN ecosystem was significantly higher than in the FOR and SHD ecosystems (Fig. 1).

Similarities in SHD and FOR ecosystems may stem from similar plant community structure. According to Marcano-Vega et al. (2002), *Coffea arabica* and shade tree species tend to persist in secondary forests that develop after abandonment of coffee plantations. These forests tend to have species composition similar to those of shade coffee plantations even 20-40 years after abandonment. Similarities in plant community structure between SHD and FOR ecosystems likely result in similarities in earthworm habitat.

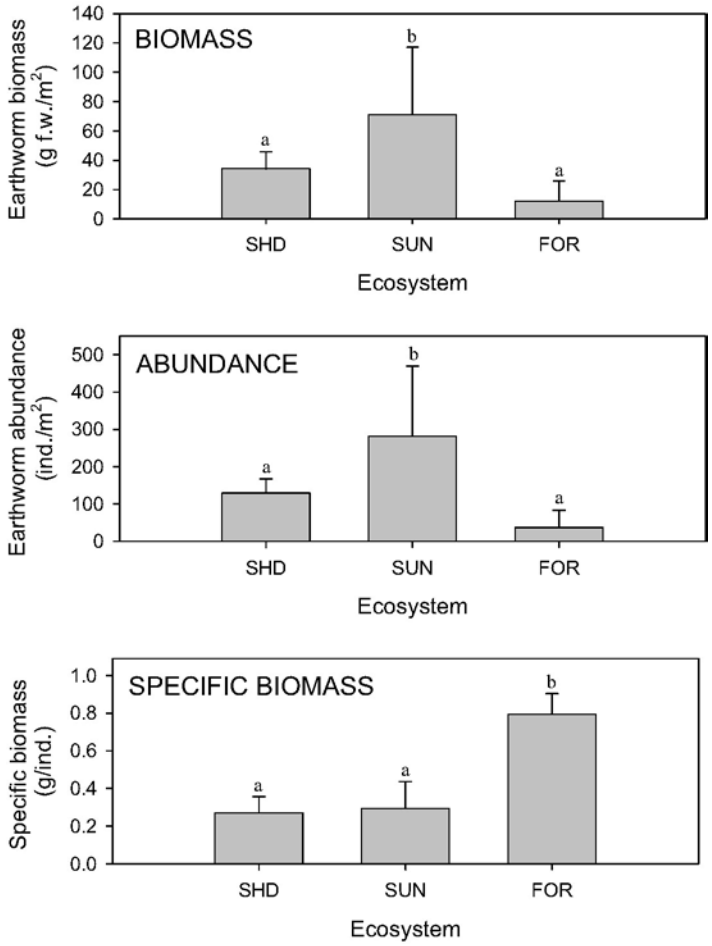


Figure 1. Biomass, abundance, and specific biomass of earthworms from shade (SHD) and sun (SUN) coffee and secondary forest (FOR) ecosystems in Puerto Rico. Treatments with the same letter were not significantly different.

Higher abundance and biomass of earthworms in SUN relative to SHD and FOR ecosystems may be associated with differences in the physical (e.g. open canopy) and biotic structure of these ecosystems. Lower moisture content and higher temperatures in the soil in SUN coffee plantations may result in greater rates of earthworm survival and reproduction than in SHD or FOR ecosystems. In general, the number of cocoons produced by earthworms is higher, the time to hatch is shorter, and the time to sexual maturity is shorter as temperature increases, given adequate soil moisture (Edwards and Bohlen, 1996).

Relationship to resource quality and quantity. Within the FOR ecosystem, a strong, positive correlation was observed only between the specific biomass of earthworms and soil pH (Table 2). In the SUN ecosystem, earthworm biomass was negatively correlated with the C content and C/N ratio of leaf litter. Earthworm specific biomass was positively correlated with litter biomass and soil moisture. In the SHD ecosystem, earthworm biomass was negatively correlated with litter biomass. Specific biomass was negatively correlated with litter biomass and soil N content.

Table 2. Pearson correlation coefficients for earthworm and resource quality and quantity parameters in secondary forest (FOR), partial shade coffee (SHD) and sunlight coffee (SUN) ecosystems in Puerto Rico. Statistically significant correlations are indicated in bold.

		Litter			Soil				
Ecosystem	Parameter	Mass	Min. cont.	C/N ratio	C cont.	N cont.	C/N ratio	Water cont.	pH
FOR	Biomass	-0.322	0.062	0.157	0.057	0.146	-0.419	0.227	-0.193
	Abundance	-0.353	-0.203	0.005	0.096	0.097	-0.020	0.184	-0.461
	Spec. biomass	-0.090	0.407	-0.404	-0.494	-0.453	-0.558	-0.406	0.861
SHD	Biomass	-0.688	0.103	0.339	-0.476	-0.485	-0.148	-0.348	0.432
	Abundance	0.008	0.447	0.285	0.182	0.211	-0.065	0.030	0.316
	Spec. biomass	-0.780	-0.188	0.028	-0.641	-0.711	0.051	-0.455	0.213
SUN	Biomass	0.329	0.262	-0.866	0.051	0.027	0.331	0.143	0.349
	Abundance	-0.230	0.115	-0.421	-0.254	-0295	0.343	-0.296	0.167
	Spec. biomass	0.830	0.059	-0.539	0.598	0.605	0.203	0.762	0.444

Ramos et al. (unpublished) found that earthworm species richness at our sampling sites was highest in SUN and SHD (3 species each), with 2 species found in FOR. *Ponstoscolex corethrurus*, an exotic endogeic (soil-dwelling) was the most prevalent species in all three ecosystems. Anecic (surface litter-feeding, vertical burrowing) species constituted 3.2% and 1.4% of the earthworms population found in SUN and SHD ecosystems, respectively, whereas no anecic species were found in FOR ecosystems. Our results suggest that the feeding ecology of earthworms may be an important determinant of effects of litter quality and/or quantity. Significant correlations of biomass or specific

biomass with litter quality and/or quantity were observed only in the SHD and SUN treatments, the two ecosystems where anecic earthworms were present, lending support to this view. By contrast, only soil pH was correlated with earthworms in the FOR ecosystem, where only soil-dwelling earthworms were found.

Role in carbon and nitrogen cycling. Carbon and nitrogen isotope values of soil, leaf litter and earthworms were used to examine the role of litter and soil as sources of C and N for earthworms in SUN, SHD and FOR ecosystems. Differences in δ13C and δ15N between consumers (earthworms) and food sources (soil and leaf litter) allow for determination of the relative importance of these sources to the earthworms. In general, trophic transfer between an organism and its food is expected to result in a <1‰ increase in δ13C values and a ~3‰ increase in δ15N (Wada et al., 1991). Carbon isotope values of earthworm tissues suggest that soil was the main source of C for earthworms in SHD ecosystems (Fig. 2). The δ13C values of earthworm tissues were slightly enriched compared to soil (0.3 to 0.7 ‰), while leaf litter was enriched 3-5‰, suggesting that leaf litter is not a likely source of carbon for earthworms in SHD ecosystems. Soil also appears to be the main source of N for earthworms. Nitrogen isotope values of earthworm tissue were enriched ~3 ‰ relative to soil (Fig. 2). Similar to carbon, δ15N values of litter were depleted 4-5‰ in comparison to earthworm tissue, making it an unlikely nitrogen source for earthworms in SHD ecosystems. These results are consistent with an ecosystem dominated by endogeic earthworms that feed primarily on surface soil. The Lares site appears to be an exception, with larger than expected differences between soil and earthworms in δ 13C (~2.5 ‰) and δ15N (~5 ‰), and even larger differences between litter and earthworms. These results suggest a food source with higher δ 13C and δ 15N values, possibly soil from deeper areas within the profile, which generally is more enriched in 13C and 15N than surface soil (Hendrix et al., 1999).

The extent of differences in 13C enrichment between earthworms and soil and earthworms and litter (Fig. 2) in the SUN ecosystems suggests that both litter and soil are sources of earthworm carbon. Differences in δ 15N values between soil and earthworms are less than the expected 3‰, which may indicate a greater contribution of N from the more isotope-depleted litter. These results are consistent with an earthworm community in which both anecic and endogeic earthworms are present.

Earthworm tissue in FOR ecosystems in Jayuya and Lares (Fig. 2) had higher values of δ13C and δ15N relative to soil (3 to 6‰) and litter (5 to 9‰), making them unlikely sources of C. Earthworms at these sites may consume soil from deeper in the soil profile, which has a higher δ13C (Hendrix et al., 1999). Nitrogen isotope values of earthworm tissue were enriched ~3‰ relative to soil, suggesting that surface soil is the main source of N. Earthworm tissue sampled from Jayuya was depleted in 15N relative to surface soil, suggesting that earthworms are foraging deeper in the soil profile (Hendrix et al., 1999). These results are consistent with an earthworm community in which endogeic earthworms are dominant.

ACKNOWLEDGEMENTS

We are grateful to Jacqueline Vega, Emmanuel Feliciano, Glenny López and Melissa Matos for technical assistance, to Sonia Borges and Cynthia Ramos for fruitful discussions, and to Eduardo Schroeder for access to field sites, all at the University of Puerto Rico-Mayagüez Campus. We thank the EPA Atlantic Ecology Laboratory, Narragansett, RI for use of the C/N analyzer. J. A. is grateful to the Barreto, Otero and Quiñones families, and to C. Añeses for their support and hospitality. This research was funded by a grant to D. S.-R. from the UPR–Mayagüez Campus Atlantea Program and by the authors' personal funds. The study was conducted while J. A. was on sabbatical leave at UPR-Mayagüez.

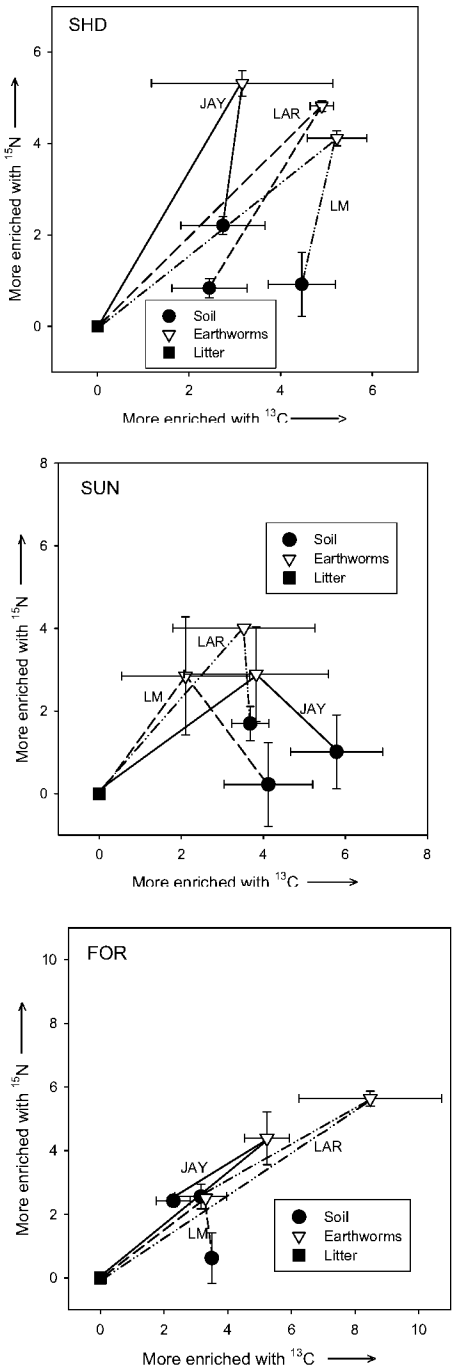


Figure 2. Mean (n = 3) values of $\delta^{13}C$ and $\delta^{15}N$ of leaf litter, soil and earthworms in shade (SHD) and sun (SUN) coffee and forest (FOR) ecosystems in Jayuya (JAY), Lares (LAR) and Las Marias (LM) sites. Units for both axis are ‰. Bars represent standard error. In order to facilitate comparisons among sites, isotopic enrichment data were adjusted for differences in enrichment of litter at a particular site by subtracting the enrichment value for litter from all values.

REFERENCES

Aranguren, J., Escalante, G., and Herrera, R. (1982). Nitrogen cycle of tropical perennial crops under shade trees. Plant and Soil 67, 247-258.

Brown, G. G., Pashanasi, B., Villenave, C., Patron, J. C., Senapati, B. K., Giri, S., Barois, I., Lavelle, P., Blanchart, E., Blakemore, R. J., Spain, A. V., and Boyer, J. (1999). Effects of earthworms on plant production in the tropics. In "Earthworm Management in Tropical Agroecosystems" (P. Lavelle, Brussaard, L., and Hendrix, P.F., ed.), pp. 87-147. CAB International, Wallingford, UK.

Edwards, C. A., and Bohlen, P. J. (1996). "Biology and Ecology of Earthworms," 3rd/Ed. Chapman & Hall, New York.

Estado Libre Asociado de Puerto Rico - Departamento de Agricultura (2004). "Anuario Estadístico, 2003. Oficina de Estadísticas Agrícolas. Estado Libre Asociado de Puerto Rico, Departamento de Agricultura."

Hendrix, P. F., Lachnicht, S. L., Callaham, M. A., and Zou, X. (1999). Stable isotopic studies of earthworm feeding ecology in tropical ecosystems of Puerto Rico. Rapid Communications in Mass Spectrometry 13, 1295-1299.

Jones, C. G., Lawton, J. H., and Shachak, M. (1994). Organisms as ecosystem engineers. Oikos 69, 373-386.

Marcano-Vega, H., Aide, T. M., and Báez, D. (2002). Forest regeneration in abandoned coffee plantations and pastures in the Cordillera Central of Puerto Rico Plant Ecology 161, 75-87.

Perfecto, I., Rice, R. A., Greenberg, R., and Van derVoort, M. E. (1996). Shade coffee: A disappearing refuge for biodiversity. BioScience 46, 598-608.

Smith, R. M., and Abruña., F. (1955). "Soil and water conservation research in Puerto Rico. 1938 to 1949. Bulletin 124. University of Puerto Rico. Agricultural Experiment Station. Rio Piedras, PR.

Wada, E., Mizutani, H., and Minagawa, M. (1991). The use of stable isotopes for food web analysis. Critical Reviews in Food Science and Nutrition 30, 361-371.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):365-378. 2008

Poster #2

Factores de Transferencia Suelo-Hojas de Metales PesadoS (Co, Cu, Ni, Zn) en *Prunus Persica L.*

[b]*Orihuela, DL.* [a]*Hernández, J.C.;* [b]*Colón, W.; and Bastida, F.*
[a]*Escuela Politécnica Superior La Rábida;* [b]*Universidad del Este. Carolina. Puerto Rico.*
orihuela@uhu.es Tlf: 959-017524

RESUMEN

La cantidad de un elemento que la planta es capaz de absorber de un suelo ha sido objeto de numerosos estudios científicos. El Factor de Transferencia (FT) se define, conceptualmente, en la literatura científica, como la relación entre la concentración en la planta, o en un órgano de ella, de un elemento determinado y la concentración de ese elemento en el suelo. Esta definición desde una óptica matemática sería un modelo lineal muy simplista. Los modelos matemáticos que expresan los datos experimentales del Factor Transferencia (FT) serán, por lo general, más complicados, pero siempre tienen la notable ventaja de ayudar a entender parte del proceso de traslocación de los elementos nutritivos desde los suelos a las plantas cuantitativa y temporalmente.

El objeto de este trabajo es estudiar en un cultivo de melocotones, *Prunus persica L.* los FT de los metales pesados más importantes cuando la solubilidad del suelo se altera por un proceso de corrección de pH. Concluimos que los modelos de transferencia de metales pesados (Co, Cu, Ni y Zn) expresados por el valor de FT desde suelos calizos hacia las hojas en cultivos de melocotón (*Prunus persica* L.) son por lo general modelos lineales. La mayoría de ellos salvo casos singulares como el Zn, además, son modelos casi horizontales expresando el hecho de que las concentraciones de estos elementos en hojas son independientes de las concentraciones en el suelo, y que las alteraciones del pH modifica escasamente los valores de FT.

PALABRAS CLAVES: Factor Transferencia, Metales pesados, Melocotones, *Prunus persica* L.

ABSTRACT.

The quantity of an element that the plant is able to absorb of a soil has been object of numerous scientific studies. Transfer Factor (FT) is defined, conceptually, in the scientific literature, as the relation between the concentration either in the plant, or in an organ of it a certain element and the concentration of that element in the soil. From a mathematical point of view, this definition would be a deceivingly simple lineal model. The mathematical models that express the experimental data of the Transfer Factor (FT) are, in general, more complicated, but they always have the remarkable advantage of quantitatively and temporally helping to understand part of the process of soil-to-plant traslocación of the nutritious elements.

The aim of this work is to study the FT of the most important heavy metals in peaches (*Prunus persica* L.) when the solubility of the soil change with a process of pH correction. We conclude that the models of transfer of heavy metals (Co, Cu, Ni and Zn)

in calcareous soil toward the leaves in peach tree expressed by the value of FT are in general lineal models. Most of these models of transfer of heavy metals with exceptions such as the Zn, also, they are model almost horizontal model showing the fact that the concentrations of these elements in leaves are independent of the concentrations in the soil, and that the alterations of the pH of the soil scarcely modify the values of FT.

KEYWORDS: Transfers Factor, Heavy Metals, Peach, *Prunus persica* L.

INTRODUCCIÓN

Las plantas están involucradas en sofisticadas estrategias para la absorción de micronutrientes relativamente escasos (Zn, Mn, Fe) del suelo y estos micronutrientes esenciales suelen ser altamente reactivos y algunos potencialmente tóxicos, por lo que su absorción, transporte y acumulación es un proceso bien coordinado y regulado (León, 2002).

Las carencias, que son en definitiva un proceso de descoordinación o de imposibilidad de absorber determinados micronutrientes en las plantas, y sus síntomas, están relativamente bien descritos en la literatura científica. Carencia de hierro (clorosis férrica) de zinc (foliocelosis) etc., no solo están bien descritas sino que su corrección, además, entra dentro de la practicas comunes que los agricultores incorporan a su actividad.

Por otra parte, y tratándose de metales pesados hay que añadir la preocupación de que la ruta suelo-planta es la ruta mas común por la que entran estos metales en la cadena alimentaría, por lo que este asunto ha sido de notable preocupación por el mundo científico. No enjuiciaremos aquí ni el proceso celular que asegura una distribución correcta de estos elementos ni los mecanismos hoy conocidos que emplea la planta para defenderse de un exceso de determinados metales en su absorción. El objeto de este trabajo es cuantificar la relación entre las concentraciones de determinados elementos en el suelo y su correspondiente concentración en las hojas. Esta transferencia es un proceso de enorme complejidad afectado por procesos naturales y antropogénicos (Kabata, 2004).

La absorción de un determinado elemento por la planta desde las raíces hacia la parte aérea depende de numerosos factores que de forma resumida son los siguientes (Carini, 2001).

- Las características físico químicas de suelo (humedad, pH, Capacidad de Intercambio Catiónico, potencial redox, aplicación de fertilizantes, textura y estructura, materia orgánica)
- La interceptación y absorción radicular (superficie radicular, velocidad de crecimiento radicular, genotipo, etc.)
- El transporte iónico a través de las membranas radiculares (tipo de membrana, tipo de ión)
- La traslocación iónica (transporte unidireccional en el xilema y bi-direccional en el floema)
- La remobilización iónica de las zonas de acumulación (transporte desde hojas o maderas a las zonas sumidero, como frutos o yemas)
- Exudación radicular (modificación del pH, exudados para micorrizas)
- Micorrizas, (asociaciones plantas-micorrizas, actividad total de la rizosfera)

Así, para Kabata (2004) la biodisponibilidad de un elemento para una planta esta gobernada por una serie de factores, que en orden de importancia serían: pH y potencial rédox, textura, materia orgánica, composición mineral del suelo y régimen de humedad.

Así, la clorosis férrica (imposibilidad de absorber hierro) está asociada a pH alto, en suelos calizos y plantas sensibles (vid, cítricos, melocotones, etc.). La corrección con quelatos de esta deficiencia es práctica agrícola común cuyas únicas limitaciones son, generalmente, las de carácter económico. La corrección del pH de los suelos, que es la causa primaria de la clorosis, con productos de costo más razonable, es una de las posibles soluciones a este problema.

La bajada del pH de los suelos básicos implica por lo general importantes beneficios en todos los sentidos para las plantas y para el medio microbiano, pero también presenta aspectos colaterales, no deseables, que son importantes conocer. Uno de ellos es el aumento de la solubilidad de algunos elementos antes citados, que en un medio básico estaban insolubles. El aumento de solubilidad pudiera llevar, por una parte a la corrección de la deficiencia, objeto de la mejora, pero por otro, a un proceso de aparición de toxicidad de algunos elementos antes insolubles.

Hay especies de árboles incapaces de adaptarse a un proceso brusco de aumento de concentración en la solución del suelo de estos metales, y solo algunos ecotipos, o la propia intervención de mejora del hombre (portainjertos resistentes) hace posible su utilidad (Kahle,1993).

La valoración de todos estos procesos individualmente es de notable complejidad por lo que se procede a sistematizarlos y resumirlos, a veces, por conceptos más sencillos. Uno de esos conceptos es el Factor de Transferencia (FT).

El FT relaciona la cantidad de un elemento que hay en el suelo con la que hay en la planta, total o parcialmente, es decir con la planta completa o con una parte de ella (hoja, fruto, etc), y puede ser expresado como la cantidad de producto que hay en una relación de peso seco suelo a peso seco planta (IAEA, 1994); o como área de suelo (a una profundidad de 20 cm para cultivos o 10 cm para pastos) a peso seco de planta (Frissel, 1997); o como también peso seco de suelo a peso fresco, lo que es más normal en el caso de frutos. La forma más sencilla de definir el FT, en la literatura científica, es el cociente entre la concentración en la planta, o en un órgano de ella, de un elemento determinado y la concentración de ese elemento en el suelo.

$$C_{planta} = FT*C_{suelo} \qquad (1)$$

También se encuentra la definición de... *cantidad esperada de un elemento que entra en una planta de un suelo en condiciones de equilibrio* (Chojnacka, 2004). En este caso, las condiciones de equilibrio, no obstante, son difíciles de definir.

Ese concepto básico de traslocación o absorción, se ha aplicado a metales pesados (Chamberlain, 1983; Gast, 1998) a pesticidas (Trapp, 1990), a radionucleidos (Ehlken, 2002; Blanco, 2002), etc.

La anterior definición asume dos hechos de dudosa certeza; que la relación entre ambas concentraciones es lineal y, además, que es constante. Una larga lista de citas en la literatura científica demuestra que, en muchos casos, ni es lineal ni es constante y que en una misma planta y suelo puede llegar a tener una notable variabilidad, indicando así que esa relación lineal exacta no tiene porque existir, es puntual en el tiempo y en el espacio.

Esa variabilidad es obvia, dada el gran número de factores (climáticos, biológicos, genéticos, etc.) y parámetros (pH, CIC del suelo, humedad, competencia entre iones, etc.), que gobiernan las relaciones suelo-planta.

La formulación simplista de un modelo lineal para explicar como se gobierna el proceso de absorción por la planta de un elemento, con relación al sistema agua-suelo procede tomarla, pues, con suma precaución. Los casos encontrados en la literatura asumen modelos lineales principalmente para elementos que se encuentran en el suelo en muy baja concentración, y con valores de un amplio rango de variación (Blanco, 2002). Lo anterior significaría que la transferencia de un elemento del suelo a la planta, en el caso de rectas muy horizontales, no dependería, para estos elementos, de la concentración del suelo. Si además existiera una gran dispersión de los valores de FT con respecto a su propia media, se expresaría el hecho que el elemento considerado estaría en forma de sales muy insolubles y es difícilmente absorbible por la planta, o por el contrario en forma de sales muy solubles que facilita la absorción por la planta.

Modelos de transferencia lineales algo más elaborados formulan la relación de concentraciones como la ecuación de una recta que corta al eje de la Y en un punto:

$$C_{planta} = a*C_{suelo} + b \quad (2)$$

Si b es cero, que es el caso de la ecuación (1) se asume que el elemento considerado solo entra en la planta por las raíces. La discusión en cuanto al coeficiente angular de la recta (a = FT) sería el mismo que anteriormente.

Relaciones más complejas encontradas en la literatura científica expresan la relación de absorción con una ecuación hiperbólica de tipo:

$$C_{planta} = m*C^{n}_{suelo} \quad (3)$$

Si n=1 la curva se transforma en una recta con coeficiente angular igual a m. Si n=0 la recta es horizontal y la concentración en la planta es constante e igual a m. Si n<1 los valores de la concentración en la planta disminuirían cuando se incrementan los valores de concentración en el suelo.

Existen modelos para la determinación de FT que tienen en cuenta la transpiración de la planta y la humedad del suelo como el modelo usado por Ambe (1999).

$$FT = ST_c / (\theta + K_d) \quad (4)$$

S es el Coeficiente de Absorción selectiva del elemento; Tc el coeficiente de transpiración (cc/g), que es el agua requerida para la producción de un gramo de planta; θ es el contenido de agua del suelo (cc/g) y Kd el coeficiente de distribución (cc/g).

El uso de modelos algo más complejos, se ha utilizado en diversos campos de la investigación. Se han planteado modelos como los aquí expresados pasando por modelos conceptuales teóricos como el de Mitscherlich (Tudoreanu, 2004), modelos dinámicos

(TERMOD, NRPB, RADFOOD, PATHWAY, RADAL o DYNAMON) o modelos estáticos (HERMES, UNSCEAR, USNRC, ECOSYS) cuya revisión se ha realizado por Kabai, 2004 e incluso el modelo dinámico del autor citado ETM-2002, mucho más complejos, etc., que incorporan un número notable de variables tales como deposición aérea, superficie de la planta, agua intersticial, superficie de suelo considerado, concentración del elemento en la zona radicular, etc.

El uso de FT ó modelos de trasferencia es casi una constante, especialmente en aquellos autores que investigan transmisión de radionucleidos, metales pesados y fitorestauración. Su traslado a cultivos que sean comestibles, como es nuestro caso, por sus hojas, frutos, etc. puede ayudar a entender el movimiento de los metales pesados, con escasas concentraciones, en los sistemas suelo-hojas. Estos modelos, posiblemente, no serían trasladables a macroelementos nutritivos ni cuantitativa y/o temporalmente.

La International Union of Radioecologist está planteándose actualmente la posibilidad de calcular modelos de transferencia para cereales que sirvan de unidades, que mediante un factor de conversión, puedan ser aplicados a otros cultivos (Frissel, 2002; Nisbet, 2000).

METODOLOGÍA

- **Parcela experimental**

Se eligió un cultivo melocotones y se determinó un área experimental sita en Cartaya (Huelva-España). El área de experiencia tenía una superficie cuadrada de 36x36 m. Los árboles están situados a un marco de plantación de 6x3 m. Las muestras se toman en la línea de árboles alternativamente, árbol si árbol no, de tal manera que la malla de muestro es cuadrada a 6x6 m. El suelo es una arcilla pliocénica clasificada como Aquic Palexeralfs .

- Técnica de muestreo en campo

Primera toma datos de suelos se realiza en Septiembre del primer año, llamándose a éstas muestras Suelos1, referentes a la 1ª toma de muestras. La segunda toma de suelos se realiza en Septiembre del segundo año, llamándose a éstas Suelos3. Todas las muestras son introducidas en bolsas y son etiquetadas debidamente para su correcta identificación, mostrando en ella el árbol de la cual es cogida y la fecha, para su envío al laboratorio.

Las correcciones para bajar el pH de los suelos se han realizado con Sulfato Ferroso Monohidratadfo (SFM), procedente de la industria del titanio obtenido por tratamiento de la ilmenita. Se realiza una mejora equivalente a 600kg/ha, aplicada en la proximidad de los goteros de cada árbol. Se muestrean en total 36 árboles. Se toman muestras de hojas en Septiembre del primer año y en Septiembre del segundo año.

- **Análisis químico**

Método: Basado en Standard Methods

- Aparatos: ICP-MS (espectrómetro de masas con fuente de ionización de plasma acoplado inductivamente). Serie 4500 de Hewlett Packard.
- Espectrofotómetro Lambda-2 de Perkin-Elmer.
- pH-metro WTW con electrodo combinado de calomelano.

- Las muestras de hojas se trocearon y se lavaron con agua de 18,2 MW producida en un equipo Milli-Q Ro siendo en esta solución donde se procedió a las determinaciones mediante ICP-MS.

Para la disgregación ácida se empleó 10 ml de agua regia inversa sobre 1 gr de muestra en el caso de las hojas. Las medidas de pH se fueron tomando cada 10 min.

Condiciones instrumentales

- Para ICP-MS: La sintonía y comprobación de la calibración del ICP-MS se efectuó con una solución de 10 ppb de ^{7}Li, ^{89}Sr y ^{205}Tl, consiguiéndose una RSD inferior al 5\%.
- Para la calibración externa se emplearon estándares multielementales, con una concentración inicial en cada elemento de 10 ppm de Spex Cheminal y a partir de estos, se prepararon por disolución los estándares para la estandarización del sistema, de 1 ppb, 10 ppb, 50 ppb y 100 ppb.
- Para el espectrofotómetro: El sistema se calibró usando patrones de 5, 10, 20, 25, y 30 ppm de sulfatos preparados por dilución a partir de un patrón de 1000 ppm.
- Para el pH-metro: El sistema se calibró a dos puntos pH 4 y pH 7,02 empleando soluciones amortiguadoras para tal fin de la casa Merck.

- Características del Sulfato de Hierro Monohidratado (SFM)

Se trata de un Sulfato de Hierro Monohidratado con otros microelementos y con ácido sulfúrico que se presenta en forma cristalina. Es un producto preventivo de clorosis férrica para todo tipo de cultivos, actúa como acidificante del suelo y aporta microelementos previniendo su carencia.

Las características técnicas (Información facilitada por la empresa Huntsman-TOXIDE S.L.) son las siguientes: Fe soluble en agua 20,5 %; SO_3 soluble en agua 40,0 %; Ti soluble agua 1,5 %; Mn soluble en agua 1,0 % y Zn soluble en agua 0,5 %.

- Tratamiento estadístico

Para la obtención de los modelos se utiliza el programa Informático SPSS 12.0.

Resultados y discusión

Una vez obtenidos los datos analíticos de suelos y hojas se tratan estadísticamente y se realizan los estudios correspondientes. Se estudian las concentraciones en hojas frente a la concentración en suelos mediante cuatro modelos (lineal, logarítmico, cuadrático y cúbico). Los datos expresados en la Tabla nº 1, son los dos modelos mejor ajustados (Lineal y Logarítmico).

Tabla nº 1: Valores de las rectas de regresión lineal y logarítmica de los metales pesados a estudio

Variable Dependiente	Variable Independiente	Modelo	Rsq	g.l.	F	Sig.	b0	b1
Co1f	Co1s	Lineal	,027	34	,93	,342	,2020	-,0057

Co1f	Co1s	Logarítmico	,018	34	,62	,437	,2300	-,0358
Co3f	Co3s	Lineal	,000	34	2,3 (-0,5)	,996	,1994	-4 (-0,5)
Co3f	Co3s	Logarítmico	,000	34	,01	,912	,1884	,0056
Cu1f	Cu1s	Lineal	,193	34	8,15	,007	3,9982	,4118
Cu1f	Cu1s	Logarítmico	,188	34	7,85	,008	-4,6540	5,4934
Cu3f	Cu3s	Lineal	,091	34	3,42	,073	7,5564	-,1006
Cu3f	Cu3s	Logarítmico	,078	34	2,87	,100	8,7337	-,9783
Ni1f	Ni1s	Lineal	,030	34	1,05	,313	5,0010	-,0348
Ni1f	Ni1s	Logarítmico	,030	34	1,05	,312	6,6112	-,7724
Ni3f	Ni3s	Lineal	,003	34	,11	,747	1,8053	-,0060
Ni3f	Ni3s	Logarítmico	,000	34	1,3E-03	,971	1,6263	,0154
Zn1f	Zn1s	Lineal	0,004	34	0,13	0,724	11,1663	-,0306
Zn1f	Zn1s	Logarítmico	0,011	34	0,36	0,550	6,4091	1,6535
Zn3f	Zn3s	Lineal	0,187	34	7,84	0,008	6,0301	,0622
Zn3f	Zn3s	Logarítmico	0,194	34	8,29	0,007	-1,6336	2,7952

Nota: g.l.: Grados de libertad; Sig: Significación; b0 = FT; b1 = Coordenada en el origen;

Tabla nº 2: Valores de Factor Transferencia para los elementos a estudio

Elemento	N	Mínimo	Máximo	Media	Desviación Std.
pH1	36	7,27	8,39	8,0761	0,2618
pH3	36	3,27	7,77	6,1694	1,3797
Co1	36	0,01	0,04	0,0197	0,00810
Co3	36	0,01	0,07	0,0292	0,01131
Cu1	36	0,43	1,17	0,7042	0,15230
Cu3	36	0,18	1,43	0,6956	0,31920
Ni1	36	0,10	0,39	0,1914	0,05885
Ni3	36	0,03	0,12	0,0767	0,02318
Zn1	36	0,23	0,58	0,3742	0,08473
Zn3	36	0,16	0,38	0,2481	0,05280

Nota: pH1: pH en primera toma de suelo ; pH3: pH en segunda toma de suelo Co1: Cobalto en primera toma; Co3: Cobalto en segunda toma; Cu1: Cobre en primera toma; Cu3: Cobre en segunda toma; Ni1: Níquel en primera toma; Ni3: Níquel en segunda toma; Zn1: Cinc en primera toma; Zn3: Cinc en segunda toma;

Gráfico nº 1: Representación de las regresiones lineales (línea continua) de los distintos elementos, las líneas discontinuas representan la concentración en las hojas frente a la concentración en el suelo

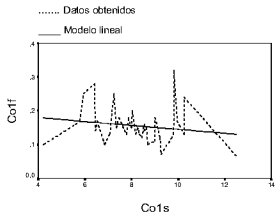


Grafico 1.1: Variación de la Concentración de Co en hojas frente a la concentración en suelos (ppm) en primera toma

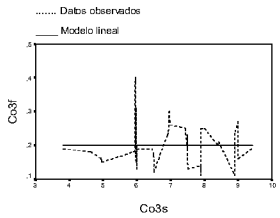


Grafico 1.2: Variación de la Concentración de Co en hojas frente a la concentración en suelos (ppm) en segunda toma

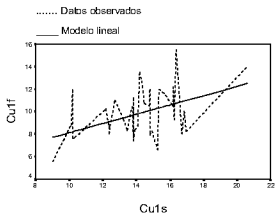
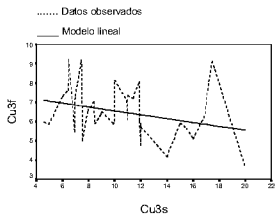
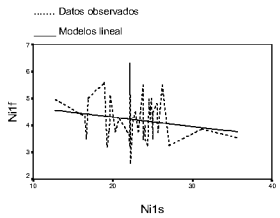


Grafico 1.3: Variación de la Concentración de Cu en hojas frente a la concentración en suelos (ppm) en primera toma





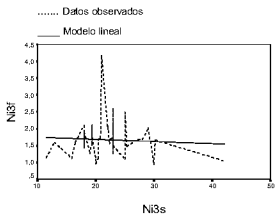
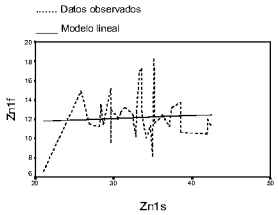


Grafico 1.4: Variación de la Concentración de Cu en hojas frente a la concentración en suelos (ppm) en segunda toma

Grafico 1.5: Variación de la Concentración de Ni en hojas frente a la concentración en suelos (ppm) en primera toma

Grafico 1.6: Variación de la Concentración de Ni en hojas frente a la concentración en suelos (ppm) en segunda toma



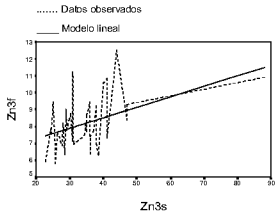


Grafico 1.7: Variación de la Concentración de Zn en hojas frente a la concentración en suelos (ppm) en primera toma

Grafico 1.8: Variación de la Concentración de Zn en hojas frente a la concentración en suelos (ppm) en segunda toma

Gráfico nº 2: Variación de los valores de FT sobre la concentración de los diferentes elementos a estudio. La línea representa el valor medio.

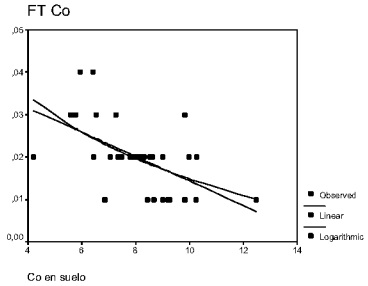


Grafico 2.1: Variación del FT del Co en hojas frente a la concentración en suelos (ppm) en primera toma

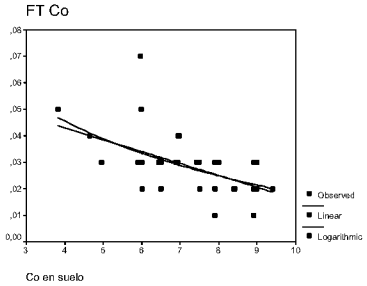


Grafico 2.2: Variación del FT del Co en hojas frente a la concentración en suelos (ppm) en segunda toma

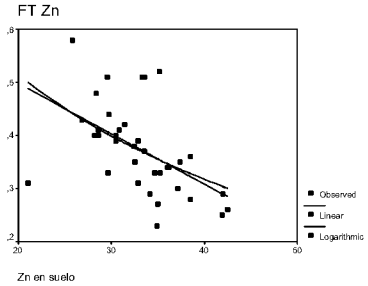


Grafico 2.3: Variación del FT del Ni en hojas frente a la concentración en suelos (ppm) en primera toma

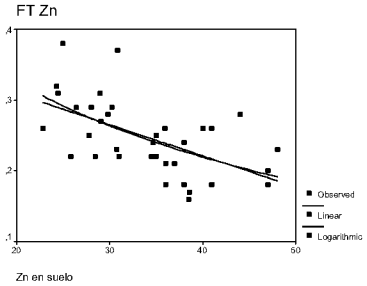


Grafico 2.4: Variación del FT del Ni en hojas frente a la concentración en suelos (ppm) en segunda toma

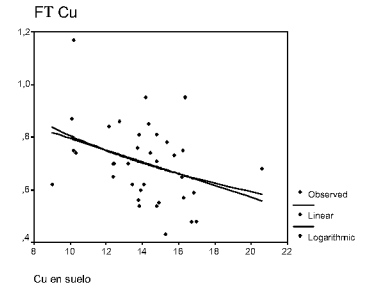


Grafico 2.5: Variación del FT del Cu en hojas frente a la concentración en suelos (ppm) en primera toma

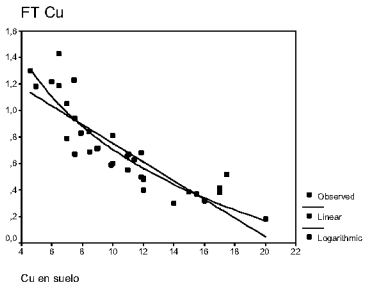


Grafico 2.6: Variación del FT del Cu en hojas frente a la concentración en suelos (ppm) en segunda toma

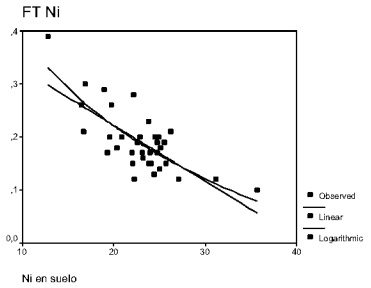


Grafico 2.7: Variación del FT del Ni en hojas frente a la concentración en suelos (ppm) en primera toma

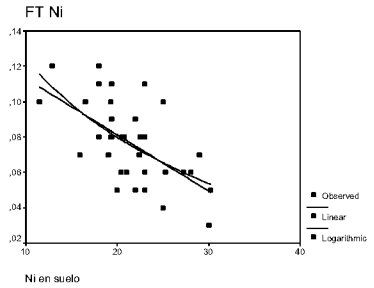


Grafico 2.8: Variación del FT del Ni en hojas frente a la concentración en suelos (ppm) en primera toma

Cobalto

Al comienzo de la experiencia las relaciones de concentración hojas/suelos están correlacionadas por una recta de regresión (modelo lineal de regresión) cuya ecuación es $C_{hoja} = -0{,}0057C_{suelo} + 0{,}2020$, y al final de la experiencia esa recta tiene la ecuación $C_{hoja} = -0.5000C_{suelo} + 0{,}1994$. Lo anterior nos indica que el modelo de regresión sigue siendo lineal y que el aumento de la concentración de Co en los suelos hace la recta más horizontal, es decir **la concentración en hojas se hace prácticamente independiente de la concentración en suelo**. (Gráficos 1.1 y Gráficos 1.2).

El FT medido por el cociente $FT=C_{hoja}/C_{suelo}$, con respecto a la concentración del suelo, comienza con un modelo prácticamente lineal plano de ecuación $FT = -0{,}0029C_{suelo} + 0{,}0431$ y termina con un modelo $FT = -0{,}0045C_{suelo} + 0{,}0609$ igualmente plano. Esto significa que, a los niveles que se ha conseguido mover el pH de este suelo, el FT no se ha modificado para este elemento, es decir **las modificaciones del pH no alteran los modelos de FT**.

Este elemento presenta situaciones de muy **poca estabilidad** en sus estados de solubilidad con una dispersión notable respecto a su media (Media de FT inicial = 0.0197±0.00810). Al final sigue manteniendo su dispersión de valores (Media de FT final = 0.0292±0.01131). (Gráficos 2.1 y Gráficos 2.2). Los procesos de solubilidad/ insolubilidad son notables en pequeños rangos de concentración en el suelo.

Cobre

Al comienzo de la experiencia las relaciones de concentración hojas/suelos estaban correlacionadas por una recta de regresión (modelo lineal de regresión) cuya ecuación era $C_{hoja} = 0{,}4118C_{suelo} + 3.9982$, y al final de la experiencia esa recta tiene la ecuación $C_{hoja} = -0.1006C_{suelo} + 7.5564$. Lo anterior nos indica que el modelo de regresión sigue siendo lineal pero no horizontal y que **el aumento de la concentración de Cu_{suelos} si influye débilmente en el valor del Cu_{hoja}**. Esto está en concordancia con Hooda (1997) cuando afirma que la absorción de Cu por las plantas no aumenta demasiado cuando se aumenta la concentración del suelo.

Cuando se hace la corrección de pH se observan dos hechos. El primero es que la recta se vuelve horizontal con lo que, ahora la concentración de Cu_{hoja} deja de ser independiente de la Cu_{suelo}, y que esa recta corta al eje de la Y en un valor casi doble que el inicial. La elevación del punto de corte de la recta puede hacer sospechar que las hojas, en este caso, pudieran estar afectadas por **tratamientos con productos cúpricos**, los cuales han sido aplicados para evitar enfermedades fúngicas (Gráficos 1.3 y Gráficos 1.4).

El FT medido por el cociente $FT=C_{hoja}/C_{suelo}$, con respecto a la concentración del suelo , comienza con un modelo prácticamente lineal plano de ecuación $FT = -0{,}0224C_{suelo} + 1.0190$ y termina con un modelo $FT =-0{,}0704C_{suelo} + 1.4568$ igualmente plano. Esto significa que, a los niveles que se ha conseguido mover el pH de este suelo, el FT no se ha modificado para este elemento, es decir **las modificaciones del pH no alteran los modelos de FT**.

Este elemento presenta, **al principio**, situaciones de **mayor estabilidad** en sus estados de solubilidad con una dispersión pequeña respecto a su media (Media de FT inicial = 0.7042±0.1523). Es posible que al principio la forma iónica más probable sea CO_3Cu cuyo proceso de solubilidad no depende del pH.

En el rango de disminución de pH como el aquí conseguido los valores, finalmente, se hacen más dispersos (Media de FT final =0.6956±0.3192), (Gráficos 2.5 y Gráficos 2.6) y los procesos de solubilidad/insolubilidad se hacen más aleatorios debido a la presencia de otros tipos de compuestos tales como $Cu(OH)_3^-$ o $Cu(OH)_4^=$, cuya dependencia del pH es manifiesta.

Niquel

El Ni es un micronutriente básico para la vida de las plantas superiores siendo esencial como componente de la ureasa enzima que influye en los procesos de nitrificación. El transporte de Ni dentro de ella depende de las especies, de la edad y del estatus nutricional.

Al comienzo de la experiencia las relaciones de concentración hojas/suelos estaban correlacionadas por una recta de regresión (modelo lineal de regresión) cuya ecuación era $C_{hoja} =-0.0348C_{suelo} + 5.0010$, y al final de la experiencia esa recta tiene la ecuación $C_{hoja} =-0.0060C_{suelo} + 1.8053$. Lo anterior nos indica que el modelo de regresión es lineal y horizontal y que el aumento de la concentración de Ni_{suelos} no influye en el valor del Ni_{hoja} (Gráficos 1.5 y Gráficos 1.6). Las concentraciones de **Ni_{hojas} , en el rango de valores de pH que nos movemos, son pues independientes de las C_{suelo}.** Esto esta en concordancia con (Kashem, 2002). Se observa, además que la recta del modelo de regresión corta al eje de la Y en un valor bastante más bajo que inicialmente, es decir se ha desplazado hacia abajo. Es posible que la mejora de las condiciones de desarrollo de la planta produzcan un efecto **dilución** (igual cantidad de elemento en más desarrollo foliar).

El FT medido por el cociente $FT=C_{hoja}/C_{suelo}$, con respecto a la concentración del suelo, comienza con un modelo prácticamente lineal plano de ecuación $FT = -0{,}0105C_{suelo} + 0.4322$ y termina con un modelo $FT =-0.0032C_{suelo} + 0.1448$ igualmente plano. Esto significa que, a los niveles que se ha conseguido mover el pH de este suelo, el FT no se ha modificado para este elemento, es decir **las modificaciones del pH no alteran los modelos de FT**. Lo anterior concuerda con las investigaciones de Kashem cuando asegura que los cambios leves de pH afectarían poco a la dinámica del Ni en suelos (Kashem, 2002) y consecuentemente a la absorción y traslocación a las partes aéreas de las plantas. Por otra parte es posible que muchas plantas sean capaces de regular el flujo de Ni hacia sus órganos aéreos independientemente de las concentraciones en el suelo.

Este elemento presenta, al principio por su probable unión a formas carbonato, situaciones estables en sus estados de solubilidad (Media FT inicial = 0.1914±0.05885).

En el rango de **disminución de pH** como el aquí conseguido, los valores, finalmente, no se modifican sustancialmente (Media de FT final =0.0767±0.02318), (Gráficos 2.7 y Gráficos 2.8) y los **procesos de solubilidad/ insolubilidad no se alteran.** Lo anterior esta en consonancia con la revisión de las formas de Ni presentes en los suelos realizada por Uren (1992), que pone de manifiesto que el Ni es un elemento relativamente inerte cuya dinámica depende esencialmente de la capacidad de cambio, de las condiciones redox y de la materia orgánica de los suelos. En nuestro caso, es posible que, la adicción al suelo de iones sulfato reduzca la adsorción de Ni en los componentes orgánicos.

Zinc

Al comienzo de la experiencia la concentración hojas dividido por la concentración en suelos estaban relacionadas mediante una recta de regresión (modelo lineal de regresión) cuya ecuación era C_{hoja} =-0.0306C_{suelo} + 11.1663, y al final de la experiencia esa recta tiene la ecuación C_{hoja} =-0,0622C_{suelo} + 6,0301. Lo anterior nos indica que el modelo de regresión en ambos casos lineal, pero ocurren dos hechos. El primero es que la recta de coeficiente angular negativo se hace de coeficiente positivo y valor casi doble del inicial lo que supone un giro considerable. El segundo es que la recta cortaba inicialmente al eje de las Y en el punto 11.1663 y termina cortándolo solo en 6,0301, es decir prácticamente al mitad. Así pues es probable que la concentración de Zn **en hojas dependa de la concentración en suelo, en los niveles de esta experiencia**. (Gráficos 1.7 y Gráficos 1.8). La bajada del pH disminuye el punto de corte de la recta lo que hace pensar en un efecto "dilución" por aumento del desarrollo foliar del árbol al mejorar las condiciones de cultivo. Es decir la disminución del pH hace al elemento más soluble y la traslocación hacia las hojas depende ahora de la concentración en suelo.

Podría pensarse con Hedal (1999) que el proceso de fertirrigación, y el incremento de conductividad que ello conlleva a nivel de los sistemas radiculares afecta sustantivamente al comportamiento del Zn en melocotones. Así, Helal (1999) opina que, el aumento de concentración salina a nivel radicular puede alterar notablemente el proceso de absorción del Zn en *Leucaena Leucocephala*. Según ello, el aumento de la Conductividad Eléctrica que implica el propio proceso de fertirrigación al que están sometidos estos árboles, además de la aplicación del SFM, podría elevar la cantidad de este metal que se transfiere hacia las hojas.

Si lo anterior fuese cierto, entonces, todo ello podría ser debido fundamentalmente a que los factores que más influirían en este caso estarían relacionados, (como en el caso de *Leucaena*) no tanto con las características estructurales y físico-químicas del suelo, sino con las características del sistema radicular del melocotonero.

La opinión de Helal (1999) no concuerda con la expresada por Ambe (1999) para *Brassica rapa* var. *perviridis*, donde el coeficiente de absorción del Zn disminuye cuando la Conductividad Eléctrica aumenta. Estos dos hechos serían solo aparentemente contradictorios ya que como expresa Mollah (1998) los valores de transferencia pueden variar no solo entre especies distintas para situaciones aparentemente iguales, sino entre distintas variedades de una misma especie. En nuestro caso nos inclinamos a pensar que es la disminución del pH producida por el SFM la que ha alterado las condiciones de solubilidad de este elemento.

El FT medido por el cociente $FT=C_{hoja}/C_{suelo}$, con respecto a la concentración del suelo, comienza con un modelo prácticamente lineal plano de ecuación $FT = -0{,}00951C_{suelo} + 0{,}6880$ y termina con un modelo $FT =-0{,}0044C_{suelo} + 0{,}3969$ igualmente plano. Esto significa que, a los niveles que se ha conseguido mover el pH de este suelo, el FT no ha cambiado para este elemento, es decir **las modificaciones del pH no alteran los modelos de FT**.

Este elemento presenta situaciones de estabilidad en sus estados de solubilidad con los mismos porcentajes de dispersión al principio (Media de FT inicial = 0.3742±0.08473) y al final (Media de FT final =0.2481±0.05280). (Gráficos 2.3 y Gráficos 2.4) Por ello los **procesos de solubilidad/ insolubilidad que puedan darse en el rango de pH** considerado son estables.

CONCLUSIONES

No se ha encontrado en la literatura científica valores de transferencia suelos-hojas en melocotones en suelos calizos para su posible comparación. Los estudios mas parecidos son las revisiones de Carini (2001) en frutos de melocotón.

Las concentraciones de los metales considerados en las hojas, por lo general, son independientes de las concentraciones en el suelo, salvo casos como el Zn. Por lo que respecta a las cantidades absorbidas se puede citar como singularidad el caso del Cu, que puede verse afectado por los tratamientos antifúngicos que a lo largo del periodo de crecimiento de la hoja modifique elevándolos, o así mismo el caso del Zn por un posible efecto "**dilución**" por mejor desarrollo foliar del árbol

Los modelos de transferencia de metales pesados (Co, Cu, Ni y Zn) desde suelos calizos hacia las hojas en cultivos de melocotón (*Prunus persica L.)* son **por lo general modelos lineales**. La mayoría de ellos salvo casos singulares como el Zn, además, son modelos casi horizontales, expresando el hecho de que las concentraciones relativas transferidas de estos elementos hacia las hojas son independientes de las concentraciones en el suelo. La bajada del pH de los suelos calizos con mejoradores edáficos tales como el Sulfato de Hierro Monohidratado (SFM) modifican escasamente los niveles de traslocación de estos elementos en las cantidades que esta experiencia ha aplicado.

REFERENCES

Ambe S, Shinonaga T, Ozaki T, Enomoto S, Yasuda H and Uchioda S 1999 Ion competition effects on the selective absorption of radionuclides by komatsuna (Brassica rapa var. perviridis). Environmental and Experimental Botany. 41, 185-194.

Blanco P, Vera F and Lozano J C 2002 About the assumption of linearity in soil-to-plant transfer factor fro uranium and thorium isotopes am ^{226}Ra. The Science of the Total Environment. 284, 167-175.

Carini F 2001 Radionuclide transfer from soil to fruit. Journal Environment Radioactivity. 52, 237-279.

Chamberlain A C 1983 Fallout of lead and uptake by crops. Atmospheric Environment. 17, 693-706.

Chojnacka K, Chojnacki A, Górecka H and Gó recki H 2004 Bioavailability of heavy metals from polluted soils to plants. Science of the Total Environment. In Press.

Ehlkem S and Kirchner G 2002 Environmental processes affecting plant root uptake of radioactive trace elements and variability of transfer factor data: a review. Journal of Environmental Radioactivity. 58, 97-112.

Frissel M J 1997 Protocol for experimental determination of soil to plant transfer factors (concentration ratios) to be used in radiological assessment models. UIR Newsletter. 25, 5-8.

Frissel M J, Deb D L, Fathonyhttp://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VB2-44C8691-3&_user=705994&_coverDate=12%2F31%2F2002&_alid=268529846&_rdoc=1&_fmt=full&_orig=search&_cdi=5914&_sort=d&_st=4&_docanchor=&_acct=C000039438&_version=1&_urlVersion=0&_userid=705994&md5=dbce54abf31be644d31e2b6ba5a22986 - affc M, Lin Y M, Mollahhttp://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VB2-44C8691-3&_user=705994&_coverDate=12%2F31%2F2002&_alid=268529846&_rdoc=1&_fmt=full&_orig=search&_cdi=5914&_sort=d&_st=4&_docanchor=&_acct=C000039438&_version=1&_urlVersion=0&_userid=705994&md5=dbce54abf31be644d31e2b6ba5a22986 - affe A S, Ngohttp://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VB2-44C8691-3&_user=705994&_coverDate=12%2F31%2F2002&_alid=268529846&_rdoc=1&_fmt=full&_orig=search&_cdi=5914&_sort=d&_st=4&_docanchor=&_acct=C000039438&_version=1&_urlVersion=0&_userid=705994&md5=dbce54abf31be644d31e2b6ba5a22986 - afff N T, Othman I, Robison W L, Skarlou-Alexiou V, Topcuogluhttp://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VB2-44C8691-3&_user=705994&_coverDate=12%2F31%2F2002&_alid=268529846&_rdoc=1&_fmt=full&_orig=search&_cdi=5914&_sort=d&_st=4&_docanchor=&_acct=C000039438&_version=1&_urlVersion=0&_userid=705994&md5=dbce54abf31be644d31e2b6ba5a22986 - affj S, Twining J R, Uchida S and Wasserman M A 2002 Generic values for soil-to-plant transfer factor of radiocesium. Journal Environment Radioact. 58, 113-118.

Gast C H, Jansen E, Bierling J and Haanstra L 1988 Heavy metals in mushrooms and their relationship with soil characteristics. Chemosphere. 17, 789-799.

Helal H M, Upenov A and Issa G J 1999 Growth and uptake of Cd and Zn by *Leucaena leucocephala* in reclaimed soils as affected by NacCl salinity. Journal Plant Nutrition. Soil Science. 162, 589-592.

IAEA 1994 Handbook of parameter values for the prediction of radionuclide transfer in temperate environments. Technical Report Series 364. Vienna.

Kabai E, Zagybai P, Láng-Lázi M and Oncsik M B 2004 Radionuclide migration modeling through the soil-plant system as adapte for Hungarian environmen. Science of the total Environment. 330, 199-216.

Kabata A 2004 Soil-plant transfer of trace elements, a environmental issue. Geoderma. In Press.

Kahle H 1993 Response of roots of trees to heavy metals. Environ. Exp. Bot. 33, 99-119.

Leon V, Pence N S, Letham D, Pineros M and Magalhaes J 2002 Mechanisms of metal resistance in plants: aluminium and heavy metals. Plant and Soil. 247, 109-119.

Nisbet A F and Woodman R F 2000 Soil-to-plant transfer factor for radiocesium and radiostroncium in agricultural systems. Health Phys. 78(3), 279-288.

Trapp S, Matthies M, Scheunert I and Topp E M 1990 Modelingthe bioconcentration of organic chemicals in plants. Environmental Science and Technology. 24, 1246-1252.

Tudoreanu L and Phillips C J C 2004 Modeling cadmiun uptake and accumulation in plants. Advences in Agronomy. 84, 121-157.

Uren, NC 1992 . Forms, reactions and availability of nickel in soils. *Adv, Agromon.*, 48; 141-203.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):379. 2008

Poster #3

Caracterización del Transporte de Nutrientes y Sedimentos en Suelos Enmendados con Residuos Orgánicos ve Vaquería

G. Ardila[1], D. Sotomayor Ramírez [1], G. Martínez [1] y L. Perez Alegría[2]*
Universidad de Puerto Rico - Recinto de Mayagüez (UPRM), Colegio de Ciencias Agrícolas, Departamento de Agronomía y Suelos, Mayagüez, Puerto Rico; [2]Departamento de Ingeniería Agrícola y Biosistemas, UPRM.
** Autor de contacto: dsotomayor@uprm.edu*

RESUMEN.
La escorrentía con concentraciones elevadas de nitrógeno (N) y de fósforo (P) proveniente de suelos agrícolas contribuye a la reducción en la calidad de las aguas superficiales. La disponibilidad ambiental y agronómica de P en suelos puede ser evaluada por medio de un análisis de suelos que sirve de predictor de las concentraciones de P en escorrentía. Se estudiaron las relaciones entre niveles de P extraíble en suelo, niveles de aplicación de estiércol bovino, y tiempo transcurrido entre la aplicación de la enmienda y la precipitación sobre las concentraciones de N, P y sedimentos en la escorrentía de un suelo de la serie Humatas arcilloso (*Typic Haplohumults*) bajo la producción de forraje (*Brachiaria Decumbens*). Suelos con niveles (Bray1) "bajos" (30 a 90 mg P kg^{-1}) y "altos" (120 a 200 mg P kg^{-1}) fueron enmendados con una aplicación baja (15.5 kg N ha^{-1} y 5.6 kg P ha^{-1}) y alta (31 kg N ha^{-1} y 11.2 kg P ha^{-1}) de estiércol bovino y se sometieron a simulaciones de lluvia con intensidad de 70 mm h^{-1} para producir 30 minutos de escorrentía. Las concentraciones de P disuelto, P total, y N total en la escorrentía fueron mayores en los suelos con mayor contenido de P extraíble y con la aplicación alta de estiércol ($P<0.05$). No hubieron diferencias significativas en las concentraciones de nutrientes en suelos con "bajo" contenido de P extraíble con la aplicación baja de estiércol y el suelo sin enmienda. Es de importancia caracterizar el P extraíble que corresponde al grado de saturación de P umbral para predecir adecuadamente el punto cuando las concentraciones de P en escorrentía se incrementarán.

PALABRAS CLAVE: escorrentía, fósforo, enmienda orgánica.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):380-386. 2008

Poster #4

Tillage Effects on a Crop Rotation of Yam, Eggplant, Bean and Corn in Oxisol, Ultisol and Vertisol Soils in Puerto Rico

Wanda I. Lugo, Agenol González, Elvin Román, Nydia Rafols and Héctor Lugo. Agricultural Experiment Station, University of Puerto Rico-Mayagüez. wandalugo2001@yahoo.com

ABSTRACT.
Three tillage methods, conventional till, minimum till and deep till versus no till and their respective interaction with three fertilizer levels (0, 1x and 2x the recommended amount) were evaluated in a crop rotation that included yam (*Dioscorea alata* L.), eggplant (*Solanum melongena* L.), bean (*Phaseolus vulgaris* L.) and corn (*Zea mays* L.). The experiment was established at three ecologically different locations with three different soil orders: Ultisol, Oxisol and Vertisol. Yam, the first crop in the rotation, was planted after soil preparation according to the treatments. The crops that followed in the rotation were planted no till in the same plots. A fifth treatment, in which all crops in the rotation were planted under conventional tillage, was used as a check. Yield response of the rotation crops varied with location. Yam yields in the no till plots were significantly lower than in the conventional till plots in the Ultisol and Vertisol soils, but not in the Oxisol soil. Response to fertilizer was observed only in the Oxisol. Yield response of eggplant with respect to the tillage treatments was similar to that observed for yams, thus suggesting that there was a residual effect of tillage. For the bean and corn crops, the third and fourth crops of the rotation, the residual effect of the tillage practices performed at the beginning of the rotation cycle was little if any.

KEYWORDS: Tillage, crop rotation, tropical soils

INTRODUCTION

Soil management techniques that result in efficient use and conservation of land resources have been adopted because they are less erosive, less costly and in many cases more profitable for crop production. In Puerto Rico the use of these cultural practices has been limited to crops such as fruit trees, coffee, plantains and bananas. In experiments conducted in Puerto Rico with root crops, legumes and vegetables, the response to conservation tillage varied considerably, depending on soil type and climate. Experiments conducted in a Mollisol suggested that watermelon, tomato and pigeon pea could be grown with minimum or even no tillage (Lugo-Mercado et al., 1987). Limited research has been conducted in Puerto Rico concerning tillage methods for yam production. Vicente-Chandler et al. (1966) obtained yam yields that were as high in undisturbed as in thoroughly tilled, highly weathered soils of the mountain region. Lugo et al. (1978), however, reported a 75% yield reduction in taniers (*Xanthosoma* spp.) grown in an undisturbed Oxisol.

Since under no tillage conditions soil nutrients may not be as readily available to the plant as when under conventional tillage, increased rates of fertilizer might

compensate for reductions in yield. However, if this assumption is proven correct, the high cost of fertilizer constitutes a limiting factor. The research herein reported was conducted to evaluate the effect of tillage treatments and fertilizer rates on a crop rotation of yam, eggplant, bean and corn.

MATERIALS AND METHODS

A tillage-rotation experiment was established at the Isabela, Corozal and Lajas substations in Oxisol, Ultisol and Vertisol soils, respectively. Crops in the rotation were yam, eggplant, bean and corn. Tillage treatments were 1) no till (undisturbed); 2) conventional tillage (disc-plowed at a depth of 20 to 30 cm, and harrowed, raised beds); 3) deep tillage (plowed to a depth of over 30 cm); 4) minimum tillage (either chiseled to a depth of 20 cm or tilled to a depth of 10 cm with a cultivator). Tillage treatments were applied before planting the first crop of the rotation. For studying tillage residual effects, all other crops of the rotation were planted no till in the same plots. The order of the crops in the rotation was according to their tillage requirements (in decreasing order). A fifth treatment (continuous conventional), in which plots were conventionally tilled for all the crops in the rotation, was used as a check. For all the crops in the rotation the plots were split into three subplots, and fertilizer was applied at rates of 0, 1 and 2 times the recommended levels.

Tuber sections of yam were direct planted, spaced at 46 cm within the row and at 122 cm between rows. Plants were staked when vines were 0.45 m long. The fertilizer was applied in two equal amounts, two and five months after planting. Eggplant cv. Rosita plantlets were transplanted to the undisturbed soil. Half of the fertilizer was applied one week after transplanting, the other half at flowering. Beans (LW-227) were planted after the harvesting of the eggplant, and then harvested when completely dry (approximately 90 days after planting). Fertilizer was split into two applications. Corn, the last crop of the rotation, was planted in double rows. Part of the fertilizer was applied at planting, and the rest was applied as ammonium sulfate one month after planting. For all crops, irrigation was applied as necessary. All the other practices were as recommended. No tillage operations were performed after planting the yams, except in the control plots.

RESULTS AND DISCUSSION

Differences in yam plant growth were observed from early in the season. Plants in the minimum and no till plots developed more slowly than the plants in the other plots. Differences in the amount of foliage were also observed among the fertilizer treatments. Yams were harvested about seven to eight months after planting. Table 1 shows yields from the three locations. Yields were very low at Lajas and Isabela because of anthracnose. Significant yield differences were observed among tillage treatments at Lajas and Corozal. At Isabela (Oxisol) there were no significant differences among the tillage treatments. At Corozal, in a heavier soil (Ultisol), the higher yam yields were obtained in the deep till and conventionally tilled plots, whereas at Lajas (Vertisol), the significantly lower yields were obtained in the no tilled plots. Increasing the fertilizer level over the recommended amount (1X) did not significantly increase yields at any of the locations.

Table 2 presents yield data from eggplant, the second crop of the rotation. At Isabela no differences in yield were observed among the previous tillage methods. There were, however, significant differences between the fertilizer levels, as if the high level of fertilizer offset the detrimental effect of the reduced tillage. A similar trend was observed at Lajas. At Corozal, the highest eggplant yields were observed in the continuous conventional treatment, where eggplant was planted after conventional tillage as compared to yields of the other treatments where no tillage operations were performed.

At Isabela and Corozal bean yields were significantly higher under the continuous conventional tillage (Table 3). The residual effect of the tillage treatments had been diminished to the point that no further benefit was obtained. However, at Lajas yields in the continuous conventional tillage treatment were significantly different from only those in the no till plots, thus suggesting that there was some residual effect. The effect of the fertilizer level varied among locations.

At Corozal corn yields in the continuous conventional tillage treatment were significantly higher than yields with any other treatment thus indicating that there was no residual effect (Table 4). A similar pattern was observed at Lajas. At Isabela there were no yield differences among treatments; however, yields were very low at this location in all treatments, possibly because of some other factor. The response of corn to the fertilizer levels was the same at all locations. The 2X and 1X levels produced significantly higher yields than the 0 level.

REFERENCES

Lugo, W.I., A. González, F. Román and E. Román, 2007. Tillage residual effect on a crop rotation of taro, cabbage and eggplant in Oxisol, Ultisol and Vertisol soils of Puerto Rico. Proc. Caribbean Food Crops Society 43: 204-208.

Lugo-Mercado, H. M., J. Badillo-Feliciano and J. López-García, 1978. Effects of soil compaction on tanier yields. *J. Agric. Univ. P.R.* 62: 52-56.

Lugo-Mercado, H. M., J. Badillo-Feliciano and F. H. Ortiz-Alvarado, 1987. Yield response of watermelon, tomato and pigeon pea to land preparation techniques in southern Puerto Rico. *J. Agric. Univ. P.R.* 71:203-208.

Vicente-Chandler, J., R. Caro-Costas and E. Boneta, 1966. High crop yields produced with or without tillage on three typical soils of the humid mountain region of Puerto Rico. *J. Agric. Univ. P.R.* 50: 146-50.

Table 1. Yam yields under variable tillage and fertilization regimes.

Tillage Treatment		Fertilizer Level			
		0	1	2	Mean[1]
			kg/ha		
			Corozal		
Conventional		39630	53440	42600	9270c
Deep-till		46440	37640	40690	45230a
Minimum		22770	27230	25740	41590ab
No-till		3870	10720	13220	25250bc
Continuous Conventional		43500	45380	56100	48330a
	Mean	31240	34880	35670	
			Isabela		
Conventional		12800	17530	18350	6780b
Deep-till		11910	16600	17840	16230ab
Minimum		11790	16450	12680	15450ab
No-till		3760	9630	6960	13640ab
Continuous Conventional		15180	20940	18350	18160a
	Mean	11090b	16230a	14830a	
			Lajas		
Conventional		18760	19460	22340	8140c
Deep-till		17080	14180	23100	20190a
Minimum		9780	9730	12240	18120ab
No-till		5960	9310	9140	10580bc
Continuous Conventional		15120	16990	11880	14660abc
	Mean	13340	13940	15740	

[1] Means followed by different letters are significantly different $P \leq 0.05$.

Table 2. Eggplant yields under variable tillage and fertilization regimes.

Tillage Treatment		Fertilizer Level			
		0	1	2	Mean[1]
			kg/ha		
			Corozal		
Conventional		14190	21060	25680	7100c
Deep-till		8760	13020	19630	20310b
Minimum		4920	10750	14370	13800bc
No-till		2850	9740	8720	10010c
Continuous Conventional		20280	32590	41820	31560a
	Mean	10200c	17430b	22050a	
			Isabela		
Conventional		6490	36070	50400	27160
Deep-till		7190	38430	42880	30990
Minimum		5050	39170	46410	29500
No-till		3920	34360	43200	30210
Continuous Conventional		13460	47490	55780	38910
	Mean	7220c	39100b	47730a	
			Lajas		
Conventional		4190	11430	13000	9630
Deep-till		4400	10270	13400	9540
Minimum		3190	9190	13210	9360
No-till		3550	11970	13370	8530
Continuous Conventional		6090	11720	11800	9870
	Mean	4280c	10920b	12960a	

[1] Means followed by different letters are significantly different $P \leq 0.05$.

Table 3. Bean yields under variable tillage and fertilization regimes.

Tillage Treatment		Fertilizer Level			
		0	1	2	Mean[1]
			kg/ha		
			Corozal		
Conventional		460	610	880	490b
Deep-till		310	580	760	650b
Minimum		390	440	660	550b
No-till		320	560	580	490b
Continuous Conventional		890	1300	1310	1170a
	Mean	470c	700b	840a	
			Isabela		
Conventional		310	400	360	450b
Deep-till		290	560	610	360b
Minimum		320	640	390	490b
No-till		330	480	530	450b
Continuous Conventional		470	890	870	740a
	Mean	350b	590a	550a	
			Lajas		
Conventional		1000	1210	1430	1100b
Deep-till		1010	1160	1470	1210ab
Minimum		1310	1000	1340	1210ab
No-till		960	1130	1200	1220ab
Continuous Conventional		1460	1310	1500	1420a
	Mean	1150b	1160b	1390a	

[1] Means followed by different letters are significantly different $P \leq 0.05$.

Table 4. Corn yields under variable tillage and fertilization regimes.

Tillage Treatment		Fertilizer Level			
		0	1	2	Mean[1]
			kg/ha		
			Corozal		
Conventional		1860	2740	2880	2520b
Deep-till		2400	3480	3420	2490b
Minimum		2240	2940	3000	3100b
No-till		1780	3300	2480	2730b
Continuous Conventional		3900	4340	3120	4540a
	Mean	2440b	3360a	3430a	
			Isabela		
Conventional		2860	4180	4510	4310
Deep-till		3030	5210	6360	3850
Minimum		3240	3940	4910	4870
No-till		3000	4460	5470	4030
Continuous Conventional		2960	5610	4200	4260
	Mean	3020b	4680a	5090a	
			Lajas		
Conventional		6115	12430	10910	5740c
Deep-till		5240	6590	10190	9820a
Minimum		8690	10000	8860	7340bc
No-till		4360	5520	7340	9180a
Continuous Conventional		7210	9630	9440	8760ab
	Mean	6320b	8830a	9370a	

[1] Means followed by different letters are significantly different $P \leq 0.05$.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):387. 2008

Poster #88

(Appears out of sequence after Poster #4)

Relationship between Vegetative Covers and Soil Physical Properties of one Mollisol on *Phytophthora cinnamomi* Occurrence in Avocado *Persea americana* Mill. in Puerto Rico.

Beatriz E. Torres Ordóñez[1], C. Estévez de Jensen[2], V. Snyder1 y M. Vazquez[1]. [1]Department of Agronomy and Soils, [2]Department of Crop Protection. College of Agricultural Sciences, University of Puerto Rico-Mayagüez Campus. P.O.Box 9032 Mayagüez, P.R. 00680. bettorres25@yahoo.com

ABSTRACT.

Puerto Rico imports 80 percent of the avocado that is consumed, which indicates economic potential of increasing its local production. However, the production of this crop have been affected with the high incidence and severity of the root rot associated with *Phytophthora cinnamomi*. This condition is exacerbated soil saturation conditions during the rainy season (July – December), high air temperatures and soil cracks during the dry season causing mechanical damage to the rooting system. During May 2006 an avocado plantation was established with the Semil 34/Semil 34 variety (pattern/graft) in order to evaluate the *Arachis pintoi* and *Arachis glabrata* influence in San Antón soil series, a fine-loamy Cumulic Haplustoll. The vegetative covers were established at the avocado trees surroundings during June 2006. The vegetative covers were compared with a control (no coverage legume) in a completely randomized design with four repetitions for treatment. The analyzed soil physical properties were: aggregates stability percentage, which after 21 months of coverage provided significant differences ($p<0.05$) between the *Arachis glabrata* (46.24%) versus the control (22.36%); also provided significant differences in field infiltration and bulk density. The moisture retention curves highlighted a better performance in *A. glabrata* versus the control after 12 months. The analyzed soil chemical properties were: total nitrogen percentage and available phosphorous (ppm) which provided significant differences; no significant differences were found in organic matter and pH. This investigation will continue to evaluate the soil properties until the end of a two year period.

KEYWORDS: *Arachis pintoi, Arachis glabrata*, avocado, soil physical properties.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):388. 2008

Poster #5

Respuesta de Líneas de Habichuela (*Phaseolus vulgaris L.*) a Diferentes Niveles de Fertilidad en un Oxisol

R. Dorcinvil[1], D. Sotomayor Ramírez[1], and J. Beaver[1], Universidad de Puerto Rico - Recinto de Mayagüez, Colegio de Ciencias Agrícolas, Departamento de Agronomía y Suelos, Mayagüez, Puerto Rico*
** Autor de contacto: dsotomayor@uprm.edu*

RESUMEN.
La baja disponibilidad de fósforo (P) y de nitrógeno (N), seguido por factores de acidez del suelo como exceso de aluminio (Al) y de manganeso (Mn) constituyen las limitaciones más importantes para la producción de habichuela (*Phaseolus vulgaris L.*) en el trópico. El desarrollo de genotipos adaptados a estas condiciones es una estrategia económica y ecológicamente viable para enfrentar el problema. Se realizaron dos experimentos para identificar líneas de habichuela adaptadas a condiciones de baja fertilidad en un Oxisol de Puerto Rico. En el primer experimento, 6 líneas hermanas de habichuela (3 con sistema radicular superficial y 3 con sistema radicular profundo) y 9 combinaciones de mezclas de semillas fueron sembradas bajo dos niveles de fertilidad (sin fertilizante y aplicación de 50 kg/ha de N, P_2O_5, K_2O respectivamente). En el segundo experimento, 38 líneas mayoritariamente de grano rojo y negro provenientes de una selección previa de 228 líneas del programa de mejoramiento de la Escuela Agrícola Panamericana de Honduras denominado Vivero de Adaptación Centroamericano (VIDAC) fueron evaluadas bajo 3 regímenes de fertilización: (i) 50 kg N/ha, 57 kg P_2O_5/ha (+N+P); (ii) 0 kg N/ha, 57 kg P_2O_5/ha (-N+P); y (iii) 50 kg N/ha, 0 kg P_2O_5/ha (+N-P); todas las parcelas recibieron 54 kg K_2O/ha. Las líneas con sistema radicular superficial y mixto obtuvieron mayores rendimientos y mayores concentraciones de N y de P que las líneas con sistema radicular profundo en las parcelas de baja fertilidad. Las líneas con un sistema radicular superficial y extenso como VAX 3 y las líneas RBF tuvieron rendimientos similares independiente del régimen de fertilidad. Los rendimientos en las lineas con un sistema radicular profundo como SER 16 y las XRAV tuvieron rendimientos en el orden de +N+P > +N-P > -N+P. La arquitectura de la raíz es una adaptación genotípica de la habichuela para la adquisición de N y de P.

PALABRAS CLAVE: Fertilidad de suelos, Habichuelas, Adaptación genotípica

2008 Proceedings of the Caribbean Food Crops Society. 44(2):389-392. 2008

Poster #6

Response of Taro var. Lila or Bun Long to Levels of Supplemental Irrigation

Luis E. Rivera[1], Carlos E. Ortiz[1] and John J. Cho[2], [1]Department of Agronomy & Soils, University of Puerto Rico, Mayaguez Campus; [2]Department of Plant Pathology, University of Hawaii. cortiz@uprm.edu

ABSTRACT.
Production of taro (*Colocasia esculenta*) throughout the Caribbean Basin has been drastically reduced as a consequence of the taro leaf blight. Traditional variety Lila (known as Bun Long in Hawaii) is very susceptible to the blight. In the short term there is interest in the production of Lila under drip irrigation, a system under which blight incidence tends to be lower. The objective was to provide practical information in regard to growth, yield, corm quality and the minimum irrigation requirement for taro Lila grown under upland conditions and under the presence of the blight. Three irrigation treatments were evaluated: rainfed and supplemental irrigation based upon Class A pan factors of 1.0 and 1.3. Providing Lila with supplemental irrigation of at least 1.0 ET resulted in increased growth. Irrigation was non significant for stand. There were no differences for corm fresh weight, nor in plant dry weight or harvest index between plants subjected to 1.0 and 1.3 Class A pan factors. This study suggests that to obtain a Lila crop under upland conditions and under the presence of the leaf blight water to be applied by irrigation should replace at least that lost through evapotranspiration.

KEYWORDS. *Colocasia esculenta*, upland taro, irrigation

INTRODUCTION

Production of taro (*Colocasia esculenta*) throughout the Caribbean Basin has been drastically reduced as a consequence of the taro leaf blight (*Phytophthora colocasiae*) (Mendez et al., 2005; Ortiz et al., 2007). Before the blight, over 95% of taro production in Puerto Rico was under wetland conditions. Traditional variety Lila –highly regarded for its table quality- is very susceptible to the blight (Rosa-Márquez et al., 2006). Lila is identical to the Hawaiian variety Bun Long (Schnell et al., 1999). Blight-tolerant varieties from Hawaii, currently under evaluation in Puerto Rico, appear not to have the culinary characteristics preferred by consumers in the Caribbean.

Work done before the blight shows Lila is adapted to cultivation under upland conditions (Goenaga, 1995). Thus, in the short term there is interest in the production of Lila under drip irrigation, a system under which blight incidence tends to be lower. The objective was to provide practical information to farmers in regard to growth, yield, corm quality and the minimum irrigation requirement for taro Lila grown under upland conditions and under the presence of the leaf blight.

MATERIALS AND METHODS

The experiment was conducted from May 2007 to January 2008 at Gurabo, Puerto Rico. Plots consisted of a 9.2-m-long x 0.61-m-wide bed. Suckers were planted 0.46 m apart in a double row within the bed. There were 40 plants per plot. A drip irrigation line was placed on the surface along the center of each bed. Three irrigation treatments were arranged in a randomized complete block design with eight replications. Treatments were rainfed and supplemental irrigation based upon Class A pan factors of 1.0 and 1.3. The plants were subjected to treatments from 67 to 237 days after planting. Treatments were applied Monday, Wednesday and Friday. Except for irrigation, management practices followed standard procedures. Samples were taken 123 and 231 days after planting. Harvest was performed at 243 days after planting. Corm fresh weight was recorded at harvest. Harvest index was calculated from plants sampled at harvest.

RESULTS AND DISCUSION

Early and mid season: Mild infection of the taro leaf blight was present throughout the crop cycle. Rainfall received by the plants totaled 1493 mm. Goenaga (1995) reported maximum leaf area index for Lila at 117 days after planting. With this information, we chose to sample 123 days after planting. At 123 days, irrigation was significant for leaf area, plant dry weight and plant height (a visual indicator of growth) (Table 1). As expected for a variety adapted to wetland conditions, providing Lila with supplemental irrigation of at least 1.0 evapotranspiration (ET) resulted in increased growth (Table 1). Up to 123 days into the cropping cycle, irrigating with 1.0 ET or 1.3 ET made no difference in growth (Table 1).

Late in the season: Irrigation was non significant for stand (average 78%) thus indicating that no effect was observed in the number of plants completing the crop cycle. As for 123 days, at 231 days into the cropping cycle, irrigation was significant for plant dry weight. Rainfed plants had significantly less dry weight than those irrigated (Table 2). Under leaf blight pressure, irrigation increased Lila's corm fresh weight (Table 2). Corm fresh weight is an indicator of yield. However, there were no differences for corm fresh weight, nor in plant dry weight or harvest index between plants subjected to 1.0 and 1.3 ET treatments (Table 2). Average fresh corm weight of 479 and 542 g obtained with 1.0 and 1.3 ET treatments, respectively (Table 2), tend to be lower than those preferred by consumers of Lila (900-1,000 g). This study does not provide evidence that irrigation based upon 1.3 ET resulted in better performance than irrigation based upon 1.0 ET (Table 2). A pan factor of 1.0 means that the water applied to the plants replaces that lost through calculated evapotranspiration; this amount is considered the theoretical optimum (Goenaga et al., 2004).

Having a limited access to drip irrigation infrastructure and water, tuber farmers in the Caribbean have to make decisions on whether to produce taro or another aroid crop such as cocoyam (*Xanthosoma* spp.). This study suggests that to obtain a Lila crop under upland conditions and under the presence of the leaf blight, water to be applied by irrigation should replace at least that lost through evapotranspiration. Taro production under upland conditions is commercially efficient when corms are adequate for the market. Corm quality characteristics are of paramount importance because in the Caribbean taro is primarily grown for table use. We made an informal assessment of quality with corms harvested from this study, an assessment which includes taste, texture and acridity. Corms evaluated tend to be similar in eating attributes to those grown under

wetland conditions. However, fine tuning for field management is needed for increased corm size.

REFERENCES

Goenaga, R., E. Rivera and C. Almodovar. 2004. Yield of papaya irrigated with fractions of Class A pan evaporation in a semiarid environment. J. Agric. Univ. P.R. 88:1-10.

Goenaga, R. 1995. Accumulation and partitioning of dry matter in taro [*Colocasia esculenta* (L.) Schott]. Ann. Bot. 76:337-341.

Mendez, R.M., R. Angeles, M. Reyes y R. Hernandez. 2005. Tizon foliar: enfermedad de la yautia coco (*Colocasia esculenta* L. Schott) causado por (*Phytophthora colocasiae)* en la Republica Dominicana. Proc. Caribbean Food Crop Soc. 41 (2):515-519.

Ortiz C.E., J.J. Cho, E. Rosa-Márquez y L.E. Rivera. 2007. El tizon foliar de *Colocasia esculenta* en Puerto Rico. Proc. Caribbean Food Crop Soc 43: 134-138.

Rosa-Márquez, E., W.I. Almodovar, C.E. Ortiz and M. Díaz. 2006. Taro leaf blight (*Phytophthora colocasiae*): A new disease in Puerto Rico. J. Agric. Univ. P.R. 90:137-138.

Schnell R.J., R. Goenaga and C.T. Olano. 1999. Genetic similarities among cocoyam cultivars based on randomly amplified polymorphic DNA (RAPD) analysis. Scientia horticulturae. 80 (3-4): 267-276.

Table 1. Leaf area, dry weight and height of taro plants at 123 days after planting as affected by irrigation.

	123 Days After Planting		
Irrigation	Leaf Area	Plant Dry Weight	Plant Height
	- sq.cm/plant -	- g/plant -	- cm -
Rainfed	1751 b [1]	70 b	22 b
Rain+1.0 ET [2]	4729 a	152 a	39 a
Rain+1.3 ET	3870 a	137 a	42 a

[1] Means within columns separated by LSD ($P \leq 0.05$).
[2] ET stands for evapotranspiration.

Table 2. Plant dry weight and harvest index and corm fresh weight of taro plants affected by irrigation.

	Plant	At harvest		Theoretical
Irrigation	Dry Weight at 231 days	Harvest Index	Corm Fresh Weight	Yield for 23,900 plants/ha
	- g/plant -		- g/corm -	- t/ha -
Rainfed	94 b [1]	0.39 b	215 b	5.1
Rain+1.0 ET [2]	305 a	0.44 ab	479 a	11.4
Rain+1.3 ET	288 a	0.53 a	542 a	12.9

[1] Means within columns separated by LSD ($P \leq 0.05$).
[2] ET stands for evapotranspiration.

ACKNOWLEDGMENT. This study was supported by the USDA-CSREES Special Grant Tropical & Subtropical Agricultural Research (T-STAR); Project Award: 2006-34135-17654.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):393-397. 2008

Poster #7

Production of Table Cucumber (*Cucumis sativa*) on Two Trellis Systems in North Florida

C. S. Gardner, G.L. Queeley, K. T. Grant, B. G. Brown and T. Hylton

Cooperative Extension Program Florida Agricultural and Mechanical University (FAMU) College Of Engineering Sciences Technology and Agriculture 202 Perry – Paige Building South, Tallahassee, FL 32307. E-mail: cassel.gardner@famu.edu. Fax: (850) 561-2151

ABSTRACT.
The use of trellises to support vine crops such as tomato, squash and cucumber may result in increased fruit quality compared to the conventional practice of allowing the vines to run freely on the ground. Other stated advantages of the trellis system include better canopy light interception, better control of pest and ease of harvesting. However, there is still much debate over whether the use of trellises results in increased yield. The objective of this study was to determine the performance of trellis grown cucumber vs. conventional practice. A two year study was done at the FAMU research and extension center, Quincy Florida. The experimental design was a randomized complete block with three treatments: A-frame trellis, wire trellis and conventional practice as a control. Parameters measured included fruit size (length and circumference), fruit quality and total yield. Treatment effects were evaluated by Analysis of Variance and Fisher's exact test. Despite numerically higher numbers of spoiled fruits from the conventional practice, the results showed no significant treatment effect. The study concluded that the use of trellises provided no advantage over the conventional system with respect to the parameters measured.

KEYWORDS: *Cucumis sativa*, trellis, light interception, conventional practice, quality measures.

INTRODUCTION

It is widely believed that growing cucumbers on trellises will lead to superior performance as opposed to growing these crops using conventional methods where the plants are allowed to run freely over the ground. Proponents of the trellis system have claimed certain advantages over conventional methods, including less fruit spoilage and better canopy interception resulting in higher total fruit production. However, opponents of the trellis system have argued that trellises expose more fruit to predators such as birds and insects and the amount of light intercepted by the crop is not sufficient to offset any losses realized from conventional methods.

MATERIAL AND METHODS

The experiment was laid out as a Randomized Complete block Design (RCBD) with three treatments. Treatment one involved an A-frame wooden trellis using wooden strips spaced approximately 12 inches apart for vine support. Treatment two was a wire trellis with parallel lines spread approximately 12 inches apart for vine support. In treatment three (the control) the plants were allowed to run at will over bare ground covered with plastic mulch; a practice traditionally used by cucumber growers. All plots were drip irrigated periodically on an 'as needed basis'. Data were collected weekly on fruit yield, fruit circumference, fruit length and the number of spoiled fruits. A total of six harvests were conducted, three in each year of the study. All mature fruits were harvested from within a 400 square feet (4306 sq meter) area. After taking the total weight of the harvested fruits from each treatment, thirty fruits were selected at random, examined for blemishes and deformities then their circumference were taken. Quantitative data were analyzed by analysis of variance to determine significant treatment (trellis) effects. Quality measures which included counts of deformed, discolored and rotted fruits were subjected to Fisher's exact test. The 0.05 level of significance was used for all of the statistical analyses.

RESULT AND DISCUSSION

The highest numerical yield, 5332 lb/acre (5972 kg/ha) was obtained from the control treatment. This was followed by the A-Frame, 5059 lb/acre (5666 kg/ha) and the wire trellis, 4351 lb/acre (4873 (kg/ha). Fruits from all three treatments were similar in size (circumference and length). The overall results indicated no treatment effects on yield parameters (Figures 1, 2 and 3). With respect to fruit quality, the control resulted in a slightly higher percentage of spoiled fruits. This was anticipated since the fruits in this treatment experienced some ground contact as well as exposure to moist damp conditions and other related factors could potentially cause fruit spoilage. However, since harvesting was done on a weekly basis, this period of exposure was not sufficient to result in any significant fruit spoilage (Fig.4).

CONCLUSION

With the exception of a slightly lower percentage of spoiled fruits, the use of trellises did not provide any significant benefits over the conventional method of growing cucumbers. In fact, despite being statistically insignificant, the yield parameters (fruit weight and size) were numerically higher under the conventional system. Although production costs were not assessed during this study, it is evident that the conventional method may be more suited for commercial production due to its low requirements for equipment and labor. However, trellises may be better suited for small scale production and elderly home gardeners since they facilitate easy harvesting of mature fruits.

REFERENCES

Hochmuth, C. 2001. Greenhouse Cucumber production: Florida Greenhouse Vegetable production Handbook, Vol. III. University of Florida IFAS Extension.

Hochmuth, J. and C. Hochmuth. 2003. Key to Successful Tomato and Cucumber Production in Perlite Media. University of Florida IFAS Extension.

Nischit, V.,S. Wehner and C. Wehner. 2002. Screening the Cucumber Germplasm Collection for Fruit Yield and Quality. Crop Sci. Soc. of Am.42:2174-2183.

Swiader, J.M., G.W. Ware and J.P. MacCollum.1996. Commercial Cucumber Production: Producing Vegetable Crops. Interstate Publishers Inc., Danville, Illinois.

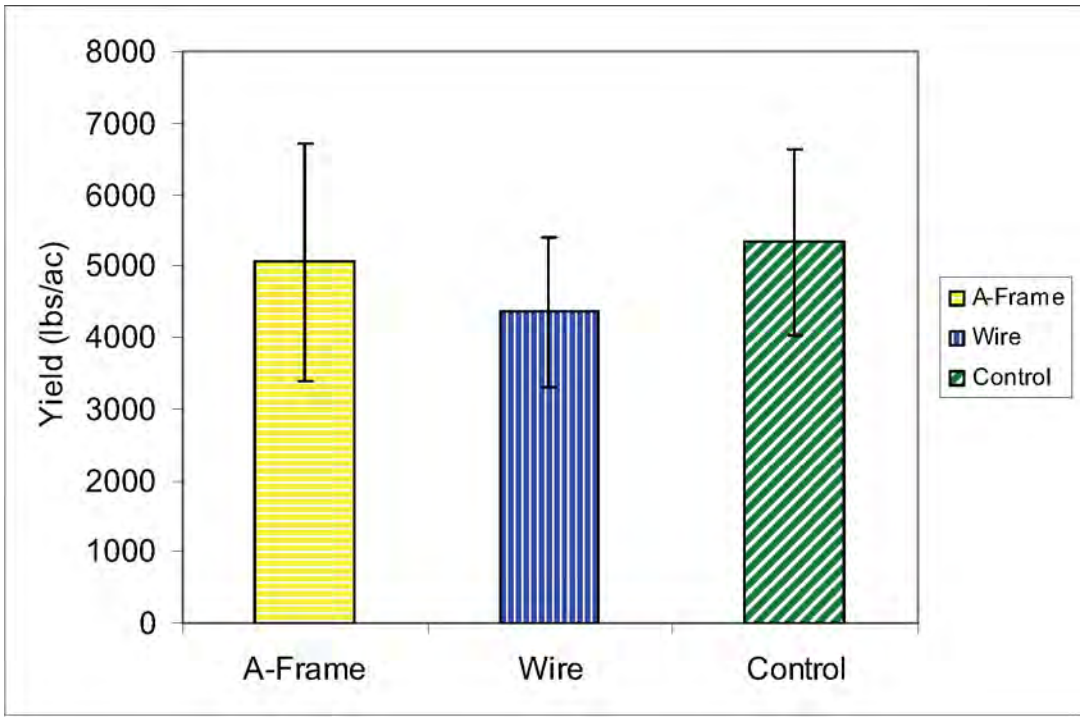


Figure. 1. Fresh fruit yield. (Data represent an average of two years)

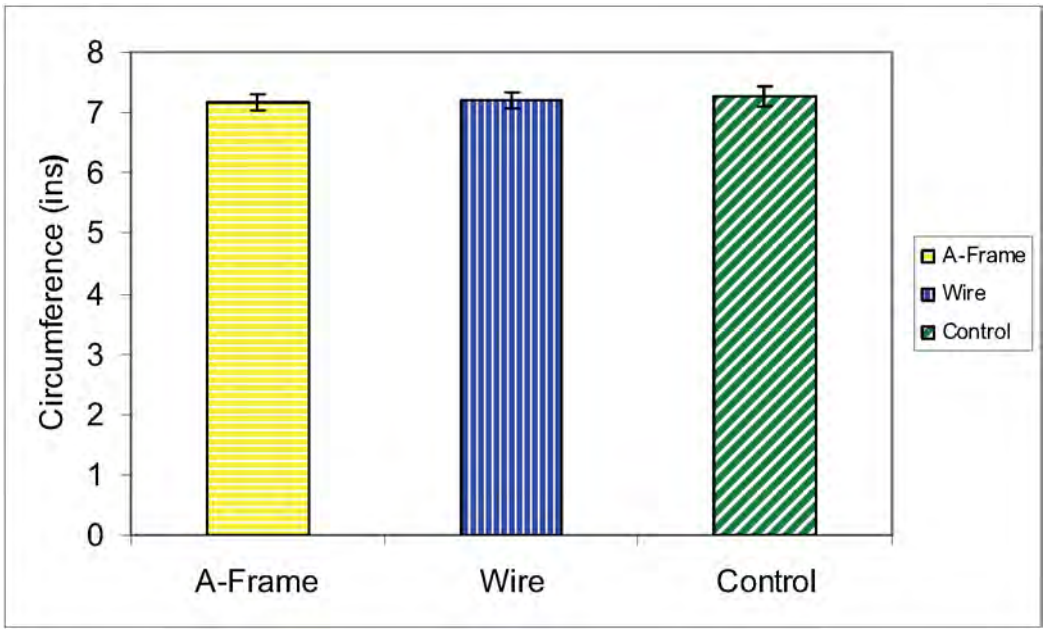


Figure. 2. Mean circumference of cucumber fruits (Data are an average of two years)

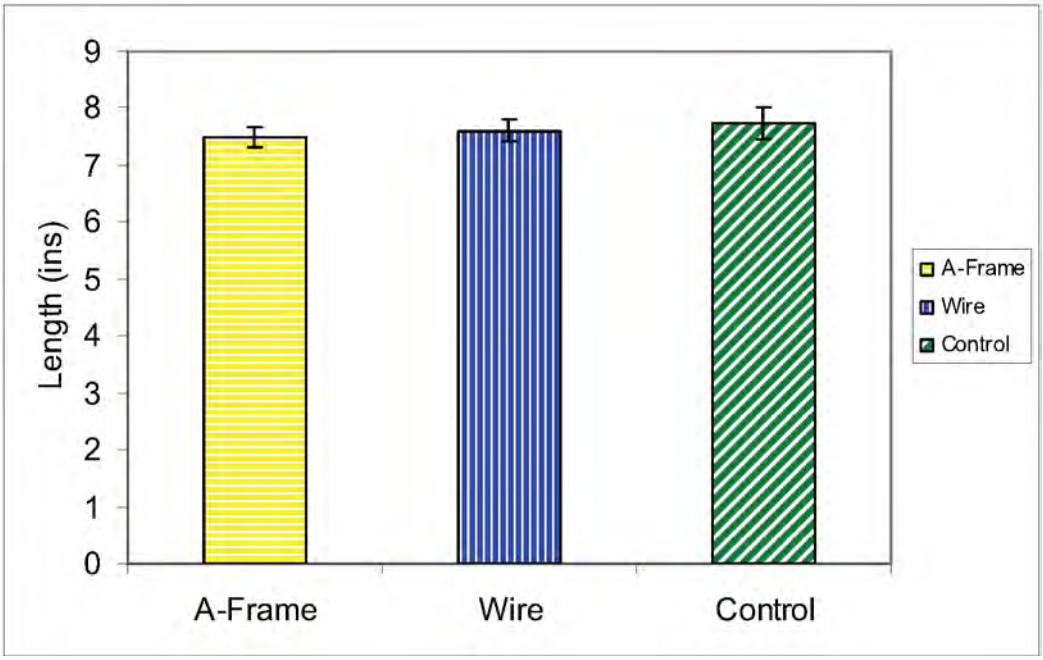


Figure. 3. Mean fruit length of table cucumbers. (Data are an average of two years)

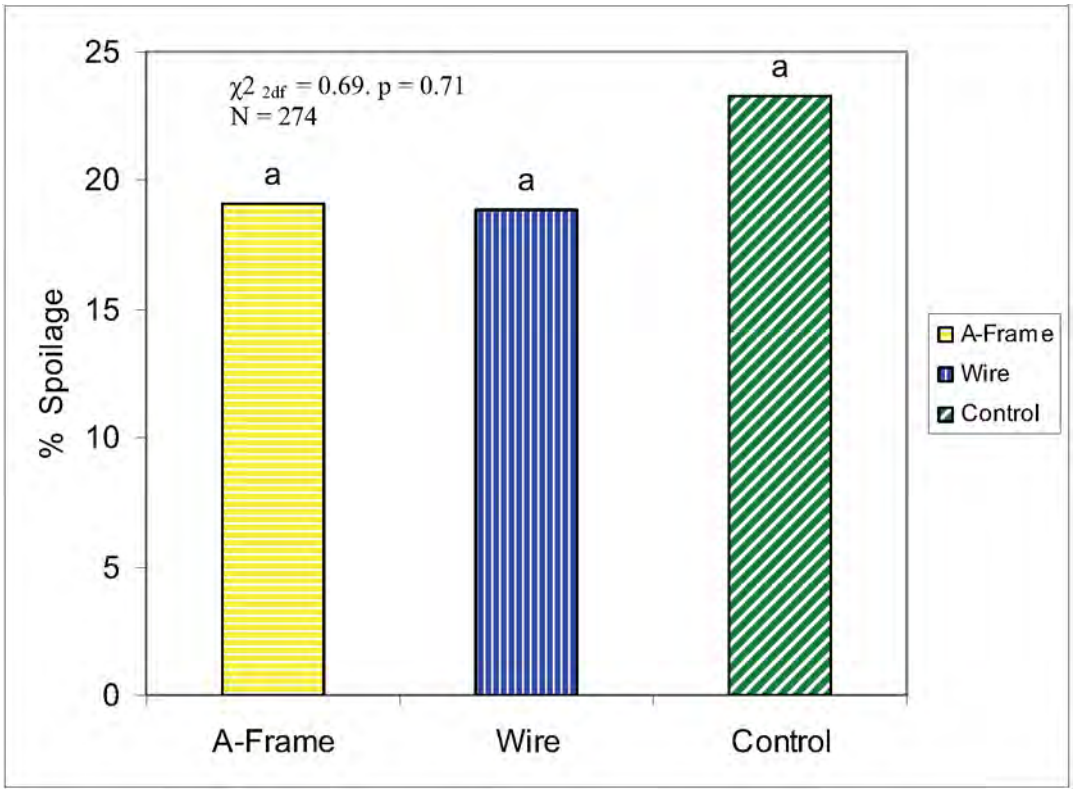


Figure. 4. Percentage of spoiled cucumber fruits (Data are an average of two harvests)

2008 Proceedings of the Caribbean Food Crops Society. 44(2):398. 2008

Poster #8

Effects of Bulbils Weight Used as Seed on Tuber Yield of Greater Yam Belep *(dioscorea alata l.)*

David Hammouya, Marceau Farant, J. Lator, and J. L. Irep. INRA, Unité expérimentale de Duclos Godet, Cluny, 97131, Petit-Canal, Guadeloupe.
david.hammouya@antilles.inra.fr

ABSTRACT.

Traditionally, yams are grown from tuber cuttings, termed setts. Aerial tubers named bulbils could constitute, for some species, an alternative way to produce yam seeds in order to benefit safe seed and more earnings of harvested tubers.

Work reported in this paper comes from experimentation conducted during two years on effects of bulbil weight on tuber yield. An experiment was carried out on vertisols at Godet experimentental station in Guadeloupe. Four bulbil classes of weight were combined and some of the results obtained are presented in this paper.

Bulbil weight strongly affected the yield, whereas the effect on tuber number was not significant for the commercial tuber yield and the number of non commercial tubers. Commercial tuber yield tended to increase asymptotically with increasing bulbil weight.

KEYWORDS: yam, bulbils, seed, setts

2008 Proceedings of the Caribbean Food Crops Society. 44(2):399. 2008

Poster #9

Performance of a Quality Protein Maize Variety Grown in a Vertisol

Elvin Román-Paoli[1], and James Beaver[2], [1]Professor, Department of Agronomy y Soils, College of Agricultural Science, University of Puerto Rico. HC-O2 BZ 11656, Lajas, PR 00667-9714. Tel.(787) 899-1530, Fax (787) 899-1265, eroman@uprm.edu. [2]Professor, Department of Agronomy y Soils, College of Agricultural Science, University of Puerto Rico. Mayagüez, PR

ABSTRACT.
Almost all of the maize consumed in Puerto Rico (PR) is imported. The artificial scarcity of maize due to its destination for ethanol production has contributed to a worldwide price increase. Quality protein maize (QPM) are hard-endosperm maize developed by the ¨Centro Internacional de Mejoramiento de Maíz y Trigo¨ (CIMMYT). QPM has the recessive *opaque-2* gene that contains higher lysine and tryptophan content than common maize. The objective of this research is to develop appropriate management practices for the production of QPM in PR. Field trials were conducted at the Lajas Substations to evaluate the performance of a QPM variety. During 2007, a QPM variety was submitted to three nitrogen fertilization rates (120, 160, 200 kg/ha) split in two applications. Plants were also fertilized with 50 and 100 kg/ha of P_2O_5 and K_2O, respectively. Final plant density was 36,580 plants/ha. No significant differences were found among N rates with an average yield of 2,770 kg/ha. A split-plot arrangement of a Randomized Complete Block Design was used in an experiment established during 2008 where levels of microirrigation treatments were the whole-plots and plant density the sub-plots. Whole plot treatments consisted of 100, 75 and 50% ET_0 applied through drip irrigation. The sub-plot treatment consisted of 50,000, 62,000 and 71,400 plants/ha. The results obtained in this research will be shared with swine producers and farmers who may be interested in producing QPM to partially substitute maize imports in PR.

KEYWORDS: Maize, yield, Quality Protein Maize

2008 Proceedings of the Caribbean Food Crops Society. 44(2):400. 2008

Poster #10

Effects of Plastic Mulch on Development and Nodulation of Cowpeas

Steven H. Wysinger, E. G. Rhoden, V. Khan, C. Stevens, and J. R. Bartlett. George Washington Carver Agricultural Experiment Station, Tuskegee University, Tuskegee, AL 36088. rhoden@tuskegee.edu

ABSTRACT.
Cowpeas or Southern peas (*Vigna unguiculata L. Walp*) are a warm season crop and its growth and development are impacted by various soil and environmental conditions. Cowpea is an important crop in the southeastern United States for both animal and human consumption. It contains approximately 24.8% protein, 63.6% carbohydrate and many trace minerals. When cowpeas are intercropped it provides nitrogen to its companion crops thereby reducing the need for mineral nitrogen. Due to advances in plasticulture many warm season crops are able to be planted earlier without significant yield losses. Despite these advances very little is known about the effects of plastic mulch in cowpea production. This study was conducted to compare the effects of white and black plastic mulches as opposed to bare soil in terms of cowpea development and nodulation. The experiment was conducted as a complete randomized design consisted of three treatments (white and black plastic with bare soil as the control) planted on a 150' rows. Plant height was monitored throughout the study while nodule number and weights were taken at the 10% bloom stage. Cowpeas yield comprised of three harvests (once per week for 3 weeks) There were no significant difference in the yield between white (WP) and black plastic (BP) but these were significantly higher than bare soil (BS). In terms of nodulation, WP treatment had the highest nodule weight followed by BS; on the other hand, BP had numerous small nodules. Further evaluations are being conducted to quantify the differences in soil temperature, solar reflectance and microbial activities in the soil that might explain some of the differences observed in the various treatments.

KEYWORDS: plastic mulch, cowpea, nodulation, legume development

2008 Proceedings of the Caribbean Food Crops Society. 44(2):401-407. 2008

Poster #11

The Effect of Lime Application on Emergence and Growth of Castor Oil Plants

Ronald J. Smith, Errol G. Rhoden, Janette R. Bartlett, Victor A. Khan, Crystal Drakes and Prosanto K. Biswas. George Washington Carver Agricultural Experiment Station, Tuskegee University, Tuskegee, AL. Corresponding author: 308 Milbank Hall, Tuskegee Univ., Tuskegee, AL, 36088; (334) 727-8435; rhoden@tuskegee.edu

ABSTRACT.

Castor oil (*Ricinus communis*) has been cultivated for centuries and its production is currently being scrutinized because of the ricin content of the plant and its possible use in terrorist activities. The objective of this study was to measure the effects of lime application on the emergence, growth and development of castor accessions under greenhouse conditions. Lime was applied to a Norfolk Sandy loam soil and incubated for three months. Castor oil seeds were planted into a soil with a pH of either 5.3 or 5.9. The five accessions used in the study were obtained from: Tanzania (TZ1, TZ2), Guyana (GY-PAR), and Jamaica (JA2, JA4). The study was conducted in the greenhouse facilities at the G. W. Carver Agricultural Experiment Station at Tuskegee University. Data were collected on plant emergence, height, and vigor, as well as dry matter yield. Four weeks after emergence, TZ2 and GY-PAR had the highest percent germination (96%), while JA2 exhibited the lowest (80%) when limed. One week later, the highest percent germination remained the same, and JA2 had the lowest percent germination (88%). When soil was left unlimed (pH 5.3) TZ1 had the highest percent germination (88%), while only 76 % of JA4 seeds had germinated. One week later, TZ1 remained the same, and all other accessions exhibited 80% germination. At 4 weeks only JA2 plants showed increased foliage production when limed. However, 8 weeks after emergence, JA2 and JA4 produced more foliage when limed. After 8 weeks, the results also indicated that plants that were limed had higher dry weights (66.1 g/pot) than unlimed plants (63.3 g/pot). At 12 weeks only JA2 had increased foliage production under limed conditions. It is possible that both the Tanzania and the Guyana accessions produced more dry matter at 4 and 8 weeks, when no lime was applied, because the soil types in both locations were predominantly acid. On the other hand, the Jamaican accessions give higher dry weights under limed conditions because they were taken from soils that were calcareous. Further studies are needed to identify accessions that are suitable for the southern US.

KEYWORDS: castor, germination, accession

INTRODUCTION

The castor bean (*Ricinus communis* L.) is an herbaceous perennial that has been cultivated for centuries to obtain the oil produced by its seeds (Weiss, 1971). According to Moshkin (1986b), ancient interest in castor was not only for the medicinal use of its parts (seeds, roots, and leaves), but also for its oil that was used in making perfumes and

fuel. Furthermore, the author pointed out that the Ancient Egyptians burned castor oil in lamps more than 4000 years ago, and seeds have been found in their tombs.

Castor is commonly referred to as a "bean," however it is not a legume. It is a native of tropical Africa and the plant is considered a member of the spurge family (Brigham, 1993). Castor is grown widely throughout many regions of the world and the principal producing countries are India, Brazil and China. Other areas of cultivation include Latin America, the West Indies, Africa, Asia, and the United States. In the tropics, the castor plant is a perennial, but it is cultivated as an annual in temperate regions, requiring a frost-free period of 140 to 180 days (Shroyer and Erickson, 1987; Glaser et al., 1992). Generally, germination of the seed is slow, which usually occurs within 21 days after planting (Labalette et al., 1996). Based on the oil requirements, production characteristics of commercial varieties vary and they grow to a height of 3 to 10 feet.

Castor plant seeds contain varying levels of oil. Moshkin (1986a) noted that castor plant seeds contained between 50-55% oil. Labalette et al. (1996) also documented seeds containing up to 55% of natural oil rich in ricinoleic acid. Among all the vegetable oils, castor oil is distinctive because of its high level of ricinoleic acid (over 85%), a fatty acid consisting of 18 carbons, a double bond between the ninth and tenth position, and a hydroxyl group attached to C12. As a result, castor oil has one of the highest and most stable viscosity indexes among vegetable oils combined with high lubricity, especially under low temperature conditions.

The seeds of the castor plant contain the toxic protein ricin and the alkaloid ricinine, which are poisonous to humans and animals. Gale et al., (1981) described ricin as a cytotoxic protein that inhibits protein synthesis by inactivating ribosomes. Consumption of a seed causes nausea and eating several seeds may result in death. According to the Centers for Disease Control and Prevention (2005), initial symptoms of ricin poisoning by inhalation may occur within 8 hours of exposure. Within a few hours of inhaling significant amounts of ricin, likely symptoms include: difficulty breathing, fever, coughing, nausea, and tightness in the chest. Heavy sweating may follow as well as fluid build-up in the lungs. This would make the situation worse by making breathing more difficult, and eventually the skin turns blue. Finally, low blood pressure and respiratory failure may occur, leading to death.

Anyone that has been exposed to ricin should seek medical care if they have respiratory symptoms that started within 12 hours of inhaling ricin. If someone swallows a significant amount of ricin, vomiting is the first symptom followed by diarrhea and in extreme cases the excreta becomes bloody. As a result, severe dehydration will result, followed by low blood pressure. Other symptoms include hallucinations, seizures, and blood in the urine. Within several days, the person's liver, spleen, and kidneys will stop functioning leading to death. Ricin in powder or mist form can cause skin and eye irritation. The major symptoms of ricin poisoning depend on the route of exposure and the dose received, though several organs may be affected in severe cases. Death from ricin poisoning could take place within 36 to 72 hours of exposure, depending on the route of exposure (inhalation, ingestion, or injection) and the dose received. If death has not occurred in 3 to 5 days, the victim usually recovers. As a result, there is fear of use of ricin as a biological agent.

Historically, castor oil was used in the manufacture of hydraulic fluids, greases, and lubricants for military equipment (Brigham, 1993). It is also used in the synthesis of cosmetics, toiletries, and as a purgative. Castor oil is used extensively in the manufacture of artificial leather used in upholstery. It furnishes a coloring for butter, and 'Turkey-red' oil that is used in the dyeing of cotton textiles. Castor oil is an essential component in some artificial rubbers, celluloid, the making of certain waterproof products, and is used extensively in the manufacture of transparent soaps. It also furnishes sebacic acid that is employed in the manufacture of candles, and caprylic acid, which is mixed into varnishes (Bhardwaj et. al, 1996; Ogunniyi, 2005). In the mid 1990s, world annual production of castor oil was about 460,000 tons (1.1 million metric tons of seeds); the main producers are India, Brazil, and China. The United States is the largest importer and consumer of castor oil in the world. Castor oil was classed as a strategic material critical to U.S. national defense by the Agricultural Materials Act P.L. 98-284 passed by Congress in 1984 (Brigham, 1993). According to Roetheli et al. (1991), Public Law 81-774 requires that sufficient supplies of such materials be acquired and stored in the United States to meet national defense needs in case of war. Due to new outlets for castor oil (such as anticorrosive products or odorant captivators), demand is expected to increase over the next ten years.

Castor oil has various applications in different industrial sectors: paintings and coatings, polyurethane coating, plastics, transport, cosmetics, textiles, and leathers (Labalette et. al, 1996). One of the major products derived from castor oil is Rilsan B, developed by Atochem (France). This 100% castor-based product has numerous applications such as rotating glass car-wipers, ski boots fixatives, and for use in air-brake systems on trucks. Many new uses, based on biodegradability of castor oil derived products, are expected in the future. Therefore, the objective of this research was to determine the growth characteristics of five accessions of castor and to ascertain the possibility of the crop being included in the cropping system of small-scale limited resource farmers in Alabama.

MATERIALS AND METHODS.

This study was conducted in the greenhouse facilities of the George Washington Carver Agricultural Experiment Station, Tuskegee University, Tuskegee, Alabama during the 2005 and 2006 growing seasons. Five accessions of castor oil plants were germinated, established and selected for uniformity. The seeds of five accessions were obtained from the different locations:

1) Tanzania 1 (TZ1) - Fulwe, Tanzania
2) Tanzania 2 (TZ2) - Morogoro, Tanzania
3) Guyana (GY-PAR)- Parika, Guyana
4) Jamaica 2 (JA2) - St. Ann's Bay, Jamaica
5) Jamaica 4 (JA4) - Top Road, St. Ann, Jamaica

Twenty-six centimeter diameter polyethylene pots were placed on greenhouse benches in two strips, one limed and the other un-limed. The accessions in each strip were arranged as a complete randomized design (CRD) with ten replications. The growth media was a Norfolk sandy loam (fine, siliceous, thermic, Typic, Palendult) from Tuskegee, Alabama. To obtain the desired soil pH levels, dolomitic lime was applied to

raise the soil pH. Prior to lime application the soil pH was 5.3. After liming, pots were placed on greenhouse benches for an incubation period of three months. During this period changes in pH were monitored. The final pH obtained was 5.9. Seeds of the five accessions were planted into the pots receiving the two lime treatments (pH 5.3 vs. 5.9). Preliminary germination tests were conducted (Table.1), and emergence and growth were monitored and recorded. A day/night temperature of 30/25°C $\pm$ 2.5°C was maintained in the greenhouse for the length of the study. A nutrient solution of 20-20-20 (NPK) was given once weekly at a rate of 1.5 g/pot (approximately, 25 kg - N; P_2O_5; K_2O/ha). Data on plant height and vigor was recorded weekly for all plants. Harvest weights were then recorded for total dry matter yield, as well as leaf, petiole and stem yields. Data was subjected to analysis of variance, and where effects where significant ($P < 0.05$) the least significant difference (LSD) test was used to separate the means.

RESULTS AND DISCUSSION

Based on germination and growth parameters the accessions showed varied response to lime. Twenty-eight days after planting (DAP), germination rate was highest for TZ2 and GY-PAR (96%) with JA2 having the lowest (80%), when limed. At 35 DAP, the two highest germinating accessions remained in the same order, and although it increased, JA2 exhibited the lowest percent germination (88%). When soil was unlimed, the rate of germination decreased. Twenty-eight DAP, TZ1 had the highest percent germination (84%), and JA4 the lowest germination rate (76%) when no lime was applied. The germination rates at 35 DAP for TZ1 was highest (84%), with all other accessions exhibiting approximately 80%. When limed, average plant heights at 28 DAP ranged from 3cm (JA4) to 4.75cm (TZ2). Fifty-six DAP average plant height ranged from 11.8cm (JA2) to 16.25cm (GY-PAR), and at 84 DAP average plant height ranged from 19.7cm (JA2) to 26.25cm (GY-PAR; JA4). Average plant heights at 28 DAP ranged from 2.80 cm (JA4) to 4.03 cm (TZ2) for unlimed plants.

At 56 DAP, average plant height ranged from 12.45 cm (TZ1) to 17 cm (JA4), and at 84 DAP, average plant height ranged from 22.45 cm (JA2) to 29.95 cm (JA4). At 28 DAP; plants that were limed had dry weights ranging from 24.07 g/pot to 30.58 g/pot. However, when no lime was applied, there was an increase in plant dry weight ranging from 25.01 g/pot to 33.57 g/pot. At 56 DAP, the results indicated that the plants that were limed had higher dry weights (62.86 to 69.18 g/pot) than the unlimed plants (60.80 to 65.82 g/pot). This is a reverse of the observations made at 28 DAP where the unlimed plants had higher dry weights. At 28 DAP; JA4 produced more biomass when no lime was applied. This result was unexpected because both Jamaican accessions produced more dry matter after 56 days when limed. This followed expected results, as the native soil was predominantly alkaline. When no lime was applied, both Tanzania accessions, as well as the Guyana accession produced more dry matter at 28 and 56 DAP. These were results were expected since the native soil types in both locations were predominantly acid. These results indicate that further study of these different accessions is needed.

REFERENCES

Bhardwaj, H.L., A.I. Mohamed, C.L. Webber, III, and G.R. Lovell. 1996. Evaluation of castor germplasm for agronomic and oil characteristics. p. 342-346. In: J. Janick (ed.), Progress in new crops. ASHS Press, Alexandria, VA.

Brigham, R.D. 1993. Castor: Return of an old crop. p. 380-383. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

Centers for Disease Control and Prevention. Questions and Answers about Ricin. (2005).http://www.bt.cdc.gov/agent/ricin/qa.asp [Retrieved November 20, 2006].

Gale, E.F., E. Cundliffe, P.E. Reynolds, M.H. Richmond, and M.J. Waring. 1981. The Molecular Basis of Antibiotic Action. John Wiley and Sons, New York.

Glaser, L.K., J.C. Roetheli, , A.E. Thompson, R.D. Brigham and Carlson. 1992. Castor and lesquerella: sources of hydroxy fatty acids. Yearbook United States Department Agriculture, 1992: 111-117.

Labalette, F., A. Estragnat, and A. Messéan. 1996. Development of castor bean production in France. p. 340-342. In: J. Janick (ed.), Progress in new crops. ASHS Press, Alexandria, VA.

Moshkin, V.A. 1986a. Economic importance and regions of cultivation of castor, p. 1-5. In: V.A. Moskin (ed.), Castor, Oxonian Press Ltd. New Dehli.

Moshkin, V.A. 1986b. History and origin of castor, p. 6-10. In: V.A. Moskin In V.A. Moskin (ed.), Castor,. Oxonian Press Ltd. New Dehli.

Ogunniyi, D.S. 2005. Castor oil: a vital industrial raw material. Bioresource Tech. 97(9): 1086-1091

Roetheli, J.C., L.K. Glaser, and R.D. Brigham. 1991. Castor: Assessing the feasibility of U.S. production. Workshop summary, Plainview, TX, Sept. 18-19, 1990. USDA/CSRS Office of Agr. Materials. Growing Ind. Material Ser.

Shroyer, J.P., and D.B. Erickson. 1987. Specialty and non-traditional crops. Cooperative Extension Service Bulletin MF-844. Kansas State University. Manhattan, KS.

Weiss, E.A. 1971. Castor, sesame, and safflower. Leonard Hill, London.

Table 1. The effect of lime application on the emergence of castor seeds 28 and 35 days after Planting (DAP)

Accession	Limed 28 DAP	Limed 35 DAP	Unlimed 28 DAP	Unlimed 35 DAP
	---------- (%) ----------			
TZ2	96	96	80	80
TZ1	88	92	84	84
JA4	92	92	76	80
JA2	80	88	80	80
GY-PAR	96	96	80	80
Average	90.40	92.80	80.00	80.80

Table 2. Height of 5 castor oil plants 28, 56, and 84 days after planting (DAP) - limed

Accession	28 DAP	56 DAP (cm)	84 DAP
TZ2	4.75	13.80	22.80
TZ1	3.35	12.45	23.45
JA4	3.00	15.00	26.25
JA2	3.55	11.80	19.70
GY-PAR	4.15	16.25	26.25

Table 3. Height of 5 castor oil plants 28, 56, and 84 days after planting (DAP) - unlimed

Accession	28 DAP	56 DAP (cm)	84 DAP
TZ2	4.30	15.80	26.20
TZ1	3.05	12.45	22.60
JA4	2.80	17.00	29.95
JA2	3.15	13.65	22.45
GY-PAR	3.25	16.10	27.40

Table 4. Dry Matter Production of castor oil plants at 28 days after planting

Accession	Limed	Unlimed
	(grams)	
TZ2	27.48	31.05
TZ1	24.07	30.66
JA4	28.08	32.26
JA2	29.11	25.01
GY-PAR	30.58	33.57

Table 5. Dry Matter Production of castor oil plants at 56 days after planting

Accession	Limed	Unlimed
	(grams)	
TZ2	64.13	64.39
TZ1	62.86	65.82
JA4	65.24	63.19
JA2	69.18	60.80
GY-PAR	63.14	65.70

2008 Proceedings of the Caribbean Food Crops Society. 44(2):408-412. 2008

Poster #12

Mandarina Híbrida Fallglo: Primeros Cuatro Años de Crecimiento en Dos Localidades de Puerto Rico

Félix M. Román Pérez, Agenol González Vélez, y Raúl Macchiavelli, Catedráticos, Colegio de Ciencias Agrícolas, Estación Experimental Agrícola, Universidad de Puerto Rico, Recinto Universitario de Mayagüez, fmroman@uprm.edu

RESUMEN.
La mandarina híbrida Fallglo, Bower (*C. reticulata* x tangelo Orlando) x Temple (*C. reticulata* híbrida) liberada por el USDA en el 1987 está siendo evaluada en las localidades de Isabela y Corozal en la isla de Puerto Rico. La primera localidad es representativa de la zona costera (124 msnm) y la segunda de la zona intermedia central (200 msnm), con temperatura promedio anual de 77 y 76 ^{0}F, respectivamente. Los primeros cuatro años se observó el desarrollo y comportamiento hortícola de los árboles en las dos zonas. El primer año de producción comercial, correspondiente al cuarto año de crecimiento, las primeras frutas comenzaron a madurar en el mes de septiembre en Isabela, mientras que en Corozal comenzaron a madurar en octubre. La variedad fue injertada en los patrones Swingle citrumelo (*Citrus paradisi* x *Poncirus trifoliata*), el híbrido HRS 812 [mandarina Sunki (*C. reticulata*) x naranja trifoliada Benecke (*P. trifoliata*)], Carrizo (*Citrus sinensis* x *P. trifoliata*), y las mandarinas Cleopatra (*Citrus reticulata* Blanco) y Sun Chu Sha. Durante la primera cosecha se tomaron los siguientes datos: promedio de número de frutas por árbol, peso total y peso promedio por fruta, diámetro, altura y diámetro de copa de los árboles y volumen de copa. Los resultados de la primera cosecha muestran que los patrones produjeron significativamente mayor cantidad de frutas por árbol en la localidad de Corozal (235.2) que en la localidad de Isabela (92.8). Para la variable peso promedio de frutas por árbol los valores obtenidos para la comparación entre localidades se acercaron a la significancia (p=0.0678), indicando una tendencia a ser mayor en la localidad de Corozal que en Isabela, 48.6 kg y 29.1 kg, respectivamente. En ambas localidades no se detectaron diferencias significativas entre los distintos patrones para ninguno de los parámetros medidos. En ambas localidades, algunos árboles fueron afectados por una muerte descendente en algunas ramas, siendo la misma de origen desconocido. Síntomas muy similares a estos han sido reportados en la literatura.

PALABRAS CLAVE: cítricos, patrones, crecimiento, variedad

INTRODUCCIÓN

La mandarina híbrida Fallglo, Bower (*C. reticulata* x tangelo Orlando) x Temple (*C. reticulata* híbrida) fue liberada por el USDA en el 1987 (Hearn, 1987). La fruta es de producción temprana, grande y con bastante semilla (20 a 40 semillas por fruta), con color de cascara y jugo intenso (Hearn, 1987;Davis y Albrigo, 1993; Jackson y Futch, 2003). Una limitación de los árboles jóvenes es la muerte fisiológica de ramitas terminales y exudación de goma. Aunque la mayoría de los arbolitos no mueren, esta

condición puede afectar el área de volumen de copa. En el estado de la Florida esta condición también afecta los arboles de la mandarina 'Robinson'(Hearn,1987).

Esta mandarina está siendo evaluada en dos localidades de Puerto Rico en cinco patrones de cítricas. Se presentan los datos de los primeros cuatro años de crecimiento y desarrollo observados en estas localidades.

MATERIALES Y MÉTODOS

Se establecieron dos experimentos en las localidades de Corozal e Isabela, Puerto Rico. La primera localidad es representativa de la zona costera (124 msnm) y la segunda de la zona intermedia central (200 msnm), con temperatura promedio anual de 77 y 76 ^{0}F, respectivamente. Los primeros cuatro años se observó el desarrollo y comportamiento hortícola de los árboles en las dos zonas. La variedad Fallglo se injertó en los patrones Swingle citrumelo (*Citrus paradisi* x *Poncirus trifoliata*), el híbrido HRS 812 [mandarina Sunki (*C. reticulata*) x naranja trifoliada Benecke (*P. trifoliata*)], Carrizo (*Citrus sinensis* x *P. trifoliata*), y las mandarinas Cleopatra (*Citrus reticulata* Blanco) y Sun Chu Sha. Los árboles se sembraron a una distancia de 4.4 m x 5.9 m. Se utilizó un diseño de bloques completos aleatorizados con cuatro repeticiones. Durante la primera cosecha se tomaron datos de: número de frutas por árbol, peso total y peso promedio por fruta, diámetro, altura y diámetro de copa de los árboles y volumen de copa. Los árboles se manejaron siguiendo las recomendaciones de la Estación Experimental Agrícola para la producción de cítricas. Se estableció un sistema de riego suplementario para ambos experimentos.

RESULTADOS Y DISCUSIÓN

En el primer año de producción comercial, correspondiente al cuarto año de crecimiento, en Isabela las primeras frutas comenzaron a madurar en el mes de septiembre, mientras que en Corozal comenzaron a madurar en octubre. En ambas localidades los árboles produjeron frutas de una buena apariencia y color (Figura 1). Sin embargo, algunos árboles fueron afectados por la condición de muerte descendente de algunas ramas (Figura 2), siendo la misma de origen desconocido. Esta condición en pruebas realizadas en Florida no fue un problema serio (Hearn, 1987). Síntomas muy similares a estos han sido reportados en la literatura (Tucker y colaboradores, 1995 y 1998).

Figura 1 Cosecha de la mandarina Fallglo en noviembre de 2007.

Figura 2 Muerte de ramas en mandarina Fallglo

Los resultados de la primera cosecha muestran que los patrones produjeron significativamente mayor cantidad de frutas por árbol en la localidad de Corozal (235.2) que en la localidad de Isabela (92.8). Siendo este el primer año de producción comercial y por ser demasiado jóvenes los árboles, eran de esperarse las bajas producciones. A medida que los árboles se desarrollen los rendimientos deberán aumentar. Para la variable peso promedio de frutas por árbol, los valores obtenidos para la comparación entre localidades se acercaron a la significancia ($p=0.0678$), mostrando una tendencia a ser mayor en la localidad de Corozal que en la de Isabela, 48.6 kg y 29.1 kg, respectivamente. En ambas localidades (Figura 3) no se detectaron diferencias significativas entre los distintos patrones para ninguno de los parámetros medidos. Es necesario podar anualmente para evitar que los árboles se agobien y se quiebren las ramas por el peso de la carga de fruta, sobre todo en aquellos de crecimiento vigoroso como lo es el HRS 812 (Figura 4). Los datos de volumen de copa presentados fueron tomados en el cuarto de año de crecimiento lo cual irán cambiando en la medida que los árboles lleguen a la etapa de adultez.

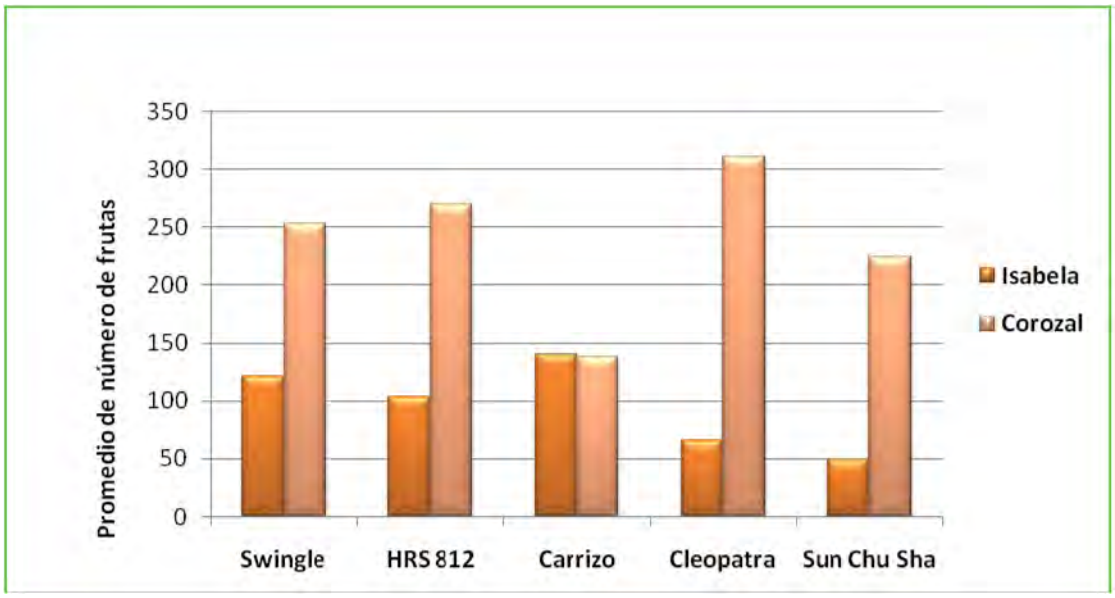


Figura 3. Promedio de número de frutas por patrones por localidad

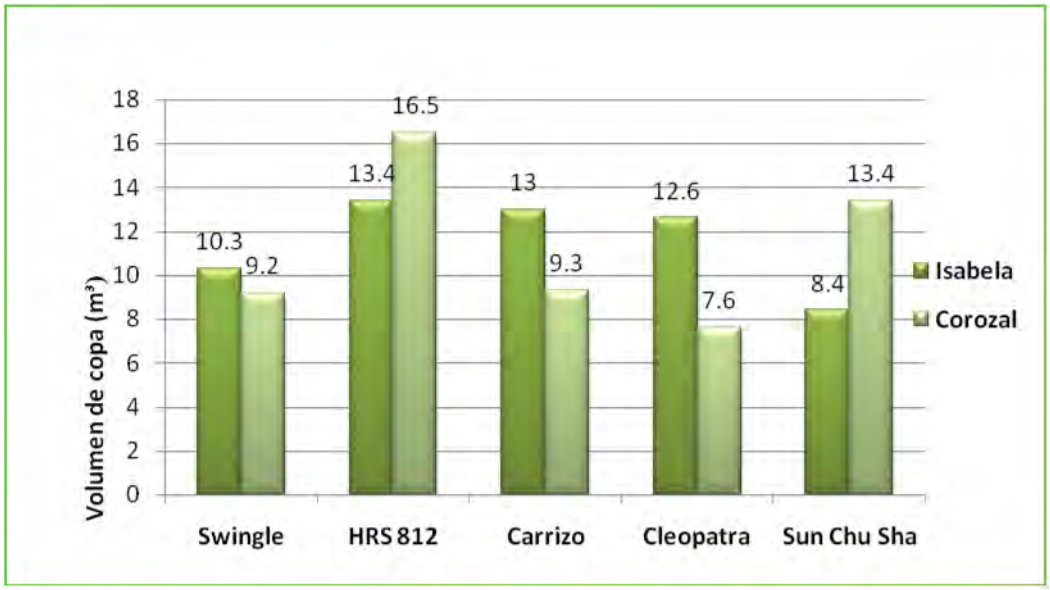


Figura 4. Volumen de copa en las localidades de Isabela y Corozal

CONCLUSIONES

Aunque los resultados de la primera cosecha muestran que los patrones produjeron significativamente mayor cantidad de frutas por árbol en la localidad de Corozal (235.2) que en la localidad de Isabela (92.8), es muy prematuro predecir el comportamiento de los mismos toda vez que no han llegado al punto óptimo de producción. Se tomarán datos de por lo menos cuatro cosechas más. En la localidad de Isabela (zona costera) se observa una tendencia de los árboles a producir frutas que

maduran ligeramente más temprano; este comportamiento se podría deber a la temperatura y humedad prevaleciente en la localidad. Los árboles en ambas localidades fueron susceptibles a la condición de muerte ascendente de ramitas y exudación de goma, condición que ha sido reportada en la literatura. Aunque la investigación no ha concluido, esta variedad promete ser una alternativa para los citricultores de la isla siempre y cuando la manejen adecuadamente y utilicen el patrón que resulte con las mejores características.

REFERENCIAS

Davis, F.S. y L. G. Albrigo. 1994. Major Taxonomic Groups within Citrus. Citrus CAB International p 35-36

Hearn, C.J. 1987 The 'Fallglo' Citrus Hybrid in Florida Proc Fla State Hort. Soc. 100:119-121

Jackson, L. and F.H. S. H. Futch. 2003. Fallglo tangerine. Fact Sheet HS-173 Florida Extension Service University of Florida Institute of Food and Agricultural Services, Cooperative Extension Service

Tucker, D.P.H., C.J. Hearn and C.O. Youtsey. 1995. Florida Citrus Varieties SP-102 University of Florida, IFAS 57 p

Tucker, D.P.H., S.H. Futch, F.G. Gmitter, and M.C. Kesinger. 1998. *Florida Citrus Varieties*. SP-102. University of Florida Institute of Food and Agricultural Services, Cooperative Extension Service. p. 40.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):413. 2008

Poster #13

Yield and Fruit Quality of Rambutan Cultivars Grown at Two Locations in Puerto Rico

R. Goenaga[1] and A. Marrero[1]. [1]USDA-ARS, Tropical Agriculture Research Station, 2200 P. A. Campos Ave., Suite 201, Mayagüez, Puerto Rico 00680-5470. Ricardo.Goenaga@ars.usda.gov

ABSTRACT.
Eight rambutan (*Nephelium lappaceum*) cultivars grown on an Oxisol and Ultisol were evaluated for three years under intensive management at Isabela and Corozal, Puerto Rico, respectively. There were significant differences in number and weight of fruits per hectare between locations and years. Significantly more fruits were produced at Corozal (357,004 fruits/ha) than at Isabela (168,083 fruits/ha). Fruit yield at Corozal and Isabela was 11,357 and 5,111 kg/ha, respectively. At Corozal, varieties were not significantly different for number of fruit and yield per hectare. At Isabela, cultivar Gula Batus and R-162 produced significantly more fruits and higher fruit weight than other cultivars averaging 234,153 fruits/ha and 6,979 kg/ha, respectively. Cultivar R-156Y had the lowest yield at both locations. Cultivars R-156Y and Rongrien had fruit with significantly more pulp (58%) than other cultivars (47%). At both locations, significantly lower fruit soluble solids (Brix) values (19.1) were obtained from fruits of cultivars R-156Y and Gula Batus; there were no significant differences in Brix among the rest of the cultivars (20.2).

KEYWORDS: tropical fruits, rambutan, adaptability, soluble solids

2008 Proceedings of the Caribbean Food Crops Society. 44(2):414. 2008

Poster #14

Calibration of SPAD-Meter Readings to Chlorophyll Content in Strawberry

D.L. Orihuela[1], W. Colón[2], J.C. Hernández[1], and C. Weiland[1],
[1]Escuela Politécnica Superior de La Rábida, Universidad de Huelva, Huelva, España,
[2]Universidad del Este, Carolina, Puerto Rico, orihuela@uhu.es

ABSTRACT.
The relationship between SPAD-meter readings to Chlorophyll content vary according to the crop sampled, crop vegetative stage, fertilization regimes, water stress, and other environmental factors. The objective of this research was to calibrate the Minolta SPAD 502 readings to chlorophyll content in strawberry (*Fragaria* x *ananasa* Duch.). Once the meter was calibrated, the model was compared to other crops and with other models. Leaf chlorophyll content was determined by the acetone extraction and spectrophotometer method. Greenhouse grown plants were exposed to 27 fertilization treatments of different levels of N-P-K with 5 replications. To obtain the best fit, linear, logarithmic, cubic, and exponential models were tested between SPAD readings and leaf chlorophyll content. The linear model equation resulted in the best fit and the relationship was µg chlorophyll/g leaf = 0.0116 SPAD reading – 0.1457.

KEYWORDS: SPAD-meter, chlorophyll, strawberry

2008 Proceedings of the Caribbean Food Crops Society. 44(2):415. 2008

Poster #15

Growth Rate and Yield of Coffee (*Coffea arabica L.*) Grown Under Partial Shade and Full Sunlight after Severe Renovation Pruning

Carlos A Flores Ortega[1] and Miguel A. Muñoz[2]. [1]Horticulture Department, [2]Agronomy and Soils Department, Agricultural Experiment Station, University of Puerto Rico, Mayagüez Campus. agro_flores@yahoo.com

ABSTRACT.
Severe renovation pruning of old coffee trees is an alternative to renovate old plantations. The success of success after implementing severe pruning may vary depending if coffee is grown under partial shade or full sunlight. It has been suggested that permanent partial shade creates a better environment for coffee renovation after severe pruning and that the crop can withstand better drought periods; it will benefit from reduced evapotranspiration; reduced wind and sun damage on new leaves and the fruit size is improved. This paper presents the results of a series of experiments on agroforestry planting systems on coffee plantations, comparing the recuperation of a severe pruned plantation under full sunlight and under shade conditions. The study was conducted for five years in the Agricultural Experimental Station at Adjuntas, located in the central region of the island. Two coffee plots of Puerto Rico 401 variety planted under partial shade of *Pithecellobium carbonarium* were used for the study. The shade was eliminated in one plot and both plots were submitted to severe renovation pruning. A factorial design was used for the study where the main plot was the treatment (partial shade and Full sun), years as subplot and 12 repetitions (trees). Data was collected on foliage development, canopy volume, harvesting, mortality and coffee quality. Climatic data on sunlight intensity, and air and soil temperature was also collected. Three methods to estimate canopy volume were evaluated. Significant differences ($p<=0.05$) on tree height was found. Average tree's height under partial shade was 1.68 m during 2004, 3.09 m during 2006 and 4.12 m during 2008 while full sun trees reached 1.34 m during 2004, 2.59 m during 2006 and 3.42 m during 2008. Canopy volume (CV) estimated by the CVF3 was the more precise among the three formulas tested. CV for full sun trees was estimated on 17.64 m while the shaded trees CV was estimated in 28.49 m, with a DMS=7.92125. Also mortality observed was three times higher at full sun treatment than at partial shade.

KEYWORDS: coffee, pruning, agroforestry.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):416-419. 2008

Poster #16

Using a Commercial Mixture of Amino Acids and a Commercial Extract of *Ascophyllum* Kelp to Reduce the Time in Nursery of 'Duncan' and 'Marsh' Grapefruits (*Citrus Paradisi* Macf.) in Puerto Rico

Note: This paper was presented as poster #16: Reducing the time in nursery for 'Marsh' and 'Duncan' Grapefruits with a Commercial Amino Acid Mixture and a Commercial *Ascophyllum* Kelp Extract"

J. Pablo Morales-Payan, Department of Horticulture, College of Agricultural Sciences. University of Puerto Rico, Mayagüez Campus. P.O. Box 9030, P.R. 00681-9030. morales.payan@upr.edu, josepablomorales@yahoo.com

ABSTRACT.

Experiments were conducted in Mayagüez, Puerto Rico, to determine the effect of two biostimulants on the in-nursery growth of grapefruit budded on 'Cleopatra' rootstock. A kelp (*Ascophyllum nodosum*) extract (Stimplex®) and a commercial mixture of amino acids (Macro-Sorb Radicular®) were drenched at several rates, starting one month after budding and repeating the applications every 10 days until the plants reached the adequate transplanting stage. Biostimulant-treated plants attained the adequate transplanting stage earlier than untreated plants. 'Duncan' and 'Marsh' responded equally to the biostimulants, and the extent of growth response was greater as the biostimulant rates increased. These results indicate that both biostimulants may be useful to accelerate the production of 'Duncan' and 'Marsh' grapefruits budded on 'Cleopatra' rootstock.

KEYWORDS: Biostimulants; growth regulators; physiological regulators.

INTRODUCTION

In Puerto Rico, tropical fruits are among the most economically important crop groups. In fiscal year 2006-2007, in Puerto Rico tropical fruit crops (excluding bananas) had a farm gate worth of approximately $38.2 million, of which approximately $8.6 million were from citrus crops (Puerto Rico Department of Agriculture, 2008).

Budded transplants are commonly used to establish commercial grapefruit orchards (Román Pérez et al., 2002), and it generally takes at least 100 days to grow citrus transplants from budding to adequate size for planting in their permanent sites in the orchards (Morales-Payan and Santiago, 2008; Santana et al., 2006). Budded grapefruit plants are deemed ready to be transplanted to their definite sites (adequate transplanting stage = ATS) when the scion (grapefruit) stem is at least 0.7 cm in diameter at its union with the rootstock, and the scion shoot is >50 cm in length.

Transplant growers are interested in reducing the time necessary to grow citrus transplants to adequate transplanting size, as a shorter time in nursery would reduce the risk of losing transplants to hurricanes, the time of exposure to pests and diseases (and the need to manage them), and as a result may help reduce production costs. In a literature search, documentation on the effect of biostimulants on grapefruit (*Citrus paradisi* Macf.) transplant growth was not found. Because biostimulants have been utilized to

reduce time in nursery for other fruit and tree crops such as coffee (*Coffea arabica*) (Villacres Vallejo, 1992), tangelo (*Citrus reticulata* x *C. paradisi*) (Morales-Payan and Santiago, 2008), orange (*Citrus sinensis*) (Santana et al., 2006), and papaya (*Carica papaya*) (Morales-Payan and Stall, 2005), it seemed feasible that biostimulants could be useful in reducing time to ATS in grapefruit as well. The objective of this research was to determine the effect of two biostimulants on the in-nursery growth of grapefruit budded on 'Cleopatra' mandarin (*Citrus reticulata*) rootstock.

MATERIALS AND METHODS

Experiments were conducted at the fruit crops nursery of the Alzamora Teaching and Research Farm in Mayagüez, Puerto Rico, in 2007 and 2008. Two biostimulants [a commercial extract of kelp (*Ascophyllum nodosum*) (Stimplex®), and a commercial blend of amino acids and peptides (Macro-Sorb Radicular®] were individually applied as drenches to 'Marsh' and 'Duncan' grapefruits previously budded onto the rootstock 'Cleopatra' mandarin. The biostimulant rates were 0, 0.25, 0.5, 0.75, and 1.0 ml per L of water. Each budded plant received 150 ml of the aqueous solutions per plant, starting 30 days after budding and repeating the application every 10 days, and ending 90 days after budding or when plants reached the adequate transplanting stage (ATS), whichever happened first. Treatments were arranged in a randomized complete block design with 10 replications. Shoot height, stem diameter, and number of fully expanded leaves were determined every 10 days after the first biostimulant application, until plants reached ATS (when the scion was at least 0.7 cm in diameter at its union with the rootstock, and the scion length was >50 cm). Regression analysis (5% level) was conducted on the data.

RESULTS AND DISCUSSION

Biostimulant rates had significant effects on grapefruit transplant growth. Rates of both biostimulants had comparable effects on grapefruit transplant growth, and thus regression data for only one biostimulant is presented here (Figure 1).

The response tendency was that of increasing growth as biostimulant rates increased. As a result, control (untreated) plants attained ATS 100 days after budding, whereas biostimulant-treated plants reached ATS earlier (Figure 1). Time from budding to ATS decreased linearly as biostimulant rate increased, from 100 days (untreated plants) to 20 days (plants treated with the rate of 1.0 ml/L of either the kelp extract or the amino acid and peptide blend), which corresponds to a reduction of 20% of time in nursery. Similar effects have been reported from research when transplants of tangelo, orange, papaya, and coffee were treated with biostimulants such as kelp extracts, amino acid + peptide mixtures, and folcysteine (Morales-Payan 2007; Morales-Payan and Stall, 2005; Morales-Payan and Santiago, 2008; Santana et al., 2006; Villacres Vallejo, 1992)

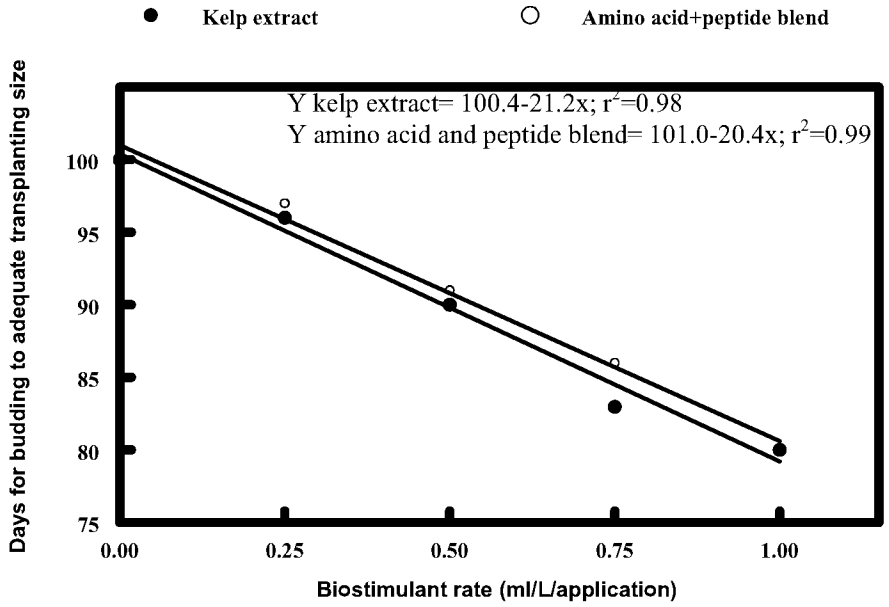


Figure 1. Effect of an *Ascophyllum nodosum* kelp extract (Stimplex®) and a blend of amino acids and peptides (Macro-Sorb Radicular®) on the time from budding to adequate transplanting stage in 'Marsh' and 'Duncan' grapefruits in Mayagüez, Puerto Rico, in 2007 and 2008. The data represents the average of both grapefruit varieties in two experiments.

The results of this research indicate the kelp extract and the blend of amino acids + peptides are promising to accelerate in-nursery growth of grapefruit transplants, reducing the time for production of adequate transplants by as much as 20%. Future research will include other citrus and other biostimulants and rates, in attempts to further reduce the time necessary to produce adequate citrus transplants in the conditions of Puerto Rico.

ACKNOWLEDGEMENTS

The author thanks Acadian Seaplants Ltd. (Nova Scotia, Canada) and BioIberica, S.A. (Barcelona, Spain) for supplying biostimulant application information and samples for this research.

REFERENCES

Morales-Payan, J. P. 2007. Growth acceleration of 'Cara Cara' and 'Valencia' oranges in nursery with an *Ascophyllum* seaweed extract and an amino acid mixture. Caribbean Food Crops Society Abstracts 43:104.

Morales-Payan, J. P. & W, M, Stall. 2005. Papaya (*Carica papaya*) transplant growth and quality as affected by nitrogen and a soil-applied seaweed extract. HortScience 40:1107-1108.

Morales-Payan, J. P., & S. Santiago. 2008. Accelerating the growth of 'Orlando' tangelo (*Citrus reticulata* x *C. paradisi*) in nursery with a commercial amino acid formulation, a commercial extract of kelp (*Ascophyllum nodosum*), and a fertilizer. Plant Growth Regulation Society of America 35rd Annual Meeting. San Francisco, California (August 2-6, 2008) 35:1.

Puerto Rico Department of Agriculture. 2008. Ingreso Bruto de la Agricultura en Puerto Rico. http://www.gobierno.pr/NR/rdonlyres/CF939105-E2DA-44EC-A0DF-41622555F06A/0/IngresoBrutoAgricola2006_07.pdf. Accessed on August 30, 2008.

Román Pérez, F. M., R. Rodríguez, O. Santana, & R. Macchiavelli. 2002. Comportamiento hortícola de la toronja 'Redblush' en tres patrones en la zona de Isabela. Abstracts Caribbean Food Crops Society 38:6.

Santana, L. M., R. Gabriel, J. P. Morales-Payan, C. H. Puello, J. Mancebo, & F. Rondon. 2006. Effects of biostimulants on nursery growth of orange budded on volkamer lemon (*Citrus volkameriana*) and 'Swingle' citrumelo (*C. paradisi x Poncirus trifoliata*). Abstr. Plant Growth Regulation Society of America 33rd Annual Meeting. Quebec City, July 9-13, 2006. Abstr. 65.

Villacres Vallejo, J. Y. 1992. Efecto del bioestimulante Ergostim (thiazolidín-4-carboxílico) en la germinación y edades de trasplante en el crecimiento de plántulas de café (*Coffea arabica* L.) cv. Caturra Roja. B. S. Thesis, La Molina National Agricultural University, Peru.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):420-424. 2008

Poster #17

Evaluation of Alternative Pesticides and Mulching for Organically-Grown Watermelons in Puerto Rico

Note: This paper was presented as Poster #17 "Organic Watermelon Yield is Affected by Alternative Pesticides and Mulching".

Mabel Vega-Almodovar, J. Pablo Morales-Payan, Sonia Martinez-Garrastazu, & Bryan Brunner. Department of Horticulture, College of Agricultural Sciences. University of Puerto Rico, Mayagüez Campus. P.O. Box 9030, PR. 00681-9030. morales.payan@upr.edu, josepablomorales@yahoo.com

ABSTRACT.
There is an increasing interest in organic horticulture in Puerto Rico. One of the main limitations for organic production is the scarcity of local research for production recommendations. Research was conducted to evaluate mulching for weed suppression and alternative pesticides for disease management in an organic watermelon system in Lajas, Puerto Rico. Plots were either not mulched or mulched with freshly-cut grass straw. The alternative pesticides were (1) a blend of oils of rosemary, clove, thyme and wintergreen, mixed with lecithin and buthyl lactate (Sporan®), (2) hydrogen dioxide (OxiDate®), (3) an oil extract from the tea tree *Melaleuca alternifolia*) (Timorex®), (4) a clarified Hydrophobic Extract of neem (*Azadirachta indica*) oil (Trilogy®), (5) mint and rosemary oils mixed with wintergreen oil, vanillin, lecithin and buthyl lactate (Ecotrol®), (6) potassium bicarbonate (Milstop®), (7) *Bacillus pumilis* strain QST 2808 (Sonata®), (8) *B. subtilis* strain QST 713 (Serenade®), (9) whole milk (10% solution in water), (10) a garlic (*Allium sativum*) extract (Garlic Barrier®), (11) (Javelin®) mixed with a copper fungicide (NuCop®) alternated with *B. thuringiensis* (Agree®) mixed with a copper fungicide (NuCop®), and (12) a check treated with water. The organic pesticides were applied weekly at recommended rates. Downy mildew was the prevalent disease throughout the season. Watermelon yield was significantly higher in mulched plots than in non-mulched plots, due to weed suppression by the mulch. Among the organic pesticide treatments resulting in the highest crop yields were hydrogen dioxide, *Bacillus pumilis* strain QST 2808, the garlic extract, and the *Melaleuca alternifolia* oil extract. These results provide valuable information for weed and disease management in organic and ecological watermelon systems in tropical regions.

KEYWORDS: Biopesticides; *Cyperus rotundus*; downy mildew; ecological pesticides.

INTRODUCTION

Interest in produce grown organically or ecologically has been increasing in Puerto Rico (Morales-Cotto and Morales-Payan, 2007a and 2007b), but scarcity of research-founded recommendations for organic and ecological production in Puerto Rico hinders the productivity and expansion of crops grown in non-traditional systems.

Organic and ecological watermelons are among the fruits that Puerto Rican consumers are interested in purchasing, more so if they are grown in the island (unpublished survey data by Morales-Payan and collaborators).

In Puerto Rico, watermelon (*Citrullus lanatus*) had a farm gate worth of approximately $2 million in the fiscal year 2006-2007 (Puerto Rico Department of Agriculture, 2008), and most of it is still grown in conventional systems. Management of weeds, diseases, and pests are among the main concerns of watermelon growers in Puerto Rico.

Weeds, particularly purple nutsedge (*Cyperus rotundus*) may be devastating to watermelon if allowed to grow unchecked or poorly managed (Roque et al., 2006; Wszelaki and Brunner, 2006). Diseases are commonly a threat to watermelons in Puerto Rico, especially fungal diseases in the southwestern region of the island (Wszelaki and Brunner, 2006). Little is known regarding the effect of crop protection inputs and practices on organic/ecological watermelon production systems in Puerto Rico.

The objective of this research was to determine the effect of mulching for weed management and application of alternative pesticides allowed in certified organic production on the yield and quality of watermelons grown as a transitioning crop in Puerto Rico. The objective of this research was to evaluate mulching and alternative pesticides for weed and disease management in watermelons grown following organic regulations in the conditions of southwestern Puerto Rico.

MATERIALS AND METHODS

Field research was conducted with transplanted 'Crimson Sweet' watermelon at the Experiment Substation of the University of Puerto Rico-Mayaguez in Lajas during June-August 2007. The treatments (mulching x alternative pesticide combinations) were established in a split-plot randomized complete block design with four replications. The large plots were either not mulched or mulched with freshly cut grass. The subplots were pesticides allowed in certified organic systems, applied according to the US National Organic Program regulations.

The alternative pesticides evaluated were (1) a blend of oils of rosemary, clove, thyme and wintergreen, mixed with lecithin and buthyl lactate (Sporan®), (2) hydrogen dioxide (OxiDate®), (3) an oil extract from the tea tree *Melaleuca alternifolia*) (Timorex®), (4) a clarified hydrophobic extract of neem (*Azadirachta indica*) oil (Trilogy®), (5) mint and rosemary oils mixed with wintergreen oil, vanillin, lecithin and buthyl lactate (Ecotrol®), (6) potassium bicarbonate (Milstop®), (7) *Bacillus pumilis* strain QST 2808 (Sonata®), (8) *B. subtilis* strain QST 713 (Serenade®), (9) whole milk (10% solution in water), (10) a garlic (*Allium sativum*) extract (Garlic Barrier®), (11) (Javelin®) tank-mixed with a copper fungicide (NuCop®) alternated with *B. thuringiensis* (Agree®) tank-mixed with a copper fungicide (NuCop®), and (12) a check treated with water. The alternative pesticides were applied weekly at label recommendation rates.

The experimental units were raised soil beds 6 m long containing 10 watermelon plants each. The crop was transplanted onto the experimental units the same day the mulching was laid on the plots, and the watermelon was managed following practices allowed under the US National Organic Program standards. Weed density, disease

incidence and severity, and pest density and damage were evaluated weekly one or two days prior to treatment reapplication. Fruit yield (fruit number and weight) were determined at harvest. Fruit grade (size, internal and external color, flesh firmness and soluble sugar concentration) were determined in post-harvest. Analysis of variance and separation of means were conducted on the resulting data.

RESULTS AND DISCUSSION

The prevalent weed during the first month was after crop transplanting was purple nutsedge (*Cyperus rotundus*). Mulching significantly affected purple nutsedge density by one month after crop transplanting, which reached approximately 500 shoots per m^2 in non-mulched plots, and approximately 100 shoots in mulched plots (data not-shown).

Downy mildew (caused by *Pseudoperonospora cubensis*) was the prevalent disease throughout the season. Alternative pesticides had significant effects on the extent of damage caused by downy mildew on watermelon. The leaf area damaged by downy mildew by the fruit enlargement stage was as low as 22% and as high as 95% (data not shown). Insect and mite presence during the watermelon season was insignificant.

Watermelon yield was significantly higher in mulched plots than in non-mulched plots, due to weed suppression by the mulch. On average, in non-mulched plots, yield was approximately 55% lower than in mulched plots, regardless of the pesticide applied (data not shown).

Most pesticide treatments had no measurable impact on disease severity and on watermelon yield. However, the copper/Bt treatment resulted in lower yields than the check (which may be partially attributable to copper toxicity)(Figure 1). In contrast, the hydrogen dioxide treatment resulted in the highest yields among all the treatments. Aside from the hydrogen dioxide treatment, among the organic pesticide treatments resulting in the highest crop yields were *Bacillus pumilis* strain QST 2808, the garlic extract, and the *Melaleuca alternifolia* oil extract (Figure 1).

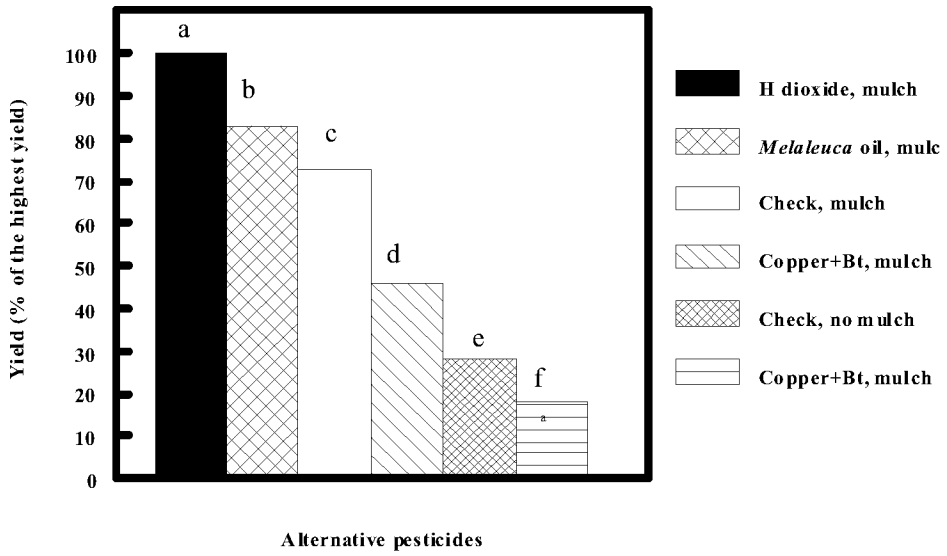


Figure 1. Effect of selected alternative pesticides and mulching on the yield of organically-grown watermelon in Lajas, Puerto Rico, in 2007.

In summary, in this research we found that (1) mulching significantly reduced purple nutsedge density and interference with organically-grown watermelon, and that (2) several alternative pesticides (mainly hydrogen dioxide) were efficacious reducing downy mildew severity and helped increase watermelon yield. In future studies, the best treatments from this research will be compared to other weed management practices and other alternative pesticides, to generate more information useful to organic and ecological watermelon growers in Puerto Rico and similar locations.

ACKNOWLEDGEMENTS

Research funded by the USDA-HATCH Program (UPR-Mayaguez Project H-405).

REFERENCES

Morales Cotto, S. & J. P. Morales-Payan. 2007a. A survey of ecological (organic) growers in Puerto Rico: Situation, challenges, and obstacles. Abstr. Society for Agricultural Sciences of Puerto Rico (SOPCA) 33:25.

Morales Cotto, S. & J. P. Morales-Payan. 2007b. Organic food production in Puerto Rico: progress, challenges, demand and quality (original in Spanish: Alimentos orgánicos en Puerto Rico: retos y avances de producción, demanda y calidad alimenticia). Abstr. Jornada del Colegio de Ciencias Agrícolas de la Universidad de Puerto Rico 2:18-19.

Puerto Rico Department of Agriculture. 2008. Ingreso Bruto de la Agricultura en Puerto Rico. http://www.gobierno.pr/NR/rdonlyres/CF939105-E2DA-44EC-A0DF-

41622555F06A/0/IngresoBrutoAgricola2006_07.pdf. Accessed on August 30, 2008.

Roque, S.M., B. Brunner and A. Wszelaki. 2006. Alternativas para el manejo de malezas en la producción de sandia orgánica tropical (Alternatives for weed management in tropical organic watermelon production). Abstracts of the Inter-American Society for Tropical Horticulture 52:70.

Wszelaki, A., and B. Brunner. 2006. Creating a more sustainable watermelon production system in Puerto Rico. Abstracts of the Inter-American Society for Tropical Horticulture 52:17.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):425. 2008

Poster #18

Crecimientos Vegetativo y Reproductivo del Aguacate 'Hass' en Varios Climas de Michoacán, México

J.L. Rocha-Arroyo, S. Salazar-García, I.J.L. González-Durán, y J. Anguiano-Contreras. INIFAP-Campo Experimental Uruapan, Uruapan, Michoacán. México. E-mail: samuelsalazar@prodigy.net.mx

RESUMEN.
En Michoacán se cultivan más de 96 mil ha de aguacate 'Hass' pero existe poca información para entender su comportamiento fenológico en los diferentes climas. El objetivo del estudio fue cuantificar la influencia del clima sobre la ocurrencia e intensidad de los flujos vegetativos (FV) y su importancia para la floración. Se seleccionaron 14 huertos adultos de 'Hass' distribuidos en siete climas. En cada huerto se eligieron 10 árboles y en cada uno de ellos se marcaron cinco ramas de 1-1.5 m de longitud; en cada rama se etiquetaron 15-20 brotes del FV de invierno para darle seguimiento a cada brote. Los brotes vegetativos producidos por cada FV fueron etiquetados para determinar el tipo de crecimiento producido (vegetativo, floral o inactivo) durante 2006-2008. En todos los climas hubo tres FV (invierno, primavera y verano) y cuatro flujos de floración: "Loca" (Ago-Sep), "Aventajada" (Oct-Dic), "Normal" (Dic-Feb), y "Marceña" (Feb-Mar). El clima influenció (P = 0.05) la intensidad de floración producida por los brotes originados en los tres FV's. La floración Normal fue la más abundante en los tres FV's y en la mayoría de los climas. El FV de invierno fue el más importante para la producción de cualquier flujo de floración. Para el FV invierno, la mayor intensidad de las floraciones Loca y Aventajada ocurrió en climas Semicálido subhúmedo (**SS**) y Templado húmedo (**TH**). En brotes de los FV's primavera y verano estas floraciones fueron más intensas en los climas SS, Semicálido húmedo (**SH**), Templado subhúmedo (**TS**) y TH. La mayor intensidad de floración Normal ocurrió en los climas SH y TH (brotes de invierno), Cálido subhúmedo (**CS**) (brotes de primavera), y en climas SS, SH y TH (brotes de verano). Para los tres FV's, la floración Marceña fue más intensa en los climas CS y SS. En cualquier FV la floración Normal tendió a ser más intensa en los climas fríos (SH, TS y TH), mientras que la Marceña se incrementó en los climas cálidos (CS y SS).

PALABRAS CLAVE: *Persea americana*, floración, fenología.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):426. 2008

Poster #19

Corrección de la Deficiencia Crónica de Zinc en Aguacate 'Hass'

S. *Salazar-García*[1], *L.E. Cossio-Vargas*[2] *y I.J.L. González-Durán*[1], [1]*INIFAP-Campo Experimental Santiago Ixcuintla, Nayarit, México.* [2]*Universidad Autónoma de Nayarit, Posgrado en Ciencias Biológico Agropecuarias. Xalisco, Nayarit, México. E-mail: samuelsalazar@prodigy.net.mx*

RESUMEN.
En los huertos de aguacate 'Hass' de los municipios de Tepic y Xalisco, Nayarit, son frecuentes los niveles foliares debajo de lo normal de zinc (Zn) y la presencia de síntomas visuales de deficiencia de Zn en hojas, brotes y frutos. Esta investigación se desarrolló del 2001 al 2005 en dos huertos comerciales de aguacate 'Hass' cultivados sin riego en el Mpio. de Tepic con el objetivo de evaluar el efecto de las aplicaciones de sulfato de zinc ($ZnSO_4$), al follaje o al suelo, sobre la producción, tamaño y forma del fruto. El suelo de los huertos era de textura ligera, pH 5.8 y bajo contenido de Zn (1.4 a 3.13 $mg \cdot kg^{-1}$). Los tratamientos al follaje fueron aplicados en 8 L agua/árbol y consistieron en: **a**) una aspersión con 4.056 g $ZnSO_4$/L agua (1.46 g Zn), y **b**) dos aspersiones con 2.028 g $ZnSO_4$/L agua (0.73 g Zn); ambos tratamientos proporcionaron 11.68 g Zn/árbol. Los tratamientos al suelo consistieron en: **a**) una aplicación (1.5 kg), y **b**) dos aplicaciones (0.75 kg c/u) anuales de $ZnSO_4$ (35.5% Zn) al suelo. El tratamiento Control no recibió Zn. Las aspersiones foliares con $ZnSO_4$ no afectaron la producción y tamaño del fruto. El promedio de las cosechas 2003, 2004 y 2005 mostró que dos aplicaciones al suelo con 0.75 kg $ZnSO_4$/árbol/año resultaron en la mayor producción total de fruto (173 kg/árbol), producción de fruto grande (170 a >266 g/fruto; 109 kg/árbol), y la relación largo-ancho del fruto (1.9), comparado con los árboles Control, que tuvieron menor producción total (136.7 kg/árbol), menor producción de fruto grande (59.2 kg/árbol), y forma más redonda del fruto (rel. largo-ancho = 1.36). La aplicación anual de 1.5 kg $ZnSO_4$/árbol mostró valores significativamente inferiores a dos aplicaciones anuales de 0.75 kg c/u, pero significativamente superiores al Control. Se encontró una pobre relación entre los niveles de $ZnSO_4$ aplicados al suelo y el contenido foliar de Zn.

PALABRAS CLAVE: *Persea americana*, producción, deficiencias nutrimentales

2008 Proceedings of the Caribbean Food Crops Society. 44(2):427-436. 2008

Poster #20

Papaya Growth in Double-Row Systems Established During the Dry Season

Thomas W. Zimmerman, University of the Virgin Islands Agricultural Experiment Station, RR 1 Box 10,000, Kingshill, VI 00850. Email: tzimmer@uvi.edu

ABSTRACT.
Papaya is an important fruit in the tropics due to its nutritional level and year round production. Papaya production in the Virgin Islands is hindered by the lengthy dry season in this semi arid environment where fresh water is lacking. Three selected papaya varieties, 'Maradol', 'Tainung 5' and 'Yuen Nong 1' were grown in 1 x 1 m, 1 x 2 m or 1 x 3 m double-row spacing regime randomized block design incorporating drip irrigation with 4L/hr emitters at 1 m intervals and grass-hay mulch. The objective was to determine water usage, plant growth and fruit set during the first six months establishment in the dry season of the U.S. Virgin Islands. Tensiometers set at 30 cm depth were used to determine when water was applied and indicated that the 1 x 1 m double row depleted the water quicker than the other two spacing regimes. Data was collected included: rainfall, irrigation water applied, plant height, height to first flower, height to first fruit, stem diameter at 1 m and number of fruit set after six months. Plants grown in the 1 x 1 m double row were taller, had thinner stems and significantly fewer fruit set for all varieties during the six months of plant establishment and growth. The 1 x 2 m double row grown papaya were similar to the 1 x 3 m double row plants for height, stem diameter and fruit set. The 1 x 2 m double row growing system is recommended to increase production where space and water are limiting factors. A grass/hay mulch is very effective in controlling weeds, conserving soil moisture and protecting the soil from erosion during sudden short heavy tropical rains.

INTRODUCTION

The crop farms in the U.S. Virgin Islands are mainly comprised of small farmers. The average amount of land for a crop farmer is 4.7 acres (National Agricultural Statistics, 2000). Though this average includes livestock farmers, the crop farmers are less than 2 acres. The small size limits the investment the farmer can make to produce a crop. They have to see a strong benefit to a technology before they invest in it and adapt it to their farming practices. New technologies are being developed for papaya production. Papaya requires nine months from seed, in the early varieties, to have a marketable crop. To have fruits available during the holiday season and peak tourist season, papayas need to be planted in late February through March. However, February through August are normally the driest months of the year in the US Virgin Islands.

Plant spacing from the past project indicated that growth and production were not influenced by plant spacing (Kowalski and Zimmerman, 2006). The plant spacing was 3 m x 3 m, 2 m x 3 m and a double-row 1 m x 3 m. The double-row provided a higher planting density and a more efficient use of space and irrigation water.

Drip irrigation technology permits the resourceful use of water and can help maximize the use of semiarid lands for agricultural use. This technology is particularly

suited to widely spaced crops as papaya. Though multiple field trials have shown the economic beneficial use of drip irrigation on vegetable and herb production in the Virgin Islands (Palada et al, 1995; Crossman et al, 1997; Palada and O'Keefe, 2001) limited information is available on the use of drip irrigation for papaya production (Kowalski and Zimmerman, 2001; 2006). It has been suggested that the water needs for papaya in Hawaii are ideally supplied with 100 mm of rainfall each month (Nakasone and Paull, 1998). This amount is seldom encountered in the semiarid climate of the Virgin Islands where erratic rainfall patterns and extended dry periods are the norm. Also, the local preference is for large, greater than two pounds, red papayas while most papaya research from Hawaii has focused on small, yellow one pound or smaller fruit. Not only are the varieties different between the Virgin Islands and Hawaii but also the soil. The soils of the Virgin Islands are calcareous, having a high pH around 8 versus volcanic base in Hawaii. Breeding and selection of papayas at the University of the Virgin Islands has resulted in early bearing varieties that meet the fruit preferences of the Virgin Islanders (Zimmernan and Kowalski, 2004).

Water is most often the limiting factor to crop production in the U.S. Virgin Islands. The municipal source of water is from desalination of ocean water. Due to the cost of the desalinated municipal water, farmers use the water sparingly. The most efficient use of water can result in economical gains for the local farmers. This research expanded on the double-row concept to include closer double-row spacing to determine the best intensive plant spacing for the most efficient use of water for fruit set.

MATERIALS & METHODS

The objectives of this research were to develop a commercial papaya producing field plot that incorporates drip irrigation and mulch for growing selected papaya varieties at multiple double-row spacing regimes and determine water usage during the dry season in the U.S. Virgin Islands. Specifically to integrate water conservation through drip irrigation and mulching into papaya production, determine water requirements of papaya grown under multiple double-row plant spacing regimes and determine the growth and production potential of papaya as influenced by spacing under drip irrigation and biodegradable mulch.

Papaya plants were established in double-row spacings during February from greenhouse grown seedlings. Water usage was recorded over a six month period which corresponds to the annual dry season from March through August with the assistance of a prebaccalaureate student. Tensiometers were used to record soil moisture levels and determine when irrigation water needed to be applied.

To study the integrate water conservation through drip irrigation and mulching into papaya production, papaya were established from seed in a greenhouse one and a half months prior to transplantation to the field at the University of the Virgin Islands Agricultural Experiment Station on St. Croix. The three varieties used were 'Maradol', 'Tainung 5' and 'Yuen Nong 1'. 'Maradol' is a compact variety producing red 4-5 lb fruit. 'Tainung 5' and 'Yuen Nong 1'are standard sized trees that produce large red and yellow fruit respectively.

A double-row plant spacing regime was followed. A nine foot distance was between double-rows to allow for tractor cultivation until the plants attain three feet. Each double-row was three feet apart. The distance between each plant within a row of

the double-row varied from three feet, six feet or nine feet which corresponds to 2,400, 1,200, or 800 plants per acre respectively. Each plant spacing was replicated three times and had ten plants of each variety per replication. Guard rows were planted on both sides of the field and between replications. Guard plants were also planted at the end of each row.

One drip line of irrigation was installed at the time of transplanting six-eight inch tall seedlings into the field. The spacing of the orifices in the linear irrigation tubing was three feet and exude one gallon per hour. The drip lines were placed near the plant base and moved outward to a distance of 1.5 feet from the base of the plant. A final drip line was added between the double rows when the plants were at three feet in height. The double rows then had a drip line outside of each row and one between the double-rows for a total of three lines per double-row. Hay mulch was applied to the whole field after the third drip line was installed. The drip lines were under the mulch and in contact with the soil. The hay mulch was spread to a depth of the three inches between plants and rows. The straw/hay was obtained from the VI Department of Agriculture as large round bales.

To determine water requirements of papaya grown under double-row plant spacing regimes soil moisture tensiometers were placed throughout the plots at a depth of 15 cm and 30 cm. The tensiometers were used to determine soil moisture content. Water meters were installed for each plant spacing plots and the amount of water applied recorded over time. Rainfall information was obtained from the IVI-AES weather station.

During the initial six month growth of the papaya plot corresponding to the dry season, data was collected on plant height, height to first flower, height to first set fruit, stem diameter at three feet from the soil surface and number of fruit set when the first fruit was ripening. This growth and production data was obtained to determine the influence of spacing and drip irrigation on papaya yield.

RESULTS AND DISCUSSION

Papaya were established under field plot conditions in early 2007 from seeds germinated in a greenhouse. The first six months of 2007, during the establishment of the papaya plot, a typical dry season was experienced on St Croix (Figure 1). Low rainfall started in January and when plant establishment occurred in early February, the soil was dry. There was a spike in rainfall during April. Heavy rains were received that lasted a week and provided seven inches of rainfall. The soil moisture content was at field capacity during these heavy rains causing the tensiometer to read zero for ten days (Figure 2). The soil tensiometers' readings increase in value as the soil dries. When the soil is saturated the readings decrease to zero. Figure 2 also indicates that plant spacing did have an influence on soil moisture available to the plants. The same dripline, with three foot emitters, was used for all spacing treatments and the 1 m x 1 m double row spacing configuration had drier soil before and after the heavy April rains. The closer the plant spacing results in more competition from the plants roots for the water available in the soil. The papaya plants in the 1 m x 1 m spacing competed more for the available water, reducing the soil moisture quicker, then was observed for either the 1 m x 2 m or 1 m x 3 m double row spacing.

During the initial six months of papaya establishment and growth, water was applied as indicated in Figure 3. The wet soils from the heavy April rains resulted in less water being applied to the papayas in April. The mulch was very effective in controlling weeds, conserving soil moisture and protecting the soil from erosion during sudden short heavy tropical rains. However, the straw mulch absorbs the light showers preventing the water from reaching the soil. Most light showers have minimal effect on the soil and availability to plants due to the high evaporation rate (Goenaga et al., 2004). The total amount of water given to each plant was 62 gallons over seven and one half months for the 1 m x 2 m plant spacing during which plant establishment, floral induction and fruit set occurred.

Plant spacing did have an influence on the height of 'Maradol' plants over time. After two months of growth, the 1 m x 1 m spacing caused the plants to be taller then the more distant spacings (Figure 4). 'Maradol' is a compact papaya variety that has a slower rate of growth but the close plant spacing caused it to stretch to have a difference of 50 cm by the forth month. 'Maradol' grew at the same rate for the 1 m x 2 m and 1 m x 3 m plant spacing.

Both 'Tainung 5' and 'Yuen Nong 1' are standard sized papaya trees. However, the close 1 m x 1 m spacing had taller plants after one month (Figures 4 and 5). The leaves start interacting with each other after a month's growth at the close plant spacing. As the plants became taller with age, the close spacing caused the plants to grow outwards resulting in a 'V' shaped double row. This leaning outward was not observed in the 1 m x 2 m or 1 m x 3 m spacing which grew perpendicular to the soil.

The stem diameter can have an influence on the plants ability to support a column of fruit as well as have tolerance to wind. Thinner stemmed plants tend to snap in wind when carrying a heavy fruit set. These varieties are grown because they are able to set 30-50 fruits (Kowalski and Zimmerman, 2001). For all three varieties the close plant spacing had the thinnest stems (Table 1). The 1 m x 3 m plant spacing resulted in significantly thicker stems then the 1 m x 1 m spacing. With 'Tainung 5' both the 1 m x 3 m and 1 m x 2 m spacing had significantly thicker stems then the 1 m x 1 m spaced plants.

The height to first flower and height of the first set fruit indicate how low the fruit is set on the stem. These three varieties were chosen because they set fruit early. Flowers are present between the first and second of field establishment. Papaya trees that set fruit early have a lower center of gravity and less prone to high winds (Zimmerman and Kowalski, 2004). Both the 1 m x 2 m and the 1 m x 3 m spaced plants had earlier flowering and fruit set lower to the soil surface for all varieties then the 1 m x 1 m plants (Figure 7). Lower fruit set also allows more fruit to be within reach for a longer period of time.

The main reason for growing papaya is for production. The number of fruit set on a papaya stem column was recorded when the first fruit ripened and indicates expected production for the tree. For all three varieties, the 1 m x 1 m double row spacing set significantly less fruit then either the 1 m x 2 m or 1 m x 3 m double row spacing (Figure 7). This indicates that the close plant spacing can't hold as many fruit and may be influenced by the water availability to the plant previously discussed. The 1 m x 2 m and 1 m x 3 m double spaced plants were not significantly different for fruit set. The 1 m x 2

m double row spacing was the most efficient for water usage and land area to produce the most fruit.

CONCLUSIONS

The papaya plants for 'Maradol', 'Tainung 5' and 'Yuen Nong 1', grown in a 1 m x 1 m double row system were taller, had thinner stems and significantly fewer fruit set then the 1 m x 2 m or 1 m x 3 m double row spacing regime during a normal dry season of six months for plant establishment and growth. The 1 m x 2 m double row grown papaya were similar to the 1 m x 3 m double row plants for height, stem diameter and fruit set. The 1 m x 2 m double row growing system is recommended to increase production where space and water are limiting factors. A grass/hay mulch is very effective in controlling weeds, conserving soil moisture and protecting the soil from erosion during sudden short heavy tropical rains.

REFERENCES

Crossman, S.M.A., M.C. Palada and J.A Kowalski. 1997. Comparison of mulch type effect on yield of parsley in the Virgin Islands. Caribbean Food Crops Society. 33:216-220.

Goenaga, R., E. Rivera and C. Almodovar. 2004. Yield of papaya irrigated with fractions of class A pan evaporation in a semiarid environment. Journal of Agriculture University of Puerto Rico 88:1-10.

Kowalski, J.A. and T.W. Zimmerman. 2001. Evaluation of papaya germplasm in the U.S. Virgin Islands. Caribbean Food Crops Society. 37:24-28.

Kowalski, J.A. and T.W. Zimmerman. 2006. Papaya production under different spacing regimes. Caribbean Food Crops Society. 42: 399-402.

Nakasone H.Y. and R.E. Paull. 1998. Tropical Fruits. CAB International, New York, NY

National Agricultural Statistics. 2000. Virgin Islands of the United States 1998 Census of Agriculture. http://www.nass.usda.gov/census/census97/vi/vi.htm

Palada M.C. and D.A. O'Keefe. 2001. Response of hot pepper cultivars to levels of drip irrigation. Caribbean Food Crops Society. 37:190-196.

Palada M.C., S.M.A. Crossman and J.A Kowalski. 1995. Water use and yield of basil as influenced by drip irrigation levels and mulching. Caribbean Food Crops Society. 31:143-149.

Zimmerman, T.W. and J.A. Kowalski. 2004. Breeding and selection for early bearing papayas. Acta Horticulturae 632:53-55.

Table 1. Diameter of papaya stems taken at a one meter height for three varieties as influenced by plant spacing in a double row system.

	Spacing (ft)*		
Variety	**3x3**	**3x6**	**3x9**
Maradol	**6.70 a**	**7.80 ab**	**9.01 b**
Tainung 5	**6.49 a**	**8.67 b**	**9.36 b**
Yuen Nong 1	**7.01 a**	**8.35 ab**	**9.86 b**

*Mean separation within rows conducted using LSD P=0.05

Table 2. Number of fruit set at the time of the first ripe fruit for three papaya varieties as influenced by plant spacing in a double row system.

	Spacing (ft)*		
Variety	**3x3**	**3x6**	**3x9**
Maradol	**23.3 a**	**35.9 b**	**38.8 b**
Tainung 5	**27.9 a**	**46.1 b**	**49.0 b**
Yuen Nong 1	**23.1 a**	**36.5 b**	**39.1 b**

*Mean separation within rows conducted using LSD P=0.05

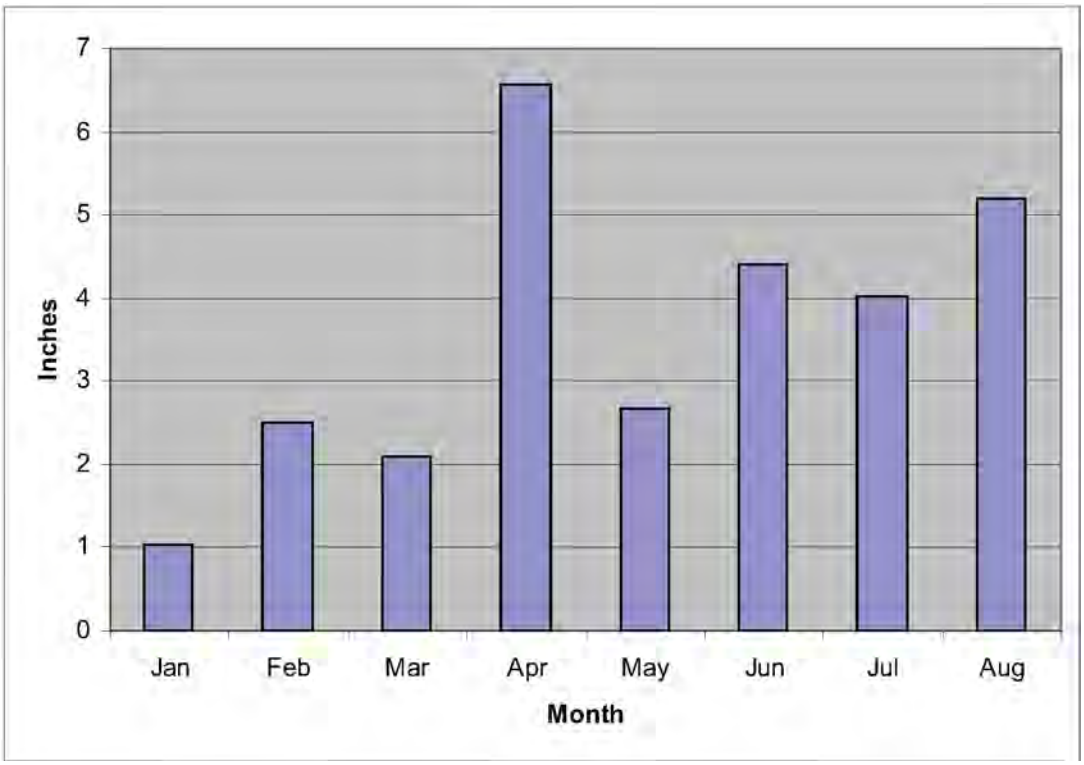


Fig. 1. Average monthly rainfall during 2007.

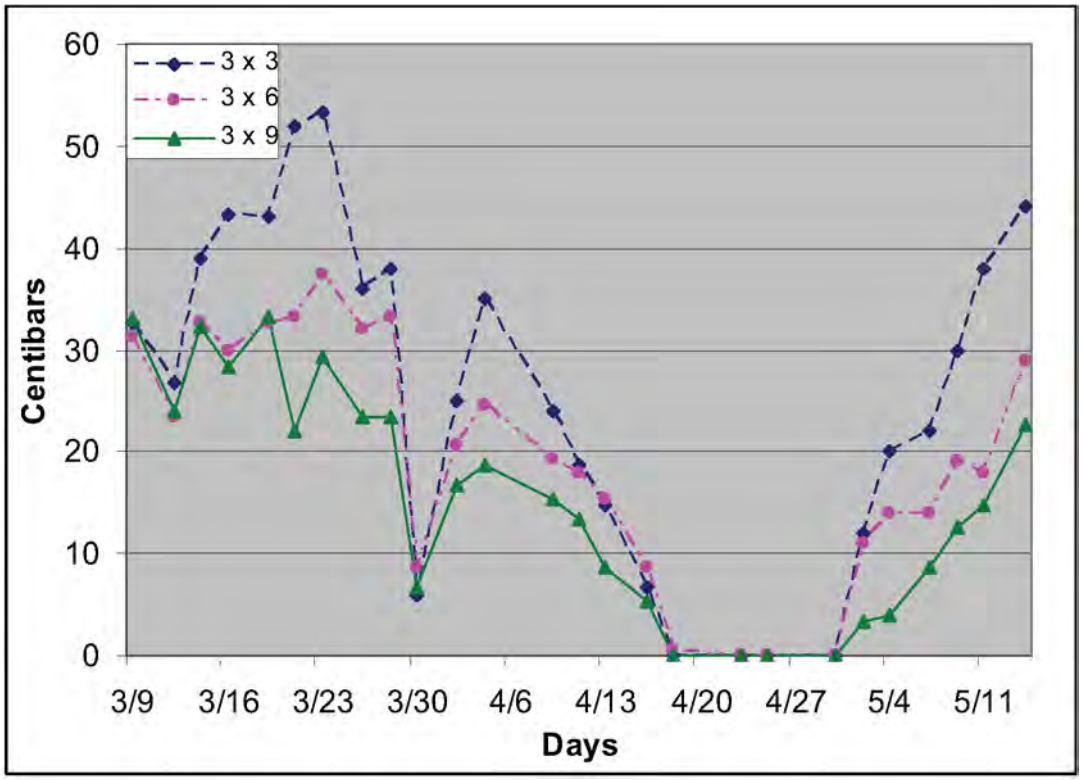


Fig. 2 Soil tensiometer readings, in centibars, over time for each papaya spacing.

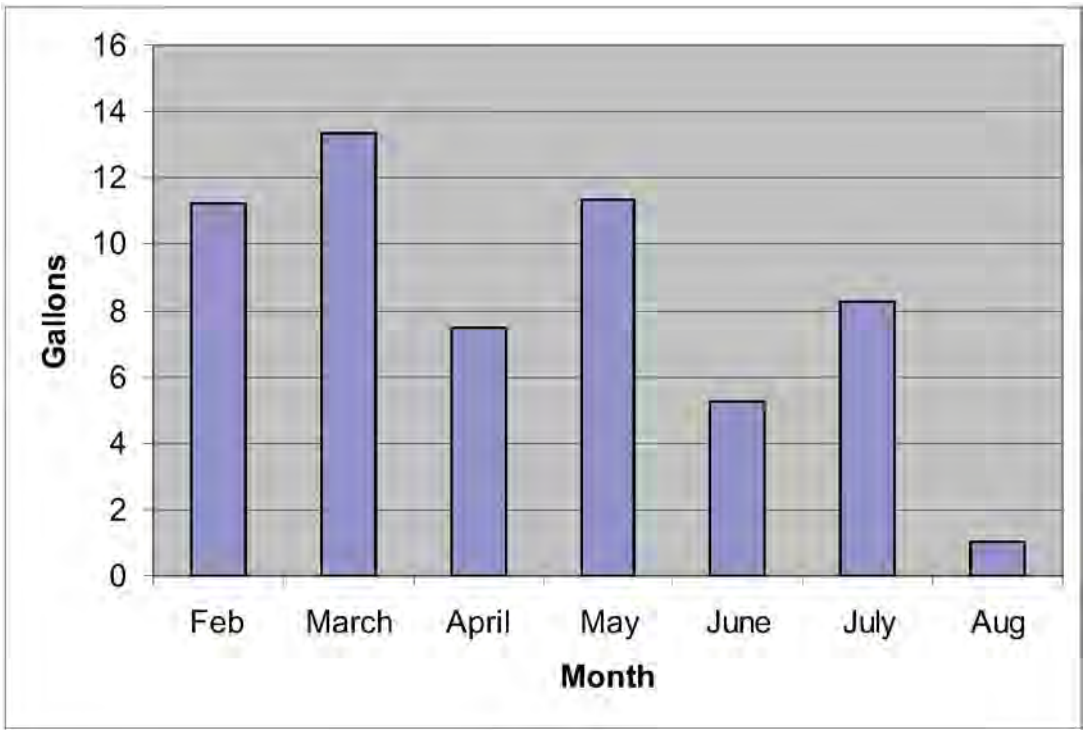


Fig. 3. Average gallons of water applied to each papaya plant.

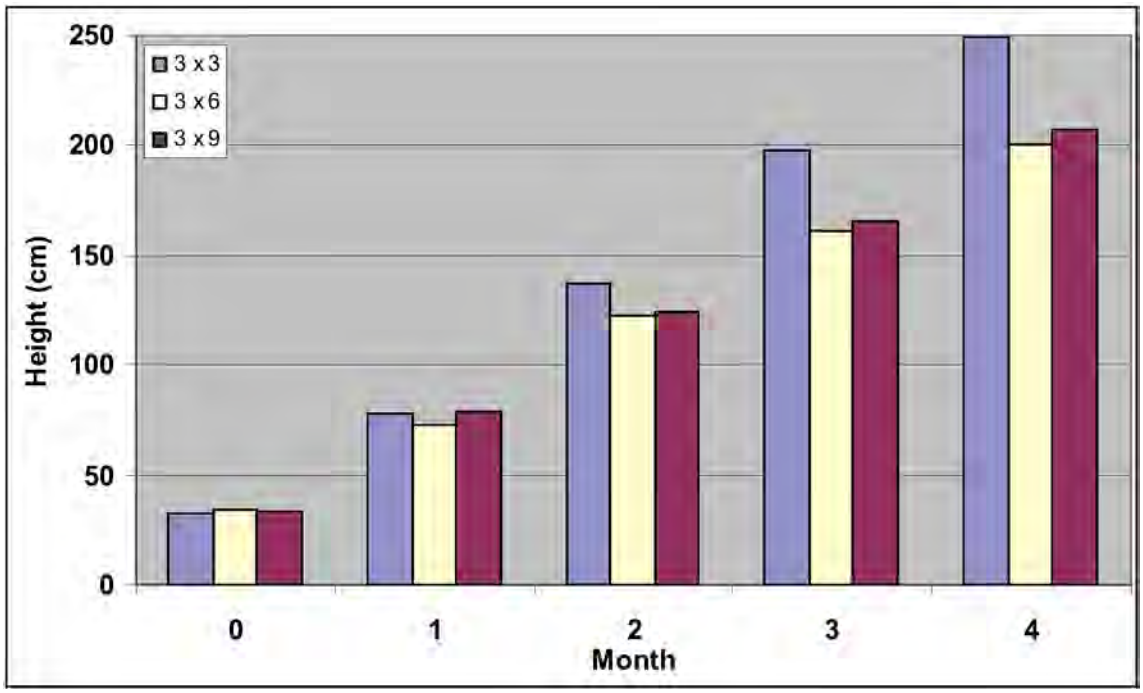


Fig. 4. Plant height of the 'Maradol' papaya plants during the first four months.

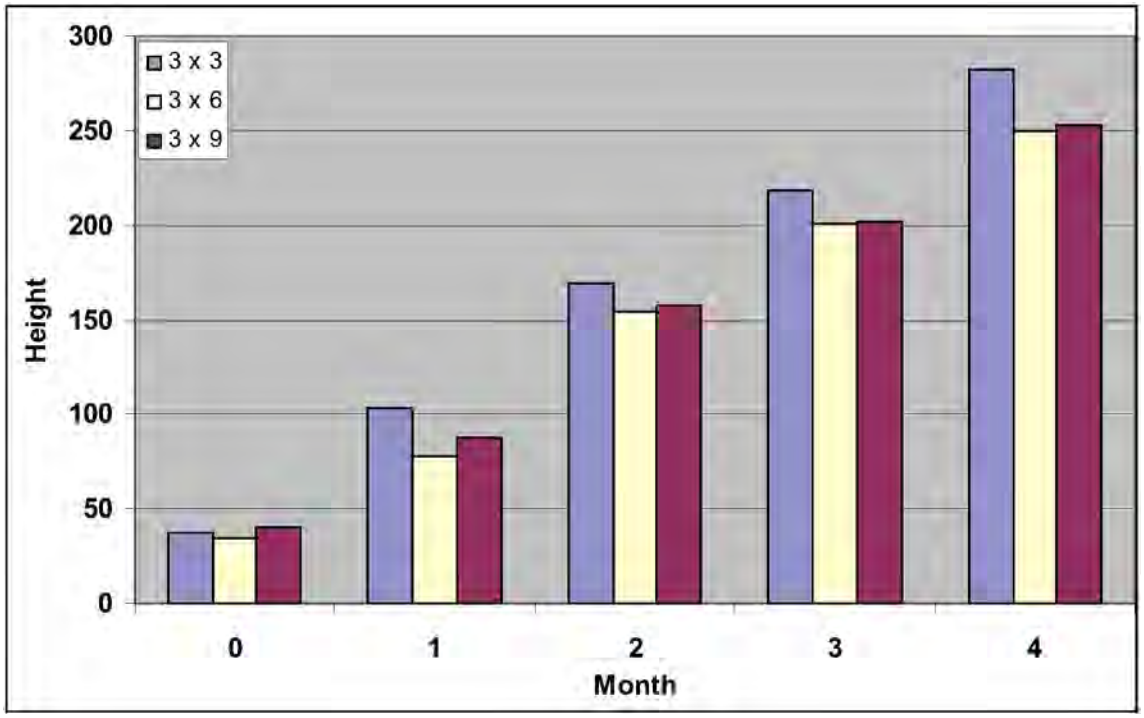


Fig. 5. Plant height of the 'Tainung 5' papaya plants during the first four months.

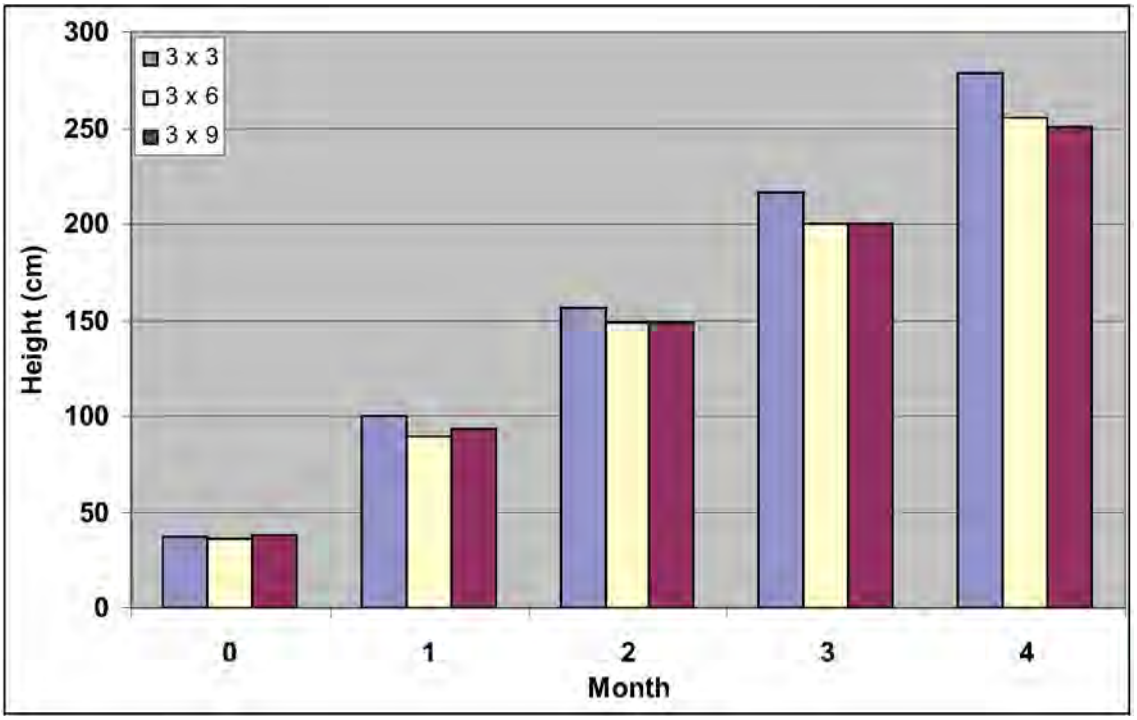


Fig. 6. Plant height of the 'Yuen Nong 1' papaya plants during the first four months.

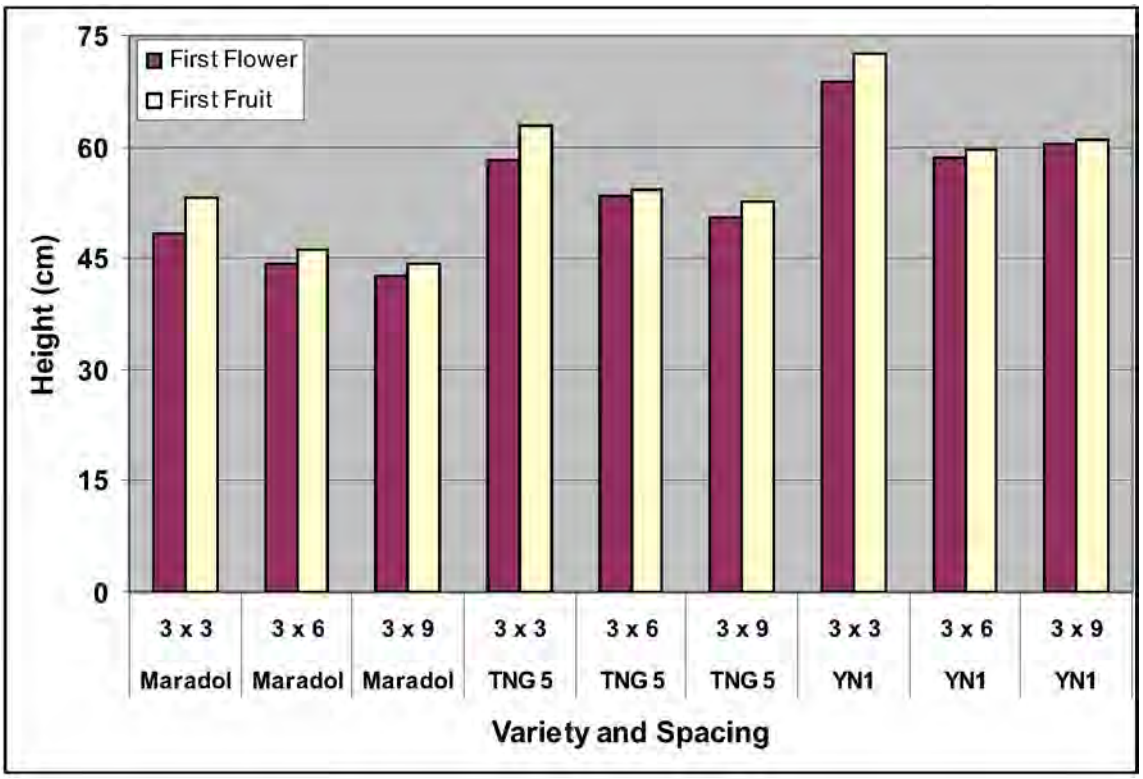


Fig. 7. Effect of plant spacing on the initiation of the first flower and setting of the first fruit for three papaya varieties.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):437. 2008

Poster #21

Agricultural Labor Issues and Immigration in Southwest Florida:

Robert D. Halman, University of Florida IFAS Extension – Collier County, 14700 Immokalee Road, Naples FL 34120. rdhalman@ufl.edu

ABSTRACT.
Southwest Florida is a major agricultural area on the Florida Gulf Coast. The sub-tropical climate of many of the counties makes the region ideal for the production of diversified agricultural crops. A large migrant labor force is responsible for land preparation, planting, harvesting and processing of the fruits and vegetables grown in the region. The recent stepped up activities of the U.S. Immigration and Customs Enforcement (ICE) responsible for investigating a wide range of domestic and international activities arising from the illegal movement of people and goods into, within, and out of the United States has been critical in labor availability. The region, as an excellent recreational, tourist and residential destination, has caused another labor dynamic in the landscape industry. These transitional labor issues as well as local law enforcement involvement will be presented.

KEYWORDS: Migrant, Immigration and Customs Enforcement (ICE), Labor

2008 Proceedings of the Caribbean Food Crops Society. 44(2):438. 2008

Poster #22

PROCINORTE'S Tropical and Subtropical Fruits Task Force: a Tri-National Effort to Improve Fruit Quality and Trade

R. Goenaga[1], S. Salazar-García[2], G. Doyon[3], J.A. Osuna-García[2], I.J.L. González-Durán [2] and J.A. Landry[4]. [1]USDA-ARS, Tropical Agriculture Research Station, 2200 P. A. Campos Ave., Suite 201, Mayagüez, Puerto Rico 00680-5470 (Ricardo.Goenaga@ars.usda.gov); [2]INIFAP-Campo Experimental Santiago Ixcuintla, Apdo. Postal 100, Santiago Ixcuintla, Nayarit, Mexico 63300; [3]Food Research and Development Centre, Agriculture and Agri-Food Canada, 3600 Casavant Blvd. West, St. Hyacinthe, Quebéc, Canada J2S 8E3; [4]University of Quebéc, 1100 Notre Dame W. St., Quebéc, Canada H3C 1K3

ABSTRACT.
Canada, Mexico and United States are countries that share many interests in agricultural affairs. The three countries have been commercial partners for many years, and most recently they have been working under the North American Free Trade Agreement (NAFTA) umbrella. The three countries are natural commercial partners sharing several common problems in agriculture. Some of these problems are related to food safety and quality, control of pests and diseases, and other issues concerning food exports and imports. One very important mechanism to facilitate the institutional and technical integration of Canada, United States and Mexico is PROCINORTE under the umbrella of the Inter American Institute for Cooperation on Agriculture's (IICA), Northern Regional Center. PROCINORTE is a cooperative Program in Research and Technology for the Northern Region, with an Umbrella Task Force that determines common research priorities. Within PROCINORTE, several initiatives or task forces have been formed. The Tropical and Subtropical Fruits Task Force was established in 2002. The main goal of this task force is to improve production, consumption and trade of tropical and subtropical fruits in the entire PROCINORTE region. Specific objectives are to: 1) encourage the communications and collaboration among scientists working in quality, safety, and production of tropical and subtropical fruits; and 2) identification of common problems and opportunities associated with tropical fruit production and quality and work jointly in research projects to solve these. A summary of activities carried out by the Tropical and Subtropical Fruits Task Force is presented here.

KEYWORDS: commerce, exportation, food safety.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):439. 2008

Poster #23

Le Programme Régional de Développement Agricole : un outil méthodologique pour la modernisation et l'adaptation de l'agriculture Guadeloupéenne.

Edmond Rubrice, *Chambre d'agriculture de Guadeloupe, Guadeloupe.*
rubrice.cda@wanadoo.fr

RÉSUMÉ

Après la réforme du financement du développement agricole et rural en France, le Ministère de l'agriculture et de la Pêche signait avec l'APCA en 2004 un premier contrat d'objectifs pour les programmes de développement agricole des chambres d'agriculture. Ce contrat commun à toutes les chambres régionales d'agriculture de France a représenté un changement méthodologique important et a amélioré la lisibilité des actions à partir de six objectifs : Accompagner les mutations des exploitations agricoles ; adapter les productions et les activités aux attentes des marchés ; gérer et préserver les ressources en eau ; participer au développement territorial ; piloter les actions en cohérence avec les autres politiques publiques.

En Guadeloupe, en complément du conseil technique individualisé, le Programme Régional de Développement Agricole a favorisé la réalisation des actions d'intérêt général et l'accompagnement des agriculteurs au changement des politiques agricoles et rurales : Organisation des filières de diversification ; nouvelles méthodes de collecte des données pour le réseau de suivi, les références systèmes et technico-économiques ; observatoire économique et social ; agro transformation ; agritourisme et animation du réseau « bienvenue à la ferme » ; sensibilisation sur les enjeux de l'agri-environnement ; partenariat avec les acteurs du système recherche développement formation ; amélioration de la gouvernance du projet.

La valorisation des acquis méthodologiques se poursuivra dans le cadre d'un second contrat d'objectifs 2009-2013. Il permettra de préparer l'avenir de l'agriculture guadeloupéenne sur les bases de quatre nouvelles priorités et en fonction des attentes de la société : satisfaire les marchés par des productions adaptées ; relever les défis environnementaux par des modes de production innovants et durables ; contribuer au développement durable des territoires par des activités et des systèmes d'exploitations adaptés ; innover dans l'exercice des métiers par des entreprises agricoles performantes avec des actifs professionnels responsables et organisés.

MOTS CLÉS : contrat d'objectifs, agriculture durable, Guadeloupe.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):440-446. 2008

Poster #24

Incubator Farms as a Sustainable Approach for 'Neo Farmers'

Puran Bridgemohan, Centre Biosciences, Agriculture, and Food Technology, University of Trinidad and Tobago, Point Lisas Campus. puran.bridgemohan@utt.edu.tta

ABSTRACT.
Trinidad and Tobago is facing a challenge of urban migration and a reduction in an already ageing farming population. There is an urgent need to attract new and emerging farmers to this vocation and guide them to be economically viable and educated farmers of the future. Incubator Farm is a unique and successfully proven approach which will be appropriate for Small Island States Economies, and will assist to educate aspiring farmers and establish their business as incubators. This paper discusses the creation of a more closed-loop food system through the establishment of several farms for the production of dwarf pommecythere, cassava, and hot peppers linked to a post–harvest facilities and multi-purpose pilot processing plant.

KEYWORDS: Incubator Farm, dwarf pommecythere, cassava, and hot peppers

INTRODUCTION:

Trinidad and Tobago food production and agro-processing industry is facing a challenge of urban migration and a reduction in an already ageing farming population. This is further complicated with consumers having to face shortages in cereals, particularly rice and wheat products. There is an urgent need to attract new and emerging farmers to this vocation and guide them to be economically viable and educated farmers. Incubator Farm is a unique and successfully proven approach which will assist to educate aspiring farmers to establish their own business and focuses on agricultural transformation (Handy, 2001).

A strategy for sustainable growth and economic development in the agro-production and processing sector can be achieved through farm incubators (Hirschman, 1958). This is used to host and train farmers and small processors as they produce, share equipment and facilities, establish their market (Eaton, 2001) and learn from each other.

There is currently a growing farming population of over 5,000 small part-time farmers or '2 acre farmers' or 'neo-farmers' in Trinidad which arose from the closure of the sugar industry[1]. Most of these 'neo-farmers' would prefer perennial crops with low input and establishment cost, minimal labour requirements and maintenance cost, early revenue generation spread evenly throughout over a 3 to 4 year period, and that can be intercropped (Anon, 1998). These new farmers, although they may have worked in an agro-processing [sugar] industry, really are not culturally farmers and lack the husbandry and skills. However, they would be exposed to low input sustainable agriculture [LISA]

[1] Sugar Adaptation Strategy for the sugarcane Industry of Trinidad and Tobago

and good agricultural practices [GAP] which will assist in production catering for fresh market and processing plants (Anon, 2002).

When pooled due to their close proximity, the farmers will benefit from irrigation facilities, and participate in a rotational cropping system to ensure a continuous supply of raw material to the processing plant (Anon, 2008). This concept mirrors the "mega-farms' now touted about by the Agricultural Planners. The most suitable crop for both production and processing on the heavy clay soils of central and south Trinidad are dwarf pommecythere, green coconuts, cassava and hot peppers/chillies. The agronomy[2] and processing protocols[3] for these crops have already been established.

This paper presents the strategy for the creation of a more closed-loop[4] food system through the establishment of several farms for the production of crops linked to a post-harvest facility and multi-purpose pilot processing plant

STRATEGIC DIRECTION:

The Rutland Area Farm and Food Link (Hubbard , 2006) had identified a need for a program to nurture beginning farmers, that will in turn start agriculturally based business in the region. The incubator farms were an ideal place where new farmers got their enterprises started and built their markets before making significant capital investments. The vision for incubator farms was for it to operate as a regional agricultural centre supporting a community based food system by providing resources that encourage farm enterprises and expand local agriculture in the community (Sayre, L. 2005).

This background was used in developing a strategic direction for the establishment of an incubator farm for the production of dwarf pommecythere, cassava and hot peppers/chillies in the Waterloo area, which is in close proximity with the Centre Biosciences, Agriculture, and Food Technology, University of Trinidad and Tobago, Point Lisas Campus. Further, it is proposed that together with CARIRI, an agro-post harvest / production and processing facility will be established along side the training facility. This is to be used for hosting and training farmers and small processors as they produce.

GOALS & OBJECTIVES:

The strategic goals and objectives of incubator farms are summarized as follows:

- To connect all people in the local area to develop a viable farms community.
- To provide an economical and diverse agro-processing industry that is market led and technology driven.
- To cultivate land, and optimize production, processing and market opportunities.
- Educate and empower aspiring and potential partners/entrepreneurs to establish their own business.
- To partner with institutions specializing in financial, marketing, R&D, and processing etc services.

---

[2] Pers. Com. (2008). Dr. Wayne Ganpat, Deputy Director, ICT, Ministry of Agriculture, Land and Marine Resources.

[3] Caribbean Industrial Research Institute.

[4] Pers. Com., (2008). Dr. Kimberly Fitch, Finance and Program Coordinator, New Entry Sustainable Farming Project.

APPROACH:

The Intervale Incubator Farms [Anon, 2008] has developed a program which has proved congenial to a wide range of different types of farms, from crops to marketing strategies to management structures. Intervale Farmers sell to farmers' markets, restaurants, local supermarkets, and co-ops. To achieve the above, the it is intended that an effective approach is to study, interact and network with personnel already in the business and conduct a feasibility on integrating production, processing and marketing "on-site", and thus encourage entrepreneurial activity.

The strategic approach[5] in the creation of this closed-loop food system is through the coalition of multiple small farm holders [2 acres] for the production of crops. These farms will be clustered in groups of 10 farms to provide 20 acre blocks so as to facilitate sequential field and harvesting operations, and expand the rotational cycle. This grouping ensures the optimum use of field equipment, irrigation facilities, and extends the supply of material and produces to th4e pilot processing plant. When this is programmed into the intercropping and crop succession cycle, a wider variety of crop will become available.

ACTIVITIES:

The following are critical activities which are essential in the establishment of a one hundred acre farm incubator, together with a multi-purpose pilot processing plant and post-harvest facility. The latter will be flexible so that it can expand operations to accommodate several similar size incubators.

[5] Pers . Com., (2008). Mike Lanier, Agricultural Economic Development Centre N.C. Cooperative Extension, Orange County Centre, N.C.

Activity	Details
Farm Incubator [fifty 2ac farms]	• germplasm management • Nursery Crop production • Access roads, drainage and irrigation facilities • Procurement of field equipment and tractors • Preparation of rotation cycles, intercropping plans, crop production schedules, pest and disease management programs.
Post Harvest Facility [multi-purpose pack-house]	• Preparation of design physical structure • Renovation / modification of existing building • Procurement of equipment and instruments
Pilot Plant/Processing Incubator	• Establishment of Pilot Plant and Post Harvest facilities • Procurement of equipment and instruments • Testing/dry run • Training and education
Evaluation of System	• Gap Analysis of system • Develop appropriate R & D studies • Marketing system • Recruit relevant R & D personnel • Implement quality assurance system

FUNDING:

The initial cost for the development and execution of this project should be borne by the state as 'seed funding'. The capital expenditure and project cost is estimated at $9.5 MTTD. This grant funding can be sourced from the Public Sector invest Program [PSIP] funds in the Ministry of Agriculture, Lands and Marine Resources as part of the

European Union Funding for the displacement of sugar farmers / workers and the diversification of the sector This will contribute to social and economic development by empowering the residents in the community to take responsibility of an entrepreneurial activity.

Expenditure	Cost Detail	**[$M.TT]**
Capital: [$M.TT]	Pilot processing plant	**3.5**
	Post harvest facility	**1.5**
	Training Room	**0.25**
	Greenhouse & screen-house	**1.25**
Project:	Field station	**0.25**
	training	**0.5**
	management	**0.75**
	Fields trials and experiments	**0.05**
	Inputs	**0.75**
	Lab. upgrades	**0.75**
	TOTAL	**9.55**

The institutional stakeholders in this Project are definitely the Ministry of Agriculture, Lands and Marine Resources, The Universities of the West Indies and Trinidad and Tobago, National Agricultural Marketing and Development Company, Caribbean Agricultural Research and Development Institute, Caribbean Industrial Research Institute, Agricultural Development Bank, Trinidad and Tobago Agri-Business Association, and National Enterprises Development Company amongst others. These institutions can facilitate research and development work, training and provide back-stopping support for the activity.

BENEFITS:

The expected benefits of this project can be summarized in the following:

- Expansion in number of viable farms [incubators]
- Preservation of productive agriculture lands
- Increased accessibility to small scale local food production and processing
- Improved management of the natural resources and protection of water quality.
- A better informed and developed food security plan with opportunities for new and emerging small scale farmers.

- An appropriate program designed with respect to creating a culture , market, educational opportunities, with identifiable mechanism and institutions
- A developed and enhanced farm and land-based enterprise that can generate economic and social opportunity while protecting the natural resources and bio-diversity of a fragile tropical island.
- A reconnection of former retrenched sugar workers, displaced sugar-cane farmers, potential new farmers, and financially struggling farmers with minimal resources,, but capable of producing fresh food to a urban people with an active lifestyle based on processed foods.

Year	Expected Output
1	A program designed to nurture beginning farmers, processors and entrepreneurs that will in time start agri-based business and build markets before making significant capital requirement
2 -3	Increased acreages under cultivation with selected crops minimum of 50 farmers with 2 acres [100ac]
2	Establish multiprocessing pilot plant and post harvest facilities .
2	Training sessions for farmers and producers, with significant publications and multi-media presentations [6]
2	Minimum of 4 M.Phil and 2 Ph.D graduate
2	A strong research and development program that will be funded by grants, University, and government

SELECTED AREAS OF RESEARCH AND DEVELOPMENT:

1. Agro-economic studies of integrated farming for specific commodities with processing potential.
2. Non-traditional crop production, processing, and marketing.
3. Value-added agro-processing of crops as natural food colours, additives, preservatives, essential oils, specialized food, and food processing waste technology.
4. Certified seed production and propagating studies.
5. Application of bio-technology advances to production and processing *viz* tissue culture and genetic engineering

REFERENCES:

Anon. (1998). A Rural non-farm income in developing countries. *The state of Food and Agriculture. Ro*me

Anon. (2002). Balance between Food Security and the Sustainable management of natural resources in Latin America and the Caribbean. Twenty –seventh FAO Regional Conference for Latin America and the Caribbean , Havana, Cuba, 22 to 26 April, 2002

Anon. (2008). New England Workers on organic Farms. http://www.smallfarms.org/newwoof/.hmtl

Anon. (2008). Intervale Farms Program, Vermont. http://www.intervale.org/FarmsProgam.hmtl

Anon. (2008).New Entry Sustainable Farming Project.Tufts University. http://nutrition.tufts.edu/research/nesfp

Eaton, M. J. (2001). Contract Farming. Partnership for Growth. FAO Agricultural Services, Bulletin145. Rome

Handy, S. (2001). Focus for Agricultural Transformation. Agric. Review. Vol. 8, No. 3, July –Aug, 2001, pp14 -38

Hirschman, A. (1958). The Strategy of Economic Development. New Haven: Yale University Press

Hubbard, P. (2006). Incubator Farm Summary. Community Food and Agriculture Coalition of Missoula County. http://intervale.org/.

Pers. Com. (2008). Dr. Wayne Ganpat, Deputy Director, Information Communication and Training, , Ministry of Agriculture, Land and Marine Resources, Trinidan and Tobago.

Pers.Com. (2008). Mike Lanier, Agricultural Economic Development Centre, N.C. Cooperative Extension, Orange County Centre, P.O. Box , 181, Hillsborough, N.C. 27278, [919-215-2063]

Pers.Com. (2008). Dr. Kimberly Fitch, Finance and Program Coordinator, New Entry Sustainable Farming Project, 9 Central St. Suite 402, Lowell, M.A. 01852, [978-654-6745]

Sayre, L. (2005). From the ground up. Framers Perspective. New Farm. Rodale Institute, May 12th.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):447. 2008

Poster #25

Policy Implications of the Composite CARICOM Business Environment

Ronald M. Gordon and John J. VanSickle. Food and Resource Economics Department, University of Florida, 1197 McCarty Hal, PO Box 110240, Gainesville, FL 32611-0240. rmg251@yahoo.com.

ABSTRACT.
Comprehensive data and information on the characteristics of the business environment of CARICOM countries are limited, likely constraining informed policy formulation. This research project sought to characterize the CARICOM business environment by interviewing and surveying representatives of firms from the countries of Dominica, Guyana, Jamaica, St. Lucia and Trinidad and Tobago.

The business environment was revealed to be heterogeneous and multi-faceted with important differences pertaining to firm size, area of operation and geographical scope. The proportion of micro firms with an annual sales volume (ASV) of less than US dollars1.0 million exceeded twice that of large firms with an ASV in excess of US dollars 6.5 million. The proportion of small firms with an ASV between US dollars 1.0 million and US dollars 2.5 million is similar to that of medium firms with an ASV between US dollars 2.5 million and US dollars 6.5 million. Some firms operated only in one sector. Others, across the firm-size groups, reported multi-sectoral operations with combinations such as agriculture and manufacturing; agriculture, manufacturing and services; manufacturing with trade and commerce; and agriculture and professional services. Some firms' geographical scope of operations also transcended the firm-size groups, with micro and large firms among those indicating global operations. Respondents viewed CARICOM positively but entrepreneurs thought CARICOM did not strengthen their business environment.

These findings suggest that CARICOM policy formulation should be more cognizant of the distinctiveness of the business environment, exhibited by the major sub-groups of firms across the countries. The policy strategy should also actively and deliberately embrace the economic and related characteristics exhibited by countries, firms and sub-sectors within the business environment.

KEYWORDS: CARICOM countries; Caribbean business environment; policy formulation.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):448. 2008

Poster #26

An Evaluation of Dairy Farming in Suriname

Samantha Engeldal, Dept. of Agriculture, Anton de Kom University of Suriname. r.tjienfooh@uvs.edu

ABSTRACT.
The dairy industry in Suriname consists of approximately 600 registered farmers who supply milk to the largest of four processing plants, the Melk Centrale Paramaribo. Recent analysis of milk samples have proven that the quality of produced raw milk does not meet the standards. The implementation of good farming practices is important to assure quality and safety of milk. A survey was conducted amongst local dairy farmers to investigate current farming practices and evaluate management on dairy farms. Results proved that in general the management strategies are below standards. It is clear that many farmers lack understanding of effective dairy farming practices. Recommendations were given to dairy farmers on how to improve the quality of milk.

KEYWORDS: standards, raw milk quality, good dairy farming practices

2008 Proceedings of the Caribbean Food Crops Society. 44(2):449. 2008

Poster #27

Exploring the Internationalizing of Extension Opportunities: A Partnership with the Antigua 4-H Youth Program

Norma Samuel[1] and *Nicole Walker*[2]. *University of Florida/Institute of Food and Agricultural Science Marion County Extension Service*[1], *and University of Florida/Institute of Food and Agricultural Sciences Polk County Extension Service*[2]. *P.O. Box 9005, Drawer HS03, Bartow, FL 33831-9005; naw@ufl.edu*

ABSTRACT.
The Youth Department within the Ministry of Education, Sports and Youth Affairs for the Government of Antigua and Barbuda is charged with reviving an almost dormant 4-H program in Antigua. The need for a structured youth development program is particularly significant in light of recent outbreaks in youth violence. Staff had minimal 4-H knowledge and needed training on use of the Experiential Learning Model (ELM) and understanding the Essential Elements of 4-H. A needs assessment was conducted to determine how UF/IFAS could assist. Norma Samuel, Marion County and Nicole Walker, Polk County, designed a program to address the needs identified. The objectives were to meet with local and regional officials to develop a 4-H support system; teach the 4-H 101 curriculum to effectively manage 4-H clubs and country-wide programming; design, implement, and evaluate a horticulture judging event; conduct a teen leadership workshop; and gather local information to enhance our own county programs. Each of the objectives was met. A meeting was held with Youth Department staff and various stakeholders to gather information on program history, technical and financial support, and program direction. The major outcome of the 4-H 101 session was an action plan developed by the group outlining the role of the Youth Department staff, partnering organizations in Antigua, and UF/IFAS. The plan is currently being implemented and followed up once per quarter. An annual evaluation of progress is planned starting January 2009. One-hundred percent of the final evaluations for the training session indicated knowledge gained in many areas, including: recognition of competencies critical for healthy youth development; understanding the history and culture of 4-H; targeting specific life skills in 4-H programs; applying the ELM; and starting 4-H clubs. Partnerships between government agricultural agencies and the growing 4-H program may contribute to a renewed emphasis on agriculture among young people.

KEYWORDS: 4-H, experiential learning, youth development

2008 Proceedings of the Caribbean Food Crops Society. 44(2):450-460. 2008

Poster #29

Environmental Damages Versus Economic Performance, Sustainability of Guadeloupean Banana Cropping Systems in Question: an Emergetic Approach

Jean-Marc Blazy[1].; Inacio de Barros[1].; Geraldo S Rodrigues[2].; Harry Ozier-Lafontaine[1].
(1) INRA UR agropédoclimatique, Domaine Duclos, 97170 Petit-Bourg, Guadeloupe (FWI)
(2) EMBRAPA Labex Europe. Unité Propre de Recherche Performance des systèmes de culture de plantes pérennes - CIRAD-PerSyst, Avenue Agropolis, 34398 Montpellier, France.
Corresponding authors: Jean-Marc Blazy jean-marc.blazy@antilles.inra.fr & Harry Ozier Lafontaine ozier@antilles.inra.fr

ABSTRACT.
Banana is an important agricultural commodity in Guadeloupe (French West Indies) and, to increase their competitivity in the international market, banana growers have intensified their production systems during the last fifteen years by increasing the use of man-made technological inputs. Such intensification strategies, that require investment increases, are economically and environmentally risky. In order to assess the environmental performance of banana production in Guadeloupe, emergy synthesis methods were applied to six different types of banana cropping systems previously identified in the island. Additionally, aiming at improving farmers decision making, environmental performance results were compared with economic analysis for each cropping system. These analyses showed that the better the environmental benefit of any cropping system, the worse its economic performance. This main result was corroborated by an increased contrast among cropping systems as related to their dependence on purchased inputs, although all of them are based on the same intensive and arguably wasteful agricultural model. Therefore, the analysis point out that sustainable banana production in Guadeloupe depends on a shift from the high fossil imported input model to a local renewable resources intensive one. In this sense, emergy flow analysis shows that innovation towards environmentally sound practices that would enhance nutrient cycling; integrate weeds, pests and diseases control; and improve the banana packing process might result most positive impacts on overall sustainability. Economic analysis showed that the high labour costs contribute largely to the dependency of banana production on public subsidies. Nevertheless, reorienting the current European agricultural income policy to an environmental performance-based subvention might represent an opportunity to achieve the present social goals while promoting sustainability in banana production.

KEYWORDS: Banana; Guadeloupe; Cropping Systems; Environmental impact; Agricultural Economics.

INTRODUCTION

Banana production is a major crop for local economy and contributes to the typical landscape of Guadeloupe. It represents 24% of local agricultural production, 12% of the total cultivated area, and generates about 5,000 direct jobs (Insee, 2001) in this caribbean french island. This sector is facing severe environmental and economic crises (Dulcire and Cattan, 2002), mostly due to a market liberalization that has prevailed during the last fifteen years, causing the price of banana to decline by an average rate of 1.4% per year (Arias et al. 2003; FAO, 2003a) and compelling farmers to intensify their production systems in order to maintain their income (Heuze, 2005; Perret and Dorel, 1999). Looking for higher productivity, farmers increment the use of technological inputs such as intensive use of machinery, fertilizers, pesticides, and irrigation, that push energy flows through the agroecosystem to unsustainable levels (Giampietro et al., 1992a,b). In Guadeloupe the systematic use of ploughing and pesticides has lead to chronic contamination of soils and waters by organochlorine compounds (Bonan and Prim, 2001). The reported contamination problem has in turn contributed to a decrease in soil biological diversity and consequent reduction in fertility (Clermont Dauphin et al., 2004), while contaminating drinking water sources (Bonan and Prim, 2001).

In order to align banana cropping systems in Guadeloupe with societal requirements for environment friendly production, and to develop actions towards sustainable cropping systems, new assessment tools are necessary to highlight innovations that would effect most significant and positive impacts. Agriculture operates at the interface between nature and the human economy, and relies on a combination of natural and economic inputs to produce goods. Therefore, both economic and environmental contributions need to be accounted in equivalent terms when comparing resource uses in agricultural systems (Campbell, 1998).

The goals of the present study are: i) to compare the different banana cropping systems observed in Guadeloupe (FWI), with regard to resource use, productivity, environmental impact, and overall sustainability; ii) to evaluate the emergy signature of the banana production as a whole in the region; iii) to contrast an ecocentric analysis (emergy) with an anthropocentric analysis (economic) of the banana cropping systems and observe their respective tradeoffs; and iv) to highlight points where innovations might result in greater improvements towards overall sustainability of banana cropping systems in Guadeloupe.

MATERIAL AND METHODS

In order to organize the diversity of existing banana cropping systems at the regional scale for emergy and economic analysis, a typology was applied according to three different dimensions: 1) Environmental: expressed by rainfall regime, solar radiation, soil category, and topography; 2) Technical: expressed by broad agronomic management aspects, and 3) Economic: expressed by financial input and output balances. Each cropping system type consolidated according to this typology regroups all individual farmers with high degree of similarity for all three dimensions. For the purposes of this study each type has been translated into an hypothetical farm that represents the average for all farms included in it. The cropping systems typology was based on farmers'interviews comprising 45 description variables for the three

aforementioned dimensions. The statistical process for the typology comprised two consecutive steps. A Principal Component Analysis (PCA) then an Agglomerative Hierarchical Clustering treatment (AHC). The validity of the system of types obtained has been thereafter assessed by applying analysis of variance to the initial quantitative variables and a Discriminant Analysis (DA) to the qualitative ones (Blazy et al. 2008). Financial performances of the different cropping systems have been assessed by a set of economic indicators calculated from the average results for each type. These economic indicators were net income as the financial surplus over costs, profitability rate and the productivity of work measured as the surplus-value obtained from labour.

Emergy analysis is based on the works of Odum (1996), Ulgiati and Brown (1998) and Brown and Ulgiati (2004a, b). The procedure begins by drawing system diagrams to identify all inputs, outputs and internal components for the studied system. The studied banana cropping systems have been subdivided in two subsystems: subsystem I refers to the banana field and includes operations of fertilization; weed, disease and pest control; plant anchorage and bunch covering, and labelling; while subsystem II reports on the operations related to harvesting, sorting, packing and transporting bananas to market or port for export. This division corresponds to the usual rationale of banana production in Guadeloupe.

After quantifying annual flows for each component and cropping system in physical units (i.e., joules, grams, US$), these values were translated into emergy units (seJ) through previously calculated transformities for each item. For some components and products, different transformities had been derived in different contexts, so the transformity calculated under the most similar conditions to those observed in the studied situation has been selected (Lefroy and Rydberg, 2003). Furthermore, each component or production item was classified whether it is an endogenous resource (L) or a resource purchased from outside (P), whether it is a renewable (R) or non-renewable resource (N) or an exported product (Y). The percentage of renewable and non-renewable emergy supporting labour was determined based on previous studies (Ulgiati et al., 1994). In Sweden and Italy, 87 and 90%, respectively, of the emergy supporting labour was provided by non-renewable sources (Panzieri et al., 2002; Rydberg and Jansen, 2002). As the living standards in Guadeloupe are similar to those observed in European countries, 87% of the emergy supporting labour was assumed to be nonrenewable. In order to make the flows easily comparable among cropping systems and facilitate calculations, the amounts of the different components and items have been normalized both for area (1 ha) and time (1 year), for the various cropping systems studied. On the other hand, when the emergy synthesis of the overall banana production system was analyzed, the flows were expressed for the total area cropped with banana in Guadeloupe (2,350 ha), according to FAO (2008) and weighed by the respective area fraction for each cropping system type. Several performance and sustainability indices have been calculated for the different cropping systems. These indices were derived in Ulgiati et al. (1994), Odum (1996), and Ulgiati and Brown (1998) and summarize systems resource use intensity, process efficiency, economic-environment interactions and quantify sustainability.

RESULTS

Renewable flows (sunlight, wind, rainfall geopotential energy and rainfall chemical energy) were expressed for the emergy accounting of banana cropping systems

mostly as evapotranpiration, which is the largest flow and integrates sunlight-derived flows. Little variation was observed in the inputs of renewable resources between the different banana cropping systems, mainly because of the high rainfall regime in all regions cultivated with banana in Guadeloupe (between 2.6 and 4.6 m, evenly distributed yearly rainfall average). As a consequence, crop evapotranspiration is near maximum and no water stress is generally experienced. Hence, as evapotranspiration (the main item of renewable flows) is similar among cropping systems, overall renewable flows are also similar. Differences were observed mainly in the fraction of human labour and organic matter amendment from discarded bananas attributed as a renewable source. Actually, only the type III cropping system farmers return the non-commercialized bananas as organic matter amendment to their fields, which means an additional emergy input of about $13.08E^{+13}$ sej.ha^{-1}.year^{-1}. Non-renewable resources used included important flows referred to soil erosion, which varied from 0.98 up to $6.19E^{+13}$ seJ.ha^{-1}.year^{-1}. The low levels of non-renewable emergy flow caused by soil erosion in the studied cropping systems are explained by the fact that banana crops provide good soil coverage (high leaf area index), and are cultivated mainly in the Andisols and at a lesser extend in Ferralsols areas of Guadeloupe.

The main differences between the cropping systems studied were observed in the use of purchased resources that varied 3 folds from the lowest value ($1.86E^{+16}$ seJ.ha-1.year-1 for type V) to the largest flow observed ($6.25E^{+16}$ seJ.ha-1.year-1 for type III) reflecting the cropping intensity levels observed in the typology. In spite of these differences, all banana production systems in Guadeloupe may be considered as highly dependent of purchased resources, since these represent between 89 and 96% of the total emergy use. When the overall banana production sector is considered, the emergy flow due to purchased resources nears the maximum value of 95%, because cropping systems types III and IV alone respond for 74% of the banana cropped surface. Of the purchased emergy inputs, between 37 and 46% is invested in the process of harvesting, sorting, packing and transporting the harvested products (Subsystem II) which represented an overall average of 39% of emergy flows among cropping systems. From this share, the largest amount is invested as emergy flow in financial resources for buying card boxes for packing. Actually, the card boxes represent the largest single item of emergy inputs for all systems studied except for the type V. Regarding the field operations (Subsystem I), the largest purchased resources are the fertilizers.

The emergy allocated to banana yield in the banana cropping systems in Guadeloupe varied 3.11 times from the lowest value observed of $2.10E^{+16}$ seJ.ha^{-1}.year^{-1} (type V) to $6.52E^{+16}$ seJ.ha^{-1}.year^{-1} for type III, resulting in transformities that showed little variation from $2.36E^{+05}$ to $3.15E^{+05}$ seJ.J^{-1}. As a whole, a total of $1.09E^{+20}$ seJ are assigned to the production of the $8.36E^{+04}$ tons of bananas, of which $7.85E^{+04}$ tons are placed in the market resulting in an overall transformity of $2.89E^{+05}$ seJ.J^{-1}. These transformity values for banana production in Guadeloupe are comparable to the $2.87E^{+05}$ obtained for fruit production (as an average) in Italy (Ulgiati et al., 1993); and the $5.97E^{+05}$ value obtained for tomatoes in Florida (Brandt-Williams, 2002), both representing intensive fruit production systems for which similar processing steps for market insertion can be assumed. By contrast, fruit production systems with much smaller ($7.03E^{+04}$ for oranges in Florida, Brandt-Williams, 2002) or much larger

($5.40E^{+06}$, tomatoes in Sweden, Lagerberg, 2000) transformities are related, respectively, to lesser or greater levels of purchased input flow and productive intensity.

The results obtained for the different economic performance indicators of banana production in Guadeloupe indicate that the sector is able to survive as an economic activity only due to important governmental subsidies. Subsidies account for the totality of net income, while covering all net financial losses, for all cropping system types and farmer classes, and correspond to about 50% of farmers' gross income. Although all cropping system types would show net financial losses without subsidies, losses decrease with increasing investment in technological inputs. Profit rates increase from 4% for type V up to 41% for type III when subsidies are included as gross income. In the same trend, labour productivity increases with increasing input use. Although subjected to a 49% higher labour cost – US$ 83.62 and US$ 56.20 per man day for types III and V, respectively the most intensive farm type III produces about US$ 1.00 of net income for each dollar invested in labour while type V (the less intensive one) produces only US$ 0.08. The large differences observed in the costs per unit of labour (from US$ 50.91 to US$ 86.93) are basically explained by differences in the family workforce engagement, representing the percentage of labour provided by family members, considered costless in the farm budget analysis. Production costs of banana in Guadeloupe is high, varying from US$ 0.60 for type V to US$ 0.71 per kilogram for type I and labour represents the most important single factor in production costs. On average, 48% (varying from 40% for type III to 55% for type V) of the costs to produce each kilogram of banana is expended in labour. This represents an average of US$ 0.31 (from US$ 0.25 for type III to US$ 0.35 for type I) labour expenditure per kilogram of banana exported. The high labour costs may explain the dependency of the banana sector on public subsidy. On average, the market price obtained by the farmers is US$ 0.37 per kilogram of commercialised banana. This value is very close to the US$ 0.31 expended in labour costs alone.

DISCUSSION

Banana production in Guadeloupe is heavily dependent on purchased inputs. The fraction of renewable emergy flow varies from 4.05 to 10.9% according to cropping system type, and an overall average of 5.19% was estimated. Considering only the subsystem I (field operations), the renewable fraction increases to 9%, varying from 6 to 20% depending of the cropping system type. As most input-intensive agricultural systems, banana production in Guadeloupe depends heavily on fossil energy in the form of fertilizers and pesticides. Together, these two kinds of inputs respond to 31 and 43%, respectively, of all emergy flows in subsystem I. In fact, together with water, nutrients are key limiting factors for crop production (Pimentel & Pimentel, 1996) and the application of chemical fertilizers generally results in yield gains. This trend has been clearly observed in this study since a linear relationship between banana yield and emergy inflow through chemical fertilizers has been estimated. However, emergy investment in chemical fertilizers reflects negatively on sustainability, as expressed by the ESI. A similar trend is observed in relation to pesticide inputs. A clear trade-off exists between producers' interest on increased yields and income and the sustainability of their fields. Therefore, innovations in cropping techniques that would enhance nutrient cycling and the control of weeds, pests and diseases through management options such as cover-crops, buffer vegetation zones in the landscape, among others might represent promising

practices to promote an adequate compromise between farmers' economic interests and systems sustainability, in a future scenario of limited access to fossil-origin resources. Farmers of cropping system types V and VI are the less dependent on purchased inputs. The renewable fraction in the subsystem I of these farmers reaches 17 and 20%, respectively. In fact, type V cropping system returns 26% of the invested flow of purchased emergy in the form of renewable resources emergy flow in the field (subsystem I). This rate decreases to 13% when the subsystem II is included, as this subsystem uses only purchased resources. As cropping systems types III and IV are at the same time the most dependent on purchased inputs, and respond to the largest share of banana production in Guadeloupe, the EYR of the overall banana production is as low as only 9 and 6% for subsystem I only, and subsystem II included, respectively.

Large differences were observed in the emergy invested in fuels and lubrificants across all types of cropping systems varying from 0.77 to $5.83E^{+15}$ $seJ.ha^{-1}.year^{-1}$ for types V (and VI) and IV respectively.The use machinery (and fuels) in agricultural production is intended to replace human labour and therefore to increase labour efficiency measured as the amount of harvested product per man day invested. Considering energy invested in work as the sum of energetic flows of human labour plus the energetic flows of fuels, the available energy of the harvested product per unit of energy invested in work increases as the contribution of the human labour in the energy invested in work increases. However, each joule expended on fuels costs US$ $4.31E^{-08}$, while each joule of human labour costs US$ $1.82E^{-05}$ (calculated by the average prices of diesel and labour in Guadeloupe). Hence, for the same quantity of energy used, human labour costs 422 times more than fuels. This result demonstrates that although human labour is more efficient in converting energy into work than machinery, it is financially more interesting for farmers to invest in mechanization because fuel is an energy source much less expensive than labour.

The largest environmental loading ratio (ELR) among all cropping system types was observed in type III. Taking ELR is a measure of the ecosystem stress due to production (Ulgiati and Brown, 1998) - because most purchased resources cause environmental degradation during their production, use and environmental assimilation (Martin et al, 2006) - the global environmental impact caused by cropping system type III is 4 times higher than that observed for type V. As the larger ELR are observed among the cropping system types that correspond to the larger surfaces of production in Guadeloupe, the ELR of banana production in this island is 18.28, which is higher than the ELR observed for the French economy, estimated as 5.19 (SAHEL, 2008). This clear unbalance between the amount of non-renewable (including purchased) and renewable resources for banana production, with strong dependence on purchased resources, reflects an important degree of potential environmental stress. In general, the processes of harvesting, sorting, packing and transporting contribute to nearly 40% of the total emergy of banana production, varying from 38 to 45% according to cropping system type. Of this share, the highest contribution comes from the card boxes used to pack the product which, alone, respond to about half of emergy used in the subsystem II. As these boxes are a one-way use material, substantial improvements in the sustainability of the banana production in Guadeloupe could be achieved by replacing them by more durable ones that could be used several times. All banana exports from Guadeloupe have the European Community as destination. There, quality standards for bananas are normalized. This

regulation impacts strongly on the sustainability of banana production. For instance, established quality standards for bananas rely basically on aesthetic aspects of the product, and most of the discarded bananas have the same organoleptic and nutritive characteristics as the marketed ones. Comparing the emergy-net income ratio (ENR) and the rate of discarded bananas, it is possible to realize that the economic sustainability of farmers would be improved in direct proportion with the marketed production. Therefore, an acceptance for a product with the same nutritional and taste qualities but with aesthetic characteristics slightly out of the standards would represent a step towards sustainability of the sector. Furthermore, substantial non-renewable and purchased emergy inflows in banana production aim at increasing the compliance with aesthetic quality regulations and not necessarily improve productive efficiency.

Banana production in Guadeloupe depends on EU subsidies to remain in business (Frémeaux, 2003). Alone, the activity consumes 70% of all public subsidies paid to agricultural production in Guadeloupe, which is disproportional with spatial and economic weight in the region (Chia and Dulcire, 2005). On average, production costs are 81% (varying from 34% for cropping system type III to 145% for type V) higher than returns paid by the market, and this difference is been covered by public subsidies. This dependency on the EU agricultural income policy may be explained by the high costs of production. While the average banana production costs amount to around US$ 0.17 per kg in Costa Rica, US$ 0.16 in Equator, and US$ 0.20 in Colombia (Paggi and Spreen, 2003), the cost in Guadeloupe was estimated as US$ 0.65 per kg in the present study (average of all cropping system types), close to the US$ 0.67 per kg reported by Paggi and Spreen (2003) for Martinique, another French overseas department. The key factor explaining this much higher production costs in Guadeloupe seems to be the high cost of labour. Actually, labour costs in Guadeloupe represent 48% of the total costs of banana production on the average of all cropping system types (varying from 40% for type III to 55% for type V) while in Costa Rica it represents 28%, in Equator 31% and in Colombia 39% (calculated from Little, 2000). Additionally, while each kg of banana produced in Guadeloupe needs an average investment of US$ 0.31 in labour, only US$ 0.05 is necessary in Costa Rica and Equator, and US$ 0.08 in Colombia (calculated from Little, 2000). Therefore, to increase profits (including subsidies), farmers should increase the productivity of labour. The higher the investment in external inputs, the higher the profit and the productivity of labour. Hence, following the current agricultural model adopted by Guadeloupean banana growers, improvements in economic performances depend on the rate of investment in external inputs. However, Pimentel and Giampietro (1994) stated that though human-made technological capital such as fertilizers, pesticides, and irrigation may be used to substitute for natural capital to increase yields, as well as to substitute for human labour to increase labour productivity; the heavier use of technological inputs causes environmental damage and push energy flows through the agroecosystems to unsustainable levels (Gianpietro et al., 1992a,b). Increasing the investment in external inputs increases yields, profits and labour productivity but, at the same time, it reduces FR (fraction renewable) and ESI while increasing ELR. As a general rule, the better the economic performance of banana production in Guadeloupe, the worse is the environmental performance. This result is most probably due to the fact that though differing in the amount of purchased inputs, all cropping system types follow the same intensive and arguably wasteful agricultural model. This approach is being

presently strongly criticized due to its reliance on non-renewable resources. Therefore, the improvement of sustainability of banana production in Guadeloupe will depend on a change of the agricultural model used, shifting from a high fossil input model to a natural resources intensive one that enhances the contribution of local renewable resources.

Several initiatives are on-going elsewhere to endorse the adoption of environmentally friend cropping systems for banana and other crops. However, such efforts are still not in the banana production agenda in Guadeloupe. In order to promote such change in the agricultural model, innovative cropping systems with environmentally sound practices have to be developed and the innovations adopted by the farmers. Innovation adoption, however, will depend on their financial attractiveness. This represents an opportunity to reorient current European agricultural income support policies and may lead to a system of subsidies based on environmental performance, and hence decoupled from agricultural commodity production levels, albeit likely to reward most of the same farm political constituency (Zinn, 2005; Swinton et al., 2006).

CONCLUSION

As emergy analysis quantify natural and man-made, as well as renewable and non-renewable inputs to agricultural systems on a common basis, it helps comparison across different cropping systems and allows the identification of the critical elements to be improved in order to achieve greater sustainability. In the present case, emergy indices show that banana production in Guadeloupe has very low environmental performance and that, as a general rule, increases in environmental performances would imply decreases in yields, profits and labour productivity. The most probable reason is that the six different types of banana cropping systems identified in Guadeloupe, represent simply a gradient in the use of purchased inputs following the same intensive model. This model prises the augmentation of land and work productivity by the use man-made technologies in the form of fertilizers, pesticides, machinery, and other purchased resources associated to financial investment and potential environmental damage, due to reliance on non-renewable resources. Therefore, innovative production systems based on ecologically intensive cropping techniques are necessary to improve the sustainability of banana production in Guadeloupe. The emergy analysis of the different banana cropping system types highlighted several points were environmentally sound innovations would effect most positive and significant impacts. First, fertilizers and pesticides alone are responsible for 74% of all emergy flows in the field operations and therefore, cropping techniques aiming to enhance nutrient cycling; and weeds, pests and diseases integrated management should be regarded as priorities. Second, although field practices are more frequently emphasized and criticised, the processes of sorting, packing and transporting represent 40% of the total emergy in the banana production system. The one-way card boxes used to pack the product correspond to near half the emergy used and, hence, improvements in the material used for packing bananas may have significant positive impacts on overall sustainability. And last, the EC regulation on quality standard for commercial bananas, by imposing strict aesthetic benchmarks, have a negative effect on the sustainability of banana production because substantial non-renewable and purchased emergy inflows into banana production systems aim to improve aesthetic standards over sound ecological management. Besides, an acceptance for a product with the same nutritional and taste qualities but with aesthetic characteristics slightly out of the

established standards would increase the ENR and therefore the financial profit of farmers. The economic analysis shows that, under the current agricultural model, increasing investment in external inputs would lead to increased profit and labour productivity. Nevertheless, the sector depends heavily on EU subsidies. This dependency stems from higher production costs, mostly related to high labour costs. Agricultural subsidies aim to promote equity in income levels between agriculture and other sectors of the French society and are therefore a political instrument for the country's and for Europe's social cohesion. However, as subsidy is coupled with banana production levels, it encourages farmers to intensify their cropping systems in order to increase yields. This intensification, however, brings potential environmental damage. Therefore, a reorientation of the European agricultural income support policies towards a system of subsidies based on environmental performance would be an opportunity to enhance the adoption of ecologically intensive agricultural innovations, while warranting and reinforcing their economic and social goals.

REFERENCES

Arias, P.; Dankers, C.; Liu, P.; Pilkauskas, P., 2003. The World Banana Economy, 1985-2002. FAO Commodity Studies 1. FAO, Rome, 97 pp.

Blazy, J.M.; Peregrine, D.; Diman, J.-L.; Causeret, F., 2008. *Ex ante* assessment of banana farmers' room for manoeuvre for adopting agro-ecological innovations in Guadeloupe: a functional and typological approach. In: Proceedings of the 8th European IFSA Symposium, Workshop 3 "Adaptive farming systems". (In press)

Bonan, H.; Prim, J.L., 2001. Rapport sur la presence des pesticides dans les eaux de consommation humaine en Gudeloupe. Rapport N° 2001-070. Ministère de l'Aménagement du Territoire et de l'Environnement, Ministère de l'Emploi et de la Solidarité. Paris.

Brandt-Williams, S.L., 2002. Folio #4. Emergy of Florida Agriculture. Handbook of Emergy Evaluation. A Compendium of Data for Emergy Computation Issued in a Series of Folios. Center for Environmental Policy. University of Florida. Gainesville, FL. Brown, L., 1993. A new era unfolds. In: L. Brown et al. (Eds.), State of the World 1993, pp. 3-21. W.W. Norton & Company, New York.

Brown, M.T.; Ulgiati, S., 2004a. Energy quality, emergy, and transformity: H.T. Odum's contributions to quantifying and understanding systems. Ecol. Model. 178:201-213.

Brown, M.T.; Ulgiati, S., 2004b. Emergy analysis and environmental accounting. Encyclopedia energy 2:329-354.

Campbell, D., 1998. Emergy analysis of human carrying capacity and regional sustainability: an example using the state of Maine. Environ. Monit. Assess. 51:631-659.

Clermont-Dauphin C., Cabidoche YM., Meynard JM., 2004. Effects of intensive monocropping of bananas on properties of volcanic soils in the uplands of the French West Indies . Soil Use and Management 20:105-113

Dulcire M., Cattan P., 2002. Monoculture d'exportation et développement agricole durable : cas de la banane en Guadeloupe. Cahiers Agricultures, 11, 313-321

FAO, 2003a. Banana projections to 2010. Committee on Commodity Problems. Intergovernamental Group on Bananas and on Tropical Fruits. Third Section, Puerto de la Cruz, Spain. 11-15 December. FAO. Rome.

FAO. 2008. FAOSTAT database (PRODSTAT/Crops). http://faostat.fao.org/. (Accessed on14/03/2008).

Frémeaux P., 2003. Guadeloupe en progrès, mais peut mieux faire. Alternatives économiques, 215, 33-35.

Giampietro, M., Cerretelli, G. and Pimentel, D., 1992a. Energy analysis of agricultural ecosystem management: human return and sustainability. Agriculture, Ecosystems and Environment 38: 219-244.

Giampietro, M., Cerretelli, G. and Pimentel, D., 1992b. Assessment of different agricultural production practices. Ambio 21(7): 451-459.

Heuze, S. 2005. Hydrological behaviour of banana crops on a tropical: estimation of the properties of an andosol and identification of the water processes at local scale. M.Sc. Dissertation. Cranfield University, Silsoe (GBR), 72 pp. Available at: http://hdl.handle.net/1826/1294 (Accessed on14/03/2008)

INSEE, 2001. Tableaux Economiques de la Guadeloupe. Pointe à Pitre

Lefroy, E.; Rydberg, T., 2003. Emergy evaluation of three cropping systems in southwestern Australia. Ecol. Model. 161:195-211.

Little, V., 2000. Towards a Competitive Banana Industry in the Caribbean. Comuniica on-line. Year 4 Nr. 14. Available at: http://webiica.iica.ac.cr/comuniica/n_14/english/art.asp?art=5 (Accessed on 12/03/2008)

Martin, J.F.; Diemont, S.A.W.; Powell, E.; Stanton, M.; Levy-Tacher, S., 2006. Emergy evaluation of the performance and sustainability of three agricultural systems with different scales and management. Agri., Ecos. Environ. 115:128-140.

Odum, H.T., 1996. Environmental Accounting: Energy and Environmental Decision Making. John Wiley and Sons Inc., New York.

Odum, H.T., 1998. Suggestion for a project for the International Society for Ecological Modelling: Representing simulation models with energy systems (pp. 1–11). In: Ecomod, Newsletter of International Society for Ecological Modelling, December 1998.

Paggi, M.; Spreen, T., 2003. Overview of the world banana market. In: Josling, T. E.; Taylor, T.G. (Eds). Banana Wars: The Anathomy of a Trade Dispute. CABI Publishing. 240 p.

Panzieri, M.; Marchettini, N., Bastianoni, S., 2002. A thermodynamic methodology to assess how different cultivation methods affect sustainability of agricultural systems. Int. J. Sustain. Dev. World Ecol. 9:1-8.

Perret, S.; Dorel, M., 1999. Relationship between land use, fertility and Andisol behaviour: examples from volcanic islands. Soil Use and Management 15: 144-149.

Pimentel, D.; Giampietro, M., 1994. Food, land, population and the U.S. economy. Carrying Capacity Network. Available at http://dieoff.org/page40.htm (Accessed on 12/03/2008)

Rydberg, T.; Jansen, J., 2002. Comparison of horse and tractor traction using emergy analysis. Ecol. Eng. 19:13-28.

SAHEL., 2008. Environmental Accounting and Systems Synthesis of Land Management Interventions at Multiple Scales in the Sahel Region of West Africa/ Database Resource./ France, 2000/ Table 2. At: http://sahel.ees.ufl.edu/ (Acessed on 28/01/2008).

Ulgiati, S.; Brown, M.T., 1998. Monitoring patterns of sustainability in natural and man-made ecosystems. Ecol. Model. 108:23-36.

Ulgiati, S.; Odum, H. T.; Bastianoni, S. 1993. Emergy analysis of Italian agricultural system. The role of energy quality and environmental inputs. *In*: Bonati, L.; Consentino, U.; Lasagni, M.; Moro, G.; Pitea, D.; Schiraldi, A., (eds). Second International Workshop on Ecological Physical Chemistry, Milan. p. 187-215.

Ulgiati, S.; Odum, H.T.; Bastianoni, S., 1994. Emergy use, environmental loading and sustainability. An emergy analysis of Italy. Ecol. Model. 73:215-268.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):461. 2008

Poster #30

Banana Sector in the French West Indies (FWI) in the 21st Century: Typology of Farmers' Room for Manoeuvre in Adapting their Cropping Systems to Crisis

Jean-Marc Blazy, M.Sc.; Jean-Louis Diman, M.Sc.; François Causeret; Danny Peregrine, M.Sc. INRA UR agropédoclimatique, Domaine Duclos, 97170 Petit-Bourg, Guadeloupe (FWI). diman@antilles.inra.fr

ABSTRACT.
Production of bananas for export in the French West Indies is passing through a severe economic and environmental crisis. To help farmers in adapting their cropping systems to cope with these new constraints, local agronomic research is focusing on different innovative agro-management techniques. To improve the adoption of innovations, room for manoeuvre of farmers in adapting their cropping system had to be taken into account early in the innovation conception process. The objective of this paper is to present the construction of a farm typology which models the diversity of banana cropping systems management on a regional scale. Indicators were chosen with the help of a conceptual generic model of farmers' decision making. Data for typology elaboration was collected through interviews with a significant sample of farmers. The typology has been built by combining principal component analysis (PCA) and Agglomerative Hierarchical Clustering (AHC). Correspondence analysis (CA) and analysis of variance analysis (ANOVA) treatments were used to validate the pertinence of the final typology. Six different types of farm were found with a wide range in room for manoeuvre. While some types present high flexibility in terms of work resources reallocation due to the familial and non declared nature of workers, they are highly constrained by low financial margins, cash flow and land availability. The latter could include, for example, a strong limitation for the adoption of improved fallow. On the other hand, some types present high rooms for financial manoeuvre in terms of land use reallocation and financial resources mobilization. However, the latter type has no capacity for managing a temporary decrease in work demand because their manpower is abundant, mainly full-time established and contracted due to the importance of the scope of farm production. Finally, this paper discusses how such kind of study can improve the adoption of innovations through the early integration of farmer's room for manoeuvre as a framework of constraints into the innovation conception process.

KEYWORDS: banana sector; farmer's decision; typology; cropping systems; innovation

2008 Proceedings of the Caribbean Food Crops Society. 44(2):462. 2008

Poster #31

Village du Millénaire : Expérience d'Haïti

Ronald Bien-aimé. Project Medishare, University of Miami
bronald75@yahoo.es

RÉSUMÉ

L'Université de Miami de concert avec l'Université de Floride met en œuvre le premier Village du Millénaire dans le Nouveau Monde. Ce projet assiste la Section communale de Marmont dans le Plateau Central pour qu'Haïti atteigne sûrement les objectives 2015 des Nations Unies en lui fournissant des services de base (santé, agriculture et développement communautaire). L'UF a conçu un stimulant programme d'agriculture et d'environnement (janvier 2008), prenant en compte la réalité du pays, pour accroître la production, transformer les surplus, fournir des services de vulgarisation et nourrir 16,000 âmes. Engager la nouvelle génération a prouvé être une puissante stratégie de communication et est pensé comme étant plus durable dans le moyen et long terme en ce qui concerne la production agro-écologique.

Le Village est aussi un modèle de développement local qui présente les principales caractéristiques suivantes:

a- L'approche est centrée sur les gens. Elle les place au cœur du développement, les fait participer de façon active et effective, considérant qu'elle les aide et les accompagne à atteindre leurs propres objectifs de développement.

b- L'approche est holistique. Elle reconnait l'effet d'influences multiples sur les gens, la présence ou l'apport d'acteurs divers (Gouvernement, ONG, entreprises privées et publiques, organisations de base), l'adoption de stratégies variées par les individus pour s'assurer des moyens d'existence durables.

c- L'approche est dynamique. Elle met à profit les leçons apprises de manière à renforcer les tendances évolutives positives et à contribuer à réduire les négatives.

d- L'approche renforce les qualités. Elle priorise les qualités aux besoins. Elle se propose d'aider les gens à devenir plus résistants, plus forts, mieux préparés et mieux capables d'atteindre leurs propres objectifs.

e- Le modèle prône une approche multidisciplinaire, interinstitutionnelle et intersectorielle.

f- Le développement du modèle s'appuie sur l'utilisation et l'exploitation des ressources humaines et environnementales disponibles localement.

En somme, le Village du Millénaire repose sur la base stratégique de la réduction de la pauvreté pour l'amélioration des conditions de vie de la population de Marmont.

MOTS CLÉ: développement holistique, Village du Millénaire, Haïti

2008 Proceedings of the Caribbean Food Crops Society. 44(2):463-472. 2008

Poster #32

Effects of Palm Kernel Cake on Daily Gain and Carcass Yield of Broiler Chicks; Efecto de la Sustitución de Palmiste por Maíz en la Dieta de Pollo Engorde Sobre la Ganancia Diaria y el Rendimiento de Canal

Neirin Matos, Rosina Polanco, Carlos M. De Jesús[1], and Rafael A. Vásquez[2]*
Department of Animal Science[1]; Facultad de Ciencias Agroalimentarias y del Ambiente[2]; Universidad ISA; Ave. Antonio Guzmán Fernández, Km 51/2, La Herradura, Santiago, Dominican Republic. cdejesus@isa.edu.do

ABSTRACT.
Corn and soybean meal, used in the diet of broiler chickens are expensive and they are imported commodities in the Dominican Republic. Therefore, feeding alternatives to these ingredients are needed in this country. Palm kernel cake (PKC) has shown to improved body weight and feed conversion of chickens, pig and cattle. However, it has not been evaluated in the Dominican Republic conditions. The objective of this study was to evaluate the effect of PKC on broiler performance and carcass yield at 43 days of age. Two separate trials were conducted using a total of 200 chicks per trial and the results were combined for the statistic analysis. These chicks were randomly distributed in five treatment groups (40 chicks/treatment group/trial). The treatment groups include a normal corn-soybean meal diet, which met or exceeded the nutritional requirements of NRC, 1994 or the same diet with 6%, 12%, 24% and 30% of PKC. Chickens were weighted weekly and the feed intake was registered daily. The feed intake for the whole period of the experiment (43 days) was significant higher at 6%, (3.04 ± 0.18 kg) 12% (3.38 ± 0.18 kg), 24% (3.63 ± 0.18 kg) and 30% (3.60 ± 0.18 kg) compared to PKC control diet (2.42 ± 0.18 kg). The PKC treatments increased the daily weight gain (56.40 ± 1.06 g/d (from day 0 to 43) at 12 % compared to 0% (44.75 ± 1.06 g/d). The feed efficiency was improved at 6% PKC (79.34 ± 1.40) compared to 30% (62.14 ± 1.39). Carcass yield was not affected by the PKC levels. The data of the present study suggest that the addition of PKC in the diet of chicken may substitute the corn without affecting chicken performance; moreover, PKC may represent an alternative to reduce the cost in the poultry industry

KEYWORDS: Chicken, palm kernel cake, daily gain

INTRODUCCION

La producción de pollos en la República Dominicana, ha mostrado un crecimiento importante en los últimos años y es fácil entender el motivo, la cría de pollos no tiene restricciones u objeciones religiosas en cuanto a su consumo, cuenta con bajos niveles de colesterol y es rápida su producción, cualidades importantes para satisfacer al consumidor moderno. Así mismo, este auge se evidencia en las siguientes cifras: para el año 2005 se

produjeron 296,642 TM de carne de pollo, (Cabrera, 2006), representando un consumo per cápita entre 29.5 a 34 kg /año, lo que explica la importancia de este rubro en la economía del país y como fuente de proteína en la dieta del dominicano, (Oficina de la Presidencia, 2005).

La alimentación de los pollos de engorde juega un papel muy significativo en la sustentabilidad del sector avícola, ya que la contribución de la alimentación en el costo total de producción se ubica entre 70 y 80% (León *et al*, 1991). Tomando esto en consideración podría ser el momento oportuno para dinamizar el sector agropecuario mediante cambios profundos de las prácticas tradicionales, ya que la explotación avícola está relacionada con la utilización de alta tecnología y el uso de cereales y soya, teniendo una influencia directa en el factor económico, debido a que la adquisición de estas materias se encuentran sujeta al constante cambio monetario de la tasa del dólar y a las políticas de importación que rigen para cada país.

El uso de materiales regionales de bajo costo se convierte en una de las opciones más recomendadas, una alternativa de subproducto agroindustrial lo constituye el palmiste, material obtenido de la extracción mecánica de aceite de la nuez de la palma africana (*Elaeis guineensis*) con niveles de energía metabolizable de 2,198 Kcal. Kg.; 15.6% de proteína cruda, 0.27% de calcio y 0.61% de fósforo, lo que permite definirlo como un producto de alto potencial nutricional (Vargas y Zumbado, 2003), para sustituir los ingredientes principales en la dieta de pollos.

En ese sentido se han llevado a cabo varias investigaciones en el país utilizando este subproducto agroindustrial en monogástricos y rumiantes, sin embargo, aun no existen publicaciones nacionales en donde se haya estudiado el uso del palmiste en la alimentación aviar. Aunque, en el caso de cerdos en etapa de desarrollo y engorde, específicamente estudios realizados en la universidad de Costa Rica en 1992 no recomiendan incluir más de 10% en la dieta y en la alimentación de cerdas gestante se permite un máximo de un 20% (Campabadal y Navarro, 2002), mientras, en pollos de engorde y pollas ponedoras la incorporación de un 15% no afectó los parámetros zootécnicos de los animales (Vilariño *et al*, 1996).

Consecuentemente otros ensayos realizados por Zumbado *et al,* 1992, indican que la inclusión entre 10 y 12 % de palmiste en dietas de pollos de engorde mejoró significativamente la ganancia de peso y la conversión alimenticia de los animales, demostrando ser una excelente alternativa como fuente de energía. De igual forma, Marín (1987) y Chavarria (1987) citados por (Zumbado y Jackson, 1996) encontraron que era factible utilizar hasta 20% de palmiste sin afectar el rendimiento de pollos de engorde durante los primeros 28 días de edad, siendo evidente la importancia que tiene este subproducto como ingrediente alternativo en la alimentación avícola. Por lo tanto se plantea un estudio para evaluar la inclusión de cinco niveles de palmiste en dietas de pollo de engorde.

MATERIALES Y METODOS

Animales y corrales

400 pollos de ambos sexos de la Línea Cobb 500 de un día de edad fueron distribuidos en los distintos tratamientos. Se recibieron dos repeticiones de 200 pollos bebe, los cuales se provinieron de un mismo lote de gallinas reproductoras. Los períodos

de las repeticiones fueron 13 Julio al 24 Agosto y 11 Septiembre al 24 de Octubre del 2007. Las aves fueron alojadas en una nave experimental con dirección Este-Oeste, se construyeron 10 corrales de 1.0 Pie^2/animal con una capacidad para 20 pollos. Cada pollo se identifico con una cinta en la pata acorde con el tratamiento y la repetición.

Diseño experimental

Se utilizó un diseño completamente al azar (DCA) con cinco tratamientos y cuatros repeticiones, cada tratamiento tuvo 20 pollos por repetición. Se realizaron dos repeticiones en tiempo con el objetivo de incrementar el número de animales por tratamiento y debido a las limitaciones de las facilidades del área experimental que sólo permitía tener dos repeticiones por tratamiento.

El modelo estadístico que se utilizó para analizar la variación entre los tratamientos y el error fue el siguiente:

$$Yij = \mu + P_i + Eij$$

Donde:

Yij = Valor observado de la variable A.
μ = Media general.
P_i = Efecto de los niveles de palmiste (0, 6,12, 24 y 30%)
Eij = Efecto del error experimental

Las variables estimadas y calculadas en los distintos tratamientos fueron: Consumo del alimento diario (g), Ganancia diaria de peso de los pollos (g), Conversión alimenticia (%), Rendimiento de la canal (%) y la Relación Beneficio \ Costo .

Tratamientos

Los tratamientos consistieron en la inclusión de cinco (0, 6, 12, 24 y 30%) niveles de palmiste en dietas de pollo de engorde. La dieta estuvo constituida por mezcla de maíz, soya, premezcla de vitaminas y minerales, aditivos y el nivel de inclusión de palmiste. Todos los tratamientos estuvieron en iguales condiciones ambientales y de manejo.

Los tratamientos consistieron en la inclusión de los siguiente niveles de palmiste:$\mathbf{T_0}$=Testigo, 0% de palmiste;.$\mathbf{T_6}$= 6% de palmiste; $\mathbf{T_{12}}$=12% de palmiste; $\mathbf{T_{24}}$=24% de palmiste; $\mathbf{T_{30}}$=30% de palmiste.

Manejo del Experimento

Se utilizó un programa de alimentación basado en tres etapas fisiológicas de acuerdo a los días de vida: 0 - 3 semanas, etapa inicial, 3 - 6 semanas etapa de crecimiento, 6 - 7 semana etapa de engorde o finalización. El agua y el alimento fue suministrado a voluntad, con el objetivo de que los pollos siempre tuvieran alimento y agua disponible.La composición de las dietas en las fases de inicio, crecimiento y finalización se formularon según a los requerimientos de la NRC, 1994 de energía metabolizable, proteína, macro y microminerales y vitaminas en las distintas etapas de desarrollo y la guía de manejo Coob-Vantress Inc.,1994.

Una semana antes de la llegada de los pollitos la nave fue lavada y desinfectada con la aplicación de creolina, yodo y cal viva, luego se cubrió el piso con cascarilla de arroz hasta formar una capa de aproximadamente 5 cm de espesor. El galpón fue protegido con cortinas para contrarrestar las corrientes de aire e impedir la entrada de la lluvia y con esto proteger a los pollitos a cambios de temperatura. A partir de los 8 días se subieron las cortinas en el día y se bajaron en la noche hasta los 15 días, luego se dejaron subida todo el tiempo y sólo se bajaron en caso de lluvia o vientos fuertes.

Se utilizaron calentadores a base de gas, los cuales se encendieron una hora antes de la llegada de los pollitos y se utilizaron para mantener la temperatura constante dentro de la nave, hasta los 8 días de instalado el experimento. Además se instalaron comederos de tolvas a razón de uno por cada 20 pollos hasta el día 10 donde fueron sustituidos por comederos de tubo. Se utilizaron bebederos de galón uno por cada 20 pollos, hasta los 8 días siendo reemplazados por bebederos de campana.

A la llegada de los pollitos se preparó una solución anti estrés disolviendo un sobre de vitaminas con electrolitos (227 g/ 700 gl de agua), durante el día 1 para hidratar y suministrar energía a los pollitos y disminuir el estrés causado durante el transporte desde la incubadora hasta la granja. En los primeros tres días de iniciado el experimento se inspeccionaba constantemente el funcionamiento de las calentadoras, la temperatura debajo de estas y el efecto de la misma en el comportamiento de los animales.

Desde el inicio del estudio se aplicó un programa de vacuna oral preventiva contra las enfermedades de Newcastle, Gumboro y Bronquitis según las instrucciones de los laboratorios fabricantes. Frecuentemente fue lavado y desinfectado el tinaco destinado para el abastecimiento del agua, una vez higienizado y llenado de nuevo se le aplicaba cloro (0.01%) al agua de bebida.

Durante toda la fase experimental, los comederos se movieron constantemente para estimular el consumo de los animales, se suministró alimento a tiempo y en cantidad suficiente. Los bebederos se higienizaban dos veces al día con yodo, se mantuvo buena ventilación e higiene tanto dentro como fuera de la granja.

Análisis de Datos

Los datos recolectados en las variables evaluadas fueron sometidos a un análisis de varianza usando el cuadrado mínimo del modelo lineal general (GLM) con el programa estadístico SAS™ 8.1 Inc. Si hubo diferencias significativas las medias fueron sometidas al análisis de separación de medias de Tukey a un nivel de confiabilidad de 95%.(Cody y Smith ,1997).

RESULTADOS Y DISCUSION

Consumo

El consumo de alimento durante el periodo de iniciación 0-21 días (grafica1) fue significativamente ($P>0.05$) mayor en los niveles 24 y 30% del palmiste, con un consumo de 1.01 ±0.06 kg y 1.13 ±0.06 kg comparado con el tratamiento sin palmiste, en el cual el consumo de alimento fue de 0.76±0.06 kg . El consumo obtenido en este estudio en la etapa de iniciación de (0-21 d) es superior a los reportados por Peña y Guerrero (1996) al evaluar el efecto de la inclusión de harina de semillas de palma real de

0, 5, 10, 15 y 20% como fuente energética en la alimentación de pollos de engorde (0.520, 0.720, 0.583, 0.764 y 0.809 kg).

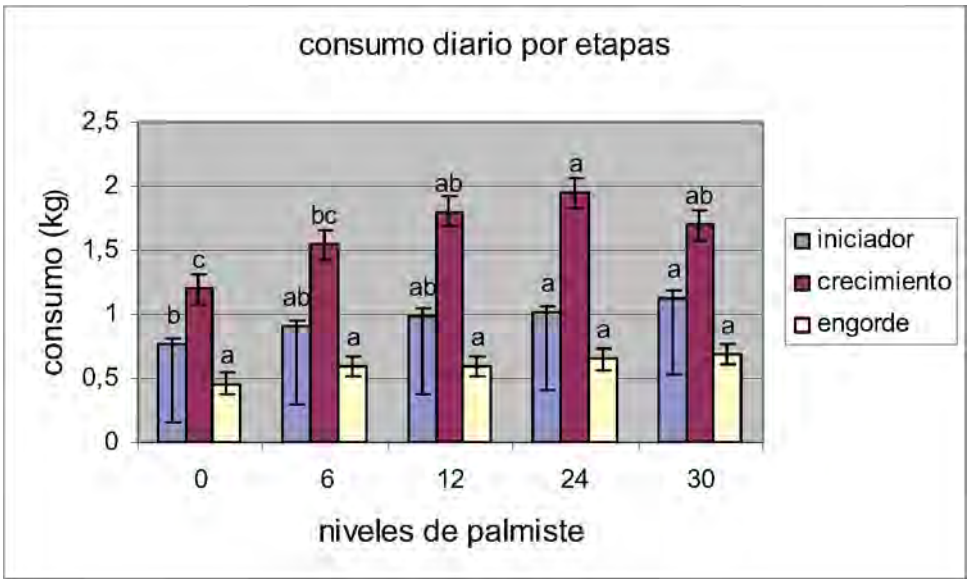


Figura 1 Efecto de los niveles de palmiste en el consumo de pollo de engorde

En cuanto al consumo total durante la etapa de crecimiento 22-35 días (grafica 1) existen diferencias significativas (P>0.05) entre los niveles 12, 24 y 30% que obtuvieron consumos de 1.80 ± 0.12, 1.95 ± 0.12 y 1.77 ± 0.12 kg con relación al nivel 0% que obtuvo un consumo de 1.20 ± 0.12 kg de alimento. Estos resultados coinciden con los reportados por Zumbado (1992) quien evaluaba el efecto de la composición de palmiste en pollos de engorde (0, 5, 10,15 y 20%) hasta los 28 días.

En la etapa de engorde (grafica 1) se puede observar que los animales no mostraron diferencias significativas(P>0.05) en cuanto al consumo de alimentos, sin embargo, en el consumo promedio total del experimento (0-43 días) se encontraron diferencias (P>0.05) estadísticamente superiores entre los niveles con palmiste, los cuales presentan consumos de 3.04 ± 0.18, 3.34 ± 0.18, 3.63 ± 0.18 y 3.6 ± 0.18 kg, respectivamente, con relación al nivel 0% de palmiste, el cual mostró un consumo total de 2.43 ± 0.18 kg. Al comparar estos resultados son superiores con los obtenidos por Belliar y Ropceau (1996) quienes evaluaron la inclusión de diferentes niveles de harina de guineo de rechazo como fuente de energía en la alimentación de pollos de engorde.

Ganancia Diaria

En lo referente a la ganancia diaria total durante la etapa de iniciador (0-21 días) (tabla 1) existen diferencias significativas (P>0.05) entre los niveles 0 y 6% los cuales presentan ganancia de 72.95 y 73.83 g en comparación con los niveles 24 y 30% que obtuvieron ganancia de 77.23 y 78.27 g con relación al nivel 12% que muestra 83.91 g de ganancia.

Tabla 1. Efectos del palmiste sobre la ganancia diaria en pollo de Engorde

Ganancia (g)	**iveles de inclusión de Palmiste %**				
	0	**6**	**12**	**24**	**30**
Sem 1	14.04 ± 0.39c	15.76 ± 0.39b	18.84 ± 0.39a	16.26 ± 0.39b	17.92 ± 0.39a
Sem 2	25.23 ± 0.94c	32.01 ± 0.94b	37.03 ± 0.94a	34.31 ± 0.94b	33.44 ± 0.94b
Sem 3	41.03 ± 1.74c	54.54 ± 1.74b	66.71 ± 1.74a	57.21 ± 1.74b	54.23 ± 1.74b
Total iniciador	72.95±1.166c	73.83±1.166c	83.91 ±1.16a	77.23 ±1.15b	78.27± 1.15b
Sem 4	54.13±2.43c	73.59± 2.43 a	64.30± 2.43 b	72.48± 2.43 a	65.17±2.43b
Sem 5	65.97±2.58b	74.35± 2.58 a	76.29± 2.58 a	73.16± 2.58 a	79.24±2.58a
Total crecimiento	129.79±1.75ab	125.95±1.75b	134.76±1.78a	129.56±1.75ab	130.03±1.75ab
Sem 6	67.04±2.53c	75.08±2.53ab	73.67± 2.53bc	81.36± 2.53a	70.92±2.53bc
Total engorde	60.07±2.022c	70.26±1.99b	73.91±2.021ab	78.44±1.99a	73.15±1.99ab
G/D Total	44.75 ± 1.06b	54.04 ± 1.06 a	56.40 ± 1.06a	55.99 ± 1.06 a	53.49 ± 1.06a

Nota: Letras diferentes en filas presentan diferencias significativas (P≤0.05), entre las medias (± error estándar)

En cuanto a la ganancia diaria total durante la etapa de crecimiento (22-35 días) (tabla 1) existen diferencias significativas (P>0.05) entre el nivel 6% que presenta una ganancia de 125.95 g con relación al 12% que muestra 134.76 g de ganancia de peso, por lo que al comparar estos resultados con los reportado por Zumbado (1992) quien evaluaba el efecto de la composición de palmiste en pollos de engorde (0, 5,10,15 y 20%) hasta los 28 días muestran mayores ganancia de peso a medida que se aumentaron los niveles de palmiste (864 g/d).

En la ganancia diaria total durante la etapa de engorde (35-43 días) (tabla 1) muestran diferencias significativas (P>0.05) el nivel 6% que presenta una ganancia 70.26 g con relación al 24% que obtuvo 78.44g de ganancia de peso respectivamente, asimismo, se observan diferencias significativas entre los niveles 6, 12,24 y 30 % con relación al nivel 0 % de palmiste que muestra una ganancia de 60.07g de peso.

Como se puede observar en la ganancia diaria total del experimento (0 – 43 días) (tabla 1) muestran diferencia estadísticamente superiores en los niveles 6, 12, 24, 30%, los cuales presentan ganancia de 54.04g, 56.40g, 55.99g y 53.49g con relación al nivel

0% de Palmiste, el cual mostró una ganancia de 44.75 ± 1.06 g. y semejanza a un estudio hecho por Sundu y Dingle (2004) sobre el uso de una enzima para mejorar el valor nutritivo de la dieta con palma y copra en pollos quienes reportaron diferencias significativas en la ganancia de peso diaria y obtuvieron por ende un peso de 621.9±22 g mayor que en este experimento.

Eficiencia Alimenticia

En la eficiencia alimenticia (tabla 2) Los niveles 6 y 12% no difieren del control, sin embargo, se presenta diferencias estadísticas en los tratamientos 24 y 30% comparado con el tratamiento control 0% y el 6%.

Tabla 2. Efecto del palmiste sobre la eficiencia alimenticia en pollo de engorde

Niveles de inclusión de palmiste	Eficiencia Alimenticia
0%	75.92 ±1.40a
6%	79.34±1.40a
12%	70.55±1.41ab
24%	65.13±1.39b
30%	62.14±1.39b

Nota: Letras diferentes en filas presentan diferencias significativas (P≤0.05), entre las medias (± error estándar)

Rendimiento de canal

Los pesos vivos (tabla 3) fueron estadísticamente superiores en los niveles 6,12,24 y 30% los cuales obtuvieron pesos de 2566.6, 2629.5, 2652.2 y 2652.5 g en comparación al nivel 0% de palmiste que alcanzó 2250.0 g de peso. De igual forma para la canal caliente (tabla4) presentan diferencias significativas (P>0.05) los tratamientos con palmiste quienes consiguieron 1920.8g, 1970g, 1922.08g, 1957.5g de peso con relación al nivel 0% que obtuvo 1662.5g de peso. Mientras que para el rendimiento de la canal (tabla 4), no se aprecian diferencias significativas (P>0.05) entre los tratamientos. Con relación a la grasa abdominal se presentan diferencias significativas (P>0.05) el nivel 0% que presenta un peso de 20.03 g con relación a los niveles 12 y 24% los cuales muestran 31.63 y 30.53 g de peso.

Tabla 3. Características de la canal de cabritos mestizos estabulados.

Descripción	Niveles de inclusión de palmiste %				
	0	**6**	**12**	**24**	**30**
Peso vivo(g)	2250.0±81.1 b	2566.6±81.1 a	2629.5±81.1a	2652.5 ±81.1a	2652.5±81.1a
Canal cal.(g)	1662.5±70.9 b	1920.8±70.9 a	1970.0±70.9a	1922.08±70.9a	1957.5±70.9a
Rend. en canal(%)	73.575±1.61 a	75.073±1.61a	75.221±1.6a	72.415±1.61 a	73.809±1.61 a
Grasa abd.(g)	20.033±2.9 b	26.766±2.9ab	31.633±2.9a	30.525±2.9a	24.191±2.9ab
Pechuga(g)	512.5±29.8 b	620.8±29.8 a	615.0±29.8 a	620.0 ±29.8 a	638.7±29.8a
Muslo Corto(g)	255.1±12.79 b	276.4±12.7ab	305.5±12.7 a	284.1 ±12.7ab	295.5±12.7a

Nota: Letras diferentes en filas presentan diferencias significativas (P≤0.05), entre las medias entre las medias (± error estándar)

Al evaluar los pesos de la pechuga (tabla 3) se puede observar diferencias significativas (P>0.05) entre el nivel 0% que obtuvo un peso de 512.5g con relación a los niveles 6, 12,24 y 30% los cuales obtuvieron peso de 620.8, 615.0, 620.0 y 638.7g, respectivamente al confrontarlos con un estudio de (Okeudo et al., 2005) sobre el crecimiento, características de la canal y calidad organoléptica de niveles de palma en pollos (0, 10, 20, 30%), resultan ser mejores y significantes. De igual forma para el muslo corto (tabla 3) se presentan diferencias significativas (P>0.05) el nivel 0% que muestra 255.1g de peso con respecto a los niveles 12 y 30% los cuales presentan peso de 305.5 y 295.5g.

Analisis Economico

En el análisis económico (tabla 4)., se determinó que el mayor beneficio neto por animal (RD$ 9.69) fue obtenido con una ración de 24% de palmiste en la dieta de pollos de engorde seguido por el tratamiento 12% y 6% presentando una mayor relación beneficio-costo los niveles de inclusión de 24% 12 y 6% respectivamente Sin embargo, el costo de producción mayor por animal fue (RD$80.69) registrado en el nivel 12% y el menor (RD$ 74.38) se registro en el nivel 0%.

Tabla 4 Relación Beneficio-Costo del engorde de pollo de engorde con la inclusión de cuatro niveles de palmaste

Ingreso y costo por animal vivo	**0**	**6**	**12**	**24**	**30**
Ingreso, RD$/animal	71.22	86.12	90.23	89.04	85.08
Costos, RD$/animal	74.38	76.83	80.69	78.66	78.64
Beneficio Brutos, RD$/animal	-3.16	9.30	9.53	10.38	6.44
Interés, 20 % anual del total costos	-0.21	0.62	0.64	0.69	0.43
Beneficio Neto	**-2.95**	**8.68**	**8.90**	**9.69**	**6.01**
Relación B/C	**0.96**	**1.12**	**1.12**	**1.13**	**1.08**

CONCLUSIONES Y RECOMENDACIONES

En base a los resultados obtenidos en la evaluación del Efecto de la sustitución de maíz (Zea mays) por palmiste (Elaeis guineensis) en dietas de pollos de engorde se puede concluir que el palmiste afecta positivamente el consumo de alimento, ganancia diaria y rendimiento en canal caliente de los pollos de engorde comparado con el control y que el nivel de 6% presenta una mejor relación beneficio- costo. Sin embargo, un nivel palmiste mayor de 24% en pollos de engorde afecta negativamente la eficiencia alimenticia comparada con el control.

REFERENCIAS

Belliard, C. Ropceau, M. A . 1996. Evaluación de la inclusión de diferentes niveles de la Harina de guineo de rechazo como fuente de energía en la alimentación de pollo de engorde. Tesis Ing.Zootecnista, Programa ISA, Santiago, Rep. Dom.

Campabadal, C. M., Navarro, H. 2002. Alimentación de los cerdos en condiciones tropicales. Colonia Los Morales Polanco, México D.F, 3era ed. Editora Segrain, S.A. Pág. 207-208.

Cabrera, C. 2006. Banco Central. Obstáculo no impiden lograr metas productivas.

Cobb – Vantress, Inc. 1994. Guía de manejo para el parrillero Cobb 500. Arkansas. USA.

Cody, R. P. y Smith J. K. 1997. Applied Statistic and the SAS Programming Language. Fourth Ed. Prentice Hall, New Jersey. U.S.A.

Dingle, J. G. 2005. Palm kernel meal in broiler diets: effect on chicken performance and health. School of Animal Studies. The University of Queensland. Australia.

Oficina de la Presidencia. 2005. Presidencia de la República Dominicana, Septiembre 2005. Autoridades agropecuarias planifican con avicultores producción de pollo. http://www.presidencia.gov.do.

Okeudo N.J., Eboh K.V., Ndidi, Izugboekwe V., Akanno E.C. 2005. Growth rate, carcass, characteristics and organoleptic quality of broiler fed graded levels of palm kernel cake.

National Research Council. Nutrient Requirements of Poultry. 1994. National Academy Press Washington, D. C. Pag. 27.

Sundu, B y Dingle, J.G. 2004. Use of enzymes to improve the nutritional value of palm kernel meal and copra meal. Quensland Poultry. Sci. Symp. Australia.

Vargas, E., Zumbado, M. E. 2003. Composición de los subproductos de la industrialización de la palma africana utilizados en la alimentación animal en Costa Rica. Agronomía Costarricense: 07-16.

Vilariño, M., León, M., Picard, M. 1996. Efecto de la composición y presentación del alimento sobre el comportamiento de las aves en clima tropical.Centro Nacional de Investigaciones Agropecuaria de Venezuela (Ceniap).

Zumbado, M.; Jackson, F. 1996. Efecto de la presencia de endocarpo en el palmiste integral (Elaeis guinensis) sobre su valor nutritivo. II. Rendimientos de pollos de engorde en iniciación. Agronomía Costarricense: 145-149.

Zumbado, M.; Madrigal, S.; Marin, M. 1992. Composición y valor nutricional del palmiste o coquito integral de palma africana (Elaeis guinensis) en pollos de engorde. Agronomía Costarricense: 83-89.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):473. 2008

Poster #33

Evaluacion de Nitrogeno Líquido (ULB-35®) para la Produccion de Forraje en Puerto Rico

*Alexander Recamán-Serna[1], David Sotomayor Ramírez[1], Yamil Quijano[1], y Gilberto Lozada[2]. [1] Universidad de Puerto Rico, Colegio de Ciencias Agrícolas, Departamento de Agronomía y Suelos, Mayagüez, Puerto Rico, [3]Pan American Fertilizer, Guánica, PR. * Autor de contacto: dsotomayor@uprm.edu*

RESUMEN.
La fertilización con nitrógeno (N) representa el costo más alto en la producción de forrajes debido a que se requieren altos niveles de N para lograr altos rendimientos y contenido protéico. En Puerto Rico, gran parte de la producción de forraje, está destinada para satisfacer la demanda de la industria lechera, por lo que es importante mantener su estabilidad a largo plazo. La utilización de N en forma de urea líquida (ULB-35®) puede mantener los niveles de producción, mejorar la eficiencia de utilización de N, y reducir los costos de producción. Se realizaron tres experimentos en tres fincas comerciales (Lajas, Sábana Grande y Arecibo) para evaluar la eficacia de ULB-35® sobre la producción y rendimiento del forraje. En Lajas, se evaluaron tres niveles de ULB-35® (112, 224 y 336 kg N/ha*año) y se compararon con 336 kg N/ha•año de 15-5-10 (N-P_2O_5-K_2O) granulado. En Sábana Grande, se evaluaron tres fuentes de N: ULB-35®, sulfato de amonio (SA) y mezcla completa de 15-5-10, a una dosis de 336 kg N/ha*año. En ambos casos, se complementó con fósforo (P) y potasio (K), proporcional a los niveles aplicados con 15-5-10. En Arecibo, se evaluó la aplicación de ULB-35® en tres concentraciones de N diferentes (1.5% N, 3% N y 7.5% N) y un control con sulfato de amonio. Los resultados indican que en Lajas, la producción de materia seca de forraje fue mayor para el tratamiento con 15-5-10, seguido de los niveles medio, alto y bajo de ULB-35®. En Sábana Grande, la producción de materia seca de forraje fue mayor para ULB-35®, seguido por 15-5-10 y SA. En Arecibo, la producción de materia seca fue mayor para SA, seguido por las concentraciones baja, media y alta de ULB-35®. Es necesario evaluar formas alternas de aplicación de ULB-35®, para mejorar la eficiencia de utilización en la producción de forraje.

PALABRAS CLAVE: urea líquida, forraje, fertilización

2008 Proceedings of the Caribbean Food Crops Society. 44(2):474. 2008

Poster #34

Tecnicas de Aplicación de Nitrogeno Líquido (ULB-35®) en la Produccion de Forraje en Puerto Rico

Alexander Recamán-Serna[1], David Sotomayor-Ramírez[1] y Gilberto Lozada[2]*
*[1]Universidad de Puerto Rico, Colegio de Ciencias Agrícolas, Departamento de Agronomía y Suelos, Mayagüez, Puerto Rico, [2]Pan American Fertilizar, Guánica, PR. * Autor de contacto: dsotomayor@uprm.edu*

RESUMEN.
La fertilización con nitrógeno (N) en la producción de forrajes de corte y pastoreo, se realiza en forma granulada al voleo mediante equipos especiales. Sin embargo, muchas de las vaquerías y fincas productoras de forraje, cuentan con sistemas de riego por aspersión que son utilizados normalmente durante la época seca. La inyección de un fertilizante líquido, al sistema de riego podría mejorar la eficiencia de aplicación y reducir los costos de producción de forraje. El material ULB-35® es una fuente de urea-N liquido con 15% de N que no contiene metales pesados, patógenos y con bajo biuret disponible en el mercado de Puerto Rico. El costo del material es 68 y 200% mas barato que la misma cantidad de N en forma de urea y sulfato de amonio, respectivamente. El uso de ULB-35®, como fuente de N, es una opción que debe ser evaluada y cobra mayor importancia cuando se mezcla con los residuos orgánicos de vaquerías aplicados a pasturas ya que puede mejorar la eficiencia en la utilización del N y aumentar el valor nutritivo del forraje. Se demostrarán las técnicas de inyección de N líquido a pasturas, en la tubería de succión de la bomba del sistema de aspersión de residuos orgánicos, en el sistema de riego aéreo por cañones, sistema de riego con pivote central y por aspersor móvil.

PALABRAS CLAVE: sistema de riego, urea liquida, forraje, fertilización.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):475-480. 2008

Poster #35

Plant Density and Dry Matter Yield of 'Ubon Stylo' (*Stylosanthes guianensis*) in an Oxisol of Puerto Rico

Jorge Luis Olivares-Lopez[1], Elide Valencia[2], and Abner Rodríguez-Carías[3]. [1]Graduate Student, Agronomy and Soils Department; [2]Professor, Department of Agronomy and Soils, Univ. of Puerto Rico, Mayagüez, and [3]Professor, Department of Animal Industry, Univ. of Puerto Rico, Mayagüez. Jolivares67@hotmail.com

ABSTRACT. The focus of this research was to evaluate plant density and dry matter yield of 'Ubon Stylo' (*Stylosanthes guianensis*) (95% germination) at seeding rates of 5, 10, 15, and 20 kg/ha. 'Ubon Stylo' was planted in August 2007 at the Isabela Substation of the Agricultural Experimental Station, University of Puerto Rico. The aftermath (first harvest) was 100 days after establishment. The experimental design was a complete randomized block with four replicates for the seeding rates. Variables assessed were: 1) Ubon Stylo and weed density (number of emerged plants in 1 m^2) and dry matter yield (DMY; kg/ha). There were significant differences ($p<0.05$) between plant density of Ubon Stylo and weed species. Ubon Stylo plant density averaged 82 plants/m^2 determined at the highest seeding rate (20 kg/ha). There was significant difference in DMY among seeding rates. Lowest DMY yield was observed at low seeding rate of 5 kg/ha (2758 kg/ha), but no difference was observed between the 10 (5,200 kg/ha) and 15 kg/ha (4752). Planting at a high rate 20 kg/ha (6100 kg/ha), although statistically significant from other rates, does not justify seed costs. It is concluded that seeding rates of Ubon Stylo between 10 and 15 kg/ha provides adequate plant densities and excellent DMY.

KEYWORDS: Ubon Stylo, plant density, Dry matter yield.

Densidad de Siembra y Rendimientio de Materia Seca de ubon stylo (*Stylosanthes guianensis*) en un Oxisol de Puerto Rico

Olivares-López, J. L.[1], E. Valencia[2], y A. Rodríguez-Carías[3]. [1]Estudiante Graduado, Departamento de Agronomía y Suelos, Universidad de Puerto Rico, Mayagüez,. [2]Catedratico, Departamento de Agronomía y Suelos, Universidad de Puerto Rico, Mayagüez y [3]Catedratico, Departamento de Industria Pecuarias. Box 9030, Mayagüez, PR 00681
Jolivares67@hotmail.com

RESUMEN:
El enfoque de esta investigación fue evaluar el efecto de cuatro tasas (5, 10, 15, y 20 kg/ha) de siembra de 'Ubon Stylo' (*Stylosanthes guianensis*; 95% de germinación) en densidad de plantas y rendimiento de materia seca (MS). Ubon Stylo fue sembrado en agosto 2007 en la Subestación de Isabela de la Estación Experimental Agrícola,

Universidad de Puerto Rico. La cosecha fue a 100 días después de establecido. El diseño utilizado fue en bloques completos aleatorizados con cuatro repeticiones para las densidades de siembra. Las variables evaluadas fueron: 1) densidad de Ubon Stylo y malezas (numero de plantas emergidas en 1 m^2) y 2) rendimiento de materia seca (RMS). Se encontró diferencia significativa ($p<0.05$) entre las densidades y especies de plantas, basados en el número de plantas de Ubon Stylo y malezas. El mayor número de plantas de Ubon Stylo (82 plantas/m^2) se observó en tasas de siembra de 20 kg/ha. Hubo diferencia significativa para el RMS entre la tasas de siembra de 5 kg/ha (2758 kg/ha) y las otras tasas, pero no se encontro diferencias entre tasas de 10 (5200 kg/ha) y 15 kg/ha (4752 kg/ha). EL RMS en la tasa de siembra de 20 kg/ha (6100 kg/ha) aunque estadísticamente significativa, no justifica la inversión en costo de semilla. En conclusión, tasas de siembra entre 10 a 15 kg/ha de Ubon Stylo provee una alta densidad y excelente RMS.

PALABRAS CLAVES: Ubon Stylo, densidad de plantas, rendimiento de materia seca.

ABSTRACT. The focus of this research was to evaluate plant density and dry matter yield of 'Ubon Stylo' (*Stylosanthes guianensis*) (95% germination) at seeding rates of 5, 10, 15, and 20 kg/ha. 'Ubon Stylo' was planted in August 2007 at the Isabela Substation of the Agricultural Experimental Station, University of Puerto Rico. The aftermath (first harvest) was 100 days after establishment. The experimental design was a complete randomized block with four replicates for the seeding rates. Variables assessed were: 1) Ubon Stylo and weed density (number of emerged plants in 1 m^2) and dry matter yield (DMY; kg/ha). There were significant differences ($p<0.05$) between plant density of Ubon Stylo and weed species. Ubon Stylo plant density averaged 82 plants/m^2 determined at the highest seeding rate (20 kg/ha). There was significant difference in DMY among seeding rates. Lowest DMY yield was observed at low seeding rate of 5 kg/ha (2758 kg/ha), but no difference was observed between the 10 (5,200 kg/ha) and 15 kg/ha (4752). Planting at a high rate 20 kg/ha (6100 kg/ha), although statistically significant from other rates, does not justify seed costs. It is concluded that seeding rates of Ubon Stylo between 10 and 15 kg/ha provides adequate plant densities and excellent DMY.

KEYWORDS: Ubon Stylo, plant density, Dry matter yield.

INTRODUCCIÓN

La producción de leche en Puerto Rico se basa en forrajes de bajo valor nutritivo, y alta suplementación de concentrados sintéticos para llenar los requerimientos nutricionales de vacas lecheras. En los últimos años la industria lechera ha experimentando incrementos en los costos de alimentación de concentrados, por lo cual forrajes de alto valor nutritivo son necesarios (Ej. Leguminosas forrajeras; Argel, 2006).

En los trópicos, el uso de las leguminosas en la dieta de los rumiantes no ha tenido mucho éxito debido a falta de información sobre un buen establecimiento, carencia de persistencia y manejo adecuado. Ubon Stylo (*Stylosanthes guianensis*) es una leguminosa tropical con amplio rango de adaptación, buen rendimiento y alto contenido

de proteína (18 a 20%). Estudios previos en Puerto Rico indican que Ubon Stylo se adapta a suelos ácidos (Barbara 1988). Su producción de biomasa en Argentina ha alcanzado 10 t MS en suelos pobres y 18 t de MS en suelos fértiles (Ciotti et al., 2003). Existe poca información en tasas de semillas necesarias para un buen establecimiento y tener una buena densidad de plantas. Estudios en Argentina recomiendan 3 kg/ha (Ciotti et al., 2003, Camero et al., 1997).

Ubon Stylo se considera material promisorio para conservación de forraje por la cual es importante desarrollar sistemas de establecimientos y evaluar su persistencia y rendimiento de materia seca bajo corte. Información sobre prácticas de manejo agronómico como densidad necesaria para mejor su persistencia no existe. El objetivo des este estudio fue evaluar cuatro tasas (5, 10, 15, 20 kg/ha) de semilla de Ubon Stylo en una siembra convencional para medir su efecto sobre densidad de plantas y rendimiento de materia seca.

MATERIALES Y METODOS

Esta investigación se realizó en las facilidades de la Estación Experimental de Isabela, de la Universidad de Puerto Rico, Recinto Universitario de Mayagüez, ubicado a 18° 30' N latitud y 67°00' Longitud oeste, a una altura de 128 msnm, con precipitación promedio anual de 1675 mm y temperatura media de 25° C, con fluctuaciones de 19° a 29° C. Ubon Stylo se estableció en un suelo Oxisol coto clay, Tropetic haplothox, caolinitico hisohipertermico. El análisis químico del suelo indica un pH de 5.42 con 2.64% de materia orgánica y 9, 85, 1107 ppm de P, K, CA respectivamente.

El ensayo se estableció el 28 de agosto del 2007 en un arreglo factorial de parcelas en bloques completos aleatorizados con cuatro repeticiones. El área de siembra se preparo 30 días antes de siembra con un pase de arado a 45-cm de profundidad y dos de rastra (grada) a 25 cm de profundidad (labranza convencional) con 8 días de intervalo entre grada y un pase de rototiller antes de siembra. Para el control de malezas se aplicó post-emergente Fusilade, a razón de 4 litros por ha.

Se utilizó el cultivar Ubon Stylo (95% de germinación) y la siembra se realizó a chorrillo con una sembradora de tracción mecánica (Brillion). Las semillas fueron distribuidas en líneas continuas de 3 m a lo ancho de cada parcela por 78 m de largo, para un área de 234 m^2 con separación de 0.5 m entre parcelas y 1 m entre bloques. La parcela útil estaba conformada por 1 m^2 en tres sitios de muestreo aleatorizados en cada unidad experimental, y cada área de muestreo se cosecho, se tomo el peso total fresco.

Las tasas de siembra fueron 5, 10, 15 y 20 kg/ha de semilla de Ubon Stylo. Se evaluaron las densidad de plantas (numero de plantas en un 1m^2) y el rendimiento de materia Seca (MS; kg/ha). Las plantas fueron cortadas a 15-cm de altura en cada área de 1 m^2 seleccionado aleatoriamente en tres sitios de la parcela y luego submuestras representativas (500 g) se tomaron. Las submuestras se pesaron y se secaron en un horno de aire forzado a 60° C por 48 hrs para determinar su MS. Los datos fueron analizados usando el modelo general lineal de SAS [Statistical Advances System SAS (V.9)], y para la separación de medias tukey (P=0.05).

RESULTADOS Y DISCUSSION

Se observo una interacción ($p<0.05$) entre densidad y especies de plantas basado en el número de plantas de Ubon Stylo y malezas germinadas en 1 m^2 de área. Se observa

que al incrementar las tasas de siembra de 5 a 20 kg/ha la densidad población de plantas germinadas de Ubon Stylo supera la población de plantas germinadas de malezas de hoja ancha y se observa una reducción en densidad de gramíneas (Figura 1).

Se observó diferencia significativa ($P<0.05$) en rendimiento de MS entre las tasas de siembra de 5 kg/ha y 20 kg/ha de semilla, presentando un rendimiento promedio de 2758 kg/ha y 6100 kg/ha), respectivamente. Se observa un incremento de MS (>2000 kg/ha) al incrementarse las tasas de siembra entre 5 a 10 kg/ha, pero no hay diferencia en rendimiento de MS entre las tasas de 10 y 15 kg/ha Figura 2). Estos resultados coinciden con lo sustentado por Barbara (1988), quien reporta una respuesta similar en la alta densidad de siembra en la cual los rendimientos fueron superior al de la baja densidad.

Estos resultados preliminares de rendimiento de MS con tasas de siembra de 10 kg/ha de semilla, son superiores a los rendimientos manifestados por Quintero et al., (1997), quien asegura que leguminosas con menos de 80 plantas por metro cuadrado no supera los 3000 a 4000 kg/ha por año. En esta investigación esos rendimientos son superiores utilizando una tasa de siembra de 10 kg/ha, en un corte 100 días después de siembra (Figura 2).

CONCLUSIONES

Tasas de siembra de 10 kg/ha de semilla de Ubon Stylo proporciona un rango de densidad entre 33 a 55 plantas m^2. A partir de esta tasa inicia la mayor cantidad de plantas respecto a la cantidad de malezas de hoja ancha por m^2. De igual manera, al incrementar las tasas de siembra de 15 a 20 kg/ha, la densidad poblacional de Ubon Stylo es superior a la población de malezas de hoja ancha por m^2, mientras la densidad de gramíneas se ve afectada por la cantidad de plantas de Stylo.

También estos resultados dejan clara evidencia que en un suelo Oxisol, con una densidad de 60 plantas de leguminosa de Ubon Stylo por m^2, supera los 4500 kg/ha de MS en un corte a 15-cm de altura a 100 días de establecido. Por lo que se considera que una tasa de siembra 10 kg/ha provee una densidad adecuada de plantas para ejercer efecto competitivo en población de malezas de hoja ancha o gramíneas y proporciona rendimientos altos de MS (≈ 5000 kg/ha).

AGRADECIMIENTO

Esta investigación obtuvo apoyo financiero de TSTAR "Improving the productivity of warm season legumes"

LITERATURA CITADA

Argel, P. J. 2006. Contribution of improved pastures to animal productivity in dual purpose systems. Arch. Latinoam. Prod. Anim. 14 (2): 65-72.

Barbara, B. 1988. Response of *Stylosanthes guianensis* varieties to two population densities and three cutting dates in Western Puerto Rico. MSc. thesis. University of Puerto Rico, Mayagüez, pp. 63.

Camero, A.; J.C. Camargo, M. Ibrahim, y A. Schlönvoigt. 2000. Agroforestería y Sistemas de Producción Animal en América Central. En: Intensificación de la Ganadería en Centroamérica – Beneficios Económicos y Ambientales.

Editores: Carlos Pomareda y Henning Steinfeld. CATIE, FAO, SIDE. San José, Costa Rica, pp. 177-198.

Ciotti, E. M.; M. E. Castelan, C. E. Tomei, I. P. Monaco y J. F. Benítez. 2003. Answer of *Stylosanthes guianensis* CIAT 184 to fertilization with low doses of phosphorus. Comunicaciones Científicas y Tecnológicas RIA, 32(2), 137-148.ISSN 0325-9718. INTA, Corrientes Argentina.

Quintero C.E.; N.G. Boschetti y R.A. Benavides. 1997. Efecto Residual y fertilización fosfatada de pasturas implantadas en Entre Ríos (Argentina).Ciencias de Suelo 15:1-5.

Figura 1. Efecto de cuatro tasas de siembra en densidad de Ubon stylo, gramíneas, y malezas de hoja ancha.

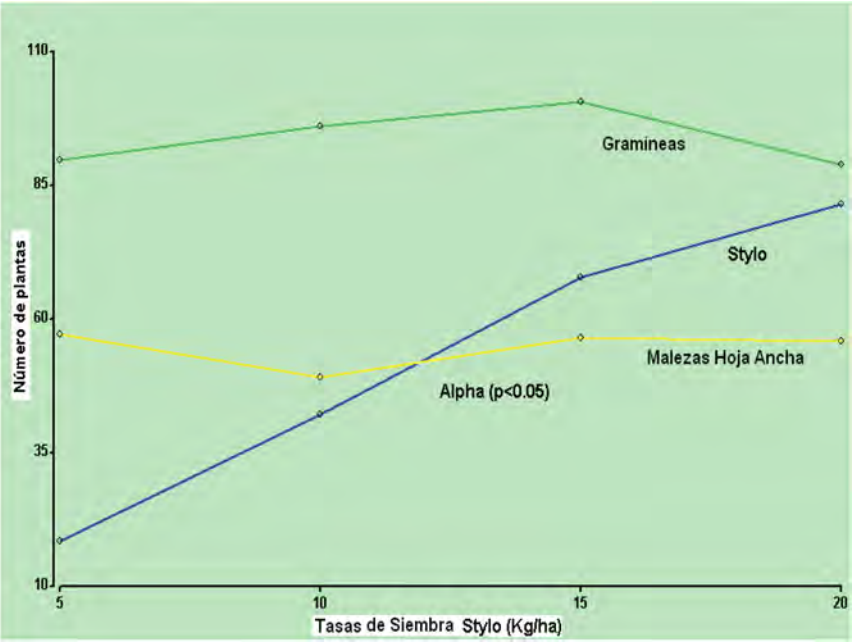
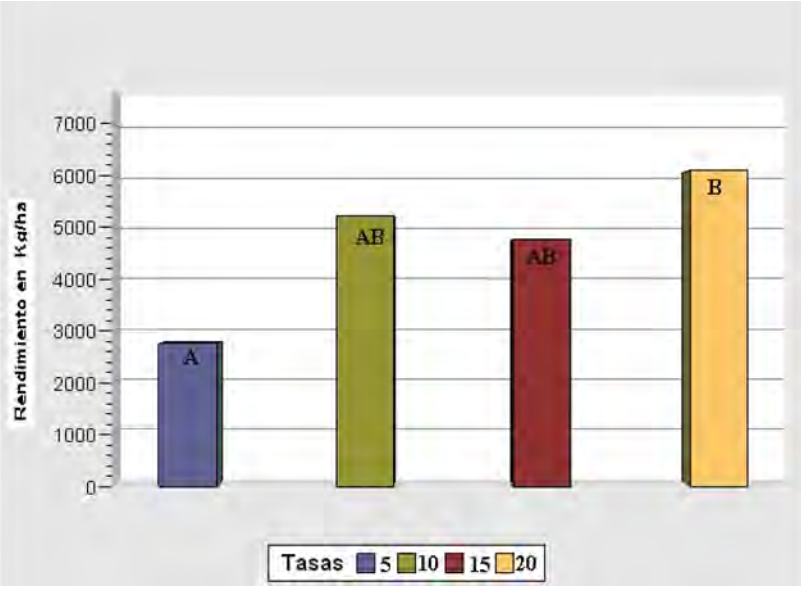


Figura 2. Efecto de cuatro tasas de siembra Ubon Stylo en rendimiento de materia seca (kg/ha).



Medias con letras distintas son significativamente diferentes (p<0.05).

2008 Proceedings of the Caribbean Food Crops Society. 44(2):481-488. 2008

Poster #36

Effects of Planting Density and Cut Frequency on Dry Matter Yield of Mulberry (*Morus Alba) and* Guacima *(Guázuma ulmifolia);*

Influencia de Diferentes Densidades de Siembra y Frecuencias de Corte sobre el Rendimiento en Biomasa de *Morus alba* y *Guázuma ulmifolia*

Ramón A. Marte Estévez[1], Carlos M. de J. Arias[2], Rafael A. Vásquez Martínez[3]. [1]Veterinary Medicine and Animal Science Department, [2]Animal Science Department. [3]Facultad de Ciencias Agroalimentarias y del Ambiente, Universidad ISA, La Herradura, Santiago, Republica Dominicana. ramonmarte@yahoo.com; rmarte@isa.edu.do; cdejesus@isa.edu.do;car1070@yahoo.com*

ABSTRACT.

A study was set to evaluate the dry matter (DM) yield and nutritional composition of the species *Morus alba* and *Guázuma ulmifolia* under 3 plantation densities and 3 cut frequencies. Every treatment combination of 2 x 3 x 3=18 was replicated four times in a randomized complete block design. Four plants per plot were randomly selected to test the DM and crude protein contents. The higher total DM yield of *Morus alba* ($P \leq 0.05$) was registered on 25,000 plants/ha and 60 d at cut treatment combination, whereas the planting density and cut frequency of larger DM was at 75 d and 25000 plants/ha in *Morus alba*. The average plant height was 280.3±43.4 cm on *Morus alba* and 260.9±43.4 cm on *Guázuma ulmifolia*. The leave crude protein content was 28% in *Guázuma ulmifolia* with a planting density (25,000 plants/ha) of 75 d, however, leave crude protein contents were 21.9% on 45 days of age and 25,000 plants/ha in *Morus alba*. We conclude that the best planting density is 25,000 plants/ha and the cut frequency is 60 and 75 d in Mulberry and *Guázuma ulmifolia*, respectively.

KEYWORDS: guácima, mulberry, density plantation, cut frequency

INTRODUCCIÓN

Las especies morera (*Morus alba* L.) y guácima (*Guázuma ulmifolia* Lam.), especialmente la primera, están siendo usadas como fuentes de proteínas en la alimentación de ganado bovino, ovino y caprino en la República Dominicana. Los conocimientos sobre ambas especies, respecto a la densidad de plantación óptima para mayor rendimiento en biomasa y los períodos apropiados de corte de cada una en condiciones intensivas de cultivo son escasos.

MATERIALES Y MÉTODOS

Se realizó un estudio para determinar el rendimiento en biomasa de las especies *Morus alba* (Foto 1) y *Guázuma ulmifolia* (Foto 2) sometidas a tres densidades de siembra y tres frecuencias de corte. Se estableció un diseño por bloques completos al azar con arreglo factorial 2 x 2 x 3 con tratamientos con densidades de siembra de 25,000, 16,666 y 12,500 plantas por hectárea y marco de plantación de 1.0 x 0.80, 1.0 x 0.60 y

1.0 x 0.40 metros respectivamente. Las frecuencias de corte usadas son 45, 60 y 75 días (Foto 3). Este estudio se realizó en condiciones de altitud 169 m, humedad relativa de 73%, temperatura media anual de 25.3 °C, precipitación media anual de 824 mm y pH de 7.9 a 8.3. Se utilizó un sistema de riego por aspersión. El experimento se realizó del 09 de noviembre del 2006 al 18 de julio 2007. Se realizaron 3 cortes según las frecuencias de corte y se midieron los rendimientos y el % de proteínas de las hojas. Para analizar los datos se utilizó el software Statistical Analysis System (SAS) v8.1. Se realizó un análisis de varianza (ANOVA) y para la separación de medias se aplicó la prueba de Tukey a un nivel de significación de 5%.

Foto 1. *Morus alba.*

Foto 2. *Guázuma ulmifolia.*

Foto 3. Plantación experimental.

RESULTADOS Y DISCUSIONES

Se observaron diferencias significativas (P≤0.05) en la producción de materia seca para las especies, las frecuencias de corte y las densidades de siembra utilizadas. Según los Cuadros 1, 2 y 3 la mayor producción ocurre en la morera a una frecuencia de corte de 75 días y una densidad de siembra de 25,000 plantas por hectárea.

Cuadro 1. Comportamiento del Rendimiento en las Especies *Morus alba* y *Guázuma ulmifolia* Influenciado por Tres Frecuencias de Corte y Tres Densidades de Siembra.

Corte	Variable	Especie		C.V.[3]	s[4]
		M[1]	G[2]		
1	Materia seca total en kgMS/ha.d	62.6 a	33.0 b	50.5	24.1
2	Materia seca total en kgMS/ha.d	66.1 a	42.9 b	44.2	24.1
3	Materia seca total en kgMS/ha.d	65.5 a	52.9 b	46.2	27.4

Letras diferentes tienen diferencias significativas a P≤0.05; 1: *Morus Alba*; 2: *Guázuma ulmifolia*; 3: Coeficiente de variación; 4: Desviación estándar.

Cuadro 2. Comportamiento de los Rendimientos Agrupados en las Especies *Morus alba* y *Guázuma ulmifolia* Influenciado por Tres Frecuencias de Corte.

Corte	Variable	Frecuencia de corte, d		
		45	60	75
1	Materia seca total en kgMS/ha.d	39.6 b	48.6 a	55.3 a
2	Materia seca total en kgMS/ha.d	28.7 c	53.8 b	81.0 a
3	Materia seca total en kgMS/ha.d	31.3 b	70.4 a	75.8 a

Letras diferentes tienen diferencias significativas a P≤0.05.

Cuadro 3. Comportamiento de los Rendimientos Agrupados en las Especies *Morus alba* y *Guázuma ulmifolia* Influenciado por Tres Densidades de Siembra.

Corte	Variable	Densidad, plantas*1000		
		25	16.6	12.5
1	Materia seca total en kgMS/ha.d	58.1 a	45.7 b	39.6 b
	Relación hojas/tallos	1.8 a	1.8 a	1.7 a
2	Materia seca total en kgMS/ha.d	66.1 a	54.6 b	42.9 c
	Relación hojas/tallos	1.6 a	1.6 a	1.5 a
3	Materia seca total en kgMS/ha.d	70.4 a	62.3 a	44.9 b
	Relación hojas/tallos	1.3 b	1.6 a	1.4 ab

Letras diferentes tienen diferencias significativas. P≤0.05.

En la interacción especie*densidad de siembra*frecuencia de corte resultó que en cada densidad de siembra, la producción de MS mantiene la misma tendencia para las tres frecuencias de corte utilizadas en las dos especie (Figura 1 y 2).

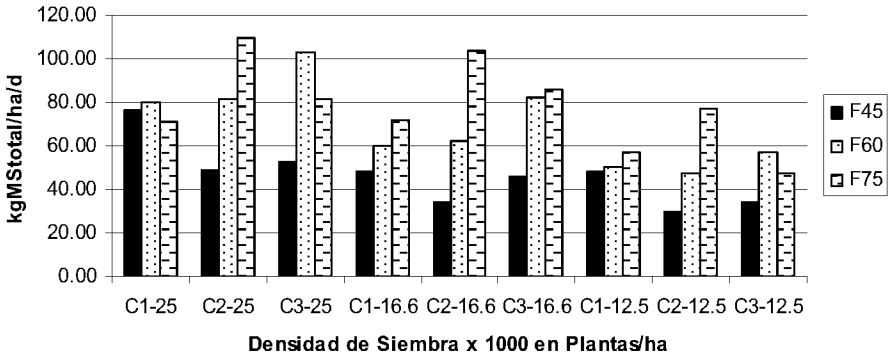


Figura 1. Comparación de las Medias de Producción Total de la Morera (kgMStotal/ha.d) en el corte 1 (C1), corte 2 (C2) y corte 3 (C3) influenciada por las densidades de siembra y frecuencias de corte.

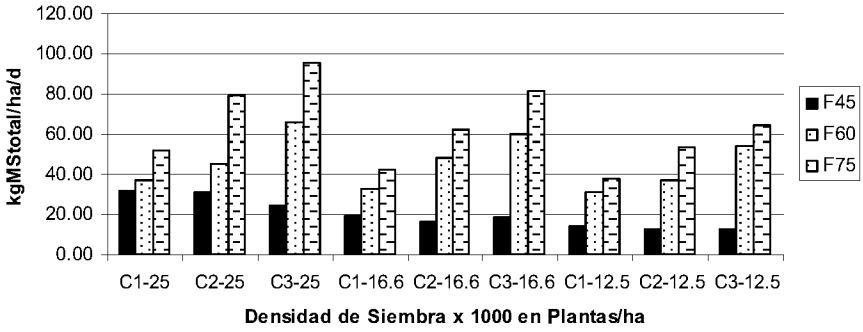


Figura 2. Comparación de las Medias de Producción Total de la Guácima (kgMStotal/ha/d) en el corte 1 (C1), corte 2 (C2) y corte 3 (C3) influenciada por las densidades de siembra y frecuencias de corte.

Se observó que la guácima alcanza valores en % de proteínas crudas (%PC) por encima de la morera (Cuadro 4).

Cuadro 4. Comparación Entre las Medias del % de Proteínas Crudas en las Hojas de las Especies Morera y Guácima Según la Influencia de Tres Densidades de Siembra y Tres Frecuencias de Corte.

Densidad siembra*1000 (plantas/ha)	Frecuencia de corte (días)	n	% PC	
			M[1]	G[2]
25	45	8	21.9	26.8
25	60	8	19.3	22.9
25	75	8	19.1	22.6
16.6	45	8	21.7	25.7
16.6	60	8	18.0	24.3
16.6	75	8	20.9	23.0
12.5	45	8	21.2	25.5
12.5	60	8	19.6	23.3
12.5	75	8	20.2	28.0

1: Morera; 2: Guácima.

REFERENCIAS

Almeida, JE de; y Canto, F. 2000. A Contribution to the introduction of the high-trunk mulberry system in tropical climates. Estación Experimental de Zootecnia e Instituto de Zootecnia, BR. Electronic Conference on "Mulberry for animal production" 1st Mayo – 31 June 2000. FAO. Consultado 17 mar 2002. Disponible en http://www.fao.org/ag/AGA/AGAP/FRG/Mulberry/Posters/HTML/Almeida2.htm

Benavides. J. 1995. Arboles y arbustos forrajeros para las montañas americanas. En: Sistemas pecuarios sostenibles para las montañas tropicales. Pp103-123 CIPAV, Cali, Colombia. Citado en Uribe, F.. 2000. Mulberry for rearing dairy heifers. Electronic Conference on "Mulberry for animal production" 1st Mayo – 31 June 2000. FAO. Consultado 15 mar 2002. Disponible en http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/FRG/MULBERRY/Posters/Html/Uribe.htm.

Benavides, J.E. 1998. Utilización de la morera en sistemas de producción animal. En: Agroforestería para la producción animal en Latinoamérica. Memorias de la conferencia electrónica. FAO, Roma (in press). Consultado 24 feb. 2002. Disponible en http://www.fao.org/ag/aga/agap/frg/agrofor1/bnvdes12.htm.

Botero, J; David, P; y Saldarriaga, J. 1995. Efecto de tres densidades de árboles en el potencial forrajero de un sistema silvopastoril situado en bosque seco tropical. Tesis Zootecnia. Universidad Nacional de Colombia. CO. 105 p. Citado en Giraldo A. 1999. Potencial de la arborea Guácimo (*Guázuma ulmifolia*) como componente forrajero en sistemas silvopastoriles. Universidad Nacional de Colombia. CO. Conferencia electrónica de la FAO sobre "Agroforestería para la producción animal en Latinoamérica". Consultado 24 feb 2002. Disponible en http://www.fao.org/ag/aga/agap/frg/agrofor1/Giral13.htm.

Centro Agronómico Tropical de Investigación y Enseñanza (CATIE). 1986. Silvicultura de especies promisorias para la producción de leña en América Central. Silvoenergía. Serie Técnica. Informe Técnico No. 86. Turrialba. CR. Citado en

Giraldo A. 1999. Potencial de la arborea Guácimo (*Guázuma ulmifolia*) como componente forrajero en sistemas silvopastoriles. Universidad Nacional de Colombia. CO. Conferencia electrónica de la FAO sobre "Agroforestería para la producción animal en Latinoamérica". Consultado 24 feb 2002. Disponible en http://www.fao.org/ag/aga/agap/frg/agrofor1/Giral13.htm.

CATIE. 1991. Guácimo (*Guázuma ulmifolia*) especie de árbol de uso múltiple en América Central. Proyecto Cultivo de Arboles de Uso Múltiple (MADELEÑA). Turrialba, CR. Serie Técnica. Informe Técnico No. 165. ISBN 9977-57-091-4. 72 p.

Cifuentes, CA; y Han, KM. 1992. Manual de sericultura. Plan Nacional de Rehabilitación Ed. Imprimiendo Ltda., Pereira, Colombia. Citado en Uribe, F.. 2000. Mulberry for rearing dairy heifers. Electronic Conference on "Mulberry for animal production" 1st Mayo – 31 June 2000. FAO. Consultado 15 mar 2002. Disponible en http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/FRG/MULBERRY/Posters/Html/Uribe.htm.

Duke, JA. 1978. The quest for tolerant germplasm. p. 1–61. In: ASA Special Symposium 32, Crop tolerance to suboptimal land conditions. Am. Soc. Agron. Madison, WI. *Compendiado en:* Purdue University, West Lafayette. Center for New Crops & Plant Products. Consultado 3 mar. 2002. Disponible en http://www.hort.purdue.edu/newcrop/duke_energy/Morus_alba.html.

Duke, JA. 1983. Handbook of energy crops. Unpublished. *Compendiado en:* Purdue University, West Lafayette. Center for New Crops & Plant Products. Consultado 3 mar. 2002. Disponible en http://www.hort.purdue.edu/newcrop/duke_energy/Morus_alba.html.

Esquivel, J., Benavides, J.E., Hernández, I., Vasconcelos, J., González, J., & Espinoza, E. 1996. Efecto de la sustitución de concentrado con Morera (Morus alba) sobre la producción de leche de vacas en pastoreo. En: Resúmenes. Taller Internacional "Los árboles en la producción ganadera". EEPF "Indio Hatuey", Matanzas, Cuba. p25.

Geilfus, F. 1989. El árbol al servicio del agricultor. Principios y técnicas. Guia de especies. Manual de Agroforestería para el desarrollo rural. Enda-Caribe. Centro Agronómico y Tropical de Investigación y Enseñanza (CATIE). Editorial Santo Domingo, República Dominicana. 2 v.

García F. et al, 2002. Altura de corte de Morera (Morus alba) http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/FRG/AFRIS/espanol/Document/Morera/morera12.htm Abril 2002, 3552 bytes. Consultado 2 oct. 2007. Disponible en http://www.unet.utafoundation.org/articulos/xiv_jortecgan.pdf.

Instituto Nacional de Recursos Hidráulicos (INDRHI). 1970. Estudio del área de influencia de la presa Tavera. Río Yaque del Norte. Santiago, DO. (RD-YN-310). Estudio Agrológico. Ingenieros Consultores y Proyectistas (C.I.E.P.S.s.c). Planos de series de suelos. v 3.

Martín, G; García, F; Reyes, F; Hernández, I; González, T; y Milera, M. 2000. Agronomic studies with mulberry in Cuba. Estación Experimental de Pastos y Forrajes "Indio Hatuey". Matanzas, Centro Politécnico "Villena Revolución", La

Habana, CU. Electronic Conference on "Mulberry for Animal Production" 1st Mayo – 31 June 2000. FAO. Consultado 17 mar 2002. Disponible en http://www.fao.org/ag/AGA/AGAP/FRG/Mulberry/Papers/HTML/Martin.htm.

Pezo, D; Kass, M; Benavides, J; Romero, F; y Chaves, C. 1990. Potential of legume tree fodders as animal feed in Central America. In: Shrubs and tree fodders for farm animals. (1989, Denpasar, Indonesia). Proceeding of Workshop. Ed. Po C. Devendra. Ottawa, Canada. IDRC. p 163 –175.

Reynald, JJ; Mevs, RA. 1998. Evaluación de las especies forrajeras morera (*Morus alba*) y margarita haitiana (*Tithonia diversifolia*) y su utilización en la alimentación de ovinos de engorde. Tesis Ing. Zootecnista, República Dominicana, ISA. 73 p.

Roger, JP. 2002. Description of mulberry tree. Conservatoire Botanique National Méditerranéen de Porquerolles – France. Consultado 3 mar. 2002. Disponible en http://www.unifi.it/project/ueresgen29/ds15.htm.

Sánchez, MD. 1998. Mulberry: an exceptional forage available almost worldwide. IT FAO. Electronic Conference on "Mulberry for animal production" 1st Mayo – 31 June 2000. FAO. Consultado 24 feb 2002. Disponible en http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/FRG/MULBERRY/Papers/text/Sanchez2.txt.

Sanginés G., Lara L., Rivera L., Pinzon L., Ramos P., Murillo J., Itra, M., Fuentes C. y G Azcorra. 2001. Avances en los programas de investigación en morera (Morus alba) enYucatán. http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/FRG/AFRIS/espanol/Document/Morera/MORERA20.HTM.71753 bytes. Consultado 2 oct. 2007. Disponible en http://www.unet.utafoundation.org/articulos/xiv_jortecgan.pdf.

Santander F, CI; y Campos A, JJ. 1983. El Guácimo (*Guázuma ulmifolia* Lam.,) especie forestal de uso múltiple para los trópicos. San José, CR. CATIE. 15 p. Simposio Internacional sobre Plantaciones Forestales plantadas en los Neotrópicos como Fuente de Energía, 1983; Viscosa, Minas Gerais, BR. Citado en CATIE (Centro Agronómico Tropical de Investigación y Enseñanza). 1991. Guácimo (*Guázuma ulmifolia*) especie de árbol de uso múltiple en América Central. Proyecto Cultivo de Arboles de Uso Múltiple (MADELEÑA). Turrialba, CR. Serie Técnica. Informe Técnico No. 165. ISBN 9977-57-091-4. 72 p.

Santander F, CI; y Campos A., JJ. 1988. El Guácimo (*Guázuma ulmifolia* Lam.,) especie forestal de uso múltiple para los trópicos húmedos. San José, CR. Consultoría y Asesoría Agroforestal. 36 p. Citado en CATIE (Centro Agronómico Tropical de Investigación y Enseñanza). 1991. Guácimo (*Guázuma ulmifolia*) especie de árbol de uso múltiple en América Central. Proyecto Cultivo de Arboles de Uso Múltiple (MADELEÑA). Turrialba, CR. Serie Técnica. Informe Técnico No. 165. ISBN 9977-57-091-4. 72 p.

Secretaría de Estado de Agricultura (SEA). 1979. Requerimiento de agua para la agricultura según el clima de la República Dominicana. Sub-secretaría de Recursos Naturales. Departamento de Tierras y Aguas. Cooperación del OEA (Instituto Interamericano de Ciencias Agrícolas). Documento Técnico N°. 02. Preparado por Ernesto Reyna y Manuel Paulet. DTA-DT N°. 4. IICA-AID-27/79. Santo Domingo, DO. p A-13. 132 p.

SEA. 1998. Registro Nacional de Productores Agropecuarios. Consultado el 24 febrero del 2002. Disponible en http://www.agricultura.gov.do/mcenso.htm.

Singh, B.; Goel, G.C. and Negi, S.S. 1984. Effect of supplementing muberry (Morus alba) leaves ad libitum to concentrate diets of Angora rabbits on wool production. Journal of Applied Rabbit Research 7(4):156-160.

Solano, R. 1986. El caulote (*Guázuma ulmifolia* Lam.,) para la producción de forraje y leña en Nueva Concepción, Guatemala. In Investigación en componentes de apoyo al desarrollo de la alternativa mejorada para el sistema mixto en Nueva Concepción, Guatemala. CATIE. Serie Técnica. Informe Técnico No. 96 p. 80-86. Citado en CATIE (Centro Agronómico Tropical de Investigación y Enseñanza). 1991. Guácimo (*Guázuma ulmifolia*) especie de árbol de uso múltiple en América Central. Proyecto Cultivo de Arboles de Uso Múltiple (MADELEÑA). Turrialba, CR. Serie Técnica. Informe Técnico No. 165. ISBN 9977-57-091-4. 72 p.

Soto S., R. 1980. Curso de ecología de plantaciones. San José, DR. Universidad de Costa Rica – Organization for Tropical Studies. 6 p. Citado en CATIE (Centro Agronómico Tropical de Investigación y Enseñanza). 1991. Guácimo (*Guázuma ulmifolia*) especie de árbol de uso múltiple en América Central. Proyecto Cultivo de Arboles de Uso Múltiple (MADELEÑA). Turrialba, CR. Serie Técnica. Informe Técnico No. 165. ISBN 9977-57-091-4. 72 p.

Ting-Zing, Z; Yun-Fang, T; Guang-Xian, H; Huaizhong, F; y Ben, M. 1998. FAO Agricultural servicies bulletin. No. 73/1. FAO, IT. 127 p. Citado en Benavides, J. 2000. Utilización de la Morera en sistemas de producción animal (en línea). CR. FAO. Consultado 24 feb. 2002. Disponible en http://www.fao.org/ag/aga/agap/frg/agrofor1/bnvdes12.htm.

Trigueros, R.O. y Villalta, P. 1997. Evaluación del uso de follaje deshidratado de morera (Morus alba) en alimentación de cerdos de la raza Landrace en etapa de engorde. En: Resultados de Investigación, CENTA, El Salvador p150-155.

Uribe, F. 2000. Mulberry for rearing dairy heifers. Electronic Conference on "Mulberry for animal production" 1st Mayo – 31 June 2000. FAO. Consultado 15 mar 2002. Disponible en http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/FRG/MULBERRY/Posters/Html/Uribe.htm.

Wagner J, B; Vargas G, M. y Almanzar R, E. 2006. Caribbean Food Crops Society 42th Annual Meeting July 9 – 15, 2006. Food Safety and Value Added Production and Marketing in Tropical Crops. Puerto Rico. Vol. XLII-Number 2. ISSN 95-07-0410.

Ye, Z. 2000. Factors influencing mulberry leaf yield. College of Animal Sciences, Zhejiang University, Hangzhou, Zhejiang, CN. Electronic Conference on "Mulberry for animal production" 1st Mayo – 31 June 2000. FAO. Consultado 17 mar 2002. Disponible en http://www.fao.org/ag/AGA/AGAP/FRG/Mulberry/Posters/Html/ZHIYI.htm

2008 Proceedings of the Caribbean Food Crops Society. 44(2):489-494. 2008

Poster #37

The Mineral Status of Sheep and Goats with Reference to Swayback in Central Trinidad

Aphzal Mohammed[1] and Fayez G. Youssef[2]. [1]The University of Trinidad and Tobago, lot 74-98 O'Meara Industrial Park, Arima Trinidad; [2]Department of Food Production, The University of the West Indies, St. Augustine, Trinidad, West Indies. aphzal.mohammed@utt.edu.tt

ABSTRACT.
There have been many occurrences in Trinidad of lambs and kids that have died within 6 months of birth of suspected Cu deficiency resulting in clinical signs resembling swayback. Animals displayed an inability to stand at birth or hind limb ataxia progressing to an inability to stand in the delayed forms. The condition continues to be of economic importance because of poor growth rates and high mortality of lambs and kids of affected farms.

OBJECTIVES.
This study investigates the mineral status of

1) Swayback (n=50) and apparently normal lambs (n=39) and adult sheep (n=42) and
2) Swayback (n=24) and apparently normal kids (n=21) and adult goats (n=41) of affected farms of Central Trinidad

MATERIALS AND METHODS.
Calcium, Mg, Na, K, Cu and Zn concentrations were evaluated by atomic Absorption spectroscopy and colorimetrically for P, on blood serum of swayback and apparently normal sheep and goats. The identical minerals including Fe and Mn were evaluated on grasses of swayback affected farms or locations (Table I).

RESULTS.
Significantly lower ($p < 0.001$) serum Ca, Cu, and Zn levels were found in swayback than in apparently normal lambs and adult sheep. Serum Cu was also lower ($p < 0.001$) in swayback than in apparently normal kids and adult goats. Several swayback lambs had low concentrations of Ca (< 2.0 mmol/L), P (< 1.3 mmol/L) and Zn (< 9.2 μmol/L), while most swayback lambs and kids had critically low Cu (< 7.9 μmol/L). Several adult sheep and goats were also deficient in Cu and P, while about half of the grasses analysed had low Cu (< 5 ppm) (Tables II, III, & IV).

CONCLUSIONS.
Critically low serum Cu in swayback lambs and kids was probably caused by the low Cu concentrations found in the grasses. Twenty four, 47 and 16% of grasses also had levels of Ca, Mg, and P below minimum requirements (< 0.20% DM).The study provides

a basis for the inclusion of Cu and P supplementation to enhance productivity of sheep and goats of Central Trinidad.

REFERENCES.

NRC, 1985. Nutrient Requirements of Sheep. 6th edn. (National Academic Press, Washington, D C)

Smith, M.C. and Sherman, D.M., 1994. Musculoepithelium System In Goat Medicine,(Lea and Febiger, Philadelphia, U.S.A.)

Underwood, E.J.and Suttle N.F., 1999. The Mineral Nutrition of Livestock. 3rd edn., (Commonwealth Agricultural Bureaux, London.)

TABLE 1
Blood samples collected from Swayback and Apparently normal sheep and goats

farm/location	swayback		apparently normal			total
Sheep	Newborn	1 - 6 mth	Newborn	1 - 6 mth	1 - 4 yr	
Petrotrin Sheep Farm	0	6	0	9	3	18
Chaguanas Location	1	10	2	12	12	37
Mon Jaloux Livestock Farm	24	2	2	9	19	56
Sugarcane Feeds Centre	0	7	1	4	8	20
Total Sheep	25	25	5	34	42	131

farm/location	swayback	apparently normal		total
Goats	1 - 6 mth	1 - 6 mth	1 - 4 yr	
Couva Location	13	8	22	43
Chaguanas Location	11	5	15	31
Sugarcane Feeds Centre	0	8	4	12
Total Goats	24	21	41	86

TABLE II
Serum macro (mmol/l) and micro (µmol/l) mineral levels in swayback and apparently normal sheep of Central Trinidad

Mineral	Swayback				Apparently Normal						Sig.[1]
	I	± SE	II	± SE	III	± SE	IV	± SE	V	± SE	
(n)	25[a]		25[a]		5[b]		34[b]		42[c]		
Ca	2.60	0.10	2.39	0.07	2.91	0.16	2.72	0.06	2.53	0.06	***
Mg	1.03	0.06	0.99	0.04	1.07	0.09	1.09	0.04	1.02	0.03	NS
P	1.32	0.12	1.42	0.09	1.91	0.19	1.59	0.07	1.39	0.07	*
Na	138.17	2.52	137.70	1.90	139.70	4.11	141.83	1.59	137.04	1.51	*
k	5.26	0.16	5.46	0.12	5.77	0.26	5.86	0.10	5.26	0.10	***
Cu	4.41	0.47	4.88	0.38	9.44	0.83	8.50	0.31	8.03	0.30	***
Zn	10.25	0.69	10.55	0.55	16.98	1.22	14.68	0.47	13.46	0.44	***

Serum mineral concentrations found in sheep and goats are compared with the following critical levels: Ca 2.0, Mg 0.6 and P 1.3 mmol/L; Cu 7.9 µmol/L and Zn 9.2 µ mol/L (Underwood and Suttle, 1999)

a,b,c I, Newborn lambs affected with congenital swayback; II, 1 to 6 month old lambs affected with delayed ataxia; III, newborn lambs, apparently normal; IV, 1to 6 month old lambs, apparently normal; V, 1 to 4 year old adult sheep, apparently normal.

[1] * $P < 0.05$; *** $P < 0.001$; NS Not Significant

TABLE III
Serum macro (mmol/l) and micro (µmol/l) mineral levels of swayback and apparently normal goats of Central Trinidad

Mineral[1]	Swayback		Apparently Normal				Sig.[2]
	II	± SE	IV	± SE	V	± SE	
n	24[a]		21[b]		41[b]		
Ca	2.47	0.07	2.56	0.07	2.47	0.05	NS
Mg	1.11	0.04	1.14	0.04	1.19	0.03	NS
P	1.63	0.07	1.56	0.06	1.48	0.05	NS
Na	132.70	2.39	137.96	2.25	136.39	1.80	NS
K	5.51	0.11	5.69	0.10	5.54	0.08	NS
Cu	6.14	0.55	8.97	0.52	7.87	0.42	***
Zn	13.31	0.92	15.75	0.86	13.77	0.69	NS

[a,b] II, 1 to 6 month old kids affected with delayed ataxia; IV and V, 1 to 6 month old kids and 1to 4 year old adult goats, apparently normal

[1] Normal expected Levels : Ca 2.3-2.9 ,Mg 1.1-1.5 and P, 1.5-5.3 mmol/L; Cu 9.4-23.6 and Zn 12.7-16.8 µmol/L (Smith and Sherman,1994)

[2] * $P < 0.05$; *** $P < 0.001$; NS Not Significant

TABLE IV
Forage macro (% dm) and micro (ppm) mineral levels of swayback affected farms

Mineral	Mean[1] and range	± SD	Minimum requirement[2]	% Below requirements
Ca	0.36 (0.07 - 0.86)	0.20	0.20	24
Mg	0.26 (0.10 - 0.86)	0.13	0.12(0.20)	0(47)
P	0.26 (0.07 - 0.79)	0.09	0.16(0.20)	0(16)
Na	0.16 (0.03 - 0.18)	0.14	0.09	40
K	1.80 (1.03 - 3.66)	0.72	0.50	0
SO_4	0.14 (0.12 - 0.16)	0.01	----	0
Cu	5.3 (1.2 - 10.7)	2.18	7(5)[3]	85(49)
Zn	58 (26 - 175)	28.8	20	0
Fe	133 (74 - 356)	56.9	20	0
Mn	186 (16 - 797)	150.2	20	0

[1] Based on 45 grass samples
[2] Lower Limit or Minimum Requirements for Sheep (NRC, 1985)
[3] Deficient level associated with swayback in lambs (Underwood and Suttle, 1999))

2008 Proceedings of the Caribbean Food Crops Society. 44(2):495-499. 2008

Poster #38

Lamb's Voluntary Intake and Digestibility of Forage Soybean 'Hinson Long-Juvenile" (*Glycine max*) and Lablab 'Rongai' [*Lablab purpureus* (L.) Sweet]

Rivera-Melendez, F.[1], A. Rodriguez-Carias[1] and E. Valencia[1], [1]Department of Animal Industry and [2]Agronomy and Soils Department, University of Puerto Rico, Mayagüez, Box 9030, Mayagüez, PR 00681. frm9612@uprm.edu

ABSTRACT.
In Puerto Rico, tropical grasses do not adequately meet the nutritional requirements of dairy cows. For this reason, imports alfalfa hay and costly concentrate based diets are used in the dairy industry. It has been widely documented that legumes are generally higher in nutritive value than grasses, but information on forage intake and nutritive value of the annual legumes forage soybean Hinson Long-Juvenile (HLJ) (*Gyicine max*) and lablab cv. Rongai [*Lablab purpureus* (L.) Sweet] is limited. The research objective was to compare daily intake, and dry matter, crude protein (CP), and neutral detergent fiber (NDF) digestibility of 'HLJ' and 'Rongai' hay when fed to mature lambs. The experiment was conducted at the University of Puerto Rico, Finca Alzamora using rams (28.4±4 kg BW) in a completely randomized design with three replicates. Rams were housed in individual cages and fed treatment diets for a 7d adaptation period and 5d of data collection. Higher voluntary feed intake ($P<0.05$) was observed by rams fed 'HLJ' than Rongai (0.944 vs. 0.852 kg/d). Crude protein and NDF concentration were 15.7 and 15.5% and 42.8, and 41.7% for HLJ and Rongai, respectively. CP and NDF digestibility of HLJ and Rongai did not differ ($P>0.05$). But DM Digestibility (56.2 vs. 49.6%) was higher ($P<0.05$) in HLJ than Rongai. Both HLJ and Rongai exhibit potential for use in hay conservation systems to improve the feeding value of diet basal on grass hay and minimize concentrate use in dairy cows.

KEYWORDS: Voluntary intake, forage soybean, lablab

RESUMEN.
En Puerto Rico, las gramíneas tropicales no cumplen adecuadamente los requerimientos nutricionales de las vacas lecheras. Por consiguiente, se utilizan henos de alfalfa y dietas basadas en alimentos concentrados de altos costos en la industria lechera. Se ha documentado extensamente que las leguminosas generalmente tienen mayor valor nutritivo que las gramíneas, pero información en el consumo y valor nutritivo forrajero de las leguminosas anuales soya forrajera Hinson Long-Juvenile (HLJ) (*Gyicine max*) y Lablab cv. Rongai [*Lablab purpureus* (L.) Sweet] es limitada. El objetivo de esta investigación fue comparar el consume diario de materia seca, proteína bruta (CP), y fibra detergente neutro (NDF) y digestibilidad de henos de HLJ y Rongai en la alimentación de ovinos adultos. El experimento fue conducido en la Universidad de Puerto Rico, Finca Alzamora utilizando ovejos (28.4±4 kg peso vivo) en cajas individuales y alimentados por un periodo de 7 días de adaptación y 5 de recolección de

datos. Se observo mayor consumo voluntario (P<0.05) por los ovejos alimentados por HLJ en comparación con Rongai (0.944 vs. 0.852 kg/d), no se encontró diferencia significativa (P>0.05) en el contenido de proteína bruta y de FDN, los cuales se obtuvieron 15.7%, 15.5% y 42.8, 41.7 para HLJ y Rongai respectivamente. Aunque la digestibilidad (56.2 vs. 49.6%) fue mayor (P<0.05) en HLJ en comparación con Rongai. Ambas leguminosas forrajeras HLJ y Rongai presentan gran potencial en sistemas de conservación utilizando henos para mejorar el valor alimenticio de dietas básales de gramíneas y reducir la utilización de concentrados en las industrias lecheras.

PALABRAS CLAVES: Consumo voluntario, soya forrajera, lablab

INTRODUCTION

Forage intake, especially the fibrous part, is vitally important in ruminant feeding. Ruminants require a high level of quality fiber in their diets for good rumen function, feed efficiency and production (milk, meat, hair). In Puerto Rico, native or naturalized grasses do not meet the nutritional requirements of high producing ruminants. For this reason, alfalfa hay and concentrate based diets are used in the dairy industry.

Tropical forage legumes represent an alternative to increase animal performance in the tropics (Skerman et al., 1992) and are an option to minimize the use of concentrates and alfalfa in milk production systems in Puerto Rico. The addition of legumes in tropical pastures can improve CP concentration, rate of passage and feed intake (Kretschmer and Pitman, 2001).

Forage soybean (*Glycine* max) and Lablab (*Lablab purpureus*) are legumes with potential for use in dairy production systems in Puerto Rico. Soybean has been considered one of the best annual proteinecius seed and hay producing plant (Sheaffer et al., 2001). It provides high protein and energy feed supplement that compliments ruminant nutritional requirements (Rotz et al., 2001). Lablab can be grazed or used for hay or silage; its foliage has high protein and digestibility (Murphy et al., 1999) and lablab is among the most palatable legume for livestock (Valenzuela et al., 2002).

In Puerto Rico, information on forage intake and nutritive value of the annual legumes forage soybean Hinson Long-Juvenile ('HLJ') (*Gyicine max*) and lablab cv. Rongai [*Lablab purpureus* (L.) Sweet] are limited. Research objectives were to compare daily intake, and dry matter, crude protein (CP), and neutral detergent fiber (NDF) digestibility of HLJ and Rongai hay when fed to mature lambs.

MATERIAL AND METHODS

The experiment was conducted at the University of Puerto Rico, Finca Alzamora using rams (28.4±4 kg BW) in a completely randomized design with three replicates. Rams were housed in individual cages and feed treatment diets for a 7d adaptation period and 5d of data collection. Treatments used were Soybean cv. Hinson Long-Juvenile (HLJ) and. Rongai sun cured hay (66-d re-growth) at 4% of body weight and fed *ad libitum*. Hay offered, rejected and digestibility [(intake-feces/intake) *100)] were determined. At the end of the period rams were weighed and representative samples were taken of feed offered, rejected and feces for crude protein and NDF determination.

Chemical analyses were conducted at the Animal Nutrition Laboratory of the University of Puerto Rico, Mayagüez. Crude protein was determined by micro-Kjeldhal

method using a nitrogen analyzer *Kjeltec system 1002* (CP = N*6.25). Neutral detergent fiber (NDF) was determined with the Fiber Analyzer Ankom 200, following the methodology of Van Soest et al. (1991) (CC = 100-NDF). Data were analyzed according to a completely randomized design with a SAS program (2006) with α= .05.

RESULTS AND DISCUSSION

There was treatment difference (P<0.05). Higher voluntary feed intake (P<0.05) was observed by rams fed HLJ than Rongai (0.944 vs. 0.852 kg/d). Higher intake (100 g) of HLJ hay (80% of forage on offer consumed) can be attributed to a higher leaf:stem ratio as compared to Rongai (75% of forage on offer consumed). Crude protein and NDF concentration were 15.7 and 15.5% and 42.8, and 41.7% for 'HLJ' and Rongai, respectively. Both CP and NDF digestibility of HLJ and Rongai did not differ (P>0.05), but DM digestibility (56.2 vs. 49.6%) was higher (P<0.05) in HLJ than Rongai (Table 1 and Figure 1).

Voluntary intake is the most important factor in production systems and is associated with quality and palatability. In this study we observed that both hays were readily consumed. Valenzuela and Smith (2002) described lablab as highly palatable with 55% digestibility and similar to the digestibility of Rongai observed in this study. Dry matter digestibility of HLJ was in the range reported previously (56.2%).

Crude protein (>15%) and NDF (42%) values for both HLJ and Rongai reflect a high quality forage. Tobias and Villalobos (2004) reported that soybean harvested at R6 stage (full seed 90-d) had 20% CP and 42% of NDF. It is well documented that season of the year has an effect in plant development and disposition of nutrient content. Many studies also found an increase in the fiber fraction of the plant with it maturity (Murphy and Colucci, 1999). Additional studies should assess date of maturity of both HJL and Rongai.

CONCLUSIONS

Both HLJ and Rongai exhibited high voluntary intake, as well as excellent CP and NDF supporting their potential for use in hay conservation systems to improve the feeding value of grass hay based diets and minimize concentrate use in dairy cows in Puerto Rico. Lambs feed with HLJ showed more voluntary intake and higher digestibility in comparison with Rongai hay. It was observed that leaves were preferred by lambs rather than stem fractions. Others nutritional and non-nutritional factors have to be considered to determine which one of these legumes hays have better forage quality.

ACKNOWLEDGMENTS

Research was financially supported by the TSTAR grant "Improving the productivity of warm season legumes"

REFERENCES

Murphy, A.M., P.E. Colucci, and M.R. Padilla. 1999. Analysis of the growth and nutritional characteristics of *Lablab purpureus*. Livestock Research for Rural Development. (11)3:1999. http://www.cipav.org.co/lrrd/lrrd11/2/colu112.htm

Murphy, A.M. and Colucci, P. E. 1999. A tropical forage solution to poor quality ruminant diets: A review of *Lablab purpureus*. Livestock Research for Rural Development. (11)2:1999. http://www.cipav.org.co/lrrd/lrrd11/2/colu112.htm

Pirela, M. F. 2005. Valor nutritivo de los pastos tropicales. Manual de Ganadería de doble Propósito.

Sheaffer C. C., J.H Orf, T.E. Devine and J.G. Jewett. 2001. Yield and Quality of forage soybean. Agron. J. 93:99-106.

Skerman, P. J., D. G. Cameron y F. Riveros 1992. Leguminosas forrajeras tropicales. Colección FAO: Producción y Protección Vegetal 2:1-635 (1992).

Tobias, C. y E. Villalobos. 2004. Producción y valor nutritivo del forraje de soya en condiciones tropicales adversas. Revista Agonomía Costaricense. 28 (1): 17-25.

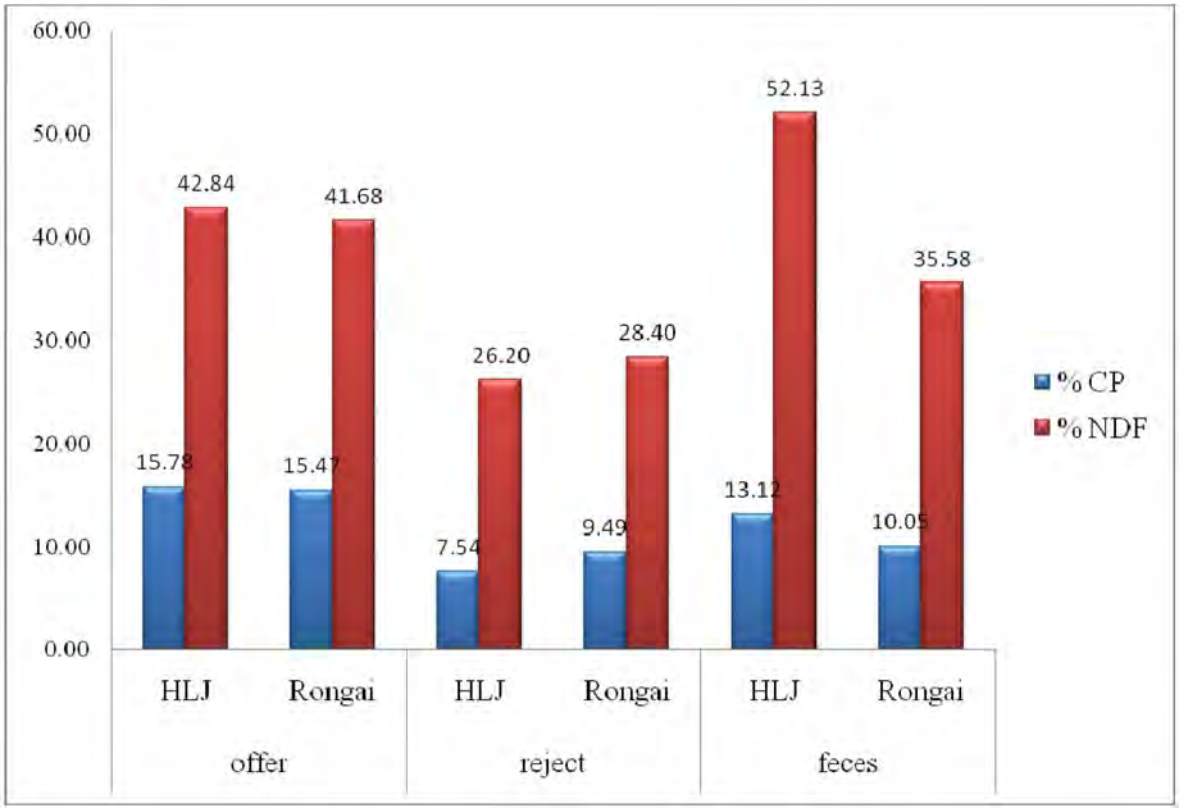
Valenzuela, H. and J. Smith. 2002. Lablab. Cooperative Extension Service College of Tropical Agriculture and Human Resources. University of Hawaii, Manoa.

Table 1. Voluntary daily intake and digestibility of forage soybean Hinson long-juvenile and lablab cv. Rongai hay.

Treatments	Voluntary Intake (Kg)	Intake of total offered (%)	Digestibility (%)
Soybean (HLJ)	0.94a	80.05a	56.22a
Rongai	0.85b	75.01b	49.59b

Values followed by the same letter are not significantly different.

Figure 1. Crude Protein and NDF concentration of forage soybean Hinson long-juvenile (HLJ) and Lablab cv. Rongai hay



2008 Proceedings of the Caribbean Food Crops Society. 44(2):500. 2008

Poster #39

Composición Química de *Stylosanthes guianensis* Fresco o Fermentado en Pacas Cilíndricas durante dos Periodos de Fermentación

Vázquez, M.S.[1], A.A. Rodríguez[1], E. Valencia[2], y P. Randel[1]. [1]Departamento de Industria Pecuaria y [2] Departamento de Agronomía y Suelos, Universidad de Puerto Rico, Recinto Universitario de Mayagüez. marie_socky@hotmail.com

RESUMEN.
Las leguminosas tropicales ofrecidas como forraje fresco o heno son una alternativa para utilizarlas en dietas para rumiantes, sin embargo, su uso potencial como henilaje fermentado en pacas cilíndricas todavía no está bien documentado. El objetivo de este estudio fue comparar la composición química de heno de gramíneas tropicales (HGT) y *Stylosanthes guianensis* fresco (SGF) o henilado en pacas cilíndricas durante 30 (SGF1) o 72 días (SGF2). Muestras de HGT y de SGF se analizaron para determinar su contenido de MS, PB, FDA, FDN, hemicelulosa (FDN-FDA), carbohidratos no fibrosos (CNF) y NDT. Además, tres pacas de stylosanthes a cada largo de fermentación (SGF1 y SGF2) se analizaron para las mismas variables de composición química y para la relación N-NH_3/N-total. La data se analizó mediante un diseño completamente aleatorizado utilizando el paquete estadístico de SAS. La separación de medias se realizó mediante la prueba de Tukey. La composición química del SGF fue de 14.1% PB, 59.80% FDN, 47.00% FDA, 20.50% CNF, 57.00% NDT y 12.80% hemicelulosa, mientras que la de HGT fue de 7.01% PB, 70.70% FDN, 41.8% FDA, 15.90% CNF, 54.00% NDT y 28.90% hemicelulosa. Henilar SG en pacas cilíndricas durante 30 o 72 días disminuyó el contenido de CNF 7.7% y 2.77% respectivamente, pero aumentó el contenido de FDN 9.60% después de 30 d de fermentación y 3.60% después 72 d. La relación N-NH_3/N-total fue mayor en SGF2 (7.38%) que en SGF1 (4.16%). En resumen, SGF contiene un mejor perfil de nutrientes que HGT. Henilar SG en pacas cilíndricas degrada proteínas a N-NH_3, disminuye el contenido de CNF y aumenta el % de FDN, sin embargo estos cambios son menos apreciables en henilaje fermentado durante períodos de fermentación más cortos (30 vs 72d).

PALABRAS CLAVES: Stylosanthes, Henilaje, pacas cilíndricas

2008 Proceedings of the Caribbean Food Crops Society. 44(2):501-504. 2008

Poster #40

Liquid Urea Rate Effects on Nutritive Value of 8-Week Regrowth of Guineagrass (*Panicum maximum* Jacq.) Hay

Almodóvar L. E.[1], E. Valencia[1], y A. Rodríguez[2]. [1]Department of Agronomy and Soils University of Puerto Rico Mayagüez and [2]Department of Animal Industry University of Puerto Rico Mayagüez, Box 9030, Mayagüez, PR 00681.

ABSTRACT.
Guineagrass (*Panicum maximum* Jacq.) is a valuable grass in grazing systems in Puerto Rico, but when conserved as hay, its low protein (<6.0%) concentration limits both meat and milk production. This study assessed the effect of applying liquid urea (LU) on hay harvested at 8-weeks regrowth of guineagrass cvs. 'Mombasa' and 'Tanzania' hay. Liquid urea were applied in a fine mist at baling at low (L; 0 lt/ha), medium (M; 204 lt/ha) and high rate (H; 807 lt/ha). Hays were stored for 8 week and core samples (250 g) were taken for determination of chemical composition of crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) using a completely randomized design. There were cultivar effects and LU rate effects ($P<0.05$) for CP, but there was no interaction. Crude protein averaged 13 and 17.7% for cv. Mombasa and Tanzania, respectively. There was a linear increase ($P<0.05$) in CP with an increasing rate of LU. Mean CP was 12, 15 and 20% for the L, M, and H rate, respectively. Additive LU did not affect ($P<0.05$) either NDF or ADF concentration in Mombasa and Tanzania. This study shows that adding LU at baling increases CP, but has no effect on NDF or ADF. Liquid urea at either concentration can be used to increase the nutritive value of low quality hay in Puerto Rico. Forage intake and digestibility and nitrogen balance studies, however, are needed to determine potential losses of N.

KEYWORDS: Grazing systems, crude protein, NDF, ADF

INTRODUCTION.

Guineagrass (*Panicum maximum* Jacq.) is naturalized in the Caribbean Island and Puerto Rico and used mainly for grazing and green chop. It is seldom conserved as hay because of its low protein (<6.0%) concentration and low digestibility. In hay conservation systems in Puerto Rico hay producers generally give greater importance to yield (quantity per acre) than the quality of the same. Rodriguez et al. (2004) noted that hay conserved in tropical conditions is usually of poor nutritive value because the pastures are not harvested at the appropriate vegetative stage, and it is very common to see hay from pastures after the flowering period.

Hay nutritive value can be improved by N fertilization and harvesting at early re-growth stages (60d). Chemical treatment (e.g., ammonization) has been used to improve the nutritional value of fodder preserved in the form of hay (Brown, 1993). The N concentration is usually increased by ammonization to levels considered to meet animal requirements. Amonification allows conserving starches and sugars of high energy value

in the original form, avoiding its loss by fermentation, which is then translated in forage of a high nutritious value. Ammonia hydrolysis of linkages between lignin and structural polysaccharides has been shown to increase digestibility (Conrad et al., 1990).

New guineagrass cv. Mombasa and Tanzania exhibit potential for forage conservation (hay or haylage) in Puerto Rico (E. Valencia; personal communication) but its nutritive value needs to be improved if it is to be fed to dairy cows. Liquid urea (LU) nitrogen (ULB-35; 15% of the active ingredient is Urea Low Biuret) is being promoted as N fertilizer in pastures, but limited plant response is observed. The objective of this study was to assess the effect of applying LU in a fine mist at baling at a low (L; 0 lt/ha), medium (M; 204 lt/ha) and high rate (H; 408 lt/ha) to 8-wk regrowths of Mombasa and Tanzania on its nutritive value after an 8-wk storage.

MATERIALS AND METHODS.

The experiment was conducted at the Lajas Agricultural Experimental substation of the University of Puerto Rico. Soil type was of the Fraternidad series (fine, smectitic Isohyperthermic Typic Haplusterts).

Guineagrass cvs. were planted in 8 plots of 0.22 ha each; four plots of Mombasa and four plots of Tanzania. At 120d, established plots were clipped to 15-cm height, and subdivided in three subplots. Plots at clipping were maintained with a base N fertilizer (56 kg/ha amonium sulfate).

Experimental treatments were randomly assigned and included a low (L; 0 kg/ha), medium (M; 30kg/ha) and high (H; 60 kg/ha) LU (15% N). At 8-wks regrowth guineagrass plots were clipped at 15-cm, and air dried for 3-d. When baled, LU was applied in a fine mist using a boom sprayer. Bales were stored in a dry place for 8-wks prior to sampling. Core samples, three randomly selected bales from each LU treatment and cv. (24 bales) were taken using a master forage probe. Representative samples of each bale (500 g) were ground in a Willey mill and analyzed for crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF) using standardized laboratory procedures.

Data was analyzed using Proc. Mixed of SAS (2008). Linear and quadratic treatment effects determined.

RESULTS.

There were cultivar effects and LU rate effects ($P<0.05$) for CP, but there was no interaction. Crude protein averaged 13 and 17.7% for cv. Mombasa and Tanzania, respectively. There was a linear increase ($P<0.05$) in CP with an increasing rate of LU. Mean CP was 12, 15 and 20% for the L, M, and H rate, respectively. The fertilization only with the ammonium sulfate gave from 10 to 13% of CP for cv. Mombasa and Tanzania, respectively. Additive LU did not affect ($P>0.05$) either NDF or ADF concentration in Mombasa and Tanzania (Table 1). Merrill et al. (1961) and Rodriguez-Carrasquel et al. (1983) reported similar increases in CP with N or urea applications to mature hays.

CONCLUSION.

This study shows that adding LU at baling increases CP, but has no effect on NDF or ADF. Liquid urea at either concentration can be used to increase the nutritive value of

low quality hay in Puerto Rico. Forage intake and digestibility and nitrogen balance studies, however, are needed to determine potential losses of N.

ACKNOWLEDGMENTS.
Research was financially supported by HATCH formula funds (H-401) of the Agriculture Experiment Station, Univ. of Puerto Rico.

REFERENCES.

Brown, W., 1993. Cane molasses and cottonseed meal supplementation of ammoniated tropical grass hay for yearling cattle. J. Anim. Sci. 71:3451.

Conrad J., R. Pastrana. 1990 Amonificacion usando urea para mejorar el valor nutritive de materials fibrosos. Revista ICA-Informa, Bogotá-Colombia. v. 24(2) p. 5-11.

Knapp, W. R., D. A. Holt and V. L. Lechtenberg. 1975. Hay preservation and Quality improvement by anhydrous ammonia treatment. Agron. J. 67:766-769.

Merrill, W. G., J. K. Loosli, R. L. Mitchell and W. K. Kennedy. 1961. Effects of foliar application of urea on the yield and nutritive value of some grass hays. J.Anim. Sci. 20:785-791.

Rodriguez-Carrasquel, S., C. F. Chicco, y E. Chacón. 1983. Efecto de la aspersión de urea sobre el rendimiento, composición química y digestibilidad del pasto pangola y A-24. Agronomía Tropical 24(3):183-192.

Rodríguez-Romero, N., O., Araujo-Febres, y B., González., 2004. Efecto de la adición de urea sobre la composición química y digestibilidad *In vitro* de la materia seca de heno de *Brachiaria humidicola* (Rendle) Shweick cosechado a diferentes edades. Arch. Latinoam. Prod. Anim. Vol.12 (2): 52-58.

Ventura, M., A. Barrios., I. Morales, C. Toro, K. Barreto, F. Noguera. 2002. Efecto de la Amonificacion seca sobre el valor nutricional de la soca de sorgo (*Sorghum bicolor* L. Moench). Revista Científica Vol.XII-Suplemento 2, Octubre, 513-516.

Table 1. Effect of liquid urea rates (kg/ha) on crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF) % of guineagrass cv. Mombasa and Tanzania.

	cv. Mombasa			cv. Tanzania		
Liquid Urea	CP	ADF	NDF	CP	ADF	NDF
Kg/ha	%			%		
0	10.5±1.67	42.8	67.6	13.7±1.67	42.0	66.7
30	14.4±1.67	41.8	65.6	15.5±1.67	39.6	67.2
60	17.0±1.67	41.4	66.3	24.1±1.67	43.0	67.0
†L	*	NS	NS	*	NS	NS
††Q	NS	NS	NS	NS	NS	NS

†Linear
††Quadratic

2008 Proceedings of the Caribbean Food Crops Society. 44(2):505. 2008

Poster #41

Fermentation Characteristics and Consumption of Forage Sorghum and Sudax Ensiled in Round Bales

W. Rodríguez[1], A.A. Rodríguez[1] and E. Valencia [2]. [1]Departament of Animal Industry[1] and [2]Department of Agronomy and Soils, University of Puerto Rico, Mayagüez Campus. Wandaliz_rodriguez@yahoo.com; abner@uprm.edu

ABSTRACT.
Forage sorghum ([*Sorghum bicolo*r (L.) Moench.] is an important forage crop in the tropics because of its high productivity and ability to utilize water efficiently. However, information about it potential use in ruminant diets as haylage fermented in round bales (RB) is limited. The objective of this experiment was to compare the fermentation characteristics forage sorghum and sorghum x Sudangrass hybrid (Sudax) and to determine daily intake by sheep. Forage sorghum (FS; DM 34%) and Sudax (DM 35%) were harvested at 90 days of growth and preserved as haylage in round bales (RB; 400 kg). Eight RB per variety were prepared and two were opened and sampled after 3,7,14 and 30 d of fermentation and pH and fermentation products determined. Data was analyzed as a completely randomized design with a 2 (sorghum varieties) by 5 (days of fermentation) factorial arrangement of treatments. To assess forage intake, 8 lambs were assigned to either forage (N=4) in individual pens. Forages were offered and orts were collected during 12 d with a 7 d adaptation and 5 d data collection period. Daily forage on offer was 3% of lamb BW on dry matter basis. Final pH was lower (P<.05) in FS (6.10) than in Sudax (6.14), however, sorghum variety did no affect final lactic acid, acetic acid and butyric acid content. There were no differences in forage intake between varieties by lambs (624 and 676 g/d for FS and Sudax, respectively). In summary, fermentation characteristics of SF were greater than Sudax as evidenced by lower pH, however, sorghum variety did not affect lamb haylage intake.

KEYWORDS: Sorghum, haylage, round bales, lambs intake

2008 Proceedings of the Caribbean Food Crops Society. 44(2):506. 2008

Poster #42

Composición Química y Consumo Voluntario de *Calliandra calothyrsus* Deshidratada o Fresca por Ovinos y Caprinos

Lisa Dillon[1], Melanie Román Zayas[1], Abner A. Rodríguez Carías[1] y Elide Valencia[2]. [1] Departamento de Industria Pecuaria [2] Departamento de Agronomía y Suelos, Universidad de Puerto Rico, Recinto de Mayagüez. abner@uprm.edu, ldf23932@uprm.edu

RESUMEN.
Se realizaron dos experimentos con el objetivo de evaluar la composición química y la inclusión de hojas de *Calliandra calothyrsus* deshidratada (CCD) o ramas frescas de la misma leguminosa (CCF) a razón de 25% de la materia seca (MS) dietética sobre el consumo voluntario (CV) de heno de gramíneas tropicales (HGT) utilizando ovinos y caprinos. Se utilizaron cuatro caprinos en el experimento uno con CCD y cuatro ovinos con CCF en el experimento dos. En cada estudio los animales fueron confinados en jaulas individuales y alimentados con 100% HGT ó 75% HGT y 25% CCD o CCF. El ofrecimiento del forraje fue basado en un CV de MS total estimado en 4% PV/d. Los forrajes se analizaron para determinar su contenido de PB, FND y FAD. Ambos experimentos se llevaron a cabo durante dos periodos de diez días con cinco días de adaptación a la dieta y cinco días de recolección de data. En cada estudio, se registró la cantidad de forraje ofrecido y rechazado para calcular el CV. La data de ambos experimentos se analizó según un diseño cuadrado latino 2 * 2. Los valores de PB, FND y FAD de CCD fueron de 14.2, 40.9 y 33.9 %, respectivamente. Las ramas frescas de la leguminosa presentaron contenidos de PB, FDN y FDA de 10.6, 58.6 y 55.3%, respectivamente. En Ambos experimentos el consumo total de forraje fue mayor en cabros y ovinos alimentados con 75% HGT y 25% CCD o CCF que los alimentados con 100% HGT. En resumen, la composición bromatológica y la forma física (hojas vs. ramas y deshidratada o fresca) afecta la composición química de *Calliandra calothyrus*. Sin embargo, en ambos experimentos los animales demostraron un mayor CV cuando se les ofreció 25% CCD o CCF en la dieta. La CC henificada o fresca representa una excelente fuente de nutrientes para pequeños rumiantes. Estudios futuros deben realizarse incluyendo CCD o CCF en la dieta en porcientos mayores de 25.

PALABRAS CLAVES:

2008 Proceedings of the Caribbean Food Crops Society. 44(2):507-515. 2008

Poster #43

The Evaluation of Three Feeding Regimens and Three Anthelmintics in a Meat Goat Production System: a Florida A&M University Research/ Extension Project

T. E. Peterson, R. Mobley, G. Nurse, F. Okpebholo, C. J. Lyttle-N'guessan, G. Queeley, T. Kahan; Cooperative Extension Program, College of Engineering Sciences, Technology and Agriculture, Florida A&M University, Tallahassee, Florida. Thomas.peterson@famu.edu

ABSTRACT.
Food safety starts at the farm gate. Proper management and feeding are important to the productivity and survivability of the farm as well as to the health and safety of the food supply. Nutrition and internal parasites are two factors that affect the growth of the meat goat industry in Florida. The project evaluated three common feeding strategies [(i) a cracked corn feed, (ii) a 12% crude protein commercial feed, and (iii) a 16% crude protein commercial feed)] and three anthelmintics for their effects on weight gain and economic efficiency, and any resistance among the herd, respectively. The results indicated that the 12% crude protein commercial feed-feeding regimen was the most economical / sustainable, and had the lowest weight gain. In addition, the results indicated that Florida A&M University, Research Extension Center herd might be resistant to the Levamisole type anthelmintic. One of the objectives, also, was to apply the most efficient resources to maintain food safety. The aim is to attain healthier animals through proper nutrition, weight gain and carcass quality, thereby maximizing safe food supply.

KEYWORDS: food safety, anthelmintic, resistance

INTRODUCTION

Feed management and internal parasites are two of the biggest constraints to the growth of the meat goat industry in Florida. Proper management of these issues is a necessity to the survival of a small ruminant enterprise in terms of profitability and productivity. Producers must think of efficiency and effectiveness when developing a management system for their herd.

In most livestock production systems, cost of feed amounts to 60-75% of the total cost of production. Feed efficiency is, therefore, key to the profitability of a livestock project. The basic goal of feed efficiency is to maximize profits while assuring that the animals receive the necessary amount of nutrients to perform for growth and development. For small farmers in particularly, sustainability is important.

Internal parasite infection is one of the biggest problems in the small ruminant industry. Internal parasite infestations of herds cause great losses to the producer by decreasing the performance ability of the herd. Since anthelmintic resistance among goat herds is increasing, the proper management of internal parasites is extremely important to the success of the goat producer. The misuse (or overuse) of anthelmintics is one of the main cause of the build up of resistance. Misuse and overuse of anthelmintics also impact

the farmer economically, as anthelmintics can be very expensive (Waller, 2004). Goat producers must be knowledgeable about proper internal parasite management techniques, especially in tropical and subtropical areas like Florida, where internal parasites are a major problem.

The purpose of this project was to evaluate the effectiveness of three common feeding strategies on weight gain and economic efficiency. The project also evaluated three anthelmintics to detect if there was a resistance at the Florida A&M University Research and Extension Center (FAMU REC).

MATERIALS AND METHODS

Weight Gain Analysis:

Thirty-six kids with an average live weight of 36.1 pounds and an average age of five months were used to conduct this study at the Florida Agricultural and Mechanical University Research and Extension Center (FAMU REC) in Quincy, FL. The eight week study was conducted on bahia grass pastures between September and November 2006.

For the feeding regimen evaluation, the animals were randomly placed into three groups of 12 animals with similar average weights. The first group was fed cracked corn (corn) at the rate of 1.0 lb per animal daily and was allowed to graze freely on pasture. The second group was fed a 12% crude protein commercial feed (12%CP) at the rate of 1.0 lb per animal daily and was also allowed to graze freely on pasture. The third group was fed a 16% crude protein commercial feed (16%CP) ad-libitum but was limited in their ability to graze. The conditions of the third treatment simulated a feedlot situation. The animals of the 16%CP group were placed on a smaller amount of pasture land (approximately half the area of the other two groups) in order to increase the stocking density. The pasture of the 16%CP group was also cut to the ground weekly to allow only minimal access to grass. All the animals were weighed every two weeks (Days 0, 14, 28, and 54) for the duration of the study.

The animals in each feed regimen were then randomly divided into three groups of four animals and were treated with either avermectin (Cydectin© at 1 milliliter per 25 pounds), albendazole (Valbazen© at 0.75 milliliter per 20 pounds), or levamisole (Levasol© at 1 milliliter per 50 pounds). The dosages were based on the suggested rates on the label. The selection of animals for the evaluation of the anthelmintics was done so that there would be an even number of animals among each feed regimen. Fecal samples with an average weight of 1.6 grams were collected from each animal every two weeks (Days 0, 14, 28, and 54) in order to conduct a fecal analysis. Fecal egg counts (FEC) were determined with a simple flotation procedure using a salt flotation solution. The Fecal Egg Count Reduction Test (FECRT) was used to test for resistance among the anthelmintics. The FECRT is the percent reduction of the FECs from Day 0 to Day 54. Resistance in a herd is suspected if the reduction is less than 90 percent (Luginbuhl, 1998).

Economic Analysis:

Economic efficiency was evaluated by measuring the cost of production and weight gain per pound of feed used. Marginal productivity (MP) was calculated as the gain in live weight that resulted from consuming one additional pound of feed. The

marginal factor cost (MFC) and the marginal value product (MVP) were computed to determine and compare the optimum least cost production. The MFC is basically the average price per pound of feed. The MVP is the change in the total value of the product (change in live weight multiply by the price received per pound of weight) as a result of feeding one additional unit of feed. The difference between the MVP and the MFC was used to determine if the feeding regimen would earn more revenue than it would cost to follow the regimen. If the MVP is greater than the MFC, the regimen results in a product that could possibly earn a profit when considering only the cost of feed. Also, note that the comparison between the regimens was based only on the purchased inputs of feed and not the other costs related to the management of the animals such as the economic value of the pasture, the cost of medications, etc. The comparison relates the relative efficiency in live weight gain and profit potential between the feeding regimens with respect to the use of purchased inputs (McGowan & Leong, nd). The feed conversion rate and the feed per pound of weight gain were also calculated.

Fecal Analysis:

The fecal egg count (FEC) was used to identify the level of internal parasite infestation. The level of infestation was evaluated based on the following chart, which is the protocol for the FAMU REC.

100-250 EPG = Not a significant amount
250-500 EPG = Low infection level
500-1000 EPG = Moderate infection level
>1,000 EPG = High infection level

Statistical analysis was done using the general linear model procedure (PROC GLM) of SAS© software (SAS Institute, Inc., 1998). Significant differences were analyzed using the Least-squared Denominator test, using a level of significance of alpha=0.05. The percent reduction of the fecal egg counts from Day 0 to Day 14 was calculated and used to determine if there was resistance to the particular anthelmintic based on the limit of 90%.

RESULTS AND DISCUSSION

Weight Gain:

Animals under the 16%CP feeding regimen had the highest average weight, while animals in the 12%CP feeding regimen had the lowest average weight (Figure 1). Overall, animals under the 16%CP feeding regimen had the highest mean weight gain compared to the other treatments. The reason could be linked to the higher plane of nutrition because of the high protein level of the 16% feed and to the fact that the animals in this group were fed *ad libitum*. For the corn group, the weight gain was higher than that of the group fed with the 12%CP feed. This could relate to the fact that the corn feed contained more energy than the 12%CP feed. For the 12%CP group and the corn group, weight loss began to occur during the 55-70 day period, whereas the animals in the 16%CP treatment continued to gain weight. One possible explanation for this is that the quality of the pasture normally begins to decrease as winter approaches. The 12%CP

group and the corn group relied on pasture more than the 16%CP group, which was limited in its ability to graze and was given supplement *ad libitum*.

Economic Analysis

While the aim is to attain healthier animals through proper feeding and management techniques and strategies, economic efficiency and sustainability is also important. The group fed 16%CP resulted in the highest cost of feed per pound gain at $1.80 per pound of gain (Table 1). Although this is expected because protein is normally the most expensive component of a feed, the cost per pound of gain for this regimen is more than the average price that producers receive per pound of live weight, which is $1.25 per pound (Cosenza et al., 2003). Basically, this regimen would result in a producer spending more on feed than the revenue they would receive per pound of gain when the animal is sold, which would result in a negative profit. Although the average weight gain of goats in the 12%CP group was the lowest, it cost $0.79 for enough feed to produce a pound of gain. Additionally, the difference between the MVP and the MFC was the greatest for the 12%CP, which means that this feeding regimen has the possibility to produce the greatest amount of profit out of the three regimens evaluated when comparing the cost of feed to the potential revenue. Thus, the 12%CP feeding regimen is the most economically efficient.

Fecal Analysis:

The average FEC of the entire herd remain in and around the "not a significant amount" to the "low infection level" throughout the study. Although some individuals had large fecal egg counts at times, the average remained low. This also points to the need to treat individual animals instead of the entire herd because it is usually a minority of animals that shed the majority of the parasites.

Overall, the total worm FECs were similar for each feeding regimen. The difference in FECs over time did not change significantly, but a decreasing trend can be observed (Figure 2). The FECs decreased on Day 14 because of the effects of treatment with anthelmintics and increased after Day 14 because of re-infestation of the herd by parasites on the respective contaminated pastures. On Days 42 and 54, the animals in the 16%CP group had significantly higher FECs than the other two groups. The higher FEC could be attributed to the higher stocking density of the group in the 16%CP group and the lower grass levels of the paddock of this group, which could have led to a faster rate of re-infestation. In addition, the 16%CP group had the highest FEC's of Eimeria and Strongyloides (Figure 3). The FECs of Haemonchus, Nematodirus, and Monezia were similar for each feeding regimen.

The average FEC over all days for each anthelmintic were similar (Figure 4). Generally, the efficacy of the different common anthelmintics when used properly is trivial and should not be used to decide which anthelmintic to use. Although the three anthelmintics had similar FECs on Day 0, animals treated with levamisole had the highest mean FEC on Days 14 and 28. The percent reduction in FEC according to the FECRT described previously was found for each anthelmintic (Table 2), and it is suspected that the herd at the FAMU REC might be resistant to levamisole. Scarfe (1993) suggests that a less than acceptable FEC reduction could also indicate an improper dosage or an improper administration of the anthelmintic evaluated. After the completion of this study,

the dosage of levamisole was increased and another FECRT was performed. The reduction in the fecal egg counts of the animals treated with levamisole increased but more research needs to be done in order to make a conclusion. If under-dosing or improper dosing is suspected on a farm, those issues should be addressed relatively quickly as they will accelerate the build up of resistance. In addition, it is important to note that resistance varies between herds and the fact that resistance is suspected in one herd does not mean that another herd will also have the same level of resistance. The FECs between all anthelmintics at Day 54 were similar, which suggest that all the drugs no longer had any residual effects and were excreted from the system by this time.

The effects of the anthelmintics on the FECs of the individual species of parasites were also similar (Figure 5). According to the product labels, avermectin and levamisole are not effective against Monezia; whereas, albendazole is effective against Monezia. The mean FECs of Eimeria (coccidia) were similar for each anthelmintic. None of these anthelmintics are effective against coccidia. Coccidiosis is normally treated with sulfa drugs (Albon©) and Amprolium (Corid©). The sulfa drugs do not directly cure the coccidiosis but instead prevent secondary bacteria diarrhea.

CONCLUSION

Many of the methods of evaluation used in this study including the economic efficiency, weight gain, the FEC, and the FECRT can all be done on the farm of the average producer. It is important to evaluate feeding regimens for economic efficiency and their effect on animal performance. The most expensive feeds are often the least economically efficient. It is suggested that an extension agent be contacted to help develop a suitable feeding regimen for a particular production system.

For this study, the most economically efficient feeding regimen was the 12%CP feeding regimen although this feeding regimen had the lowest weight gain. With regards to the use of anthelmintics to control internal parasites, the most important consideration when using an anthelmintic is not what anthelmintic is used but proper dosage and administration techniques to impede the build up of resistance. It is important to consult a credible and knowledgeable source on proper management of internal parasites because many stress the importance of finding methods of parasite control that will allow producers to decrease their reliance on anthelmintics. The ability to properly manage and evaluate feeding regimens and internal parasite infestations will be beneficial to any goat producer.

REFERENCES

Cosenza, G. H., Williams, S. K., Johnson, D. D., Sims, C. and McGowan, C. H. (2003). *Development and evaluation of a fermented cabrito snack stick product.* Meat Science. 64: 51-57.

McGowan, C. H. and Leong, S. S.. (n.d.) *Comparative analysis of two meat goat management systems in north Florida.* Retrieved May 15, 2007, from http://www.famu.edu/oldsite/acad/colleges/cesta/comparative-analysis.html

Luginbuhl, J. (1998). *Gastrointestinal parasite management of meat goats.* Retrieved January 16, 2007, from http://www.cals.ncsu.eu/an_sci/extension/ animal/meatgoat/MGWormer.htm

Scarfe, A. D. (1993). *Approaches to managing gastrointestinal nematode parasites in small ruminants.* Retrieved March 19, 2007 from http://www.clemson.edu/agronomy/goats/handbook/nematode.html.

Waller, P. J. (2004). *Management and control of nematode parasites of small ruminants in the face of total anthelmintic failure.* Tropical biomedicine. 21:7-13.

Parameters Evaluated	Corn	12%CP	16%CP
Initial Avg. Weight (lbs)	32.2	31.3	32.0
Final Avg. Weight (lbs)	42.6	40.2	45.4
Avg. Weight Gain[a] (lbs)	10.4	8.9	13.4
Avg. Feed Consumed[b] (lbs)	69.9	70.5	136.0
Feed Conversion Rate[c] (lbs)	1 : 6.7	1 : 7.9	1 : 10.1
Feed Cost/Pound of Feed[d]	$ 0.17	$ 0.10	$ 0.18
Feed Cost/ Pound of Weight Gain[e]	$ 1.14	$ 0.79	$ 1.80
Marginal Productivity[f]	$ 0.15	$ 0.13	$ 0.10
Value of Marginal Product[g]	$ 12.99	$ 11.16	$16.80
Marginal Value Product[h]	$ 0.19	$ 0.16	$ 0.10
Marginal Factor Cost[i]	$ 0.17	$ 0.10	$ 0.18

Table 1. Analysis of the economic efficiency of three feeding regimens.

[a]Avg. Weight Gain (AWG) = (Final Avg. Weight – Initial Avg. Weight)
[b]Avg. Feed Consumed (AFC) = Amount Fed / Number of Days
[c] Feed Conversion Rate (FCR) = AFC / AWG
[d] Feed Cost/Pound of Feed (FC:F) = Cost of Feed / Total Amount of Feed
[e]Feed Cost / Pound of Weight Gain (FC:WG) = FC:F x AFC / AWG
[f]Marginal Productivity (MP) = AWG / AFC
[g]Value of Marginal Product (VMP) = (AWG x price per pound of weight) /AFC
[h]Marginal Value Product (MVP) = VMP / AFC
[i]Marginal Factor Cost = FC:F

Table 2. Fecal egg count reduction test (FECRT)

	Avermectin	Levamisole	Albendazole
FECRT[a]	0.95	-0.11	1.00

[a]FECRT equals the average fecal egg count of Day 0 minus the average fecal egg count of Day 14 divided by the average fecal egg count of Day 0.

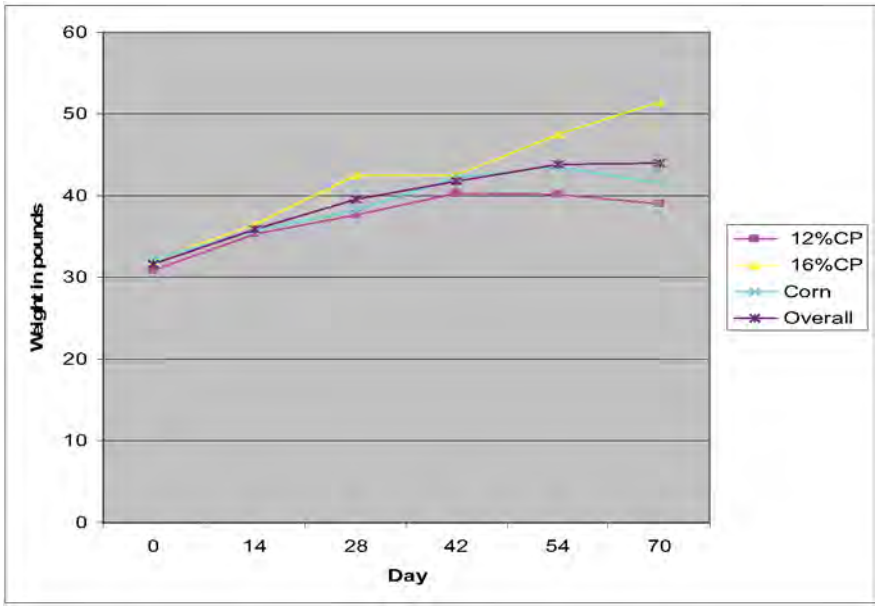


Figure 1. Average weight by feed regimen over time

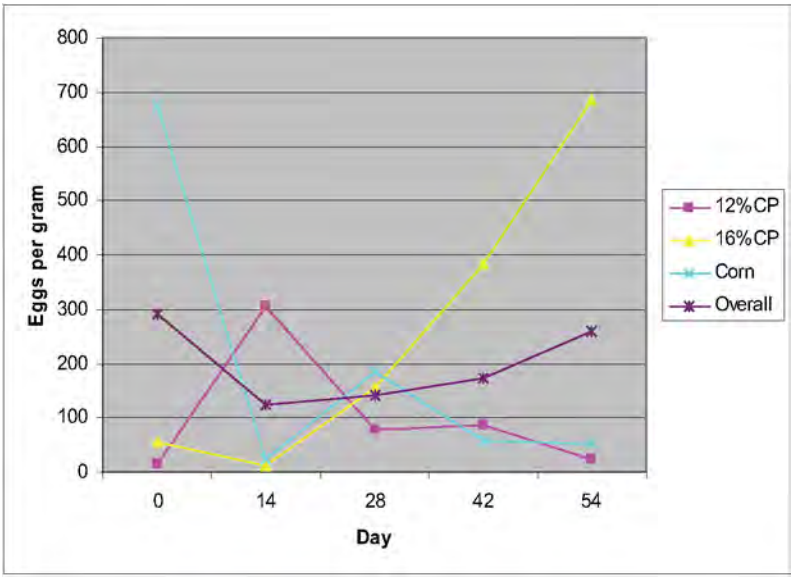


Figure 2. Fecal egg counts by feed regimen over time

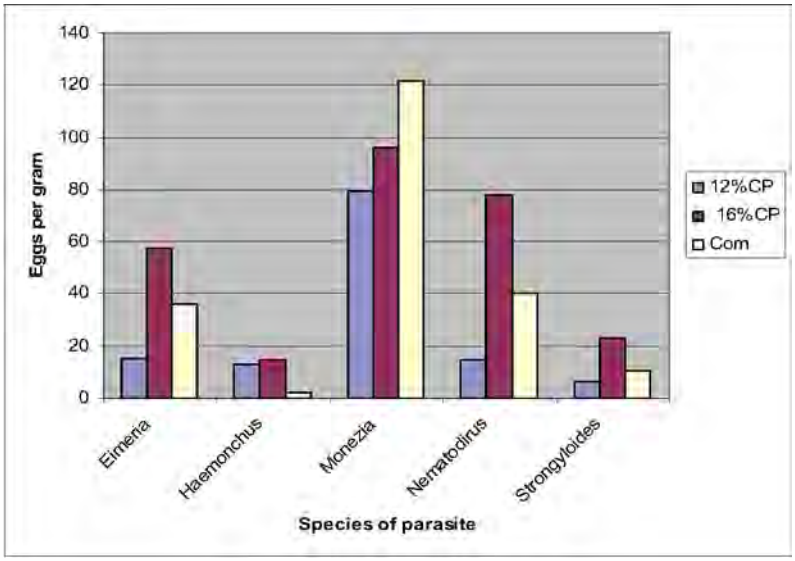


Figure 3. Fecal egg counts by species of parasite for each feed regimen

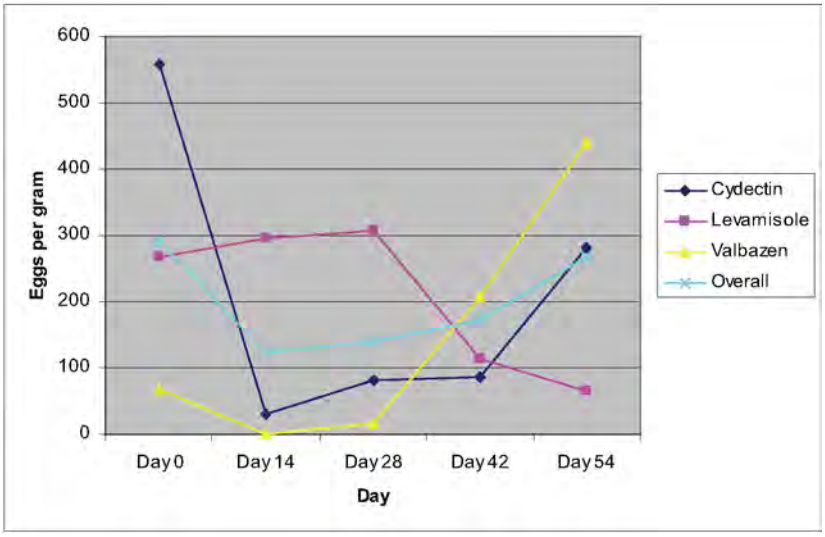


Figure 4. Fecal egg counts by anthelmenthic

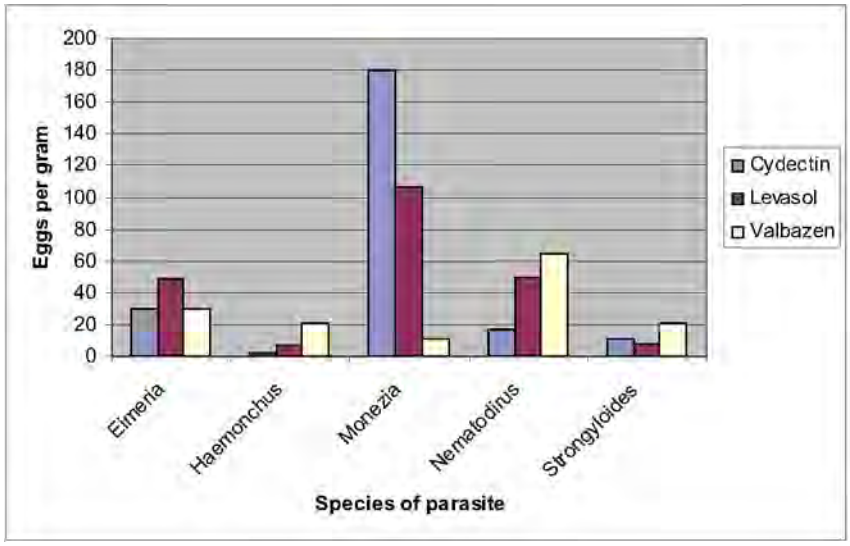


Figure 5. Fecal egg counts by species of parasite for anthelminthics

2008 Proceedings of the Caribbean Food Crops Society. 44(2):516-521. 2008

Poster #44

Stocking Rate Trial with Boer X Spanish Goats under Thinned Loblolly Pines

Nadine Gordon-Bradley and O. U. Onokpise, Agronomy, Forestry and Natural Resources Conservation Program, College of Engineering Sciences, Technology and Agriculture, Florida A&M University, Tallahassee, Florida 32307. gordonnadine@hotmail.com

ABSTRACT.
Goat meat is said to be one of the most highly consumed meat in the world. The perception of using goats for vegetation management other than as a grazing livestock remains very high. As the demand for goats increases due to healthy diet needs and ethnic population presence, the need to increase production using various grazing practices for small ruminants has begun to receive attention. The present study was conducted to determine stocking rates of Boer x Spanish goat crossbreeds in a silvopastoral system of loblolly pines and Tifton9 bahiagrass. The experimental area consisted of loblolly pine plantation that was planted in 1979 and thinned in November 2001 to 1.2- x 12-m spacing. Tifton-9 bahiagrass was planted between widely spaced loblolly pine trees. Treatments consisted of (1) shaded pastures and open pastures of Tifton-9 bahiagrass as the main plots, and (2) two stocking rates (10 and 17 goats per ha) crossbred goats as the subplots using a split-plot arrangement. Goats grazed paddocks using a rotational stocking method. Live weight data was used to calculate the average daily gain (ADG) and weight gain or loss of animals over the grazing period to determine recommended stocking. For Year 1, there was no significant difference in ADG of the animals for the shade treatment ($P = 0.124$) or stocking rate treatment ($P = 0.673$). For Year 2, the results showed a significant effect of stocking rate ($P = 0.003$) on ADG. The result from this study indicated that the low stocking rate was best for the goats evaluated. High stocking rates for both years caused weight loss thus indicating that a low stocking rate will be best for the paddock sizes used for the study. A silvopastoral system with goats at a stocking rate of 10 goats ha^{-1} averaging 34 -45 kg body weight on bahiagrass grown under trees can provide adequate forage.

KEYWORDS: silvopastoral system, Tifton-9 bahiagrass, stocking rate.

INTRODUCTION.

Meat goat production is increasing in the United States due to goats' economic value as efficient converters of low quality forages into quality meat, milk, and hides products for specialty markets (Engle et al., 2000). According to the National Agricultural Statistics Service, there are approximately 60,000 head of meat goats found in the state of Florida for 2007. The main reason for meat goat increase in the United States is the wide variety of ethnic groups that have settled in the United States who have a desire for goat meat, milk and other goat products (Engle et al., 2000). Another reason

is that with limited resources a small herd of goats may be the only livestock that a small farmer can raise in self-sustainable enterprises (Engle et al., 2000).

Farmers can use goats as brush control since goats tend to browse shrubs and trees more readily than grass (Mislevy et al., 2000). However, goats will graze well on improved grass pastures (Mislevy et al., 2000). Mature goats have a daily dry matter (DM) intake ranging from 30 to 50 g kg-1 of their body weight (Pinkerton et al., 1991). The quantity of the forage eaten by the animals per day is influenced by availability, DM concentration, digestibility, and rate of passage (Pinkerton et al., 1991).

Research data on stocking rate of small ruminant for silvopastoral systems is not readily available. With the increased influx of goat farmers in Florida and other southern states, coupled with the need for tree maintenance for environmental benefits, this type of information is needed for the farmers to decide upon an actual stocking rate using goats as the livestock component. The objective of this study was to provide information for an optimal stocking rate for Boer x Spanish crossbred goats for a silvopastoral system with loblolly pine trees.

MATERIALS AND METHODS.

Study Site

The site for this study is located at Florida A&M University Research and Extension Center Farm, Quincy, Florida. The farm is located in the lower southeastern region of the United States Geological Survey (USGS), 7.5-minute Dog-town quadrangle topography map. The property lies west of state road 267 and south of state road 272 at 30° 36″ N latitude and 84° 33″ W longitude (Clarke, 1999). The major land cover includes pine, mixed hardwood/pines forests, agriculture and non-vegetative urban infrastructure (Darbyshire, 1993).

The area used for this research consisted of loblolly pine that was planted in 1979. This area was thinned in November 2001 from the original spacing of 1.2 x 2.4 m to a 1.2 x 12-m spacing (Whilby, 2004).

Experimental Design

A split plot experimental design was used for these studies. Treatments consisted of 1) shaded pastures (existing under the established loblolly pines) and open pastures of Tifton 9 bahiagrass as main plots, and 2) two stocking rates (10 & 17 goats per hectare) of Boer x Spanish crossbred goats as subplots.

The total acreage used for this research was 1.62 hectares of land; 0.8 hectare shaded and 0.8 hectare unshaded. Both the shaded and unshaded areas were divided into four 0.2-ha experimental units. Each experimental unit was then further subdivided into two 0.1-ha paddocks. Each experimental unit consisted of two stocking rates of Boer x Spanish crossbreed of goats and there were two replications of each treatment. Goats grazed paddocks using a rotational stocking method. Goats were placed in each 0.1 ha paddock for 14 d then rotated to the second 0.1-ha paddock within that experimental unit for the next 14 d, that is, a 14-d grazing period followed by a 14-d rest period in each 0.1-ha paddock. Thus, there was a 28-d grazing cycle in all the experimental units.

Animal Management

For Year 1, thirty-two 18-month old animals were dewormed with cydectin at a rate of 1 cc per 9 kg animal weight. Iron (Ferrodex 5 ml / 23 kg) was given to each animal one week before assignment to pastures. For Year 2 the same deworming program was used, however, these animals were 36 months old. The animals were bred at Florida A&M University Research and Extension Station in Quincy, Florida. Animals were assigned randomly to treatments but balanced for average weight of animals. For Year 1, the average initial weight of the animals was 23 kg (0.08 AU). Animals were assigned to pastures on September 27, 2005. For Year 2, 32 adult animals were selected averaging 45 kg initial body weight (0.17 AU) and assigned to pastures on August 22, 2006. Each paddock within each experimental unit was grazed by the assigned stocking rates for the Boer x Spanish goats.

Data Collection for the Goat Weights

Live weight data was collected for goats during a two-year study. For Year 1, initial weights of animals were collected before they entered into the grazing trial and another weight was taken 6 wk later at the end of the grazing trial. For Year 2, goats were weighed at the beginning and every 28 d after being introduced into the paddocks.

Weight Analysis for Goats

Live weight data was used to calculate the average daily gain (ADG) and weight gain or loss of animals over the grazing period. Average daily gain was calculated using the following formula:

$$\frac{FW - IW}{\text{\# of grazing days}}$$

FW = final weight, IW = initial weight

Statistical Analysis

Animal performance responses were analyzed using the Proc Mixed of SAS at the 0.05 probability level. The treatments were shade (shaded versus unshaded) and stocking rate (high (17 animals ha^{-1}) and low (10 animals ha^{-1}) animals) with two replications. Average weight for the animals over the entire grazing period was also analyzed using analysis of variance. Treatments were stocking rate, shade and dates.

RESULTS/DISCUSSION.

For Year 1, there was no significant difference in average daily gain (ADG) of the animals for the shade treatment (P = 0.124) or stocking rate treatment (P = 0.673). Animals in the shaded area lost an average of 0.017 kg d-1 while the goats in the unshaded area gained an average of 0.016 kg d^{-1}. Goats in the low stocking rate gained an average of 0.004 kg d^{-1} while the goats in the high stocking rate loss 0.005 kg d^{-1}. Kallenbach et al., (2006) indicated that ADG of heifers was the same for animals in shaded and unshaded pastures. The average weight gain/loss for the animals during Year 1 showed that the animals maintained their body weight throughout the grazing period (Table 1). These results were expected since the grazing period was very short thus a significant weight gain would not be seen in the animals. Another reason for these results could be due to the age of the animals. These animals were older and so they are expected

to have a lower growth rate when compared to yearlings or six months old animals that are expected to have a faster growth rate.

For Year 2, the results showed a significant effect of stocking rate (P = 0.003) on ADG. The animals in the low stocking rate were gaining an average of 0.047 kg d^{-1} while the animals in the high stocking rate were losing an average of 0.011 kg d^{-1}. The average weight gain/loss analysis for Year 2 showed that the animals in the low stocking rate gained weight while the high stocking rate lost weight (Table 2).

Similar results have being obtained by Goodwin et al., 2004, who reported that goats reared in a grass only pasture had an average daily gain of 27 g d^{-1}.

The results obtained showed the lower stocking rate performed better than the high stocking rate. This result could be due to increased availability of forage for the animals, which could provide for the weight gains.

SUMMARY.

The results from this study indicated that the low stocking rate was best for the goats evaluated. High stocking rates for both years caused weight loss in the animals, thus indicating that the stocking was too high for the paddock sizes used. The shade did not significantly affect the stocking rate of the animals. The data obtained for Year 1 showed no significant differences among the treatments. It was expected that the animals in the low stocking rate in the shaded pastures would perform better due to the shade which would allow the animals to be grazing more frequently than the animals in full sunlight. These results however could have come from factors such as the management conditions of the animals before they were placed on pasture. The animals used were being supplemented and when they were used in the study, no supplementation was given to these animals. The removal of the supplementation could have resulted in loss of some vitamins or essential nutrients found in the supplementation feeds that were not available in adequate proportions in the grass.

REFERENCE.

Clarke, F.L.G. 1999. Investigating the spatial distribution of American beech and southern magnolia with remotely sensed data. M.S. Thesis, Florida A&M University, Tallahassee.

Darbyshire, J. 1993. Forestry management plan. F&W Forestry Services, Quincy, Fl. pp 8.

Engle, C., G. Greaser and J. Harper. 2000. Meat Goat Production (Agricultural Alternatives). Penn State University, University Park. (http://www.das.psu.edu/user/publications/pdf/ua340.pdf).

Goodwin D.J., J.P. Muir, R.D. Wittie and T.F. Brown. 2004. Goat weight gains, forage selectivity and forage quality dynamics in three cultivated warm season pastures in north-central Texas. Small Rumin. Res. 52: 1-2, pp 53-62.

Kallenbach, R.L., M.S. Kerley and G.J. Bishop-Hurley. 2006. Cumulative forage production, forage quality and livestock performance from an annual ryegrass and cereal rye mixture in a Pine-Walnut Silvopastoral. Agrofor. Syst. 66: 43-53.

Mislevy, P., F.G. Martin, and J.T. Nelson.2000. Selectivity of tropical grasses by Spanish x Boer Goats. Soil Crop Sci. Soc., Florida Proc. 59:77-81.

Pinkerton, F., D. Scarfe, and B. Pinkerton. 1991. Meat goat production and marketing. Fact Sheet M-01 E. (Kika) de la Garza Institute for Goat Research. Field Day Proceedings No. M-01. Langston University, Langston, OK.

Pratt, M. and G. A. Rasmussen. 2001. Determining your stocking rate, Range Management Fact Sheet, NR/RM/04. Utah State University Extension (https://extension.usu.edu/files/natrpubs/range4.pdf).

Whilby, L.A. 2004. Evaluation of bahiagrass (*Paspalum notatum* Flugge) and bermudagrass (*Cynodon dactylon* (L.) Pers.) as pastorable pastures under newly thinned loblolly pine (*Pinus taeda* L.) plantation. Master's Thesis, Florida A &M University, Tallahassee.

Table 1: Mean Weight gain/ loss (kg) of Boer x Spanish Crossbreed goats by shade and stocking rate during Year 1 of a Two year Silvopastoral study.
[a] Converted from 3 goats and 5 goats per 0.1 ha paddocks respectively.

Effect	Weights				
	Weight Dates	Initial weight (8-22-06)	9-19-06	10-17-06	Final weight (11-14-06)
Shade	Shaded	48	48	49	50
	Unshaded	47	48	46	46
Stocking Rate	Low (10 goats/ha)[a]	47	48	49	49
	High (17 goats/ha)[a]	47	48	48	47

Table 2: Mean Weight gain/ loss (kg) of Boer x Spanish Crossbreed goats by shade and stocking rate during Year 2 of a Two year Silvopastoral study.
[a] Converted from 3 goats and 5 goats per 0.1 ha paddocks respectively.

Effect	Stocking Rate	Initial weight (9/27/2005)	Final weight (11/8/2005)
Shaded	10 goats/ha[a]	30	30
	17 goats/ha	30	30
Unshaded	10 goats/ha	30	30
	17 goats/ha	30	30

2008 Proceedings of the Caribbean Food Crops Society. 44(2):522-529. 2008

Poster #45

Effects of Palm Kernel Cake in the Diet of Dairy Goats on Milk Production and Kid Daily Gain;

Efecto del Palmiste (*Elaeis guineensis*) Sobre el Comportamiento Productivo de Cabras Lecheras.

Juan C. Ureña, Marco E. Fernández, Carlos M. De Jesús, Rafael A. Vásquez.

Animal Science Department, Universidad ISA, Avenida Antonio Guzmán Fernández, Km 51/2, La Herradura, Santiago, República Dominicana. cdejesus@isa.edu.do; Departamento de Ciencia Animal, Universidad ISA, Avenida Antonio Guzmán Fernández, Km 51/2, La Herradura, Santiago, República Dominicana. cdejesus@isa.edu.do

ABSTRACT.
A field trial was carried out to evaluate the effects of the inclusion of palm kernel cake (PKC) in diets of dairy goats on goat performance, milk yield, kid daily gains and, milk composition. Forty-eight (48) last quarter gestating crossbreed dairy goats in the last quarter of gestation with 54 kg of BW were randomly distributed in eight PKC treatments arranged in 3 blocks in a randomized block design. The treatments were 0, 15, 30, 45% of PKC and two milking frequency (one and twice at day). The dairy ration was formulated (NRC, 1981) to contain 62.93 g of DP and 2.4 Mcal/kg NEL per dairy goat weighing 54 kg and producing milk containing 4.0 % milk fat. The ration consisted in hay grass (Transvala) and grains supplement. Body condition, feed intake, profit, milk production and composition, were measured with respect to the dairy goats and daily gain was registered with respect to the kids. The body condition was not affected by the PKC levels. The PKC treatments did not affect goat feed intake, which was 2.81kg /animal/d and 1.92 kg/animal/d when goats were milked once or twice per day, respectively. The average kid daily gain was 72.57 g/d in those lactated by goats that were milked once per day. Milk production was 18.62 kg per animal and 12.95 kg per animal in goats milked once and twice per day, respectively. The milk of dairy goats milked twice per day had higher milk fat content (4.45 %) than of those milked once per day (3.45 %). With goats milked once per day the highest profit was obtained with 15 % of PKC in the ration, and with goats milked twice per day the highest profit was obtained with 30 % of PKC in the ration.

KEYWORDS: dairy, goat, feed intake, milk, yield, ration

INTRODUCCION

En los países subtropicales como la República Dominicana, la tendencia es la intensificación del sector caprino lechero debido a la importancia que este reviste en la economía agropecuaria y en la salud humana. Otra de las razones es el aprovechamiento de la gran cantidad de fuentes de forrajes con que cuenta nuestro país, lo que representa un gran potencial para desarrollar dicha explotación pecuaria en las diferentes regiones.

Esto se puede observar en el intervalo 1999-2002 durante el cual ha habido un incremento en el volumen (TM) de productos de origen caprino-ovino de 29 % (Banco Central, 2003).

Para maximizar la rentabilidad de la explotación caprina, es necesaria la inclusión de subproductos de origen agroindustrial y de producción nacional. El empleo de dietas con inclusión de subproductos agroindustriales es una alternativa para cubrir el déficit de nutrientes originados en algunas ocasiones por la escasez de alimentos y pastos de baja calidad en la sequia y los altos costos de materia prima importada para la elaboración de alimentos (Sánchez et al., 2001)

Es necesario buscar alternativas que ayuden aumentar la producción de leche caprina de calidad con el menor costo posible, ya que esto puede ser una solución a los problemas que enfrenta el sector pecuario den la República Dominicana, como es el alto costo productivo. En cierto punto, la producción de leche depende del número de ordeños que se efectué puesto que esto estimula la producción láctea en la glándula mamaria (Bath et al., 1985). Se han realizado investigaciones en ordeño de cabras en la Universidad ISA empleando palmiste, Pasta de arroz y otros subproductos agroindustriales con una producción promedio de leche de 0.74 kg/día/animal, donde el factor frecuencia no fue evaluado (Alcántara, 2006). Sin embargo, es una necesidad determinar la sustentabilidad de una producción intensiva de leche en cabras con varias frecuencias de ordeño bajo nuestras condiciones climáticas. Por lo tanto se planteo un estudio con cabras mestizas bajo dos frecuencia de ordeño y la inclusión de subproductos agroindustriales

MATERIALES Y METODOS

Animales y corrales

Las 48 cabras multíparas utilizadas se obtuvieron del rebaño caprino de la Universidad ISA compuesto por las razas Nubia-Boer, Alpina-Nubia, Alpina-Criolla. Las cabras tenían un peso promedio de 54.6 Kg y estaban el ultimo tercio de gestación .y fueron confinadas en grupo de dos cabras con una densidad de 3 m^2 /animal.

Diseño experimental

Se utilizo un diseño completamente al azar con arreglo factorial (4x2) con 3 repeticiones con un total de 24 unidades experimentales. Los factores evaluados fueron 4 niveles de palmiste y 2 frecuencias de ordeño.

El modelo estadístico que se utilizó para analizar la variación entre los tratamientos y el error fue el siguiente:

$$Y_{ijk}= \mu + F_i + P_j + (FP)_{ij} + E_{ijk}$$

Donde:

Y_{ijk} = Valor observado de la variable A.

μ = Media general.

F_i = Efecto de la frecuencia de Ordeño (i = 12 y 24 h/día)

P_i = Efecto de los niveles de palmiste (J = 0, 15, 30 y 45%)

E_{ijk} = Efecto del error experimental

Las variables estimadas y calculadas en los distintos tratamientos fueron: Peso del cabrito al nacer (kg), Peso del cabrito al destete (kg), Consumo de MS diario en las cabras (kg), Ganancia diaria de peso de los cabritos (g), Condición corporal en cabra,

Producción láctea (kg), Índice de conversión alimenticia(%) y la Relación Beneficio \ Costo .

Tratamientos

Los tratamientos consistieron en la inclusión de cuatro (0, 15, 30 y 45%) en dietas de cabra lecheras mestizas. La raciones fueron formuladas de acuerdo a los requerimientos nutricionales de las cabras según al NCR, 1981 (ver tabla 1). La dieta base estuvo constituida por forraje y concentrado (60:40); el alimento balanceado consistió en un suplemento (40 %) de la dieta total. Este suplemento estuvo constituido por una mezcla de maíz, soya, premezcla de vitaminas y minerales, aditivos y el nivel de inclusión de palmiste. El forraje (60%) provino de heno de Pasto Transvala (*Digitaria decumbens*) que fue suministrado 700 y 1600 h, conjuntamente con el concentrado. Los animales dispusieron de agua y alimento a voluntad.

Manejo del Experimento

Todos los tratamientos estuvieron en iguales condiciones ambientales y de manejo. Esto incluye la desinfección y encalado de los corrales previo al experimento y además las cabras recibieron un vermífugo y vitaminas.

El consumo de forraje y suplemento en cabras y cabritos se registro diariamente con relación al peso corporal, donde el consumo real fue la diferencia entre el monto ofrecido y el rechazado. Al momento del parto se registro el peso al nacer del cabrito y curado del ombligo y se identificaron los cabritos y se confirmo la ingestión de calostro por los recién nacidos y la expulsión de la placenta en las cabras. El ordeño se realizo en forma manual, donde se registraba diariamente la cantidad (kg) de leche producida. El grupo de cabras ordeñadas una vez (24 h) por día se apartaba los cabritos de sus madres a 1800 h para su ordeño a las 600 h y en caso de dos veces (cada 12 h) por día se realizaba el ordeño a 600 h y 1800h. Los cabritos del grupo de 12 h se destetaron un día posterior al nacimiento y fueron alimentados con leche de vacas y concentrado. Cada dos semanas, los cabritos fueron pesados y se registro al condición corporal de las cabras según la escala de Langston University.

Análisis de Datos

Los datos recolectados en las variables evaluadas fueron sometidos a un análisis de varianza usando el cuadrado mínimo del modelo lineal general (GLM) con el programa estadístico SAS™ 8.1 Inc. Si hubo diferencias significativas las medias fueron sometidas al análisis de separación de medias de Tukey a un nivel de confiabilidad de 95%.(Cody y Smith ,1997).

RESULTADOS Y DISCUSION

Consumo alimento

No se registro diferencias significativas ($P \leq 0.05$) en el consumo de las cabras lecheras alimentadas con diferentes niveles de palmiste (ver tabla 1). El consumo vario de 1.92-2.86 kg/día/animal. Al comparar estos resultados son superiores con los reportados por Alcántara (2006), en la alimentación de cabras con palmiste. La frecuencia de ordeño tuvo un efecto significativo en incrementar el consumo en las cabras que se ordeñaron cada 24 h con relaciona 12h.

El consumo total de MS en las cabras lecheras fue significativos en las cabras alimentadas con 15% de palmiste con 3.95 kg/día/animal con relación a los demás niveles

de inclusión 0, 30 y 45 % (ver tabla 1). Asimismo, la frecuencia de ordeño cada 24h registro el mayor consumo MS en las cabras lecheras.

Producción láctea y condición corporal

Los niveles de inclusión de 0, 15, 30 y 45% no afectaron ($P \leq 0.05$) la producción láctea (kg) en las cabras lecheras mestizas. Sin embargo, la frecuencia de ordeño tuvo un efecto positivo ($P \geq 0.05$) al incrementar la producción total de leche (18.62 kg cada en 12 h vs 12.95 kg cada 24h) (ver tabla 1) Resultados inferiores fueron reportados por Alcántara, 2006 al alimentar cabras lecheras con 30 % de palmiste comparados con registrados por este estudio de 15.12, 18.06, 10.72 en los niveles de inclusión de 15, 45 y 30 %, respectivamente.

Los niveles de inclusión de palmiste y frecuencia de ordeño no afectaron ($P \leq 0.05$) la condición corporal de las cabras lecheras mestizas ni al inicio ni al final de la lactación, lo que indica que las cabras satisficieron los requerimientos nutricionales con las dietas sin afectar sus reservas corporales.

Ganancia Diaria de los cabritos

La inclusión de palmiste 15% alcanzo la mayor ganancia diaria con 105.5 g/d/animal con relación a los demás niveles de inclusión 30 %(85.51 g/d), 45% (74.38 g/d) y 0% (73.68 g/d). De igual forma, la frecuencia de ordeño cada 12 h registro la mayor ganancia diaria (95.56 g/d) con al ordeño de 24h (72.57 g/d) (ver tabla 1).

Eficiencia Alimenticia

Al comparar las medias de la eficiencia alimenticia entre los grupos de cabras alimentadas con los niveles de inclusión de palmiste no presentaron diferencias significativas ($P \leq 0.05$) (ver tabla 1). Sin embargo, las cabras ordeñadas dos veces al día tuvieron una eficiencia mayor con valor de 47 % comparado con un ordeño por día con 27 %.

Porciento de sólidos no grasos y grasa en la Leche

La composición de grasa y sólidos no grasos en la leche no fue afectada ($P \leq 0.05$) por la inclusión de palmiste en la dieta de cabras lecheras (ver tabla 1). Aunque, al comparar el efecto de la inclusión de palmiste en las frecuencia de ordeño de dos veces y una vez por día se observo una diferencia ($P \geq 0.05$) significativa entre estas. El contenido de grasa registrado en la leche fue de 4.45 % en el doble ordeño y 3.45 % en el ordeño una vez por día. En cambio, los sólidos no grasos en leche fue de 8.09 % y 7.75 % al ordeñar las cabras cada 12 y 24 h.

Relación Beneficio Costo

El análisis económico marginal (Perrin et al., 1988) determino que los mayores beneficios neto fueron en los niveles de 45 y 15 % de palmiste con RD$ 3,357.32 y RD$ 2635.03 con los mas bajos costos de RD$ 1,688.62 y RD$ 1,728.06 (ver tabla 1). Aunque, la tasa de retorno marginal fueron negativas para todos los niveles y más recomendable fue el nivel de 30% de Palmiste. Al evaluar la tasa de retorno marginal en las diferentes frecuencias de ordeño, el nivel de inclusión de 15 % de palmiste arrojo el mayor beneficio neto con RD$ 2,225.87 (ver tabla 1).

CONCLUSIONES Y RECOMENDACIONES

Al realizar la investigación sobre el comportamiento productivo de cabras mestizas bajo dos frecuencias de ordeño alimentadas con cuatro niveles de palmiste se concluye que los niveles de inclusión no ejercieron efectos negativos sobre el consumo y

la producción de leche. Sin embargo, el contenido de grasa y sólidos no grasos en la leche fue afectado por los niveles de palmiste. Con respecto a la relación beneficios/costo, la mejor opción económica es la el nivel de 15% de palmiste con un ordeño por día y 30% en doble ordeño.

REFERENCIAS

Alcántara, M.A. 2006. Evaluación de la Inclusión de Subproductos Agroindustriales (Palmiste, Pasta de Arroz y Afrecho de Trigo) en la dieta de Cabras Lechera Mestizas. Tesis para optar por el titulo de Ingeniero en Producción Animal. Universidad ISA. Santiago, República Dominicana.

Banco Central de la República Dominicana. 2003. Volumen y Valor Producción Pecuaria, Silvicultura y pesca.

Bath, D. L., Dickinson, F.N., Tucker, H.A., Appleman, R.D. 1985. Dairy Cattle: Principles,Practices, Problems, Profits. Third edition. Lea and Febiger. Philadelphia. USA. Pag. 301.

Cody, R. P. y Smith J. K. 1997. Applied Statistic and the SAS Programming Language. Fourth Ed. Prentice Hall. New Jersey. U.S.A.

National Research Council. Nutrient Requirements of Goat: Angora, Dairy, and meat Goats in temperate and tropical countries. 1981. National Academy Press Washington, D. C.

Perrin, R.K., Winkelman, D.L., Moscardi, E., Anderson, J.R. 1988. La Formulación de Recomendaciones a partir de Datos Agronómicos. En: Un manual metodológico de Evaluación Económica. Centro International para Mejoramiento de Maíz y Trigo (CIMMYT). El Batan. México.

Sánchez Seiquer, P., Alemán Sabater, S., Dejodar Sánchez, I., Muelas Domingo, R., Rubert Alemán, J., Lizaso Azkarte, J., Fernández Martínez, C. 2001. Empleo de tres fuentes de proteína en la alimentación con raciones completas de las cabras Muricano-Granadino. XXVI Jornadas Científicas y V Internacionales de la Sociedad Española Ovinotecnia y Caprinotecnia. Pag. 617.

TABLAS

Tabla 1. Parámetros productivos de Cabras lecheras alimentadas con 4 niveles de palmaste

	Niveles de inclusión palmiste			
Ingredientes	0	15	30	45
Palmiste (%)	0	15	30	45
Maíz molido (%)	54	42	32	21
Soya 48% (%)	38	35	31	27
Grasa (%)	2	2	2	2
Piedra Caliza (%)	3	3	3	3
Fosforo Dicalcico(%)	1.5	1.5	1.5	1.5
Sal (%)	0.05	0.05	0.05	0.05
Premezcla Vit. y Minerales	0.04	0.04	0.04	0.04
Total	100			
Nutrientes				
Proteina Cruda(%)	21	21	21	21
E M (MJ/kg)	24.90	24.90	24.90	24.90
MS (%)	88	88	88	88
Calcio (%)	1.41	1.43	1.41	1.43
Fosforo(%)	0.88	0.87	0.88	0.87

Tabla 2. Parámetros productivos de Cabras lecheras alimentadas con 4 niveles de palmiste[1]

Variables	Niveles de Palmiste				Frecuencia		
	0	15	30	45	24 h	12 h	CV
Ganancia Cabrito (g/d)	73.68b	105.01a	85.51b	74.38b	72.57b	95.56a	6.63
Consumo de alimento (kg)	2.44a	2.86a	2.20a	1.97a	2.81b	1.92a	2.71
Consumo MS (kg)	3.09b	3.95a	2.94b	2.81b	6.00a	3.82b	1.77
Eficiencia Alimenticia (%)	0.32a	0.42a	0.34a	0.49a	0.27b	0.47a	0.05
Condición Corporal	3.85a	3.61a	3.96a	3.73a	3.71a	3.83a	0.12
Producción láctea (kg)	19.56a	18.06a	10.78	15.12a	12.95b	18.62a	3.37
Contenido de grasa (%)	3.65a	4.23a	4.17a	4.42a	3.45b	4.45a	0.12
Contenido de Sólidos no grasos (%)	8.01a	7.86a	7.86a	7.71a	8.09a	7.75b	0.05

[1]Letras diferentes en filas presentan diferencias significativas ($P \leq 0.05$), entre las medias (± error estándar)

Tabla 3 Análisis Marginal[1] para el ordeño una vez por día en cabras mestizas alimentadas con cuatro niveles de palmiste.

Tratamientos	**Beneficio Neto Parcial (BNP)**	**Costos Variable**	**Incremento Marginal BNP**	**Incremento Marginal Costo Variable**	**Tasa Retorno Marginal**	**Costo Capital (Interés 20%)**	**BNP después de pagar interés**
0	1,390.48	2,402.92	*	*			
15	2,378.80	2,294.04	988.32	-108.89	-9.08%	152.94	2,225.87
30	925.78	1,981.32	-1,453.03	-312.72	4.65%	132.09	793.69
45	1,234.41	2,126.86	308.63	145.54	2.12%	141.79	1,092.62

[1]El análisis marginal se realizó según la metodología de Perrin et al., 1988.

Tabla 4 Análisis Marginal[1] para la frecuencia de doble ordeño en cabras mestizas alimentadas con cuatro niveles de palmiste.

Tratamientos	Beneficio Neto Parcial (BNP)	Costos Variable	Incremento Marginal BNP	Incremento Marginal Costo Variable	Tasa Retorno Marginal	Costo Capital (Interés 20%)	BNP después de pagar interés
0	2,446.58	2,857.76	*	*			
15	2,750.23	1,728.06	303.66	-1,129.70	-0.27%	115.20	2,635.03
30	2,388.73	1,741.26	-361.51	13.19	-27.40%	116.08	2,272.64
45	3,469.90	1,688.62	1081.17	-52.64	-20.54%	112.57	3,357.32

[1]El análisis marginal se realizó según la metodología de Perrin et al., 1988.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):530-534. 2008

Poster #46

Development of Small Scale Aquaculture Farms in North Florida

Uford A. Madden[1], G. Nurse[1], J. Beaudouin[1], A. Bolques[1], L. Muralles[1], S. Harris-Thompson[1], A. Wallamsley[2], M. May[3], and F. Chapman[4], [1]Extension and Outreach Program, College of Engineering Sciences, Florida A & M University, Tallahassee, Florida [2]Florida Farm Bureau Federation, Gainesville, Florida, [3]Florida Department of Agriculture and Consumer Services, Tallahassee, Florida, and [4]University of Florida, Gainesville, Florida .

ABSTRACT.
This program provides teaching, research and extension assistance to small farmers operating small-scale aquaculture farms, which utilize natural water bodies to contribute to food production. Thus the program supports the development of the aquaculture industry and the economy of Florida. A specific objective was to bring together production, economic and marketing specialists in integrated demonstration of projects to optimize production systems (ponds, tanks, raceways cages and hybrid systems), spawning and hatchery techniques, microencapsulated feeds, batch plankton culture procedures, preventive aquatic animal health practices and product value. The program addresses problems/needs of small, limited resource and economically disadvantaged farmers and facilitates cooperation of specialists and county agents in finding solutions to various challenges encountered in the industry. Initially the project involved ten (10) existing and new farmers in counties within a one hundred (100) mile radius. Farmers currently growing fish and those interested in growing fish, with or without ownership of existing water bodies, were identified. The project began in July 2006 at FAMU Research and Extension Center, Quincy, Florida, where there are ponds; and it provided classroom and hands-on training and a farm visit was made with each farmer. A training curriculum was developed with modules and information used for the instruction. Fourteen farmers were trained on the best management practices and alternative methods for improvement of production systems for fish (e.g. Bait fish and Sturgeon). Marketing strategies were addressed to sustain the increased production of fish and profitability. Four ponds were revitalized and once per week pH, temperature, depth and dissolved oxygen data were collected as the ponds stabilized. Brochures were developed to support development of small scale enterprises, production of fingerlings and utilization of existing natural resources and reduction of specialized inputs.

KEYWORDS: Aquaculture, small scale farms, fish production

INTRODUCTION.

Aquaculture can contribute to increase in food production and the agricultural economy of the State of Florida by development of small scale aquaculture farms. It has been hypothesized that fresh water aquaculture is one of the fastest growing sectors in the United States agricultural economy. In 2003, Florida had 34 catfish operations with a

total of 660 acres of water surface area which indicated a 25% decrease (220 acres) from 2002. Foodsize fish (590 acres) and fingerlings (45 acres) accounted for the majority of the acreage. In 2002, majority of the sales were to processors and total sales were $756,000. In 2003, a survey conducted for the Division of Aquaculture, Florida Department of Agriculture and Consumer Services, showed that reported sales by aquaculture producers were $95.5 million. These were comparable to sales reported in 2001 of $99.5 million that were reported for 2001 which is the third highest volume of sales recorded by survey since it was started in 1988. In 1997, 102 million of sales was recorded and is the largest volume of sales realized from aquaculture products.

Increased sales for Tropical Fish, Tilapia, Catfish, Live Rock, and Other Aquatics were reported in 2003 whereas Aquatic Plants, Clams and Oysters, Alligators, Shrimp, and Other Fish sales decreased. A total of 544 operations utilized 6,450 acres in 2003, whereas in 2001 684 operations used 7,010 acres. In the 2003 survey, 80 active operations had no sales, which may as be as result of new operations that had no product for sale or operations in business that did have sell any product for sale. Thirty (30) operations sales to foreign markets totaled $5.3 million. Most aquaculture operations in Florida are small farm enterprises. In 2003, 43.9 percent of the 544 operations were less than 3 acres and represent many of the clam producers, with lease of 2 acres of water in the Gulf of Mexico or the Indian River Lagoon, and included some of the small tropical fish farmers. Approximately 20.6% of the operations utilized 3 to 6 acres of land and/or water and operations that used 50 acres or more accounted for 3 percent.

Florida A & M University (FAMU) has eight fish ponds that can be used to make significant contribution to increase fish production. In North Florida, there are several farmers with existing ponds, lakes, and other water bodies that are producing fish but there are other water bodies that are not been utilized for fish production. There is a need to develop programs that will allow farmers to utilize existing water bodies and integrated with tank production systems to produce fish to increase their productivity and profitability and development of small scale farming enterprises.

OBJECTIVES.

The specific objectives of this project was to address food production by utilization of integrated demonstration projects that bring production, economic and marketing specialists together are needed to improve or develop production systems (ponds, tanks, raceways cages and hybrid systems), spawning and hatchery techniques, microencapsulated feeds, batch plankton culture procedures, preventive aquatic animal health practices and product value. The program objectives were: 1).To provide services in teaching, research and extension to small farmers in the development of small-scale aquaculture farms utilizing natural water bodies to contribute to food production, the development of the Aquaculture industry and to the economy of the State of Florida; 2) To address the objective: Integrated demonstration projects that bring production, economic and marketing specialists together are needed to improve or develop production systems (ponds, tanks, raceways cages and hybrid systems), spawning and hatchery techniques, microencapsulated feeds, batch plankton culture procedures, preventive aquatic animal health practices and product value

MATERIALS AND METHODS.

Four ponds were available for conducting research, hands-on training and demonstrations for small, limited resource farmers and economically disadvantaged farmers. Farmers who are currently growing fish and farmers who are interested in growing fish with or without ownership of existing water bodies were identified. The farmers were trained on the best management practices and on alternative methods for improvement of production systems for fish (Bait fish and Sturgeon). Marketing strategies were addressed at the beginning of the program in order to prove information to assist farmers on how to develop plans that will help them to sustain market for the increased production of fish and profitability of these farms. Farmers were assisted in the development of plans for small scale enterprises and producing fingerlings for their own production. The project was designed to work initially with ten (10) existing and new farmers in counties within a one hundred (100) mile radius. The project utilized the Florida A & M University Community Development Center (CDC), formerly Research and Extension Center in Quincy, Florida, where there are existing ponds. County agents and the Florida Farm Bureau Federation personnel assisted in the identification and recruitment of these farmers. The project provided classroom and hands-on training at the FAMU CDC on the various aspects of fish production. Hands-on training was conducted at the FAMU CDC and farm site visits were with each farmer to provide the technical support for the type of production system. A curriculum was developed and a training package with the modules was provided to each farmer with information used for the instruction. The information gathered from this project will be disseminated in lectures, at workshops, conferences, seminars and field demonstrations. The information will be incorporated into teaching and extension education activities to students and limited resources producers. Research findings will be presented at conferences and seminars locally and nationally. Workshops and field demonstrations will be conducted for small and limited resource producers to increase their awareness of the importance of good production practices, appropriate preventative aquatic animal health practices and their potential impact on product value, production, efficiency, and profitability of their farms.

RESULTS AND DISCUSSION.

A training curriculum was developed with modules and information used for the instruction. Fourteen farmers were trained on the best management practices and alternative methods for improvement of production systems for fish (e.g. Bait fish and Sturgeon). Marketing strategies were addressed to sustain the increased production of fish and profitability. Four ponds were revitalized and once per week pH, temperature, depth and dissolved oxygen data were collected as the ponds stabilized. Brochures were developed to support development of small scale enterprises, production of fingerlings and utilization of existing natural resources and reduction of specialized inputs. Further consideration is for the development of a website or for posting the information on various websites that can be accessed and links can be made to other websites. Presently, there are websites that may be considered: smallfarms.ifas.ufl.edu; www.fl-aquaculture.com; FAMU.CESTA; Small Business and Florida Farm Bureau. Farmers,

A pond at the start of the project

A revitalized pond ready for fish production

Teachers, students and the public will be able to access the information posted on these websites. The information gathered from this project will be disseminated in lectures, at workshops, conferences, seminars and field demonstrations. The information will be incorporated into teaching and extension education activities for students and limited resources producers. Research findings will be presented at conferences and seminars locally and nationally. Workshops and field demonstrations will be conducted for small and limited resource producers to increase their awareness of the importance of good production practices, appropriate preventative aquatic animal health practices and their potential impact on product value, production, efficiency, and profitability of their farms.

ACKNOWLEDGEMENTS.

The authors would like to thank the collaborators and professionals in the various areas who assisted with the classroom lectures, hands-on training and provided invaluable technical information that was used in the development of the project and the undergraduate students who participated in this project with sample collection and data analysis.. This project provided a source of experiential learning for two undergraduate students involved in the work study program in Cooperative Extension Service, College of Engineering Sciences, Technology and Agriculture at Florida A&M University. Also, this project served as a resource for one student in the Summer Rattler Phase III Internship Program in 2007. The student prepared a research paper on "Two Species of Fish That Are Commonly Raised by Farmers in Florida" and prepared and presented the information by Power Point as part of the requirement for the program. This project was funded in part by the State of Florida Department of Agriculture and Consumer Services, Division of Aquaculture Programs, Honorable Charles Bronson, Commissioner.

REFERENCES.

1. Core, J. and Spillman, A. 2003. Keeping Catfish on Consumers' Menus. ARS National Program (# 106). www.nps.ars.gov. (1/28/05).
2. Elstein, D. 2004. Training Dogs to Smell Off-flavor in Catfish. ARS National Program (# 106). www.nps.ars.gov. (1/28/05).

3. Florida Agricultural Statistics Service. Aquaculture(2/2003). http://www.nass.usda.gov/fl (5/11/05).
4. Florida Agricultural Statistics Service. Aquaculture. http://www.nass.usda.gov/fl (5/11/05).
5. Seafood and Aquaculture Marketing: Marketing Florida Agriculture. http://www.florida-agriculture.com/seafood.htm (5/11/05).

2008 Proceedings of the Caribbean Food Crops Society. 44(2):535-541. 2008

Poster #47

Comparison of Oral Administration of Various Doses of Moxidectin and Ivermectin Pour-On Formulations Against Intestinal Parasites in Meat Goats

Uford A. Madden[1], N. Wilson[2], G. Nurse[1], and J. Beaudouin[1], [1]Extension and Outreach Program, College of Engineering Sciences, Technology and Agriculture, Florida A& M University, Tallahassee, Florida, and [2]Marion County Extension, University of Florida, Gainesville, Florida.

ABSTRACT.
A total of 64 meat goats (6 months old) were used to investigate the effects of various doses of two anthelmintics on naturally occurring intestinal parasites in two feeding systems (32 animals each). Animals in the extensive system received grazing only and those in the semi-intensive system received grazing plus 1.1 kg of a 12% protein pellet per head per day. Animals in both systems received treatments of Moxidectin (MOX) and Ivermectin (IVM) at 0.275 mg/kg; 0.550 mg/kg and 0.825 mg/kg bodyweight and 0 mg/kg (CONT). Two males and 2 females were randomly assigned to each treatment. A single dose of MOX or IVM was administered orally to each treated animal at Day 0. A fecal sample was taken from each animal on Days 0, 7, 28, 56, and 84 for evaluation of parasite eggs. Body weights were taken on Days 0, 28, 56, and 84. Sampling began on March 8, 2005 and ended on June 15, 2005. In the extensive system, IVM-treated animals (19.95 kg) had a higher average bodyweight gain than those treated with MOX (17.14 kg). MOX-treated animals, 0.550 mg/kg had slightly higher bodyweight gain (5.77 kg) than CONT animals (5.14 kg). In IVM-treated animals, 0.825 mg/kg had the highest bodyweight gain (6 kg). In the semi-intensive system, MOX-treated animals (25.23 kg) had slightly higher average bodyweight gain than IVM-treated (24.64 kg). MOX-treated, 0.825 mg/kg and CONT animals had similar bodyweight gain (6.59 and 6.54 kg). IVM-treated animals, 0.825 mg/kg had the highest bodyweight gain (7.59 kg). Fecal samples showed marked reductions in parasite egg counts in MOX-, IVM-treated and CONT animals for both systems. In the extensive system, MOX-treated animals, had parasite eggs only in animals treated with 0.550 mg/kg whereas IVM-treated animals had no eggs in animals treated with 0.825 mg/kg, and CONT animals at the end of the study. In the semi-intensive system, no parasite eggs were detected in any sample in MOX- treated but were in CONT animals at the end of the study. In IVM-treated animals, 0.550 mg/kg, and CONT animals, no parasite eggs were detected at the end of the study.

KEYWORDS: Moxidectin, ivermectin, meat goats

INTRODUCTION.

Small, mid-size and economically disadvantaged family farms are important as they continue to be significant to national agricultural productivity. Sustaining agriculture in rural communities is not only critically important for the livelihood and self-sufficiency of farm families, but will strengthen families and maintain stability and

quality of life in these long-standing communities. Information on investigation of the efficacy of various doses Moxidectin and Ivermectin can be used to enhance implementation of strategies in areas of production systems to reduce the potential impact of nematodes on small, mid-size and economically disadvantaged family farms and coupled with the appropriate education can influence national economic health and well-being manifested in these communities. Improvement of on-farm technologies and management systems coupled with the appropriate research and extension education activities will allow for enhanced production, efficiency, profitability and long-term survival of small, mid-size farms and economically disadvantaged farms operated by farm families as we make strides in animal health care and incorporate food safety and animal health measures to improve the socio-economic condition, performance and profitability of small, mid-size and economically disadvantaged farmers

Small, mid-sized and economically disadvantaged family farms are defined as: (1) farm comprise of 200 acres and/or (2) farms with annual sales totaling less than $50,000 and/or (3) farms that are in operation but the farm operators' chief source of income is from activities other than farm activities. In 1997, 78% of Florida's farm sales came from farms with total annual sales of less than $50,000. According to the 1997 Agricultural Census, Florida had 28,645 farms with 200 acres of less. Total sales of 27,077 farms were less than $50,000 and the principal source of income of 19,017 farms was not from far-related activities. These farms were 82% of the 78% of farms with total annual sales of less than $50,000 and 55% of all farms in the state. The types of small farms described above accounted for 6.4% of the agricultural product sales in Florida in 1997, but represent most of the farm population in the state.

According to 1997 Agricultural Census, Florida had 18,000 beef cattle farms, 636, sheep farms, and 2,556 goat farms. Of the18,000 beef farms in the state, 16,000 had less than100 animals, 14,500 had less than 50 animals [1999 Florida Livestock, Dairy, Poultry Summary(Florida Agricultural Statistics Service, July 2000)] and 40 to 50 animals and 25 to 30 animals respectively for goat and sheep farms of 50 acres or less. There are numerous challenges encountered by these small, mid-size and economically disadvantaged livestock producers during on-farm activities that need to be addressed. The persistence of anthelmintic efficacy is important in the control of naturally occurring nematodes in affected animals. In a comparative study of the efficacy of topical formulations of doramectin, ivermectin, eprinomectin, and moxidectin in beef calves against naturally acquired nematode infections, anthelmintic activity of moxidectin was greater than that for ivermectin based on fecal egg counts (Williams et al., 1999) In weaned calves, moxidectin pour-on treated animals gained 19.4 pounds more than untreated controls and 11.7 pounds more than ivomectin pour-on treated animals (Fort Dodge Animal Health, 2000). Determination of the efficacy of moxidectin and ivermectin in meat goats will provide information on a treatment that is effective in reducing the potential impact of nematodes on these farms animals and the potential long-term effect on meat goat production in the state of Florida.

Small farm agriculture continue to make important contributions to Florida and national aggregate agricultural production, therefore information on moxidectin or ivermectin should be considered when making determinations for improvement of on-farm animal health and management systems. These producers will be able to implement better management practices and technologies that incorporate appropriate strategies

(protocols) for treatment, prevention and control of parasites in meat goats that will impact their ability to continue to make contributions to the economies of the state and the nation and to the viability, sustainability and the quality of life of rural communities.

OBJECTIVES:

The overall objective of this project was to compare the efficacy of various doses of Moxidectin and Ivermectin in meat goats to determine the most effective dose that would reduce the potential impact of intestinal parasites (e.g. nematodes) on these farms animals and the potential long-term effect on production systems, harvesting, processing, handling, distribution and marketing of food products on small, mid-size economically disadvantaged livestock family farms.

MATERIALS AND METHODS.

A total of 64 meat goats (6 months old) were used to investigate the effects of various doses of two anthelmintics on naturally occurring intestinal parasites in two feeding systems (32 animals each). Animals in the extensive system received grazing only and those in the semi-intensive system received grazing plus 1.1 kg of a 12% protein pellet per head per day. Animals in both systems received treatments of Moxidectin (MOX) and Ivermectin (IVM) at 0.275 mg/kg; 0.550 mg/kg and 0.825 mg/kg bodyweight and 0 mg/kg (CONT). Two males and 2 females were randomly assigned to each treatment. A single dose of MOX or IVM was administered orally to each treated animal at Day 0. A fecal sample was taken from each animal on Days 0, 7, 28, 56, and 84 for evaluation of parasite eggs. Body weights were taken on Days 0, 28, 56, and 84. Sampling began on March 8, 2005 and ended on June 15, 2005. Fecal samples were subjected to fecal flotation and intestinal parasite egg counts were expressed as egg per gram (EPG) of feces. Evaluation of fecal data was done to determine the effectiveness of MOX and IVM to control intestinal parasites in meat goats. Evaluation of body weights was done to determine the effect of MOX and IVM on performance and production efficiency of meat goats and potential economic gain for goat farmers Data collected on body weight and fecal EPG count were analyzed for system, treatment, day effects using the SAS System software package and utilizing General Liner Model Procedures for Analysis of Variance Procedure (SAS, 2005). Variable means showing significance were indicated using Duncan's Multiple Range Test. All statements of significance were based on a probability value at 0.05

RESULTS AND DISCUSSION.

In the extensive system, differences observed in average body weights for treatments were not significant ($p < 0.4020$) but the differences for days were significant ($p < 0.0001$) (Table1). IVM-treated animals (19.95 kg) had a higher average bodyweight gain than those treated with MOX (17.14 kg). MOX-treated animals, 0.550 mg/kg had slightly higher bodyweight gain (5.77 kg) than CONT animals (5.14 kg). In IVM-treated animals, 0.825 mg/kg had the highest bodyweight gain (6.03 kg). Average body weight was significantly higher on Day 84 than Days 0 and 28 but was not different from Day 56. At Day 56, average body weight was significantly higher than at Day 0 but was not different from Day 28. Average body weight for Day 28 was not different from Day 0. Average body weights observed in the semi-intensive system for treatments were not

significantly different ($p < 0.7622$) but the differences for days were significant ($p < 0.0001$) (Table 1). MOX-treated animals (25.23 kg) had slightly higher average body weight gain than IVM-treated (24.64 kg). MOX-treated, 0.825 mg/kg and CONT animals had similar bodyweight gain (6.59 and 6.54 kg). IVM-treated animals, 0.825 mg/kg had the highest bodyweight gain (7.59 kg). Average body weight was significantly higher on Days 84 and 56 than Days 0 and 28 which were not different from each other. At Day 28, average body weight was significantly higher than at Day 0. In the extensive system, no significant differences ($p < 0.2821$) were observed in EPG counts for treatments but the differences for days were significant ($p < 0.0001$) (Table 2).EPG counts for Day 7 were significantly higher than for Days 0, 28, 56 and 84 which were not different from each other. MOX-treated animals had parasite eggs only in animals treated with 0.550 mg/kg whereas IVM-treated animals had no eggs in animals treated with 0.825 mg/kg and CONT animals at the end of the study. In the semi-intensive system, no significant differences ($p < 0.4200$) were observed in EPG counts for treatments but the differences for days were significant ($p < 0.0121$) (Table 2). EPG counts for Day 7 were significantly higher than for Days 0 and 56 but were not different from Days 28 and 84. EPG counts for Days 0, 28, 56 and 84 were not different from each other. No parasite eggs were detected in any sample in MOX- treated animals but were in CONT animals at the end of the study. In IVM-treated animals, 0.550 mg/kg and CONT animals, no parasite eggs were detected at the end of the study. Fecal samples in MOX-, IVM-treated and CONT animals showed marked reductions in parasite egg counts for both systems.

ACKNOWLEDGEMENTS.

The authors would like to thank Mr. Gilbert Queeley for his assistance with statistical analysis and the undergraduate students who participated in this project with sample collection and data analysis. This project was funded in part by the Center for Cooperative Agricultural Programs and provided a source of experiential learning for students attending the Animal Sanitation and Disease Control course and for students involved in the work study program in Cooperative Extension Service, College of Engineering Sciences, Technology and Agriculture at Florida A&M University.

Table 1.
Average bodyweight (kg) of control and treated meat goats with various doses of pour-on formulations of moxidectin (cydectin) or ivermectin (ivomec) orally at Day 0[a]

Extensive	(n = 4)	Experimental days			
Treatment	Day 0	Day 28	Day 56	Day 91	Mean Gain
Moxidectin					
0.825 mg/kg	22.39a	22.50a	23.52a	26.14a	3.75
0.550 mg/kg	21.25a	24.09a	25.80a	27.05a	5.77
0.275 mg/kg	21.48a	22.84a	24.66a	23.98a	2.50
0.0 mg/kg	22.73a	24.66a	25.45a	27.84a	5.14
Total					17.16[d]
Ivermectin					
0.825 mg/kg	22.61a	25.57a	24.20a	28.64a	6.03
0.550 mg/kg	21.82a	23.86a	25.00a	27.79a	5.97
0.275 mg/kg	21.48a	23.75a	24.09a	25.23a	3.75
0.0 mg/kg	22.27b	23.52ab	25.11ab	27.05a	4.78
Mean	22.00c	23.85bc	24.73ab	26.36a	19.95[d]

Semi-intensive	(n = 4)	Experimental days			
Treatment	Day 0	Day 28	Day 56	Day 84	Mean Gain
Moxidectin					
0.825 mg/kg	22.39a	25.80a	27.95a	27.84a	5.45
0.550 mg/kg	21.36a	26.02a	27.50a	27.50a	6.14
0.275 mg/kg	21.59b	26.70a	28.18a	27.61a	6.02
0.0 mg/kg	22.39b	26.14ab	27.95a	28.98a	6.59
Total					24.20[d]
Ivermectin					
0.825 mg/kg	22.27a	26.36a	29.43a	29.32a	7.05
0.550 mg/kg	21.59b	24.43ab	27.61a	27.95a	6.36
0.275 mg/kg	21.59c	24.77b	27.05ab	27.50a	5.91
0.0 mg/kg	22.05b	26.48ab	28.64a	28.52a	6.48
Mean	21.90c	25.84b	28.04a	28.15a	25.80[d]

[a]Different letters in the same row indicate significant differences at $p < 0.05$.

[d]Total mean body weight gain

Table 2.
Mean parasite egg counts (egg per gram) in control and treated meat goats with various doses of pour-on formulations of moxidectin (cydectin) or ivermectin (ivomec) orally at Day 0[a]

Extensive	(n = 4)	Experimental days			
Treatment	Day 0	Day 7	Day 28	Day 56	Day 84
Moxidectin					
0.825 mg/kg	34.21a	90.60a	31.05a	0.00a	0.00a
0.550 mg/kg	95.25a	31.45a	35.15a	0.00a	30.75a
0.275 mg/kg	1.94b	158.50a	6.40b	0.00b	0.00b
0.0 mg/kg	15.80b	442.50a	0.00b	0.00b	0.00b
Ivermectin					
0.825 mg/kg	9.70b	1121.50a	201.50b	0.00b	0.00b
0.550 mg/kg	6.40a	1210.30a	6.00a	0.00a	17.80a
0.275 mg/kg	0.00a	33.25a	15.60a	0.00a	83.25a
0.0 mg/kg	4.50a	634.00a	23.10a	0.00a	0.00a

Semi-intensive	(n = 4)	Experimental days			
Treatment	Day 0	Day 7	Day 28	Day 56	Day 84
Moxidectin					
0.825 mg/kg	33.25ab	127.40a	0.0b	5.55b	0.00b
0.550 mg/kg	0.00a	20.48a	16.65a	0.00a	0.00a
0.275 mg/kg	2.00a	20.50a	283.00a	2.40a	0.00a
0.0 mg/kg	23.50a	739.30a	64.10a	0.00a	277.50a
Ivermectin					
0.825 mg/kg	6.65b	294.53a	13.88b	0.00b	9.50b
0.550 mg/kg	22.28a	151.50a	5.75a	0.00a	0.00a
0.275 mg/kg	0.00a	155.20a	421.80a	0.00a	37.20a
0.0 mg/kg	13.30a	365.60a	79.40a	0.00a	0.00a

[a]Different letters in the same row indicate significant differences at $p < 0.05$.

REFERENCES.

1. 1997 Agricultural Census, National Statistics Service. United States Department of Agriculture. 1998.

2. 1999 Florida Livestock, Dairy, and Poultry Summary. Florida Agricultural Statistics and Service. 2000.

3. Williams, J. C., Loyacano, A. F., DeRosa, Gurie, J., Clymer, B. C., and Guerino, F. 1999. A Comparison of Persistent Anthelmintic Efficacy of Topical Formulations of Doramectin, Iveremctin, Eprinomectin, and Moxidectin Against Naturally Acquired Nematode Infections. Veterinary Parasitology. 85: 277-288.

4. Fort Dodge Animal Health. 2000. A Comparison of the Persistent Efficacy of Pour-On Formulations of Moxidectin (Cydectin) and Iveremctin (Ivomec) Against Naturally Acquired Nematode Infections of Beef Cattle (Cows and Calves) Following a Single Treatment. Technigram. FDP802 5M.

5. Diagnostic Services, AVC, 2003. Parasitology. Atlantic Veterinary College, University of Prince Edward Island. http://www.upei.ca/~diagserv/paras.htm.

6. SAS, 2005. SAS for Window Version 9.1. SAS Institute, Cary NC.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):542. 2008

Poster #79

A Comparison of Grass vs. Legume Free Range Small Ruminant Finishing Systems for the Tropics

S.A. Weiss, R. Ben-Avraham, R.C. Ketring, and R.W. Godfrey, Agricultural Experiment Station, Agronomy Program, University of the Virgin Islands, St. Croix. stuweiss@yahoo.com

Small Ruminant Special Session during evening Poster Session
Tuesday July 15, 2008, Mediterranean West and Center

ABSTRACT.
The objective of the present study was to evaluate live animal performance and carcass characteristics of Dorper X St. Croix White lambs managed in two types of post-weaning alternative pasture finishing systems in the tropics. After weaning and background grazing on native pasture for eight months, lambs (n = 37) were stratified by weight and sex into two treatments consisting of native pasture (NP) and improved pasture (IP), with energy supplement. Native pasture consisted of a mix of guinea grass (*Panicum maximum*) and hurricane grass (*Boithrocloa pertusa*), while IP consisted of a mix of seeded tropical legumes (*Vigna unguculata*, *Clitoria ternetea*, and *Lablab purpureus*) and volunteer guinea grass in 0.45 ha paddocks where forage availability was not a limiting factor. All lambs were supplemented with crushed corn daily at a rate of 1 % of their body weight for 100 days and slaughtered at approximately 365d of age. During the finishing trial IP lambs had greater total weight gain ($P < 0.0001$) than NP lambs (10.7 ± 0.4 vs. 7.5 ± 0.4 kg, respectively). In addition, IP lambs had higher ADG ($P < 0.0002$) than NP lambs (104.3 ± 4.5 vs. 77.9 ± 4.5 g/d, respectively). Compared to NP lambs, IP lambs were heavier at slaughter ($P < 0.05$; 40.6 ± 1.1 vs. 36.9 ± 1.1 kg, respectively) had heavier carcasses ($P<0.05$; 20.5 ± 0.6 vs. 18.1 ± 0.6 kg, respectively) and greater dressing percent ($P < 0.05$; 50.4 ± 0.4 vs. 48.9 ± 0.4 %, respectively). Further, IP lambs had greater body wall thickness ($P < 0.05$; 14.1 ± 0.6 vs. 11.9 ± 0.6, mm, respectively) and rib eye area ($P=0.08$; 10.1 ± 0.3 vs. 9.2 ± 0.3 cm^2, respectively) than NP lambs. Back fat thickness, KPH fat, and leg circumference for IP and NP lambs was not significantly different. Results of this study indicate that the adoption of alternative pasture finishing practices utilizing mixed legume improved pasture with corn supplementation can lead to improvements in animal performance and carcass muscularity of crossbred hair sheep lambs under tropical conditions.

KEYWORDS: sheep, legumes, pasture finishing, carcass characteristics

2008 Proceedings of the Caribbean Food Crops Society. 44(2):543. 2008

Poster #80

Development and Evaluation of a Ready to Cook Vacuum Packaged Goat Meat Product

N. Djeri[1], S. K. Williams[1], R. Mobley[2], A. McKenzie-Jakes[2], K. Sarjeant[1], and A. Ruiz[1], [1]Department of Animal Sciences, University of Florida, Gainesville, FL and [2]Florida Agricultural & Mechanical University, Tallahassee, FL. noufoh@ufl.edu

ABSTRACT.
The objective of this study was to develop a goat meat rib product. Four product prototypes were developed containing either all goat meat ribs, no additives and marinated in water (control) (Treatment 1); goat meat ribs marinated in water and apple cider vinegar (Treatment 2); goat meat ribs marinated in water only and manually rubbed with a spice blend (Treatment 3); and goat meat ribs marinated in apple cider vinegar and water and manually rubbed with a spice blend (Treatment 4). The products were vacuum-packaged and stored at 4 ± 1°C for 21 days. Sensory evaluation using a trained sensory panel, microbiological analyses, pH and processing yields were determined from 0 to 21 days storage. The panelists detected no significant differences ($P > 0.05$) in overall tenderness between the four treatments. The goat meat ribs formulated with apple cider vinegar only were rated significantly higher ($P < 0.05$) for goat flavor intensity and off-flavor, when compared to all other treatments. *Staphylococcus aureus, Salmonella* spp., *E*scherichia *coli* O157:H7, generic *Escherichia coli* and fecal coliforms were not detected in any of the treatments. Total aerobic plate counts, total coliforms and anaerobic bacteria were significantly lower ($P < 0.05$) for goat meat ribs marinated with apple cider vinegar and ribs marinated with both apple cider vinegar and manually rubbed with the spice blend, when compared to ribs marinated with water only, and ribs marinated with water only and manually rubbed with the spice blend. Psychrotrophic counts were significantly lower ($P < 0.05$) for ribs marinated with apple cider vinegar and manually rubbed with the spice blend when compared to all other treatments. Results from this study suggested that marinating and applying a spice rub to goat ribs could produce an acceptable value added product.

KEYWORDS: goat meat ribs, sensory analysis, psychrotrophs, coliforms

2008 Proceedings of the Caribbean Food Crops Society. 44(2):544. 2008

Poster #84

Development and Evaluation of Pre-Cooked Vacuum Packaged Goat Meat Products

N. Djeri[1], S.K. Williams[1], R. Mobley[2], A. McKenzie-Jakes[2], K. Sarjeant[1], A. Ruiz[1]. [1]Department of Animal Sciences, University of Florida, Gainesville, FL and [2]Florida Agricultural & Mechanical University, Tallahassee, FL. noufoh@ufl.edu

ABSTRACT.
Production of value added pre-cooked goat meat products could increase demand, consumption, acceptability, and marketability of goat meat. The objectives of this study were to develop and evaluate proximate composition, pH, sensory and microbiological characteristics (fecal coliforms, aerobic plate counts, psychrotroph counts, anaerobic plate counts) of refrigerated pre-cooked vacuum-packaged goat rib products. Racks from ten Boer Crossbred Spanish meat goats were cut into three longitudinally proportional rib units, and randomly assigned to four groups and formulated with either 1) no treatment, control, 2) apple cider vinegar only, 3) Spice rub only or 4) spice rub plus apple cider vinegar. After formulation, all goat ribs were baked to an internal temperature of 74°C in a conventional gas oven, vacuum packaged, and stored at 4 ± 1°C for 42 days.

The trained panelists rated all samples slightly bland (4.00) to slightly intense (5.68). Overall, there was no significant difference ($P > 0.05$) between treatments through the 42 days shelf life for overall tenderness. Overall flavor of marinated goat rib with spice rub applied. The texture of both samples was similar ($P > 0.05$). The consumer panelists were also more likely to purchase the goat meat that had been marinated and a spice rub applied, over goat meat with a spice rub applied only. Psychrotrophic organisms counts varied from 0 to 5.95 log CFU/g: except for the spice rub, the data demonstrated a decrease in psychrotrophic organisms through 42 days for all treatments. No organisms of public health safety (*Staphylcoccus aureus*, Salmonella, *Escherichia coli* 0157:H7, and *Listeria monocytogenes*) were found. The trained and consumer panelists found the products acceptable, regarding goat flavor intensity, overall tenderness, and texture (consumer panel only). Manufacturing a pre-cooked marinated vacuum packaged goat rib product could be a successful venture.

KEYWORDS: pre-cooked, goat ribs, vinegar

2008 Proceedings of the Caribbean Food Crops Society. 44(2):545. 2008

Poster #86

The Effects of Synchronization Treatments on Estrous Response in Seasonal Does

Angela McKenzie-Jakes, G. Nurse, and G. Byrant. Research and Cooperative Extension Programs, Florida A&M University. angusboer34@hotmail.com

ABSTRACT.
Reproduction efficiency is one of the most important economic traits in terms of livestock production. Maintaining good reproductive functions in the herd is pivotal to the success of any livestock production system. Productivity and profitability in the goat herd is measured by ovulation rate, conception rate, the number of kids born, the number of kids weaned and the frequency in which they are produced. Theoretically, a gestational period (pregnancy) of five months should support more than one kidding interval per doe per year. However, the se repetición fue el asonal breeding behavior of goats in the U.S. has seriously limited the ability of the producer to increase herd productivity and to access markets that bring about the highest economic returns. In recent years, estrus synchronization has become a valuable reproductive tool for controlling and manipulating the breeding period in goats. Studies have shown that differences exist in the onset and duration of estrus between various breeds of goats and even among individuals within the same breed. The objective of this study was to determine efficacy of different treatment regimens on inducing cyclic heat in breeding does. Sixty does were randomly assigned among three treatment groups. Goats in group A (n=20) were the control group (no treatment). Goats in group B were synchronized using CIDR, (Controlled Internal Releasing Device) in combination with lutalyase (1ml) and goats in group C were exposed to a vasectomized buck for 21 days. Blood samples were collected after the does were observed in standing heat. Immunoassays test were used to determine serum progesterone concentrations in the experimental does. Cyclic heat was observed in 85% of the does within 24 hours after the implants were removed (treatment B), 24 hours after the vasectomized buck was remove from the pen (treatment C) and 40% of the does were in heat in the control group 24 hours after being exposed to an intact buck.

KEYWORDS: goats, reproduction, synchronization, CIDR

2008 Proceedings of the Caribbean Food Crops Society. 44(2):546. 2008

Poster #87

An Integrated Approach to Increasing Food Safety Awareness at the Farm Level among Small and Limited Resource Goat Producers in Florida

[1]A. McKenzie-Jakes, [1]R. Mobley, DVM, [1]T.E. Peterson, DVM, [2]P. Hunter, DVM, [1]G. Nurse, J. Beaudouin, [1]G. Bryant, [1]G. Queeley, [1]S. Thompson, [3]N. Tillman, and [1]L. Anderson. [1]Florida A&M University, Research and Cooperative Extension Program, [2]Florida Department of Agriculture (DOACS) and [3]Southeaster Small Farmer's Network. angusboer34@hotmail.com

ABSTRACT.
Many researchers today agree that most food borne illnesses start on the farm. The Center for Disease Control and Prevention (2007) estimated that 76 million food borne illnesses occur each year in the United States. In 2007, the Master Goat Producers Program was initiated through Florida A&M University's Research and Cooperative Extension program to address increasing incidents of food borne illness and herd health issues linked to goat production. The goal of this program was to educate producers about the real threat of food borne illnesses. Furthermore the program was established to ensure that producers took strides in protecting their animals and consumers from microbial ford borne contaminations and other infectious diseases.

In view of this a 5 day comprehensive training program was developed for small and limited resource goat producers followed by on-farm inspections. The program emphasized training on food safety and associated heard health problems with small ruminants.

A survey conducted revealed that prior to attending the program most of the participants were unfamiliar with HACCP (77.78%), biosecurity (66.67%), quality assurance (68.00%) and bioterrorism (57.69%). These results may explain why only 3% of the participants passed the pre-examination. Contrastingly, 89% of the producers passed the post-examination with a score of 70% or greater. From the pool of producers that applied for certification status, 64.3% passed their initial farm inspection and adopted 5 or more sustainable goat production practices on their farm. These results provide convincing evidence that extension programs of this nature are highly warranted.

KEYWORDS: food borne illness, food safety, Master Goat Program

2008 Proceedings of the Caribbean Food Crops Society. 44(2):547. 2008

Poster #48

First Report of *Cladosporium tenuissimum* Cooke on Taro in Puerto Rico

Evelyn Rosa-Márquez[1] *and Carlos E. Ortíz*[2]
Crop Protection Department, Agricultural Experiment Station, Agronomy and Soils Department, University of Puerto Rico, Mayagüez. eve_rosa@hotmail.com

ABSTRACT.
Cladosporium tenuissimum Cooke has been identified in Puerto Rico on taro [*Colocasia esculenta* (L.)] Schott. At the onset of the symptoms, the fungus causes reddish-brown leaf spots that become tan to brown with age. Spots are circular or irregular. In the upper leaf surface pale greenish- yellow spots were observed that belongs to the corresponded spot at the lower. Spots often coalesce to form large necrotic areas. Pathogen city test were performed with pure culture of the fungus, isolated in potato-dextrose agar by misting conidial suspensions in sterile distilled water on healthy plants in pods. Typical lesions developed six days after inoculation. The causal agent was reisolated. This fungus was having been previously reported in both Cuba and Puerto Rico. It is reported here for the first time in Puerto Rico affecting both cultivated and non-cultivated taro.

KEYWORDS: disease symptoms, Koch's postulates

2008 Proceedings of the Caribbean Food Crops Society. 44(2):548-549. 2008

Poster #49

Relación entre las Propiedades Físicas de un Oxisol y Coberturas Vegetales en la Incidencia de *Phytophthora cinnamomi* en Aguacate *Persea americana Mill.*

Beatriz E. Torres Ordóñez[1], C. Estévez de Jensen[2], V. Snyder1 y M. Vazquez[1]. [1]Department of Agronomy and Soils, [2]Department of Crop Protection, College of Agricultural Sciences, University of Puerto Rico-Mayagüez Campus. P.O. Box 9032 Mayagüez, P.R. 00680. bettorres25@yahoo.com

RESUMEN.
En Puerto Rico se importa el 80 por ciento del aguacate que se consume, lo cual indica el potencial económico de aumentar la producción local del cultivo. Sin embargo, las áreas de producción se han visto afectadas con la alta incidencia y severidad de pudrición de la raíz asociada a *Phytophthora cinnamomi.* Dicha condición se ve acentuada por condiciones de saturación del suelo durante la época lluviosa (julio – diciembre), altas temperaturas, y agrietamiento del suelo en épocas de sequía que causan daño mecánico al sistema radicular. En mayo de 2006 se estableció un huerto con la variedad Semil 34/Semil 34 (patrón/injerto) para evaluar la influencia de *Arachis pintoi* y *Arachis glabrata* en un Cumulic Haplustoll, serie San Antón, franco arcilloso. Las coberturas fueron establecidas alrededor de los árboles en junio de 2006, las cuales se comparan con un control (no cobertura leguminosa) en un diseño completamente aleatorizado con 4 repeticiones por tratamiento. Las propiedades físicas del suelo consideradas en este estudio son: estabilidad de agregados donde después de 20 meses de establecidas las coberturas se encontró diferencias significativas ($p<0.05$) entre el tratamiento con *Arachis glabrata,* 46.24%, versus el control, 22.36% de estabilidad, también se encontraron diferencias significativas en infiltración en campo, potencial mátrico inicial. Hasta el momento no se han encontrado diferencias significativas para Densidad aparente, permeabilidad en laboratorio, y curvas de retención de humedad, pero cabe destacar un mejor comportamiento de estas propiedades con las coberturas versus el control. Algunas propiedades químicas evaluadas fueron Nitrógeno total y Fósforo, en donde se encontraron diferencias significativas; no se han encontrado diferencias en materia orgánica, ni en pH. Se continuará evaluando las propiedades del suelo hasta completar un período de dos años.

PALABRAS CLAVE: *Arachis pintoi, Arachis glabrata*, aguacate, propiedades físicas de suelos.

Relationship between Vegetative Covers and Soil Physical Properties of one Mollisol on *Phytophthora cinnamomi* Occurrence in Avocado *Persea americana* Mill. in Puerto Rico.

ABSTRACT.
Puerto Rico imports 80 percent of the avocado that is consumed, which indicates economic potential of increasing its local production. However, the production of this crop have been affected with the high incidence and severity of the root rot associated with *Phytophthora cinnamomi*. This condition is exacerbated soil saturation conditions during the rainy season (July – December), high air temperatures and soil cracks during the dry season causing mechanical damage to the rooting system. During May 2006 an avocado plantation was established with the Semil 34/Semil 34 variety (pattern/graft) in order to evaluate the *Arachis pintoi* and *Arachis glabrata* influence in San Antón soil series, a fine-loamy Cumulic Haplustoll. The vegetative covers were established at the avocado trees surroundings during June 2006. The vegetative covers were compared with a control (no coverage legume) in a completely randomized design with four repetitions for treatment. The analyzed soil physical properties were: aggregates stability percentage, which after 21 months of coverage provided significant differences ($p<0.05$) between the *Arachis glabrata* (46.24%) versus the control (22.36%); also provided significant differences in field infiltration and bulk density. The moisture retention curves highlighted a better performance in *A. glabrata* versus the control after 12 months. The analyzed soil chemical properties were: total nitrogen percentage and available phosphorous (ppm) which provided significant differences; no significant differences were found in organic matter and pH. This investigation will continue to evaluate the soil properties until the end of a two year period.

KEYWORDS: *Arachis pintoi, Arachis glabrata*, avocado, soil physical properties.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):550-552. 2008

Poster #50

Weed Management During and After Rhizoma Perennial Peanut Establishment

María de L. Lugo-Torres[1] and Teodoro Ruiz[2]. [1]Weed Scientist, Dept. of Crop Protection, [2]*Professor, Dept. of Animal Science, University of Puerto Rico, Mayaguez Campus. mlugo@uprm.edu*

ABSTRACT.
Beef and dairy enterprises are among the most economically important agricultural activities through the Caribbean Islands of the US. Rhizoma perennial peanut is currently being considered in the Caribbean as an alternative forage because of its low requirements for nitrogen fertilization, relatively high protein content, adaptability to contrasting ecological areas and low susceptibility to pests. The objective was to evaluate strategies to control weeds during and after rhizoma perennial peanut establishment. Four herbicide treatments of imazethapyr and dimethenamid were evaluated. Predominant weeds were junglerice, purple nutsedge, horse purslane, wild poinsettia and common purslane. Differences were detected for dry weight of the peanut and weeds among herbicides treatments at establishment. After establishment, evaluations indicated the best weed control was obtained on the early application dates.

KEYWORDS: rhizome perennial peanut, weeds

INTRODUCTION

Beef and dairy enterprises are among the most economically important agricultural activities through the Caribbean Islands of the US. There is considerable interest in this area to improve production and quality of forages. Rhizoma perennial peanut (RPP) (*Arachis glabrata*) is currently being considered in the Caribbean as an alternative forage because of its low requirements for nitrogen fertilization, relatively high protein content, adaptability to contrasting ecological areas and low susceptibility to pests. The response of weeds and rhizoma perennial peanut to imazethapyr and dimethenamid in tropical and sub tropical conditions are unknown. Thus, the objective of this study was to evaluate strategies to control weeds during and after RPP establishment.

MATERIALS AND METHODS

A field experiment was established at Juana Díaz, Puerto Rico. The soil was a Mollisols with a pH of 7.7. Two RPP accessions, USDA 17033 and USDA 17095, were used. Plot size was 4.57m x 6.0 m and consisted of five rows 0.76 m apart. Planting material was freshly dug rhizomes that were planted continuously in the row at 10-cm depth.

Herbicide treatments were: 1)-imazethapyr at 0.070 kg ai/ha, preemergence (PRE); 2)-dimethenamid at 1.68 kg ai/ha – PRE; 3)-dimethenamid at 3.36 kg ai/ha – PRE; and 4)-imazethapyr at 0.070 kg ai/ha early postemergence (early POE, applied 16 days after planting). Preemergence herbicide treatments were applied the day after planting with a

portable CO2 pressured backpack sprayer delivering 187 L/ha. Treatments were arranged in a RCBD with four reps. To ensure plant survival, plots were uniformly irrigated with sprinklers the day after the PRE herbicides treatments were applied.

After herbicides treatments, and to complete weed management until RPP establishment, plots received uniformly bromoxynil at 0.28 kg ai/ha 4, 8, 11 weeks after planting and clethodim at 0.28 kg ai/ha at: 4, 11, 24, 31 WAP. By week 42 after planting, glyphosate at rate mix of 20:1 water:herbicide was applied with a weed wiper adjusted 40 cm above the ground.

Data and Analyses: Data for analyses included: *1)*-Weed dry weight and RPP were evaluated, 6 six and 12 months after planting. 2)-Relative yield among plots at 7 and 13 weeks after the leveling cut (2 years after planting). All data were subjected to analysis of variance, and means were separated using the Tukey´s test at the $P \leq 0.05$ level.

RESULTS AND DISCUSSION

Predominant weeds were junglerice (*Echinochloa colona)*, purple nutsedge (*Cyperus rotundus)*, horse purslane (*Thrianthema portulacastrum*), wild poinsettia (*Euphorbia heterophylla*) and common purslane (*Portulaca oleracea*).

Dry weight of weeds and RPP yield during establishment (Table 1)*:* Differences were detected for dry weight of RPP and weeds among herbicides treatments at establishment (Table 1). Those plots receiving imazethapyr as an early postemergence had 44 g/m^2 more dry weight of weeds than dimethenamid at the lowest rate, but not significant differences were found among the other treatments. The lowest weight of RPP as compared with the other three herbicide treatments, was that with imazethapyr early POE (Table 1). No difference was observed when comparing dimethenamid at the two rates. No differences were detected for dry weight of RPP and weeds among herbicide treatments at six months nor at 12 months after harvest.

Dry weight of weeds and RPP yield after establishment (Table 2): Imazethapyr early POE was not as effective as the rest of the treatments in controlling weeds. As a response to imazethapyr early POE, RPP yield was significantly lower (Table 2). Overall, taking into account all rates and dates of herbicide applications, the best weed control was obtained on the early application dates. A prior study by Ruiz et al. (2000), indicated high yield of the RPP when high doses of imazethapyr were combined with appropriate irrigation.

Table 1. Dry weight of rhizoma perennial peanut and weeds during the establishment at Juana Díaz, Puerto Rico [1]

Herbicide Treatment	Rate kg ai/ha	Dry weight of peanut		Dry weight of weeds	
		----- g/m^2 -----		----- g/m^2 -----	
Imazethapyr PRE[2]	0.07	203.6	a	54.7	ab
Imazethapyr – early POE	0.07	92.6	b	77.1	a
Dimethenamid PRE	1.68	286.2	a	32.9	b
Dimethenamid PRE	3.36	203.2	a	64.2	ab

[1] Means within a column followed by the same letter are not significantly different according to Tukey's at the $P < 0.05$ probability level.
[2] PRE = preemergence; early POE = early postemergence.

Table 2. Dry weight of weeds and yield of rhizoma perennial peanut after two years of establishment at Juana Díaz, Puerto Rico on 2005 [1].

Herbicide Treatment	Rate kg ai/ha	----- Dry matter -----					
		Weeds		Perennial peanut			
		----- g/m^2 -----		----- g/m^2 -----			
				7 WAL		13 WAL	
Imazethapyr PRE	0.07	90.3	a	509.9	a	826.3	a
Imazethapyr- early POE	0.07	210.8	b	307.9	b	290.1	b
Dimethenamid PRE	1.68	56.5	a	719.7	a	1001.7	a
Dimethenamid PRE	3.36	91.8	a	538.7	b	997.8	a

[1] Means within a column followed by the same letter are not significantly different according to Tukey's at the $P < 0.05$ probability level

REFERENCES

Ruiz, T.M., R. Ramos–Santana and A. Sotomayor-Rios. 2000. Establishment of rhizoma perennial peanut (*Arachis glabrata*) under irrigation at two semiarid sites in the Caribbean. J. Agric. Univ. of PR. 84:105-114.

ACKNOWLEDGMENT:
This study was supported in part by the USDA-CSREES special grant Tropical/Subtropical Agricultural Research (T-STAR).

2008 Proceedings of the Caribbean Food Crops Society. 44(2):553. 2008

Poster #51

Black Sigatoka IPM in Puerto Rico

W. Almodóvar[1] and M. Díaz[2], [1]Crop Protection Department, and [2]Horticulture Department, University of Puerto Rico, Mayagüez Campus. walmodovar@uprm.edu

ABSTRACT.
The Black Sigatoka Management (BSM) Program of the University of Puerto Rico Extension was funded in part by the Southern Region IPM Center and the USDA/ES/IPM program. There were two field day workshops for Extension Agents held at the Gurabo Research Station. Each workshop introduced the concepts and practice of BSM. Seventy-five Extension Agents were trained to identify the stages of Black Sigatoka, determine the incidence of this disease using the Stover scale, and calculate the percentage infection. An experimental plot of plantain infected with the disease was used for this purpose. A field guide with an electronic presentation in Spanish about BSM was created. Each attendee received a copy of these educational materials, and agreed to conduct field day and training meetings for growers on the topics discussed in the BSM program. All attendees increased their knowledge and attitudes toward non-chemical management of Black Sigatoka, and pesticide safety. They considered the field guide and the set of electronic presentations appropriate to train growers to implement effective and environmentally responsible management strategies for the protection of plantain and banana from Black Sigatoka. The outcomes of this project will lead to reduce the potential for Black Sigatoka problems on plantain and banana and to decrease pesticide use in the environment. This project expands the existing pesticide safety, and IPM programs in Puerto Rico. The field guide and electronic presentations about the BSM can be reached at:
http://academic.uprm.edu/walmodovar

KEYWORDS: Stover scale, plantain, banana, strategies

2008 Proceedings of the Caribbean Food Crops Society. 44(2):554-562. 2008

Poster #52

Crianza Masiva de Mirax Insularis Muesebeck, el Parasitoide Exótico del Minador del Café *Leucoptera coffeella* Guérin-Ménéville (Lepidoptera: Lyonetíidae) en Puerto Rico[5]

Fernando Gallardo[1], Evelio Hernández[2], Marcela Daza[3] y Jennifer Pagán[4]
[1]Catedrático, [2]Ayudante de Investigaciones, [3]Estudiante Graduada, [4]Auxiliar de Investigaciones. Universidad de Puerto Rico, Recinto Universitario de Mayagüez, Departamento de Protección de Cultivos, Apartado 9000, Mayagüez. PR 00920. fgallardo@uprm.edu *[5]Este trabajo de investigación es financiado en parte por "USDA-Special Grants in Tropical Agriculture, Project TSART-110 "Augmentation of Mirax insularis Muesebeck for the population suppression of the coffee leafminer Leucoptera coffeella in Puerto Rico".*

RESUMEN.
El minador del café, *Leucoptera coffeella* (Guerin Ménéville) es una de las plagas principales del cultivo del café mundialmente. Cuando las prácticas de control no son apropiadas ocasionan defoliación a los arboles de café afectando su producción. Desde hace algunos años se han estado buscando alternativas de control que sean viables tanto económicamente como ambientalmente. Una de las técnicas sugeridas es la incrementación de uno de sus más abundantes parasitoides en el Caribe, el bracónido, *Mirax insularis* Muesebeck. Para la crianza masiva del huésped del bracónido utilizamos plántulas de café (*Coffea arabica* L. cultivar Catuaí) de tres meses. Expusimos 65 plántulas de café, cultivadas libres de insectos, a 60-80 adultos del minador del café dentro de una cajuela de infestación durante tres días. Removimos las plántulas al cuarto día después de la infestación y a los tres días siguientes introducimos los adultos del parasitoide para que parasitaran las minas presentes en las hojas por espacio de 48 horas. Al cabo de 13 días podamos las hojas de cada plántula y las mantuvimos *in Vitro* para la recuperación de adultos. La introducción de los parasitoides se hizo de acuerdo al momento más adecuado de su huésped que es cuando las larvas del minador están en el primer o segundo instar, evento que ocurre entre los tres y siete días post-oviposición. En promedio se recuperaron 4 ± 0.25 ($\mu \pm$ SEM) adultos del parasitoide por cada hembra introducida. La recuperación de los adultos del parasitoide estuvo muy por debajo de lo esperado. La capacidad reproductiva del parasitoide bajo las condiciones de este estudio nos obliga a repensar la viabilidad de un programa de control biológico por incrementación utilizando a *Mirax insularis* como agente de biocontrol.

ABSTRACT.
The coffee leafminer, *Leucoptera coffeella* (Guerin-Méneville), is one of the key pests of coffee worldwide. When the control practices are not appropriate they cause defoliation to the coffee trees affecting its production. For many years, we have been looking for alternative controls that are viable as much economically as environmentally. One of the control method suggested is the augmentation of one of his more abundant parasitoids in

the Caribbean, the braconid, *Mirax insularis* Muesebeck. For the massive rearing of its host, we used three months old coffee seedlings (*Coffea arabica* L. cultivar Catuaí). Sixty-five seedlings, cultivated free of insects, were exposed to 60-80 adults of the coffee leafminer inside a rearing cage during three days. Three days post-infestation, the seedlings were removed to a parasitoid-infestation cage and during the next three days we introduce adults of *M. insularis* so that the present mines in the leaves would be parasitize. After 13 days we pruned the leaves of each seedling and maintained *in Vitro* for the recovery of the parasitoids adults. This procedure was replicated four times. The introduction of the parasitoid were done according to the most suitable moment of its host that is when the coffee leafminer larva is in the first or second instar, event that happens between the three and seven days post-oviposition. In average we recovered 4 ± 0,25 (μ ± SEM) adults of the parasitoid by each female introduced. The parasitization rate that we observed during this study was very below to what can be expected. Thus, the low reproductive capacity of *Mirax insularis* under the conditions of this study forces us to rethink the viability of a biological control program by augmentation of the braconid to suppress the coffee leafminer in Puerto Rico.

PALABRAS CLAVE: Café, *Coffea arabica*, Biocontrol, Minador del Café, *Mirax insularis*, Crianza Masiva.

INTRODUCCIÓN

El minador de la hoja del cafeto, *Leucoptera coffeella* Guérin-Ménéville, es una de las plagas principales de *Coffea arabica* L. en Puerto Rico. Su oruga penetra en el mesófilo de la hoja alimentándose y causando una mancha marrón irregular que afecta la capacidad fotosintética del cafeto disminuyendo su producción hasta un 50% (Figura 1) (Cibes & Pérez 1958). Aunque su control es obtenido con la aplicación de insecticidas sistémicos granulares es necesario buscar otras alternativas de control, tales como el uso de enemigos naturales. La incrementación de parasitoides para control de las poblaciones del minador ha sido propuesto como una de las alternativas viables a este problema (Gallardo 1992).

En Puerto Rico el minador tiene una amplia gama de parasitoides siendo el bracónido *Mirax insularis* Muesebeck el más abundante (Figura 2). Este parasitoide fue introducido desde la isla caribeña de Guadalupe a Puerto Rico a principios de la década del cuarenta (Gallardo 1988). En la actualidad se encuentra distribuido en todas las zonas cafetaleras de Puerto Rico y su nivel de parasitación llega alcanzar el 32.4 % (Gallardo 2006). Este parasitoide es un koinobionte con tres estadios larvales y su ciclo de vida se completa en 15 días emergiendo su adulto de la pupa del minador del café (León 1997). Estudios realizados de la dinámica poblacional de su huésped nos indican que en Puerto Rico tenemos dos picos de abundancia del minador definidos por un periodo de lluvia seguido por tres o más semanas de sequía. Con el objetivo de criarlo masivamente y liberarlo en los momentos estratégicos antes que comiencen a aumentar las poblaciones del minador se estableció una crianza artificial del minador y posteriormente se estudio la capacidad de reproducción masiva de *M. insularis*.

MÉTODOS Y MATERIALES

El procedimiento de crianza de *M. insularis* se divide en los siguientes pasos: 1) en el invernadero de producción (libre de insectos) sembramos en tiestos las plántulas de café, las cuales serán utilizadas al cabo de los tres meses 2) recolectamos en el campo hojas infestadas de minador y con el parasitoide, 3) en el laboratorio recolectamos los adultos del parasitoide según van emergiendo de las muestras de hojas traídas del campo, 4) exponemos las plántulas de café previamente infestadas con el minador a los adultos del parasitoide recolectados en el paso anterior, 5) mantenemos las plántulas tratadas anteriormente en el invernadero de infestación hasta los 13 días post-infestación con el parasitoide, 6) cortamos las hojas infestadas por el minador, 6) llevamos las hojas podadas al laboratorio y las mantenemos in Vitro, y 7) recolectamos los adultos del parasitoide en el laboratorio (Figura 3). Los costos de producción se dividen en recurrentes (plántulas, fertilizantes, mano de obra, medio de crecimiento y citokinina) y no recurrentes (tiestos, cajuelas de recolección, infestación y crianza, aspirador de vacío, tubos plásticos, y aspiradores). El costo de espacio y utilidades es provisto por la Estación Experimental Agrícola de Adjuntas (EEAA), de la Universidad de Puerto Rico y no es considerado en los análisis de costo.

Condiciones Ambientales: Todos los procedimientos de crianza en el invernadero se realizan en la EEAA a unas temperaturas de 18 a 25 °C, 65 ± 5% HR. Toda la crianza in Vitro del minador es realizada en el laboratorio en un cuarto de crianza (25 ± 1 °C y 45 ± 5% HR) en la EEAA. La fuente de luz utilizada son tubos fluorescentes "cool-white", 40 voltios, con un ciclo de 12 hr L:O.

Producción de Plántulas: Plántulas del cultivar Catuaí, seleccionado como el más apropiado (data no publicada) para la crianza del minador, fueron sembradas en tiestos plásticos (19.6 cm. dia.) y depositadas en un invernadero preparado para mantenerlas libres de insecto, (15.23 x 15.23 x 2.43 m altura); cubierto con tela Lumite$^{(R)}$ (50 x 24 mesh), dentro de un invernadero en la EEAA. El invernadero de crecimiento tiene cuatro bancos con capacidad de 250 tiestos cada uno, lo cual nos permite una producción de 1,000 plántulas cada tres meses. Sembramos una plántula por tiesto en medio estéril (Pro-Mix$^{(R)}$ sphagnum peat moss) las cuales se irrigan a mano dos veces por semana y se fertilizan mensualmente (20-20-20 Nutrileaf$^{(R)}$).

Infestación con minador: Transferimos las plántulas de café (3 meses), cultivadas libre de insectos, a las cajuelas de infestación (183 X 183 X 183 cm.) cubiertas con Lumite$^{(R)}$ (32 X 32 mesh) (Figura 5) dentro de un invernadero en la EEAA. Cada cajuela de infestación tiene cabida para 65 tiestos o plántulas. Miel y agua se proveen como fuente de alimento. Inoculamos cada cajuela con 60 hasta 80 adultos del minador por cada ciclo de crianza.

Recolección de adultos del parasitoide. Recolectamos hojas de cafeto atacadas por el minador semanalmente en diversas fincas de la Zona Cafetalera de Puerto Rico y las transportamos a la EEAA. Depositamos aproximadamente 50 hojas en cada cajuela de recolección (Figura 4). Miel y agua se proveen como fuente de alimento. Cada mañana se recogen los parasitoides que emergen en las cajuelas de recolección y se transfieren inmediatamente a las cajuelas de infestación. En el Cuadro 1 se presentan los totales de parasitoides recolectados del campo e introducidos a las cajuelas de infestación.

Infestación con el parasitoide y crianza del minador: Removimos las plántulas de café luego de tres días post-infestación y las mantenemos dentro de una cajuela de crianza similar a la cajuela de infestación. Esto nos permite sincronizar su crianza ya que

casi todos los huevos depositados por la hembra del minador tendrán una misma edad y por lo tanto el desarrollo de larva es controlado. De tres a siete días post-infestación se encuentran la mayor cantidad de larvas del minador en los estadios primero y segundo los cuales son los preferidos por el parasitoide para ser parasitados (Navarro 2007).

Recolección *In Vitro* de minador: Tres semanas después de la exposición a los adultos de *M. insularis* separamos las hojas de las plántulas y las llevamos al laboratorio. Cada pecíolo de la hoja es insertado y fijado en un "foam" de polietileno (densidad 28, y 3-cm. espesor) conteniendo agua destilada para el mantenimiento de las hojas separadas de la plántula in Vitro y depositados dentro de una caja acrílica de emergencia (Figura 6). La hojas se mantienen bajo condiciones de laboratorio hasta que emergen los adultos del minador o del parasitoide.

RESULTADOS Y DISCUSIÓN

Para la crianza del parasitoide y el minador en 65 plántulas nos tardamos 25:38 horas en completar todas las tareas (sembrar y mantener las plántulas, recolectar hojas minadas en el campo, infestar las plántulas, transferir y mantener las plántulas infestadas en las cajuelas de crianza, inocular con los parasitoides, podar las plántulas, transferir y mantener las hojas podadas in Vitro, y recolectar adultos del parasitoide. El costo de labor es estimado en $ 187.81 (25:38 horas x $ 7.40). El costo inicial para producir 7,020 minas es estimado en $ 5,653.91 (Cuadro 2). Este estimado incluye los costos no-recurrentes como los recurrentes. Sin embargo, después que la crianza esta en producción solo los costos recurrentes deben ser considerados. Por la tanto, los costos recurrentes de producir 7,020 minas es de $ 361.21 (aproximadamente $ 0.05 por mina). Una crianza mensual utilizando solamente 250 plántulas nos produce aproximadamente 27,000 minas. Utilizando las facilidades actuales podemos producir 324,000 minas por año, si aumentáramos nuestra capacidad de crianza podríamos criar masivamente al minador y a sus enemigos naturales.

Realizamos la introducción de los parasitoides de acuerdo al momento más adecuado de su huésped que es cuando las larvas del minador están en el primer o segundo instar, evento que ocurre entre los tres y siete días post-oviposición. En total introducimos un promedio de 300 adultos por cada cajuela comenzando en el mes de julio de 2007 hasta marzo de 2008 (Cuadro 1) . En promedio recuperamos 12 ± 0.25 ($\mu \pm$ SEM) adultos por cada cajuela durante el periodo del experimento. Además, estimamos que en promedio se recuperaron 4 ± 0.25 ($\mu \pm$ SEM) adultos del parasitoide por cada hembra introducida.

CONCLUSIÓN

Hemos demostrado que podemos criar masivamente al minador de la hoja del café, *L. coffeella*. Desarrollamos un método para producir masivamente al minador, desde huevo hasta adulto, bajo condiciones entoaxénicas utilizando plántulas de café de tres meses y hojas mantenidas *in Vitro*. Esta metodología maximiza los recursos disponibles para criar al minador evitando la contaminación por residuos de insecticidas sistémicos. Aunque la recuperación de adultos del minador utilizando esta metodología sobrepasa las expectativas y sin lugar a dudas podemos criarlo masivamente libre de toxicidad por insecticidas sistémicos o de parasitoides no es así para su parasitoide principal el bracónido *M. insularis*. La recuperación de los adultos del parasitoide estuvo

muy por debajo de lo esperado en comparación con su tasa de parasitización observado en el campo. La capacidad reproductiva del parasitoide bajo las condiciones de este estudio nos obliga a repensar la viabilidad de un programa de control biológico por incrementación utilizando a *M. insularis* como agente de biocontrol.

REFERENCIAS

Cibes H. R. & M. Pérez. 1958. Minador de la hoja disminuye en grado considerable el vigor de los cafetos. *El café de El Salvador* 28: 325-326.

Gallardo F. 1988. Faunal Survey of the coffee leaf miner, *Leucoptera coffeella*, parasitoids in Puerto Rico. *Journal of Agriculture of the University of PuertoRico* 72 (2): 255-263.

Gallardo F. 1992. Augmentation of *Mirax insularis* Muesebeck: An alternative for the population control of the coffee leafminer, *Leucoptera coffeella* Guérin-Ménéville in Puerto Rico. *Journal of Agriculture of the University of PuertoRico* 76(2): 43-54.

Gallardo F. 2006. Population dynamics of the exotic coffee leaf miner *Leucoptera: coffeella* Guerin-Meneville (Lepidoptera: Lyonettídae) larvae parasitoid, *Mirax insularis* Muesebeck, in a sunlight coffee plantation of Puerto Rico. *In*: Caribbean Food Crops Society. Forty Second Annual Meeting. Carolina, Puerto Rico. Vol. 42 (2):87-92.

Navarro, P., 2007. Larval stages (instars) of the coffee leafminer *Leucoptera coffeella* (Guerin-Ménéville)(Lepidoptera: Lyonetiidae) and its synchronization with the parasitoid *Mirax insularis* Muesebeck (Hymenoptera:Braconidae) in Puerto Rico. Tesis M.S. Universidad de Puerto Rico, Mayagüez, P.R. 75 pp.

León, A. 1997. Descripción de las etapas inmaduras del ciclo de vida de *Mirax insularis* (Hymenoptera: Braconidae) in vitro y el efecto de su relación parasítica con el minador de hoja de café, *Leucoptera coffeella* (Lepidoptera: Lyonetidae). Tesis M.S. Universidad de Puerto Rico, Mayagüez, P.R. 55 pp.

Cuadro 1. Numero de adultos de *Mirax insularis* Muesebeck introducidos en las cajuelas de infestación y adultos del parasitoide criados artificialmente in vitro. Julio 2007 hasta Marzo 2008.

Cajuela de Crianza	Introducidos	Criados
1	400	1
2	261	4
3	364	7
4	197	37
TOTAL	**1222**	**49**

Figura 1. Hojas de cafeto atacadas por el minador de la hoja del café, *Leucoptera coffeella*, Guerin-Ménéville..

Figura 2. *Mirax insularis* Muesebeck. A) Hembra, B) Macho

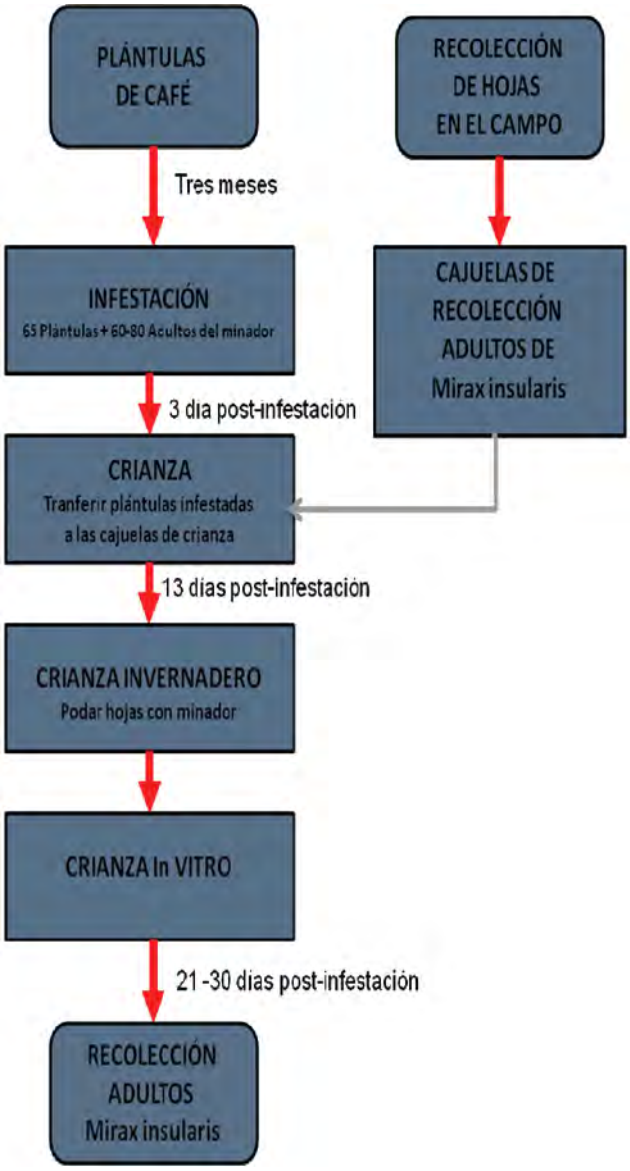


Figura 3. Diagrama de flujo de los pasos y tiempos necesarios para la crianza del bracónido *Mirax insularis* en su huésped el minador de la hoja del cafeto, *Leucoptera coffeella.*

Figura 4. Cajuelas transparente para la recolección de adultos del minador del café, *Leucoptera coffeella* y de *Mirax insularis*

Figura 5. Cajuela para la infestación del minador del café, *Leucoptera coffeella* y posteriormente con el parasitoide.

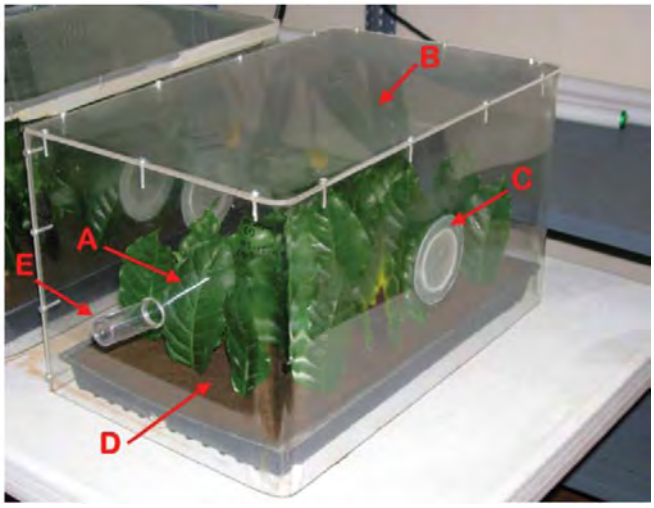


Figura 6. Cajuela de emergencia para la recolección in Vitro del minador del café, *Leucoptera coffeella.* A) hojas del cafeto; B) Caja Acrílica; C) Aperturas de ventilación cubiertos con Lumite; D) "foam" E) Tubos de recoleción (9 drams).

Cuadro 2. Costos estimados para la crianza del minador del café, *Leucoptera coffeella,* en 65 plántulas de café, *Coffea arabica*, cult. Catuaí.

	Cantidad	Precio Unidad ($)	Total ($)
Costos No-Recurrentes			
Tiestos (3.78 L)	65	0.40	26.00
Cajuela Axenica[1]	1	2,960.90	2,960.60
Cajuela Recolección[1]	10	18.75	187.50
Aspirador Vacío	2	264.25	528.50
Aspiratores	4	6.70	26.80
Tubos Plásticos, 9 Drams	200	1.85	370.00
Cajuela Infestación[1]	1	315.40	315.40
Cajuela Crianza[1]	1	315.40	315.40
Cajas Acrílico In vitro[1]	25	22.50	562.50
		Total	**$ 5,292.70**
Costos Recurrentes			
Plántulas de café	65	0.35	22.75
Bolsas Plásticas	100	0.04	4.00
Medio de Crecimiento[2]	1	25.00	25.00
Fertilizante (Triple 20 Nutrileaf)	1 Kg	5.95	5.95
Oasis	1 box	95.00	95.00
Benzyladenin	1 gram	20.70	20.70
Labor	25:38 hours	7.40	187.81
		Total	**361.21**
		Gran Total	**$ 5,653.91**

[1] Construído en la Estación Experimental de Adjuntas; costo incluye labor.
[2] Pro-Mix(R) sphagnum peat moss (0.107) metros cúbicos

2008 Proceedings of the Caribbean Food Crops Society. 44(2):563-570. 2008

Poster #53

Extracts of Native and Non-Native Plant Species for the Control of Cogongrass (*Imperata cylindrica* L)

Lissa D. Reid, Bravo G. Brown, and Oghenekome U.Onokpise, Florida A&M University, Tallahassee, Florida. Lissa1.reid@famu.edu

One of the most invasive species in Florida and other Gulf Coast States is Cogongrass. Cogongrass poses a major problem in natural habitats, on forested lands, rights-of-way and interstate highways. The present study was undertaken to evaluate the performance of cogongrass when grown in extracts of muhly grass (*Muhlenbergia capillaries* Lam) and chenopodium (*Chenopodium ambriosiodes* L). Genets and ramets of cogongrass were transplanted into magenta vessels containing 50% solution of root and shoot extracts of muhly grass and chenopodium, and placing magenta vessels in a growth chamber maintained at 28°C, 16/8 hour photoperiod and a relative humidity of 55 %. The genets and ramets of cogongrass were evaluated once per week for shoot and root growth, as well as rhizome extension after transplanting. Preliminary results show that the extracts of muhly grass and chenopodium reduced shoot growth and rhizome extension of cogongrass. Shoot extracts of muhly grass and chenopodium were more effective in reducing the performance of cogongrass compared to muhly grass and chenopodium root extracts. Root: shoot ratios of cogongrass also decreased by 50-70%. Thus, muhly grass and chenopodium extracts may contain some allelochemicals that could impact the invasiveness of cogongrass.

KEYWORDS: culms, *in vivo*, *in vitro*, Chenopodium, Muhly grass, genets, ramets, extracts, magenta vessels, allelochemical.

INTRODUCTION

Cogongrass (*Imperata cylindrica* L.) sometimes called japgrass, blady grass, spear grass and alang-alang, is a C_4 rhizomatous perennial weed with culms that grow erect typically reaching a height of 1.2 m but may sometimes grow as tall as 3m. The fibrous roots are extensive and extend from a scaly rhizome (Brown, 1944). Cogongrass is one of the most difficult weed to control. It can grow almost any where in the world and under any temperature. Cogongrass is not found in the Antarctica (Willard et al, 1990). Cogongrass was introduced to the United States in the late nineteenth century and early twentieth centuries. Today, cogongrass is an invasive weed in the Gulf Coast States of southeastern United States. Cogongrass is considered a serious invasive species in parts of Florida, southern Alabama, southern Mississippi, and Georgia where it invades pastures, nurseries, pecan plantation, highway right-of-way, lawns, phosphate mined areas, pine plantation, parks and recreational areas (Onokpise, 2000; Patterson et al., 1980). It constitutes an impediment to efforts aimed at reclamation and restoration of these sites to their natural conditions or productive lands. Cogongrass is mainly spread by rhizomes and seed. Once cogongrass is established it competes with neighboring crops

and plants and reduces their yields (Bolfrey-Arku et al.; 2002, 2004). The persistent and aggressive rhizome of cogongrass remains the main mechanisms for survival and spread, while its resilience makes it difficult to control. Besides the rhizomes, wind blown seeds have aided in the establishment of vast areas of cogongrass.

Based on studies conducted on the species (Shilling et al., 1997) a combination of herbicides (glyphosphate and imazapyr), and mechanical treatments provide excellent control. However a single herbicide application is costly. Reinvasion by cogongrass rapidly occurs if ecological niche is not replaced by another plant species. Imazapyr is the recommended herbicide because it is effective and has a long lasting residual effect on soil and prevent revegetation of the controlled areas while glyphosphate and others are relatively biodegradable. The impact on non target species from the use of herbicide often has severe implications causing reinvasion of cogongrass or invasion by other weed species (Gaffney and Shilling, 1996). For economic and environmental reasons the current control strategies are often not acceptable and necessary considerations need to be given other control methods. Studies conducted in other parts of the world with leguminous plant species, have revealed that these species provide effective control of cogongrass in their natural habitat (Bolfrey-Arku et al., 2002; Chikoye et al., 1999)

Biological control is the action of one organism (plant or animal) in the control or maintenance of another organism. The aim is to maintain the organism at economic level. There are many advantages of using biological control for the management of weeds. There are no environmental residues, self reputation with human assistance, non toxic to animals and human, and more sustainable to the environment (Zimdahl, 1993). The use of native plant species, as biological control agents (Onokpise et al.; 2007), maybe an expensive and efficient way of controlling cogongrass which will prove beneficial to the forestry, agricultural, and other communities in the southern region of United States. Species with potential for use in the biological control of cogongrass are Chenopodium (*Chenopodium ambrosioides*) and Muhly grass (*Muhlenburgia capillaries* Lam.). These species may possess natural chemicals that may inhibit the growth and extension of cogongrass rhizomes. The objective of this study was to evaluate extracts from two plant species for effectively controlling cogongrass *in vitro*.

MATERIALS AND METHODS

1. Preparation of planting materials

The cogongrass plant materials were collected from an infested area on Tram Road Tallahassee, Florida. They were harvested by digging the cogongrass from the soil with a Hisco garden spade blade hollow back size 67/8 inches x 105/8 inches. Ramets were separated from genets, cleaned, washed and then cut into three inches pieces and placed in 36 cell plastic flat trays measuring 30 cm x 14 cm. The trays were then filled with commercial ready made potting medium ("Pro-Mix" Premier Horticulture, Quebec, Canada). Approximately one, two-node ramet was planted in each cell. Ramets were grown in the George Connoly Greenhouse on Florida A&M campus until they were at two-leaves stage and ready to be transplanted.

2. Extract Preparation

The Chenopodium plants were obtained from the FAMU Research and Extension Farm, Quincy, Florida and Muhly grass plant materials were obtained from the St. Marks

National Wildlife Refuge, Florida. The study was conducted in the growth chambers, in the Forestry and Agronomy Laboratory located in Room 303 South Perry-Paige Building at Florida Agricultural and Mechanical University, Tallahassee, Florida.

The chenopodium and muhly grass plants were collected by using heavy duty garden fork with four angular back tines so the soil could plunge through. The hands were used to remove unwanted leaves and soil. The chenopodium and muhly grass were then washed under a steady stream of water from the top. Then the plants were separated into different plant parts (root, stem and leaf). They were then cut into ¼ inche pieces washed and weighed into 140 gram and placed 140 gram into storage bags. Materials from each 140 gram bags were retrieved and blended with 400 ml of distilled water using Hamilton Beach blender at high speed until the parts became liquefied. The liquid was then poured from the blender into a four gallon mixing bowl the extract was thoroughly mixed for about five minutes. Cheese cloth (grade #10 with 20 v x12 h threads per inch) was cut and was used to filter the extract to remove remaining pieces of plant parts. The extract was then strained a second time with the cheese cloth folded into four layers so as to remove the very small particles. The resulting solution (plant extract) was then measured into aliquots of 100 ml and poured into magenta vessels. Cogongrass at the two leaves-stages were then retrieved and removed from trays. They were washed in a laboratory tray to remove soil particles from roots of plants and one plant each was inserted into each magenta vessel containing plant extracts. The magenta vessels were then placed into a growth chamber set at 28°C and 16/8 hour photoperiod. The plants were observed for new roots and new leaf at seven days intervals. The data collected was the number of new cogongrass root and new shoot produce after planting. Data was analyzed using SAS 9.0 (SAS 2003).

RESULTS AND DISCUSSION

A pair wise comparison was done following analysis of data. When muhly grass leaf extract and control when compared there was no significant difference in the survival rate (figure 1). Also muhly grass root extract when compared with control showed no significant difference between the two treatments. However, when the muhly grass root with muhly grass shoot extract were compared cogongrass survival rate was a significantly difference between these two treatments (Figure 1). The muhly grass root however, was more effective in controlling cogongrass growth (Figure 1). However, there was no significant difference for survival percentages for cogongrass treated with chenopodium root and stem extracts (Figure 2). The root and stem extracts of chenopodium were equally effective in controlling cogongrass growth (Figure 2). However the chenopodium leaf was the least effective in controlling the growth of cogongrass. When the control was compared against chenopodium treatments, chenopodium stem and root did better in controlling the growth of cogongrass (Figure 3). There is very limited information in literature in the use of plant extracts form muhly grass and chenopodium for controlling cogongrass. While some information exist for the possible allelochemical of cogongrass it is possible that muhly grass and chenopodium may possess such allelochemicals that will significantly impact cogongrass development and growth. The results from our study may allow for utilization

FIGURES (Following 3 pages)

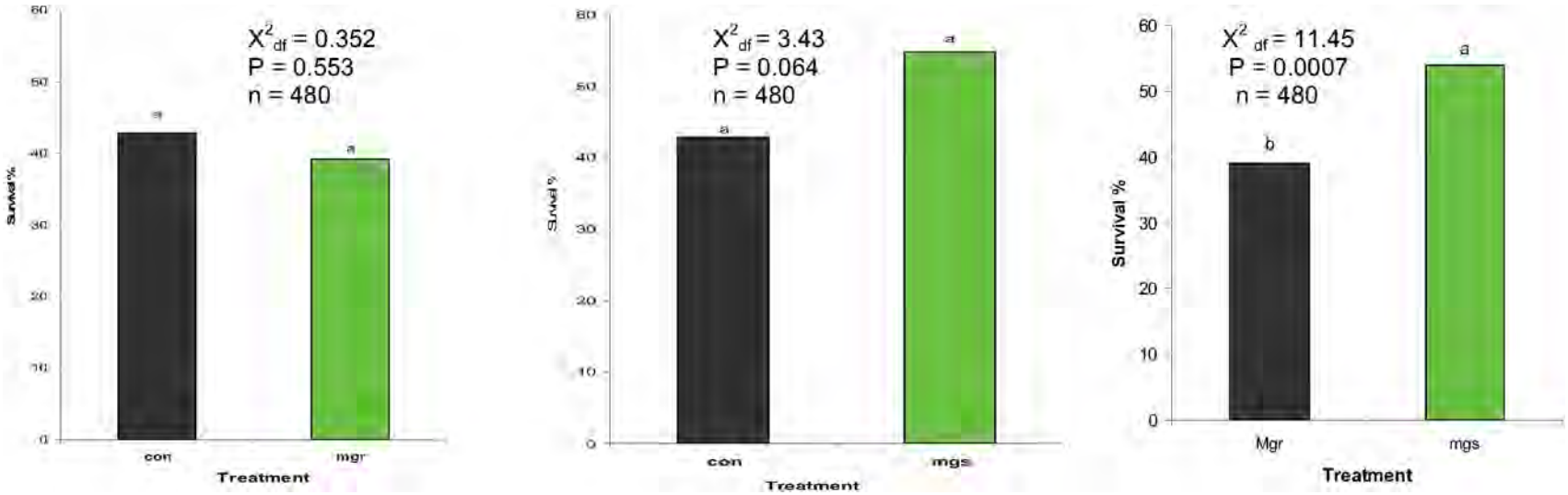


Figure 1. Proportion of Cogongrass Survival in Muhly grass root (mgr) extract, Muhly grass shoot (mgs) extracts and control (con) after six weeks

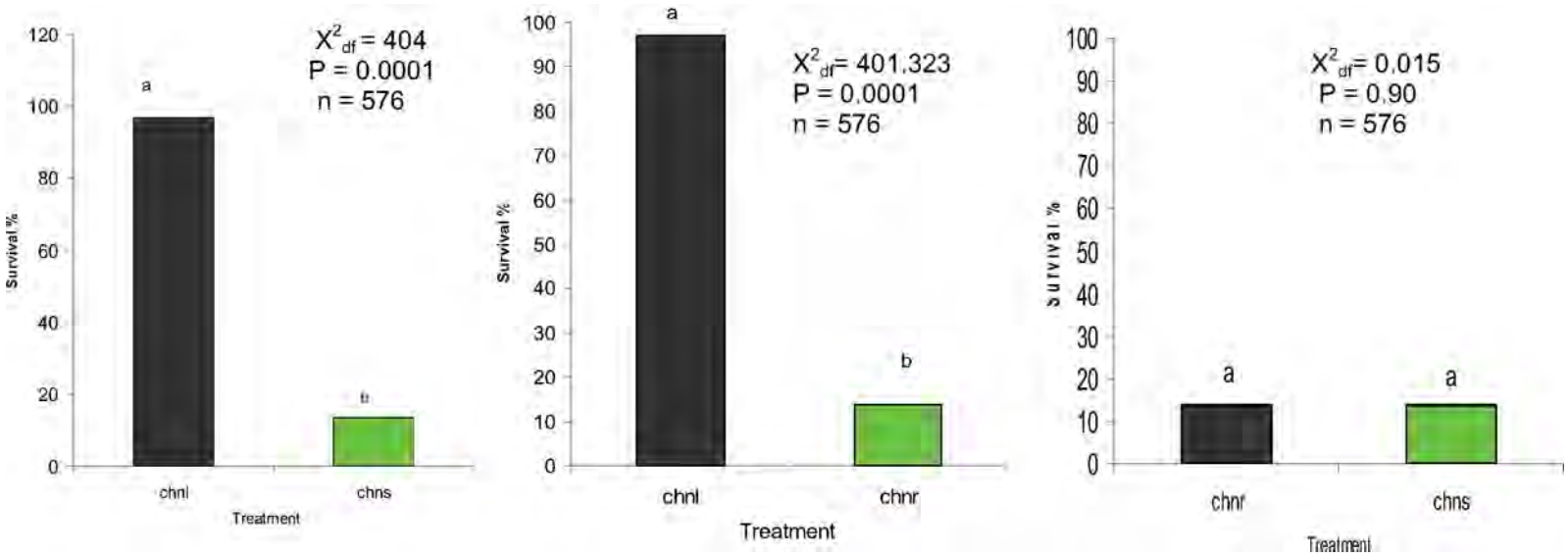


Figure 2. Proportion of cogongrass survival from Chenopodium root (chnr) Chenopodium leaf (chnl) and chenopodium stem (chns) extracts after six weeks

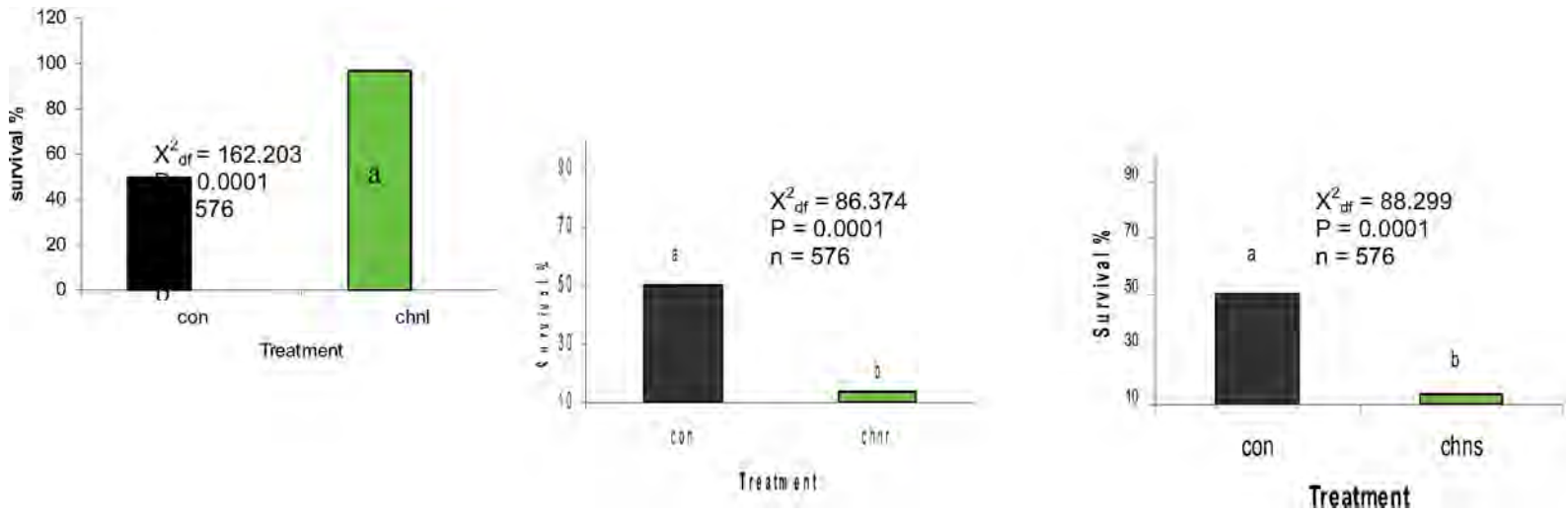


Figure 3. Proportion of cogongrass survival from Chenopodium root (chnr), Chenopodium leaf (chnl), chenopodium shoots (chns) extract and control (con) after six weeks

ACKNOWLEDGEMENT

This study was made possible in part, by a grant #2005-38814-16377 from USDA-CSREES 1890 Capacity Building Grant Program. Thanks are extended Dr. S. Bambo, Dr. J. Muchovej and Mr. G. Queeyl for assistance in the course of this study.

REFERENCES

Bolfrey_Arku, G. 2004. Management of Noxious weed speargrass (*Imperata cylindrica* (L) Beauv.) in the forest and forest-savanna transition agro-ecological zones of Ghana. Ph.D Thesis , Department of Crop Science, University Cape Coast, Takoradi, Ghana.

Bolfrey-Arku, G., O. U. Onokpise, D. Shilling and C. Coultas. 2002. Land preparation and legume cover crop for biological control of cogongrass. Soil Crop Science Society. Pro. 61: 4-9.

Brown, D. 1944. Cogongrass is now considered a serious invasive species in parts of Florida, southern Alabama, southern Mississippi, and where it invades pastures, nurseries, pecan plantation, highway right-of-way, lawns, and natural habitats Anatomy and Reproduction in *Imperata cylindrica*. Joint Publication NO.7:15-18.

Chikoye, D., F. Ekeleme and J.T. Ambe. 1999. Survey of distribution and farmer's perception of speargrass [*Imperata cylindrica* (L)Raeuschel] in cassava based systems in West Africa. Int. Journal Pest Management 45: 305-311.

Gaffney, J.F. and Shilling. 1996 The presence of *Imperata cylindrical* to chemical control followed by revegetation with desirable species, pp. 981-986. In Brown, H. (ed.) Proceedings of Second International Weed Control Congress. Copenhagen, Denmark, June 25-28, 1996. Department of Weed Control and Pesticide Ecology, Slagelse, Denmark.

Onokpise, U. O., J. Moody, H. Dueberry, L. Reid, J.L. Norcini, J. J. Muchovej, and S. Bambo. 2007. Comparative Studies on the Control of Cogongrass (Imperata cylindrical L.). Journal of Environmental Monitoring and Restoration. 3: 323-330

Onokpise, O.U. 2000. Population of cogongrass (*Impeata cylindrica* L) in Leon County, Florida. Association of Research Directors, Inc., Symposium. April 19-21, 2000, Washington D.C., pp 97

Patterson, D. T., E. P. Flint, and R. Dickens. 1980. Effect of temperature, photoperiod, and population source on the growth of cogongrass (Imperata cylindrical". Weed Science. Vol.28, Issue 5:505-509.

SAS 2003

Shilling, D. G., T.A. Bewick, J. F. Gaffrey, S.K. McDonald, C.A Chase and E.R.R.L. Johnson. 1997. Ecology, physiology and management of cogongras (*Imperata cylindrica* L) Final Report: FPIR Project No93-03-107.128 pp

Willard, T. R., D. W. Hall, D.G.Shilling, J.A. Lewis, and W. L. Currey. 1990. Cogongrass (*Imperata cylindrica*) distribution on Florida highway right-of-way. Weed Technology 4:658-660

Zimdahl, R. 1993. Fundamentals of Weed Science. Academic Press, Inc. New York, N.Y. 48-54.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):571-575. 2008

Poster #54

Evaluation of Acibenzolar-S-Methyl, PGPR and Silicon for Their Effects on Growth and TYLCV of Tomato

Shouan Zhang, Thomas L. White, and Waldemar Klassen. Tropical Research and Education Center, University of Florida, IFAS, Homestead, Florida 33031, USA

ABSTRACT.
TYLCV is a major limiting factor for tomato production in south Florida. There is no single method which provides adequate control of TYLCV on tomato. In the greenhouse assays, Actigard® at 3 mg/l, plant growth-promoting rhizobacteria (PGPR) strains SE34 and IN937b at 1×10^7 CFU/ml, and silicic acid at 1.5 mM and 0.15 mM applied as soil drench significantly increased plant height when compared with the nontreated control. SE34, IN937b and silicic acid significantly increased stem caliper, and IN937b increased the chlorophyll content in the leaves of tomato seedlings. All treatments with disease resistance inducers significantly reduced disease severity of TYLCV compared to the nontreated control. In the field trial, tomato plants treated with Actigard® at 3 mg/l had significantly less disease than the nontreated control plants 4 weeks after transplanting.

KEYWORDS: Tomato yellow leaf curl virus, TYLCV, growth promotion, induced disease resistance, tomato

INTRODUCTION

Tomato yellow leaf curl disease, caused by Tomato yellow leaf curl virus (TYLCV), has become one of major disease problems of tomato in south Florida (Polston et al., 1999). TYLCV is only transmitted by the sweet potato whitefly (Bemisia tabaci Biotype B = Bemisia argentifolii) which has a broad host range including vegetable, ornamental crops and weed species (Cohen and Antignus, 1994; Mansour and Al-Musa, 1992). Tomato plants can be severely stunted if infected at an early stage, and consequently this can result in substantial yield losses. Chemical control is relied on heavily to reduce the impact of TYLCV. However, chemical control methods have become progressively less effective due to high whitefly population densities and their mounting resistance to insecticides (Schuster, 2007). Although the development of resistant cultivars holds promise in reducing the impact of TYLCV (Lapidot et al., 2001) and the highly resistant cultivars are now available for use, they are lacking in the ideal horticultural traits appropriate for Florida. Production practices are only partially effective in ameliorating TYLCV disease because reservoirs of whiteflies exist year-round, and population levels of whiteflies are very high in south Florida. Development of alternatives including induced disease resistance is imperative for management of TYLCV on tomato in south Florida. The specific objective of this research was to evaluate acibenzolar-S-methyl (ASM), plant growth-promoting rhizobacteria (PGPR) and silicic acid for their potential (i) to enhance plant growth and (ii) to ameliorate the impact of TYLCV on tomato production in south Florida.

MATERIALS AND METHODS

Greenhouse experiments were conducted with tomato cv. 'FL47'. Seeds of tomato were planted in Styrofoam flats (Speedling, Inc., Sun City, FL) containing potting mix. Four applications at weekly intervals of the disease resistance inducers were each applied as a soil drench (5 ml/plant) beginning at 1 week after planting (WAP). The treatments were ASM (Actigard® 50 WG, Syngenta, Inc.) at 30 and 3 mg/l, PGPR strains SE 34 and IN937b each at 1×10^7 CFU/ml, and silicic acid at 1.5 and 0.5 mM. Tomato plants treated with imidacloprid (Merit®) served as the standard chemical control and nontreated plants served as the blank control. Plants were transplanted at 5 WAP following the last treatment into 4-inch diameter pots containing potting mix. Treatments were arranged as randomized complete blocks with twelve replications for each treatment and one plant per replication. Plant height, stem caliper and chlorophyll content in leaves of tomato plants were measured at 6 WAP using SPAD-502 (MINOLTA Co., LTD, Japan).

For TYLCV infection, one plant from each treatment (a total of eight plants) was placed in a cage for 1 week containing viruliferous whiteflies (kindly provided by Dr. D. J. Schuster). Tomato plants were then transferred onto greenhouse benches for 2.5 weeks when the disease severity of TYLCV was rated based on a 0-4 scale described by Lapidot et al.(2001): 0 = no visible symptoms, inoculated plants grow similarly as noninoculated plants; 1 = very slight yellowing of leaflet margins on apical leaves; 2 = some yellowing and minor curling of leaf ends; 3 = a wide range of leaf yellowing, curling and cupping with reduction in size, yet plants continue to develop; and 4 = very severe plant growth stunting and yellowing, pronounced leaf curling and cupping, and plants stop growing.

A field trial was carried out at the Tropical Research and Education Center, University of Florida, Homestead, FL in the spring of 2008. Tomato (cv. 'FL47') seedlings in Speedling trays treated with the same compounds or PGPR at 2, 3 and 4 WAP were transplanted into the field beds 5 WAP on March 3, 2008. Two more applications by soil drench of the inducers were made at 1.5 and 2.5 weeks after transplanting (WAT). A randomized complete design was employed with four replications for each treatment and fifteen plants for each replication. Tomato plants were naturally infected with TYLCV by whiteflies. Severity of TYLCV disease was rated at 4 WAT based on a rating scale as described above.

Data from greenhouse and field experiments were analyzed by analysis of variance using JMP software (SAS Institute Inc., Cary, NC). The significance of effects of treatments was determined by the magnitude of the F value ($P = 0.05$). When a significant F test was obtained for treatments, the separation of means was accomplished by Fisher's protected Least Significant Difference (LSD).

RESULTS AND DISCUSSION

In the greenhouse experiment, all treatments except Actigard® at 30 mg/l significantly increased plant height by 6 WAP compared to the nontreated control ($P < 0.05$) (Table 1). Stem caliper was significantly increased by treatment with PGPR strains SE34 and IN937b and by silicic acid at both test concentrations; the chlorophyll content in the leaves of tomato plants treated with IN937b was significantly greater than that of the nontreated control plants.

For TYLCV disease, all treatments in the greenhouse assay except for imidacloprid (Merit®) significantly reduced disease severity of TYLCV compared to the nontreated control (Figures 1, 2). In the field trial, tomato plants treated with Actigard® at 3 mg/l had significantly less disease than the nontreated control plants (Figure 3). The whitefly populations had become very high at the time when the field trial was performed, the occurrence of TYLCV disease was found in the tomato field as early as 2 WAT. The disease severity of TYCV by 6 WAT was high, and most plants were severely stunted by TYLCV. The incidence of TYLCV disease was nearly 100%, and the disease severity rating was 3 or 4. Therefore, this field trial should be repeated in the winter and early spring seasons in south Florida when the whitefly population densities are low or moderate. We plan to retest the disease resistance inducers for their effects on TYLCV in the 2008-2009 winter tomato production seasons.

REFERENCES

Cohen, S., and Antignus, Y. 1994. Tomato yellow leaf curl virus, a whitefly-borne geminivirus of tomatoes. Pages 259-288 in: Advances in Disease Vector Research. Vol. 10. Springer-Verlag, New York.

Mansour, A., and Al-Musa, A. 1992. Tomato yellow leaf curl virus: Host range and virus-vector relationships. Plant Pathol. 41:122- 125.

Lapidot, M., Friedmann, M., Pilowsky, M., Ben-Joseph, R., and Cohen, S. 2001. Effect of host plant resistance to tomato yellow leaf curl virus (TYLCV) on virus acquisition and transmission by its whitefly vector. Phytopathology 91: 1209-1213.

Polston, J.E., McGovern, R. J., and Brown, L.G. 1999. Introduction of tomato yellow leaf curl virus in Florida and implications for the spread of this and other geminiviruses of tomato. Plant Dis. 83:984-988.

Schuster, D. J. 2007. Whitefly resistance update. Pp. 23-27, In A. Whidden, P. Gilreath and E. Simonne (eds.). Florida Tomato Institute Proceedings, University of Florida, PRO 524.

Table 1. Effects of ASM, PGPR and silicic acid on plant growth of tomato in greenhouse assays

Treatment	Plant height (cm)	Stem caliper (mm)	Chlorophyll content
Actigard® 30 mg/L	13.7 d [z]	5.8 f	31.0 b
Actigard® 3 mg/L	16.1 c	6.5 de	30.5 b
silicic acid 1.5 mM	16.7 bc	7.3 ab	29.4 b
silicic acid 0.15 mM	17.7 a	7.8 a	29.5 b
SE34	17.3 ab	7.1 b	30.0 b
IN937b	16.0 c	6.7 cd	33.3 a
CK	13.4 d	6.0 ef	30.7 b

[z] Means within each column with a letter in common are not significantly different (P=0.05, LSD).

Figure 1. Effect of ASM and PGPR treatments on TYLCV disease of tomato in the greenhouse. Treatments (left to right): nontreated control, ASM, PGPR strains IN937b and SE34

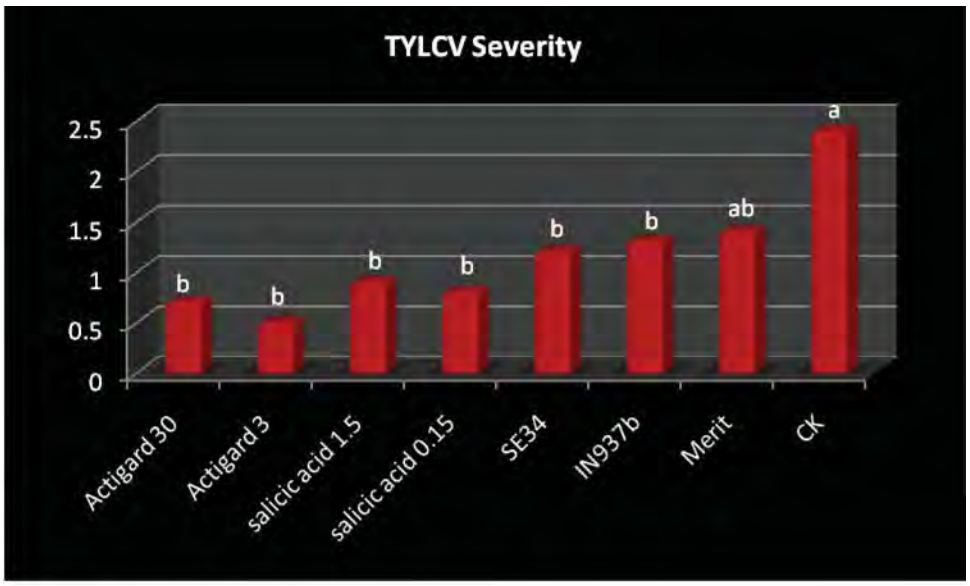


Figure 2. Suppression of TYLCV on tomato by ASM, PGPR and silicic acid in the greenhouse. values with a letter in common are not significantly different (P=0.05, LSD).

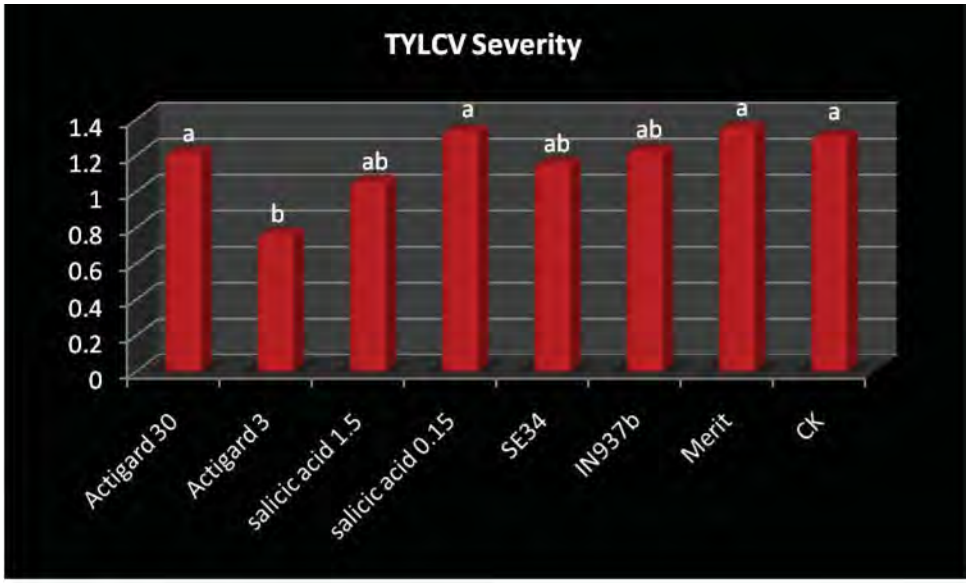


Figure 3. Effect of ASM, PGPR and silicic acid on TYLCV of tomato in the field trial. Values with a letter in common are not significantly different (P=0.05, LSD).

2008 Proceedings of the Caribbean Food Crops Society. 44(2):576. 2008

Poster #55

Evaluation of Triazole and Strobilurin Fungicides, Alone and in Combination, for Control of *Exserohilum turcicum* on Sweet Corn

Richard N. Raid, Everglades Research and Education Center, University of Florida, IFAS, Belle Glade, FL 33430. rnr@ifas.ufl.edu

ABSTRACT.
Northern corn leaf blight, incited by *Exserohilum turcicum*, is one of the most important foliar diseases of sweet corn (*Zea mays*). Causing large elliptical lesions that may coalesce and result in significant levels of leaf necrosis, fungicides are frequently relied upon for control. Two field experiments were conducted in south Florida during Spring 2008 to evaluate the efficacy of several triazole and strobilurin fungicides, alone and in pre-mixtures, for control of this fungal pathogen. The experimental design consisted of four replications of ten fungicide treatments arranged in randomized complete blocks. Experimental units were composed of two rows, 9 meters in length, separated by three non-sprayed guard rows. Fungicides were applied using a CO_2 backpack sprayer equipped with a 3-nozzle handheld boom. Fungicides investigated included the strobilurin compounds azoxystrobin, pyraclostrobin, and trifloxystrobin, as well as the triazole compounds metconazole, propiconazole, prothioconazole, and tebuconazole, either alone or in combination. The broad spectrum protectant maneb was also included. Northern corn leaf blight was severe in both experiments, along with southern corn leaf blight in one of the trials. Both trials were considered definitive. All fungicide treatments provided for significant levels of disease control, with triazole and strobilurin fungicides proving significantly better than maneb. In both trials, fungicides containing a triazole, either alone or in combination, were more efficacious than fungicides containing only a strobilurin compound. These results emphasize the benefits of including triazole chemistries in a foliar disease management program on sweet corn, particularly if northern corn leaf blight is the featured disease. Triazole/strobilurin pre-mixtures, or rotations of triazoles with strobilurin fungicides, would likely be the best candidates for controlling the prevalent sweet corn disease complex that includes the foliar blights and rust, since the strobilurins are excellent rust control fungicides.

KEYWORDS: Sweet corn diseases, fungicidal control, northern corn leaf blight

2008 Proceedings of the Caribbean Food Crops Society. 44(2):577. 2008

Poster #56

Educational Efforts Enhance Diagnostic Capabilities in the United States and the Caribbean Region

Amanda Hodges[1], Greg Hodges[2], and Russell Duncan[3], [1]Entomology and Nematology Department, University of Florida/IFAS, [2]Florida Department of Agriculture and Consumer Services, Division of Plant Industry, and [3]USDA, APHIS, International Services. achodges@ufl.edu

ABSTRACT.
The introduction of invasive, exotic arthropod species continually threatens US and Caribbean agriculture, forests, and other natural areas. Undetected pest species have the potential to cause major economic damage to a local economy or result in trade implications for producers. The warm, tropical climate of the Caribbean Region and the southern US are particularly vulnerable to new pest establishment. Proper pest identification is critical to the early detection of threatening invasive, exotic arthropod pests. The Southern Plant Diagnostic Network (SPDN), coordinated through the University of Florida/IFAS has coordinated and/or partnered with other organizations in order to provide advanced taxonomic training to US and Caribbean scientists from 2004-08. Topics for SPDN education program have include Hemiptera (Auchenorrhycha, Sternorrhycha), the pink hibiscus mealybug (*Maconellicoccus hirsutus*), Coleoptera (Chrysomelidae, Scolytinae, and Cerambycidae), and invasive species of relevance to the southern US. USDA-APHIS, International Services provided lead coordination for Caribbean workshops in partnership with the Inter-American Institute for Cooperative Agriculture (IICA), Barbados Ministry of Agriculture, and Ministry of Agriculture in Jamaica. Scale insects and mealybugs (Hemiptera: Coccoidea), a particularly problematic taxon in terms of identification and potential status as an invasive or actionable pest, were the focus of the Caribbean training workshops (2007-08). Workshop outcomes for both US and Caribbean training sessions generally included 1) an increase in technical skill and confidence for genus, and in some cases species-level, determinations of fairly complex taxa groups 2) follow-up communications with specialist instructors and 3) early pest detections and/or new pest detection reports.

KEYWORDS: Invasive species, SPDN, diagnostics, USDA, APHIS, entomology identification, Coccoidea, scale insects, mealybugs

2008 Proceedings of the Caribbean Food Crops Society. 44(2):578. 2008

Poster #57

Response of the Melon Thrips, *Thrips palmi* Karny, and the Chilli Thrips, *Scirtothrips dorsalis,* to some Selective Insecticides

Dakshina R. Seal, Vivek Kumar Jha, Waldemar Klassen, and Catherine M. Sabines, University of Florida-IFAS, Tropical Research and Education Center, Homestead, FL 33031. vivekiari@ufl.edu

ABSTRACT.
The melon thrips and the chilli thrips are important pests of fruit, ornamental and vegetable crops. The melon thrips is very difficult to control. None of the currently registered insecticides provide satisfactory control of this pest. On the other hand, insecticides of various classes provide satisfactory control of chilli thrips. Neonicotinoid insecticides are effective in controlling chilli thrips; but provide insignificant reduction of melon thrips. Pyrethroid insecticides are not effective against the melon thrips nor rhe chilli thrips. Spinetoram and Spintor have provided significant reduction of populations of both thrips species. However, these insecticides showed reduced levels of control of the melon thrips in our recent studies conducted in 2008. Spinetoram (8.0 oz/acre) in combination with Dyne-Amic (0.25% v/v; nonionic organosilicone surfactant) provided better reduction of both thrips than when Spinetoram was used alone. We also investigated two new Insecticide chemistries, Rynaxypyr™ and Cyazypyr ™ for the control of melon thrips and chilli thrips. In our preliminary study, we did not record any significant reduction of thrips populations when these products were applied as a soil drench. Voliam flexi™, a premix product containing Coragen® and Actara® provided significant reduction of chilli thrips. Our main focus of this study was to use Spinetoram in rotation with other effective products to develop a lasting management program against melon thrips and chilli thrips.

KEYWORDS: melon thrips, chilli thrips, chemical insecticides, reduced control of melon thrips

2008 Proceedings of the Caribbean Food Crops Society. 44(2):579. 2008

Poster #58

Development of IPM Field Guides for Coffee, Citrus, Plantain and Banana

Ada N. Alvarado Ortíz, Crop Protection Department, University of Puerto Rico, Mayagüez Campus, aalvarado@uprm.edu

ABSTRACT.
The nature of tropical agriculture in Puerto Rico is one of a multiplicity of crops, most of these grown in small farms, threatening by a diversity of pests and diseases that impact crop production, causing economic loss to their producers. Coffee, Plantain, Banana and Citrus are commodities of great economic importance in Puerto Rico Agriculture. During year 2004 - 2005 altogether contributed with 130 millions to the agricultural income, in approximately 105,746 acre devotes to them. The great variety of pests and diseases that our tropical environment sustains and the agronomic intensive practices carried out by growers in their farms makes necessary a new vision in keeping them informed and updated in the identification and pest management strategies.

In an effort to assist growers, Extension personnel and other agricultural educators, IPM Field Guides for Coffee, Citrus, Plantain and Banana were developed to help in the fast and accurate identification of pests and diseases. The main goal is to promote the adoption and implementation of effective strategies responding to specific needs of growers working with management of pests in crops of major importance in the Island. The guides are available at no cost online at http://academic.uprm.edu/aalvarado. The guides are for field use by a wide range of people, they carry descriptions and color photographs of fungal, bacterial and viral diseases as well as arthropods. Also, include a narrative section with the description and development of symptoms and information about how to identify key pests and diseases.

The educational materials created under this project complement the ongoing pesticide safety and IPM programs in Puerto Rico. The outcomes of this project will lead to minimize the impacts and reduce the potential of pests in plantain and banana, citrus and coffee.

KEYWORDS: field guides, pest, diseases

2008 Proceedings of the Caribbean Food Crops Society. 44(2):580. 2008

Poster #59

Erythrina Gall Wasp, *Quadrastichus erythrinae* (Hymenoptera: Eulophidae), a Pest of Coral Trees (*Erythrina* spp.) Recently Found in the Western Hemisphere

Forrest W. "Bill" Howard, University of Florida, IFAS, Fort Lauderdale Research & Education Center, 3205 College Avenue, Fort Lauderdale, Florida, 33301 USA. FWHOWARD@UFL.EDU

ABSTRACT.
Various species of the coral tree genus, *Erythrina* (Fabaceae), are grown as shade trees and for soil improvement in coffee and cacao crops in the American Tropics. The Erythrina gall wasp, *Quadrastichus erythrinae* Kim (Hymenoptera: Eulophidae), believed to be native to Africa, was recently spread to localities in Asia and Oceania where its galls have seriously damaged coral trees of various species. The insect was first found in the Continental US in Miami-Dade County, Florida, in October, 2006. Five months later, we observed galls on foliage of *E. variegata* growing 65 km north of the former site and reared *Q. erythrinae* from the galls. We began field observations of *Q. erythrinae* to determine characteristics of its damage, its host preferences among *Erythrina* spp., and characteristics of its population dynamics and dispersal behavior. The gall wasps showed a marked tendency to remain close to their natal host tree and attack it repeatedly, rather than disperse from it, yet they nevertheless found and infested isolated *Erythrina* plants. *Erythrina* spp. appeared to have pronounced differences in susceptibility, with *E. herbacea* (native to Florida) highly resistant compared to several Eastern Hemisphere species upon which the wasps caused extensive galling. Massive galling of some *Erythrina* trees caused extensive defoliation and branch die-back, in some cases resulting in the death of the tree. The numbers of Erythrina gall wasps caught in traps in *Erythrina* trees and the incidence of galling on hosts fluctuated considerably during the one-year period of observation. Some trees of exotic *Erythrina* spp. survived almost total defoliation caused by galling, but recovered and currently have a low incidence of galling. The potential for *Q. erythrinae* to spread in the Caribbean Region, and preliminary research on management methods for this pest will be discussed.

KEYWORDS: insect pests, invasive pests, crop shade trees.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):581. 2008

Poster #60

Climate Factor Comparison Analysis for Red Palm Mite, Raoiella Indica

D. Borchert and D. Fieselmann, USDA, Plant Protection and Quarantine, Center for Plant Health Science and Technology, Raleigh, North Carolina, USA. Daniel.A.Fieselmann@aphis.usda.gov

ABSTRACT.
The red palm mite, *Raoiella indica* was first detected in the Western Hemisphere in Martinique in 2004. It has rapidly spread through the Caribbean Basin causing extensive foliar damage, especially on young coconuts, other palms and bananas. Red palm mite has been reported in Israel and Egypt for over 25 years without causing significant damage. The aim of this study is to investigate the climatic factors that might explain the difference in pest status between the Mediterranean Region as opposed to the Caribbean Basin. The web based NAPPFAST (North Carolina State University- Animal and Plant Health Inspection Service Plant Pest Forecasting) system was used to compare various climatic factors that may determine red palm mite populations. Three climatic factors utilized in the analysis are present in the countries where *R. indica* is reported to be a pest. This NAPPFAST model may be useful for predicting areas at high risk for red palm mite. This model may also be useful to assess the risk from other pest species based upon climatic factors.

KEYWORDS: *Raoiella indica*, Climate matching, NAPPFAST

2008 Proceedings of the Caribbean Food Crops Society. 44(2):582. 2008

Poster #61

Tropical Race 4 of Panama Disease: A Dangerous Threat to Sustainable Production of Banana and Plantain

Randy C. Ploetz, University of Florida, IFAS, Tropical Research & Education Center, 18905 SW 280th Street, Homestead, FL 33031-3314 USA. RCPloetz@ifas.ufl.edu

ABSTRACT.
Panama disease, aka fusarium wilt of banana, is caused by *Fusarium oxysporum* f. sp. *cubense*. A dangerous new variant of this pathogen, tropical race 4 (TR4), was reported in Southeast Asia in the early 1990s. TR4 has since spread widely in that region, and represents a serious threat to banana production in the Americas. Over 80% of the bananas that are produced worldwide are susceptible to this new race, including all commercial cultivars of the Cavendish subgroup, the plantain subgroup, important AAA and ABB cooking bananas, and diverse AA, AB, AAA and AAB dessert bananas. TR4 could easily be moved to the Americas in infected plants and suckers, and would devastate dessert, plantain and cooking banana production wherever it established. This poster outlines the nature and magnitude of the threat, measures that should be taken to exclude TR4 from the region, and strategies for containing the pathogen should it spread to the hemisphere.

KEYWORDS: Cavendish subgroup, plantain subgroup, prevention of spread

2008 Proceedings of the Caribbean Food Crops Society. 44(2):583. 2008

Poster #62

Distribution and Host Associations of *Proba distanti* (Atkinson) (Hemiptera: Miridae), a Plant Bug Recently Established in Florida

Thomas T. Dobbs[1], Thomas J. Henry[2] and Alfred G. Wheeler, Jr[3].
[1]Miami Plant Inspection Station, United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine; [2]Systematic Entomology Laboratory, United States Department of Agriculture, Agricultural Research Service c/o National Museum of Natural History, Smithsonian Institution; [3] Dept. of Entomology, Soils and Plant Sciences, Clemson University. thomas.dobbs@aphis.usda.gov

ABSTRACT.
The Neotropical plant bug, *Proba distanti* (Atkinson) (Hemiptera: Miridae), was first detected in Florida in 1990 in Palm Beach County. Extensive surveys have revealed that it is now widely established throughout much of the Florida peninsula. The majority of specimens were collected from two common herbaceous weeds that we consider primary hosts: ragweed (*Ambrosia artemesiifolia* L.) and dogfennel (*Eupatorium capillifolium* (Lam.) Small). These weeds are common in open fields, disturbed sites, and along roadsides. In Florida, their vegetative growing seasons do not generally overlap. Ragweed is typically a spring and summer plant whereas dogfennel appears in the fall and persists through the winter. Colonization of ragweed by *P. distanti* normally begins in February and extends until host die-back, usually around September. The bug then migrates to dogfennel, feeding on that host from late September through the winter months. Ragweed and dogfennel support a rich diversity of heteropteran herbivores, but P. *distanti* can frequently be observed on each as the dominant mirid species. *Proba distanti* is distributed in Florida from the southernmost county of Monroe throughout the peninsula as far north as Clay County, just northeast of Gainesville. As a diagnostic aid, we provide redescriptions of the genus *Proba* and the species *P. distanti*, along with a checklist of the North American species and their distributions.

KEYWORDS: *Proba*, Florida, exotic species

2008 Proceedings of the Caribbean Food Crops Society. 44(2):584-585. 2008

Poster #63

The Caribbean Pathway Analysis - Evaluation of Pathways for Exotic Plant Pest Movement into and within the Greater Caribbean Region

Heike E. Meissner, Christie A. Bertone, Lisa M. Ferguson, Andrea V. Lemay, and Kimberly A. Schwartzburg, United States Department of Agriculture (USDA), Raleigh, North Carolina 27606, USA. Contact: Heike.E.Meissner@aphis.usda.gov

ABSTRACT.
The analysis "Evaluation of pathways for exotic plant pest movement into, within, and out of the Greater Caribbean Region", is a collaborative effort between the Caribbean Invasive Species Working Group (CISWG) and the United States Department of Agriculture (USDA). The objective of this analysis is to contribute to an improved understanding of pathways of exotic pest movement as they pertain to the Greater Caribbean Region, thereby helping CISWG to enhance or refine the Caribbean Regional Invasive Species Intervention Strategy (CRISIS) for preventing the introduction or spread of exotic pests. The scope of the pathway analysis includes nearly all countries bordering the Caribbean Sea and all terrestrial, non-vertebrate, plant pests. Among the pathways evaluated in the context of this analysis are: airline passenger baggage, international mail, people movement, maritime cargo, and wood packaging material. Some of these topics are discussed in other papers published in these proceedings.

KEYWORDS: Caribbean Region, pathway analysis

What is the Caribbean Pathway Analysis?

The project "Evaluation of pathways for exotic plant pest movement into and within the Greater Caribbean Region" is a collaborative effort between the Caribbean Invasive Species Working Group (CISWG) and the United States Department of Agriculture (USDA). This project is also referred to as the "Caribbean Pathway Analysis."

What is the objective of the Caribbean Pathway Analysis?

The objective of the Caribbean Pathway Analysis is to contribute to an improved understanding of pathways of exotic pest movement as they pertain to the Greater Caribbean Region and to develop recommendations for improved safeguarding, thereby helping CISWG to enhance or refine the Caribbean Regional Invasive Species Intervention Strategy (CRISIS) for preventing the introduction or spread of exotic pests. Among the pathways evaluated in the context of this project are:

- Airline passenger baggage
- International mail
- Movement of people
- Hitchhiker pests
- Wood packaging material

- Natural spread

The results of some of these evaluations were also presented at this meeting.

Who is carrying out the Caribbean Pathway Analysis?

This project is being conducted under the leadership of CISWG. A team of five risk analysts from the USDA-Animal and Plant Health Inspection Service (APHIS) is responsible for: Collecting relevant information through literature research, expert consultation, site visits, and mining of databases; evaluating, analyzing, organizing, and summarizing this information; and producing a comprehensive report. The project process allows for the participation of all nations of the Greater Caribbean Region, as well as major organizations or working groups (*e.g.*, CABI, CIRAD, *etc.*) operating in the Region.

What is the timeline for the Caribbean Pathway Analysis?

- September 2006: USDA-APHIS makes offer to assist CISWG in conducting analysis
- October 2006: CISWG acceptance of offer
- November 2006: Establish partnering responsibilities; planning and coordination
- December 2006: Begin data gathering and contacting experts
- August 2007: Risk Assessors officially start work on the project
- August 2008: Distribution of draft report for review
- October 2008: End of comment period
- December 2008: Revisions completed; delivery of final report to CISWG for distribution to stakeholders

2008 Proceedings of the Caribbean Food Crops Society. 44(2):586. 2008

Poster #64

Population Dynamics of the Red Palm Mite (*Raoiella indica* Hirst) and the Search for Sustainable Management Options in Jamaica

J. V. Goldsmith, and L. R. Myers, Research and Development Division, Ministry of Agriculture, Jamaica. *julietgoldsmith@gmail.com*

ABSTRACT.
The red palm mite (*Raoiella indica* Hirst), first detected in Jamaica in April 2007, has spread to several parishes, affecting coconut and ornamental palms, some severely. The search for sustainable management practices for the pest involved two initial studies: population dynamics including a hunt for natural enemies and the determination of an environmentally friendly treatment for coconut palm seedlings under nursery conditions.
The seasonal dynamics of *Raoiella indica* were studied between July 2007 and May 2008. The study was conducted in a commercial orchard, to which bi-weekly visits were made. *Raoiella indica* populations increased during dry periods, and declined during periods of persistent rainfall. Two predators; a phytoseiid mite (*Amblyseius largoensis)*, and a thrips (*Leptothrips* sp) were found feeding on the red pal mite. *Amblyseius largoensis* was the most abundant predator. This predator and *R. indica* exhibited similar population fluctuations throughout the sampling period.
Twelve plots, each measuring 1m x 2m and containing 55 coconut palm seedlings (at the 6-leaf stage) were established in Spring Gardens, Portland and treated with six chemicals: abamectin, diafenthiuron, soybean oil, sulphur, insecticidal soap and spiromesifen. The treatments were replicated two times in a randomized complete block design and included two unsprayed (control) plots. All the treatments were effective in reducing red palm mite populations. Insecticidal soap had the least impact on the predators (efficacy 53%). Thus low populations of *Raoiella indica* are favoured by high rainfall conditions and can be achieved by the application of select chemical treatments.

KEYWORDS: *Raoiella indica*, population dynamics, Jamaica

2008 Proceedings of the Caribbean Food Crops Society. 44(2):587. 2008

Poster #65

Management of Pink Hibiscus Mealybug (*Maconellicoccus hirsutus* Green) in Jamaica

Michelle A. Sherwood[1], L. R. Myers[1], M. Young[2], D. Robinson[3] and J. Lawrence[4].
[1]Ministry of Agriculture, Research and Development Division, Plant Protection Unit; [2]Rural Agricultural and Development Authority (RADA); [3]University of the West Indies, (Mona), Life Sciences Department, Entomology; [4]Caribean Agricultural Research and Development Institute (CARDI). ***mishanton@yahoo.com***

ABSTRACT.
Pink Hibiscus Mealy Bug (PHMB), *Maconellicoccus hirsutus* Green, a polyphagous pest (>300 host plants) of economic and quarantine importance was first reported in Jamaica in June 2007. As of May 2008 the PHMB infestation is limited to the parishes of Portland and Kingston. Containment and management of the pest is based on an integrated pest management programme involving primarily surveillance, biological control and cultural control components, underpinned by public education and awareness efforts. Locally ornamentals, fruit trees, vegetables and weeds have been attacked by this pest. The parasitoid wasp *Anagyrus kamali* Moursi was sourced through the United States Department of Agriculture (USDA) and released at all infested sites. A total of 168,200 adult *A. kamali* were received between August 15, 2007 and May 13, 2008. Pre-release monitoring was conducted at 12 sites in Portland and two in Kingston. Monthly post-release monitoring continues by sampling Hibiscus plants to determine PHMB populations and parasitism levels.

Initial parasite recovery was observed within three months of the programme in Portland. After eight months the mean PHMB population at all monitoring sites in Portland had decreased by 75 - 100% of pre-release levels and 97-100% parasitism levels recorded at 50% of the sites in Portland and Kingston. In January 2008 resurgence in PHMB populations was observed at several sites however not up to pre-release levels. Local natural enemies observed include species of ladybird beetles, a predatory reduvid bug and a parasitoid wasp. The programme has proven effective to date by containing and reducing the PHMB population in the affected parishes with the PHMB remaining only an urban pest with little or no impact on agriculture and natural areas.

KEYWORDS: *Maconellicoccus hirsutus*, biological control, *Anagyrus kamali*, Jamaica

2008 Proceedings of the Caribbean Food Crops Society. 44(2):588-592. 2008

Poster #66

Impact of Organic Mulches on Watermelon Fruit Yield and Purple Nutsedge Tuber Productivity in an Ecological Production System

Note: This paper was presented as Poster #66 "Purple Nutsedge Tuber Productivity as Affected by Organic Mulches in a Watermelon Production System"

J. Pablo Morales-Payan[1], Pedro Marquez-Mendez[1], Erin Rosskopf[2], Yasser Shabana[3], Raghavan Charudattan[3] & Waldemar Klassen[4]
[1]Department of Horticulture, University of Puerto Rico-Mayagüez Campus, PO Box 9030, Mayagüez, PR 00681; [2]USDA, ARS, USHRL, 2001 South Rock Road, Fort Pierce, FL 34945; [3]Department of Plant Pathology, University of Florida, 1453 Fifield Hall, PO Box 110680, Gainesville, FL 32611, and [4]Tropical REC, 18905 SW 280 St., PO Box 111569, Homestead, FL 33031. jpmorales@uprm.edu

ABSTRACT.

Research was conducted in Isabela, Puerto Rico, to determine the tuber productivity of the weed purple nutsedge (PN) and the yield of 'Crimson Sweet' watermelon when grown with or without organic soil bed mulches [hays of millet (*Pennisetum glaucum*), nutsedge (*Cyperus rotundus*), sunn hemp (*Crotalaria juncea*), sorghum (*Sorghum bicolor*), cowpea (*Vigna unguiculata*), cogongrass (*Imperata cylindrica*), Bahiagrass (*Paspalum notatum*), and rye (*Secale cereale*)]. The mulches covered the top of the soil beds, and were set the same day the watermelon was established. Natural populations of PN on the site were approximately 100 viable tubers/m^2. PN shoots able to grow through the mulches were left unchecked until the final harvest of the crop. For non-mulched checks, we had a bare soil weed-free treatment and a bare soil season-long-PN-infested treatment. There were significant effects on watermelon yield and PN tuber productivity by mulch material. The tuber productivity of PN production was significantly reduced when watermelon was mulched with Bahiagrass (68% lower), nutsedge (45% lower), cogongrass (36% lower), millet (36% lower), and sorghum (34% lower), as compared to PN-infested checks. When mulching with cogongrass and nutsedge, watermelon yield was significantly higher than with other mulches.

KEYWORDS: Organic horticulture; vegetable crops; weeds

INTRODUCTION

In Puerto Rico, watermelon (*Citrullus lanatus*) is a popular horticultural crop grown all year long. In fiscal year 2006-2007, watermelon's farm gate worth in Puerto Rico was approximately $2 million (Puerto Rico Department of Agriculture, 2008). Among the main limiting factors for watermelon production in Puerto Rico are weed, pest, and disease management.

Crop protection is a major concern for the increasing number of ecologically-oriented growers in Puerto Rico that decide not to use synthetic pesticides. Weeds in general and PN (*Cyperus rotundus*) in particular are in the top priority list of production

obstacles pointed out by those growers. Unchecked interference from PN is known to significantly reduce the yield of watermelon (Webster et al., 2008). Mulching with straw or with green (recently cut) plant shoots is one of the non-pesticide alternatives for management of PN and other weeds in watermelon, and has been shown to reduce PN interference in other horticultural crops such as tomato (*Lycopersicon esculentum*)(Shabana et al., 2008). Straw or hay mulching has the additional advantage that it does not have to be removed from the field when the crop season ends, and can be used to amend the soil (Johnson et al., 2004). Because of the scarcity of recommendations based on local research, there is an urgent need to generate information about alternative means of weed suppression, such as mulches. The objective of this research was to determine the tuber productivity of the weed purple nutsedge and the yield of 'Crimson Sweet' watermelon when grown with or without selected organic soil bed mulches.

MATERIALS AND METHODS

Field research was conducted at the Experiment Substation of the University of Puerto Rico-Mayagüez in Isabela, Puerto Rico. The site of the experiment had a natural population of approximately 100 viable PN tubers per m^2. Plots were 3 m long with 6 watermelon plants each. The organic mulches were set covering the top of the soil beds the same day the crop was established. The organic mulches were hays of millet (*Pennisetum glaucum*), nutsedge (*Cyperus rotundus*), sunn hemp (*Crotalaria juncea*), sorghum (*Sorghum bicolor*), cowpea (*Vigna unguiculata*), cogongrass (*Imperata cylindrica*), Bahiagrass (*Paspalum notatum*), and rye (*Secale cereale*). The weedy checks were plots infested season-long with PN, and non-mulched weed-free checks were kept by weekly removal of emerging weeds. The treatments were established in a randomized complete block design with three replications.

The 'Crimson Sweet' watermelon crop was grown without synthetic pesticides and fertilizers. PN plants able to grow through the mulches were left unchecked until the end of the crop, and no further PN management was implemented. Watermelon fruits were harvested at commercial maturity, their number and weight being recorded. Four days after the final watermelon harvest, PN tuber number and weight were determined from soil samples 20 cm long x 20 wide x 20 cm deep collected from each plot of the experiment. Analysis of variance and separation of means (Duncan's Test) at the 5% level were conducted on the data.

RESULTS AND DISCUSSION

Organic mulches had significant effects on PN tuber productivity and on watermelon yield. PN tuber productivity was the lowest when the watermelon plots were covered with Bahiagrass mulch, with a 68% reduction in PN tuber productivity as compared to the watermelon plots infested with PN season-long (Figure 1). Mulching with nutsedge, cogongrass, millet, and sorghum resulted in PN tuber productivity being reduced by 34 to 45%. The least efficacious mulches for suppression of PN tuber propagation were cowpea (10% reduction of PN tuber productivity), sunn hemp (20% reduction of PN tuber productivity), and rye (22% reduction of PN tuber productivity)(Figure 1). The differential effect of these mulches on PN tuber productivity

may be partially due to the speed of their decomposition on the soil surface (legumes such as cowpea and sunn hemp decomposing more rapidly than the non-legume mulches; data not shown) and/or natural chemicals being released from the mulches and their decomposing parts. No attempt was made to determine potential allelopathic compounds released from the mulches.

Figure 1. Effect of selected organic mulches on the tuber productivity of purple nutsedge (*Cyperus rotundus*) in ecologically-managed watermelon in Isabela, Puerto Rico. Bars with the same letters are not significantly different.

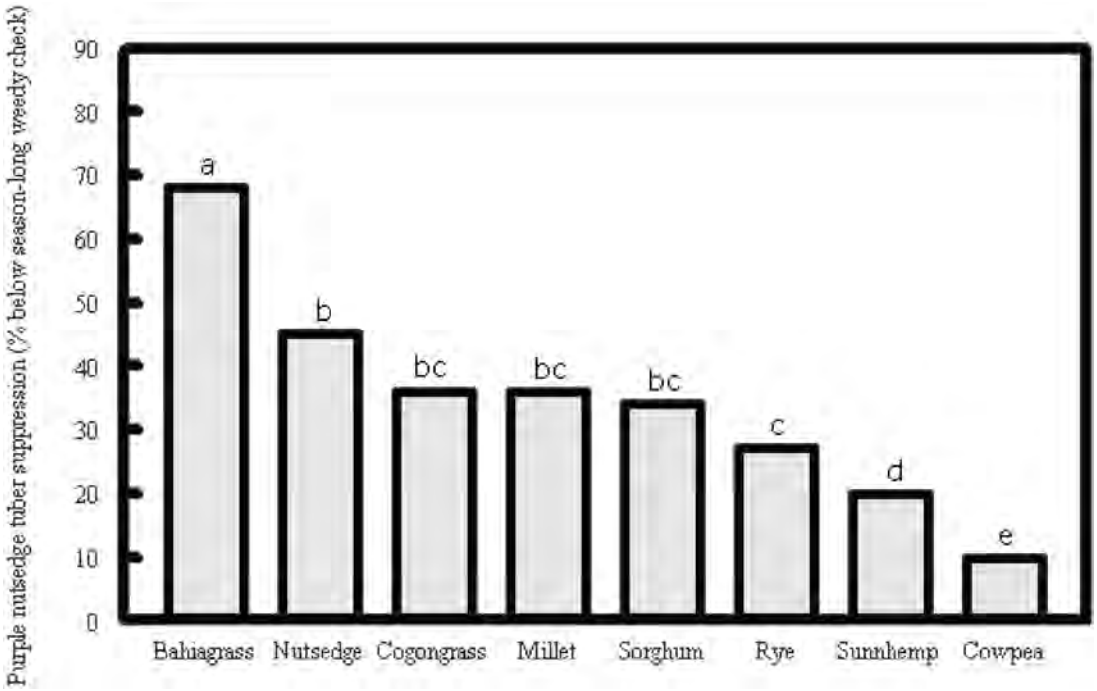
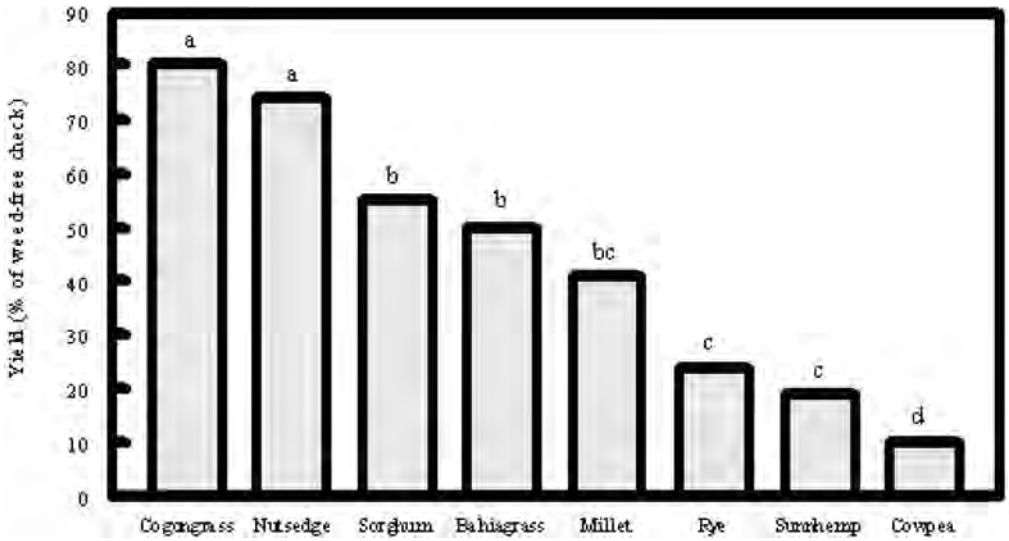


Figure 2. Effect of selected organic mulches on the yield of ecologically-managed watermelon in Isabela, Puerto Rico. Bars with the same letters are not significantly different.



There were also differential effects of organic mulches on watermelon yield. The highest watermelon yields were found in plots mulched with cogongrass and nutsedge hays. In those two treatments, watermelon yield averaged 75-80% that of the yield found in the permanently weed-free checks (Figure 2), which may be acceptable for ecological growers. It is likely that those yields may be improved if in addition to mulching other means of weed control were implemented.

Mulching with hays of sorghum, Bahiagrass, and millet (all of them grasses) resulted in watermelon yields 45-55% those of the weed-free checks (Figure 2), which for most growers would be unacceptable. Watermelon yields were the lowest when mulching with rye, sunn hemp, and cowpea.

Rye, sunn hemp, and cowpea had the lowest performance for both watermelon yield and reduction of PN tuber productivity. The other mulches were more efficacious in terms of watermelon yield and suppression of PN propagation. These results show that some of the organic mulches tested in this research may be useful components of integrated weed management systems for organic and ecological watermelon production in Puerto Rico and similar locations.

ACKNOWLEDGEMENTS

Research funded by the T-STAR Program (UPR-Mayagüez Project ZTS-36).

REFERENCES

Johnson, J. M., J. A. Hough-Goldstein, & M. J. Vangessel. 2004. Effects of straw mulch on pest insects, predators, and weeds in watermelons and potatoes. Environmental Entomology 33:1632-1643.

Puerto Rico Department of Agriculture. 2008. Ingreso Bruto de la Agricultura en Puerto Rico. http://www.gobierno.pr/NR/rdonlyres/CF939105-E2DA-44EC-A0DF-

41622555F06A/0/IngresoBrutoAgricola2006_07.pdf. Accessed on August 30, 2008.

Shabana, Y., E. Rosskopf, J. P. Morales-Payan, A. H. Abou Tabl, W. Klassen, & R. Charudattan. 2008. Use of hay, green, and plastic mulches to suppress nutsedge in horticultural crops. Abstr. Caribbean Food Crops Society 44th Meeting, Miami, Florida, July 13-17, 2008. http://cfcs.eea.uprm.edu/44th_Meeting/OralPresentations.htm. Accessed August 30, 2008.

Webster, T. M., T. L. Grey, J. W. Davis, & A. S. Culpepper. 2008. Glyphosate hinders purple nutsedge (*Cyperus rotundus*) and yellow nutsedge (*Cyperus esculentus*) tuber Production. Weed Science 56:735-742.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):593-600. 2008

Poster #67

Effects of Altitude and Harvest Period on Broca (*Hypothenemus hampei Ferrari*) infestations in Coffee (*Coffea arabica L.*) Beans in the Dominican Republic; Efecto de la Altitud y Períodos de Cosecha en la Infestación por la Broca (*Hypothenemus hampei Ferrari*), en Granos del Cultivo de Café (*Coffea arabica L.*), Barahona, República Dominicana

Yluminada O. López, Miguel M. Campo, and José B. Nuñez. Departamento de Agronomía, Universidad ISA, Avenida Antonio Guzmán Fernández, Km 51/2, La Herradura, Santiago, Dominican Republic. jnunez@isa.edu.do; cdejesus@isa.edu.do

ABSTRACT.
In the Dominican Republic, the area planted with coffee is 132,500 ha which produces an annual harvest of 36,636,364 kg through the efforts of more than 50,000 coffee farmers. Since 1997, the broca (*Hypothenemus hampei*) pest has infested the coffee fields in the country and has reduced crop yield and quality. The objectives of this study were to evaluate the influence of altitude and harvest period on the incidence of the broca incidence and on coffee bean grain quality. The experimental design was a completely randomized design with a factorial arrangement with 4 replicates. The twelve treatment combinations were formed from four altitudes (400-500, 600-700, 850-950 and 1000-1100 meters) and three harvest periods (November, December and January). The variables were crop management, percentage of infected grains, and commercial quality of the beans. The results showed that from 78.4% to 100% of the farmers controlled the shade at 850-950 meters of altitude while 74.75% did so at 400-500 meters of altitude. The higher incidences (22.33 % and 20.00 %) of infected beans were at 400-500 and 600-700 meters of altitude, respectively. The lineal regression analysis showed an inverse relationship between altitude and percentage of infected grains. Moreover, this analysis showed a direct relationship between altitude and bean quality AAA, but an inverse relationship with quality AA and A. The highest percentage of beans with quality AAA (69.44 %) and AA (52.61 %) were at 1000 -1100, and 400-500 meters of altitude, respectively. The data suggest that altitude affects the yield and quality of coffee beans.

KEYWORDS: altitude, harvest periods, broca, coffee berry borer, bean,

RESUMEN
En la República Dominicana, aproximadamente (2002, 2003 y 2004), el área sembrada es de 132,500 ha, de estas, a 28,220 ha se les da manejo tecnificado. La cosecha promedio es de 36,636,364 kg por año e involucra a 50,000 caficultores. A partir del 1997, la broca (Hypothenemus hampei) afecta la producción cafetalera, reduciendo la conversión de café uva en café pergamino. Esta investigación, tiene el objetivo de evaluar la influencia de la altitud y los períodos de cosecha, sobre la prevalecia de granos infestados por broca y la calidad del grano cosechado. Se realizó en la Provincia de Barahona, Republica Dominicana en el período noviembre 2004 y enero 2005. Utilizamos un diseño completamente al azar con arreglo factorial con 4 repeticiones. El factor A, la altitud con

los niveles 400-500, 600-700, 850-950 y 1000-1100 msnm y el factor B, períodos de cosechas, con los niveles noviembre, diciembre y enero. Variables evaluadas: prevalecia de granos infestados por broca y calidad comercial de los granos. Resultados obtenidos. La mayor prevalencia de granos infestados por broca, fueron la altitud 400-500 msnm con 22.33 % y 600-700 msnm con 20.00 %. Los resultados de la ecuación de regresión lineal simple, indicaron, que por cada aumento de 1 msnm de altitud, el porcentaje de infestación baja en uno por ciento. El mayor porcentaje de granos calidad grado AAA se obtuvo en la altitud 1000 -1100 msnm con 69.44 %, el mayor porcentaje de granos calidad grado AA, se cosechó en la altitud 400-500 msnm con 52.61 % y la altitud con mayor porcentaje de granos calidad grado A fue 400-500 msnm. Las ecuaciones de regresión lineal para el grado de calidad de los granos, significaron que, por el aumento en 1 msnm de altitud, el porcentaje de granos calidad grado AAA aumenta en siete por ciento, el grano calidad grado AA baja en cinco por ciento y el grano calidad grado A baja en dos por ciento.

INTRODUCCIÓN

En la República Dominicana el cultivo de café es un renglón importante para la exportación. Se siembra, aproximadamente 132,500 ha y de esta, a 28,220 ha se les da manejo tecnificado, involucrando a 50,000 caficultores. En el manejo de este cultivo se emplean alrededor de 500,000 personas anualmente La producción promedio de las cosechas de los años 2002, 2003 y 2004 fue de 36, 636,364 kg. A partir del año 1997 la rentabilidad del cultivo se ha visto afectada por la broca (Hypothenemus hampei Ferrari), al afecta la calidad de grano y la bebida y disminuir los rendimientos hasta en un 50 %, al reducir la conversión de café uva en café pergamino. La broca prospera en zonas bajas, y puede hacer daños en plantaciones con altura de 800 hasta 1200 msnm, dependiendo de las condiciones del ambiente.

Objetivo

Evaluar la influencia de las altitudes, entre 400 - 500, 600 - 700, 850 - 950 y 1,000 - 1,100 metros sobre el nivel del mar, y los períodos de cosecha, (noviembre, diciembre y enero), sobre la prevalecía de la broca (Hypothenemus hampel Ferrari) y la calidad del grano de café cosechado.

MATERIALES Y MÉTODOS

Ubicación

Se realizó en el período octubre de 2004 a febrero de 2005. En la provincia de Barahona, República Dominicana. Las temperaturas registradas oscilan entre 17 a 22 ˚C con pluviometría media anual de 2,296 mm. La altitud de cada localidad evaluada, fue determinada mediante un altímetro.

Diseño Experimental

Diseño completamente al azar con arreglo factorial y cuatro repeticiones. Factor A la altitud, con cuatro niveles: 400-500, 600-700, 850-950 y 1000-1100 msnm respectivamente y el factor B períodos de cosechas con tres niveles, correspondientes a los meses de noviembre, diciembre y enero (3X4=12 tratamientos).

Muestreo

Conjuntamente con técnicos del Consejo Dominicano del Café (CODOCAFE), se determinó evaluar cuatro fincas por cada altitud, con áreas variadas de 3.9 a 32.1 ha y seleccionada al azar. Estas fueron divididas en 9 áreas y escogidas al azar 20 plantas por área. Cosechamos cinco granos por planta, para un total de 100 granos por muestra y 900 granos por finca. Se realizaron tres muestreos por período por finca, con un intervalo de 10 días, aproximadamente.

Manejo de la Cosecha

Los frutos cosechados, fueron observados y separados los granos sanos de los brocados (presencia de agujero en el ápice). Para el beneficiado, los frutos sanos fueron despulpados manualmente el mismo día de la selección. Los granos fueron fermentados de forma natural durante 15 horas. Luego se procedió a la remoción del mucílago mediante el lavado o fricción manual de los granos. Los granos fueron secados en piso de cemento, al sol y removido cada dos horas, durante un periodo de 39 horas. Los granos se dejaron 48 horas en reposo y en la sombra, para que se estabilizaran sus características organolépticas. La humedad fue llevada a 12 %. Se procedió al descascarado del pergamino, manualmente. Estos fueron llevados al laboratorio para el análisis de clasificación de calidad de los granos.

Variables Evaluadas

Prevalencia de Granos Infestados por Broca: los granos infectados por brocas fueron abiertos con una pinza y observados con una lupa, reportamos la cantidad de especimenes cada estadio.

Calidad Comercial de los Granos Cosechados: las muestras fueron pesadas individuamente, en una balanza. Pasados por un vibrador con mallas de orificios de diámetros diferentes (números entre 14 y 20). Los granos retenidos en las mallas números 20, 19 y 18 fueron clasificados de grado AAA, grande, forma redondeada y duro. Los granos retenidos en las mallas números 17 y 16 fueron clasificados como grado AA, mediano y forma alargada, y los granos retenidos en las mallas número 15 y 14 fueron granos de grado A. Estos fueron pesados y se obtuvo su respectivo porcentaje.

Análisis Estadístico

Los datos obtenidos fueron analizados mediante el programa estadístico SAS, a un nivel de significancia de 5 %. Para las medias que presentaron diferencias estadísticas, se aplicó a prueba de rangos múltiples de Duncan. Además se realizaron análisis de regresión lineal.

RESULTADOS Y DISCUSIÓN

Prevalencia de Granos Infestados por Broca

El análisis de varianza (Cuadro 1), indicó diferencias estadísticas significativas para el factor altitud. Para el factor período de cosecha y las interacciones entre los factores evaluados, no hubo diferencias estadísticas significativas.

Cuadro 1. Análisis de Varianza de la Prevalencia de Granos Infestados por Broca, en la Investigación Efecto de la Altitud y Período de Cosecha en la Infestación por Broca de los Granos de Café, Barahona, República Dominicana. 2004-2005

FV	GL	SC	CM	Fc	Pr>f
Altitud	3	939,63	313,21	6,71	0,0003
Período	2	59,041	24,52	0,63	0,5331
Altitud x periodo	6	291,9	48,65	1,04	0,4014
Error	132	6165,1666	46,7		
Corrección Total	143	7455,75			

Factor Altitud

La Figura1, muestra los niveles 400-500, y 600-700 msnm, con los mayores porcentajes de granos infectados por brocados con 22.33 y 20.00 %, respectivamente, resultando con igual significancia estadística. Los niveles 850-950 y 1000-1100 msnm, resultaron con los menores porcentajes de granos brocados, con 15.78 y 17.05 %, respectivamente.

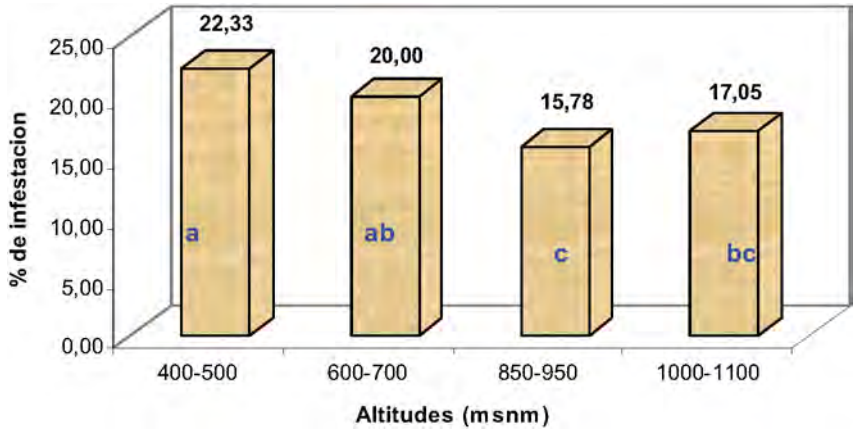


Figura 1. Comparación de Media para la prevalencia de Granos Infestados por Broca según la Altitud.

La ecuación obtenida del análisis de regresión linear (Figura 2) fue, y = -0.0112x + 27.229, con un R^2 de 0.2439. Esta significó que, por cada aumento en 1 msnm de altitud, la prevalencia de granos infestados por broca se reduce uno por ciento.

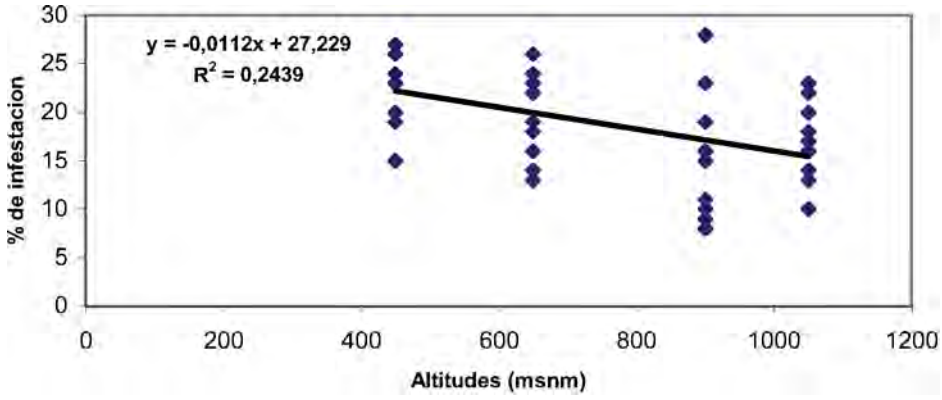


Figura 2. Regresión Lineal para la Prevalencia de Granos Infestados por Broca según la Altitud

Calidad Comercial de los Granos Cosechados

Los análisis de varianza (Cuadro 2) indican que hay diferencia estadísticas significativas para los factores altitud y periodo de cosecha, también para su interrelación.

Cuadro 2 Análisis de Varianza para la Variable Calidad del Grano de Café para Exportación (AAA), en el efecto de la Altitud y Período de Cosecha

FV	GL	SC	CM	Fc	Pr>f
Altitud	3	24811,8888	8270,62963	37,41	
Periodo	2	2466,7222	1233,3611	5,58	0,0047
Altitud x Periodo	6	5370,61111	895,10185	4,05	0,0009
Error	132	29185,333	221,10101		
Corrección total	143	61834,555			

Factor Altitud

El Cuadro 3, muestra el nivel 1000-1100 msnm con el mayor porcentaje de granos calidad grado AAA con 69.44 %, resultando estadísticamente diferentes a los demás niveles del factor altitud. La altitud que presentó menor porcentaje de granos calidad grado AAA fue la de 400-500 msnm, con 32.77 %; también este nivel resulto con mayor porcentaje de granos grados AA y A con 52.61 y 14.44 % respectivamente.

Cuadro 3. Comparación de Medias para la Calidad Comercial de los Granos Cosechados según la Altitud.

Altitud (msnm)	Grado (AAA) %		Grado (AA) %		Grado(A) %	
400-500	32.77	C	52.61	a	14.44	a
600-700	51.80	b	38.02	b	9.63	b
850-950	46.66	b	48.97	a	4.25	c
1000-1100	69.44	a	26.75	c	3.77	c

Para el grano calidad grado AAA, la ecuación de regresión obtenida fue, $y = -0.0112x + 27.229$, la cual tuvo un R^2 de 0.2439 (Figura 3). Esta nos significó que, por cada aumento de 1 msnm de altitud el grado de calidad aumenta en siete por ciento.

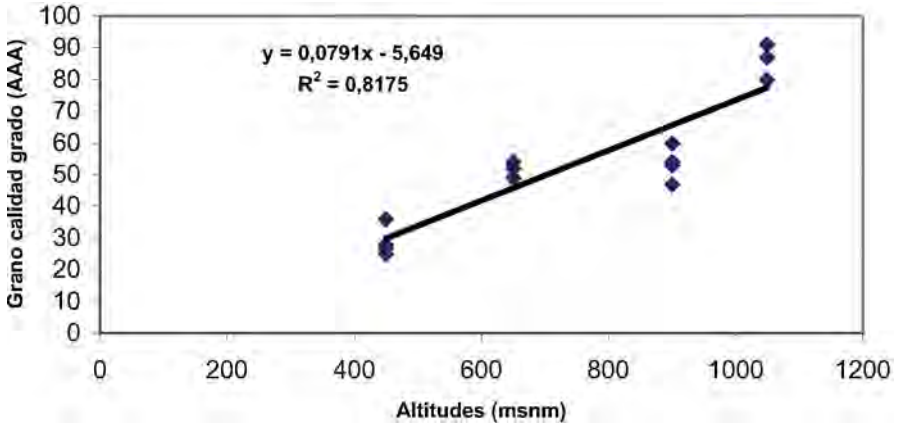


Figura 3. Regresión Lineal Para la calidad del Grano Grado (AAA) por Altitud.

Para los granos calidad grado AA, la ecuación de regresión lineal obtenida fue, $y = -0.0523x + 76.857$ y $R^2 = 0.5545$. Esta significó, que por cada aumento de 1 msnm de altitud el grano de calidad grado AA baja cinco por ciento (Figura 4).

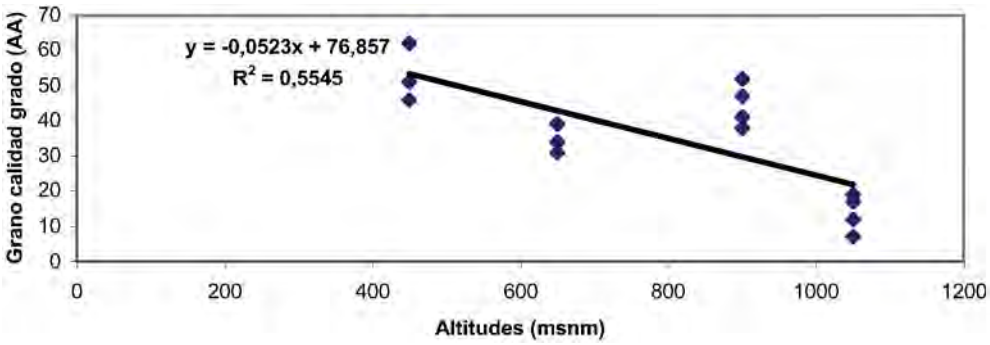


Figura 4. Regresión Lineal Para la Calidad del Grano para la Exportación (AA) por Altitud.

Para el grano calidad grado A, la ecuación regresión lineal fue, y = -0.0295x + 31.169 la cual tuvo un R^2 = 0.675. La misma significó que por cada aumento de 1 msnm de altitud el grado de calidad A baja dos por ciento (Figura 5)

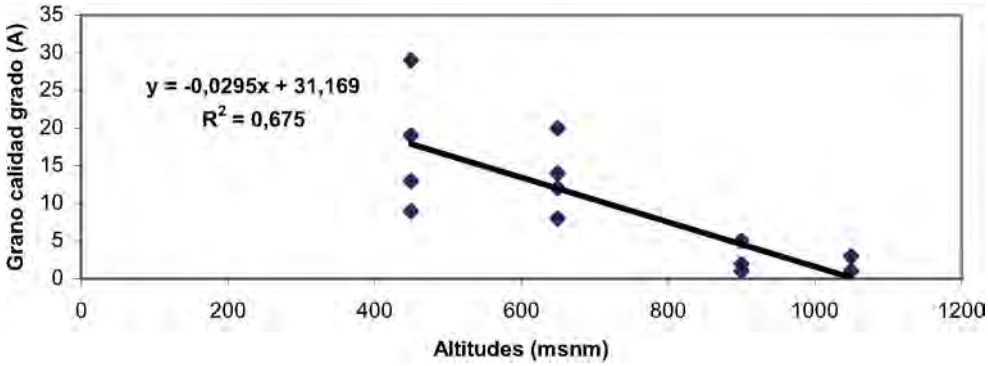


Figura 5. Regresión Lineal Para la Calidad del Grano para la Exportación (A) por Altitud

Factor Periodo

La comparación de medias (Cuadro 4), muestra los mayores porcentajes de granos de calidad grado AAA los niveles de diciembre y enero, con 54.62 y 51.29 % de granos, resultando con igual significancia estadística. Las medias de granos grado A, resultaron con igual significancia estadística, para los niveles.

Cuadro 4 Comparación de Medias para la Calidad Comercial de los Granos Cosechados según Período de Cosecha

Periodo	Grado (AAA) %	Grado (AA) %	Grado(A) %
Noviembre	44.66 b	45.31 a	9.91 a
Diciembre	54.62 a	37.54 b	7.75 a
Enero	51.29 a	41.91 ab	6.41 a

CONCLUSIONES

La prevalencia de granos infectados por broca, es influenciada por la altitud, disminuyendo uno por ciento por cada metro de altitud. El periodo de cosecha no afecta la prevalencia de granos Infestados por broca.

Al aumentar 1 msnm de altitud, el porcentaje de granos de calidad grado AAA aumenta en siete por ciento, el grano calidad grado AA baja en cinco por ciento y el grano calidad grado A baja en dos por ciento

REFERENCIAS

Abud. A. 1995. La Broca del Café (Hypothenemus hampei Ferrari Coleóptero: Scolitidae) en Republica Dominicana, Santo Domingo, Republica Dominicana.

Borbón, o. 1991. La Broca del Cafeto (H, hampei) Programa Cooperativo de Café, San José Costa Rica.

Camilo G., D. A. 1987. Manual de la Caficultora Dominicana. Subsecretaria de Producción y Mercadeo. Departamento de Café. Republica Dominicana. Pág. 110.

Cantor et. al. 2001. Biología de Phymastichus Caffea Lasalle Himenóptera: Eulophidae endoparacitoide de la Broca del Café, en Tres Altitudes Diferentes de la Zona Cafetalera Colombiana. Congreso de la Sociedad Colombiana de Entomatología. Colombia.

Consejo Dominicano del Café (CODOCAFE). 2002. Boletín estadístico No. V. Santo Domingo, Republica Dominicana.

Castillo, A. et. al. 2001. Investigaciones Sobre la Broca del Café Realizadas por ECOSUR, Soconusco, Chiapas, México.

Federación de Desarrollo Agropecuario Inc. (FDA). 1997. La Broca del Café (Hypothenemus hampei, Ferrari) su Biología y Control, Santo Domingo, Republica Dominicana.

Fundación Salvadoreña para Investigaciones del Café (PROCAFE). 1997. Manual del Caficultor Salvadoreño. El Salvador.

Garcías, A. y Campos, O. 2001. Orientación de la Investigación para el Manejo de la Broca del Café (Hypothenemus hampei Ferr.) Guatemala

García, A. Medina, R. Roca R., 1996. Observaciones Sobre Patogenidad de Cepas de B. bassiana Hacia la Broca del Café. Nata técnica ANACAFE, Guatemala.

Instituto Interamericano de Cooperación para la Agricultura (IICA). 1998. La Broca del Fruto del Cafeto. Biología y Control. Primera Edición. San José, Costa Rica.

Junta Agroempresarial Dominicana (JAD), 1997. Estrategia para el Manejo Integrado de la Broca del Café (Hypothenemus hampei Ferrari) en la Republica Dominicana, Santo Domingo Republica Dominicana.

Perez, A. 2002. Validación de la Efectividad y Eficiencia de la Repela, Pepena y Graniteo en el Control de la Broca (Hypothenemus hampei Ferrari). Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF), Barahona, Republica Dominicana.

Quijano, J. 2003. Manual del Caficultor. Fundación Salvadoreña para Investigaciones del Café PROCAFE, Nueva San Salvador, El Salvador.

Sánchez, A. 1984.Manual de las Enfermedades y Plagas del Café. Daños y técnicas de Control. Guatemala, C. A.

Secretaría de Estado de Agricultura (SEA). 2004. Manual del Caficultor Dominicano. Consejo Dominicano del Café (CODOCAFE). Instituto dominicano de Investigaciones Agropecuarias y Forestales (IDAF), Republica Dominicana.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):601. 2008

Poster #68

Disease Management Programs for Basil Downy Mildew

R. N. Raid[1], P. Roberts[2], and P. Harmon[3], Department of Plant Pathology, University of Florida, IFAS, [1]Everglades Research and Education Center, Belle Glade, [2]Southwest FL Research and Education Center, and [3]Dept. of Plant Pathology, Gainesville, FL rnr@ifas.ufl.edu

ABSTRACT.
During the summer of 2007, a severe foliar disease was noted on basil grown in south Florida. The disease was characterized by foliar chlorosis, frequently delineated by leaf veination, with a light grey fungal growth evident on lower leaf surfaces. Initially observed in the lower canopy, the disease subsequently developed in the mid to upper canopy. Severely infected leaves frequently dehisced. The disorder displayed fungal signs associated with downy mildew. Crop losses in individual fields ran as high as 100%, with a number of basil shipments being rejected at delivery due symptom development in transit. The performance of Koch's postulates has verified the disease as being caused by a fungal species, most likely within the genus *Peronospora*. To identify prospects for chemical control of this disease, a number of field experiments were conducted during fall 2007 through spring 2008. Trials were conducted in commercial fields where basil was grown on 20-cm raised beds. The crop was direct-seeded in four rows set on 25-cm centers, with an in-row plant spacing of approximately 2.5-cm. The experimental design consisted of 3-4 replications of fungicide treatments arranged in randomized complete blocks. Experimental units were composed of 4 basil rows, 4 meters in length, separated by 2-m non-sprayed buffer plots. Fungicides were applied using a CO_2 backpack sprayer equipped with a handheld boom calibrated to deliver 580 l/ha at 2.1 x 10^5 Pa. High levels of natural inocula in the area and long dew periods created ideal conditions for downy mildew development. Disease conditions were severe and all tests were judged definitive. A number of different chemistries showed promise, among them various phosphonic compounds, mandipropamid, fenamidone, dimethomorph, propamocarb, and azoxystrobin. Tank-mixtures, and/or alternations of phosphonic fungicides, with the aforementioned other chemistries, provided for excellent control when applications were initiated before disease onset and applied on a weekly basis.

KEYWORDS: basil, downy mildew, fungicidal control

2008 Proceedings of the Caribbean Food Crops Society. 44(2):602-607. 2008

Poster #69

A New Lethal Disease of *Syagrus romanzoffiana* and *Washingtonia robusta* in Florida is Caused by *Fusarium oxysporum*

Monica L. Elliott[1] and Elizabeth A. Des Jardin[1]

[1]Fort Lauderdale Research and Education Center, University of Florida – IFAS, Fort Lauderdale, Florida 33314, USA Corresponding author: melliott@ufl.edu

ABSTRACT

Syagrus romanzoffiana and *Washingtonia robusta* are popular landscape ornamental palms grown throughout most of Florida. Since late 2004, we have noted mature specimens in the landscape and juvenile material in nurseries of *S. romanzoffiana* with symptoms not observed previously for this species. Symptoms are first observed on the oldest leaves, with individual leaves exhibiting chlorosis and necrosis initially only on one side. A distinct reddish-brown stripe is visible on the petiole and rachis, and there is a corresponding discoloration internally. Within 2-3 months after onset of initial symptoms, the entire canopy desiccates and turns brown as if freeze-dried *in situ*. Similar symptoms were observed on *W. robusta* beginning in the spring of 2007 in landscapes and a nursery. *Fusarium oxysporum* was consistently isolated from symptomatic petiole tissue from both palm species. DNA was extracted from single-spore isolates, and a portion of the translation elongation factor 1-alpha (TEF) was amplified using the polymerase chain reaction and the ef1 and ef2 primers. The resulting amplicons were sequenced. Comparison of the sequences obtained with TEF sequences in the FUSARIUM-ID database (http://fusarium.cbio.psu.edu) demonstrated that this *F. oxysporum* is likely to be a new forma speciales. Koch's postulates were completed using *S. romanzoffiana* and *W. robusta* and *F. oxysporum* isolates obtained from both palm species. *F. oxysporum* isolates from *S. romanzoffiana* were pathogenic on *W. robusta*, and, likewise, isolates from *W. robusta* were pathogenic on *S. romanzoffiana*.

KEYWORDS: *Fusarium oxysporum*, palm diseases, *Syagrus romanzoffiana*, *Washingtonia robusta*

INTRODUCTION

Syagrus romanzoffiana (queen palm) and *Washingtonia robusta* (Mexican fan palm) are landscape ornamental palms grown throughout most of Florida. Quickly dying (within 2-3 months), mature queen palms in landscapes across the southern half of Florida were brought to our attention beginning in late 2004. In spring 2007, Mexican fan palms were observed with similar symptoms and disease progression, also throughout southern Florida. The symptoms are similar to those associated with Fusarium wilt of other palm species, such as *Phoenix canariensis* (Simone, 2004). Symptoms are first observed on the oldest leaves, and the disease progresses up through the canopy. Early, individual leaf symptoms include one side of the leaf blade exhibiting chlorosis and

necrosis (one-sided wilt or death), and a distinct reddish-brown stripe is visible on the petiole or rachis. There is a corresponding internal discoloration. Within 2-3 months after onset of initial symptoms in the oldest leaves, the entire canopy is desiccated and necrotic as if freeze-dried *in situ*. There is no indication of trunk or root infection. Studies were initiated to determine the etiological agent of this lethal decline.

MATERIALS AND METHODS

Internal petiole or rachis tissue of symptomatic leaves was obtained by carefully cutting away the petiole or rachis epidermis. Small internal tissue pieces were placed directly on 1/5 strength potato dextrose agar. *Fusarium*-like colonies were consistently isolated from symptomatic tissue. Therefore, such colonies were selected, purified, single-spored and stored for future use. Isolates were identified morphologically by placement on 1.5% water agar with irradiated carnation leaves embedded in the agar surface (CLA). After 2-4 weeks growth at 26°C with 12 hours light, cultures were examined for presence and characteristics of microconidia, mesoconidia, macroconidia and chlamydospores (Leslie and Summerell, 2006).

Fusarium isolates were identified molecularly by obtaining fungal DNA and subjecting to a standard polymerase chain reaction (PCR) protocol using the ef1 and ef2 primers to amplify a portion of the translation elongation factor 1-alpha gene (TEF), a highly informative region for differentiating *Fusarium* species and formae speciales of *F. oxysporum* (Geiser et al., 2004). The approximately 690 bp amplicon was viewed using agarose gel electrophoresis, purified, and then used as a template for DNA sequencing by the DNA Sequencing Core Laboratory, ICBR, UF, Gainesville. Sequences were edited and then queried against the FUSARIUM-ID database using the BLAST search tool (http://fusarium.cbio.psu.edu; Geiser et al., 2004)).

F. oxysporum isolates PLM-140B and PLM-153B were selected for the first pathogenicity experiment, which was conducted with juvenile queen palms (3-4 true leaves) and initiated in April 2006. Both isolates were obtained from symptomatic mature queen palms growing in landscapes. Isolates were grown on potato dextrose agar (PDA) at 26°C with 12 hours light. Spore suspensions (10^7 per ml) were made with sterile water. Each palm was inoculated with two methods. First, a 4-mm hole was drilled into the palm 8-10 cm above the soil line (and above the apical meristem), and then a 2 ml spore suspension was slowly injected internally. Second, a 5-cm shallow slit was made on the adaxial surface of the petiole of the second, youngest fully-expanded leaf, and a 1 ml spore suspension was dribbled on this slit. Palms designated as controls were handled in the same manner but with sterile water. Palms were immediately placed in clear, polyethylene bags and placed in an area with no direct sun for 3 days. Bags were removed, and the palms placed in a sun nursery with daily overhead irrigation. There were four replicate palms per treatment.

Fusarium oxysporum isolates PLM-140B (queen palm, Broward Co. landscape), PLM-246B (queen palm, Lee Co. field nursery) and PLM-249A (Mexican fan palm, Lee Co. field nursery) were selected for the second pathogenicity experiment, which was conducted with seedling queen and Mexican fan palms (3-4 seedling leaves) and initiated in May 2007. Isolates and spore suspensions were prepared as described previously. Palms in conetainers were inoculated by pipeting 40 ml spore suspension between the leaf bases, with excess suspension percolating through the potting mix. Palms designated

as controls were handled in the same manner but with sterile water. Palms were immediately placed in clear, polyethylene bags and placed in an area with no direct sun for 3 days. Bags were removed, and the palms transplanted into 450-ml pots using a peat moss/sand/perlite (1:1:1) potting mix. Palms were placed in a covered shadehouse and irrigated daily. There were five replicate palms per treatment, and each palm species was inoculated with each fungal isolate.

This experiment was repeated in October 2007 using these same three *F. oxysporum* isolates plus *F. proliferatum* PLM-137B and *F. semitectum* PLM-138B. These latter two isolates and *F. oxysporum* PLM-140B had been isolated from the same symptomatic queen palm. All experimental preparations and conditions were the same as described above.

RESULTS AND DISCUSSION

The vast majority of the isolates were tentatively identified as *Fusarium oxysporum* based on morphological characteristics. Macroconidia were formed on CLA in orange sporodochia, and were 3-4 septate with a foot-shaped basal cell and curved apical cell. Microconidia were produced in false heads on short phialides, were unicellular and were primarily oval, elliptical or reniform in shape. Chlamydospores were readily produced by most isolates in less than 4 weeks. The only other *Fusarium* species isolated were identified as *F. proliferatum* and *F. semitectum*. *F. proliferatum* had macroconidia that were longer and more slender than the *F. oxysporum* isolates, and microconidia (distinctively club-shaped with flattened base) were present in long chains on polyphialides. *F. semitectum* was identified based on lack of microconidia production, but production of fusoid-shaped mesoconidia were readily observed in characteristics pairs on polyphialides. Macroconidia were shorter than the *F. oxysporum* isolates. These two species were not consistently isolated from symptomatic tissue as was *F. oxysporum*.

The vast majority of the *Fusarium* isolates most closely matched *Fusarium oxysporum*, but did not match any of the formae speciales TEF sequences currently available in the database, including those for *F. o. canariensis*, the etiological agent of Fusarium wilt of *Phoenix canariensis* which is already present in Florida. A phylogenetic tree was developed using representative *F. oxysporum* isolates from queen and Mexican fan palms and *F. o. canariensis* (isolates from diseased *Phoenix* spp. in Florida), with a *F. semitectum* isolate from a queen palm used as the root (Figure 1).

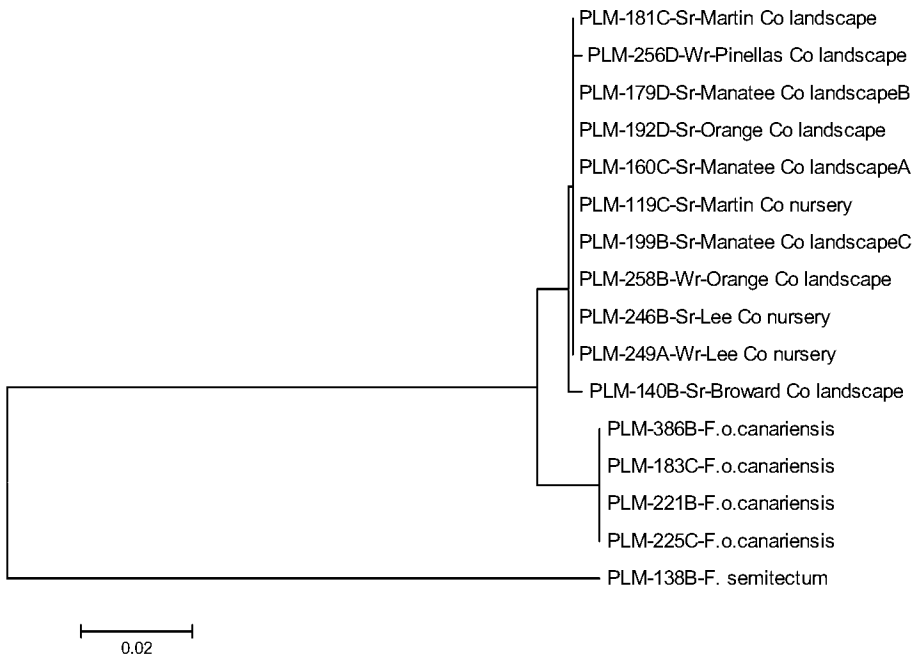


Figure 1. Phylogenetic tree of *Fusarium oxysporum* isolates causing a new, lethal disease of *Syagrus romanzoffiana* (Sr) and *Washingtonia robusta* (Wr), compared with *Fusarium oxysporum* f. sp. *canariensis*.

In the pathogenicity experiment using juvenile queen palms, all control palms were healthy after 9 months, but 2 of 4 inoculated palms of each *F. oxysporum* isolate treatment had died after exhibiting leaf symptoms typically observed in the landscape. *F. oxysporum* was isolated from symptomatic tissue. The remaining 2 replicate palms of each pathogen-inoculation treatment were healthy and never exhibited symptoms during the 9-month period.

In the pathogenicity experiment using seedling queen and Mexican fan palms, symptoms were observed on Mexican fan palms within 3 weeks of inoculation, and all five replicate palms of all three *F. oxysporum* treatments were dead after 5 weeks. Controls were healthy. For queen palms, no symptoms were observed until 8-9 weeks after inoculation. By November 2007, all five replicate palms infested with PLM-249A were dead, 3 of 5 replicate palms infested with PLM-246B were dead, and 2 of 5 replicate palms infested with PLM-140B were dead. By January 2008, the remaining inoculated palms had not died, but were severely stunted, had ceased to produce new leaves, and only the youngest leaf or leaves were still green. Controls remained healthy. *F. oxysporum* was isolated from symptomatic tissue.

The repetition of this pathogenicity experiment yielded similar results with the *F. oxysporum* isolates. All 5 replicate Mexican fan palms of all three isolate treatments were dead after 6 weeks. By 12 weeks, 4 of 5 replicate queen palms of all three isolate treatments were dead and the 5th replicate was declining. All control palms for both species remained healthy, as did the palms inoculated with *F. proliferatum* and *F. semitectum* (Figure 2).

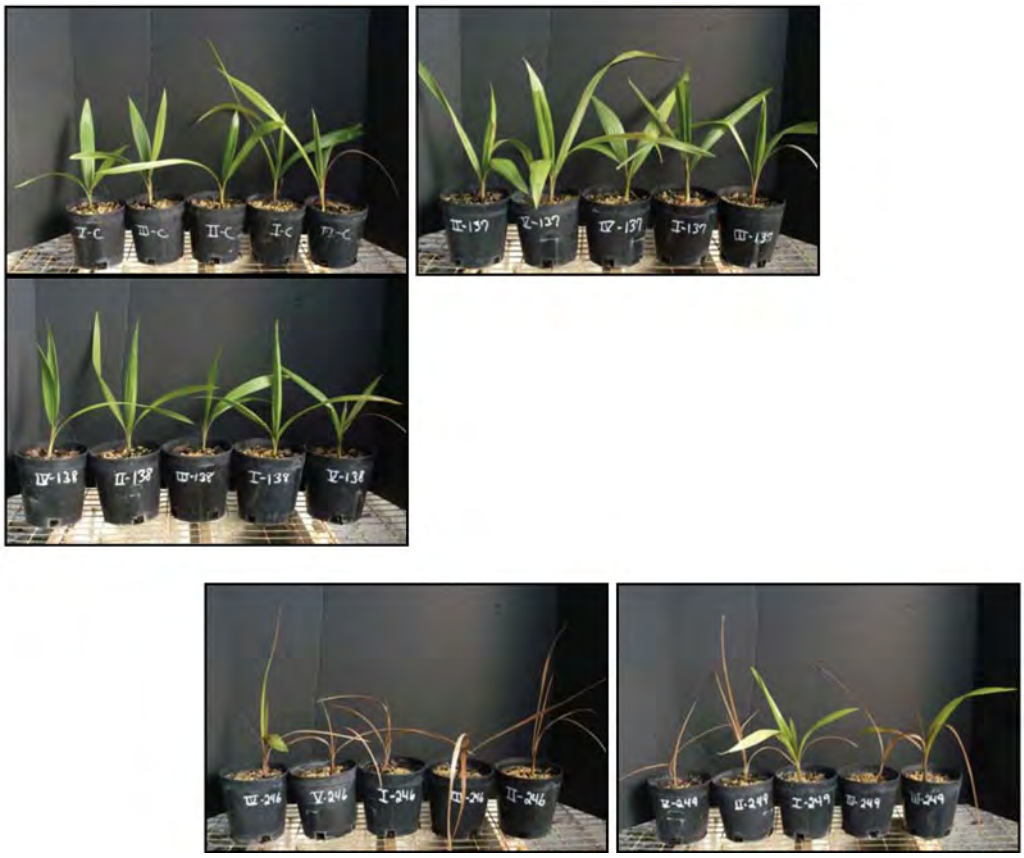


Figure 2. Appearance of *Syagrus romanzoffiana* at 10 weeks after inoculation with *Fusarium* isolates. Top row: Control, *Fusarium proliferaturm* PLM-137B, *Fusarium semitectum* PLM-138B. Bottom row: *Fusarium oxysporum* PLM-246A, *Fusarium oxysporum* PLM-249A.

Based on the results obtained to date, we believe a new forma speciales of *Fusarium oxysporum* is the etiological agent of a new lethal disease of queen and Mexican fan palms occurring in Florida. While the disease is primarily observed in mature landscapes, where palms have been established for 5 or more years, it has been observed in three nurseries, one was a container nursery and two were field nurseries with juvenile palms. Because of the wide geographic range of the disease in Florida, wind movement of the pathogen is implicated.

REFERENCES

Geiser, D. M., Jimenez-Gasco, M. M., Kang, S., Makalowska, I., Veeraraghavan, N., Ward, T. J., Zhang, N., Kuldau, G. A., and O'Donnell, K. 2004. FUSARIUM-ID v. 1.0: A DNA sequence database for identifying *Fusarium*. European Journal of Plant Pathology 110:473-479.

Leslie, J. F. and Summerell, B. A.. 2006. The *Fusarium* Laboratory Manual. Blackwell Publishing, Ames, IA.

Simone, G. W. 2004. Fusarium wilt, pp. 17-22, Compendium of ornamental palm diseases and disorders, M. L. Elliott, T. K. Broschat, J. Y. Uchida, and G. W. Simone (eds.). The American Phytopathological Society, St. Paul, MN.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):608-616. 2008

Poster #70

In Vivo Study of Cogongrass (*Imperata Cylindrica* L.) Rhizome Production

Oghenekome U. Onokpise, James J. Muchovej, and Susan K. Bambo. College of Engineering Sciences, Technology and Agriculture, Florida A&M University, Tallahassee, Florida 32307. susan.bambo@famu.edu

ABSTRACT.
Cogongrass is an aggressive, rhizomatous, invasive perennial grass that is scattered throughout the tropical and subtropical regions of the world, and has become a serious problem in Florida and other Gulf Coast States. A greenhouse study was conducted to evaluate the growth and spread of rhizomes of grass species grown in combination with other native grass species. Native grass species used included: switchgrass (*Panicum virgatum* L), maidencane (*Panicum hemitomon* Schult.), and muhlygrass (*Muhlenbergia capillaries* (Lam) Trin.). All plants were raised in tubbets and then transplanted to 7.6 L greenhouse pots in different combinations with cogongrass. Data on rhizomes of cogongrass and maidencane (rhizomatous species) were recorded during the harvest periods (6, 12, 18 or 24 weeks). The mean number and mean total length of cogongrass rhizomes ranged from 3 to 8 and 0.06 to 0.14 m at 6 weeks to 40 to 94 and 8.37 to 20.39 m at 24 weeks, respectively. Similarly, the mean number and mean total length of maidencane rhizomes ranged from 0.01 to 3 and 0.05 to 0.27 m at 6 weeks to 11 to 26 and 1.57 to 3.31 m at 24 weeks, respectively. There were 51 to 74% and 47 to 74% reductions in the mean total length of cogongrass rhizomes grown in combination than those grown individually at 12 and 18 weeks, respectively. The mean number of cogongrass rhizomes had 54 to 71% reductions when in combination than individually at 12 weeks. Likewise, at 18 weeks the mean number and mean total length of rhizomes of maidencane were reduced by 51 to 65% and 20 to 75%, respectively, when grown in combination with others grasses than alone. The number and spread of rhizomes explain cogongrass' invasiveness and competitiveness. The reduction of cogongrass in combination with native species shows a prospect that some Florida native grasses could reduce the invasiveness of cogongrass in the Gulf Coast States.

KEYWORDS: Cogongrass, rhizomes, native grasses

INTRODUCTION

Cogongrass is considered "the seventh worst weed in the world" (Dozier et al. 1998; Holm et al. 1997). It is an aggressive, rhizomatous, perennial grass that is distributed widely in the tropical and subtropical zones of the world. It occurs in 73 countries and has infested more than 500 million hectares of plantation and agricultural land worldwide (Holm et al. 1977). It was first introduced into the USA both accidentally (into Mobile Alabama through a packaging material in a shipment from Japan) in 1911 and intentionally (into Alabama, Mississippi and Florida as a forage plant and soil stabilizer) from the 1920s to 1940s (Patterson et al. 1980; Dickens 1974; Tabor 1952;

Tabor 1949). Unfortunately, the purpose of its introduction was not achieved, as its evaluation in these states in the 1920 to the 1940s was only acceptable as a short-term forage crop and soil stabilizer. From 1940s to date, it has developed into a major invasive noxious species and serious weed problem in Florida, Georgia, Alabama, Louisiana, Mississippi, and some recent reports include S. Carolina and Eastern Texas (Bolfrey-Arku et al. 2006; Miller 2000). The spread of cogongrass in these areas was by illegal plantings and inadvertent transport in forage and in soil contaminated with cogongrass rhizomes during roadway constructions (Holm et al., 1977; Dickens, 1974). It has become established in the southeastern United States within the last fifty years, with Alabama, Mississippi and Florida having extensive acreage of roadway and pasture infested with cogongrass (Gaffney 1996). It is commonly found along roadways, in forests, parks, residential areas, grasslands, less cultivated agronomic lands, mined areas, and natural areas, and has been reported to be a serious problem in these areas (Dozier et al. 1998; Bryson and Carter 1993; Coile and Shillings 1993; Holm et al. 1977).

Cogongrass has numerous attributes that contribute to its extremely invasive nature. Cogongrass produces new rhizomes readily, even with rhizome fragments. The persistent and aggressive rhizome of *I. cylindrica* is the main mechanism of survival and spread, while its resilience makes it difficult to control. Established stands may produce over 7 tons of rhizomes per hectare (Soerjani 1970). These rhizomes can also spread up to 3 to 4 m forming a mat of internodes with potential to produce hundreds of new plants. Cogongrass has received extensive research attention due to its agriculture, economic and social implications in various regions of the world. It has little advantages including short-term poor forage production, erosion control, thatch and to a limited extent it has been used in paper making (Coil and Shilling 1993). On the other hand, it has caused injury to tuber crops, inhibited desirable perennial grass species to establish, produced poor habitats for wildlife animals, and increased fire hazards that destroy most fire intolerant species (Lippincott 2000; Shilling et al. 1995; Boonitee and Ritdhit 1984).

In the Western Hemisphere, cogongrass weedy habit outweighed its usefulness and over fifty years ago, Pendleton (1948) stated that steps should be taken at once to completely eradicate this noxious weed. After several years, many considerable research efforts have been underway to understanding the spread of cogongrass, throughout many habitats, and management for its control and possible eradication as a noxious weed and an invasive species (Chikoye et al. 1999; Shilling et al. 1997; Holm et al. 1997). Control measures included mechanical, chemical, biological control, and some combination of mechanical, chemical, or biological treatments (Onokpise et al. 2007; Dozier et al. 1998; Shilling and Gaffney 1995). Different methods of integrated approaches have been used to control cogongrass, and different levels of successes have been achieved (Chikoye et al. 2005). However, cogongrass finally begins to re-infest, regardless of the control measure. It is essential to introduce desirable vegetation as quickly as possible to avoid cogongrass from re-infesting the area, once a stage of good management is achieved. Some of these desirable species are native species to the Gulf Coast States. To eliminate cogongrass, control strategies should include limiting or destroying the rhizome production. It is important to study which native species can grow in association or reduce the spread of cogongrass rhizomes. Therefore the objectives of this study were to evaluate the performance of rhizomes of cogongrass grown in combination with Florida's

native grass species, and also evaluate the growth of maidencane (a native grass species) rhizomes in such combinations.

MATERIALS AND METHODS

The experiment was conducted in the George Connolly greenhouse on Florida A&M University campus, Tallahassee, Florida in the USA. The grass species used for this study were cogongrass and three native species, which included switchgrass (*Panicum virgatum* L), maidencane (*Panicum hemitomon* Schult.), and muhlygrass (*Muhlenbergia capillaries* (Lam) Trin.). Cogongrass materials used were obtained from a naturally infested site on Tram Road in Tallahassee, Florida. Muhlygrass was harvested from its natural habitat at St. Marks National Wildlife Refuge, St Marks, Florida. A shovel was used to dig up the cogongrass and muhlygrass plants. 'Citrus' maidencane (*Panicum hemitomon* Schult.) and switchgrass (*Panicum virgatum* L.) were obtained from the United States Department of Agriculture - Natural Resources Conservation Service, Plant Materials Center (USDA-NRCS PMC) Brooksville, Florida.

Rhizomes of cogongrass and maidencane were cut into pieces of about 4 cm segments. These pieces of rhizomes were planted in plastic trays (pro-tray) that were filled up with Jungle Grow® potting mix. Muhlygrass and switchgrass were divided into smaller clumps that were potted into 5.5 cm diameter tubetts using the same potting mix. Both cogongrass and the native species were placed on greenhouse benches where they were watered daily for about 6 weeks before transplanting into larger pots.

The pots used for the study were the Accelerator® Model AP-3 (7.6 L) that had a series of slots on the sides to allow for aeration. Pots were filled up with a potting mix purchased from Graco Fertilizer Company, Cairo, Georgia. Potting mix was composed of 80 % bark, 10 % sand and 10 % peat (Graco Fertilizer Co, Cairo, GA). Plants were planted into the mix either alone or in all possible combinations with cogongrass. This study was laid out in a randomized complete blocked design with nine treatments and four replications. Each pot received one table spoon of Osmocote® (19-6-12) every 4 weeks. Destructive sampling was conducted at 6, 12, 18, and 24 weeks after planting (WAP) in 7.6 L greenhouse pots. During harvest or sampling, the content of each pot was removed and the plant material was separated from the peat. Data on rhizomes of cogongrass and maidencane (rhizomatous species) were recorded. Data collected included the number of rhizomes and length of rhizomes produced by each plant species. Data was analyzed using SAS 9.1 (SAS 2002). Means were separated using LSMEANS statement.

RESULTS AND DISCUSSION

The mean number of rhizomes of cogongrass varied from one harvest period to another, although, at 6 and 24 WAP, there were no significant differences among cogongrass mean number of rhizomes growing alone or in combination with native species (Figures 1). The number of rhizomes range from 3 to 8 and 40 to 94 at 6 and 24 WAP, respectively. The mean number of rhizomes were not significantly different, except at 12 ($P = 0.005$) WAP, where all cogongrass grown in combination with native species was reduced by 53 to 71 % (Figure 1). At this harvest period the reduction in the number of rhizomes occurred in all combinations compared cogongrass alone. At the first harvest, there was an indication that cogongrass rhizomes did not encounter the

competition from the native species. However, at the 24 WAP, despite the greater number of rhizomes produced by cogongrass growing individually, there was an overlap in the range between the treatment combinations.

The mean total length of cogongrass rhizomes did not vary at the first and last harvest periods and the range was from 0.32 to 0.88 m and 8.37 to 20.40 m at 6 and 24 WAP, respectively. On the other hand, the mean total length of rhizomes of cogongrass varied among treatment combinations at 12 ($P = 0.003$) and 18 ($P = 0.01$) WAP (Figure 2). There was 51 to 74% and 47 to 74% reduction in the mean total length of cogongrass rhizomes grown in combination than those grown individually at 12 and 18 WAP, respectively. Cogongrass rhizomes growing in combination with any native species were similar throughout the sampling periods. Native grasses were selected on the basis of their growth habit, resistance to adverse environmental conditions, and their ability to grow with the invasive cogongrass (Evans 1991). The mean number and total length of cogongrass rhizome indicated that muhlygrass alone may not compete effectively with cogongrass. The presence of switchgrass in the planting combination generally reduced cogongrass rhizome production. Employing biological control strategies to manage cogongrass is especially pertinent in natural ecosystems and low maintenance areas where the cost of chemical and mechanical control methods would be prohibitive and/or impracticable. The ability of these native species to compete and grow with cogongrass in a short term was viewed possible. Field experiments are needed to validate these native species as a valuable biological control mechanism to control cogongrass.

Considering treatments with maidencane and their rhizome performance, variability occurred from one harvest period to the next. The mean number of maidencane rhizomes ranged from 1 to 3 and 11 to 26 at 6 and 24 WAP, respectively (Figure 3). Likewise, the mean total length of maidencane rhizomes ranged from 0.01 to 0.03 m and 1.57 to 3.31 m at 6 and 24 WAP, respectively (Figure 4). It was observed that maidencane had similar mean total length of rhizomes and the mean number of rhizomes throughout the sampling periods, except at 18 WAP (Figures 3 and 4). At this sampling period, the mean number and mean total length of rhizomes of maidencane were reduced by 51 to 65% and 20 to 75%, respectively, when grown in combination with others grasses than alone. Maidencane generally had a stable performance in the treatment combinations. The presence of switchgrass in the planting combination occasionally reduced maidencane rhizome production.

It is remarkable to note that the 4 cm segmented pieces of rhizomes from each species were able to produce the number and length of rhizomes reported. This study confirmed the earlier studies on cogongrass which suggested that shoots may form from the smallest of rhizome segments (Hubbard et al. 1944). During this study, rhizomes of cogongrass grew both from apical buds and along the length of the rhizomes from axillary buds (Figure 5). Other researchers, for instance, Ayeni (1985) and Wilcut et al (1988) report that rhizomes are apically dormant; while English (1998) investigation reported that cogongrass does produce axillary buds. The rhizome system of cogongrass is undoubtedly a competitive strength of the species as reported by Ayeni and Duke (1985).

It can be concluded that the number and spread of rhizomes explain cogongrass' invasiveness and competitiveness. The performance of maidencane in maintaining it rhizome growth with other species in most of the sampling periods indicated it potential

to grow in association with cogongrass. The presence of switchgrass had large impact on cogongrass rhizomes than on maidencane rhizomes. The reduction of cogongrass in combination with native grass species showed a prospect that some of these native grasses could grow in association with cogongrass or reduce the invasiveness of cogongrass in the Gulf Coast States. Controlling cogongrass requires persistence and diligence by the land manager but will be well worth the effort for protecting our natural resources from this very serious exotic invader.

ACKNOWLEDGEMENTS

Funding for this project is principally from USDA-CSREES 1890 capacity Building Grant # 2005 38814 – 16377. These funds are gratefully acknowledged. Special thanks are extended to Dr. Mimi Williams, Ms. Anne-Marie Gunter and all the staff at the USDA-NRCS PMC Brooksville, Florida for their tremendous assistance in these studies.

REFERENCES

Ayeni, A. 0.1985. Observations on the vegetative growth pattern of speargrass (Imperata cylindrica (L.)Beauv.). Agriculture, Ecosystems and Environment 13: 301-307.

Ayeni, A. O. and W. B. Duke. 1985. The influence of rhizome features on subsequent regenerative capacity in Speargrass (*Imperata cylindrica* [L.] Beauv.). Agriculture, Ecosystems and Environment 35: 309-317.

Bolfrey-ArKu, G. E-K., O. U. Onokpise, D. G. Shilling, C. C. Coultas, and A. G. K. Carson. 2006. The speargrass *(Imperata cylindrica* (L.) Beauv) menace in Ghana; Perception, practices and incidence in the forest, and forest-savanna transition zones. West African Journal of Applied Ecology 10:177-188.

Bryson, C. T., and R. Carter. 1993. Cogongrass, *Imperata cylindrica*, in the United States. Weed technology 7:1004-1009.

Chikoye, D., F. Ekeleme, and J. T. Ambe. 1999. Survey of distribution and farmers' perceptions of speargrass [*Imperata cylindrica* (L.) Raeusche] in cassava-based systems in West Africa. Journal of International Pest Management. 45:305-311.

Chikoye, D., U. E. Udensi, and S. Ogunyemi. 2005. Integrated management of cogongrass (*Imperata cylindrica* (L.) Rauesch. *In* corn using tillage, glyphosate, row spacing, cultivar and cover cropping. Agronomy Journal 97:1164-1171.

Coil, N. C., and D. G. Shilling. 1993. Cogongrass, *Imperata cylindrica* (L.) Beauv.: a good grass gone bad! Botanical circulation No. 28. Gainesville, Florida: Florida Department of Agriculture and Consumer Services, Division of Plant Industry, 3 pp.

Dickens, R. 1974. Cogongrass in Alabama after sixty years. Weed Science 22:177-179.

Dozier, H., J. F. Gaffney, S. K. McDonald, E. R. R. L. Johnson, and D. G. Shilling. 1998. Cogongrass in the United States: history, ecology, impacts, and management. Weed Technology 12:737-743.

Evans, H. C. 1991. Biological control of tropical grassy weeds, pp. 52-72. *In* Baker, F. W. G. and P. J. Terry (eds.). Tropical Grassy Weeds. CAB International, Wallingford, United Kingdom.

Gaffney, J. F. 1996. Ecophysiological and technical factors influencing the management of cogongrass (*Imperata cylindrica*). Ph.D. dissertation, University of Florida, Gainesville, FL, USA. 111 pp.

Holm, L. G., D. L. Pucknett, J. B. Pancho, and J. P. Herberger. 1977. The World's Worst Weeds. Distribution and Biology. Univ. Press of Hawaii, Honolulu, HI. 609 pp.

Hubbard, C. E. 1944. *Imperata cylindrica.* Taxonomy, Distribution, Economic Significance, and Control. Imperial Agriculture Bureau Joint Publication No. 7, Imperial Bureau Pastures and Forage Crops, Aberystwyth, Wales, UK. 63 pp.

Lippincott, C. L. 2000. Effects of *Imperata cylindrica* (L.) Beauv. (cogongrass) invasion on fire regime in Florida sandhill. Natural Areas Journal 20:140-149. Natural Areas Journal. 20:140-149.

Miller, J. H. 2000. Refining rates and treatment sequences for cogongrass (*Imperata cylindrica*) control with imazapyr and glyphosate. Proceedings of the Southern Weed Science Society of America 53:131-132.

Onokpise, O. U., H. Dueberry, L. Reid, J. L. Norcini, J. J. Muchovej, and S. K. Bambo. 2007. Comparative studies on the control of cogongrass (*Imperata cylindrica* L.). Journal of Environmental Monitoring and Restoration (JEMREST): 3:325-331.

Pendleton, R. L. 1948. Cogongrass, *Imperata cylindrica*, in the western hemisphere. Journal of the American Society of Agronomy. 40: 1047-1049

Patterson, D. T., E. P. Flint, and R. Dickens. 1980. Effects of temperature, photoperiod, and population source on the growth of cogongrass (*Imperata cylindrica*). Weed Science. 28: 505-509.

SAS Institute. 2002. SAS/STAT user's guide. Version 9.1. SAS Inst., Cary, NC, USA.

Shilling, DG, and J. F. Gaffney. 1995. Cogongrass control requires integrated approach (Florida). Restoration and Management Notes 13: 227.

Shilling, D. G., T. A. Bewick, J. F. Gaffney, S. K. McDonald, C. A. Chase, E. R. R. L. Johnson. 1997. Ecology, physiology, and management of cogongrass (*Imperata cylindrica*). Publication No. 03-107-140. Gainesville, FL: University of Florida. 128 p.

Soerjani, M. 1970. Alang-alang *Imperata cylindrica* (L.) Beauv., pattern of growth as related to its problem of control. BIOTROP Bulletin in Tropical Biology 1:88-96.

Tabor, P. 1949. Cogongrass, *Imperata cylindrica* (L.) Beauv., in the southeastern United States. Agronomy Journal 41:270.

Tabor, P. 1952. Comments on cogon and torpedo grasses: A challenge to weed workers. Weeds 1:374-375.

Wilcut, J. W., R. R. Dute, B. Truelove, D. E. Davis. 1988. Factors limiting distribution of cogongrass, *Imperata cylindrica*, and torpedograss, *Panicum repens*. Weed Science 36:577-582.

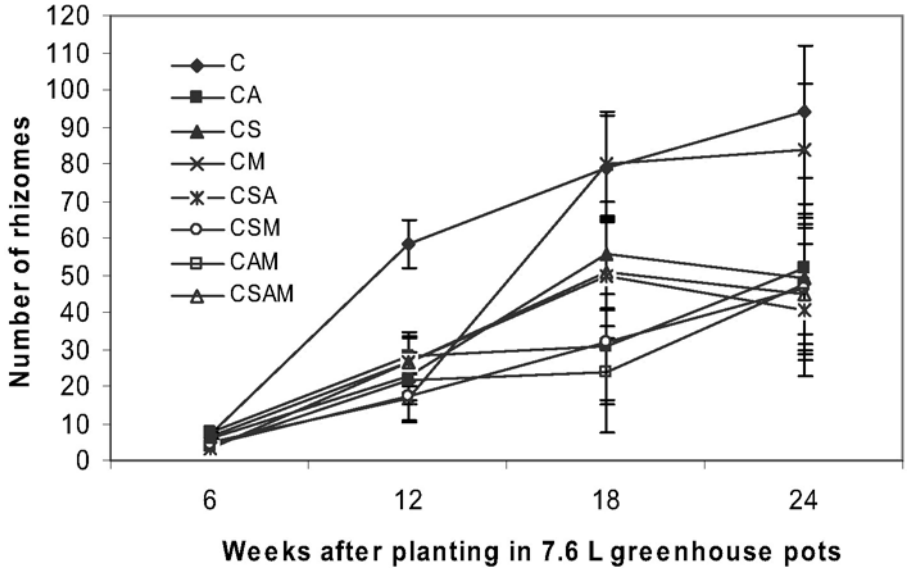


Figure 1. Mean number of rhizomes of cogongrass in response to competition from different native grass species combinations. C, cogongrass; CS, cogongrass and switchgrass; CA, cogongrass and Maidencane; CM, cogongrass and muhlygrass; CSA, cogongrass, switchgrass and maidencane; CSM, cogongrass, switchgrass and muhlygrass; CAM, cogongrass, maidencane and muhlygrass; CSAM, cogongrass, switchgrass, maidencane and muhlygrass. Vertical bars are the standard error of the mean.

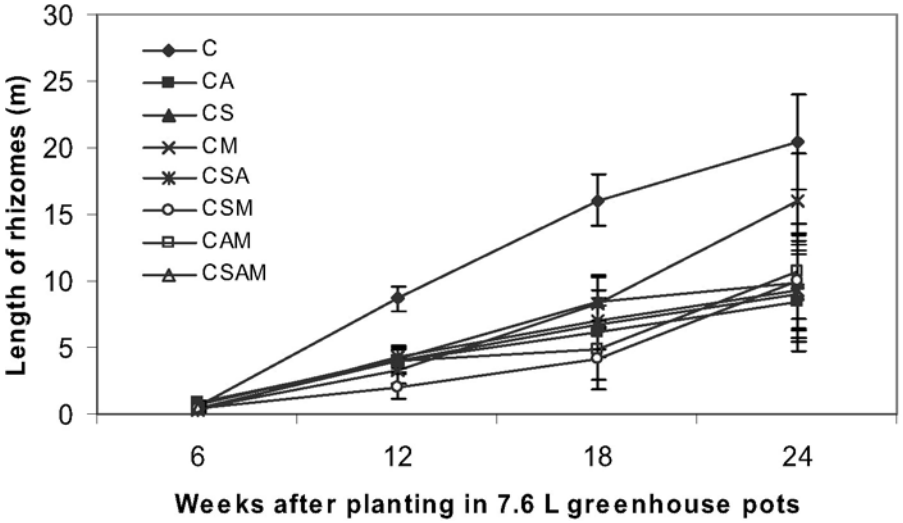


Figure 2. Mean total length of rhizomes of cogongrass in response to competition from different native grass species combinations. C, cogongrass; CS, cogongrass and switchgrass; CA, cogongrass and Maidencane; CM, cogongrass and muhlygrass; CSA, cogongrass, switchgrass and maidencane; CSM, cogongrass, switchgrass and muhlygrass; CAM, cogongrass, maidencane and muhlygrass; CSAM, cogongrass,

switchgrass, maidencane and muhlygrass. Vertical bars are the standard error of the mean.

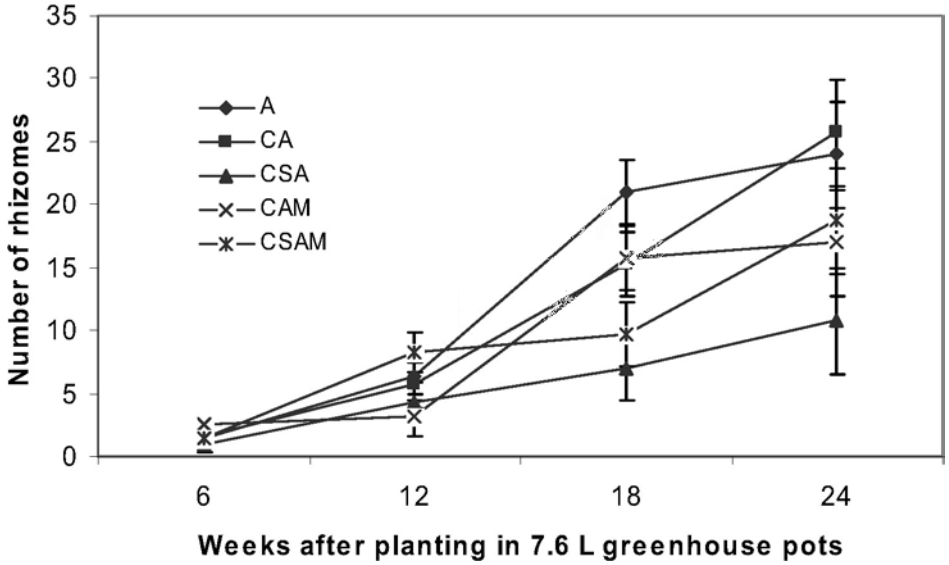


Figure 3. Mean number of rhizomes of maidencane in response to competition from cogongrass and different native grass species combinations. A, Maidencane; CA, cogongrass and maidencane; CSA, cogongrass, switchgrass and maidencane; CAM, cogongrass, maidencane and muhlygrass; CSAM, cogongrass, switchgrass, maidencane and muhlygrass. Vertical bars are the standard error of the mean.

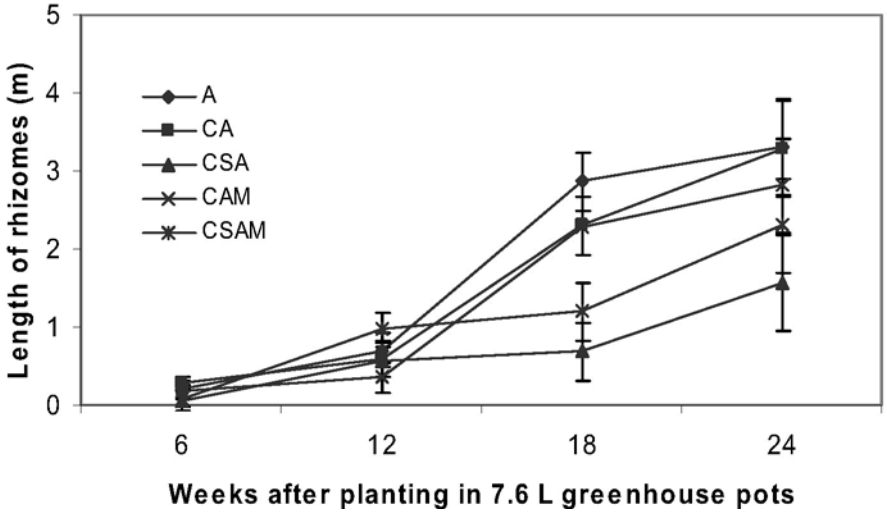


Figure 4. Mean total length of rhizomes of maidencane in response to competition from cogongrass and different native grass species: A, Maidencane; CA, cogongrass and maidencane; CSA, cogongrass, switchgrass and maidencane; CAM, cogongrass, maidencane and muhlygrass; CSAM, cogongrass, switchgrass, maidencane and muhlygrass. Vertical bars are the standard error of the mean.

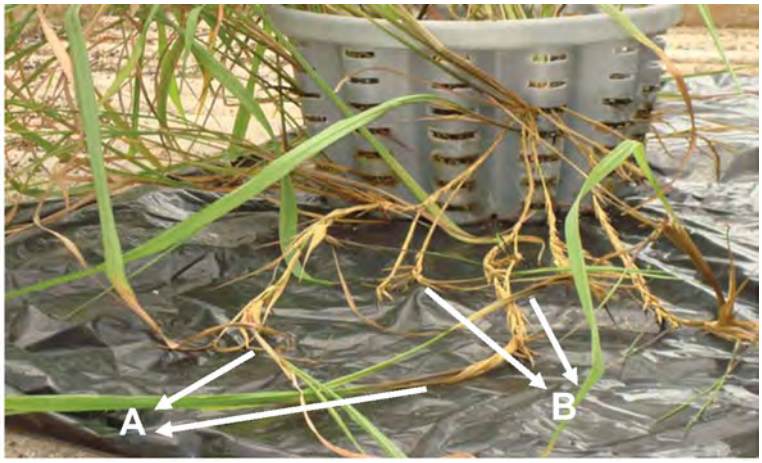


Figure 5. Cogongrass rhizome development at both apical (A) and auxiliary (B) buds

2008 Proceedings of the Caribbean Food Crops Society. 44(2):617-620. 2008

Poster #71

Natural Spread of Pests within and into the Greater Caribbean Region

Christie A. Bertone, Heike E. Meissner, and Andrea V. Lemay, United States Department of Agriculture (USDA), Raleigh, North Carolina 27606, USA. Contact: Heike.E.Meissner@aphis.usda.gov

ABSTRACT.
Natural spread of exotic pest organisms mediated by wind may play a significant role in the movement of pests throughout the Greater Caribbean Region. Biological and atmospheric events and processes interact to facilitate aerial dispersal of organisms over long distances. Our objective was to review the scientific literature to answer questions about natural spread of exotic plant pests into and within the Greater Caribbean Region, *e.g.*, whether it occurs, patterns of movement, types of pests prone to natural spread, and possible methods for reducing the likelihood of establishment. Certain plant pathogens seem to have wind-dispersed from Africa into the Caribbean, and wind-assisted dispersal within the Greater Caribbean Region occurs on an ongoing basis. The effects of natural dispersal may be mitigated through stringent surveys supported by predictive modeling. Knowing which pests are capable of becoming established and causing economic damage within a given area and intervention as soon as a pest is introduced may reduce the likelihood of establishment.

KEYWORDS: wind dispersal, natural movement, pest spread

INTRODUCTION

Natural spread of pests throughout the Greater Caribbean Region seems likely, given the close proximity of islands and land masses. Biological and atmospheric events and processes often facilitate aerial dispersal of plant pathogens, insects, and mites, which can be transported over long distances and cause widespread infections or infestations.

Once a pest is established in a new area, it is difficult to determine the pathway of introduction. The route of natural movement between close land masses most likely follows prevailing winds, which move from the Windward Islands (the most southeasterly islands), toward the northwest to the Leeward Islands, and on to the Greater Antilles and the southeastern United States. Hurricanes and tropical storms are also potential conduits for pest movement. In the Greater Caribbean Region, tropical storms and hurricanes can occur at any time from June through November, but most develop during August, September, and October (**Figure 1**). An average of 15 tropical cyclones occur each year, including seven or eight hurricanes, but many do not reach land (Quantick, 2001).

EXAMPLES OF EXOTIC PEST MOVEMENT

Pest Movement from within the Greater Caribbean Region. *Spodoptera frugiperda*, the fall armyworm, follows "rainy" seasons and migrates from the Caribbean islands to the United States each year (Luginbill, 1928). The moth survives year-round in Puerto Rico, the U.S. Virgin Islands, Guadeloupe, and French Guiana, but it cannot survive the winter in the United States, except in southern Florida and southern Texas (Luginbill, 1928).

Raoiella indica, the red palm mite, was detected in Martinique in 2004. Less than a year later, the mite appeared on coconut palms on nearby islands. Finding *R. indica* populations on tall and established coconut palms in St. Lucia strongly supports the premise that wind currents dispersed the mite (Hoy *et al.*, 2006). Soon after, *R. indica* became established in Dominica, Guadeloupe, St. Martin, St. Lucia, and Trinidad and Tobago. It was found in Puerto Rico in November of 2006 and in West Palm Beach, Florida, in December of 2007. The pest is spreading rapidly, aided by winds as well as commerce, and it is expected to become established throughout the subtropical and tropical regions of the Western Hemisphere.

Pest Movement from outside of the Greater Caribbean Region. Some exotic plant pests are capable of long-distance migration from Africa to the Greater Caribbean Region (**Figure 2**). A few significant plant pathogens, including sugarcane smut (*Ustilago scitaminae*), sugarcane rust (*Puccinia melanocephala*), and possibly blue mold of tobacco (*Peronospora tabacina*), were carried by wind from Africa into the Greater Caribbean Region (Purdy *et al.*, 1985; Nagarajan and Singh, 1990).

Schistocerca gregaria, the migratory locust, has probably been carried repeatedly from Africa to the Caribbean by tropical cyclones, though it never became established (Richardson and Nemeth, 1991).

Thomas (2000) showed that only a small percentage of the exotic arthropods in Florida originated in Africa and that the major sources are Asia, the Pacific Islands, and the Neotropics. Thus, although there are some examples of pests that have exhibited long-distance migration, other pathways (*i.e.,* trade, commerce, and tourism) appear to be of greater importance for the introduction of plant and animal pests and diseases into the Greater Caribbean Region.

COUNTERING NATURAL DISPERSAL

When plant pests and pathogens move naturally without human assistance, little can be done to stop them without investing considerable resources. National Plant Protection Organizations (NPPOs) should emphasize alternative strategies to reduce the risk of establishment of these pests.

- **A surveillance and diagnostic network is necessary** to monitor the arrival of any new pests. Predictive modeling works well for some plant pathogens and arthropods. Risk mitigation must be handled on a case-by-case basis, with foresight given to the likelihood of new pest establishment.

- **Sterile insect technique** has successfully been used to prevent pests from invading and spreading further into the United States.

- **Host-free zones** work well for pests and pathogens with only a few hosts, but they may not be feasible for highly polyphagous pests.

- **Classical biological control** has proven to be an important means to mitigate the impacts of some exotic pests.

REFERENCES

Hoy, M. A., J. E. Pena, and R. Nguyen. 2006. The red palm mite, *Raoiella indica* Hirst. Featured Creatures. http://creatures.ifas.ufl.edu/orn/palms/red_palm_mite.htm.

Luginbill, P. 1928. The Fall Army Worm. USDA Tech. Bull. No. 34. 91 pp.

Lutgens, F. K. and E. J. Tarbuck. 2007. The Atmosphere: An Introduction to Meteorology. 10th ed. Pearson Prentice Hall, Uppersaddle River, NJ. 520pp.

Nagarajan, S., and D. V. Singh. 1990. Long-distance dispersion of rust pathogens. Annual Review of Phytopathology 28:139-153.

Purdy, L. H., S. V. Krupa, and J. L. Dean. 1985. Introduction of sugarcane rust into the Americas and its spread to Florida. Plant Disease 69(8): 689-693.

Quantick, H. R. 2001. Climatology for Airline Pilots. Blackwell Science, Malden, MA. 284 pp.

Richardson, C. H. and D. J. Nemeth. 1991. Hurricane-borne African Locusts (*Schistocerca gregaria*) on the Windward Islands. GeoJournal 23(4):349-357.

Thomas, M. C. 2000. The Exotic Invasion of Florida. A Report on Arthropod Immigration into the Sunshine State. Florida Department of Agriculture and Consumer Services.

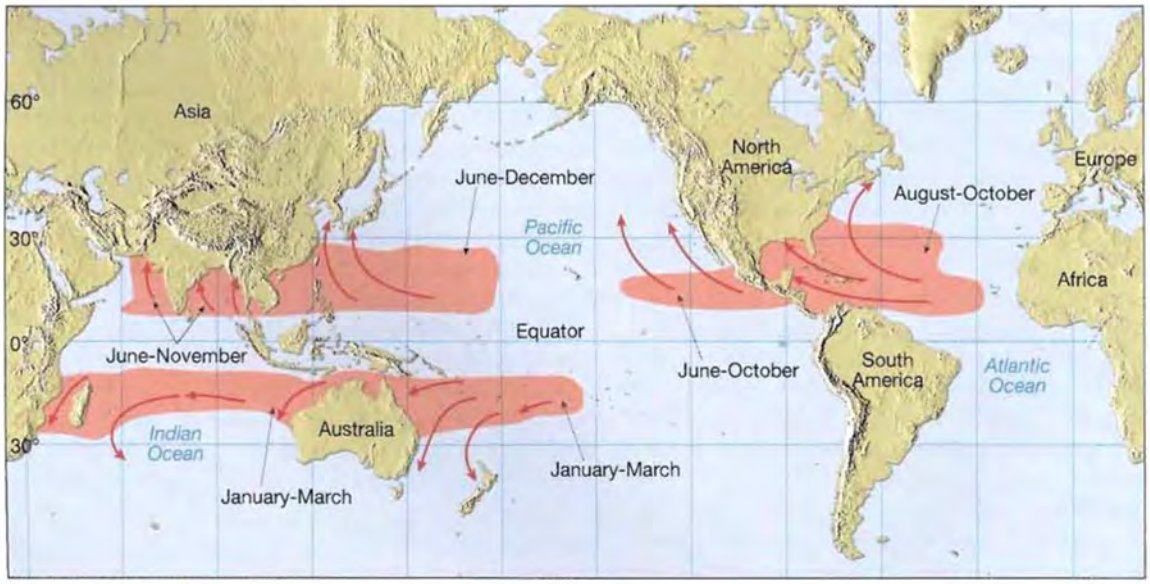


Figure 1. Areas and times of hurricane formation and directions of prevailing winds (or likely track for hurricane movement?) (Lutgens and Tarbuck, 2007)

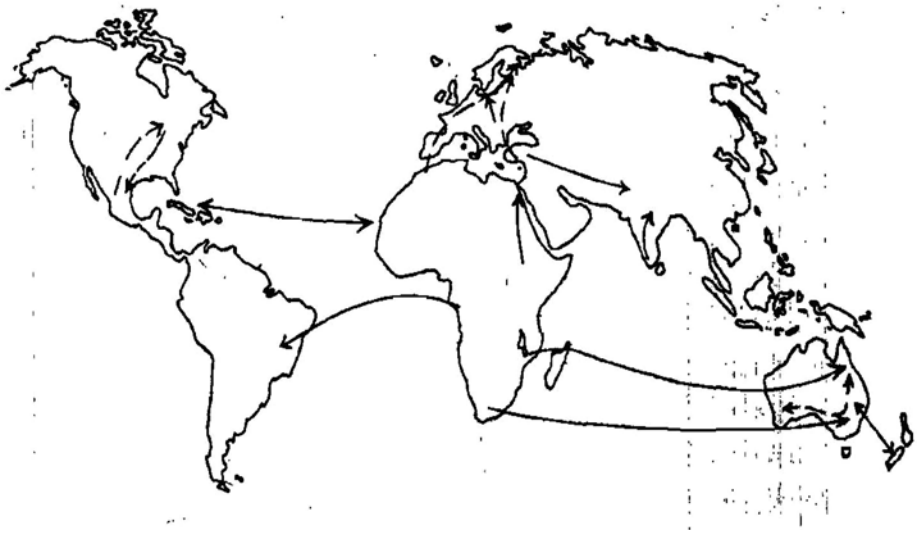


Figure 2. Pathways for long-distance dispersal (Nagarajan and Singh, 1990)

2008 Proceedings of the Caribbean Food Crops Society. 44(2):621-627. 2008

Poster #72

Wood Packaging Material as a Pathway for the Movement of Exotic Insect Pests into and within the Greater Caribbean Region

Heike E. Meissner, Thomas W. Culliney, Andrea V. Lemay, Leslie P. Newton, and Christie A. Bertone, United States Department of Agriculture (USDA), Raleigh, North Carolina 27606, USA. Contact: Heike.E.Meissner@aphis.usda.gov

ABSTRACT.
Pallets, crates, and dunnage made of wood are commonly used packaging materials in international trade. Our objective was to use data collected by the United States Department of Agriculture (USDA) to discuss the current role of wood packaging material (WPM) in the movement of pest species into and within the Greater Caribbean Region. For both maritime and air cargo, significant differences were found between countries of origin in terms of the percentage of shipments that contain WPM. A list of species intercepted on WPM at U.S. ports-of-entry after full enforcement of the international standard ISPM 15, as well as a list of species associated with WPM that have the potential to establish in the Greater Caribbean Region, are presented.

KEYWORDS: Wood packaging material, pest interception, pallets

INTRODUCTION

Wood packing material (WPM), such as pallets, crates, and dunnage, is used worldwide in agricultural and non-agricultural shipments. WPM has been recognized as a pathway for the spread of exotic pests, including arthropods, nematodes, mollusks, weeds, and plant pathogens (Pasek, 2000; Allen and Humble, 2002). WPM is often produced from low-grade wood of multiple species (Clark *et al.,* 2001), often with bark still attached. WPM is routinely re-used and re-conditioned (Clarke *et al.*, 2001; Bush *et al.*, 2002), making it difficult to determine its origin. Countries that have adopted the standard ISPM 15 of the International Plant Protection Convention (IPPC, 2006) now require WPM to be either fumigated or heat-treated prior to import. The United States began full enforcement of its requirements based on ISPM 15 on July 5, 2006.

MATERIALS AND METHODS

Agricultural Quarantine Inspection Monitoring (AQIM) data on maritime and air cargo, collected between Sept. 16, 2005 and Aug. 15, 2007, were used to estimate the proportion of maritime and air cargo shipments that contain WPM. The data were collected at several ports throughout the United States according to the USDA AQIM Handbook (USDA, 2006). Maritime shipments were selected randomly, and the presence or absence of WPM was recorded.

The samples were divided into two categories: 1) perishable, agricultural cargo and 2) non-agricultural cargo (excluding Italian tiles). On air shipments, samples were randomly collected from perishable agricultural cargo, including cut flowers. The

following commodities were specifically excluded from both air and maritime cargo: a) commodities which were pre-cleared at foreign sites; b) commodities admissible under the National Agricultural Release Program; c) frozen commodities; d) commodities which undergo mandatory treatment other than cold treatment (*e.g.*, fumigation, irradiation, hot water treatment) at work locations; and e) oil, salt, iron ore, coal, and similar bulk materials. The USDA PestID database was consulted for pest interception records at U.S. ports-of-entry.

RESULTS AND DISCUSSION

The percentage of cargo that contained WPM differed among countries of origin. (Only countries of origin with sample sizes of 30 or higher are discussed here.) In terms of maritime cargo (Figure 1), several Caribbean countries (Costa Rica, Guatemala, and the Dominican Republic) had high percentages of export cargo with WPM. Other countries with a high incidence of WPM in export cargo were New Zealand and several European countries. Cargo from Honduras, Nicaragua, Venezuela, and Panama had comparatively lower incidences of WPM. Shipments from China had the lowest incidence of WPM, significantly lower than that from most other countries. This was true for both agricultural and non-agricultural maritime cargo, confirming results reported by MAF (2003) (Figures 2, 3). In the air cargo samples, far fewer countries were represented. Notably, imports from The Netherlands had by far the highest incidence of WPM in air cargo (Figure 4). In contrast to maritime cargo, air cargo shipments from Costa Rica and the Dominican Republic had a low incidence of WPM.

Obviously, the phytosanitary hazard is not presented by the WPM itself, but by pest organisms that may be associated with it. Unfortunately, there is little published data available on the incidence of pests associated with WPM. The New Zealand Ministry of Agriculture and Forestry found that, of 1,517 maritime containers with WPM inspected, about 16% had contaminations that resulted in phytosanitary action, such as fumigation or incineration (MAF 2003). Among the organisms detected on the WPM were a large number of fungi and insects, as well as isopods, millipedes, mites, plant materials, spiders, mollusks, and reptiles. A 2006 study carried out at several U.S. ports-of-entry resulted in an estimate of 0.1% of all marked WPM being infested with live wood-boring beetles (Haack *et al.*, 2006).

Table 1 lists organisms associated with wood intercepted at U.S. ports-of-entry between July 5, 2006 (date of full enforcement of ISPM #15) and January 1, 2008. The large majority of the interceptions were wood-boring beetles of the families Scolytidae, Cerambycidae, and Curculionidae. A variety of other insect orders were also found, in addition to weeds and mollusks. These data suggest that live pests are entering with WPM in spite of ISPM #15. It is unknown whether the presence of pests is due to ineffectiveness of the required treatments, incorrectly applied treatments, re-infestation of the wood after effective treatment, or fraudulent use of the stamp/seal.

Table 2 lists some examples of insect species commonly associated with WPM that have the potential to become established in the Greater Caribbean Region or to spread within the region if they already are established in some Caribbean countries.

REFERENCES

Allen, E. A. and L. M. Humble. 2002. Non-indigenous species introductions: A threat to Canada's forests and forest economy. Canadian Journal of Plant Pathology 24:103-110.

Bush, R. J., J. J. Bejune, B. G. Hansen, and P. A. Araman. 2002. Trends in the use of materials for pallets and other factors affecting the demand for hardwood products. 30th Hardwood Symposium.

Clarke, J. W., M. S. White, and P. A. Araman. 2001. Performance of pallet parts recovered from used wood pallets. Forest Products Journal 51:1-8.

Haack R. A., T. R. Petrice, P. Nzoku, and D.P. Kamden. 2006. Do insects infest wood packing material with bark following heat-treatment? IUFRO UNIT 7.03.12 Alien Invasive Species and International Trade Inaugural Meeting, Jedlnia, Poland.

IPPC. 2006. Guidelines for regulating wood packaging material in international trade (2002) with modifications to Annex I (2006). *In:* FAO (ed) International Standards for Phytosanitary Measures, Secretariat of the International Plant Protection Convention, United Nations Food and Agriculture Organization, Rome.

MAF. 2003. Sea container review (MAF Discussion Paper No: 35). Ministry of Agriculture and Forestry (MAF), Border Management Group, Auckland, New Zealand.

Pasek, J. E. 2000. Pest Risk Assessment for Importation of Solid Wood Packing Materials into the United States. USDA-APHIS/USDA Forest Service.

USDA. 2007a. Agricultural Quarantine Activity Systems - PestID. USDA-APHIS-PPQ. Available at: https://mokcs14.aphis.usda.gov/aqas/login.jsp.

USDA. 2007b. Agricultural Quarantine Activity Systems - WADS. USDA-APHIS-PPQ. Available at: https://mokcs14.aphis.usda.gov/aqas/login.jsp.

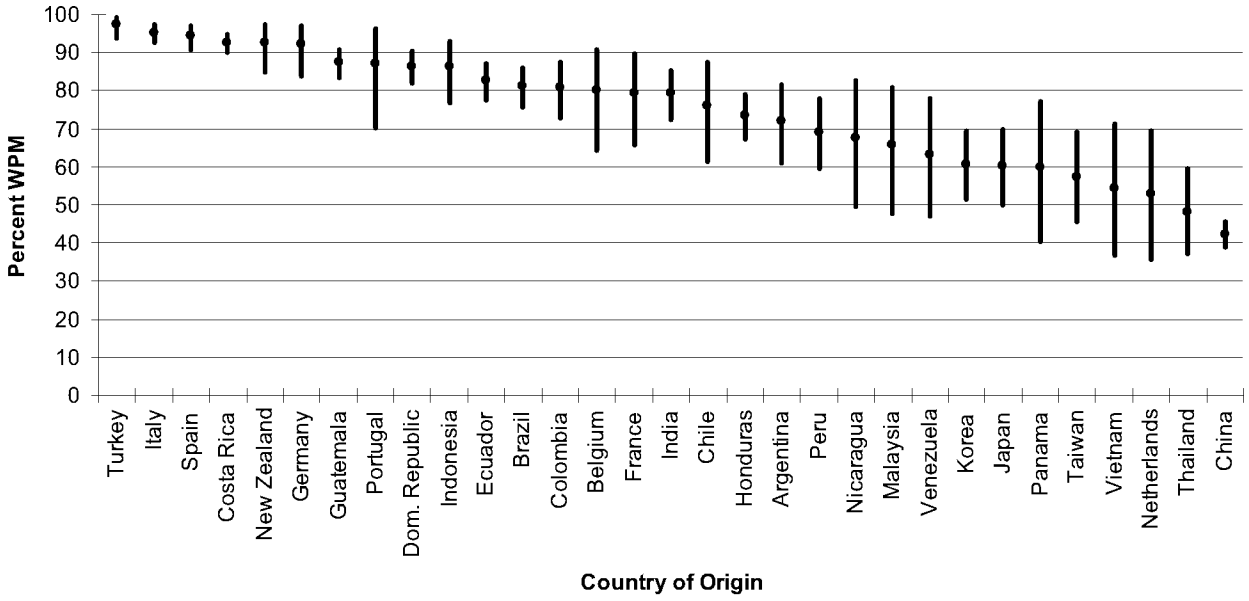


Figure 1. Percentage (and 95% binomial confidence interval) of maritime cargo (both agricultural and non-agricultural) imported into the United States that contained WPM (Data source: AQIM data, Sep 16, 2005 - Aug 15, 2007).

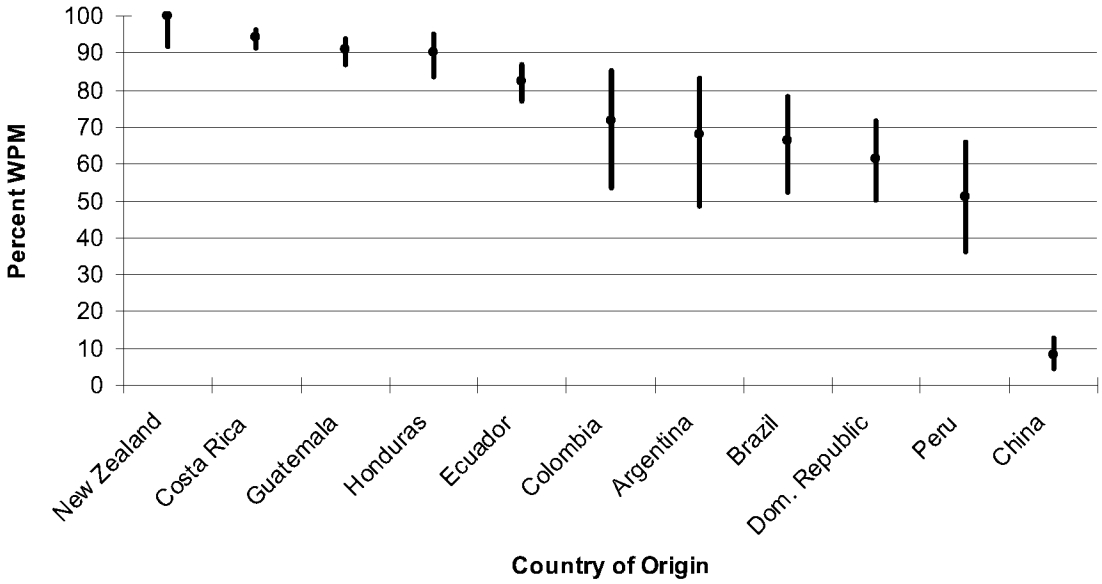


Figure 2. Percentage (and 95% binomial confidence interval) of maritime agricultural cargo imported into the United States that contained WPM (Data source: AQIM data, Sep 16, 2005 - Aug 15, 2007).

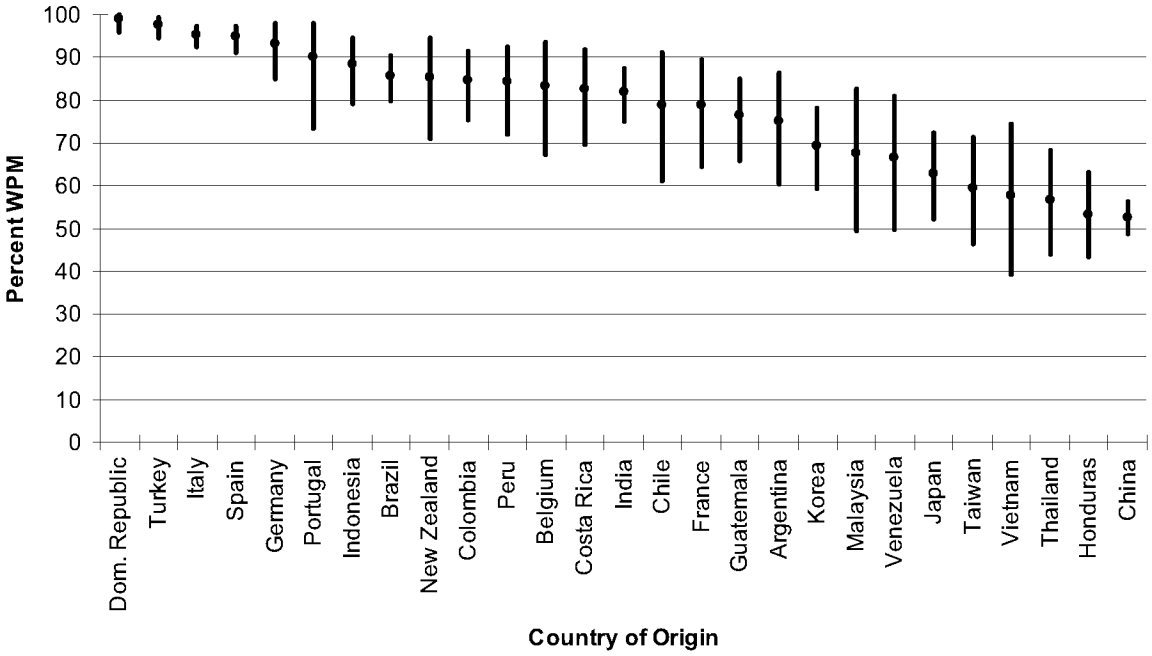


Figure 3. Percentage (and 95% binomial confidence interval) of maritime non-agricultural cargo imported into the United States that contained WPM (Data source: AQIM data, Sep 16, 2005 - Aug 15, 2007).

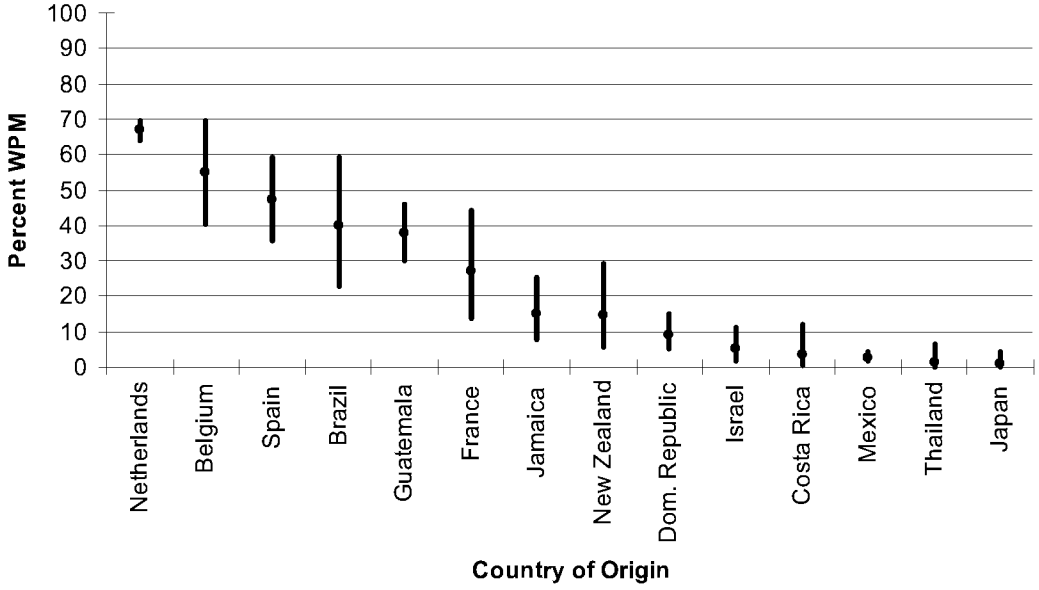


Figure 4. Percentage (and 95% binomial confidence interval) of agricultural air cargo imported into the United States that contained WPM (Data source: AQIM data, Sep 16, 2005 - Aug 15, 2007).

Table 1. Pest taxa intercepted on or in wood materials at U.S. ports-of-entry between July 5, 2006 and January 1, 2008. (Data source: PestID database).

Order	Family	Interceptions	Specimens
Coleoptera	Anobiidae	2	2
	Bostrichidae	9	32
	Buprestidae	15	16
	Cerambycidae	38	49
	Chrysomelidae	1	3
	Cleridae	3	17
	Corticariidae	1	5
	Cryptophagidae	3	3
	Curculionidae	40	131
	Histeridae	1	1
	Laemophloeidae	1	1
	Mycetophagidae	1	1
	Nitidulidae	2	8
	Platypodidae	8	13
	Scarabaeidae	2	2
	Scolytidae	247	788
	Silvanidae	5	13
	Staphylinidae	1	1
	Tenebrionidae	2	3
Diptera	Scatopsidae	1	4
Hemiptera	Aradidae	1	1
	Cixiidae	1	1
	Coreidae	1	1
	Miridae	1	1
	Reduviidae	1	1
	Rhyparochromidae	1	1
Hymenoptera	Apidae	1	1
	Formicidae	8	78
Isopoda	unknown	1	3
Isoptera	Rhinotermitidae	4	135
	Termitidae	1	4
Lepidoptera	Geometridae	2	2
	Pyralidae	3	4
	Tineidae	1	1
Mollusks	Cochlicellidae	1	3
	Helicidae	2	12
Orthoptera	Gryllidae	2	2
	Tettigoniidae	1	2
TOTAL		**424**	**1,346**

Table 2. Examples of insects that have been intercepted on WPM and have the potential to be introduced into one or more countries of the Greater Caribbean Region.

Coleoptera: Bostrichidae
Heterobostrychus brunneus, Sinoxylon anale, Sinoxylon crassum, Xylothrips flavipes
Coleoptera: Buprestidae
Buprestis haemorrhoidalis, Melanophila cuspidata
Coleoptera: Cerambycidae
Callidiellum rufipenne, Monochamus alternatus, Plagionotus christophi, Pyrrhidium sanguineum, Stromatium barbatum, Xylotrechus grayi, Xylotrechus magnicollis
Coleoptera: Curculionidae
Pissodes pini
Coleoptera: Scolytidae
Carphoborus minimus, Carphoborus pini, Cryphalus asperatus, Cryphalus piceae, Crypturgus cinereus, Crypturgus mediterraneus, Crypturgus numidicus, Dryocoetes autographus, Dryocoetes villosus, Euwallacea validus, Gnathotrichus materiarius, Hylastes angustatus, Hylastes ater, Hylastes attenuatus, Hylastes cunicularius, Hylastes linearis, Hylastes opacus, Hylesinus varius, Hylurgops glabratus, Hylurgops palliates, Hylurgus ligniperda, Ips acuminatus, Ips amitinus, Ips cembrae, Ips mannsfeldi, Ips sexdentatus, Ips typographus, Orthotomicus erosus, Orthotomicus laricis, Orthotomicus proximus, Orthotomicus suturalis, Phloeosinus rudis, Phloeotribus scarabaeoides, Pityogenes bidentatus, Pityogenes bistridentatus, Pityogenes calcaratus, Pityogenes chalcographus, Pityogenes quadridens, Pityogenes trepanatus, Pityokteines curvidens, Pityokteines spinidens, Pityophthorus pityographus, Polygraphus poligraphus, Polygraphus subopacus, Pteleobius vittatus, Scolytus intricatus, Scolytus ratzeburgi, Scolytus scolytus, Taphrorychus bicolor, Taphrorychus villifrons, Tomicus minor, Tomicus piniperda, Trypodendron domesticum, Trypodendron signatum, Xyleborinus alni, Xyleborus californicus, Xyleborus eurygraphus, Xyleborus glabratus, Xyleborus pfeili, Xyleborus similis, Xylechinus pilosus, Xyloterinus politus
Hymenoptera: Siricidae
Sirex noctilio
Hymenoptera: Xiphydriidae
Xiphydria prolongata
Isoptera: Rhinotermitidae
Coptotermes crassus

2008 Proceedings of the Caribbean Food Crops Society. 44(2):628-633. 2008

Poster #73

Airline Passenger Baggage as a Pathway for Exotic Plant Pest Movement through the Greater Caribbean Region

Heike E. Meissner, Andrea V. Lemay, and Kimberly A. Schwartzburg, United States Department of Agriculture (USDA), Raleigh, North Carolina 27606, USA. Contact: Heike.E.Meissner@aphis.usda.gov

ABSTRACT.
International air travel has long been considered a significant means of moving pest organisms. Passengers may carry pests (*e.g.*, snails, weed seeds), or items that are infested with pests (*e.g.*, fruits or vegetables). Our objective was to use data collected by the U.S. federal government to estimate plant quarantine material (QM) approach rates (the percentage of sampling units containing QMs) and the annual number of plant QMs entering the United States in airline passenger baggage. We concluded that the pest risk associated with passenger baggage may be considerable. In the United States, the risk from international airline passenger baggage can be mainly attributed to travelers who are visiting family or friends (about one third of the travelers). Several Caribbean countries were among the 25 countries of passenger origin with the highest plant QM approach rates.

KEYWORDS: luggage, human-mediated pest movement, plane travel

INTRODUCTION

International air travel has served as a conduit for the movement of pest species (Liebhold *et al.*, 2006; NRC, 2002). For example, Laird (1951) pointed out that aircraft are a pathway for insect introductions. Evans *et al.* (1963) found significant numbers of arthropods in both baggage compartments and passenger cabins of international aircraft. Takahashi (1984) reported finds of insect vectors of human diseases in airplane cabins, and Takeishi (1992) found 5% of the fresh fruits carried illegally by airplane passengers from Thailand to Japan to be infested with fruit flies. Our objective was to estimate the pest risk associated with the airline passenger baggage, based on United States Department of Agriculture (USDA) and Department of Homeland Security (DHS) data.

MATERIALS AND METHODS

We used U.S. Agricultural Quarantine Inspection Monitoring (AQIM) (USDA, 2006) data to estimate approach rates of plant quarantine materials (QMs) associated with international airline passenger baggage arriving in the United States. Plant QMs are any plants or plant parts that are prohibited from entering the United States. AQIM data are collected through a detailed inspection of randomly selected sampling units, *i.e.*, they are unbiased and thus suitable for risk quantification. AQIM data do not include useable information on pest interceptions.

The AQIM data used in this study were collected at 30 U.S. airports between Jan. 1, 2005 and Aug. 22, 2007. The plant QM approach rate is the percentage of sampling units in which plant QMs are found. The sampling unit is the group of airline passengers traveling together under one U.S. customs declaration. Estimates are presented as 95% binomial confidence intervals, *i.e.*, the limits within which the actual approach rates lie with 95% certainty (Steel *et al.*, 1997). Treatment groups with sample sizes under 30 were not considered for this analysis.

RESULTS AND DISCUSSION

An estimated 1.4 million QMs enter the United States annually in airline passenger baggage (Table 1). Only a fraction of these QMs will be infested with pests, and for most countries, the pest risk associated with airline passengers is probably not comparable to the commodity import pathway; however, the risks associated with this pathway may nevertheless be considerable. Since the worldwide air transportation network can quickly connect geographically distant but climatically similar regions (Tatem and Hay, 2007), the plant QMs that do move may carry exotic plant pests that can easily adapt to the new environment. In the United States, the risk from international airline passenger baggage can be mainly attributed to travelers who are visiting family or friends (Figure 1) (about one third of the travelers). In contrast, tourists or business travelers represent a smaller risk to the United States. For most other countries in the Greater Caribbean Region, the majority of visitors are tourists.

A total of 237 different countries of origin were represented in the AQIM data set. Of these, 164 had sample sizes of 30 or higher and were therefore included in the following analysis. Twenty-nine countries of origin with sample sizes of 30 or higher are located in the Greater Caribbean Region. Plant QM approach rate estimates for the countries of origin ranged between zero (lowest lower CL) and 62% (highest upper CL). Figure 2 shows the 25 countries with the highest plant QM approach rates. In some cases, the 95% binomial confidence intervals were large, due to relatively small sample sizes. For Angola, Botswana, French Guyana, Georgia, Luxembourg, Mongolia, Oman, Samoa, and Sudan, binomial confidence intervals included zero, *i.e.*, the plant QM approach rates were not significantly different from zero. Out of the 25 countries with the highest approach rates, ten were Caribbean countries: Haiti (21%), Bonaire (18%), St. Vincent (13%), Grenada (13%), Guadeloupe (12%), St. Lucia (11%), Antigua (9%), Bahamas (9%), Jamaica (8%), and Dominica (8%). The plant QM approach rates for all available Caribbean countries of origin are depicted in Figure 3.

Port inspections can discover only a fraction of what is entering. Thus, it is unlikely that the existing pest risk associated with airline passenger pathways can be mitigated effectively by inspection alone. It may be possible to improve inspection efficiency by increasing the number of inspectors and by providing them with more adequate inspection equipment and facilities. However, additional ways of preventing exotic species introduction will have to be pursued. Many travelers are unaware of existing laws concerning plant QMs and the potential consequences of introducing plant pests. Public awareness programs may help to keep travelers from unknowingly introducing exotic species, and larger fines may help to deter intentional smuggling.

Airline passenger baggage may present an important pathway for the movement of exotic pests into and within the Greater Caribbean Region. The following measures for improved safeguarding may be considered:

- **Show educational videos** in airplanes and in airports to ensure that travelers understand what materials are prohibited and what the biological and economic consequences of unintentional pest introduction may be. Articles in airline magazines, as well as posters at airports, may serve the same educational purpose.

- **Remind plane passengers to consume or discard prohibited materials** during the flight. The flight crew could make repeated announcements reminding travelers that they are not allowed to take certain materials into the destination countries. When collecting trash before landing, the flight crew could also specifically ask for fruits, vegetables, seeds, plants, meats, *etc.*

- **Print statement on international flight tickets** making travelers aware of the regulations and giving them a contact phone number or website address where they can find details.

- **Assess severe fines** for introducing prohibited materials. These fines should be widely advertised to serve as a deterrent to intentional smuggling.

REFERENCES

Evans, B. R., C. R. Joyce, and J. E. Porter. 1963. Mosquitoes and other arthropods found in baggage compartments of international aircraft. Mosquito News 23:9-12.

Laird, M. 1951. The accidental carriage of insects on board aircraft. Journal of the Royal Aeronautical Society 55:735-743.

Liebhold, A. M., T. T. Work, D. G. McCullough, and J. F. Cavey. 2006. Airline baggage as a pathway for alien insect species invading the United States. American Entomologist 52:48-54.

NRC. 2002. Predicting Invasions of Nonindigenous Plants and Plant Pests. National Academies Press, Washington, D.C.

Steel, R. G. D., J. H. Torrie, and D. A. Dickey. 1997. Principles and Procedures of Statistics: A Biometrical Approach. McGraw-Hill, New York.

Takahashi, S. 1984. Survey on accidental introductions of insects entering Japan via aircraft. In: Laird, M. (ed) Commerce and the Spread of Pests and Disease Vectors, pp 65-79, Praeger Publishers, New York.

Takeishi, H. 1992. A study on the fruit flies (Diptera: Tephritidae) found in the fresh fruits carried by passengers from Thailand to Narita Airport, Japan. Research Bulletin of the Plant Protection Service, Japan:75-78.

Tatem, A. and S. Hay. 2007. Climatic similarity and biological exchange in the worldwide airline transportation network. Proceedings of the Royal Society (Biological Sciences) 274:1489-1496.

USDA. 2006. Agricultural Quarantine Inspection Monitoring (AQIM) Handbook. USDA-APHIS-PPQ.

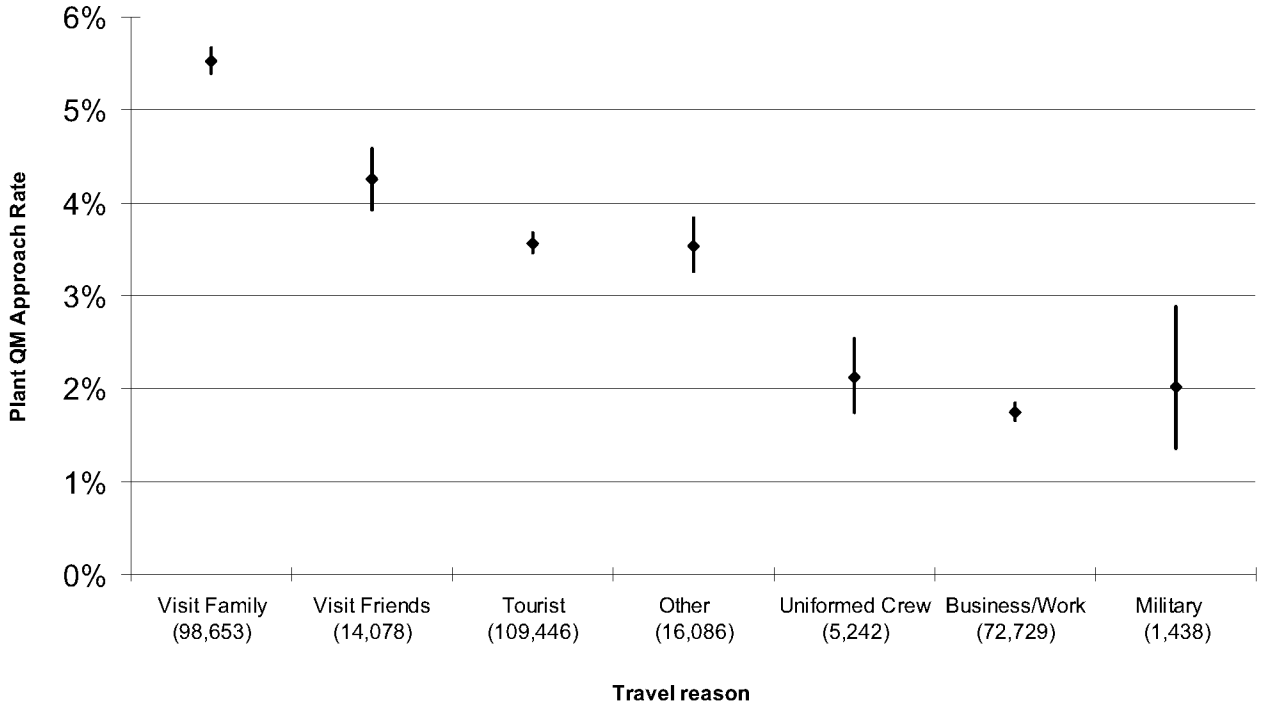


Figure 1. 95% binomial confidence intervals for plant QM approach rates in international airline passenger baggage at U.S. ports-of-entry. Sample sizes in parentheses. Sample sizes < 30 were excluded from the analysis. Data source: Agricultural Quarantine Inspection Monitoring (AQIM) data of the USDA collected between Jan. 1, 2005 and Aug. 22, 2007.

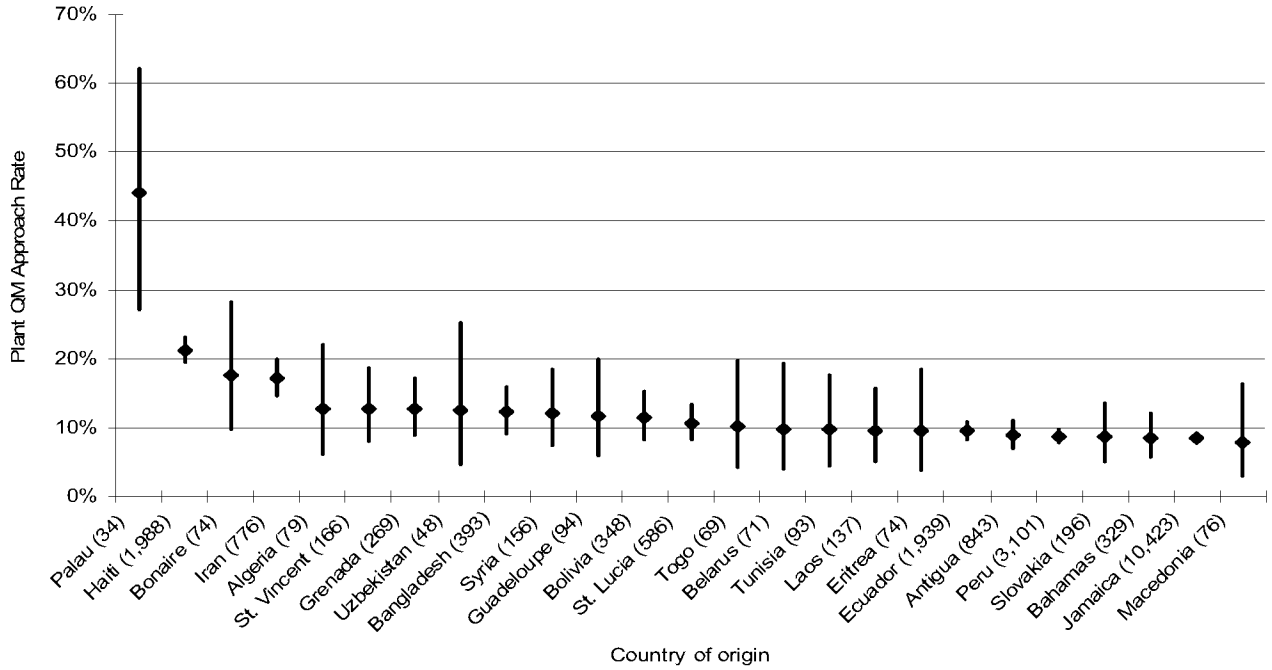


Figure 2. 95% binomial confidence intervals for plant QM approach rates in international airline passenger baggage at U.S. ports of entry. By country of passenger origin (sample sizes in parenthesis). Shows the 25 countries of origin with the highest approach rates. Countries with samples sizes < 30 were omitted. Data source: Agricultural Quarantine Inspection Monitoring (AQIM) data of the U.S. Department of Agriculture collected between January 1, 2005 and August 22, 2007.

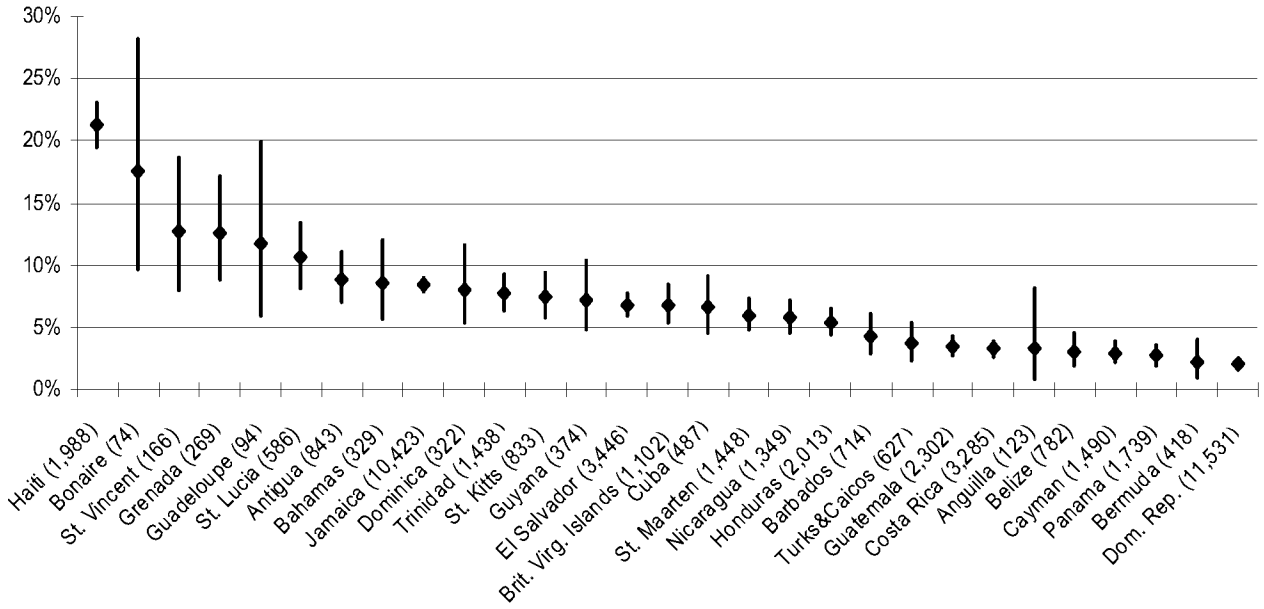


Figure 3. 95% binomial confidence intervals for plant QM approach rates in international airline passenger baggage across U.S. ports of entry. Caribbean countries of passenger origin (sample sizes in parenthesis). Countries with samples sizes < 30 were omitted. Data source: Agricultural Quarantine Inspection Monitoring (AQIM) of the U.S. Department of Agriculture collected between January 1, 2005 and August 22, 2007.

Table 1. AQIM results of international air passengers arriving at U.S. airports between January 1, 2005 and August 22, 2007.

Passenger groups with QMs [1]	Passengers Inspected [2]	Approach Rate [3]	Passenger groups Entering [4]	QMs Entering [5]
11,977	319,599	3.75%	37 million	1.4 million

[1] Number of passenger groups where QMs were found.
[2] Number of passenger groups inspected.
[3] Percentage of passenger groups inspected where QMs were found.
[4] Number of passenger groups entering the United States annually.
[5] Predicted number of QMs entering the United States annually.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):634-637. 2008

Poster #74

Likelihood of Hitchhiker Pests Being Moved into and within the Greater Caribbean Region

Andrea V. Lemay and Heike E. Meissner, United States Department of Agriculture (USDA), Raleigh, North Carolina 27606, USA.
Contact: Heike.E.Meissner@aphis.usda.gov

ABSTRACT.
A "hitchhiker" pest is defined as an agricultural pest organism moving in or on a commodity which is not one of its hosts or moving in or on a conveyance (airplane, ship) or shipping container. Our objective was to examine the movement of plant pests as hitchhikers in trade. We examined USDA data and the scientific literature to address the frequency of hitchhiking pests arriving at airports and maritime ports in the Greater Caribbean Region. We concluded that most insects, mollusks, weed seeds, and plant pathogens are likely to survive shipping conditions. Of the 6.2 million cargo containers entering maritime ports within the Greater Caribbean Region, more than 1.4 million were estimated to have arrived with contaminants. The immense number of conveyances and containers circulated in international trade make this a pathway that presents a high risk, but is difficult to control.

KEYWORDS: contaminating pest, trade-mediated pest movement, hitchhiker

INTRODUCTION

Hitchhiker pests may get into or onto a commodity, conveyance, or container either by pure chance (*e.g.*, nematodes in soil on truck tires) or because they are attracted by certain conditions or characteristics. For example, flying insects may be attracted by airplane lights during nighttime loading (Caton, 2003), or insects or mollusks may find shelter on or in cargo containers. Furthermore, pests originally associated with a shipment of a host commodity (fruit, seed, whole plant, *etc.*) may be left behind in a container or conveyance after unloading of the commodity, thus becoming hitchhiker pests. The scientific literature mentions numerous cases of hitchhiker pests arriving at ports in cargo holds, aircraft cabins, or shipping containers (Dale and Maddison, 1984; Gadgil *et al.*, 2000; Gadgil *et al.*, 2002; Smith and Carter, 1984; Takahashi, 1984).

Aircraft holds. In the United States, live pests have been intercepted in aircraft holds, stores, and quarters. Between 1997 and 2007, over 1,900 live pest interceptions, including insects, weeds, a mollusk, and a mite, were recorded from aircraft holds (Table 1) (USDA, 2007a). The majority (87%) of the pest interceptions in aircraft holds were made at Miami International Airport (MIA) in Miami, FL. Between 2005 and 2007, 677 records of live pests requiring mitigation in Florida were intercepted at MIA in aircraft holds (USDA, 2007a). Although 89,270 of the foreign aircraft arriving at MIA were inspected between 2005 and 2007 (USDA, 2007b), we were unable to calculate pest approach rates because aircraft inspections are not uniform (*i.e.*, an inspection does not

necessarily include an inspection of the holds). Due to limitations in the dataset, we also were unable to calculate contamination rates of aircraft arriving from a particular origin.

Sea cargo containers. Gadgil *et al.* (2000) estimated an approach rate of 23% for sea cargo containers arriving at New Zealand ports with external contamination with plant pests, pathogens, or soil containing plant pests or pathogens. Using this approach rate, we calculated the number of contaminated sea cargo containers entering countries within the Greater Caribbean Region (Table 2). The majority of ports in the Greater Caribbean Region report container traffic in twenty-foot equivalent units (TEU), not by actual number of container boxes. To convert TEUs to containers, we first estimated the ratio of twenty-foot and forty-foot containers arriving at a port (other container sizes exist, but twenty-foot and forty-foot containers are most common). Based on those ports in the region that reported the number of each type of container, an estimated 80% of the containers were forty-foot containers and the remaining 20% were twenty-foot containers. Based on this, we estimated that of the 6.2 million containers arriving annually at ports within the Greater Caribbean Region, ca. 1.4 million arrive with contaminants.

Maritime vessels. Maritime vessels, including ship decks, holds, and stores, may be contaminated with live pests, soil, or other debris. Inspections of maritime vessels, including ship holds and stores, at U.S. ports-of-entry have resulted in interceptions of live pests, including pests of agricultural importance (Table 1) (USDA, 2007a).

REFERENCES

Caton, B. 2003. Quantitative analysis of insect pest risks from the international cargo aircraft pathway to Miami. USDA-APHIS-PPQ, Center for Plant Health Science and Technology, Plant Epidemiology and Risk Analysis Laboratory, Raleigh, NC.

Dale, P. S. and P. A. Maddison. 1984. Transport services as an aid to insect dispersal in the South Pacific, pp. 225-256. In: M. Laird [ed.], Commerce and the Spread of Pests and Disease Vectors. Praeger Publishers, New York.

Gadgil, P. D., L. S. Bulman, R. Crabtree, K. L. Glassey, J. C. O'Neil, and R. N. Watson. 2000. Significance to New Zealand forestry of contaminants on the external surfaces of shipping containers. New Zealand Journal of Forestry Science 30:341-358.

Gadgil, P. D., L. S. Bulman, and K. L. Glassey. 2002. Quarantine risk associated with air cargo containers. New Zealand Journal of Forestry Science 32:28-42.

Smith, A. and I. D. Carter. 1984. International transportation of mosquitoes of public health importance, pp. 1-21. In: M. Laird [ed.], Commerce and the Spread of Pests and Disease Vectors. Praeger Publishers, New York.

Takahashi, S. 1984. Survey on accidental introductions of insects entering Japan via aircraft, pp. 65-79. In: M. Laird [ed.], Commerce and the Spread of Pests and Disease Vectors. Praeger Publishers, New York.

USDA. 2007a. Agricultural Quarantine Activity Systems - PestID. USDA-APHIS-PPQ. Available at: https://mokcs14.aphis.usda.gov/aqas/login.jsp.

USDA. 2007b. Agricultural Quarantine Activity Systems - WADS. USDA-APHIS-PPQ. Available at: https://mokcs14.aphis.usda.gov/aqas/login.jsp.

Table 1. Important[1] pest families intercepted at U.S. ports-of-entry on maritime vessels (including holds and stores), aircraft cargo holds, or containers (USDA, 2007a).	
Arthropods	
Coleoptera	Bostrichidae, Buprestidae, Cerambycidae, Chrysomelidae, Curculionidae, Dryophthoridae, Elateridae, Meloidae, Platypodidae, Scarabaeidae, Scolytidae, Tenebrionidae
Diptera	Agromyzidae, Chloropidae, Tephritidae
Hemiptera	Achilidae, Aleyrodidae, Alydidae, Aphididae, Aphrophoridae, Aradidae, Cercopidae, Cicadellidae, Cicadidae, Cixiidae, Cydnidae, Delphacidae, Diaspididae, Lygaeidae, Membracidae, Miridae, Oxycarenidae, Pachygronthidae, Pentatomidae, Psyllidae, Pyrrhocoridae, Rhopalidae, Rhyparochromidae, Scutelleridae, Tingidae
Hymenoptera	Apidae, Formicidae, Siricidae
Isoptera	Termitidae
Lepidoptera	Acrolophidae, Agryresthiidae, Arctiidae, Crambidae, Ctenuchidae, Elachistidae, Gelechiidae, Geometridae, Gracillariidae, Hesperiidae, Limacodidae, Megalopygidae, Noctuidae, Notodontidae, Nymphalidae, Oecophoridae, Psychidae, Pyralidae, Saturniidae, Sesiidae, Sphingidae, Tineidae, Tortricidae
Orthoptera	Acrididae, Gryllidae, Gryllotalpidae, Pyrgomorphidae, Romaleidae, Tetrigidae, Tettigoniidae
Weeds	
	Asteraceae, Solanaceae
Mollusks	
Pulmonata	Achatinidae, Agriolimacidae, Arionidae, Bradybaenidae, Cochlicellidae, Helicidae, Limacidae, Pleurodontidae, Succineidae
Stylommatophora	Hygromiidae

[1] All of these families contain many species that are pests of agricultural importance and are capable of active dispersal.

Table 2. Number of containers and estimated number of contaminated containers arriving at ports-of-entry in the Greater Caribbean Region.
(Data obtained from port authority websites, trade websites, and publications.)

Country	**Containers arriving[1]**	**Containers contaminated**
Aruba[2]	8,830	2,066
Bahamas[2]	415,758	97,287
Barbados[2]	27,752	6,494
Belize[2]	12,258	2,868
Cayman Islands[2]	18,002	4,212
Costa Rica[2]	418,835	98,007
Cuba[3]	95,132	22,261
Curaçao[2]	27,638	6,467
Dominica[2]	3,329	779
Dominican Republic[3]	107,109	25,063
El Salvador[2]	39,433	9,227
Guatemala[2]	227,409	53,214
Guadeloupe[3]	46,961	10,989
Haiti[4]	166,647	38,995
Honduras[3]	176,498	41,300
Jamaica[3,5]	543,633	127,210
Netherland Antilles[5]	481,522	112,676
Nicaragua[2]	15,073	3,527
Panama[2]	1,190,592	278,512
Puerto Rico[3]	518,217	121,263
St. Lucia[2]	12,368	2,894
St. Martin[5]	132,111	30,914
Trinidad and Tobago[3,4]	126,440	29,587
United States (Alabama, Florida, Louisiana, Mississippi, Texas)[2,3]	1,461,171	341,915
Regional total[6]	**6,272,718**	**1,467,727**

[1] Containers entering include only those arriving at the port. The number may be the actual number reported or may be estimated from the number of TEUs reported.
[2] Based on 2006 data.
[3] Based on 2005 data.
[4] Based on 2004 data.
[5] Based on 2003 data.
[6] Data for some ports and countries or territories were not available.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):638. 2008

Poster #75

Control of Broad Mite, *Polyphagotarsonemus Latus* and the Whitefly, *Bemisia tabaci*, in Open Field Pepper and Eggplant with Predaceous Mites

José Castillo and Philip A. Stansly. University of Florida/IFAS
Southwest Florida Research and Education Center, Immokalee, Florida 34142.
jacastil@ufl.edu; pstansly@ufl.edu

The broad mite, *Polyphagotarsonemus latus* (Banks), and the sweetpotato whitefly, *Bemisia tabaci* (Gennadius), are serious pests of pepper and eggplant in Florida and elsewhere. In greenhouse-grown pepper, both pests have been controlled by *Ambylseius swirskii* and broad mite has been controlled by *A. cucumeris*; however, there have been no reports regarding the effectiveness of these Phytoseiid mites in open field pepper or eggplant. We evaluated both predaceous mite species in eggplant and 'Serrano' pepper in experimental plots in southwest Florida, and also assessed control of broad mite in 'bell' pepper on a commercial farm in the same region. Both mites controlled broad mite on both crops, although fewer releases were necessary and better control was achieved with *A. swirskii* than with *A. cucumeris*. In addition, *A. swirskii* controlled *B. tabaci* which is an especially important pest of eggplant in this region. Both pepper and eggplant receiving *A. swirskii* yielded significantly more fruit than untreated plants or even eggplants receiving two acaricide sprays in 2007. However, the cost of releasing *A. swirskii* in eggplant exceeded average insecticide costs by a factor of 2 or more. Furthermore, *A. swirskii* did not provide adequate control of the spider mite, *Tetranychus urticae* Koch, another important pest of this crop in south Florida. Therefore, further research is warranted to define lower effective rates of *A. swirskii* and combinations with spider mite specific predators.

KEYWORDS: Phytoseiid mites, cost *Tetranychus urticae,* release rates

2008 Proceedings of the Caribbean Food Crops Society. 44(2):639. 2008

Poster #76

Demonstrating Integrated Pest Management of Hot Peppers

Jesusa Crisostomo Legaspi[1], Cassel Gardner[1], Gilbert Queeley[2], Norman Leppla[1], and James Cuda[3]. [1] USDA-ARS-CMAVE, Florida A&M University-Center for Biological Control,6383 Mahan Drive,Tallahassee, FL 32308; [2] Florida Cooperative Extension Service, CESTA, Florida A&M University, Tallahassee, FL 32307; [3] Entomology and Nematology Department, University of Florida, IFAS, Gainesville, FL 32611. slegaspi@gmail.com

ABSTRACT.
We studied the effects of organic and synthetic chemical fertilizers on crop growth, yield and associated insect pests for two varieties of hot pepper, *Capsicum chinense* Jacquin (Solanaceae): "Scotch Bonnet" and "Caribbean Red" in north Florida. Hot peppers were grown under three treatments: poultry manure; mushroom compost; or "Growers' Practice", (conventional pesticides and chemical fertilizers), with equivalent amounts of soil nutrients applied to all treatments. The Growers' Practice treatment permitted use of conventional insecticides if insect pests exceeded economic thresholds. Plant height and canopy diameter were significantly greater in the mushroom compost treatment for Scotch Bonnet; however, yields were not significantly affected by treatment or variety. The Growers' practice treatment resulted in lowest plant height in Caribbean Red. The dominant insect pests found were the silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring (Hemiptera: Aleyrodidae); green peach aphid, *Myzus persicae* (Sulzer) (Hemiptera: Aphidae); bandedwinged whitefly, *Trialeurodes abutilonea* (Haldeman) (Hemiptera: Aleyrodidae); and western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae). Significantly more insect pests were found on Caribbean Red than on Scotch Bonnet, but in none of the treatments did pests reach economic injury levels. Results indicate that hot peppers may be grown without using insecticides in north Florida because insect pests did not reach levels high enough to affect yield. Furthermore, the crops may be grown using relatively inexpensive organic fertilizers because the use of synthetic chemical fertilizers does not result in higher yields. We found that organic methods can be profitable for growers in Florida provided pests remain below economic threshold levels.

KEYWORDS: poultry manure; mushroom compost, organic fertilizers, economic thresholds

2008 Proceedings of the Caribbean Food Crops Society. 44(2):640. 2008

Poster #85

CIRAD Invasive Species Initiatives in the Caribbean Basin

Emmanuel Wicker[1], Catherine Abadie[2], Jean Heinrich Daugrois[3], Luc Baudouin[4], Michel Dollet[4], Claude Vuillaume[2] and Pierre-Yves Teycheney[2]. [1]CIRAD-UR 27, PRAM, 97285 Le Lamentin Cedex 2, Martinique, FWI; [2]CIRAD-UPR75 & CIRAD-DG, Station de Neufchateau, 97130 Capesterre Belle-Eau, Guadeloupe, FWI; [3]CIRAD-UPR75, Station de Roujol, 97170 Petit-Bourg, Guadeloupe, FWI ; [4]CIRAD-UPR29, Campus international de Baillarguet - TA A-29 / F - 34398 Montpellier Cedex 5. Author for correspondence : teycheney@cirad.fr

ABSTRACT.
CIRAD has developed several initiatives on invasive plant pathogens that are present in the Caribbean. These initiatives are primarily focused on Ralstonia solanacearum, Black Sigatoka, coconut lethal yellowing and viral diseases of sugarcane and banana. They include research activities, transfer of diagnosis techniques to plant protection and quarantine services, and participation to surveillance networks, either existing or under construction.

Epidemiological studies are the key component of many of our research activities, which are often carried out in the frame of collaborative projects. This is best illustrated by the surveys that were recently carried out in Grenada and that are in progress in St. Vincent on banana Moko disease (Ralstonia solanacearum race 2). Epidemiological studies were also carried out in Guadeloupe and Martinique on several pathogens affecting sugarcane, such as sugarcane yellow leaf virus and leaf scald disease, and on banana streak viruses. Likewise, surveys were carried out in St. Lucia, St. Vincent, Dominica and Suriname in order to confirm the presence/absence of Black Sigatoka, and in most Caribbean islands for characterising recent disease foci of coconut lethal yellowing.

Diagnosis and monitoring tools and techniques are one of the major outputs of our research activities. Transfers of these tools and techniques towards plant protection and quarantine services of Caribbean countries are achieved through collaborative projects and courses.

CIRAD also plays an active role in several projects and global surveillance networks such as PANDOeR and the current initiatives for promoting plant health in the Region. Its current projects involve the development of a regional Black Sigatoka surveillance and control network and a participatory database on major diseases of banana, coconut, horticultural crops, sugarcane and yam.

KEYWORDS: epidemiological surveys, surveillance and control network, participatory database, Ralstonia solanacearum, Black Sigatoka, coconut lethal yellowing, viral diseases of sugarcane and banana

2008 Proceedings of the Caribbean Food Crops Society. 44(2):641-650. 2008

Poster #77

Biogas Production from Rice Hulls and Straw Treated with Urea

Amarely Santana[1], Jerry Gabriel, Pascal Fenelus, Eliezer Louis, Juguette Badette, Carlos Miguel De Jesús Arias[2]. Animal Science Department[12]; Universidad ISA, La Herradura, Santiago, República Dominicana*

ABSTRACT.
The rice production of Dominican Republic is around half million of TM per year, from which 50% is crops residues (hull and straw). This high production of fiber is used as feed, poultry bedding and organic fertilizer. Taking in account this amount of fiber as a very good of source to produce biogas, ISA University setup two trial of 60 day to evaluate the biogas yields using two substrate of rice crops residues (hulls and straw).The trials consisted of rice hulls and straws treated with urea and rabbit urine or fresh bovine manor under environmental conditions. The Trials had a randomized design, however, the rice hull trials had two treatments and three repetitions and the straws trial had four treatments with three repetition. The evaluated variable was the biogas production (dm^3) per kg of DM in 10 d periods. The rice hulls treated with rabbit urine yields about 57.38 dm3 /kg de DM in 60 d and the rice straws treated with rabbit urine and bovine manor yields 98.28 dm^3 /kg DM. From theses trials we conclude that it is possible produces a good yields per kg of DM of biogas from rice crops residues with artisanal biodigester

KEYWORDS: Crops residues, rice, biogas, yield.

INTRODUCCION

Con el término biogás se designa la mezcla de gases resultantes de la descomposición de la materia orgánica realizada por acción bacteriana en condiciones anaeróbicas. El biogás es un gas combustible usado para secar, cocinar, hacer marchar un motor generador y producir electricidad. La tecnología del biogás se constituye una valiosa alternativa para el aprovechamiento de los desechos agropecuarios, pues permite disminuir la carga contaminante al ambiente, mejorar la capacidad fertilizante del material, eliminar los malos olores y generar combustible. Además, el efluente obtenido después de la digestión anaeróbica sustituye los abonos químicos mediante la producción de un abono biológico vegetal de gran valor compatible con las plantas (Cavidad, 1997).

Los países pobres invierten muchísimo dinero para adquirir el petróleo, como es el caso de la República Dominicana y de la República de Haití. Esta situación hace que los campesinos de estos países utilicen otros sustitutos de combustible tales como la leña y el carbón para satisfacer sus necesidades y sea necesario investigar sobre fuentes alternativas de combustible no dañinas para el medio ambiente (OMS, 2006).

Para la producción de biogás se necesita de un sustrato, el cual debe ser fermentado por una colonia de bacterias en condiciones anaeróbicas. La disponibilidad y la calidad del sustrato pueden influir en la producción del biogás (Caneta *et al.*, 2001).

Se considera que la cáscara y el rastrojo de arroz pueden ser buenos sustratos para la producción de biogás. La cáscara de arroz está disponible en la República Dominicana con una producción de más de 2.44 millones de quintales por año (IICA, 2003). En cuanto a la calidad, la degradación microbiológica de la celulosa contenida en la cáscara y rastrojo de arroz no se puede conseguir en forma directa, tal como se hace en los residuos domésticos, pues hay junto a ella un componente, la lignina que representa un 16% de la cáscara de arroz, que no es atacable por los microorganismos. Se necesita articular mecanismos que permitan utilizarlo de forma más eficiente. Una alternativa es la producción de biogás, utilizando aditivos que estimulen el proceso de fermentación. Este tratamiento puede ser a base de urea o hidróxido de sodio (Souza *et al.*, 1999). Según estudios realizados se afirmó que la amonificación de heno por medio de tratamiento con urea provocó una disminución en las fracciones FDN (Fibra Detergente Neutro), FDA (Fibra Detergente Acido), celulosa y lignina (Rodríguez, 1998; Peña, et al., 2001).

La urea es una de las mejores fuentes de nitrógeno (46%) y la misma se puede utilizar para tratar pajas y otros residuos fibrosos en la alimentación animal y en la producción de biogás. Sin embargo la orina de conejos (1 litro=20 gramos de nitrógeno) representa una fuente sostenible y valiosa de nitrógeno que puede sustituir a la urea industrial (Preston, 1999).

Producir biogás y evaluar diferentes biomasas vuelven a ser temas de estudio importantes. Tanto para República Dominicana como para Haití, las diferentes razones, antes expuestas hacen que, evaluar diferentes tipos de sustratos para producir biogás, es contribuir a la solución de disminuir el gasto en combustibles fósiles y a la preservación del ambiente (COPDES, 2006; BME, 2000). Con el propósito de comparar la producción de biogás a partir de la cáscara y rastrojo de arroz tratadas con una fuente de nitrógeno industrial, la urea y otra natural, la orina de conejos se ha hecho esta investigación.

MATERIALES Y METODOS

Localización del estudio

Los experimentos se llevaron a cabo en el campo experimental de la Universidad ISA, en La Herradura, Santiago, República Dominicana, durante el período de10 de noviembre de 2006 hasta el 10 de enero de 2007. Esta zona presentan las siguientes condiciones geoclimáticas: latitud 19°21' norte, longitud 71°44'oeste, altitud 160 msnm, temperatura media anual 26°C, precipitación media anual 970 mm y humedad relativa 84.28 %.

.

Diseño experimental y Tratamientos

En el experimento 1 y 2, se utilizó un diseño completamente al azar. Sin embargo en el experimento 1 consto de 2 tratamientos y 3 repeticiones para un total de 6 unidades experimentales y en el experimento 2 se evaluó con 4 tratamientos y 3 repeticiones para un total de 12 unidades experimentales. Los tratamientos fueron nitrógeno industrial (urea) y nitrógeno natural (orina de conejos) para tratar la cáscara de arroz en el

experimento 1 y paja de arroz sola, paja de arroz con estiércol de vaca, paja de arroz con urea y paja de arroz con orina de conejos en el experimento 2.

El modelo estadístico que se utilizó en los dos experimentos para analizar la variación entre los tratamientos y el error fue el siguiente:

$$Y_{ij} = \mu + T_i + \varepsilon_{ij}$$

donde:

μ = media de la población

T_i = efecto del i-ésimo tratamiento (i = 1, 2,...)

ε_{ij} = desviación al azar de la j-ésima repetición del i-ésimo tratamiento (error experimental)

Las variables calculadas en los distintos tratamientos fue: **producción de biogás en dm^3 por kg de materia seca**. La producción de biogás se evaluó en períodos de 10 días (PBPMS) cuyos valores se sumaron para tener una producción de biogás total (PBTMS) en dm^3 por kg de materia seca, donde PBTMS (dm^3/kg) = Σ PBPMS (dm^3/kg). La producción de biogás del período por kg de materia seca (PBPMS) (dm^3/kg) = PBP (dm^3) / peso de materia seca (kg) se calculó dividiendo la producción de biogás del período en dm^3 (PBP) por el peso seco del sustrato en kg. La producción de biogás del período PBP (dm^3) = Σ V (dm^3) para cada tratamiento se obtuvo a partir de la sumatoria de los volúmenes diarios (V) del período en dm^3. El volumen diario (V) se calculó mediante lectura tomada 2 a 4 veces al día según la cantidad de biogás producida. Para tomar la lectura se anotó la elevación (cm) de la parte superior de la campana con la ayuda de la cinta métrica. Después de tomar la lectura se dejó escapar el biogás abriendo las válvulas. Luego se aseguró mantener cerrada la salida del biogás nuevamente.

Calculo de Volumen de biogás generado por los biodigestores

El cálculo del volumen fue mediante el siguiente procedimiento: se cálculo del volumen de un tronco de cono conociendo el radio más pequeño, y la generatriz que representa la lectura, o sea el volumen del cono va a variar según la distancia del punto E al punto A donde se va a colocar el cero (ver figura 1). Por ejemplo: determinar el volumen del tronco de generatriz AE, AE', AE'' conociendo el valor de AB, EC, AE, donde AB: Radio pequeño; EC: Radio grande; AD y BC: la Altura; AE: la generatriz y la Lectura máxima.

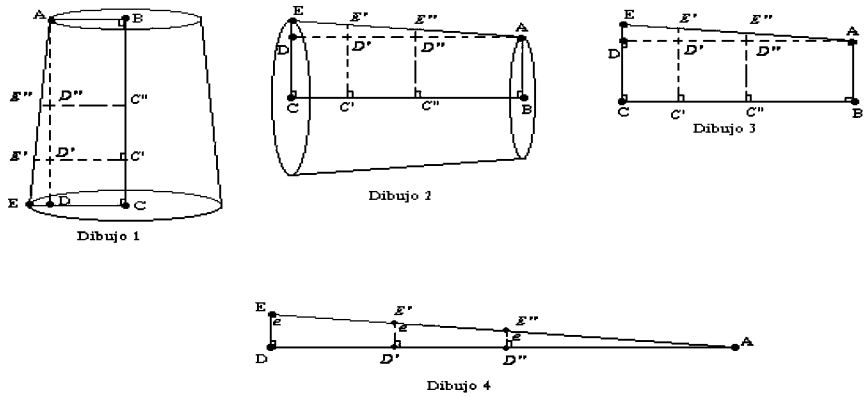


Figura 1. Campana utilizada para determinar la producción de biogás diaria de cáscara y rastrojo de arroz con urea o orina de conejos

Por lo tanto, el Volumen del tronco de cono se determino mediante la formula V = π *h (r2 + R 2 + R *r)/3, donde π = 3.1416; h = Altura del tronco del cono; r = Radio menor; R = Radio mayor; AE': Lectura 1; AE'': Lectura 2; AB = 13 cm; EC = 14.1 cm; AE =34.1 cm.

Para determinar el volumen de biogás producido en cada lectura fue necesario conocer: 1) r = AB; 2) R = E' C'; 3) h = BC'; 4) L = AE'.

El calculo de R (E' C') se determino por: 5)E' C'= E' D' + D'C'; 6) D'C'= DC = AB; 7)E'C'=E'D'+AB (5 y 6); 8)EL ángulo e = AED =AE'D'; 9)El triangulo AED rectangular en d, AE'D' rectangular D' así ;10) Cos ê = ED/ AE =E'D'/AE' (8 y 9); 11) Cos ê = E'D'/AE' (10); 12) E'D' = Cos ê * AE' (10 y 11); 13) E'C' = Cos ê * AE'+AB ; 14) R = Cos ê *L+ r (1,2, 4y 10).

El Cálculo de la altura (h) (BC'): 15)BC'= AD'; 16) Seno ê = AD/ AE =AD'/AE' (8 y 9); 17) Seno ê = BC'/AE' (15); 18) BC'= AE' * Seno ê; 19) h =L * Seno ê (1,3,4 y 18); 20) AB = 13 cm; 21)EC = 14.1 cm; 22)EC =ED+AB; 23)ED =EC-AB; 24)ED = 14.1-13 =1.1 (20 y 21); 25) AE =34.1 cm; 26) Cos ê = ED/AE =1.1/34.1 = 0.035; Cos ê =0.035(10,24 y 25); 27) ê = Cos –1 (0.035); 29) ê = 87.99 o 30) Seno ê = Seno (87.99 o) =0.999 ; Seno ê = 0.999.

Volumen del tronco = π *h (r2 + R 2 + R *r) /3

Volumen del tronco =π*L *sin e [r2 +(r+L *cose) 2 + r * (r+L *cose)] /3

V = 0.999 * 3.1416 * L * (13 ^2 + (13+0.035 L)^2 +13 * (13 +0.035 L)) /3

V = 3.138 * L * (169 +169 +2 * 13 * 0.035 * L+0.001*L^2+169+ 0.455* L)/3

V = 3.138 * L * (169 +169 + 169+ 0.91 L+0.455 L+0.001*L^2)/3

V = 3.138 * L * (507+ 1.365 L+ 0.001* L^2) /3

V = 1.046 * L * (507+1.365 L+0.001*L^2).

Manejo del Experimento

Preparación de los digestores

Se usaron 6 tanques en polietileno de 200 litros como digestores de carga discontinua o de "*Batch*", los cuales fueron cargados una vez y vaciados por completo después del tiempo de retención. Los tanques poseían dos tapas, una de ellas, se perforó un hueco en el cual se conectó una manguera de gas (1/2") que permitió el paso del biogás hacia el depósito de campana flotante. Para mantener pegada la manguera, se utilizó un pegamento para PVC rígido. La otra tapa se mantuvo cerrada durante el experimento (Ver foto 1).

Preparación de las Campanas Flotantes.

Las campanas para medir la producción de biogás estaban compuesta por dos secciones: la base y la parte superior.

Base de la campana. La base de la campana, para el experimento 1, correspondió a una caja en madera de 120 cm de largo, 40 cm de ancho y 45 cm de profundidad dividida en tres compartimientos iguales de 40 cm x 40 cm x 45 cm. Dos bases de campana fueron construidas en el taller de la Universidad ISA. Se pegó dentro de cada compartimiento dos fundas plásticas negras para evitar la filtración del agua a través de la madera (Ver figura 2). Para el experimento 2, se utilizaron tanques de cartón de 36" x 54", 55 galones los cuales fueron cortados en dos, luego se les colocó una funda de plástico, para ayudar a retener el agua (ver foto 2).

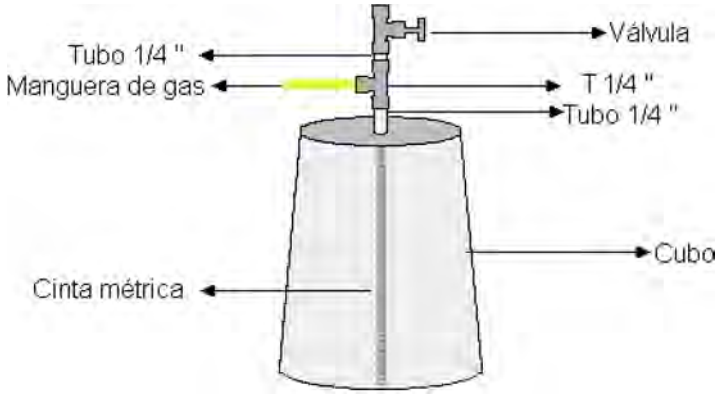


Figura 2. Diseño de la Base de Campana en la producción de Biogás a partir de la cáscara y rastrojos de Arroz tratada con Urea y con Orina de Conejos.

Parte superior de la campana. En ambos experimento, para preparar la parte superior de la campana se utilizaron cubos plásticos con capacidad para 5 galones. En el centro de cada cubo invertido se perforó un hueco en el cual se adaptó un tubo de ¼ pulgada de diámetro. A este tubo se colocó, respectivamente la T, otro tubo ¼ pulgada, la válvula. Las partes del sistema fueron mantenidas unidas por el PVC. Se aplicó silicón en las zonas donde hay uniones para sellar las posibles fugas de biogás. A la parte externa del cubo se colocó una cinta métrica que va del borde inferior al borde superior por medio de una cinta adhesiva transparente. La cinta métrica permitió tomar la lectura diariamente al subir la parte superior de la campana sobre el nivel del agua (Ver figura 3).

Montaje del Sistema Completo: Se llenó de agua los compartimientos de las bases de campana. Se introdujo la parte superior de la campana en cada compartimiento. Se aseguró que el agua contenida en los compartimientos está al nivel del punto cero de la cinta métrica colocada a la parte superior de la campana. Posterior, se cargó los tanques con el sustrato a evaluar, dejando un 20% del volumen total del tanque (40 litros) para el almacenaje del biogás. Se alimentó a los tres digestores con agua, urea pre-disuelta en agua, cáscara de arroz y los demás con agua, orina de conejos y cáscara de arroz o rastrojo según las proporciones indicadas anteriormente. Se añadió en cada digestor 1.5 kg de material inoculante a base de estiércol fresco de ganado bovino. Se tapó el digestor y selló las juntas con silicón. Terminado esto se conectó cada digestor a su sistema de depósito de gas introduciendo la manguera de gas en la salida libre de la T. Se aseguró de cerrar la salida de gas por medio de las válvulas. Para mantener recta la parte superior de la campana se sostuvo la manguera con una botella de 2 litros llena de agua (Ver foto 3.)

Análisis de Datos

Los datos recolectados en la producción de biogás en dm^3 por kg de materia seca en período de 10 días y en total fueron sometidos a un análisis de varianza usando el cuadrado mínimo del modelo lineal general (GLM) con el programa estadístico SAS™ 8.1 Inc. Si hubo diferencias significativas las medias fueron sometidas al análisis de separación de medias de Tukey a un nivel de confiabilidad de 95%.(Cody y Smith ,1997).

RESULTADOS Y DISCUSION

Producción de Biogás

En el Experimento 1, la producción de biogás durante los períodos primero, segundo y tercero, el tratamiento CAOC produjo más volumen de biogás que el tratamiento CAU . La producción de biogás para el tratamiento CAU resultó mayor durante los períodos 4 y 5. Durante el sexto período, la producción fue igual para los 2 tratamientos. Para el tiempo de retención de 60 días. El CAOC obtuvo mayor producción total (57.38 dm^3/kg) que el CAU (42.70 dm^3/kg) (ver tabla 1). El tratamiento CAOC obtuvo su pico de producción en el período 2 mientras que la CAU en el período 4. Lo que significa que el CAU obtuvo su pico 2 períodos (20 días) después el CAOC.

Tabla 1 Producción de Biogás dm^3/kg de MS a partir de Cáscara y Rastrojo de Arroz Tratada con Urea u Orina de Conejos

	Sustratos					
	Experimento 1		Experimento 2			
Periodos (días)	**CAU***	**CAOC***	**RAS***	**RA***	**RAU***	**RAOC***
1-10	4.00 b	7.15 a	4.81 a	6.70 a	14.00 a	11.58 a
11-20	4.10 b	17.97 a	4.24 b	9.47 ab	22.49 a	13.12ab
21-30	5.38 b	11.28 a	3.68 b	7.46 ab	29.64 a	31.71 a
31-40	14.69 a	9.57 b	4.32 a	6.07 a	18.24 a	14.41 a
41-50	8.93 a	6.46 b	3.51 b	7.44 ab	4.79 b	15.66 a
51-60	5.60 a	5.00 b	2.86 a	9.23 a	9.09 a	9.75 a
Total	42.70 b	57.43 a	23.45 b	46.39ab	98.28a	96.25 a

NOTA: Letras diferentes en una fila dentro de los experimentos indican diferencias significativas ($P<0.05$).
*CAU: Cáscara de Arroz con Urea; CAOC: Cáscara de Arroz con Orina de Conejo; RAS: Rastrojo de Arroz con agua; RA: Rastrojo de Arroz con inoculante; RAU: Rastrojo de Arroz con Urea; RAOC: Rastrojo de Arroz con orina de Conejo.

Este comportamiento de la producción de biogás con el CAU parece ser consecuencia de que el nitrógeno suministrado en la forma de urea a la población bacteriana no es asimilable sin la intervención de las bacterias productores de ureasa especialmente los Proteus (Cortes, 2002). Por lo tanto, la acción de los demás grupos de bacterias era mínima en los períodos 1, 2,3. Sin embargo, la disponibilidad del nitrógeno en forma de amonio ha permitido un aumento de la población bacteriana lo que puede ocasionar el brusco crecimiento de la producción en el período 4 y la caída lenta en los períodos 5 y 6.

En cuanto al CAOC se puede relacionar este comportamiento a la disponibilidad de la ureasa en la orina, la cual interviene en el proceso producción de amonio a partir de la urea y de los compuestos nitrogenitos (Dinatec, 2000) y a la presencia de los actinomicytes, los cuales son microorganismos presentes en la orina de conejos y especialmente hábiles para degradar materiales con alto niveles de lignina (Arroyo, 2004).

Normalmente, la producción de biogás varia de 200-400 dm^3 por Kg de materia seca en condiciones ambientales (ISF, 2005). Respecto a este parámetro de producción de biogás este experimento no ha alcanzado este rango debido a la posible razón: por ser un material lignificado y por su alto contenido de silicio, la cáscara de arroz presentaba una degradación lenta y baja a nivel del digestor.

El experimento 2 mostró que, durante los períodos primero y segundo, el tratamiento PAU produjo más volumen de biogás que los demás. El tratamiento PAOC produjo más que los demás en el periodo 3, 5 y 6. En el período 4 el PAU produjo más que los demás. Y finalmente para el tiempo de retención de 60 días, el PAU (98.28 dm^3/Kg de materia seca) y PAOC (96.25 dm^3/kg de materia seca) obtuvieron la mayor producción total que PA (46.39 dm^3/kg de materia seca) y PAS (23.45 dm^3/kg de materia seca), la razón podría obedecer a que si se compara con la cascara de arroz es más lignificada que la paja de arroz, mayor lignina más tiempo de retención menos producción (Yongfu *et al.* 1989).

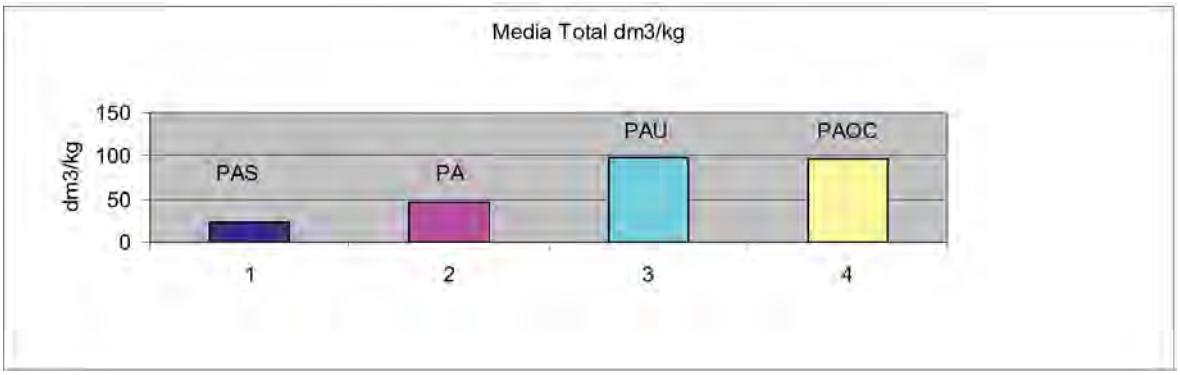


Figura 2 Comportamiento de la Producción Total de Biogás en dm^3/kg a Partir de Paja o Rastrojo de Arroz Tratada con Urea u Orina de Conejos por

Con relación a los picos de mayor producción los tratamientos PAU y PAOC tuvieron un comportamiento de pico y caída similar en el período 3. Mientras que el tratamiento PA obtuvo su pico de producción en el período 2 y el tratamiento PAS en el período 1. Esto resulta que los tratamientos PAS y PA no tuvieron la disponibilidad del nitrógeno que es la principal fuente de nutriente para las bacterias formadoras de metano (metanogénicas), mientras que los tratamientos PAU y PAOC tuvieron nitrógeno lo que permite a ellos obtener sus picos 10 días después (GTZ, 1999)

CONCLUSIONES Y RECOMENDACIONES

Bajo las condiciones de clima y las variaciones de temperatura durante el período de los ensayos, resulta más apropiado y sostenible tratar la cáscara de arroz con orina de conejos para la producción de biogás y que el rastrojo de arroz puede ser una fuente para biogás tratada con urea o con orina de conejo con una producción de 98.28 o 96.25 dm^3/kg de materia seca, respectivamente. Además es factible el tratamiento por digestión anaerobia de la cáscara y rastrojos de arroz obteniéndose así, una fuente de energía renovable. Con dicha utilización se logra una manera para deponer estos residuos de cosecha tan abundante en República Dominicana.

REFERENCIAS

Arroyo, F. J. 2004. El uso de la orina humana en los procesos de compostage. revista PGU # 10

Banco Central, 2004. Boletín Trimestral del Banco Central de la República Dominicana. Abril-Mayo

Bureau des mines et de l'énergie (BME), 2000. L'énergie en Haiti Diagnostic du Secteur de L'énergie.

Caneta, L., Álvarez, J. M. Y Moyano, C. 2001. Biomasa y Biogás. Cátedra: Máquinas Térmicas II Facultad de Ingeniería. Universidad Nacional Del Nordeste de Argentina.

Cavidad, Z. A. 1997. Utilización del Biogás para Generación de Electricidad. Fundación CIPAV.

Cody, R. P. y Smith J. K. 1997. Applied Statistic and the SAS Programming Language. Fourth Ed. Prentice Hall, New Jersey. U.S.A.

Comisión Presidencial sobre los objetivos del Milenio y el desarrollo Sostenible (COPDES), 2006. http://www.copdes.gov.do/noticias.html

Cortés, J. A. 2002. Prueba de la Ureasa.

Ingeniería Sin Fronteras (ISF). 2005. Biomasa como fuente energética en países en desarrollo. Módulo 7. Lectura 7.1. 2.

Instituto Interamericano de Cooperación para la Agricultura (IICA). 2003. Estudio sobre el Mercado de Arroz en la República Dominicana. Santo Domingo, D.N.

La Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Information And Advisory Service On Appropriate Technology (ISAT).1999. Biogas Basics. Volume I. Biogas Digest.

Organización Mundial de la Salud OMS, 2006. Las Inversiones para promover el Combustibles.

PrestonT.R.,1999 Tropical animal feeding .University of Agriculture and Forestry Ho Chi Minh City Viet Nam. FAO, Roma, Italia

Rodríguez, N y Araujo-Febres, O y Gonzales, b y Vergara, J. 1998 Efecto de la Amonificación con Urea sobre los Componentes Estructurales de la Pared celular de Heno de Brachiaria Humidicola

Souza, O. y Izabele, E. 1999. Aprovechamiento De Los Residuos Agropecuarios Tratados Con Urea En La Alimentación Animal. Facultad de Agronomía y Veterinaria, Universidad Nacional de Río Cuarto, Río Cuarto, provincia de Córdoba, República Argentina.

.Youngfu, Y., Yibo, Q., Yunxuan, G., Hui, Z., Yuansheng, X., Chenyong, X., Guoyuan, F., Jienquan, X., Taiming, Z. y Gan, L. 1989. The biogas technology in China. Agricultural Publishing House. Beijing, Pag.20-54

Foto 1. Tanque de polietileno utilizado como Digestor en la producción de Biogás a partir de la cáscara y rastrojos de Arroz tratada con Urea y con Orina de Conejos.

Foto 2 Instalación del Sistema, para la Producción de Biogás a partir de la cáscara y rastrojos de Arroz tratada con Urea y con Orina de Conejos.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):651. 2008

Poster #78

Optimization of a Clarification Process for Guava Puree using Bioguavase Enzyme

María L. Plaza[1] and Murat Balaban[1], [1]University of Florida, Gainesville, FL
mlplaza@ufl.edu

ABSTRACT.
Fruit juices are an important part of our diet. Guava (*Psidium guajava* L.) is a delicious, healthful tropical fruit that has not been used as processed juice. One of the challenges in processing guava juice is cloudiness due to suspended complex carbohydrates in the end product. Clarification of the juice is desirable in order to enhance consumer acceptability. Enzyme treatment is one method of enhancing the removal of suspended solids. Bioguavase is a commercially available pectinolytic enzyme system containing a variety of carbohydrase enzymes derived from *Aspergillus niger*. Our objective was to determine the optimal treatment time and concentration of Bioguavase for treatment of guava juice to obtain a clarified product. Four treatment times (3, 6, 9 and 12 hours) and three enzyme concentrations (400, 600 and 800 ppm) were tested in a repeated measures design at 30° C. Following treatment, juice was clarified by centrifugation and analyzed for vitamin C content (2,6-dicloroindophenol titration method), antioxidant capacity (ORAC), total soluble phenolics, turbidity and color. After 3h reaction time, the 800 ppm treatment produced the clearest juice. Juice yield did not show significant differences ($\alpha = 0.05$) at 600 and 800 ppm of enzyme concentration when the reaction time was extended beyond 13h. All enzyme treatments reduced the antioxidant capacity (between 17 and 21%) and decreased the total soluble phenolic content (between 3 and 7%) of the juice. We conclude that treatment of guava juice with 600 ppm Bioguavase for 3h is suitable for obtaining clarified juice.

Additional studies should further characterize phytochemical modifications caused by the treatment. The yield of clarified juice is significantly affected by the temperature and time used for the enzyme treatment. Increasing the temperature may produce a good clarified juice but may also reduce the phytochemical composition and ascorbic acid content due to oxidation. Using 30°C with the appropriate enzyme concentration and reaction time will help minimize the reduction of the phytochemical component.

KEYWORDS: guava, clarified juice, enzyme treatment

2008 Proceedings of the Caribbean Food Crops Society. 44(2):652. 2008

Poster #81

Relationship between Chlorophyll Fluorescence and Dry Matter Content of 'Hass' Avocado Fruit

J.A. Osuna-García[1], G. Doyon[2], I.J.L González-Durán[1], S. Salazar-García[1] and R. Goenaga[3], [1]INIFAP-Santiago Ixcuintla Experimental Station. Santiago Ixcuintla, Nayarit, Mexico. [2]Food Research and Development Centre, Agriculture and Agri-Food Canada, St. Hyacinthe, Quebec, Canada. [3]USDA-ARS, Tropical Agriculture Research Station, Mayagüez, Puerto Rico.
josunaga@tepic.megared.net.mx; osuna.jorgealberto@inifap.gob.mx

ABSTRACT.
Mexico is the main 'Hass' avocado exporter in the world with more than 100,000 ton exported every year. Canada is an important importer country accounting for 12-15% of total exports from Mexico. Normally, from December to May exported fruit to Canada have very high dry matter content which is determined with a destructive and time consuming method. The objective of this experiment was to correlate skin chlorophyll fluorescence, as a non-destructive method, with dry matter content of 'Hass' avocado fruit. From December 2007 to April 2008, 10 fruit of five different skin color categories were collected monthly from a packinghouse in Michoacan, Mexico and rated using the following scale: 1 = fully green, 2 = <25% skin blackening, 3 = 26- 50% skin blackening, 4 = 51-75% skin blackening, and 5 >76% skin blackening. Two days after harvest, individual fruit were assessed for chlorophyll fluorescence using a modulated fluorometer, Model OS1-FL reporting fluorescence under steady state conditions (Fs), maximal fluorescence under steady state conditions (Fms), and quantum efficiency yield (Y). Immediately after reading fluorescence, fruit mesocarp dry matter content (DM) was determined using a microwave oven and values were correlated with fluorescence. Fs values varied from 147 to 292; FMS from 357 to 989 and Y from 0.504 to 0.818, while DM did so from 19 to 42%. The only fluorescence parameter that correlated significantly ($P<0.001$) with DM was Fs; however, correlation was low ($r = -0.31$). This could be due to the relative high DM content of fruit (avg. 32.9%), which was much higher than the maturity standard (DM $\geq$ 21.5%). The results showed that chlorophyll fluorescence did not correlate with DM content of over-ripe avocado fruit. Efforts are underway to find out if fluorescence may be useful to predict legal maturity on unharvested 'Hass' avocado fruit.

KEYWORDS: non-destructive, fluorescence, fruit maturity

2008 Proceedings of the Caribbean Food Crops Society. 44(2):653. 2008

Poster #82

Effect of Harvest Time and Ripening Degree on Quality and Shelf Life of 'Hass' Avocado

J.A. Osuna-García[1], G. Doyon[2], I.J.L González-Durán[1], S. Salazar-García[1] and R. Goenaga[3], [1]INIFAP-Santiago Ixcuintla Experimental Station. Santiago Ixcuintla, Nayarit, Mexico. [2]Food Research and Development Centre, Agriculture and Agri-Food Canada, St. Hyacinthe, Quebec, Canada. [3]USDA-ARS, Tropical Agriculture Research Station, Mayagüez, Puerto Rico.
josunaga@tepic.megared.net.mx; osuna.jorgealberto@inifap.gob.mx

ABSTRACT.
Canada is an important avocado importer country accounting for 12-15% of total avocado exports from Mexico. 'Hass' avocado is harvested year round in the state of Michoacan. For most part of the season, fruit reach adequate mesocarp dry matter content (DM), ripen properly and consequently, quality and shelf life are excellent. However, after early January fruit DM content increases and skin blackening occurs. Shipments to Canada containing fruit with blackening skin have been rejected since this characteristic is sometimes associated with low pulp firmness and short shelf life. The objective of this experiment was to study the effect of harvest time and ripening degree on initial quality and shelf life of 'Hass' avocado. Fruit were harvested in October and December, 2007 and from January to April, 2008 and rated according to the following scale: 1 = fully green, 2 = <25% skin blackening, 3 = 26-50% skin blackening, 4 = 51-75% skin blackening and 5 > 76% skin blackening. At harvest, DM, skin color, pulp firmness, and pulp color were evaluated. Fruit were then refrigerated (6.0±1.0 ºC; 90±5% RH) for seven days to simulate terrestrial shipment to Canada. After this period, fruit were stored under market conditions (22±2 ºC; 75±10% RH) until they reached the edible ripening stage. Weight loss (WL), fruit with skin blackening, pulp firmness, and pulp color were determined every three days. Pulp DM, skin color and pulp color significantly increased with harvest time and degree of skin blackening. However, there were no significant differences for WL and firmness. Our results showed that there is no reason for Canadian retailers to reject fruit with blackened skin since fruit quality and shelf life were not affected by harvest time and degree of skin color.

KEYWORDS: skin color, maturity index, firmness

2008 Proceedings of the Caribbean Food Crops Society. 44(2):654. 2008

Poster #83

Influencia del Clima, Riego y Época de Floración Sobre la Composición Nutrimental del Fruto de Aguacate 'Hass' en Michoacán

S. Salazar-García, M. Gallardo-Valdez, y L.M. Tapia-Vargas, INIFAP-Campo Experimental Uruapan, Michoacán, México. E-mail: samuelsalazar@prodigy.net.mx

RESUMEN.
El objetivo de esta investigación fue evaluar el efecto del clima [semicálido subhúmedo (**SS**), semicálido húmedo (**SH**), y templado subhúmedo (**TS**)], la condición de humedad (con y sin riego) y época de floración que originó al fruto ["loca" (septiembre) y "normal" (enero)] sobre la composición nutrimental del fruto de aguacate 'Hass' en Michoacán. Se seleccionaron dos huertos de 'Hass' por cada clima y condición de humedad del suelo. En cada huerto se seleccionaron 10 árboles y cuando su fruto alcanzó la madurez legal (≥ 21.5% de materia seca de la pulpa), de cada árbol y tipo de fruto (floración Loca o Normal) se cortaron cinco frutos de la misma edad para diseccionarlos en sus componentes (epidermis, pulpa, tegumento y cotiledones). El clima afectó la composición nutrimental de las partes del fruto. En la epidermis, los nutrimentos afectados fueron: N, P, Ca, Cl, Fe, Mn y B; en la pulpa: N, P, K, Ca y Mn; en el tegumento: S y Mn; en cotiledones: P, S, Cu, Mn y B. La condición de humedad del suelo tuvo poco efecto sobre la concentración de macronutrimentos en el fruto. En huertos sin riego, el fruto presentó mayores concentraciones de K, Ca, y S en la epidermis, de K y Ca en la pulpa y de Mg en el tegumento. El N y P no fueron afectados. En frutos de la floración Loca (cosechados en agosto) fue mayor la concentración de N (epidermis y pulpa), Ca (cotiledones), Mg (cotiledones) y Zn (pulpa y cotiledones). En frutos de la floración normal (cosechados en octubre), solamente el N presentó mayor concentración en el tegumento.

PALABRAS CLAVE: *Persea americana*, nutrición.

NOTES:

Caribbean Food Crops Society
Sociedad Caribeña De Cultivos Alimenticos
Societé Caraibe Des Plantes Alimentaures

44TH ANNUAL MEETING
REUNION ANUAL
CONGRÈS ANNUEL

HOSTING ORGANIZATION

University of Florida
Institute of Food and Agricultural Sciences

CO-SPONSORS

Florida A&M University
Florida Cattlemen's Association
IICA
UF/IFAS International Programs
UF/IFAS T-STAR
(Tropical-Subtropical Agricultural Research)
USDA
USDA/APHIS
USDA/CSREES

Miami, Florida
July 13-17, 2008

CARIBBEAN FOOD CROPS SOCIETY 44

Forty Fourth
Annual Meeting 2008

Miami, Florida, USA

Vol. XLIV – Number 2
Plenary Session and Oral Presentations

MEETING HOST:

UF UNIVERSITY of FLORIDA IFAS

PROCEEDINGS
OF THE
44th ANNUAL MEETING

Caribbean Food Crops Society
44th Annual Meeting
July 13-17, 2008

Hosted by the
University of Florida's
Institute of Food and Agricultural Sciences
(UF/IFAS)

Miami Beach Resort and Spa
Miami Beach, Florida, USA

Repositioning Caribbean Agriculture:
Challenges and Opportunities for Sustainability

Reposicionando la Agricultura Caribeña:
Retos y Oportunidades para la Sostenibilidad

Repositionner l'agriculture de la Caraïbe :
Défis et opportunités pour la durabilité

Caribbean Food Crops Society
PLENARY AND TECHNICAL SESSIONS

Plenary Session Speakers and Oral Presentations of Scientific Papers

Plenary and Technical Sessions Edition
Vol. XLIV – Number 2
Edited by
Bala Rathinasabapathi, James P. Cuda,
Adegbola T. Adesogan, Wilfredo Colón-Guasp,
and Linda Evans

Published by the Caribbean Food Crops Society

ISSN 95-07-0410

Copies of this publication may be obtained from:

Secretariat, CFCS
P.O. Box 40108
San Juan, Puerto Rico, 00940

or from:

CFCS Treasurer
Agricultural Experiment Station
Botanical Garden South
1193 Guayacán Street
San Juan, Puerto Rico 00926-1118

Mention of company and trade names does not imply endorsement by the Caribbean Food Crops Society.

The Caribbean Food Crops Society is not responsible for statements and opinions advanced in its meeting or printed in its proceedings; they represent the views of the individuals to whom they are credited and are not binding on the Society as a whole.

EDITOR'S NOTE ON "NUMBER 2" AND "NUMBER 2 CONTINUED" FOR READERS AND AUTHORS: It was discovered at press-time that "Number 2" of the Proceedings was too thick for conventional binding in the printed-book format. To solve this production problem, the volume was broken in half. The second "half" (Number 2 Continued) is a direct continuation of the first "half" (Number 2), with the page numbering of the second half picking up directly where the page numbering ended in the first half. Number 2's Roman numeral section ("i, ii, iii") of introductory information ends at "page xi" and the Roman numeral section of Number 2 Continued begins at "page xii."

Number 2's "Arabic numeral" section (i.e. 1, 2, 3 rather than i, ii, iii) ends at page 355, while the Arabic numeral section for Number 2 Continued begins at page 356, after the introductory Roman numeral section. The Roman numeral section of Number 2 Continued includes introductory information such as this page and the Table of Contents. The Table of Contents in Number 2 Continued picks up precisely where the Number 2 Table of Contents ends. The two volumes are thus a paired set. Both "Number 2" and "Number 2 Continued" are listed as "Number 2" on the covers and in the citations for each abstract and paper, to reduce confusion when authors list their citations in CVs and other documents. "Number 2 Continued" consists of "Poster Session Abstracts and Expanded Papers," as some poster authors expanded their poster abstracts into full papers for these Proceedings.

2007-2008 CFCS BOARD OF DIRECTORS AND OFFICERS

BOARD OF DIRECTORS

Chair:	Dr. Héctor Santiago, University of Puerto Rico
Vice Chair:	Dr. Kwame Garcia, University of the Virgin Island
Secretary:	Mr. Wilfredo Colón, Universidad del Este, Puerto Rico
Treasurer:	Dr. Alberto Beale, University of Puerto Rico
President 2007- 2008:	Dr. Jimmy Cheek, University of Florida

REGIONAL REPRESENTATIVES

English:
Mr. Kwame Garcia, UVI, University of the U.S. Virgin Islands
Dr. William F. Brown, University of Florida
Mr. Bruce Lauckner, CARDI, Trinidad and Tobago

Spanish:
Dr. Wilfredo Colón, Universidad del Este, PR
Mr. Jerry Dupuy, Private Sector, Dominican Republic
Dr. Héctor Santiago, University of Puerto Rico

French:
Mr. Marceau Farant, INRA, Guadeloupe
Dr. Jean Louis Diman, INRA, Guadeloupe
Dr. Isabelle Jean-Baptiste, AMADEPA, Association Martiniquaise por le Developpement des Plantes Alimentaires, Martinique

Dutch:
Prof. Robert Tjien Fooh, ADEKUS, Suriname

ADVISORY BOARD

Dr. Altagracia Rivera de Castillo, Dominican Republic, President
Dr. Claude Vuillaume, CIRAD, Guadeloupe
Dr. Harry Ozier Lafontaine, INRA, Guadeloupe
Dr. Arlington Chesney, CARDI, Caribbean Region
Dr. Rafael Perez Duverge, IDIAF, Dominican Republic
Prof. Vivian Carro, UPR, Puerto Rico
Dr. Chelston W. D. Brathwaite, IICA, Costa Rica
Dr. Errol Rhoden, HBCU, USA
Dr. Guy Anais, INRA (retired), St. Martin
Dr. Louis Petersen, DOA, U.S. Virgin Islands
Dr. Cassel Gardner, FAMU, Florida
Dr. Wendel Parham, CARDI, Trinidad and Tobago

Caribbean Food Crops Society
44th Annual Meeting
July 13-17, 2008

Miami Beach Resort and Spa
Miami Beach, Florida, USA

Repositioning Caribbean Agriculture:
Challenges and Opportunities for Sustainability

Reposicionando la Agricultura Caribeña:
Retos y Oportunidades para la Sostenibilidad

Repositionner l'agriculture de la Caraïbe :
Défis et opportunités pour la durabilité

Caribbean Food Crops Society

PLENARY AND TECHNICAL SESSIONS

Plenary Sessions, Oral Presentations of Scientific Papers

Plenary and Technical Sessions Edition

TABLE OF CONTENTS

PROCEEDINGS OF THE 44th ANNUAL MEETING OF THE CARIBBEAN FOOD CROPS SOCIETY ii

Published by the Caribbean Food Crops Society iii

2007-2008 CFCS BOARD OF DIRECTORS AND OFFICERS iv

BOARD OF DIRECTORS iv

REGIONAL REPRESENTATIVES iv
- **English** iv
- **Spanish** iv
- **French** iv
- **Dutch** iv
- **ADVISORY BOARD** iv

TABLE OF CONTENTS Number 2 ..... v-xi

MONDAY PLENARY SESSIONS 1

Morning Plenary Session: Introductions and Official Welcome to the 2008 CFCS Meeting 1

DAVID SAMMONS 1

HÉCTOR SANTIAGO-ANADÓN 2

WILFREDO COLÓN 5

VICTOR HARABIN 7

CHELSTON BRATHWAITE 9

MAKOLA ABDULLAH 13

THE HONORABLE CHARLES BRONSON 15

JIMMY CHEEK 18

Morning Plenary Session: Setting the Stage 22
ANTHONY BRYAN 22

Morning Plenary Session: Introduction 29
ARLINGTON CHESNEY 29

Morning Plenary Session: Keynote Speaker: Perspectives on Enhancing Sustainable Growth and Development of Caribbean Agriculture 31
COMPTON BOURNE 31

Afternoon Plenary Session: Florida, Caribbean, United States Agricultural Trade and Marketing Challenges 42
THE HONORABLE CHARLES BRONSON 42

Afternoon Plenary Session: The Caribbean Community: Challenges as We Proceed into the Twenty-First Century 49
DESIREE FIELD RIDLEY 49

Afternoon Plenary Session: Perspectives on United States – Caribbean Basin Enhanced Trade and Food Safety Challenges 56
BRUCE KNIGHT 56

Afternoon Plenary Session: Vision of a New Transformation Paradigm for Caribbean Agriculture 64
CHELSTON BRATHWAITE 64

TECHNICAL SESSIONS: PAPERS PRESENTED ORALLY 77

FORAGE AND LIVESTOCK 77

Production of Eastern Gamagrass Accessions Grown under Greenhouse Conditions, *Ronald Smith and Errol Rhoden* 77

Relación Hoja-Tallo, Altura y Rendimiento de Seis Gramíneas Forrajeras, Tres Panicum y Tres Brachiarias, en un Suelo Ultisol, *Birmania Wagner and Rodys Colón* 84

Land Application of Food Processing Wastewater Residuals Effect on Dry Matter Yield of Tanner Grass, *M. St. Luce, G. Gouveia, and G. Eudoxie* 85

El Ensilaje de Barbojo de Habichuela con Niveles de Melaza/Urea, *J. Caridad, R. Silvestre y G. García Lagombra* 96

***Mucuna pruriens* Detoxification through Ensiling,** *Christiaan M. Huisden, Adegbola T. Adesogan, and Nancy J. Szabo* 101

Effect of Sonication and Two Solvent Extraction Methods on the L-dopa Concentration and Nutritional Value of *Mucuna pruriens,* *Christiaan M. Huisden, Adegbola T. Adesogan, and Nancy J. Szabo* 114

Physiological and Performance Effects on Rats Fed Detoxified *Mucuna pruriens,* *Christiaan M. Huisden, Adegbola T. Adesogan, Veronika Butterweck, Nancy J. Szabo, Jack M. Gaskin, Ademola Raji, Lv Yongning, and Elizabeth Maxwell* 123

Estudio del Tiempo de Almacenamiento Sobre la Eclosión del Huevo del Pato Pekinés, *Patricia Valerio, Gregorio García Lagombra, and Walkiria Cruz* 132

The Effects of Synchronization Treatments on Estrous Response in Seasonal Does, *Angela McKenzie-Jakes, G. Nurse, G. Byrant* 133

Poisonous Plants in the Pasture, *Mudge, D.M.* 134

FOOD SCIENCE AND POST-HARVEST TECHNOLOGY 135

Effect of Omega 6-3 and 9 Fatty Acids Plus Vitamin E on Egg and Human Blood Triglycerides and Cholesterol Levels, *Pablo de la Mota* 135

Huevos sin Colesterol: Paracol, su Efecto en la Lipidemia, *Pablo de la Mota* 136

Evaluating Hass Avocado Maturity Using Hyperspectral Imaging, *D. Girod, J.A. Landry, G. Doyon, J.A. Osuna-Garcìa, S. Salazar-García and R. Goenaga*.. 144

An Integrated Approach to Increasing Food Safety Awareness at the Farm Level among Small and Limited Resource Goat Producers in Florida, *A. McKenzie-Jakes, R. Mobley, T.E. Peterson, P. Hunter, G. Nurse, J. Beaudouin, G. Bryant, G. Queeley, S. Thompson, N. Tillman, and L. Anderson* 155

SOCIOECONOMICS AND POLICY 156

Innovative Strategies for Strengthening the Agricultural Sector of Puerto Rico, *Javier Rivera-Aquino and Wilfredo Colón-Guasp* 156

Finding an Agricultural Development Model for St. Thomas, USVI – Adapting an Extension Approach to a Small, Densely Populated, Caribbean Island, *Richard W.H. Pluke* 157

Linking Agriculture and Tourism: Constraints and Opportunities with a Focus on Local Food Chains in the U.S. Virgin Islands, *Stafford Crossman, Carlos Robles, Louis Petersen, Eric J. Wailes, and Francis A. Mwaijande* 166

Impact of Various Interventions on Revitalization of the Vital Agricultural Sector in Grenada Following the Destruction by Hurricanes Ivan and Emily in 2004 and 2005, Respectively, *Daniel Lewis*..... 170

Agriculture and CARICOM Development: Millstone or Panacea? *Timothy G. Taylor and Brian Francis* 171

Gleaning After Citrus Mechanical Harvesters – Labor Productivity, *Fritz Roka and Barbara Hyman* 172

Sweetpotato Export Market Development to the European Union, *D.H. Picha* 179

4-H Munchy Adventures Project Book, *Nancy J. Gal, Natasha Masciarelli, and Norma Samuel*..... 180

La Regencia Agropecuaria en Costa Rica, *Rojas-Cabezas, E.*..... 182

4-H Garden Project Builds Positive Life Skills in Youth, *Nancy Gal and Norma Samuel*..... 193

Biotechnology: Prospects for Development in Emerging Economies, the Case of the Caribbean, *Malachy Dottin*..... 195

The University of Florida IFAS Center for Tropical Agriculture, *Richard E. Litz* 196

CROP PROTECTION AND PEST MANAGEMENT 197

Green Genetic Engineering Technology: The Use of Endogenous Genes to Create Fungal Disease-Resistant Grapevines, *D.J. Gray, S.A. Dhekney, Z.T. Li and T.W. Zimmerman* 197

El Virus de la Tristeza de los Cítricos (CTV) en Plantaciones Comerciales y Viveros de la República Dominicana, *Luís Matos y Julio Borbón* 204

Acibenzolar-S-Methyl and PGPR Increases Host Resistance in Squash to Phytophthora Blight Under Greenhouse Conditions, *Shouan Zhang, Thomas L. White, Miriam C. Martinez, Joseph W. Kloepper, and Waldemar Klassen* 212

Management of Watermelon Vine Decline Caused by Squash Vein Yellowing Virus in South Florida, *P.D. Roberts, P.A. Stansly, S. Adkins, and W.W. Turecheck* 217

Comparison of Performance of Different Plastic Films for Soil Solarization, *Harsimran K Gill, Robert McSorley, Gaurav Goyal, Jeffery E. Pack, and Heidi Hanspetersen* 218

Policy Implications of the Entry of Black Sigatoka (*Mycosphaerella fijiensis*) into Puerto Rico, *E. A. Evans and C. I Alamo* 219

Use of Hay, Green, and Plastic Mulches to Suppress Nutsedge in Horticultural Crops, *Shabana, Yasser, Rosskopf, E., Morales-Payan J.P., Abou Tabl, A.H., Klassen, W., and Charudattan, R.* 233

Mortality to Giant African Snail *Achatina Fulica* Bowdich and Non-Target Snails Using Select Molluscicides, *Matthew A. Ciomperlik, David G. Robinson, Ian H. Gibbs, Angela Fields, Timothy Stevens, and Bret M. Taylor* 234

The Presence and Distribution of the Red Palm Mite, *Raoiella indica* Hirst (Acari: Tenuipalpidae) in Trinidad, *C. Shripat, F. Hosein, P. Siew and Y. Ali*.. 235

Establecimiento de *Doryctobracon Areolatus* (Szépligeti) (Hymenoptera: Braconidae), Parasitoide Exótico de *Anastrepha* Spp. (Diptera: Tephritidae), en la República Dominicana; Establishment of the Exotic Parasitoide of *Anastrepha* Spp. (Diptera: Tephritidae), *Doryctobracon Areolatus* (Szépligeti) (Hymenoptera: Braconidae), in the Dominican Republic, *Colmar A. Serra,*

Mileida Ferreira, Socorro García, Loeny Santana, Maira Castillo, Caridad Nolasco, Paula Morales, Timothy Holler, Amy Roda, and John Sivinski 249

Four Corn Silk Fly Species and Counting: Which Ones Are Primary Pests? *Gaurav Goyal, Gregg S. Nuessly, and Harsimran K. Gill* 261

Developing Surveillance Systems for Pests and Invasive Species- Lessons Learnt from the Jamaican Perspective and Implications for the Wider Caribbean, *P. Chung and D. Clarke-Harris* 262

DDIS and Diagnostic Networks: Building Partnerships for Safer Trade, *Carrie Lapaire Harmon, Jiannong Xin, and Timur Momol* 263

FRUITS, VEGETABLES, AND SPECIALTY CROPS 267

Impact of Elevated Carbon Dioxide and Temperature on Fresh Weight and Sugar Yield of Sugar Cane, *Leon Hartwell Allen, Jr., Joseph C. V. Vu, Joan C. Anderson, and Jeffery D. Ray* 267

Crop Water Stress Index and Yield Components for Common Bean (Phaseolus vulgaris L.) Genotypes in Greenhouse and Field Environments, *V. H. Ramirez Builes, E. W. Harmsen, and T. Porch* 279

Response of Common Bean (*Phaseolus vulgaris* L.) to Rhizobium Inoculation and Nitrogen Fertilization, *A.O. Ramírez-Madera, J.S. Beaver, D. Sotomayor-Ramírez, and C. Estévez de Jensen* 280

The Effects of Humus of Earthworm on Ivy Gourd Growing; Sustitución de Fertilizantes Químicos por Lombriz Compost en el Cultivo de la Tindora (*Coccinia grandis* L.), *Martin F. Tolentino, Jacquelin Daphinis, Jorge L. del Villar, José B. Nuñez, Carlos M. De Jesús Arias, Rafael A. Vásquez Martínez* 281

Challenges of Using Greenhouse Technologies in the Caribbean to Grow Food Crops, *Kimberly Moore and Luci Fisher* 290

Organic Agriculture in Trinidad and Tobago: Approaches and Successes of Grassroots Networks and Governmental Policies, *Mitra E. Sticklen and David Dolly* 291

An Evaluation of Factors Influencing Successful Grafting of Breadfruit on Chataigne Rootstock, *F. Solomon Jr. and L. B. Roberts-Nkrumah* 304

Analysis of External Coloration of the Low-Chill Peach 'Tropicbeauty' Grown in Puerto Rico, *María C. Padilla-Páez and J. Pablo Morales-Payan* 313

NATURAL RESOURCES 317

Microbial Population in Guyana Soils, *Subramanian Gomathinayagam* 317

Soil Biological Community Structure in Coffee (*Coffea arabica* L.) Agroecosystems in Puerto Rico, *David Sotomayor-Ramírez, Veronica Acosta-Martínez, Yusmary Espinoza, Eduardo Schröder, José Amador* 333

Training in Water Quality Concepts, Sampling and Analysis, *Yuncong Li, Kati Migliaccio, Teresa Olczyk, Ed Hanlon, Qingren Wang, and Pamela Fletcher* 346

Nutrients in Dairy Manure Sludge in Puerto Rico: Management and Implications, *David Sotomayor-Ramírez, Teodoro Ruiz, Yamil Quijano, Gustavo Martínez, Carlos Saavedra, and Alexander Recamán-Serna* 347

Fertilizer Prices and Controlled Release Fertilizers, *Yuncong Li, Edward Evans, Sikavas Na-Lampang, Xiahui Fan, Min Zhang, and T. Obreza* 355

MONDAY PLENARY SESSIONS
July 14, 2008

Morning and Afternoon Plenary Sessions: Introductions and Official Welcome to the 2008 CFCS Meeting

Welcome and Introductory Remarks by Invited Speakers and Sponsors

2008 Proceedings of the Caribbean Food Crops Society. 44(2):1-76. 2008

DAVID SAMMONS:

My name is David Sammons. I am co-chair of the Organizing Committee for the 44th Annual Meeting of the Caribbean Food Crops Society (CFCS). I'd like to welcome all of you here for our opening program this morning. Some of our speakers have not yet arrived, but we expect them to arrive in due order and we are going to go ahead and begin the program because we have quite a number of items to cover before we break for coffee. As I said, my name is David Sammons. I am at the University of Florida in the Institute of Food and Agricultural Sciences (IFAS), where I serve as Director of our Office of International Programs. Our office has taken upon itself the responsibility of providing a secretary and support services for the organization of this meeting. Many of the people you have seen around, with the word "Host" typed on their name tag, are members of my staff or IFAS staff, who are serving as co-hosts for the meeting. If you have questions or concerns, please look for the orange tags labeled "Host" and address your questions to those individuals.

I'd like to call your attention to the sponsors who have provided financial support to this meeting. Their names are listed in the small program; if you look on the back cover, there is a list of the sponsors who have provided support for this meeting. Representatives of those organizations are wearing tags that say "Sponsor." I would like to invite you to thank those individuals for their sponsorship. Without these sponsors, the program today and through this week could not have taken place. The names of the sponsors were sequenced on the screen as you came in, but just to call your attention to those sponsoring organizations, let me list them at this moment: Florida A&M University is one of our principal sponsors; the United States Department of Agriculture, Animal and Plant Health Inspection Service, or APHIS; we are grateful also to the Florida Cattleman's Association for financial support. We are grateful to IICA, the Inter-American Institute for Cooperation in Agriculture, for their support; the T-STAR program (Tropical and Subtropical Agriculture Research) is one of our principal supporters; and the University of Florida, Institute of Food and Agriculture Sciences (IFAS) and the Office of International Programs have also provided financial and organizational support for the meetings. So would you join me for a moment in showing our appreciation to these sponsors?

I hope you all enjoyed the reception last night, which was one of those events that was supported by these sponsors whom we have just thanked. You will be hearing from several of the sponsors during the next two hours and I know you will join me in expressing your appreciation for all that they have brought to us.

The meeting theme, as is printed on the front of this morning's brochure, and on the front of the program booklet, is "Repositioning Caribbean Agriculture" and then we subtitled that "Challenges and Opportunities for Sustainability." I think all of us realize that this is a timely topic, in light of current events that surround us. We are all confronted by rising food prices, by rising energy costs, the global threat to national security that is presented by these threats, and we certainly recognize that these threats impact the Caribbean Basin and all of us as well.

We have an array of notable speakers in our plenary session, which follows this opening session. It will be addressing this theme and that will continue through the latter part of this morning's program and into the afternoon. The full technical sessions will follow on Tuesday and Wednesday, and following the program booklet, you can see that we have organized the technical sessions around a variety of themes pertinent to not only the theme of the Conference, but pertinent to agriculture in its multiple dimensions here in the Caribbean Basin.

I'd like to ask you to take out your small brochure and we will begin with our formal opening ceremony at this point. I'd like to begin by introducing Dr. Héctor Santiago. Dr. Santiago, as many of you know, is the Associate Dean and Deputy Director of the Agricultural Experiment Station of the University of Puerto Rico-Mayagüez, a position he has held since 2005. He has numerous duties and responsibilities in his professional capacity. He is, for example, current president of the Puerto Rican Society of Agricultural Sciences, but most importantly, from our perspective, Dr. Santiago is chair of the Board of Directors and Chief Executive Officer of this organization, the Caribbean Food Crops Society. Dr. Santiago received his Bachelors and Master's Degrees in Animal Science from the University of Puerto Rico, and earned his PhD from Virginia Polytechnic Institute and State University in the area of Poultry Genetics and Physiology in 2002. I'd like to turn the podium over to Dr. Santiago to officially inaugurate the 44th Annual Meeting of the Caribbean Food Crops Society.

HÉCTOR SANTIAGO-ANADÓN:

Thank you, David. *¡Buenos Dias! Bonjour!* Good Morning! Good morning and welcome to the 44th Annual Meeting of the Caribbean Food Crops Society. I would like to extend a special welcome to our members and also recognize the distinguished speakers who are with us today: **Dr. Jimmy G. Cheek,** President of the CFCS and Senior Vice-President of Agriculture and Natural Resources at the University of Florida, Institute of Food and Agricultural Sciences; **Dr. David Sammons,** Director of the University of Florida IFAS International Programs Office; **The Honorable Matti Herrera Bower,** Mayor of the City of Miami Beach[1]; **Dr. Makola Abdullah,** Dean and Director of Land Grant Programs at Florida A&M University; **Mr. Victor Harabin,** Regional Director of USDA/APHIS Plant Protection and Quarantine; **Dr. Chelston**

[1] The Hon. Matti Herrera Bower did not arrive for the meeting.

Brathwaite, Director-General of the Inter-American Institute for Cooperation on Agriculture (IICA) in San Jose, Costa Rica; and **The Honorable Charles Bronson,** Florida Commissioner of Agriculture in Tallahassee, Florida.

I would like to acknowledge the participation in this meeting of certain people:

- **From Florida: Dr. Van Waddill,** Director of the University of Florida IFAS Ft. Lauderdale Research and Education Center and Director of the Tropical Research and Education Center; **Dr. Christine Waddill,** Director of the University of Florida IFAS Everglades Research and Education Center and Director of the Southwest Florida Research and Education Center; **Dr. Jack Rechcigl,** Director of the University of Florida IFAS Gulf Coast Research and Education Center.
- **From North Carolina: Dr. Eric Young**—he is the Executive Director of the Southern Association of Agriculture Experiment Station Directors.
- **From the Virgin Islands: Dr. Louis Petersen**—he is the Commissioner of Agriculture; **Mr. Herald Chichester,** Vice-Commissioner of Agriculture of the U.S. Virgin Islands.
- **From Puerto Rico: Dr. John Fernandez Van Cleve,** Dean and Director of Agriculture of the College of Agriculture and Sciences; from the University of Puerto Rico at Mayagüez; **Congressman Javier A. Rivera-Aquino,** Member of the House of Representatives, President of the Agricultural Commission; and **Dr. Ricardo Goenaga,** Director of the USDA ARS Tropical Agriculture Research Station, or TARS
- **From Costa Rica: Dr. Héctor Medrano,** Professor of EARTH University; and Agronomist-Engineer Edgar Rojas Cabezas, from the College of Agricultural Engineers of Costa Rica.
- **From Antigua: Mr. Clarence Pilgrim**—he is the permanent Secretary of the Ministry of Agriculture of Antigua.
- **From the Dominican Republic: Mr. César Cruz,** Executive Director of the Board of Directors of the Caribbean Council of Higher Education in Agriculture, or CACHE; **Mr. Juan José Espinal,** Executive Director of the *Centro para el Desarroyo Agropecuario y Forestal*, or CEDAF.
- **From Martinique: Mr. Ernest Xavier Merlini** former President of the CFCS; **Ms. Luciana Denette; Mr. Thelcide, Ms. Malsa,** and **Mrs. Laurence** from the Regional Council of Martinique; and **Mr. Ovide-Etienne,** from the Chamber of Agriculture of Martinique.

We are grateful for your participation in our meeting. I am particularly pleased to open this meeting, my first as Chairman. It is with great pleasure and excitement that I proclaim the opening of the 44th Annual Meeting of the Caribbean Food Crops Society. This is the first time that the CFCS celebrates this reunion in the United States and we are delighted to be here in Miami, Florida. The CFCS forms an integral component of Caribbean agriculture. It has provided the forum to expose problems, share knowledge, and bring solutions for forty-four years, since it was founded in 1963 in San Juan, Puerto Rico. Today, we can say with confidence that we are a strong Society comprised of more than 300 members coming from 23 countries and territories of the Caribbean. As you

may know, the central theme for this year is, "Repositioning Caribbean Agriculture: Challenges and Opportunities for Sustainability."

I can attest that the Florida Organizing Committee has worked very hard in organizing an event that will nourish our society and provide the environment to share the knowledge gained through research. The scientific program for this week is very diverse, and has, in the schedule, over 160 scientific presentations in the areas of forage and livestock, food science and post harvest technology, socioeconomics and policy, crop protection and pest management, fruits, vegetables and specialty crops, and natural resources. As in previous years, all day Tuesday will be dedicated for a forum in invasive species that pose a threat to the agricultural sector of our region. On Monday evening, we will enjoy dinner as we cruise the Miami Intracoastal Waterway for the cultural night. Scientific posters will be exhibited in the Mediterranean Room.

On Tuesday afternoon, we will gather for the author presentation and networking social. Concurrent with the scientific program, the CFCS is proud to host the fourth Director's Meeting of the Caribbean agriculture research centers and the meetings of the Board of Directors of the Caribbean Council of Higher Education in Agriculture in PROCICARIBE. The CFCS reception and awards dinner will be in the Starlight Ballroom on Wednesday evening. On Thursday will be our customary field trips that were organized to visit an array of agriculture and related science that will fulfill all interests and tastes. All field trips will convey participants to Redlands Winery, an agro-tourism winery and distillery of tropical fruit wines, where we will have lunch and enjoy the beautiful surroundings.

At this moment, I would like to introduce the members of the Board of Directors of our Society: **Dr. Wilfredo Colón,** Dean of Science and Technology of the *Universidad del Este*, in Puerto Rico—he is the Secretary; **Dr. Alberto Beale,** researcher at the University of Puerto Rico Agricultural Experiment Station and former CFCS CEO—he is the Treasurer; and **Dr. Jimmy Cheek** from the University of Florida/IFAS—he is the current President of the 2008 CFCS.

The regional representatives of the CFCS are:

- **From the English-speaking countries: Mr. Kwame García,** from the U.S. Virgin Islands; **Dr. Bruce Lauckner,** from CARDI, Trinidad & Tobago; and **Dr. William Brown,** from Florida;
- **From the Spanish-speaking countries: Dr. Jerry Dupuy,** from the private sector of the Dominican Republic, and **Dr. Wilfredo Colón** from Puerto Rico;
- **From the French-speaking counties: Mr. Marceau Farrant** from INRA, Guadeloupe; **Dr. Isabelle Jean Gaptiste,** from AMADEPA, Martinique, and **Jean-Louis Diman** from INRA, in Guadeloupe;
- **From the Dutch-speaking countries:** we have **Mr. Robert Tjien-Foo** from the University of Surinam in Surinam.

The members of the Advisory Board are: Dr. Altagracia Rivera y Castillo from the Dominican Republic—she is the current President; **Dr. Harry Ozier-La Fontaine**, from INRA in Guadeloupe; **Dr. H. Arlington Chesney**, from CARDI in Trinidad and Tobago; **Mr. Rafael Perez Duverge** from INRA in the Dominican

Republic; **Professor Vivian Carro** from the University of Puerto Rico; **Dr. Claude Vuillaume** from CIRAD, Guadeloupe; **Dr. Errol G. Rhodin,** from the historically black colleges and universities; **Dr. Cassel Gardiner** from Florida A&M in Florida; **Dr. Guy Anais** from INRA—he is retired in Saint Martin; and **Dr. Louis Petersen** from the U.S. Virgin Islands.

I would like to take a few minutes to recognize the Miguel and Aurora Lugo scholars and I will ask Dr. Wilfredo Colón to join me at this moment.

WILFREDO COLÓN:

Good morning! It is with great pleasure, and an honor, that we want to share with you our newest project. This is a project that we have been working with, or trying to establish, for a couple of years. This year was the first time that we were able to go through the whole procedure and share with you the creation of the Miguel and Aurora Lugo Caribbean Food Crops Society's student-scholars. This program was created in honor of Dr. Miguel Lugo Lopez, founding member of the Caribbean Food Crops Society and distinguished Caribbean scientist, and his wife Aurora Lugo, also a founding member of the CFCS and an active member of the Board of Directors for numerous years. Dr. Lugo passed away a couple of years ago and Aurora Lugo has just turned 90, this last May, and we had an opportunity to share with her this initiative by the Caribbean Food Crops Society. She was so honored and glad to know that we will perpetuate her name and the name of her husband.

Later in the year, we will be posting on our website more details about the biographies of these two distinguished first members of the Caribbean Food Crops Society. We established this program specifically with the following objectives: to foster research as part of the overall educational process of the students who are working in the Caribbean region, both undergraduate and graduate students; support talented students in the presentation of their research outcomes at the CFCS annual meetings; to expose students to international networking experience, which is our meetings; and to mentor talented students in the overall functions of our Society so they can eventually occupy leadership roles in the Caribbean. We placed an application form on our website at the beginning of the year and we had around eleven students who applied.

From those eleven students, five were evaluated, because they had to submit an abstract of their research program, plus two letters of recommendation from active members of the CFCS. I want to ask Mr. Frankie Solomon, Jr. to please join us and Mr. Axel Ramirez also to join us and approach the podium. I want to ask Héctor Santiago and Dr. David Sammons to join us here in the front. Mr. Frankie Solomon, Jr. will be making an oral presentation this week, and he is from the University of the West Indies, Saint Augustine, in Trinidad and Tobago, and Mr. Axel Ramirez is from the University of Puerto Rico, Mayagüez campus, and he will also be making an oral presentation this week. So we are giving them a big check—a very big check—and this will help to pay for their visit and their registration and participation in this year's annual meeting. On behalf of the Caribbean Food Crops Society, we want to present to you our first class of the Miguel and Aurora Lugo Caribbean Food Crops Society student-scholars. Let's give them a round of applause. Thank you very much.

HÉCTOR SANTIAGO-ANADÓN:

Congratulations to both of them. I think they are very good students and they really deserve some kind of help. Before concluding, I would like to express my gratitude to the members of the local Organizing Committee for their efforts and dedication towards this event: **Dr. Jimmy Cheek,** President of the CFCS Board of Directors; **Dr. Bill Brown** from the University of Florida Animal Science Department and President of the Florida Organizing Committee. We all know that he left and he is now the Associate Dean of the Agricultural Experiment Station at the University of Tennessee; **Dr. David Sammons,** Director of the International Programs Office. He took care of us, being the President of the Organizing Committee, and his staff: **Mrs. Marti Dettman-Kruse** and **Ms. Linda Evans,** for all their efforts; **Mr. Carlton Davis** of the University of Florida/IFAS Food and Resource Economics Department; **Dr. Waldemar Klassen** from the University of Florida/IFAS Tropical Research and Education Center; **Dr. Martha Roberts** from the University of Florida/IFAS, Industry Liaison, North Florida Research and Education Center; **Dr. Christine Waddill,** Director of the UF/IFAS Everglades Research and Education Center and the Southwest Florida Research and Education Center; **Dr. Van Waddill,** Director of the UF/IFAS Ft. Lauderdale Research and Education Center and the Tropical Research and Education Center; **Mr. Mark Trujillo,** from the University of Florida/IFAS T-STAR Research Office; and **Mrs. Carolina Vendrame,** from the University of Florida/IFAS Tropical Research and Education Center.

I hope that this Conference will generate new ideas and further initiatives to promote sustainable agriculture in our countries, to implement research-based initiatives, and foremost, to enhance international cooperation. We gratefully acknowledge the participation of the countries and the international organizations in this conference. The CFCS is grateful to the University of Florida for hosting this Conference, and to the cooperating institutions and organizations, whose contributions made possible the realization of this event. Thank you all for coming.

DAVID SAMMONS:

We have a special presentation for each of today's speakers; I'd like to show you what it is. I will present it to each of the speakers in turn. We have a small crystal paperweight with a globe that sits on it that actually will turn. It is quite nice. Each of these is inscribed in turn with the name of the presenter. The one I'm going to present to Dr. Santiago will say the following:

Héctor Santiago-Anadón
With great appreciation from the Caribbean Food Crops Society
44th Annual Meeting
July 13th through 17th, 2008

I am not going to take it out of the box because I don't want to risk damaging it, but Héctor, may I present this to you on behalf of the Organizing Committee with grateful appreciation and thanks?

We had expected the Mayor of Miami Beach, The Honorable Matti Herrera Bower, to be with us this morning, but it appears she has been detained, and she is not with us. So I am going to move on in the program in her absence. If she does arrive, I will introduce her at the appropriate time. I am going to go on in her absence and introduce the next welcomer: Mr. Victor Harabin.

Mr. Harabin is a distinguished plant protection specialist who began his career with the U.S. Department of Agriculture, Agricultural Marketing Services, Federal Grain Inspection Service, in 1978, in New Orleans, Louisiana. In 1980, he joined APHIS, the Animal and Plant Health Inspection Service, of PPQ, which is Plant Protection and Quarantine. He joined APHIS and PPQ as an officer in New Orleans. In 1985, in recognition of his skills, he was brought to Frederick, Maryland, to work on rewriting the PPQ Field Manual. In 1992, he was assigned to the Permit Unit in Hyattsville, Maryland, where he oversaw the issuance of import permits and initiated regulatory revisions to allow new commodities into the United States, including, notably, the *Mexican Hass* avocado, which has become an important component of the fresh fruit and vegetable markets in this country. In 1995, Mr. Harabin was selected as the State Plant Health Director for North Carolina. When APHIS went through a regional consolidation at a later date, he was selected as the Eastern Regional Director, and then later, as the Eastern Regional Director to serve as the Acting Director for the Center for Plant Health Science and Technology.

As you can see, his long and distinguished career has been built around the notion of crop protection, quarantine, and the important dimensions of those kinds of services to protect the nation. We have benefited much from his work and leadership, as have all of you in the Caribbean who share the desire to keep pest organisms under control and to manage movement across international boundaries. I would like to introduce Mr. Harabin at this point and point out that his organization—APHIS—is one of the important contributors to this meeting. Will you join me in welcoming Mr. Victor Harabin?

VICTOR HARABIN:

Thank you. Good morning, everyone: **Dr. David Sammons,** CFCS Organizing Committee and International Program Director at the University of Florida IFAS; **Dr. Héctor Santiago,** Chairman of the CFCS Board and Chief Executive Officer of the University of Florida; **The Honorable Matti Herrera Bower,** Mayor of the City of Miami Beach; **Dr. Makola Abdullah,** Dean and Director of Land Grant Programs, Florida A&M University; **Dr. Chelston Brathwaite,** Director-General, Inter American Institute for Cooperation on Agriculture; **The Honorable Mr. Charles Bronson,** Florida Commissioner of Agriculture; **Dr. Jimmy Cheek,** CFCS President and Senior Vice-President for Agriculture and Natural Resources, University of Florida IFAS, and all distinguished guests and participants at this 44th Annual Meeting of the Caribbean Food Crops Society.

It is my pleasure to welcome you here today in Miami on behalf of our APHIS administrator, Ms. Cindy Smith, who could not be here, but sends her regards. When CFCS decided to hold the 2008 Annual Meeting here in Miami, Florida, APHIS welcomed the opportunity to co-sponsor this meeting. The Organizing Committee has an

outstanding agenda planned, including tomorrow's invasive species symposium. As a partner in the greater Caribbean's efforts to deal with invasive species that affect our natural resources, food production, food safety and trade, APHIS is greatly interested in excluding new pests into the region, mitigating those that are already present, and preventing those from spreading further throughout the region.

Those interests are exemplified in our capacity-building activities involving pest surveillance, detection, and identification of exotic pests of mutual concern; pest mitigation against pests such as the red palm mite, giant African snail, and fruit flies; safeguarding at regional ports of entry, pest risk assessment and communication; and many other activities. We all need to keep in mind that international trade is not always free or safe. As our countries continue to share commodities across our borders, we need to share the responsibility of ensuring that those commodities are free of pests and diseases that could damage each other's agricultural production, food safety and future trade capabilities. Failure to do so could result in our expenditure of huge resources to eradicate or manage pests, and impact our ability to trade in certain commodities.

Our Plant Protection and Quarantine program is actively involved in some of these safeguarding efforts through coordination by our Caribbean Safeguarding Initiative (CSI). This program is currently based in Florida, but will soon be expanding with more national focus and resources. CSI's goal is to reduce the risk of plant pests moving into the US through the Florida pathway, but this goal cannot be fully effective without implementation of the Caribbean Regional Invasive Species Intervention Strategy (CRISIS). APHIS is working closely with many other agencies and institutions in the Region to reduce the risk of plant pests moving into and throughout the region, including: UF/IFAS, FAMU, Florida Department of Agriculture and Consumer Services, USDA[2] ARS[3], CARICOM[4], CARDI[5], OIRSA[6], IICA[7], CISWG[8], and the Caribbean Plant Heath Directors group. Our Offshore Pest Information Program is focusing on specific target pests and diseases of concern. Our APHIS International Services offices in Santo Domingo, Port of Spain, Port-au-Prince, Kingston, San Jose, Guatemala City, Tegucigalpa, Bogotá, Caracas, and Quito stand ready to assist the Ministries throughout the Greater Caribbean Region with trade and capacity-building issues.

We hope that you will enjoy and benefit from the fine program that has been put together by the Organizing Committee. I hope you will take the opportunity on Thursday to participate in one of the field tours that are designed to showcase some of South Florida's agricultural production and research facilities. Please enjoy the wonderful

---

[2] USDA: United States Department of Agriculture

[3] ARS: Agricultural Research Service, USDA

[4] CARICOM: an acronym for the Caribbean Community, an international organization of independent nation-states. CARICOM was established to promote regional unity and coordinate economic and foreign policy among Caribbean nations. Member countries include Antigua and Barbuda, Barbados, Belize, Dominica, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago. The Bahamas belong to the Caribbean community but not the Common Market. Information and member-nation list courtesy of Encarta Encyclopedia (online).

[5] CARDI: Caribbean Agricultural Research and Development Institute

[6] OIRSA: Organismo Internacional Regional de Sanidad Agropecuaria

[7] IICA: Inter-American Institute for Cooperation on Agriculture

[8] CISWG: Caribbean Invasive Species Working Group

"magic city" of Miami and, if possible, take the opportunity to enjoy other sites here in beautiful South Florida.

DAVID SAMMONS:

I would like to thank the Organizing Committee for the opportunity to make these few welcoming remarks and wish you all an enjoyable and productive meeting.
I would like to present Mr. Harabin with a trophy in recognition of his support, for his organization's support for the meeting, and his continuing interests in the affairs that pertain to the work that all of us do.

OK, we are going to move on with another important supporter of these meetings, in the person of Dr. Chelston Brathwaite. Dr. Brathwaite is not a stranger to us. He has been with us through many of our meetings. As many of you know, he is a citizen of Barbados, but when I talk to Dr. Brathwaite, I think of him as a citizen of the world.

Dr. Brathwaite has worked in many areas of the world: in Europe, in Africa, throughout the Caribbean Basin, Central America, and Mexico. His professional credentials span the globe. We welcome him here to our meeting in Miami Beach. As most of you are well aware, Dr. Brathwaite is currently the Director-General of the Inter-American Institute for Cooperation in Agriculture, or IICA, a position that he has held since 2001. In his role as Director-General, he has initiated a process of institutional reform at IICA that has made it an institution of excellence, with clearly-defined priorities, a decentralized operating mandate, and an institution that promotes partnership with member states for the benefit of all of the Americas, something that is a standout contribution professionally to our region.

Dr. Brathwaite started his career with the Food and Agriculture Organization of the United Nations in 1970, and since then, has served in a number of capacities that are described in the brochure which you have in front of you. He holds a doctoral degree in plant pathology from Cornell University, and has also been awarded a diploma in agriculture development, with distinction, from the University of London. I would like to invite Dr. Brathwaite to the podium to address the meeting. Dr. Brathwaite.

CHELSTON BRATHWAITE:

Thank you, **Dr. David Sammons,** Chairman, for your kind remarks; for your kind invitation. *¡Buenos Dias!* Good Morning! *Bonjour! Bom Dia!* **Dr. Héctor Santiago,** Chairman of the CFCS Board, Chief Executive Officer, University of Puerto Rico;
Mr. Victor Harabin, Regional Director, USDA/APHIS; **Dr. Makola Abdullah,** Dean and Director of Land Grant Programs, Florida A&M University, Tallahassee; **The Honorable Charles Bronson,** Florida Commissioner of Agriculture; **Dr. Jimmy Cheek,** CFCS President, Senior Vice-President of Agriculture and Natural Resources, Gainesville, University of Florida; **Dr. Anthony Bryan,** Senior Associate, Americas Program, Center for Strategic International Studies, Manchester Trade, Professor Emeritus, University of Miami; the Board of Directors of CFCS; representatives of regional international organizations; staff of the University of Florida; staff of the IICA; distinguished guests; ladies and gentlemen.

Let me begin by thanking you for the kind invitation to be present at this 44th Annual Meeting of the Caribbean Food Crops Society, to discuss the repositioning of Caribbean agriculture, the challenges and opportunities for sustainability in this changing

world in which we live. We meet at a time when food security, energy security and climate change are key issues on national, regional, and global agendas. Mr. Chairman, I wish to congratulate the Caribbean Food Crops Society on your continuing efforts to promote sustainable agriculture development in the Caribbean, and I wish to congratulate the University of Florida, Dr. Jimmy Cheek, Dr. David Sammons, Professor Carlton Davis in particular, for your kind efforts in supporting this global endeavor.

Our institute is concerned about the increases in food prices, and we have been evaluating the potential impact of increases in food prices on the agricultural sector of the Americas, and its implications for consumers, for producers, and for the rural economies. We are prepared to assist our member states with the technical knowledge and the information that can contribute to finding solutions that will improve food and energy security and promote a sustainable environment for this generation, as well as future generations. The World Bank and others have indicated very clearly that the observed increases in food prices are not a temporary phenomenon; rather, it is a trend that is likely to persist in the medium term. The reasons that have been advanced for the increase are many. We have identified four which we think are of particular importance: increased demand for agriculture products as feed stock for biofuel production; droughts in Australia, low crop output in Europe; increased demand for meat protein and cereals, especially in China and India; increased costs of agricultural inputs, such as fertilizer and pesticides and transport, as a result of increased oil prices, which we understand today is $147.00 a barrel. It is interesting to note that, in 1972, oil was $2.00 a barrel.

We believe that the sustained increase in food prices will contribute to higher levels of poverty and poor nutrition in our hemisphere. In a recent meeting in Medellin, Colombia, IICA indicated that the economic progress we have made in the last five years, of positive economic growth, where 27 million people have moved out of poverty in the hemisphere, the possibility exists that 27 more will return to poverty. It will limit our capacities to achieve the millennium development goal of reducing poverty by 50% in 2015, unless steps are taken to increase food security. In fact, the time has come when I think we are going to have to revise the millennium development goal. The Caribbean, in particular, is at a pretty good time in its history. We have a development model. We live the development model that was based on cheap food, cheap energy, protected markets, and stability in terms of our societies.

Today, we face high food prices, high energy prices, no preferential market, and increasing incidence of crime and violence. I have been given the opportunity to speak again today. And one of the things which I will indicate in that address is that we must consider a new development model, because we are in different times. IICA recognizes that food prices and food supply are not determined by any single factor. We also recognize the enormous potential of renewable fuels for global energy security, the environment, and economic well-being, and their likely implications for food security. The debate over biofuel production will be less controversial as national governments and their private sector partners, at the country level, become engaged in developing national agro-energy strategies and biofuel policies and regulatory frameworks that are based on good science and sound economic policy. The apparent global imbalance between supply and demand in relation to cereals is now an incentive for producers in developing countries to increase their national cereal production for food in a sustainable manner, to take advantage of new opportunities in the internal and external markets.

This new scenario is particularly positive for countries of Latin America and the Caribbean cereal producers who could increase their crop production in a gradual and sustainable manner, thereby creating opportunities for the rural population. Instead of a crisis, we see the increased food prices as an opportunity. In IICA, a viable approach to the so-called food-versus-fuel predicament would be to diversify the feed stock and technology from which biofuels are produced, concentrating on products with a longstanding and positive track record, such as sugar cane, and promoting the development of new, innovative technologies, such as cellulose and ethanol technology. We are of the view that agro energy and biofuel production can contribute to the world's energy supply without being a threat to food security, if we use non-cereal resources, such as sugar cane, oil palm, cellulosic biomass, agricultural wastes, Jatropha, among others, for the production of biofuels.

In addition, technical studies on a number of alternative feed stocks for biofuels are already underway, and these studies could be encouraged and should form the basis for decision-making by national governments and the private sector. It is our view that agricultural research and investment in new technologies are necessary in order to make biofuels production sustainable, economically viable, environmentally sound, and socially equitable. Government leaders, civic leaders, and leaders of the private sector have an enormous responsibility to contribute to alleviating the critical food situation. For this, they will require up-to-date technical and scientific knowledge; in that regard, what you do in this Caribbean Food Crops Society is critically important in generating knowledge and technical information that can help decision-makers develop strategies and programs to address the food security that exists in our region.

These policies must include policies that protect the most vulnerable in our societies from the impact of increase in food prices, and at the same time, they must stimulate food production to satisfy increased food demand. But a question must be recognized: that a question of production is not the only problem. The problem must be the capacity of those with limited income to buy food being an exclusive right. Our institute is of the view that a time has come for the countries of the Americas to review their food security policies and take steps to avail themselves of the technical information that will help them to design appropriate state policy—not sectoral policy—but state policy, for agricultural production and for improving food security in our countries.

Unless the welfare of farmers and food security of the nation are priority items in the national development agenda, we shall not solve the problem. So far, agricultural development and investment in agricultural technology and innovation has been on the decline in many of our countries in the last twenty-five years. The last report by the World Bank on agricultural development was written in 1982. In 1980, 30% of annual World Bank lending went to agricultural development; in 2007, that figure fell to 12%. We are pleased that the World Bank has noted, in their 2008 world development report, that agriculture is crucial and key to achieving the millennium development goals, if our goal is to reduce poverty. IICA welcomes this vision and hopes that development institutions and national governments will invest more in agricultural development.

Since 2006, in implementing our medium-term plan for 2006 to 2010, we have been assisting our member states in areas such as trade capacity-building and agribusiness, agro energy, agricultural health and food safety, biotechnology, agricultural

insurance, agro-tourism, rural agro industry, and organic agriculture, all of which have great potential for the promotion of food security in the hemisphere. Implementation of our medium-term plan will also help in the design of appropriate policies and strategies aimed at improving the welfare of the most vulnerable of our societies, offer education and training aimed at improvement knowledge and skills and the abilities, so that the vulnerable groups of women and youth and indigenous people may participate effectively in agricultural and rural markets; strengthening civil society or associations and the promotion of greater interaction among actors in the food chain in order to produce common agendas and improve their ability to negotiate and defend their interests; promotion of the modernization and expansion of agricultural services; strengthening the Extension services, which, as many of you know, were dismantled during the structural adjustment programs of the 1980s and the 1990s; strengthen agricultural and rural organizations and trade capacity and other relevant things; and the promotion of investment in agricultural research and technology innovation.

It is our firm belief that our institute's work in these areas, together with the implementation of some national policy, will help our countries modernize their agricultural sectors, and confront the challenges associated with rising food prices and food scarcity in our member states. At this time, when we face the enormous challenge of food and security in the hemisphere, our institute is prepared to support our countries in providing technical knowledge and information. Our representatives in our 34 member states have been instructed to review our national agendas and to work with international organizations, the private sector, development banks, in preparing plans and projects to meet the challenges of our time and build a more secure world.

I thank you for this opportunity, and good morning to all.

DAVID SAMMONS:

Dr. Brathwaite, let me say again how pleased we are by your support for our meeting this year, and once again, you have shown us the leadership capacity that you bring to the region, with those stimulating and thought-provoking remarks. Let me present this to you in appreciation for your service to the organization and to the region. Thank you very kindly.

Our next presenter is a new individual in the region. We are very pleased to have him with us this morning. He just arrived from Tallahassee in the last twenty minutes or so: Dr. Makola Abdullah, the newly-appointed Dean and Director of Land Grant Programs at Florida A&M University. Florida A&M University, if you are not familiar with this organization, is located in Tallahassee, our State Capital. Dr. Abdullah was appointed Dean in January, 2008, and in that capacity, he serves as the lead administrator of academic, research and extension programs that are housed in the Florida A&M University, College of Engineering Sciences, Technology and Agriculture, which is known by the acronym "CESTA." I invite you, when you have a moment, to visit the exhibit that has been put up by Florida A&M University/CESTA, to learn more about the work that is going on in this fine institution, which is a sister institution with my university, the University of Florida.

Dr. Abdullah was previously employed in the FAMU Office of Sponsored Research as Associate Vice-President for Research. He also has served as professor in the Department of Civil Engineering, in FAMU. Prior to coming to Florida, Dr.

Abdullah was at the University of Buffalo, where he served as Director of Diversity Programs for a multi-disciplinary center for earthquake engineering research. He is a native of Chicago. He received his PhD from Northwestern University, where he was recognized as the youngest African-American to ever receive a PhD in Engineering. He is a member of the National Society of Black Engineers and the American Society of Civil Engineers. He has remained committed, throughout his career, to promoting opportunities for African-Americans to enter professional fields in the so-called "STEM" disciplines: Science, Technology, Engineering, and Mathematics. We welcome him as a representative of his institution, a generous supporter of this meeting, to make some remarks to this opening session.

MAKOLA ABDULLAH:

Thank you, Dr. Sammons. To the platform guests, thank you very much for your work and your support of this particular meeting here today, and on behalf of Florida A&M University—one of the two universities here in the State of Florida that is dedicated to teaching, research and outreach in the food and agricultural sciences—I welcome you to this meeting. I also would like to congratulate the Society on fostering cooperation and dialogue for over four decades. This meeting is a very significant occasion, because it is the first time that this meeting has been held in the continental United States in forty-four years, and I would say that it comes at a very critical time for the world. The rising costs of energy and food have become daily news items. Food and energy security are our major goals for many countries. Never have the challenges been so great, and the need for even greater collaboration so important.

The theme of the meeting, "Repositioning Caribbean Agriculture, The Challenges and Opportunities for Sustainability," is very appropriate, as we have become increasingly aware of the importance of preservation of the integrity of our planet, including the mitigation of the effects of climate change, the conservation of biodiversity, and the need for development and utilization of sustainable approaches to the exploitation of ecosystem services provided by Earth. It will be necessary to improve or develop approaches that reduce the negative effects of—and vulnerability of—agriculture to climate change. It will also be vital to continue improving the understanding of resources that are essential to our farming systems, such as soil, water, and agro-biodiversity.

While advances in agricultural research have been critical in making it possible for us to meet many of our basic food needs, these benefits have not reached everyone, and the demands have continued to increase and become even more complex. It is imperative for the agricultural enterprise to be responsive to the new priorities and changing circumstances. This also comes at a time when there is greater awareness of the important, multifunctional role that agriculture plays. This multi-functionality of agriculture can only be understood and managed by the evolution of existing, or the development of new, conceptual tools to take into account the complexity of agricultural systems. So why is this meeting so important? Faced with today's challenges, training, research, and extension entities must reorient themselves in order to effectively develop solutions. It will be particularly important to develop multidisciplinary and interdisciplinary research involving a wide range of stakeholders, taking account of both spatial and temporal scales.

Florida is geographically and ecologically linked to the Caribbean Basin, and globalization has cemented some very strong social and economic ties. Because of our common links, we share many common problems, many of which will be the subject of this meeting. Why is FAMU so interested in engaging in this exercise? We, as Florida A&M University, are committed to the globalization of our institution and to providing our resources to the rest of the world in the areas in which we have expertise. Those areas of expertise include the management of invasive pests, our small-ruminant programs, and our soil, air, and water-quality programs. Our training programs are continuously being revamped and enhanced to ensure that our students, both local and international, receive the most appropriate training to ensure that they are ready to meet the challenges of a globalized and interdependent world of today and tomorrow. Enhanced institutional and organizational arrangements will be essential to support the needed integrated approaches to the development, dissemination and uptake of knowledge and technologies, with increased emphasis on interactive knowledge networks, doing research, education and extension and multidisciplinary research programs to address these new complexities.

I wish you a very productive meeting and I look forward for the opportunity for myself and for the faculty of Florida A&M University to able to interact with everyone. Thank you.

DAVID SAMMONS:

Dr. Abdullah, again; thank you and your institution for their support for this meeting, and thank you for those thoughtful and contributory remarks in the opening session. As for the other speakers, I would like to present you with a small memento of your presence here, with our grateful thanks and appreciation.

Our next speaker is The Honorable Charles Bronson, a distinguished Floridian who is a fifth-generation resident of this state. If you read Mr. Bronson's biography in the booklet in front of you, you will note that his family traces his agricultural ancestry in Florida to the year 1635, which is remarkable. Most of us are imports, as you probably have come to realize. I was born in Ohio, have lived in Indiana, Illinois, Massachusetts, New York, Maryland and Virginia along the way, and ended up in Florida two years ago, as did many of the residents of this state. Like the United States, Florida is a state of immigrants. But Mr. Bronson is one who traces his ancestry for many, many years. We welcome him here in his capacity as the tenth Agricultural Commissioner of the State of Florida.

In his capacity as Commissioner of Agriculture, Mr. Bronson manages the largest State Department of Agriculture in the United States. I will say that again, "The largest State Department of Agriculture in the United States" with more than 3,700 employees working on behalf of our major industry. His responsibilities as Commissioner of Agriculture include overseeing the State's agricultural industry, promoting its products, safeguarding the State's food supplies, protecting consumers, and managing over a million acres of State forests. Mr. Bronson was initially appointed to the office which he now holds, as Commissioner of Agriculture, in May of 2001, to fill the unexpired term of the former Commissioner. He was elected in his own right to the post in November, 2002, and then was re-elected in November, 2006, to head this office.

He is a product of the University of Georgia, where he earned a Bachelor of Science degree in Agricultural Education, and I must say, he has been a wonderful supporter of IFAS, the Institute of Food and Agricultural Sciences at the University, and we count him among our many friends in the agricultural community. In addition to his current post as Commissioner of Agriculture, Mr. Bronson also did serve a period as a member of the Florida Senate, to which he was elected in 1994. Please join me in welcoming The Honorable Charles Bronson to the podium.

THE HONORABLE CHARLES BRONSON:

Thank you, Dr. Sammons. I extend my appreciation to the distinguished guests at the head table and also to all of our good friends in the Caribbean Community. Welcome to Florida on behalf of myself as Commissioner of Agriculture and one of the Board Members of the Florida Cabinet. And welcome on behalf of all the members of the Department of Agriculture, especially our Marketing Division, which sends its people all over the world, especially into the Caribbean area, to try to find ways for us to enjoy trade with one another on a yearly basis.

Let me say that I am going to cover a number of things after lunch on some of our trade issues, but listening to the speakers earlier, it became very obvious to me that one of the major issues of concern here in Florida, around our country here in the U.S., and our partners in the Caribbean, Central and South America and around the world, is the amount of food production. I have looked at these things. I am a historian by nature, and I look at things that have happened across the world over time. I am not one who believes, necessarily, in global warming. I do believe in weather changes. We have had weather changes for eons. We have had ice ages that have happened twice before Man ever got his feet on the ground to create "global warming." So we do know, by weather pattern, that we have conditions we must learn to farm and trade under and that we have things we need to prepare for. So, having weather as part of our learning capability is very important, I think—along with our farming and trade capabilities—for the whole region.

But, as we go on, I would like to tell you that I have seen, right here in Florida, that we are growing more product, in some cases, on less acreage than ever before. That is thanks to research that has gone on at the University of Florida, Florida A&M University, universities all over this country—and around the world—who have given us a lot of information about:

- various types of food product;
- how we can do a better job of growing it;
- how we can grow with less fertilizer and still get the production levels that we need;
- how to change our water usage and our chemical usage to better benefit the quality of the food products that we are growing and;
- to take care of those pest and disease problems using new technologies that, hopefully, will have us using less and less pesticide and material that could become detrimental down the road.

We have encouraged our farmers here in Florida to follow that guideline, to work with the universities on adopting new procedures, using less water, less chemicals, but still getting the quality of food that we want to produce here in Florida, for use here in our state, around our country, and to trade with our trading partners, whether they be in the Caribbean, China, or India—some of the places our Marketing Division has gone to help us move product. I think that alternative fuels, especially with the new technologies that are going to become available to us over the next few years, are going to be critical, whether or not we put oil wells down in the Gulf of Mexico or whether we find these new ways to bring cheaper fuel. I believe that alternative sources—whether it be wind, ethanol production, or using the new technological and biological means of producing fuel—are going to be very important to us. That is especially the case if we can use food byproduct, waste product, and those types of things. That lets us make the best of a situation where currently we have had to throw away food product that cannot be used for human consumption, but can be used for something else. I think it is important that we try to utilize everything available to us without destroying our resources. And whether it is the State of Florida, or around the world, I believe that more and more people are going to be interested.

One of the things that I have looked at, and I am getting very antsy about, I guess—Dr. Cheek, I wanted to mention this to you, by the way—being a historian, I found where the first meeting of the group that was to locate the site for a college of agriculture in the state of Florida was held. I think they first met in 1870. It so happens that one of my relatives was sitting on that committee to pick out where the first university for agriculture in Florida was going to be, which, by the way, was in Eau Gallie, Florida. The first university was built there, moved to Lake City, and then became the University of Florida years later here in the state of Florida. But one of the things that has me a little bit concerned is that with all the new types of genetic modifications—and I happen to believe that if we do genetic modifications in the right way, we will probably be fine—we need to keep doing research to make sure that we are not going to have some unintended consequences on genetic modifications, as well. To keep the security of our original lines, those original lines of fruit and vegetables now in production need to be maintained.

Because I do believe, at some point in the future, that we could be in trouble going to strictly genetic-modified crops without having the original genetic lines available for all of our fruits and vegetables, so that we have a base to come back to in case we have a problem. So I hope that we are able, nationally and internationally, to save a lot of those products that we are all very familiar with in their original genetic lines so we will have something to come back to in case there is a world catastrophe down the road, with my grandchildren, great-grandchildren, or whoever is going to be in the future that could run into this problem. I believe that that is a concern I feel, even though I may be long gone, that I hope that we have the capability of coming back to those product lines.

It is important for us to be able to trade with one another, especially if we can protect against pests and disease, because once that spreads, it is hard to stop. Many of you probably have heard of our problems here in Florida with Citrus Canker, which is an Asian disease that we have had to worry with, and Citrus Greening, which is another Asian problem. We have not been able to stop these at the border, but they have gotten

out into our food supply. It could cause great angst, as you can imagine, when we are known in Florida, for the U.S., as the orange production area of the United States. I know California likes to make that claim, and they have some real pretty oranges, but they won't match ours, I can tell you. Now, there's an unsolicited advertisement for Florida oranges! The fact of the matter is that we do grow two different types of oranges, between California and Florida. So, when you think about some of the pests and diseases from around the world you realize free trade sometimes can bring you the good stuff and it can bring you the bad stuff. So our people in our Marketing—while we are trying to push product all over the world and we are receiving product from all over the Caribbean as well as other parts of the world—we also are bringing in pests and disease that can cause us all some great, great problems that we do not know how to get around very quickly. So, those will be issues that I will cover in a little bit more detail as we come into the after-lunch session.

I especially wanted to welcome all of you, especially our guests, into the State of Florida. We are very happy to have you here. We hope you have a great time. We hope you learn a lot that helps you in your trade mission, as well as our mission of learning to get along with one another and how we can do a better job of trading product. If we can all come out of this positively, then I think we will have plenty of food. The one thing I wanted to tell you that I'm convinced of, looking at the history of the world, when you think about how much food can be grown in Central and South America today that wasn't grown there just twenty years ago, and how much food that can be grown around the world that could not be grown just twenty years ago because of different constraints, we can grow food!

I am of the opinion that there are people who are starving in the world; there is no doubt about that. Maybe we have not done a very good job of getting food product all over the world. I am also convinced that today—as much as it has been for thousands of years—that political and ethnic reasons have a greater impact on why people are starving around the world than the fact that we do not have enough food to send around the world. When you think of some of the things that have happened just recently, where we have had shiploads of food sitting off the shores, ready to be unloaded, only because those who were in charge of it did not want to be put under scrutiny as to how that food was delivered and would allow the food to go bad in the process, tells me that it is not the fact that we don't have food to be grown and to be sold and traded around the world; it's how it's being done that is the problem.

Thank you very much.

DAVID SAMMONS:

Mr. Bronson, thank you on behalf of the Caribbean Food Crops Society for those welcoming remarks, and for those thoughtful comments that provide us with insight to your leadership style and views on how agriculture can grow and prosper. In appreciation for your presence here today, and for your remarks this afternoon, I'd like to present you with a small gift in honor of your presence here today. Thank you very much.

Last, but by no means certainly least, among those to welcome us to this opening session, I'd like to invite my boss, Dr. Jimmy G. Cheek. Dr. Cheek, as you are well aware, and have heard in earlier remarks, is the current President of the Caribbean Food

Crops Society. He is also, in his professional life, the Senior Vice-President for Agriculture and Natural Resources at the University of Florida. He has been a generous contributor through his office and organization and funding support for the meeting this week. Dr. Cheek was appointed to his position in January of 2005, so he is about 3½ years into his post as Senior Vice-President. In his role as Senior Vice-President for Agriculture and Natural Resources, Dr. Cheek is the administrative head of the Institute of Food and Agricultural Sciences, or IFAS, as we call ourselves. There is a nice exhibit that depicts some of the work of IFAS in the poster room adjacent to this room.

IFAS includes our College of Agriculture and Life Sciences, which is the teaching arm, the educational arm; the School of Natural Resources and Environment; the School of Forest Resources and Conservation; elements of our College of Veterinary Medicine; the Agricultural Experiment Station, which is the research arm of IFAS and includes 13 Research and Education Centers around the state, one of which will be visited by one of our field trips. It also includes the Cooperative Extension, an outreach educational branch of IFAS, as well. Prior to his position as Senior Vice-President, Dr. Cheek was Dean of the College of Agriculture and Life Sciences, the formal educational branch of IFAS. He came to the University of the Florida in 1975 as an Assistant Professor of Agricultural Education and Communication and has served as Assistant Department Chair, was promoted to full professor in that department in 1985, and has a long and distinguished record as an educator with numerous awards to his credit, listed in the program brochure in front of you. I think it is noteworthy to recognize that he is currently listed in "Who's Who in America," "Who's Who in America in Education," and "Who's Who in Science and Engineering." We welcome Dr. Cheek to the meetings this week and we welcome him to the podium at this time.

JIMMY CHEEK:

Thank you very much, David. It is certainly my pleasure to be here today. Chairman Santiago, our distinguished platform guests, colleagues from the Caribbean: the University of Florida and the Institute of Food and Agricultural Sciences is very pleased to host this meeting of the Caribbean Food Crops Society, their 44th Annual Meeting. As was said previously, this is the first time the Caribbean Food Crops Society has met in the United States in its 44 year history, and, quite frankly, we are delighted that you are here in Florida today for this meeting. As a matter of fact, I have wondered why it took 44 years, but we're delighted to have you, we welcome you, and we are very pleased that you chose to come here.

I became associated with this organization through the hard work of Carlton Davis. If any of you know Carlton Davis, he is a distinguished professor at the University of Florida; now Professor Emeritus, actually. He is still, I believe, coming to work about the same time he always came to work. He is still doing the same work that he did before; we're just not paying him as much money! It's a pretty good deal for us. We do continue to support his programs because they are so important to the Caribbean and so important to Florida. I hope all of you know Carlton Davis, because he is the person who caused me to become interested and involved in this particular society. Carlton, why don't you stand up, just so we'll recognize you!

Also, none of this would have been possible without David Sammons. He has worked with the Executive Committee and the Planning Committee very closely, and David, I greatly appreciate what you have done in putting this meeting together; it is impressive, in my opinion.

We are pleased as Floridians to be counted as part of the Caribbean family and welcome you to this part of the Caribbean world. The theme is, "Repositioning Caribbean Agriculture: Challenges and Opportunities for Sustainability." Like you, we in Florida are confronted with agricultural challenges that require our continuous attention, including issues related to Citrus Greening. It is probably one of the major agricultural issues in the world, and certainly in Florida, because of its implications of what a bacterial disease can do, perhaps to an entire industry. Our citrus industry has recently funded an effort to bring the National Academy of Sciences to Florida to develop a plan on how to attack that particular problem. The citrus industry this year in this state will put about $20 million dollars of their own personal money into research to solve the problem of citrus greening. This problem is affecting Florida; now affecting Louisiana.

The psyllids are now in Mexico and will soon, someday, be in California. That type of threat to a plant—and other plants on this planet—causes serious concern in Florida and around the world about what plant diseases can do to plant health, and our inability to adequately respond to those in a proactive manner. I hope you watch what we do with greening with great interest, because it affects all of agriculture all over the world. We are also faced with questions of land and land use, and how you maintain agriculture and natural resources lands in a state where property values escalate rapidly. We are working to confront and deal with issues such as that. We have one rancher not too far from where we are today that is being paid by the South Florida Water Management District, the Florida Department of Agriculture and Consumer Services, and the World Wildlife Fund, to sequester more water on his ranch, so that water will go into the South Florida Water Management District for use. So, they don't have to purchase that property.

We are facing huge issues that we've never faced before in the state of Florida that confront agriculture in the Caribbean as well as around the world. We also are very interested in biofuels and we have a long history of research on cellulosic ethanol. In the next two months, we will have the dedication of a small pilot plant in Gainesville that will produce more ethanol than can be produced in the laboratory. And then, on the drawing board and in the final design stages, we will have a million gallon facility built in South Florida that will convert cellulosic biomass to ethanol. The capacity of that plant, as a research and demonstration plant, will be somewhere between a half-million and a million gallons of ethanol per year. We are very committed to the area of biofuels.

I think as you look at our program, we have put together a full program, and I would like to thank all the participants in this meeting, because there are multiple sessions that should be of broad interest to everyone in attendance. This is a great opportunity for us to exchange information and to learn from one another. The University of Florida and IFAS, as you've learned before, is one of the land grant universities of the state, along with Florida A&M University, and I am delighted that they are also represented and actively participating in this program today. We view Florida A&M and the University of Florida as sister institutions and as collaborators and

partners. We are delighted that they are here with us today. Our mission as land grant universities is teaching and learning, research and discovery, and extension.

IFAS encompasses a broad array of expertise, including traditional agricultural disciplines and related fields in social sciences, natural resources, environmental sciences, food science, and human nutrition. We at the University of Florida and IFAS view ourselves as a global institution and value the opportunity to work with people from multiple nations, particularly those that share the Caribbean Basin with us. That's why this meeting is so important to us. We welcome you to our campus in Gainesville, should you have the opportunity to come to Gainesville. Also to our County Extension offices which are here in Dade County and Miami, as well as to Research and Education Centers. We thank you for your attendance here. Again, we are pleased to host this meeting. Let us know if there is anything that we can do to enhance your experience this week, and we look forward to hosting you again in Florida. We just hope it doesn't take forty-four more years for that to occur! Thank you very much for being here.

DAVID SAMMONS:

Dr. Cheek, thank you for that warm welcome, which all of us with the University of Florida share. We are very pleased, as Dr. Cheek has said, to welcome you into our state and into our midst. This is an important event for us that we have been planning for many months and looking forward to this meeting. Dr. Cheek, in recognition of your support for the Caribbean Food Crops Society, I'd like to present this gift for your office. Put it in a prominent position and tell people about the CFCS.

We are just a bit behind schedule, but we are in for a special treat at this point, before the coffee break. We're going to really move into the technical part of our program today. It's the session that addresses the Conference theme. Recall again that the Conference theme is, "Repositioning Caribbean Agriculture: Challenges and Opportunities for Sustainability." We have invited a special speaker to set the stage, to sort of open this discussion for us, and that individual is Dr. Anthony Bryan. Dr. Bryan has held numerous positions that have to do with our theme, but what I would like for you to know in particular is that he is an experienced expert on Caribbean and Latin American issues, with specializations in energy cooperation, energy security, Caribbean border security, geopolitics, and business and trade—all of them pertinent to our discussions today and through the week.

Dr. Bryan is currently a Senior Associate for the Center for Strategic and International Studies, in Washington, D.C.; he is a Senior Associate with Manchester Trade, in Washington, D.C.; a Senior Advisor to the Business Development Office of the University of the West Indies, in St. Augustine, Trinidad and Tobago; and he is also a Professor Emeritus here at the University of Miami, here in this city. He is a native of Trinidad and Tobago, but obviously, from his credentials, has broad experience across the entire Caribbean Basin and Latin America. We look forward to hearing from him. Further details about his credentials are detailed in the program, which you have in front of you, but I wanted to call particular attention to the fact that he is currently directing a five year, major research project on adapting border controls to support Caribbean trade and development, a project funded by the John D. and Catherine T. MacArthur Foundation.

With his range of experience and expertise, we welcome Dr. Bryan to the podium to set the stage. The title for his talk is, "**Petro-Politics and Pantry Politics**", a provocative title, "**Journeys in the Global Repositioning of the Caribbean**."

Morning Plenary Session: Setting the Stage
Petro-Politics and Pantry Politics: Journeys in the Global Repositioning of the Caribbean

ANTHONY BRYAN:

I am glad you got the title correct; you didn't mispronounce it! Thank you, Chairperson and colleagues for asking me to participate in this 44th Annual Meeting. All protocols for this distinguished group have been observed previously, I confirm.

I have been invited to set the stage for this conference from the perspective of one who spends much of his time writing on energy geo- politics and regional security. In justifying this request, one of the distinguished persons in this audience said to me that "agriculture is too important a subject to be left wholly to agriculturists." I now regret that I had not disagreed with him; if I had done so, I would not have found myself in this very challenging position this morning! Honestly, there is a positive side, since it is a rare occurrence for me to have a captive audience of agriculturists and food crop specialists. For the moment, I intend to make good use of the opportunity!

When I searched the recesses of what is still left of my mind, I tried to see whether there was any credibility that I could bring up for my being here. Then I recalled that my father was Trinidad and Tobago's very first Minister of Agriculture and my grandfather, apparently my paternal grandfather, pioneered a new strain of cocoa in the beginning of the twentieth century, in Trinidad. Of course, I was too young, in the case of my father, to appreciate what he was doing and in the case of my grandfather, I wasn't even in existence. Carlton Davis[9], my colleague since we were undergraduates and my friend at the University of Nebraska, I think you'll recall when we were there, that corn reigned supreme. The football team is called the Cornhuskers. We had no problem in distilling a kind of corn spirit which helped our progress academically. The one thing we were deathly scared of was the fact that there were thousands of cows in stockyards in Omaha belching methane into the atmosphere; that was a far more dangerous process than the fact that there was corn.

Pantry Politics

This leads me to the fact, when I term it "Pantry Politics"—let me tell you why. In a book called *The End of Food,* [10] published a few months ago, author Paul Roberts described a global food system on the brink of disaster. He details how our pursuit of high output, low-cost food generates of host pathologies and risks, such as third-world hunger, first-world obesity, food-borne pathogens like *E. coli*, soil erosion, depleted water tables, dead zones in our oceans, and global warming. It's all described quite graphically. Please do not read this book before dinner!

---

[9] Dr. Carlton Davis, Distinguished Service Professor and Professor Emeritus, Food and Resource Economics Department, University of Florida's Institute of Food and Agricultural Sciences, and member of the 2008 CFCS Meeting's planning committee and a co-organizer of its Invasive Species Symposium.

[10] *The End of Food*, author Paul Roberts; paperback published by Bloomsbury Publishing PLC (March 3, 2008), ISBN-10: 0747588813, ISBN-13: 978-0747588818; hardcover published by Houghton Mifflin Harcourt (June 4, 2008), ISBN-10: 0618606238, ISBN-13: 978-0618606238.

Many of today's headlines on agriculture speak of a sector in crisis. The *Economist* magazine reports that, since 2005, food prices have risen by at least 75%, most of it in the last year. My friend and colleague, Dr. Chelston Brathwaite, I think set the stage earlier, with the sort of issues that his organization is facing, and that the world is facing in general. Now, some of the repercussions of this global food crisis are already with us. The nutritional intake of the poor in many countries has already fallen by fifty percent. Since June, 2007, the rising price of food has triggered demonstrations and riots in at least 34 countries.

The future scenarios are scarier. If food-exporting nations fail to supply global markets, rising prices and crop failures will spark a humanitarian crisis. Food riots will topple governments throughout the developing world. Millions of the poor from the developing world will migrate to the developed, with resulting anti-immigration and ethnic conflict, with which, I can imagine, Lou Dobbs of CNN, will have a field day. Africa will be in the throes of a more massive famine and some East Asian economies could grind to a standstill. All of these are components of a global human tragedy, and from my point of view and my discipline, a profound crisis in international relations.

Petro Politics

Then there are parallel developments in global energy. This is your petro-politics now, where demand is rising rapidly. Overall, demand is expected to increase by 55% by 2030, and China and India will account for nearly half of this increase, in the same way that those two countries now account for the rising demand for food. The world used to depend on reliable, stable, affordable supplies of large quantities of energy, most of it derived from hydrocarbons. But the world energy market is changing. There is severe competition for oil and natural gas. It is very aggressive. Resource nationalism involving the recentralization of control over the energy industry has taken away ownership from international oil companies and given national oil companies majority interests in most concessions. To most of us, that seems good; but it also has its downside, because, as demand grows, oil and natural gas have become strategic commodities susceptible to being used for geopolitical leverage and displays of petro-politics and resource diplomacy.

A lot of this is exemplified by a newly-assertive Russia flexing its energy policy in Europe, China conducting foreign policy outreaches in Africa, the Middle East and Latin America, motivated by the urgency to satisfy its enormous energy needs. In our western hemisphere, there are several examples of this use of resource diplomacy, the most prominent being President Hugo Chavez' use of the Venezuelan national oil company—PDVSA—as a driver of Venezuela's foreign policy and an instrument of Venezuela's regional political power plays. Obviously, it is one thing to oppose President Chavez politically in Venezuela; it is quite another for energy-deficient Caribbean neighbors, or leaders of similar ideological bent in South America, to refuse his money and his oil. One of my jobs is to analyze, for the Trinidad and Tobago government, resource diplomacy, and I have had trouble with the current Venezuelan approach to resource diplomacy. What I think is that it lies in the development of a strong national oil company, bolstered by high oil prices, and legitimized by a Chavez-inspired 21st century socialism that appears to occupy a nebulous philosophical comfort

zone somewhere between Simón Bolivar and Santa Claus. If you can work that one out, you can make a lot of money!

Now, these developments present a dilemma for the Caribbean. Oil and food differ from other commodities in that they are indispensable for the functioning of society. Food shortages can trigger social and political instability with startling speed. Oil has a less immediate, but more pervasive impact. Oil and food are not merely strategic commodities, they are geopolitical commodities; and if we continue to see the elevated commodity prices in agriculture and energy, then perhaps we have entered a new geopolitical era with serious implications for the international system of the Caribbean.

How are we facing up to this dual dilemma of petro-politics and pantry politics?

Agriculture and Food Security

A brief word on agriculture: increases in food prices of 40% and over in the region during the last year have brought this dependence on imports into question. There have been serious food riots in Haiti and shortages of basic foodstuffs in most countries. We all know the reasons. And our technocrats, like Dr. Compton Bourne, Dr. Havelock Brewster—they have all warned us that, in fact, we face stagnating or declining agricultural production for domestic consumption. We have a deepening concern about the effect of imported foods on health. There is very little protection against these problems. In the Commonwealth Caribbean, the Common External Tariff seems ineffective as protection against these problems. Some governments, in fact, decided to suspend the CET in order to lower food prices, but the action does nothing to address the structural problem for the region's import dependence.

But let us be fair. The region is trying to respond to the crisis. We are all aware of the regional food security plan initiated by President Jagdeo of Guyana, as well as the series of meetings of national agriculture, health and food safety committees, to comply with various WTO agreements that relate to trade and agricultural produce. Even at the global level, you wonder sometimes whether there is any hope. I think—Chelston, correct me if I'm wrong—but the CARIFORUM[11]-European Union Economic Partnership (the EPA), with which we have spent so much negotiating time; those provisions provide little or no support in dealing with this dilemma.

But let's be positive. With foresight and planning and the willingness to develop and exploit new opportunities, the Caribbean can offset its vulnerability and harness food and energy to its development needs. Agriculture needs to be modernized, transformed, and we need to establish new bases for competitiveness in domestic markets as well as in feasible export markets. I think part of our problem is that we have dealt with the banter of exports for so long—and the market—that we fail to realize that it's sort of a very fragile way on which to build an industry. One analyst has put it succinctly, and I quote it for you: he says, "We must abandon the commodity mentality of agricultural production which is no longer supported by external preferences." Do not read him incorrectly! This does not mean the total abandonment of important crops such as sugar. Rather, it would result in *rethinking* sugar, to create a sugar industry which identifies new opportunities, such as the production, and perhaps export, of ethanol. Look at Brazil!

[11] CARIFORUM: Caribbean States of the African, Caribbean and Pacific States (ACP); i.e., only the Caribbean States in ACP, an organization designed to manage Member States' preferential economic and aid relationship with the European Union.

Most of us do not have the acreage to do that, but we certainly have every reason to do it for domestic reasons.

Similarly, the development of new linkages between local food suppliers and existing industries, such as tourism, should be accelerated and a new emphasis on farming for the local market is also needed. In the CARICOM region, we should revisit the potential importance of the large land masses of Belize, Guyana and Surinam as regional suppliers of agricultural products for home consumption. Of course, an effective regional transport system is an essential element of any such strategy.

Now, finally, what is clear to me as an observer and as a non-expert is that the traditional approach to agriculture in some countries of the Caribbean is not efficient. Success comes only when agriculture is practiced as a business. For too long, this area of economic activity has been viewed, even by those in the sector, as nonviable and wholly dependent on state or other handouts for survival. The possibilities for increased private sector investment are enhanced if viewed from a regional perspective. Some countries can be net exporters of certain products; others net importers. There ought not to be any quarrels. Market efficiency should generally determine in which country the investment is made. Successful agriculture is profitable agriculture. So, with respect to agriculture, Mr. Chairman, in all of this repositioning, it requires an emphasis on agriculture in the Caribbean and the cultivation of a theology (sic) that it can become a sunrise and not a sunset industry. I think that is the ethos that we have to work with.

Regional Energy Security

Some brief comments on our energy security: the PetroCaribe Initiative launched by Venezuela in July, 2005, has provided budgetary and development options for some countries in the region suffering from the loss of their traditional export markets for agricultural commodities. Caracas is providing almost all Caribbean nations, with the exception of Trinidad and Tobago, and Barbados, with concessionary financing framework for the purchase of Venezuelan oil. No one would deny that PetroCaribe provides a lifeline for many Caribbean and Central American nations.

But inevitably, PetroCaribe has proved to be a great accelerator of debt for Caribbean countries. In the case of Jamaica, for example, the debt had reached U.S. $446,000,000 by April, 2008. While PetroCaribe is good for providing a way out, the question is whether PetroCaribe is good for advancing regional integration in the way in which we would like to see it advance. I do not want to go into all of the issues, but some of them, a brief touch: there are diplomatic challenges, particularly for CARICOM, and the way Venezuela's financial arrangement is structured, it may also cause problems for the emerging Caribbean economy. There is a concern in regional political, business and diplomatic circles that the PetroCaribe agreement might have an impact on Caribbean diplomacy, in particular, our voting patterns in multilateral institutions and regional bodies.

There is also a suspicion that PetroCaribe may create new strategic alignments that respond to Hugo Chavez' long-term political objectives. As most of you are aware, Dominica's membership of the Bolivarian Alternative for America, or ALBA, has generated considerable debate in the region—among both policy-makers and commentators—over CARICOM's inability to reach foreign policy consensus on Venezuela's initiatives. In fact, both PetroCaribe and ALBA have become divisive

foreign policy issues and for a time, PetroCaribe's regional impact and the issue of ALBA appear to have damaged what remains of the integrity and coherence of CARICOM.

Now, none of this implies that energy-deficient and heavily-indebted Caribbean countries should reject what appears as a generous offer. But they should accept the largess with the understanding that they will increase their independence by strengthened regional energy cooperation and developing alternative sources of energy. I think this is a point that you stressed earlier.

Some observations, in light of the experiences of PetroCaribe and ALBA, are warranted: 1) Caribbean leaders should consider the establishment of a mechanism for monitoring the ongoing changes in the international geopolitical environment brought about by the dynamics of energy supply and consumption; 2) The management of Caribbean relations with Venezuela and other oil-producing countries should be approached regionally. Member states have adopted different postures towards Caracas or toward specific Venezuela policy initiatives. Dominica's decision to support the ALBA initiative demonstrated the ease with which Venezuela could capture geopolitical space within CARICOM; 3) as it now stands, PetroCaribe, even with its warts, poses a barrier to the implementation of a Caribbean regional energy policy. That model of regional energy cooperation—PetroCaribe model—is based on the primacy of Venezuelan oil, its current high revenue stream because of global markets, and the use of ideology as a strategy for regional cooperation. It is not a model for the future. Consider, for a moment, if by nature or by force, Chavez leaves the scene, and PDVSA and Venezuela have new presidents. What will happen with Cuba's oil debt, for example, and PDVSA's investments in the region?

We need, in the Caribbean, a clear vision of regional energy cooperation or integration. Any analysis or any analysts, I think, figure that what we have as a draft plan now is an energy policy document that will simply be an umbrella that recognizes the right of individual states to pursue their own course.

We can do better than that. At its best, and I spell it out specifically, such a Caribbean energy policy would integrate the region's energy policy into trade, economic, environmental, security, and foreign policies that broaden dialogue with producing and consuming countries.

Beyond Petro Politics and Pantry Politics

I would do a move beyond just petro-politics. We can no longer depend on finite hydrocarbon resources. We should assist in the global development of alternative sources of energy that would increase energy independence, create new jobs, increase agricultural productivity, attract new investment and technology, and expand and diversify our exports. We seem to be not aware of the fact that the Caribbean region is a potential powerhouse of renewable energy that, properly developed, can supply a significant proportion of the region's needs. These include hydroelectric, solar, wind, and geothermal power in some islands of the eastern Caribbean, and in the future, the exploitation of ocean thermal technology.

The recent agreement between Brazil and the United States to cooperate in the development of ethanol in Central America and the Caribbean through investment and technology transfer is a step in the right direction. This, of course, is a potential benefit

to countries such as the Dominican Republic, with a large area under sugar cane. While ethanol processed from corn in the United States has contributed to food inflation worldwide, the same is not true from ethanol made from sugar cane.

So, in the final analysis, Mr. Chairman, policies that include the development of sustainable sources of alternative energy, whatever their initial unforeseen circumstances or consequences, will do more, in the long term, for regional energy security than total dependence on hydrocarbons.

Conclusion: The need for effective diplomacy

Let me conclude by just looking at what you are going to try to do at this Conference. You are going to try to see whether there is a reason and a way to reposition Caribbean agriculture. Now, the Caribbean has been attempting global repositioning for quite some time now. In the CARICOM region, in particular, we are all familiar with the debates, starting with the report of the West Indian Commission *Time for Action* in 1992, Ambassador Richard Bernal's aggressive pursuit, subsequently, at redefining the components of such repositioning. The struggles of the CRNM[12], CARICOM and CARIFORUM to oversee and negotiate policy issues in the WTO[13], and, in an FTAA[14] now in repose, bilateral agendas such as CARICOM, with Latin American and Central American countries, and others that may be yet to come, dare I say, perhaps, an FTAA with the United States and Trinidad and Tobago, can muster the regional support and clout to do it.

There is no need to repeat the regional politics here, but two matters stick out like sore thumbs: 1) There is need, now more than ever, to strengthen the CARICOM regional integration movement in practice. We all know it is weak because of generic political-institutional factors, and we all know it is weak because regional decisions often become hostage to the domestic power politics. But it is particularly troublesome in the realm of foreign policy, where the coordination is one of the tenets of regional grouping.

The recent, harsh criticism of our integration ethos, by one Caribbean Prime Minister, though painful, is a warning shot across the bow. If the integration movement is not strengthened, it will be very bad news, since it is the support plan for much of our institutional diplomacy with respect to trade and agriculture, and in the future, the energy sector.

On the other hand, the region's experiences with Venezuela's resource diplomacy, and PetroCaribe and ALBA, may highlight a different process. Our countries now seem more willing to explore the options of multiple integration schemes simultaneously. Perhaps, as regions become more diluted, and dynamic models of regional integration seek to reposition themselves, a case can be made, as it is more flexible and dynamic. There could be various levels of cooperation among integration movements, or between them. This is entirely feasible. After all, in the end, countries do not have friends—they have interests; 2) The diversity and complexity of the negotiating arenas place huge demands on the Caribbean's diplomatic resources. These MUST be strengthened. In the 1990s, when some of us predicted the simultaneity of negotiations would do us in, it did not prove to do so. To put it bluntly, the stalled WTO Doha Trade Round, and the quiet

[12] CRNM: Caribbean Regional Negotiating Machinery (CRNM), http:// www.crnm.org
[13] WTO: World Trade Organization
[14] FTAA: Free Trade Area of the Americas

retreat of the FTAA, eased the pressure on us. We are now at an impasse where current negotiations require a political rather than technical solution.

But let me warn you—none of this should enable us with a false sense of security. The Caribbean will continue to be involved in negotiations with some of the biggest, most powerful and ruthless countries in the world. The WTO round is fundamental to the United States and the European Union, and they play hard ball. In the EPA process, the European Commission may be a little more civilized in their negotiating tactics, but confrontations with disproportionate power in diplomatic dealings, are ones that small countries cannot escape, even when acting collectively.

Our regional experiences, then, to summarize, with petro-politics and pantry politics, that is to say, with oil and food, are just a taste of what is yet to come. Ladies and gentlemen, I've taken the opportunity and the luxury of making some suggestions, albeit as someone with only very, very ancient ties to the question of agriculture. But I hope I have been able to set the stage, and that I did not simply indulge in the moral equivalent of rearranging the deck chairs on the Titanic!

Let me conclude by saying that, as I have described before, even when the odds are stacked against us, as they seem to be in the pessimist's view of the Caribbean, there is always room for optimism. I urge you to recall the story of the general in the U.S. Civil War, whose troops faced overwhelming odds on the battlefield. He realized that defeat was imminent, so he rallied his generals with following stirring words, "Gentlemen, the enemy is amassed in front of us. The enemy is behind us. It is to the left of us. It is to the right of us. I promise you that this time, the enemy shall not escape." There is a lesson there for us. Thank you very much.

DAVID SAMMONS:

Well, Dr. Bryan, you have done a fabulous job of setting the stage and providing us with food for thought as we looked at this complex array of issues confronting the Caribbean Basin. I'd like to thank you for getting us off to a good start as we begin our deliberations on our theme for the Conference. I'd like to present you with this trophy in recognition of your participation in our meetings, and invite you to stay as long as you can. Thank you again, Dr. Bryan. I regret that we are really over time or we would take some time for questions; however, Dr. Bryan will be here through much of the day, and I encourage you to find a chance to confer with him if you have further questions. We are over time; I'd like to suggest that we abbreviate our coffee break from 30 minutes to 20 minutes. We will reassemble here at 11:15 sharp to hear our keynote address from Dr. Compton Bourne, another treat we have in store for you.

SHORT BREAK

DAVID SAMMONS:

We are now at the point in our program at which we are going to hear our keynote address. The keynote address will be delivered by Dr. Compton Bourne, who is President of the Caribbean Development Bank, in Barbados, and I have invited Dr. Arlington Chesney to introduce Dr. Bourne.

Let me just tell you a bit about Dr. Chesney, who I believe many of you know. Dr. Chesney is a native of Guyana. He is currently Executive Director of the Caribbean Agricultural Research and Development Institute, or CARDI, as we know it, and is based in Trinidad and Tobago. Previous to taking this assignment, which was about a year ago, perhaps nine months ago, less than a year ago, he was a senior staff person at the Inter-American Institute for Cooperation in Agriculture, or IICA, serving first as the representative for Trinidad and Tobago; later for Barbados, and as Director of the Caribbean Regional Centre of IICA. He has had multiple responsibilities and leadership roles throughout the Caribbean Basin. Dr. Chesney holds a PhD degree in Soil Fertility and Chemistry, and Master's in Soil Chemistry and a Bachelor's in Science, with Honors. He is being asked, at this point, to take the podium and to introduce our keynote speaker.

Morning Plenary Session: Introduction of Keynote Speaker

ARLINGTON CHESNEY:

Thank you very much, Mr. Chairman. It is indeed a great honor to have the opportunity to introduce—in Spanish, we say, "*mi paisano*"—my countryman, Dr. Compton Bourne. We are both from Guyana. You see that Compton is very, very, very well placed to give this reach-out address based on his experiences, his scholastic record, and everything. So, let me tell you a little bit about Dr. Bourne.

He prefers to be called Dr. Bourne, since he went to CDB[15], rather than Professor Bourne, to indicate the difference between the two institutions. He is a graduate of the University of London, the University of Birmingham, and the University of the West Indies. He is currently President of the Caribbean Development Bank, since May 1, 2001. Prior to that appointment, he was Principal of the St. Augustine campus of the University of the West Indies, from 1996 to 2001; Pro Vice-Chancellor for Planning and Development between 1990 and 1996, and Deputy Principal of the St. Augustine campus of UWI from 1990 to 1993. He also held the appointment as Professor of Economics from 1981 to 2001, and is now Emeritus Professor of Economics in the same University. He has also served as a Director of the Central Bank of Trinidad and Tobago, from 1987 to 2000, and is a Fellow of the Caribbean Academy of Sciences; the Past President of the Caribbean Institute and Studies Association, and Past Vice-President of the Caribbean Agro-Economic Society.

He holds the Member of the Order of Excellence, which is the highest honor of the Republic of Guyana, and was also a recipient of the Caribbean Studies Distinguished Services Award in 1989; the American Foundation for the University of the West Indies Award for outstanding contributions to the Caribbean; and the National Coalition on Caribbean Affairs International Service Award, in 2005. He has been the author or editor of ten books and more than 50 refereed papers, and an unbelievable amount of development papers that are not refereed, that have helped to chart the direction for the Caribbean. He has also acted as an advisor to many Caribbean governments, foreign governments, and international development institutions and agencies. Based on that, you will notice that his career has straddled three major pillars: academic economics,

[15] CDB: Caribbean Development Bank

public policy, and institutional management. In the area of academics, he has been able to move very quickly from an initial position of lecturer, in 1971, to Senior Research Fellow in 1975, and become a full professor in less than ten years, in 1981. I think, with these credentials, the Caribbean Food Crops Society could not have found a better person to give us the featured address this morning.

I now invite Professor Compton Bourne to speak to us.

Morning Plenary Session: Keynote Speaker: Perspectives on Enhancing Sustainable Growth and Development of Caribbean Agriculture

COMPTON BOURNE:

I am honored by the invitation by the Caribbean Food Crops Society to speak at its 44th Annual Meeting. The longevity of the Society is indicative of an accumulation of knowledge and service to the agricultural sector of the Caribbean, which I, as a mere economist and occasional dabbler in the field of agricultural economics, cannot really match. Therefore, I want to thank you in advance for your kindness and tolerance.

There is a widespread perception of a food crisis in the Caribbean. The particular manifestations of the crisis are sharply rising retail prices of food staples, most of which are imported, and reduced availability of some of them. The Caribbean situation is part of a global problem, emanating from the reallocation of major grains and oil seeds from food production to the production of biofuels, adverse weather conditions in major producing countries, demand expansion by rapidly growing emergent economies, and higher energy and fertilizer prices; we've heard these listed already for the day. According to recent reports, biofuels seem to account for 75% of global food price inflation between 2002 and February, 2008, and energy and fertilizer prices for 15% of the increase in food prices on a global scale.

There are concerns about the food and nutrition status of Caribbean Community[16] residents—most of my remarks are based on the CARICOM countries with which I am familiar. There are concerns about food and nutrition problems, especially as they impinge upon vulnerable groups of poor families who comprise approximately 20% of the total population, and in that average, of course, one is ignoring the wide disparity in poverty levels—at the good end, at about 9% in a country like Barbados, and at the bad end, about 61% in a country like Haiti. Expenditures on food account for 20% of total household expenditures and for as much as 35%-40% of the household expenditures among poor households. So, food is a large component of total household budget and, therefore, there is great sensitivity among households to increases in the price of foods.

There is also political sensitivity and because of the political sensitivity of food supply and accessibility, the policy response by governments has been swift. Three kinds of actions have been taken primarily: fiscal operations to reduce or to restrain increases in consumer prices; attempting to switch import demand from the expensive foreign suppliers to less expensive foreign suppliers, so it's still within the realm of imports, but shifting the source of imports; and moral suasion on the food distribution sector to not fully pass on cost increases to final consumers; in effect, asking the importers and distributors to absorb some of the increases themselves, rather than passing them on in the form of final prices.

The food crisis in the Caribbean also seems to have given impetus to initiatives at national agricultural development within a regional framework. The Jagdeo Initiative adopted by Caribbean Community governments addresses the revitalization of

[16] Reminder: the Caribbean Community is an organization of independent nation-states known by its acronym, CARICOM.

agriculture. As the word "revitalization" suggests, the Jagdeo Initiative came out of recognition of agricultural stagnation or retardation; and the danger of the loss of European trade preferences for bananas, rice, and sugar, as well; and the heightened sense of food insecurity. Given this context that I have outlined, of renewed interest in the agricultural sector, it seems reasonable for me to examine its performance to identify the principal problems and explore possible solutions or remedial actions. Before doing so, however, it would be useful to summarily indicate the role of agriculture in Caribbean economies.

Agriculture is an important sector in most Caribbean countries, despite the economic diversification which has taken place over the last four decades, diversification particularly with the growth of services industries, notably tourism and financial services. The agricultural sector and its GDP[17] in 2005 approximated 35% of total Gross Domestic Product in Guyana; 18% in Dominica; 15% in Belize; 8% in Grenada and St. Vincent and the Grenadines. The agricultural sector GDP share varied between 3% and 6% in Antigua and Barbuda, Barbados, Saint Kitts and Nevis, and Saint Lucia. Thus, although agriculture cannot be regarded as a predominant sector on the basis of its GDP contribution, it is not without significance.

The sector's economic contribution to GDP is enhanced when the GDP of agro-industries is included. In the case of Trinidad and Tobago, for which social accounting matrices were computed for 2000 by Harry and Segura, the percentage GDP share of primary agriculture, plus agro-food industries, was 8.65% of GDP compared to only 1.7% of primary agriculture alone. So, including agro-industries does make a big difference to the share of the agricultural sector in the national income of countries. The macroeconomic importance of agriculture is further enhanced when one takes account of its role in providing intermediate inputs to other sectors (67% was the estimate for Trinidad and Tobago); its share of final consumption (42%), and its own demand for intermediate inputs from other sectors (47% in the case of Trinidad and Tobago). The agricultural sector, as is well known, is also a significant absorber of the total employed labor force in the Caribbean—altogether, 33 million agricultural workers, or 32% of the labor force, of 15 countries, including Haiti. If we leave out Haiti, we will have 1.1 million agricultural workers, or 17% of the employed labor force, still significant despite the reduction in the agricultural labor force over time.[18]

Traditionally, agricultural commodities such as bananas, sugar, rice, cigars and citrus have been among the main exports of the countries. Agricultural exports exceeded 60% of total merchandise exports in the 2001—2003 period in Belize, the Dominican Republic, Saint Lucia, and St. Vincent and the Grenadines. The agricultural export proportion was between 20% and 40% in Barbados, Dominica, Grenada, and Jamaica. Only in Antigua and Barbuda, and in the Bahamas, were agricultural exports less than 5% of total merchandise exports.

It is often asserted that Caribbean agriculture is on the decline. The evidence often adduced in support of this contention is the quite evident decrease in the sector's share of total Gross Domestic Product as I have just outlined. Between 1990 and 2005, all Caribbean countries experienced substantial decreases in agriculture's share of Gross Domestic Product; however, since sectoral shifts are a concomitant of economic growth,

[17] GDP: Gross Domestic Product

[18] This leaves 31.9 million agricultural workers on Haiti, alone.

decreases in agricultural share are not conclusive evidence that the sector is doing less well in absolute—as distinct from relative—terms. Indeed, in absolute terms, measured, for instance, by its current price GDP, agriculture's performance in the region may be viewed less unfavorably. In nine of the thirteen countries for which we have data, agriculture's GDP increased between 1990 and 2005; in one country, it was approximately stationary, and in three countries, in decline.

It is revealing to go behind the national income accounting aggregate, such as GDP, and examine performance at the commodity level between 1997 and 2006. There we get the biggest picture. Banana output decreased in the banana producing countries, most severely in Saint Lucia. The only other agriculture commodity groups with a distinct trend toward decreasing or stationary output were eggs and milk. Only in Saint Lucia, in fact, did production of milk increase between 1997 and 2006. Sugar production, in another major area, decreased in most countries: Barbados, Grenada, Jamaica, Saint Kitts and Nevis—coming to a halt in that country—and in Trinidad and Tobago; but, on the other hand, increased in Belize and Guyana. Production of meat in the CARICOM countries rose more often than it decreased. In six countries it rose; in two, it decreased. Fruit production increased in as many cases as it decreased, and production of vegetables rose in more countries than it decreased or remained stationary. If we view the sector's performance through the commodity-production lens, the performance of the agricultural sector can be described as weak, but not as disastrous.

As a result of the domestic production sector's inability to sustain increases in output, or even, in many countries, to increase output at all, trends toward higher levels of consumption have combined to perpetuate the food insecurity of Caribbean countries. The gulf between domestic consumption and domestic production has not closed. Correspondingly, dependence on imported food commodities is a central part of the Caribbean reality.

An amalgam of supply-side and demand-side factors seems to contribute to the overall weakness of agriculture in the Caribbean. These factors include: 1) Low productivity; 2) Vulnerability to natural hazards such as floods and hurricanes; 3) Lack of price competitiveness in export markets and domestic markets; 4) Divergence between the commodity composition of domestic food supply and the commodity composition of consumer demand; 5) A discordance between the quality and convenience characteristics of domestic commodity supply and the quality and convenience requirements of consumers; 6) Inadequate renewal of capital and of labor in agricultural enterprises; 7) Elimination of agricultural land; 8) Praedial[19] larceny; 9) Poor physical infrastructure.

This list of nine groups of problems confronting agriculture is by no means exhaustive; however, addressing even these few problems can help to enhance sustainable growth and development of Caribbean agriculture.

By international comparisons, productivity in the banana and sugar industries is low and thereby contributes to price uncompetitiveness. The loss of European trade preferences in the case of bananas, and the impending loss of preferences for sugar, has consequently caused a reduction in production for both commodities, except in Guyana. But productivity is also low for domestic food crops. For domestic food crops, and for bananas, the small scale of operations is a constraint on productivity. The Caribbean's main export competitors in the banana industry are Latin-American producers, who

[19] Praedial: relating to land or farming

derive significant cost economies from their much larger scale of operations, in addition to their advantages of a relatively low-wage labor force. In the domestic food crops industry, the main competitor is the United States of America, which derives decisive cost economies from its much larger scale of operations and its use of improved production technologies. There is also competition in the food crop range from producers in Europe and Latin America in particular commodity groups.

In relation to input of capital and labor, agriculture faces severe problems of input supply and capital stock. Improved chemical inputs such as fertilizers, pesticides, weedicides (sic) and medicines are imported and subject to externally-driven movements in prices. The agriculture labor force is an aging one, with the diminishing entrance of young workers and entrepreneurs who can bring new energy and ideas to the sector and sustain or increase pre-existing levels of labor utilization. Much land has been re-allocated from agriculture to other sectors, principally residential construction or tourism. This trend of re-allocation of agricultural land to non-agricultural uses reflects relative rates of private returns on investment in agriculture and in residential real estate development and other land-based production. In addition to the loss of land, there seems to be a problem of inadequate capital stock, evidenced in the vintage stocks of farm equipment and farm buildings, which are in need of maintenance or replacement. In effect, there is a production-capacity problem in Caribbean agriculture.

Agricultural producers of domestic food crops and livestock are often victims of praedial larceny, which reduces farm incomes and exerts powerful disincentive effects upon future production. Farm incomes and supply reliability can also be adversely affected by natural hazards such as floods, tropical storms, and droughts. As is well known, the Caribbean is very vulnerable to tropical storms, hurricanes, and to floods, which are a consequence of them. Climate change has intensified the strength of tropical storms and increased their frequency, as well as increased the intensity of rainfall, thereby causing extensive floods in those countries, such as Guyana and Trinidad and Tobago, not usually exposed to tropical storms.

The last supply-side factor affecting agricultural performance to which I draw your intention lies outside the sector, as such. It is the physical economic infrastructure, especially transportation and water supply and control. Intra-regional trade in agricultural commodities is not well served by the facilities for air and maritime transport. Air services are expensive. Shipping services are not sufficiently regular and predictable, and usually lack refrigerated storage capacity. Our seaports tend to be understaffed, especially with technical personnel for sanitary and phyto-sanitary inspections. In several countries, production capacity for water use, either for household or commercial purposes, is not great, leading to supply disruptions, typically unscheduled, which then makes production management difficult. In some countries, where inland waterways are important for drainage control and minimization of flooding, failure to maintain and expand capacity has added to the water control difficulties of farm enterprises.

On the matter of divergence between the commodity composition of domestic food supply and domestic consumer demand, the problem inheres partly in the static nature of the commodity composition of domestic food supply, particularly because of supply rigidities in the production of starchy staples, for example, root crops and

nutritionally unimproved rice varieties, and partly because of capacity shortages in the production of fruits and vegetables.

On the consumer-demand side, the considerable rise in household incomes, transiting from low income to upper-middle-income, developing-country status, has generated changes in consumer preferences toward commodities not readily produced, or produced as economically, locally. This shift in consumption patterns has been reinforced by the consumption preferences of the quite sizeable numbers of tourism visitors to the Caribbean. I do not say that to imply anything negative about it. Furthermore, with higher levels of income and wealth of Caribbean residents, and with the presence of international visitors on a sustained, substantial scale, has come significant changes in quality and convenience characteristics demanded by final and intermediate purchasers, such as hotels: requirements such as better grades of products, longer shelf life, availability in accessible supermarkets rather than in municipal markets and street markets, modern packaging and labeling, provision of dietary and health information for the benefit of the prospective purchaser, and dependability of supply, which is especially important to individual purchasers and hotel and restaurant industries.

The domestic food producers and suppliers have not responded effectively to these changes in preferences. The gaps that have consequently emerged between domestic production and supply of agricultural and agro-based economies, on the one hand, and the domestic and tourism demand for such goods, points to farm-level issues as well as to weaknesses elsewhere in the food-supply chain. I think that the multi-faceted approach has to be taken for enhancing sustainable growth and development of Caribbean agriculture. It must be multi-faceted because the problems exist in both the production side—farm-level side—as well as elsewhere in the general economic system.

Let us start with the supply side. In many instances, there would need to be an expansion of land capacity and of the stock of physical capital in agriculture. Depending on the extent to which technology, embodied in capital investment, is labor-saving, there need not be a commensurate requirement for additional labor. Technology innovations are also necessary for substantial productivity growth, without which Caribbean agriculture is not likely to be price competitive. Technology innovations have to be fostered by an institutional system which generates and transfers knowledge through funded primary and secondary research, experimentation, and extension services to agricultural enterprises. Innovative methods of cultivating crops and raising livestock could also be used to economize on land use and to minimize the competition for land in small countries, as has been done, for instance, in small-farm fruit and vegetable production in China, Israel and Japan. These countries use vertical cultivation methods, including drip-feed of nutrients, rather than horizontal cultivation methods.

The price competitiveness problem cannot be dealt with solely through technology, however. Diseconomies of small-scale operation in a regional agriculture characterized by miniscule and very small farm units will continue to be a serious obstacle to growth and development. Productivity gains also have to be sought through the creation of large production units. This would entail public policies for distribution of state-owned lands and ensuring the effective functioning and accessibility of institutions governing property rights and commercial transactions in order to facilitate amalgamation and consolidation of private land holdings.

There could be further gain from creation of commercial-sized farm units. Generally, the small production units typical of Caribbean food-crop production set a low ceiling for potential farm incomes absolutely and relative to income which could be earned by professionals and entrepreneurs in other sectors. This income gap partly explains the failure of the agricultural sector to retain or attract those categories of persons. The creation of larger units would raise the potential-income ceiling, thereby sending positive signals to persons contemplating a future in agriculture.

Agricultural enterprises are unlikely to make the requisite investments and capacity expansion and productivity improvements without a reasonable structure of incentives and reasonable prospects for risk management. Public policy is critical in both aspects. It is public policy, reflected in improvements in national water supply and drainage systems, which would give agricultural enterprises the confidence and encouragement to invest in irrigation as a means of reducing dependence on rainfall and in on-farm drainage linked into a national network. It is public policy, reflected in well-functioning national research and development and extension services, which would provide some quality assurances about new technologies and methods, and which would provide requisite technical assistance.

It is public policy, manifested in the national framework for disaster reduction and management, in institutional arrangements for risk insurance at the enterprise level, which would convey the likelihood of reduced risks of loss of agricultural income through natural-hazard events. It is public policy, reflected in effective enforcement of laws against praedial larceny that would minimize the risk of substantial income loss through theft of produce and livestock. It is public policy aimed at improving transportation infrastructure and port facilities that would make it easier for agricultural enterprises or middlemen to conduct sales transactions across national borders within the Caribbean.

On the demand side, consumer preferences for a different basket of agricultural products are partly susceptible to modification over the medium term by education campaigns which stress the nutritional equivalencies of locally-produced substitutes, and by improvements to the wholesale and retail segments of the food-supply chain, especially in response to product-quality characteristics which I have described previously. Particular attention should be paid to encouraging the establishment of wholesalers and commodity-purchasing enterprises through credit and fiscal concessions, because their absence in the food-supply chain puts the responsibility for produce sorting, grading, packaging, labeling, and bulking on farm enterprises which usually cannot bear the associated costs and are not equipped to perform those functions adequately.

At the same time, failure to have those functions performed causes final purchasers to withhold demand for domestic products and, instead, purchase imported goods for which the services have already been performed. The void created by the absence of wholesalers and commodity purchasing enterprises could therefore seriously weaken the market position of domestic agricultural enterprises. However, there also needs to be production adjustment by agricultural enterprises to supply the locally-produced, nutritionally-equivalent commodities in larger quantities and with greater regularity. The ability to adjust the commodity composition of agricultural output turns upon resource flexibility versus rigidity, technical change, technical assistance where there is to be commodity innovation, and the risk propensities of farmers.

It has been said that agriculture is too important to be left to agriculturalists; I will say that agriculture is too important to the economic well being of Caribbean countries to be allowed to slip into continuous retardation. Nor is it necessary to envisage or fear long-lived regimes of agricultural-income support. There is sufficient market demand for the output of the sector to make it potentially profitable. What is required are public policies which address structural constraints on agricultural performance and on the marketing and distribution of agricultural output in the Caribbean.

I hope I have succeeded in providing some broad perspectives on the warranted direction of public policy for enhancing the growth and development of Caribbean agriculture. Thank you very much.

DAVID SAMMONS:

Thank you very much, Dr. Bourne, for that insightful presentation. Dr. Bourne has consented to taking a few questions from the floor. We have about ten minutes left before the end of this session. So, I invite those who have questions to step to the microphones and we will recognize you in turn. If there are questions, this is an opportunity to raise them.

Q. It was mentioned about theft/praedial larceny as it affects production. I know, with the hard economics times, a lot of stealing is going on from farmers. So, what do you think are the best steps? What public policy should we have in Jamaica and other Caribbean countries as we try to fight against praedial larceny and loss of goods and the crops produced on the farms?

A. Well, you are quite right. I think the first requirement is for the law-enforcement agencies to recognize this as a real problem. I think that there is a laxity on the part of law enforcement agencies in the Caribbean to the question of praedial larceny. They get very excited about larceny from other sectors, of other goods, but when it involves, especially, small farmers, cases are not pursued with any particular diligence, so that an attitudinal shift in the agencies is a fundamental requirement. I noticed in Barbados, last week, in the budget discussions—budget debates—that the government is talking about strengthening legislation to deal with the matter. So in some places, we may also need to review the legislation. But I believe a lot could be done with existing laws. I think also that one could introduce certain requirements with respect to the registration of those selling agricultural commodities in any sizable quantities, and thereby break the connection between the people who steal the commodity—the crop or the livestock—and the wholesalers or the marketers who pass them on.

Q. We talk about the public policy and law enforcement. How is the attitude about the people living in communities, especially rural, where the safety of the farmers may be at risk? We would have vibrant police or other authorities being there for their protection.

A. I agree with you in saying that you need to strengthen your law enforcement. It is these, including the police. You have to have the police presence. You have to have a fairly quick response to loss of these things, to praedial larceny.

But remember that most cases of praedial larceny doesn't (sic) take place in the light of day or in the presence of the farmer. It takes place in the absence of those individuals, or at night.

Q. I am just curious as to the Caribbean Development Bank's role in facilitating or promoting more sustainable forms of agriculture—organic or permaculture—how the Caribbean Development Bank could help that growing movement.

A. Let me first of all confess that the Caribbean Development Bank, like many other development banks, regional and sub-regional, hasn't been very active directly in agriculture over the last ten to fifteen years. We have maintained financing to agriculture, but through the national development banks. We are open and actively looking at various ways of facilitating development of the sector. We are looking at the agricultural renewable-energy link. We certainly are looking at some of the greenhouse technology that might be employed. There is very soon to be a seminar or workshop on that. The consultancy work is done already and I think the study is about to be released. We are open, really, to other kinds of agriculture. We would like to see agriculture improve its technology. We see that as one of the key areas that we would be paying attention to in the near future.

Q. I certainly concur with your assessment of what is taking place in the region and a lot of the recommendations that you make. The problem I am having, however, is two things: 1) How do we go about balancing our energy needs and food needs? Currently there is a lot of the better land that we have in the region is under sugar cane. Should we continue to keep it under sugar cane and use that to produce biofuel or should we be looking at producing more food with some of those better lands? And also, 2) if you think that we are witnessing a paradigm shift in the Caribbean away from that definition that we have a food security which embraces the idea of purchasing cheap food toward one now where we should seek to produce our own. If you could comment on that?

A. To begin with the first one, I don't think that there is, if, as the region seems to be, heading in the production of biofuels, if one uses the sugar lands, I don't think there is much competition between that and producing food, partly because, as I understand it, the sugar adaptation plans that countries have involve releasing some of the sugar lands for domestic food crop production. I think this is certainly is the case of the Jamaica Plan. It is a big part of the Trinidad and Tobago Plan. Even Barbados has spoken about it to some extent. I think the land resources are much more limited there and, therefore, I think their choices might be starker. So that one sees the development of growing cultivation of sugar cane for ethanol has not really been competitive with the food production. In fact, the growing of cane for ethanol would have the positive effect of keeping much of the agricultural land in sugar, or keeping the land in agriculture altogether, because of the loss of sugar preferences, or pending loss of European preferences of sugar, much of the existing operation in countries such as Jamaica, and has been the case, dramatically, in Saint Kitts and Nevis, would not be economic, would not be a

medium-term viable position. With the possibility of ethanol, I think there is a market, a profitable use of the sugar cane. This is what explains, in Jamaica, the recent investment by one of the major Brazilian companies, in conjunction with the Petroleum Company of Jamaica, to revitalize and reorganize some of the sugar cane production in that country.

Now, you asked the question over the paradigm, and that is the harder one to answer. I think of it not so much in terms of a shift in the belief that one should access cheap food to one that you are going for more expensive food items. I think that one has to accept the shift in consumption patterns that are driven by changes in income levels and by changes, slowly but surely, by changes in people's perception of what is healthy eating. While I know we have a bigger problem in the Caribbean in terms of what there is to eat, there is a growing awareness that much of what we eat and where we eat it is not compatible with good health. So I think that these structural shifts are inevitable. So the challenge is to identify which of your domestic food crops are consistent with the changes in patterns and in what shape and form they can be kept consistent. That is why I put emphasis on questions of not only identifying nutritional equivalents, but also on the availability of supply, dependability of supply, and questions of packaging and labeling.

Q. Thank you, Dr. Bourne, for a very interesting and thought-provoking address. My question has to do with the small farmer versus large farmer. You mentioned in your address that the shift, should I say, or the recommendation, would be toward larger farms, larger holdings. However, there is always the concern of the social implications of small farmers and the marginalizing of the small farmers vis-à-vis large farmers, and I just wanted to hear your thoughts on that, because, in most of our countries, small farmers are considered as the source of food for local consumption.

A. You touch on a very important, if you like, social problem of society and politics. Let me start by saying, first of all, that the very small farmers—
2 acres, 3 acres—they are going out. Part of the generational problem in agriculture in the Caribbean is, in fact, the small holdings not being sufficient to attract the younger generation into agriculture as a business, and that is why the farming population has been aging throughout the region. So, what you want to get to is maybe a concept of larger units in which these very small operators have equity, have part ownership, rather than the small, individual, very micro-individual unit. You want farm companies, if you like, rather than small farm holdings. In addition to that, if we are going to make an impression on the cost competitiveness problem, we must have some pretty large enterprises. I was struck, listening to Dr. Marshall Hall, from Jamaica bananas[20]; two months ago, he was talking about the consolidation that has taken place in the banana industry in Jamaica. So you really don't have as many small banana producers in Jamaica as you had before, but it hasn't broken up the structure of the rural society; it's just that people have got into a

[20] Marshall Hall is chairman of Jamaica Producers Group, Jamaica's largest producer of bananas prior to Hurricane Gustav, which struck Jamaica in September 2008 and seriously damaged the country's banana plantations. **Sources:** Yahoo Finance and Wikipedia.

different kind of income relationship within the industry. I think the same thing has taken place, to some extent, in Saint Lucia.

DAVID SAMMONS:

Thank you, Dr. Bourne. Dr. Brathwaite, you wanted to make a concluding remark?

CHELSTON BRATHWAITE:

Thank you, Mr. Chairman. I know you said no more questions, but this is more of a comment rather than a question. I would like to thank Dr. Bourne for an incisive analysis of the agricultural sector in the region and the critical juncture where we are. What are the issues or the challenges which we face? His emphasis on new public policies is critically important if we are going to move forward. But public policy has to be supported by financial allocation. Public policy without financial allocation gets us nowhere. We have seen that on several occasions, where are there pronouncements and no results because there is no money. Now, the World Bank has just said that, in the current crisis, they will assign 1.2 billion dollars to agricultural development related to the food crisis. One gets the impression that a significant amount of that money is going to be assigned to Africa. The Inter-American Development Bank has just decided to put agriculture back on the front burner of their loan portfolio; in fact, in 2002, only 3% of the IDB loans were assigned to the rural sector. As I mentioned earlier, the World Bank had 30% of its portfolio, in 1970, assigned to agriculture, and then it dropped down to 12%. So, the development banks have not been giving priority to agriculture and it seems that there is now a change of policy.

My question—I'm sorry to put Dr. Bourne on the spot—is there going to be a change in the policy in the Caribbean Development Bank? Is the Caribbean Development Bank going to assign more resources to agricultural development in the Caribbean? Are there windows in the bank that will allow us to access some of the 1.2 billion that is assigned by the World Bank to agricultural development worldwide? Are we at the beginning of a new opportunity for financing agricultural development in the Caribbean? Those are my comments.

COMPTON BOURNE:

A. I will answer, first of all, for the Caribbean Bank: Yes, we plan to expand our operations in agriculture. We have not fixed a target yet, but it is very much a front-burner matter. In our new strategic plan, which we are preparing at this moment, you will see significant attention being paid to the question of agricultural financing. But, as I said earlier, we also have been maintaining an openness with respect to financing the sector, responding to requests for financing from the national development banks. I won't try to speak for the World Bank. That's a hazardous business; I won't do that! Let me say, that while I agree with you, Chelston, fully, that there needs to be a significant stepping up of the financial resources for giving effect to the things that we say we need to do for agricultural development, but I also want to say that, there is, in fact, there have been a fair amount of resources not properly utilized because the public policy framework has been lacking.

When Professor Bryan spoke earlier about the EU-CARIFORUM economic partnership agreement, and asked the question, "Well, what is there in it for agriculture?" I at once reflected on several supporting lines of credit on the EU-CARIFORUM arrangement; there has been a new development fund which sends a significant sum of money for sugar adaptation, including, in sugar adaptation, not simply making the sugar industry more competitive, but diversifying and reallocating land from sugar to domestic food supply. Secondly, the financing of agricultural diversification of the banana producers, we are talking here, I think, well in excess of 200 million Euros, a lot of which has been underused, partly because the complimentary policy actions have not been taken to make the commitment by the farmer attractive.

DAVID SAMMONS:

Thank you, Dr. Bourne, for answering this multiple array of questions. This has been a wonderful kickoff for the session which remains ahead of us this afternoon.

Before we adjourn, I would like to present Dr. Bourne with a memento of his presentation and presence here, with the warm thanks of the Caribbean Food Crops Society. Thank you, Dr. Bourne.

Afternoon Plenary Session: Florida, Caribbean, United States Agricultural Trade and Marketing Challenges

DAVID SAMMONS:

You all met Charles Bronson this morning and are aware that he is our Commissioner of Agriculture for the State of Florida. We are much honored by his presence with us today. He works out of an office in Tallahassee and travels throughout the state. We have been privileged to have him with us for a good chunk of today, something that is not easy to do. We first approached Mr. Bronson months ago about getting this on his schedule, and he very graciously accepted the invitation and he is with us.

We are going to continue addressing the theme for the Conference and that is, again, as stated on the front cover, "Repositioning Caribbean Agriculture: Sustainability: Challenges and Opportunities."

Mr. Bronson is going to address the theme, **"Florida, Caribbean, United States Agricultural Trade and Marketing Challenges**." For all of us who are concerned about expansion of trade, we understand trade is a two-way street, and when we trade, or are trading partners, we are sometimes buying and sometimes we are selling. Certainly the buying and selling relationship is one that is important to all of us in the agricultural arena, and one which raises challenges, as we've heard this morning, challenges associated in particular with issues related to invasive species and so on, but other sources of challenges, financially and infrastructure-wise and so on.

We are looking forward to hearing the message that Mr. Bronson brings to us. He has agreed, to the extent that time permits, to answer a few questions at the end of this presentation. Let me turn the podium over to Charles at this point and welcome him once again.

THE HONORABLE CHARLES BRONSON:

Thank you very much. It is a pleasure to be here with you again to talk about a number of issues. We know that here in Florida, we are faced many times with pest and disease problems that are coming from somewhere else around the world. I mentioned to you this morning that citrus canker was one of them. We fought canker for over ten years, until the 2004-2005 hurricanes finally spread the disease so far out that we could not control it, even going to the 1,900 ft. cut zones that we were using. Those were quite substantial, when you think of how many trees are in 1,900 ft., to have to cut down to try to save the rest of the citrus industry. Our biggest problem, however, was in back yards, where people did not want to give their trees up, even though they were exposed to the disease or had the disease. It is hard trying to convince home owners that one or two trees in their back yard are going to cause a big problem in the state of Florida.

Let me give you a little insight as to how bad the problem was for us: people who had young trees or trees that were in pots, even though they were told, "Don't move those trees out of the red zone, because the disease is prevalent here," would move to Central Florida and put their citrus tree on the trailer with them and move it to Central Florida. Even though the tree did not show the outward signs of canker, by the time it got transplanted and was under the pressure of transplanting, the tree would begin to show

that it did have citrus canker. Therefore, we can show four or five major spots in Florida where transplanted trees were definitely the problem. People would not listen to us when we said this could be a real issue for the citrus industry, which at that time was our number one industry in the state. Now the foliage industry is the number one industry and because of having to destroy so many citrus trees, citrus is now number two to the foliage and nursery industries of the state of Florida.

We knew, eventually, we were going to get the pink hibiscus mealy bug from the islands. Sure enough, it was just a matter of time, counting the days, and someone picked up the pink hibiscus mealy bug in South Florida down here. We had to get hold of that situation very quickly, because, once again, the nursery industry is our number one agricultural industry in the State of Florida. We certainly did not want the pink hibiscus mealy bug to end up quarantining large segments of the nursery industry to the point where we could not move our nursery stock around the state and outside of the state of Florida.

We know, by risk assessment, what we are dealing with from the plant and animal side, just by knowing—through USDA and all of our Federal partners and international trade partners—where certain hot spots for pests and diseases are around the world, whether plant or animal. We know through risk assessment what we need to be looking for. Now to the average person, like those backyard growers that we had the problem with, telling them that this one little insect could cause hundreds of millions—if not billions—of dollars of damage, they look at you like you just told them you could jump over a building. They don't understand it; therefore they don't want to believe it. The problem is, for those of us sitting in this room who have to deal with pests and disease, we know that one little insect or one little disease that looks very minor can cause hundreds of millions, if not billions, of dollars in damages. Therefore, our food industry people are in trouble when that happens, because we are going to be quarantined, for the most part, at least sectionally, if not state-wide, when some of these outbreaks take place, especially when other states don't want the potential of having this disease come to their state.

So it creates not only problems with losing trees and animals and pest/disease issues, but the food production and trade issues become a major, major impediment as to how we deal, back and forth, on trade issues. The Caribbean Basin, as we all know, and all of those who deal with the countries and the states of the Caribbean were doing their risk assessments as to what we have here that you don't want in those areas, as well. In a world of world trade and open trade, it really takes a coordinated effort for all of our organizations, from the marketing right on through to plant and animal industry personnel, the veterinarians, and the PhDs that we have looking at various pests and diseases, to help us get ahead of some of these issues quick enough to shut it down when it becomes very localized, instead of when it begins to spread to the point of having major problems.

The citrus psyllid...that little insect looks almost innocuous when you look at it, but we know now that this little insect breeds quite profusely and it carries citrus greening. I cannot remember the Chinese word for it; all I can tell you is, it's bad. We have to deal with it in a way that we know. That disease will absolutely kill the tree, you can't use any of the fruit off of a diseased tree, and you have to get it out immediately before those same psyllids spread it from that tree to other trees.

We have lost a lot of trees in the state of Florida to the two diseases I mentioned to you, both citrus cancer and the greening process. If we do not find a way to control it, if we don't get it under control at some point in time, this could potentially destroy the citrus-producing areas of the world, as long as we can't find a way to totally control the psyllid populations, both in the backyards, the commercial groves and other areas. And of course, if it was just citrus trees we were dealing with, we could probably get around it quicker. The problem is, the citrus psyllid loves Japanese boxwood and it loves a lot of different types of plants that are not true citrus plants, but it can manifest itself and use that as its hiding place and breeding ground until it's ready to go on to the citrus producing areas. So it makes it a very dangerous little insect to have to deal with.

I think, whether you live in the Caribbean countries or whether you're here in Florida or anywhere else in the United States or around the world, if you're dealing with pests or diseases that you do not have at this time that could be totally devastating to your food production, no matter what that food production may be, you have some real issues on your hand. How does a farmer stay in business having to deal with these issues? What happens when that percent of the food chain is gone? What happens to those people who are hungry and need food? What have you done to the world's food supply? So, those little pests and diseases look small to the average person, but to those in the agricultural fields, they are huge. It's huge when you think about the reduction of the food in this country and around the world because of pests and diseases that we should have been able to handle, but because we ran too fast into free trade, we did not protect ourselves from pests and diseases that we can transfer.

I believe in free trade. I think we ought to be trading, especially when it comes to our food supply, that we ought to be able to move product that is grown here in Florida to the Caribbean area and Caribbean-grown product that our people may like to try, who have not had the opportunity to try some of the different fruits and vegetables grown in the Caribbean that maybe we don't have here in Florida. People should have the opportunity to try new foodstuffs that can be healthy for ourselves and our children and our grand-children and those to come, so that everybody gets a chance to participate in everybody's cultural foods, so that people will understand what those food cultures are around the world. So, I do believe in free trade; however, I would tell you that I have talked with USDA, I have talked with Food & Drug and other people and we have to be really, really careful about what we bring in on that food supply. We have to work with our trading partners to head off anything at the location where it's going to be shipped from and where we're going to be receiving that product. No matter which way it goes, to us or from us, we should be very careful not to pass on pests and diseases that can cause major damage to our food system.

I don't care what part of the world you're in, farmers today are faced with a multitude of problems. We have the natural pests and disease issues, we have weather issues that none of us can truly control. We just have to try to make our best guess as to what type of season we're going to have during our growing seasons, knowing that we may be looking at hurricanes, knowing the weather patterns that create hurricanes for our specific area. Do we plant early? Do we plant late? Do we plant water-tolerant or drought-tolerant crops to help us get through? Those are the things that we need to really be focusing on. If we can do that, we will become much better at growing these food

crops. It may be that this year or next year, we grow one type of food crop and because of the weather patterns, we may decide to grow a totally different crop the next year or two to compensate for those weather patterns. Those are the types of things that will help us be better food producers and have the type of quality food products out there, assuming that we can keep control of pests and diseases that may hit our food supply.

Without the University systems, without those researchers in the research stations who are trying either new types of chemical or natural agents or natural competitors for different types of insects that may actually help us to control through natural means some of these predators out there, looking for the insects that bother our food crops—that's the type of stuff we get from our university system and our research stations. Without them, then every industry would have to pour so much time and money in for their specific crop, when many of these different pests—take the Mediterranean Fruit Fly or the Mexican Fruit Fly or some of these other insects that can cause damage to up to 120 different crops or more—can cause major damage to our food system. So, those are the things that we look at here in the State of Florida. We have a very good group of both plant and animal pathologists and others working on those issues, working with USDA, trying to head off these problems before they get here. I think if all of our trading partners will work together on this, we can probably get a good handle on most of the different pests and diseases, both plant and animal, that we are concerned about so that our future in food production will not be harmed.

We are growing more crops on fewer acres today than ever before. We are growing a better quality of food than ever before. We are not having to waste quite as much as we used to. We are getting a lot better at it and it's because of the research work being done at the universities, being done by USDA and others that are helping us be better stewards of the food production that we have. That is the basic message that I wanted to bring to the table today. Florida is very concerned about these issues. We don't mind taking product from any of the countries that you belong to. We don't mind taking in food from any countries around the world, as long as we can control the pest and disease and food-borne illnesses that may come in with those crops as well.

I've covered mostly pests and disease, but I've run for public office in the State of Florida twice for this position. Both times, we polled the general public and we have a little over 18 million people living in the State of Florida. We asked, through a series of things, what the general public felt was the most important issue in agriculture and consumer issues that they were concerned about. By far—way above anything else, both times we polled, four years apart—food safety was the number one issue to the general public. Mothers and grandmothers went off the chart with food safety about food for their family and their children and grandchildren. It was not even a close second in there. So, food safety—and I would assume it is going to be that way in your countries that you came from and around the world—food safety and the quality of that food is a big issue to the general public, no matter where you live in the world.

So, having that in mind, also, we get very concerned when we have an outbreak of Salmonella, or E. coli, or some of these other issues that pop up from time to time—truly not anybody's real fault if they've been treating their product the way it is supposed to be treated. Sometimes you have an accidental incursion of a disease that can cause serious problems. But we are responsible, as farmers, packers, processors, for how we prepare our fields, how we take care of those fields during the time of growth of that product,

how we treat that product before it's packaged and sent, either intrastate or interstate. Then when it gets to those stores that put that fruit and vegetable or that meat on the counter, it's the responsibility of those stores to make sure that the quality and the nutritional level and the sanitation level of that product are as high as possible to get consumers to buy the product and take it home.

When consumer confidence drops because of one very small, one percent issue, it does not just hurt the one percent where the problem was, it hurts all one hundred percent of the crop. We're seeing that in tomatoes right now. We've seen it in other crops. We've seen it in spinach. Florida adopted one of the toughest programs in the country, from the field to the grocery store. For those of you that may have seen me or heard me on either television or radio, I've said from the very beginning, that I was 99.99% sure that Florida grown tomatoes, no matter what the problem anywhere else, was not part of this potential problem with Salmonella, because we have one of the most stringent programs in the country. The reason why I can't give it that full 100% is because you never know what's going to happen that you didn't count on. So, I felt pretty assured that that was the case. Now, of course, they believe maybe tomatoes were not the problem after all. No matter where the tomatoes came from, it may be something else altogether.

The confidence-level—just to prove my point here to you—the confidence level in those people within this country who buy and eat tomatoes this time of the year, has dropped 40%, because the consumer says, "Better be safe than sorry." Even if you could prove that you were not the problem, once that message gets out that tomatoes are the problem… And of course, we got a little technical. We said Red Roma. The average citizen does not know what a Roma tomato is, they just see a red tomato and that is all they know. So, tomato and disease problems equal 40% loss in sales. So that is how careful we need to be, before we make statements about anything, to know exactly what we're dealing with, to the level of not pinpointing something until we are absolutely positive, and then we should hopefully be able to pinpoint it back to its origin so that the whole country is not penalized for a problem that may have happened in one isolated place in the process.

Those are the things that I wanted to bring to you today without taking too much more of your time and allowing maybe a few questions before I have to leave.

Q. Commissioner, I would like to know: How are you dealing with the illegal and legal migrant worker issue? Because I saw that in a poster and I know that is very important. Especially, how does that affect Florida agriculture? Because we are talking about free trade agreements, but the immigration issues are not in there. So, what is your position to make that legislation or some laws that would protect these workers?

A. That's a great question, because, as most of you probably know, Florida is a specialty-crop state. We don't have a lot of the corn and wheat and some of the staple crops that have been grown in the Midwest. We are oranges, tomatoes, strawberries, bell peppers, and squash. We are a specialty-crop state. Now, you can probably pick some of those by machine. We probably wouldn't buy 60% of them when they came off of the machine, because they would be bruised so bad that by the time you put it in the grocery store nobody would want to buy it, or we would have

to sell them as seconds. It takes real, live people who are willing to go out and pick those products and manually handle them in a way that, when they get to their final destination, they are still a good-quality product for the consumer to buy and that means very carefully hand-picked products.

We do not have a population of this country that is willing to do that type of work any more. Everybody wants their children to be doctors and lawyers and all of this stuff and it seems that we just don't have a group anymore in this country that is willing to go out, unless you happen to be a farmer, and how many kids do you have? Probably not enough to pick a thousand acres of tomatoes. So, we've got to have people who can get into this country—legally get into this country—and be able to work here. I've said from the very beginning, if you want to destroy the fruit and vegetable industry of this country, and I don't care if it is Florida, Georgia, Michigan, California… We have got to find a way to find out who's coming to our country legally, to find a way to have them with papers that gets them here, if it's a special time of year they want to work, lets them do their job, lets them take their pay home wherever they are going to go—they're doing the work, they deserve to go wherever that money is going to take them—and get our fruits and vegetables picked so that our farmers don't lose millions and millions of dollars.

If we want the food supply of this country, of this state, and around the world, to remain at a level that people have some confidence that there is a food supply to depend on, we are going to have to have people who can hand-pick a lot of these products. I want to see the machine that is going to go through and pick a field of strawberries. I'd love to see that. That ought to be really interesting. But squash, tomatoes and bell peppers, we all know that many of those fruits and vegetables bruise very easily and would have to be destroyed at such a large rate that nobody could afford to buy them if you got what was left on the market. So, with all the hype—and some of my own political colleagues are the ones out there stomping their feet. They know what they're saying and they know why they're saying it: so that they know who's coming into the country. They don't understand what they're going to do to the food supply around the world. I think they need to quit stomping their feet a little bit and get everybody's heads together and find a legal remedy to bring in workers to pick these crops.

Q. Mr. Commissioner, what is the State of Florida—how is it controlling both citrus greening and citrus canker disease. Could you expand a little bit please?

A. How are we controlling it? Well, we ask everybody, no matter what denomination they are, to go to church and pray for us, because, right now, there is no control other than taking the trees down, trying to keep the spread of the disease down as best we can. The university, the USDA, they've got a group working on this here in Florida that is trying to find ways to come up with to help control both of these diseases, whether it is genetic or whatever method they think can be used.

We know that greening is much more dangerous to us because of the psyllid and our inability to totally control the citrus psyllid right now. At least with canker, you can use that fruit until the tree just basically quits producing fruit, which can be a year, maybe two years. But eventually, citrus-cankered trees will quit producing any kind of fruit. The leaves will basically be gone and there is no use for the tree. So it's all but dead sitting in the ground as it stands. The citrus industry is feverishly pouring money into research, working with both the university system and USDA and anybody that they can get that has any knowledge of those two diseases that can help them out. They are working on that right now. They are going to spend millions of dollars of the industry's own money—not just state money, not just federal money, not just asking USDA to put in large sums of money—citrus growers are going to spend millions of dollars trying to get to the bottom of this before they lose their whole industry.

Thank you very much for having me today.

DAVID SAMMONS:

Thank you, Mr. Bronson, for that presentation and for answering the questions. He told me that he regrets that he has to leave at this point; he has to be on a plane to Detroit. He has business there beginning this evening. So we thank him again and wish him safe travels.

Our second speaker this afternoon was originally to be an individual from the Caribbean Community, Ambassador Irwin LaRoque. At the last minute, on Friday, he was detained by his superior in Guyana, and I received a phone call that he couldn't come. However, and we are very grateful for this, he arranged for his deputy to appear in his place and to read the speech which he had prepared. The next speaker will be presenting the speech prepared by Ambassador Irwin LaRoque, and this individual is Desiree Field Ridley.

Ms. Field Ridley is an Advisor for CARICOM, the Caribbean Community, on single-market and sectoral programs. I speak on behalf of our entire membership in telling you, Desiree, how grateful we are that you agreed at the last minute to step in as a substitute. We welcome you to the podium and we look forward to hearing your presentation.

Afternoon Plenary Session: The Caribbean Community: Challenges as We Proceed into the Twenty-First Century

DESIREE FIELD RIDLEY:

Greetings and Good Afternoon

Good afternoon. Whatever I say here goes to Ambassador LaRoque's doorstep! The CARICOM secretarIAT wishes to thank the Caribbean Food Crops Society for the opportunity to discuss the challenges for the Caribbean Community in these early years of the twenty-first century, and onward.

Ambassador LaRoque regrets not being able to be here, but as recently as of a few days ago, he was requested by our Secretary-General to proceed to London to participate in preparatory consultations and then to Geneva for the WTO negotiations. As I am sure you are aware, agricultural commodities—bananas, sugar, rice, and possibly rum—are currently under increasing threats in the WTO negotiations, so these meetings are urgent and important for us. Hence, I am here, to stand in for the Assistant Secretary General on this.

This is, perhaps, just one indication of how much the Region's agenda is affected by external developments and almost all of the twenty-first century is still before us, with all that is unpredictable. So I start with this first challenge.

The earlier presentations have covered developments relating to energy and food, and perspectives on achieving sustainable agricultural development, which would cover the problems and structure of our agriculture sector. I expect the later presentations would give us a vision for a new, transformed Caribbean agriculture, or at least a new approach, which suggests we might not now be doing, or going in the right direction, at least in some aspects. We have therefore already begun to highlight some of the challenges. History, Perspectives, and Vision: these cannot be examined without grappling with the Challenges, also, but I have tried to keep the potential overlap to a minimum.

This 21st century brings with it the REALITY CHECKS. To begin with, increased trade liberalization, loss of trade preferences in our traditional markets, and the graduation of some of our middle-income countries, particularly debt-ridden middle-income countries, from access to concessional resources and some preferential arrangements, and these in circumstances where the vast majority of CARICOM Member States are not yet positioned to meet the challenges or exploit the advantages, *but* where the demands of our peoples are no less ambitious than they have ever been. So, we are in a position where we have reduced resources, but our goals have not been reduced.

It was with the recognition and with the expectation that the global environment would be less accommodating and recognizing that not only have we not been producing for the markets which we had, including our own markets, but also that our survival and achievement of our goals would depend on increased and competitive production, particularly given our dependence on trade. In those circumstances, the Community[21]

[21] The use of the phrase "the Community" with this capitalization is a shorthand reference to the "Caribbean Community" or CARICOM.

took the decision, in 1989, to move to the CARICOM Single Market and Economy—the CSME—and the deepening and widening of integration arrangements, and by extension, our trading arrangements.

Now, where is CARICOM aiming to go? In 2007, CARICOM Heads of Government articulated the "SINGLE DEVELOPMENT VISION" for sustainable development, which encompasses economic, social, environmental, and governance dimensions. That includes, and I am being selective here, self-sustaining economic growth based on strong international competitiveness, innovation, productivity, and flexibility of resource use; and a full-employment economy that provides a decent standard of living and quality of life for all citizens, with the elimination or reduction of poverty and provision of adequate opportunities for young people, constituting an alternative to emigration; and spatially equitable economic growth within the Community, having regard to the high growth potential of Member States with relatively low per capita incomes and large resources of under-utilized land and labor.

As you will note, these are ambitious goals and therefore challenging. This VISION informs the further implementation of the CSME as an instrument for achieving, in a regional framework, certain development goals that are difficult or impossible to achieve individually by Member States. The VISION is an instrument for stimulating greater production efficiency and competitiveness, higher levels of domestic and foreign investment, increased employment, and growth of intra-regional trade and of extra-regional exports.

How? Well, for example, in this context of the CSME, the VISION further identifies Agriculture—primary and processed and including Fisheries and Forestry—to be one of the main drivers of economic growth and transformation, given its potential for: sustained growth of exports to international markets, both intra-regional and extra-regional, and significant growth in supplies as a key input for other sectors, and therefore providing important linkages.

So there we have a role identified for agriculture in the Region's economic development. The challenge now is to make it happen. In 2005, the VISION articulated for agriculture itself is a sector that, no later than 2015, would have made substantial progress toward contributing significantly to national and regional development and to economic, social, and environmental sustainability; that it has a transparent, regulatory framework at national and regional levels that promotes and facilitates investments and attracts (direct and indirect) inflows; and is a sector that has significantly transformed these processes and products and stimulated the innovative entrepreneurial capacity of Caribbean agricultural and rural communities; and is a sector that has enabled the Region (as a whole) to achieve acceptable levels of food and nutrition security that is not easily disrupted by natural and/or manmade disasters.

But having indicated all that is expected of Agriculture, let us go back just a little bit. As we began the 21st century, we in CARICOM were painfully aware that specific attention was required to be given to the agriculture sector if the Transformation Programme for Agriculture—that puts agriculture on a business footing as agreed in 1996 and now grounded in the "2001 Revised Treaty of Chaguaramas Establishing the Caribbean Community"—was to get off the ground. Or, rather, to be seen *in* the ground, as agriculture should be, and not off the ground.

The immediate challenges of agriculture are, therefore, to propel the transformation as envisioned in the mid '90s and to exploit the CSME arrangements being put into place to mitigate the negatives of being small, vulnerable economies separated by water, open and lacking capacity in so many ways; and to do this in a challenging global environment that was fast becoming less and less supportive, and sometimes hostile, of economies just such as ours, whether it was: reviewing the more stringent and demanding, liberalized trading arrangements like the WTO or the new EPA arrangements which now had reciprocal market access; or whether it was the reduced financing possibilities from the International Financial Institutions (IFIs), or inadequate global attention to climate change. The more recent rising food, fuel, and feed prices have only added to the urgency for action to ensure food and nutrition security.

Trade

I focus on trade particularly because, given our economies, trade is, in a sense, our lifeblood, and therefore we have to make sure that it can happen. Therefore—and in particular—the global trade regime has created special challenges for CARICOM Member States. The need for improved competitiveness through the transformation of our existing production structures, for the increased application of technology, as well as improved organizational arrangements has become a major preoccupation of policy makers in government and private sector as we expand our trading relations with third states.

For the last decade and a half, the Community has sought to meet the economic and policy obligations deriving from these multilateral trade agreements. Countries in the Community also relied on agreements which they thought were, at one point, sacrosanct; for example, for sugar, the EU Sugar Protocol stated that "The European Community undertakes for an indefinite period to purchase and import, at guaranteed prices, specific quantities of cane sugar…which originate in the ACP states…" The Community had the expectation that it would be for an indefinite period. We recognize that economic development involves transformation from traditional to modern and that international trade can contribute to or hasten that transformation.

But it also does not guarantee success. The economic challenges faced by CARICOM countries are serious enough to warrant grave concerns of rearranging the economic factors of production toward successful economic, social, and sustainable transformation. Diversification of the economies and the recombination of land, labor, and capital in the Community is an obvious strategy for renewed growth and development. In this respect, the Treaty of Chaguaramas lays the framework for addressing and facilitating the efficient use of economic factors of production—land, labor, and capital—across the Community. While some members of the Community have relatively large acreages of land—relatively—skilled labor is becoming scarce and capital is grossly insufficient.

Even while those issues of land and labor and capital are being addressed in the regions we have for the Single Market, there remain issues of property rights, labor and capital flows at the national level, which impacts on emergence and growth of agricultural enterprises across the region. We still need to look at the possibilities for using regional arrangements for production integration in its various forms across the Region.

One added element of challenge in our international arrangements is that, even as the subsidies in developed countries threaten the viability of our own farm enterprises in the Community, they also contribute to cheaper imports, which, in fact, leads to a heavy dependence on imported food in the region, apart from the fact that it increases the preferences of our consumers for imported products. This has implications for the kinds of policies we need to put in place, particularly as it is cheap to achieve some levels of food and nutrition security.

New Thrust

So, do we have a new thrust? Or is there a new thrust? When, in 2005, heads of government agreed with the recommendations from the lead head of government for agriculture that the immediate focus for agriculture must be addressing of key binding constraints in agricultural production. It is instructive to note that these countries identified were almost the same as they were decades ago. And I say "almost" just in case there may have been some shades of difference. Not that I necessarily believe so.

How do we now get action, which has been slow in previous attempts? Perhaps through concerted regional action on the immediate priorities of attracting investment and financing into the sector, and upgrading facilities for intra-regional agricultural trade and transport. This would include attention to strengthened regional collaboration in agricultural R&D and SPS measures which so many of the other speakers referred to particularly by cooperation among national R&D bodies and the revitalization of existing institutions with increased funding of regional bodies; marketing and strengthening of our private sector as the medium to facilitate development and empower entrepreneurial capacities throughout the value chain; market intelligence—sharing of information with respect to demand and supply for agricultural commodities; strengthening of private sector organizations, as a medium to facilitate, develop, and empower entrepreneurial capacity throughout the value chain; and the solving of the transportation inadequacies, which include the chicken and egg conundrum of not enough extra production to attract transport and not enough transport to encourage and support production. We are left in a situation where we just do not have a match of exports and transportation.

We have given regional focus for financing constraints when we had the Regional Donor Conference in June 2007 and this year an Investment Forum in June 2008. These will only be as good as governments are able to provide the enabling environment—physical and institutional infrastructure and incentives—for attracting investment. Since policies must emphasize competitiveness which supports commodity chain approaches that seek linkages with other sectors, investment ventures must be supported by the harmonization of planning and financing policies across the region. The Community needs to ensure that policies dictate public investment for rural and agricultural health, and food safety infrastructure, while specifically rewarding the private sector for the use of those measures which ensure the safety of food from farm to fork.

There needs to be some specific attention to the private sector, so that they are, in fact, encouraged to get involved in these areas. We now have to be able, providing we can get those investments, and recognizing that it would not be able to cover all our needs, to be able to prioritize in the areas of technology, research and marketing, since all are needed simultaneously. The challenge there will be to coordinate and to make sure

we get effective use of those resources. There is then the added challenge of how to organize and prioritize the supporting investments in technology, research, and marketing when all are needed simultaneously. How do we coordinate and manage the different stages and levels of the production and distribution chain?

The Community

At the Community level, there are further challenges to reaping the expected benefits envisioned for the agricultural sector, as these reflect the challenges that are general to the Region—and here I am not just focusing on agriculture, because agriculture is in the context of the total region—as we tackle the transition to both completing the implementation of the Single Market and also taking advantage of these arrangements, which move our perspectives from national to regional. Countries are accustomed to dealing on a national level, and we now are expecting that is the position, to shift the thinking to a regional level in order to exploit the benefits of the regional arrangements.

These are new issues of governance, especially as the Region moves to the CARICOM Single Market and Economy (CMSE).[22] So far, out of 12 small countries, we are creating a single economic space larger than any one member state, where goods, services, skilled CARICOM nationals, entrepreneurs establishing businesses, and capital can move without restrictions. Of course, there are some hiccups too, but that is not unexpected. As I said, one of the major challenges is to change that mindset which traditionally and emotionally is national, to see the entire Region as a source as well as a market. Another challenge is the forging of a Single Economy from individual sovereign states. For the moment, I'll leave that thought with you, and all that could or would be involved.

The development of regional policies has begun. For example, proposals for a Regional Fisheries Policy and Regime which takes us past the traditional access to each other's good and services, and into considerations of sustainable access to natural resources which are national assets of Member States which can be depleted; this is now on our table, and of course, not unexpectedly, there are concerns and issues.

The role of government in meeting the economic challenges in this century cannot be over-emphasized. The Community must be committed to ensuring policy coherence and implementation. At the regional level, an increasing attention is being focused on agriculture. At the national level, this must also become evident in the support and allocation of increased funding for the agricultural sector, while intensively pursuing external assistance for further development.

Conclusion

In conclusion, what is the balance sheet with which we must work? In summary, and just to highlight the immediate ones:

TO ACHIEVE: To achieve the transformation of agriculture for competitive and profitable production and exports, and for food and nutrition security and poverty elimination.

[22] CSME is the acronym for "CARICOM Single Market and Economy"

STRATEGY: What is the strategy? To complete the CSME and exploit the CSME and other free trade arrangements, of which we have quite a few. Also, to prioritize and focus on addressing key constraints so that results can be seen, by expanding and by competitive production of targeted commodities. The expectation is, if we have some successful results, that will feed on itself.

THE CHALLENGE: The challenge is finding resources in circumstances where there are revenue losses from our various Free Trade Agreements and also actual and potential market loss at the national, regional and in Third Countries, from loss of preferences and liberalization. Another key challenge is the forging of regional policies by individual sovereign States.

Finally, for agriculture, as long as Ministers of Agriculture, Ministers of Finance and Heads of Government provide the necessary support and issues of expertise, capacity and commitment are addressed, there is every reason for agriculture to be successful, that is, profitable and sustainable. This last would make the difference, but it is, perhaps, the greatest challenge.

DAVID SAMMONS:

Thank you very much, Ms. Field Ridley. That was a very thoughtfully presented paper—and please convey our appreciation to Ambassador La Roque, as well. I know the two of you worked together on that paper, I am sure. So much of the credit for the quality goes to you as well to the Ambassador. As I said at the outset, Ms. Field Ridley has agreed to take questions. Are there questions from the audience that you might address at this point? I think you've done an outstanding job, Ms. Field Ridley. We do not seem to have any questions at this moment.

BREAK BETWEEN SESSIONS

Afternoon Plenary Sessions:
Introduction of First Afternoon Speaker

DAVID SAMMONS:

Good Afternoon. We are going to begin our last session of the day. We are graced with two distinguished speakers for this session. I am going to introduce the speakers for this session. I'm going to introduce the first speaker, and then the second one in turn.

Our first speaker is Mr. Bruce Knight. Mr. Knight is currently the Under Secretary for Marketing and Regulatory Programs with the U.S. Department of Agriculture, a position which required confirmation by the U.S. Senate. This is a Presidential appointee. He was confirmed by the Senate in August, 2006, so he has been in this position for approximately two years.

In his capacity as Under Secretary, Mr. Knight is responsible particularly for leadership and oversight for the animal and plant health inspection service—this is APHIS, one of our sponsors for this meeting and to whom we are very grateful. Also under his jurisdiction is the Agricultural Marketing Service and the grain inspection, packers and stockyards administration. So, there are regulatory functions that fall under his purview as well as marketing functions. These agencies, taken as a group, protect animals and plants and promote fair, open and orderly markets for U.S. agricultural products. Prior to his appointment to the Under Secretary post, Mr. Knight served as Chief of the Natural Resources Conservation Service, another agency of the U.S. Government, and that is the lead agency for conservation on private, working agricultural land. So he brings an immense amount of experience and skill to his position.

Prior to his work with the U.S. Department of Agriculture, Mr. Knight also served in important positions with the U.S. Congress. He served on the staff of Senate Majority Leader Bob Dole; many of you may recognize his name, a Senator from Kansas, focusing on development of the conservation title of the 1996 Farm Bill. He was also a legislative assistant to Representative Fred Grandy from Iowa and to Senator James Abnor from South Dakota. Mr. Knight also served as Vice-President for Public Policy for the National Corn Grower's Association and he also worked for the National Association of Wheat Growers. So, he brings a great deal of experience, competence and knowledge about U.S. agriculture as he comes to the podium today to address the issue:

Perspectives on United States – Caribbean Basin Enhanced Trade and Food Safety Challenges

Afternoon Plenary Session: Perspectives on United States – Caribbean Basin Enhanced Trade and Food Safety Challenges

BRUCE KNIGHT:

Thanks so much for that kind introduction. It's a pleasure to be here today to get a chance to talk to you all about where there might be some additional trade opportunities in the Caribbean region, but also on ways in which we can move forward together.

Before I dive into discussing some of those things, I want to say, Congratulations, David, and to the entire University of Florida system, for being the first host to the Caribbean Food Crops Society in the United States. I know this is the first time you have brought the Society to the United States, and we really appreciate that. I hope that the University of Florida system, the U.S.D.A. folks here, from APHIS to FAS, that we are rolling out the red carpet for you and trying to be very helpful in bringing these things forward.

As you all know, and you know this or you would not be gathered here today, agricultural trade—fair, open, two-way agricultural trade—has greatly expanded just in the last few years. It has been good both for producers and consumers throughout the Caribbean region. In May, at U.S.D.A., we estimated that U.S. agricultural exports for this year will increase to $108 billion dollars. That's up more than 26 billion dollars over 2007. That's 40 billion dollars over 2006. At the same time, agricultural imports into the United States have increased significantly, and they are projected to rise, this year, to a record 78.5 billion dollars. So, much of what we are talking about here, is, "How can the folks who are gathered here today participate in that 78 billion dollars of opportunity as it pertains to agricultural imports into the United States?"

Now, the key thing to keep in mind is, "Why are imports and exports, why is trade growing so much, as it pertains to agriculture?" I think we will place some of that credit to trade agreements—NAFTA, CAFTA, any number of the bilateral trade agreements that are out there. Certainly, the single most significant contributor to that trade comes from, world wide, about a billion more people in an emerging middle class. That's where the opportunity rises for all of agriculture. It's providing food, fiber, and maybe now, perhaps, fuel products, to that emerging middle class that we see throughout the globe. You see it with the Asian nations that are growing so rapidly—China and India—but you see it in our own communities, with a middle class that is more affluent, with more opportunities and more demands as well.

Now, as I talk about the opportunities associated with these free trade agreements, I would be remiss if I did not mention some of the opportunities that are out there before the U.S. Congress with some of the *pending* trade agreements that we are hoping to get passed: Colombia, Panama, and South Korea. Normalizing trade with these three countries is extraordinarily important and a high priority for the Bush Administration. Last year, we were able to move forward with a very similar agreement with Peru. The next one up that many of you will be watching has to do with the Colombia free trade agreement. You know, approving this free trade agreement, when Congress picks it up, will immediately lift tariffs on more than 70% of U.S. agricultural exports to Colombia. This is a tremendous opportunity for U.S. farmers, and it is about normalizing trade, because many of the Colombian products today have unfettered access to the United States. As a matter of fact, since the completion of the Colombia free trade agreement,

nearly one billion dollars worth of tariffs and duties will no longer need to be imposed, had been imposed upon U.S. products going into Colombia. That is one of the reasons why we need to move forward with these free trade agreements and why we all need to be working to expand opportunities for two-way trade.

This afternoon, as we talk about this, I want to talk about a number of the programs and the regulations within the U.S.D.A. that APHIS, the Animal/Plant Health Inspection Service, utilizes to address the concerns of controlling pests, disease, invasives that may pose a risk of coming into the border of the United States.

Now, first, in the mid 1990s, the U.S. created a specific initiative to keep pests just from entering Florida from the Caribbean countries. This effort has, since then, been expanded to include offshore coordination, and now—and I was talking with several of the folks during the break about this—also about technical assistance to help other countries within the Caribbean with their own safeguarding initiatives. Recently, we have expanded this program, and it now goes by the name of the Caribbean Safeguarding Initiative. Today, we have a much broader focus: to protect the health and value of agriculture, natural and other resources in the entire Caribbean region, by excluding, detecting, and controlling pests.

In short, we made the determination that the best policy is to look beyond the borders of Florida, or beyond the borders of the U.S., in working in partnership and being able to move forward. Our strategy is simple: it is to develop a regional parameter approach, partnering with everyone in the Caribbean region; we are emphasizing risk communication, training, and trying to do the kind of capacity-building that will be necessary for long-term success. With this approach, all the countries of the region will be able to identify high-risk pathways and conduct surveillance and mitigation programs.

As you know, in 2003, the U.S.D.A. merged its agricultural quarantine inspection efforts with the newly-created U.S. Department of Homeland Security. The U.S.D.A. now has a responsibility for handling the scientific, technical and regulatory aspects of that joint mission. That is why you will be continuing to work in partnership with the U.S.D.A. on the science and the policy of pest detection and exclusion. DHS, Customs and Border Protection, focuses now on law-enforcement through border inspection. It is important, any time I'm talking to group of folks about international opportunities, to share with people where some of the successes have been as we move forward with that partnership. That partnership has been in place for several years, and what we recently did was create a joint task force targeted at working through the growing pains associated with creating a new agency, creating a new mission, and moving forward with that protection. That task force is a vital part of the outreach, the effort, and the commitment—continual commitment—to improvement, that both the U.S.D.A. and DHS has to our border protection.

Customs and Border Protection (CBP) has several initiatives that I want to share with you, the successes that have been the outgrowth of that. APHIS has developed, with Customs and Border Protection, an effort to streamline the inspection procedures for high-volume, low-risk agricultural commodities. This offers two benefits for folks that are out there, whether it is importers or exporters: with these low-risk, high-volume shipments, they move more quickly; more importantly, CBP is now able to focus resources on the most high-risk shipments and have the manpower and the resources to adequately inspect those. Another example of targeting is one that we do right here in

Miami, where we found that one of the greatest invasive pest risks we had was actually associated with tile imported from Italy. So, we now specifically target that upon inspection. Further, APHIS is now able to fully tap into a massive database the CBP mans and augments on a daily basis to make sure that we really target those things that will have the greatest need for inspection, and have the greatest risk for exposure as we move forward.

We have had a number of joint operations that we have been able to do as well. One of those is one that we have actually done through SITC, which is APHIS' Smuggling Interdiction and Trade Compliance Unit. SITC, as I mentioned earlier, works very closely with Customs and Border Protection and, as a result of its efforts, SITC has confiscated over 344,000 pounds of prohibited products just last year alone. One of those issues that SITC addressed, as we opened the border with India on mangos, we found a sudden rush of illegal product coming in by targeting that. Many of those were expedited shipments that were sent right here through Miami. We were able to intervene there, confiscate that product, and allow appropriate approved trade to continue to move forward. We have had a similar effort as it pertains to—and I know this is primarily a plant group, but I'll mention it anyway—products that might have risk of avian influenza, which it is extraordinarily important that we control that and bring that forth. In 2006, SITC, working with CBP, targeted and interdicted over 216,000 pounds worth of poultry products—at risk of avian influenza—that people were trying to bring, knowingly and illegally, into the United States.

I mentioned one of those products that we are working on to help folks in this room with that same sort of joint effort, and that is—Commissioner Bronson mentioned it—citrus here in Florida as a problem with citrus canker. Because of that, we need to be watching closely potential illegal movements of citrus from Florida into either the U.S. Virgin Islands or Puerto Rico. As a result of those same SITC efforts, 45,000 pounds of product was trying to be illegally moved from Florida into Texas, Puerto Rico, and the U.S. Virgin Islands has recently been interdicted and stopped.

Now, I mention a little bit about those successes. I would be remiss if I didn't mention one of the real challenges that is facing us as we move forward in our relationship and our work with the Caribbean islands, and that is a pesky little creature called the Red Palm Mite. I think many of you might have seen even on the poster sessions, you see the effort that is back there. As many of you know, this invasive pest loves coconut, date palms, also banana plants. It arrived in the Caribbean in 2004, and by 2006, it spread to nine of the islands, including Puerto Rico. That is a very rapid spread, by anybody's measure. It was first detected here in the United States, in Florida, in late 2007. So far, it has been identified in four Florida Counties: Broward, Dade, Palm Beach and Monroe.

Unfortunately, the Red Palm Mite reproduces very quickly, in very large numbers. While it can spread by wind, its most important vector are tourists. Folks who, unknowingly, help that infested product move around by bringing the products home from a trip. So, it's traveling right now by handicrafts made from green palm leaves such as tote bags, woven palm hats; those sorts of things. As a result of that, we've had to increase inspections. Now, I know how important tourism is, and—everybody in this room—if you hear folks complaining about heightened vigilance, either airline transport or on cruise ships, that's what we are looking for and that's why we are looking at those

particular products, recognizing that the cost of a few disgruntled tourists is far outweighed by the importance of protecting the economies, the agricultural economies, of every body that is in this room.

Let me turn now to a couple of the rules that we are going to be moving forward that are going to change, in some way, shape, or form, some of the business that is, in fact, done between our respective countries. The first one that I want to mention is one that we are moving forward this year. It goes by the name of the Q37 rule. That's short for the basic basket of rulemaking that covers plants coming into the U.S. for planting. We are making a major overhaul of this rule to reduce the risk of importing pests by requiring pest risk management measures in countries that export to us. We have been working on this one for several years, so it should not come as a surprise to many people. We've decided to update the rule in incremental steps, beginning now with three proposed rules. We will release the first rule this fall.

It will create a new category of regulated plants that cannot be brought into the U.S. without a pest risk assessment and implementation of adequate pest risk management measures. We anticipate adding about 200 invasive plants and ten host plants to this "not authorized pending pest risk analysis" list in the first rule. So, you want to watch that rule when it comes out. The second step will involve restructuring Q37 in consolidating other regs that impact plants for planting. The proposed rule will list standard measures that may be used to mitigate pest risks associated with plants for planting. We will, in turn, maintain this list up on the website so that folks can go to it and move more quickly. What you will see is a much more nimble, a much more rapid regulatory process that can move much more expeditiously. Our goal is to publish this second rule by the end of this calendar year. The third proposal will cover controlled import permits. These permits cover importation of small quantities of restricted plant material for research purposes. We will have this one out as soon as we can, following the completion of those two things. That is Q37. That controls plants for planting. That one may have an adverse impact on some of your trade relations.

Let me mention to you one that we put in place last year that is ground-breaking in providing greater opportunities for streamlining, for you to be able to send products into the U.S. That is called Q56. Q56 governs the movement of food products into the United States. It is a streamlined process for being able to do that. Under Q56, we do away with the old method of making a risk assessment for a country, one at a time. We will be able to look at regions in total, normalize the trade with that, talk about the risk measures that may be able to come forward and the products that can move forward under that. With that, a number of Central American countries have moved very expeditiously in bringing products in, I think like blueberries from Guatemala and a number of products from Africa. This should be an excellent opportunity for people who are gathered here in this room to move more quickly through our regulatory regime for being able to send agricultural products into the U.S. as they move forward.

I talked, probably, in more depth than any of you ever wanted to have, about the U.S. regulatory process. So, let me, as I come to a close, mention a few things that are also out there on the policy front that are resulting from the recently-passed U.S. Farm Bill. The Farm Bill recently has been passed by the House, the Senate; it is now law. I make no bones about it. The Administration—we felt that the Farm Bill should have been more robust, it should have been more supportive of open trade. It should have

been less distorting on subsidies in trade, but it also provides certain opportunities. I want to talk a little bit about some of the opportunities that may be of interest to folks that are in this room. One of the key things it did was provide additional opportunities for specialty crops. It was certainly targeted at specialty crop opportunities domestically, in the United States. But, many of these things are going to provide opportunities for producers of specialty crops in the Caribbean or anywhere else in Latin and South America.

The Farm Bill expands, significantly, purchases by our school lunch program, of fresh fruits and vegetables. We are really trying to put the kind of dietary habits in our own children that we can best do through that school lunch program. That means over one billion dollars in purchases specifically targeted: fresh fruits and vegetables targeted at creating the right dietary habits with our young people at the right stage in their lives. We also have a specific program—250 million dollars—of purchases through the Department of Defense Fresh Program. It will put fresh fruits and vegetables right into the school program. One of the things I was talking to Commissioner Bronson about earlier that is going to be out there that many of the states will be applying for—466 million dollars in block grants for State Departments of Agriculture for specialty crop development, research, market enhancement efforts; 200 million dollars for the market access program for specialty crops as well. One of the things that APHIS will be moving forward is a pest and disease program focused specifically on invasive pests and diseases that will again be in partnership with those state block grants. Finally, a major initiative on specialty crops that pertains to the research that is needed for many of the specialty crops. There will be opportunities for everybody in the community on those as it pertains to reaping the benefits. The benefits of improving food safety, the benefits of improving the food chain, the benefits of a more streamlined and more robust transportation system.

In closing: At U.S.D.A., at the Department of Agriculture, we are very committed to free and open trade and the market opportunities that are going to come out as a result of that. Also very important, while we expand those trade opportunities, it is very important to know that we are also very committed to having adequate safeguards and protections from plant disease and pests posed by invasives. We are trying to make sure that those decisions are made on the best, most sound science that can possibly be done. By having the appropriate regulations; by having the appropriate safeguards, I think we can improve trade relationships throughout the Caribbean nations.

With that, I would love to take any questions folks may have about my formal address, or any questions you may have on the much broader issues that are facing the U.S.D.A. or the American agricultural system as a whole. With that, I would be pleased to answer any questions that may come from the floor.

Q. You mentioned about products made from coconut leaves or other stuff like that; I know a lot of tourists who go to the Caribbean buy straw hats and some other products that they might want to bring back. How do you plan to look at, say, hats and other products that they might buy, just walking on the beach or from a vendor on the street?

A. How to differentiate between untreated products and those that are? One of you want to take that? The great thing about having 12,000 employees—you've always got somebody you can dump the tough answers onto. *Bob Ballum, Offshore Issues Coordinator working with*

APHIS. Right now, we do not have a good protocol for treating palm hats or any of the other palm handicrafts. So, at this point in time, any kind of palm handicraft that comes from a country that is infested with Red Palm Mite is considered a prohibited product; it will be confiscated at the U.S. border/port of entry.

Q. As I thought about what you were saying, though, I am looking at tourist trade and all those things and I know where the handicraft work goes on. But, since this is a part of tourism that is big in the Caribbean, I was thinking about some of those things where we might be able to get with some of the commercial or trade association with the people who make those products and offer them some kind of relief. And I would think we might be able to use radiation for some of those materials we might use to make some of these products. So therefore we don't put a stop in their doing their business, because it is their lifeline. We have to support those people because these small projects and handicrafts are the main staple of those families. So as we try to keep the small investors, small entrepreneurs, small farmers in business, we have to think about them rather than think about the grand scheme for the big producers. So we need to keep that in mind. I would like us to formulate policies which look to address those things.

A. It's very sage advice. One of the things that we need to do on the Red Palm Mite is: we've got to be working together. Because, with it's ability to impact palm production, you're going to have an adverse impact on many of your own producers, not just on the tourism industries. We've got to find the right controls and the right ways to put safeguards in, and we always have to find these solutions such that they are size-neutral, that they will work very well for both small and large operations.

AMY RODA:

My name is Amy Roda. I'm going to be coordinating or facilitating the 7:00 pm meeting tomorrow night, on Tuesday, and one of the main issues or points of that meeting is to draw out what needs to be done in a collective effort: how can we pool our resources together to address how we're going to treat palm handicrafts? Right now, nobody is addressing that, in terms of research. So, please bring those types of points and hopefully, at the 7:00 meeting, we can at least develop a framework to start addressing some of these problems.

BRUCE KNIGHT Q&A Continued:

Q. Based on your presentation, I've got a distinct impression that you are very concerned about pest-related problems that exist in Florida and other states and U.S. related territories like Puerto Rico, the Virgin Islands, since you mentioned, Texas. What measures are put in place to avoid those problems which implicate the Caribbean?

A. From my talk, yes, you definitely heard I have, very much, a focus on keeping the pests out, primarily because that's my job. That's the mandate that we have through our legislation. One of the things that we are wanting to do, however, is move in partnership and cooperation away from a 100 year old border inspection method of keeping pests out, to one that moves upstream, with our best partners, to talk about how to do that. That is one of the reasons why you see, probably, well over a half-dozen USDA/APHIS employees here this week. With our Caribbean safeguarding initiative, we are recognizing full well the importance of partnership with the nations that are gathered here, and the need to transfer assistance, expertise—whatever we can do to help—to be able to work closely with folks in being able to address that. Because of the unique nature of the Caribbean: boat traffic, airline traffic, tourism, a very porous system of borders, there is a tremendous number of unique, creative things that we are going to have to do to be able to prevent pests from moving throughout the Caribbean. The Red Palm Mite is a good example of this. Three or four years ago, none of us were talking about it or concerned about it. Now it's in nine countries and expanding. We need to work together on those kinds of solutions.

Q. Just a clarification: the program that you spoke about under the Farm Bill, where they will be purchasing fruits for the school lunch; does it matter the source? Is it only for U.S. growers, or where can it be from?

A. I end up having to implement what Congress puts into law sometimes, whether I personally agree with it or not. One of the provisions that Congress puts in place on the school lunch program is that we have to utilize U.S. products in doing that. However, I mention that, in that, you also know, how, when the tide comes in, every boat in the harbor goes up. When you have a program as large as the school lunch program, purchasing U.S. commodities, whether it's fruits or vegetables or anything else, creates demand elsewhere for other products. The thing that is most attractive about the U.S. school lunch program is actually what it does as far as building the right habits with our young people at an early age, in establishing, with the efforts that we are doing right now with fruits and vegetables, getting people in the habit of using fruits and vegetables as a snack as opposed to cake and cookies and highly processed products, which lead to obesity and any number of other things that are out there. So, it is only for U.S. products, but there are some ripple benefits for folks that are in this room.

Q. You spoke about widening your borders outward with some of your strategic partners. In the wider Caribbean, we have had a project with invasive species for the last three, four or five years. Part of the process is that we need to improve the capacity of the folks in the wider border. Does your program…will it cater for that? Because there are two or three project documents that have been written, and nothing has been happening; maybe that is why the Red Palm Mite has spread. So, if we

could get the type of support to facilitate the institutional capacity building, it would be very helpful.

A. I appreciate that suggestion very much. You can be assured that we will take a look at every proposal that comes in to see where the opportunities may arise. One of the things that was mentioned by a few folks earlier; as I move forward on some of the rules of the Farm Bill, I've got to look at how flexible we can be on some of those efforts, in being able to see if we can go beyond the borders on some of those additional financial resources we may have. What I do know, is that I can lend expertise of our personnel that we have already got overseas and put additional people out there to be able to work, country-by-country, on anywhere we are invited to be able to help on that infrastructure building.

With that, it has been an honor to be with you all this afternoon. I appreciate very much the chance to address you. I wish you good luck in this meeting.

DAVID SAMMONS:

Thank you very much, Bruce, for that fine presentation and for answering the questions as well as you did. It was very helpful to our discussion and you have provided some insight around the whole question of trade and trade restrictions to regulatory issues that impact trade. On behalf of the Caribbean Food Crops Society, we would like to present you with a memento of our appreciation for your participation in our meeting, and we ask that you put this on your desk in a prominent position.

We are now going to turn to the final paper in this plenary session. This will be presented by Dr. Chelston Brathwaite. You heard from Dr. Brathwaite this morning, and if you will recall, Dr. Brathwaite is a citizen of Barbados, but I characterized him as a citizen of the world in my introduction, by virtue of the fact that he has worked in many parts of the world on important leadership activities in the agricultural domain.

Dr. Brathwaite in the Director General of the Inter-American Institute for Cooperation in Agriculture, or IICA, as many of us know it, and has held that position since 2001. He has initiated numerous reforms and new directions for the activities of that institution and has provided important direction as that institution has continued to grow, prosper and impact for the benefit of all of us who care about agriculture in the region.

Dr. Brathwaite will address the topic, "Vision of a New Transformation Paradigm for Caribbean Agriculture." Dr. Brathwaite, we welcome you to the podium once again.

Afternoon Plenary Session: Vision of a New Transformation Paradigm for Caribbean Agriculture

CHELSTON BRATHWAITE:

Thank you, David. Mr. Chairman, thank you very much. I am glad to be here again.

In cricket, I would be considered a night watchman. Not only a night watchman, but a night watchman who is coming in after their four hundred runs on the board. And after to listening to Dr. Bourne, Compton Bourne, and Dr. Anthony Bryan and Ms. Field Ridley, I am not going to say too much.

But I want to tell you a little joke which I think will set the stage. First of all, recently, a quotation attributed to Yogi Berra, who said, "The future is not what it used to be." There were two friends in the forest who went on a jogging trail. They took off their shoes as they were jogging. And one of the friends looked back, while they were moving forward, and he saw a lion coming. He told his friend, "George, look back at the lion there." And George stopped and put on his running shoes. The other friend looked at George and said, "George, what are you doing? Putting on your running shoes? That's a lion! Do you think you can outrun a lion?" And George said, "I don't want to outrun the lion; I want to outrun you!" It seemed to me that there is a relationship here. The future is not what it used to be.

I am delighted to be here and have this opportunity to address this distinguished body. I note, with satisfaction, the range of important scientific papers that you will present in an attempt to "Reposition Caribbean agriculture: Challenges and Opportunities for Sustainability." I want to congratulate you, because, you, like us, have kept the faith in spite of the decline of fortunes of Caribbean agriculture. You have continued to labor on. To do what you think is appropriate in scientific investigation and presenting knowledge and presenting solutions, although many times, we seem to be a voice in the wilderness. I congratulate you for your efforts. But I can tell you: neither your efforts, nor our efforts, are going to achieve the noble objective of a sustainable Caribbean agriculture unless and until we forget the colonial legacy of dependence of our agriculture on primary agricultural products under protected regimes for export to Europe and South America, and embrace a new agriculture based on agro-industrial development that exploits the inter-sector linkages of agriculture with the rest of the economy, which promotes food security and real prosperity.

Some twenty-five years ago, we had the Caribbean Food Plan, the Caribbean Food and Nutrition Strategy. And it seems to be that there is a prevailing myth in the agricultural literature, which a lot of our leaders seem to believe: that as the country developed, the importance of agriculture declines. Given that the statisticians recognize it as being of single digit percentages—three percent, four percent, two percent—that those who believe we should not worry with that at all. But I beg to differ. Because food is a critical input for sustainable development, and agricultural importance, in my view, increases as we develop because of the linkages to agribusiness, the food industry, input industries, tourism industry, agro-industry, health and nutrition and its contribution to rural prosperity, balanced development, social equity, and social peace.

In this country, the United States of America, it is often written that only 2% of the population is involved with primary agricultural production. But there is evidence also that 22% of the population is involved in the food industry. It is that kind of statistic that we need to be aware of. It is not only primary production; it is all those linkages with the rest of the economy. Let me give you an example: we have often heard, in the Caribbean, we are moving toward service economies. The economists tell me that that is about tourism and financial services without realizing that an important part of a service economy is the food service economy. The food service economy in the Caribbean is about 70,000 companies with annual sales of $5.6 billion annually. There are those who talk about a service economy as if agriculture does not matter and food does not matter. And yet, all our people have to eat, every day. You don't have to bathe every day, but you have to eat every day.

The Caribbean region is the most food-insecure region in the hemisphere. Our small size does limit our capacity to produce all the food we need. But, we could produce more of what we consume. I am told that one out of every ten meals that we eat comes from abroad; we produce one! The other nine come from somebody else. We are prepared, apparently, to let other people feed us. The historical foundations of Caribbean agriculture, as you know, were based on the good old colonial model. Produce sugar and bananas and we will provide you with food.

So, in this twenty-first century, we have to decide whether we will continue to be fed, or we are going to continue to produce some of what we consume. Whether we are going to continue to give our children and grandchildren a diet based on what others produce, or whether we give them a diet based on what we are capable of producing.

The implementation of the Jagdeo Initiative, a proposal for modernization of Caribbean agriculture, has great potential. But that proposal only has relevance if there is a mechanism to remove the binding constraints. We talk about the ten binding constraints—what is the mechanism to remove the binding constraints? Otherwise, we can talk from now until the end of the world and nothing is going to happen, unless there are mechanisms to remove the binding constraints.

I am here today to suggest that a food and agricultural sector in the Caribbean which was once the bedrock of our economies—let's not forget that food and agriculture was once the bedrock of our economies—still has the potential to generate future employment—jobs and wealth—in the region, in addition to protecting our natural environment and responding to the realities of climate change. I am not speaking of traditional agriculture. I am talking about a new agriculture. A new agriculture that is far removed from the mass production of raw materials for preferential markets, and one that increasingly embodies cutting-edge technologies, innovation and knowledge; one that offers agribusiness opportunities in an expanding range of food and nonfood services.

I speak to seven areas—very quickly: organic agriculture; herbal, medicinal and cosmetic products; agro-energy; agro-biotechnology; food for ethnic markets; agri-tourism; and food from the sea.

Globally, organic agriculture is developing rapidly and now is practiced in more than one hundred twenty countries of the world. The latest survey of organic farming worldwide reports 31 million hectares being managed organically. A lot of that is in Australia, Argentina, China and the United States of America. The Organic Monitor, an international magazine which tracks these developments, reported that global sales of

organic food and drink increased 43% from 23 million to 33 million dollars in 2005. The Organic Monitor expects sales to approach $40 billion in 2007. Although organic agriculture is now practiced in most parts of the globe, the demand is increasing in Europe and North America.

Against this background, we have sort of led, as IICA, development in the Caribbean to promote organic agriculture. To produce food that is safe and healthy, that responds to the reality of the norms for those kinds of foods, and can support a healthy diet in our tourist industry. But the organic industry requires more investment, not only the production of food. We need to invest in the production of organic fertilizers and the production of organic pesticides. There are tremendous opportunities for the production of organic coconut, cocoa, coffee, pimento, nutmeg, etc., and the production of materials for the spa and the tourist industry.

Herbal and medicinal products—big business! $800 million a year in business! Aromatic oils, vegetable oils, soaps, vegetable alkaloids, spices and herbs. The Caribbean has a long tradition of high-quality spices and ethno-medicines. However, the region has a very low share of this market. It is a considered a hot spot due to the wide range of raw materials in development of new, unique bio-products: dried and fresh herbs; herbal teas; essential oils; liquid extracts; tinctures; exotic herbal drinks; neutraceuticals; cosmeceuticals; and plant-derived pure pharmaceuticals. Great potential here!

Investment opportunities also lie in joint ventures for the establishment, testing and certification of laboratories and services for these products, and branding unique commodities from our part of the world, especially in countries—such as Guyana, Jamaica, St. Vincent[23]—that have such natural vegetation. We could produce a range of organics and herbals from these countries. Recently, IICA and the Center for Development Enterprise have established an initiative called the Caribbean Herbal Business Association which has laid the foundation for the possible profitable investment and rapid expansion of the herbal industry. There are opportunities there.

Agro-energy. With the exception of Trinidad and Tobago, Caribbean countries are predominantly net importers of energy, heavily dependent on fossil fuel. Currently, imported oil, or based-on-oil products of $140 a barrel, cost in excess of $6.5 billion. Somebody told me, in a certain Caribbean country today, the cost of oil imports is more than the GDP. These are challenges—serious challenges. Some countries have initiated efforts in the production of ethanol. Ethanol is attractive if we can get the feasibility right. As you know, Brazil has pioneered this business, but Brazil is a huge country. We need to look at the economies of scale and feasibility, to make sure that it can be successful. Some of my friends have told me that it can be. In fact, one professional told me, "If we had done like Brazil and started the production of ethanol in 1973, we would have produced six times as much capital income as we have produced from sugar. Sugar prices are declining, as you very well know, and oil prices are increasing, as you very well know. Any country that produces a product whose price is decreasing and imports a product whose price is increasing is on the pathway to going broke. Biofuels, biodiesel, also has great potential. Whether we use palm oil or we use some of the other crops that are considered relevant, this crop lends itself, and the biodiesel lends itself to small-scale

[23] St. Vincent is one island in the island-nation of St. Vincent and the Grenadines.

production in a way that ethanol does not; it is something we need to look at, using Jatropha or whatever else that can be produced, the feasibilities have to be done.

We commissioned a study in 2005 to look at agro-energy in the Caribbean; the document is available. It has some very useful information in it. We have shared it with the Ministries of Agriculture. I do not know if it has reached the Ministries of Energy, but clearly, there are opportunities there, and we know that some of the big companies, such as CLICO[24], have indicated their interest in getting into the ethanol business.

Biotechnology. The Caribbean is already behind in the biotechnology revolution. This is a critical area of work. Biotechnology offers the possibility to be the lead technological tool of the 21st Century. But we are not investing in biotechnology. Our universities do not have the capacity, the human capacity, nor the money, to get involved in a serious way in biotechnology. Most of the biotechnology research that has been done in the world has been done on temperate crops: corn, wheat, soya bean, maize, etc. Who is doing the research on the biotechnology of sweet potato? Who is working on the biotechnology of yam? Breadfruit? Bananas? Who is working on these biotechnologies? If we do not do the biotechnology, it is clear that we will be left behind.

The only tropical crop that seems to have attracted significant funding for biotechnology today is rice, where they are doing some work on the genome of rice, a very important piece of work. We need to look at biotechnology. We need to attract joint ventures. This is where a joint venture with the University of Florida is probably something to consider, because I know that you have done excellent work in these areas. Why shouldn't we have a joint venture with some of our North American colleagues, to look at the biotechnology of those crops that are interesting to us? The biotechnology of yam, sweet potato, breadfruit—we may discover some interesting things.

Then, I could not go on without talking about ethnic foods. We know that there are a lot of us who are outside the Caribbean—in New York, in Miami, California, London, Montreal, Toronto—that love to eat ethnic foods. We like to have something from back home. There is a market there. We need to look at the market for ethnic food. We need to begin to look for the possibility of producing products that can be exported to those ethnic markets. For Jamaica, "Akee" in the U.S. market and other markets which I will talk about later. We have established an office in Miami—an IICA office here in Miami—that is helping some of our Caribbean producers understand the U.S. market. Understand the bioterrorism law. Understand the recent U.S. agricultural trade bill. To understand the reality of this market place. Understand the challenges related to pests and diseases. Understand the reality of packaging, labeling, in order to get into this market. Because, if trade is going to be free and fair, it cannot be one way.

In the new agriculture, opportunities also exist in the area of agriculture and tourism. In the past, both industries developed separately from each other. The results being that neither agriculture nor tourism developed, in my view, in a sustainable manner. The need for the linkage is clear. I have a statistic that says that, in 2005, 20 million tourists visited the Caribbean—the Caribbean in a global sense—and taking the cruise industry, the land-based tourists, etc. Twenty million! I would ask a simple question, "Who feeds the Caribbean tourists?" I assume they have to eat. If we were to calculate

[24] CLICO: Colonial Life Insurance Company, established in Trinidad and Tobago in 1936; CLICO includes a subsidiary, CL Financial, an investment entity designed to fund capital-intense ventures such as energy development.

the number of breakfasts, lunches and dinners consumed by 20 million tourists, and translate that into fresh fruits and vegetables, seafood, meat, dairy products, bottled water, we would be astounded at the value of the foreign exchange that is leaked out of the region by those who come to the region. I am told that that leakage is 85% in the Bahamas, which means that you get 15 cents of every dollar remaining in the country. I am told that, in my country, it is 45%. So, you get 45 cents out of every dollar and the other 55 cents go elsewhere.

The other side of the coin, of course, is the opportunities for the Caribbean to supply fresh and authentic food to visitors. We must ensure that the tourists to the Caribbean sample Barbados Blackbelly Lamb and Jamaican Akee and Salt Fish, and Guyana Pepper Pot, and Trinidad Roti. If we are not doing that, then the tourist is not enjoying the gastronomic experience that they should have. If we do that, we will provide jobs for our people. It is not every tourist that comes to our shores that would like to eat Idaho potatoes and Texas beef. There are some who would like a change: "I want to eat something different." We should provide them with the opportunity to do so.

Then, there are the artisanal products that can be derived from animal hides, straw, seeds, roots, grasses, for the souvenir industry, a lot of which are now imported from China. I am heartened by some of the recent orientation in the tourist industry that seem to show that they are prepared to source some of their products locally. Because I am sure that this will contribute to the food security of the nation and will help to provide jobs in the local market place. The consumption of local food is good for all the surge of "foodies"—tourists who come to the Caribbean for the ultimate gastronomic experience and for the music. It also means that if you link agriculture with tourism, you keep some of the land in agriculture; farmers can realize increased farm-gained incomes from tourism-related revenue and achieve sustainable livelihoods in rural areas.

I had a joke the other day I was told by this gentleman, who—many tourists went to his farm to have the experience of milking a cow. They would drink the milk and give the farmer $10 for the experience of milking a cow. You know, some people come over from New York, they've never milked a cow in their lives. Nice, interesting experience. I understand that the hotel manager got a little annoyed with these fellows going onto the farm and coming back late and all that kind of thing. And I'm told—I didn't see it, but I'm told—that the gentleman moved his cow to the hotel gate and had people come outside the hotel and milk the cow. That's agri-tourism for you!

That is a joke, but it's serious, because the guy was making a living, and we very much prefer for people to make an honest living doing such things than going out there and stealing. Or going to town and becoming part of the unemployed, with all the social dislocation that that involves. So, I hope that the tourist industry will begin to recognize their corporate social responsibility to the society and not the corporate social responsibility to send all their profits abroad. Give back something to the society in which they are based, and so stimulate agriculture in a strategic way. I am told that Sandals, in Saint Lucia, has reported savings of over a million dollars a year by sourcing local fruits and vegetables. That's the kind of thing that is possible.

So, forging agriculture-tourism linkages is not rocket-science. To me, it is logical. But we have to get our people to understand that in this new scenario, we have to stimulate jobs in the local economy, because it is not now easy to migrate abroad to find a job in the city or any other place. We need to promote the unique tourism product that

we have—health and wellness tourism; agricultural tourism—and we need to link the tourism products strategically with agriculture in a better way. If 20 million people come to our shores, those are 20 million people that we can feed additionally, and we do not have to export those products abroad. Greenhouse technology, hydroponic production and organic production can help stimulate this particularly.

It would be remiss of me if I did not mention the Caribbean Sea. After all, the Caribbean Sea belongs to the Caribbean. Sometimes it seems like it doesn't belong to the Caribbean. We are very loathe to take advantage of the tremendous potential of the Caribbean Sea as a source of high-quality protein from fish and other marine life. We use it as a source of bathing and cruising and surfing. We need to improve our capacity to exploit the Caribbean Sea. When those flying fish leave Barbados and go to Trinidad, we have to make sure there is a reason for them to come back. We need to ensure that the fish are able to find a favorable environment in which to grow and multiply so that we can have a source of protein for the future. There are two critical areas for the future as we face food shortages down the road: the sea and biotechnology are two important aspects for the future. We need to look at the Caribbean Sea as a source of food, not only for bathing and surfing. There are a lot of fish out there, but other people passing through are collecting all of them. We need to find a way to be part of the business.

In a new agriculture, we will have to invest in human resource development. The University of the West Indies has a very important responsibility, and all the universities in the Caribbean—tertiary level institutions—to produce the kind of human resource that is necessary for the new agriculture. There are no programs in agri-tourism. There are hardly any programs in trade development. I understand CAFIL has just started something in that area which I think is a very positive area. We need more people in science and technology. Human resource development is key in food safety, in biotechnology, in herbal products, etc. Our universities must become proactive.

Then, the private sector. The private sector has to work more strategically with the governments in a way that make all this possible, providing leadership, investment capital, etc., as we move forward. In the last 25 years, the world has seen a reduction of attention to financing agriculture. The development banks dismantled their agricultural divisions. The governments of our countries invest less in technology and innovation. We dismantled the extension services. When enduring a period of structural adjustment, reduced government expenditure became necessary, we reduced the ministries of agriculture. Investment in the rural economy in the Americas, where 40% of the population live, we invest 6% of national budgets. In a lot of the countries in the Caribbean, the investment in agriculture is between 2%--6%. We have established millennium development goals, and now we are told by the World Food Program that, instead of reaching the goal a 100 million people in the current scenario will return to poverty. In Latin America and the Caribbean in the last five years of good economic growth, 27 million people, according to EPLAC, came out of poverty. EPLAC now says that they will go back.

The crisis we face is not insurmountable. There are those who say we need a new green revolution. For those of you who are too young to know—there was something called the Green Revolution in the 1960s, where we had increased agricultural output resulting from the use of new crop varieties, irrigation, the use of fertilizers, pesticides, mechanization, for which Norman Borlaug won the Nobel Peace Prize in 1970. Without

doubt, the Green Revolution resulted in reducing hunger and food insecurity in many countries and is credited with saving a billion lives. But those who advocate a new Green Revolution must also take into consideration some of the negative aspects of the last Green Revolution: social exclusion of small producers; dependence on the pesticide-fertilizer complex; and many environmental problems related to pollution of land and water supplies. There can be no doubt that technology, biotechnology and technological innovation will be critical for our search for solutions to the current food crisis. But I do not think we need a new Green Revolution.

I think we need a new development model, a new development model that values the contribution of multidimensional agriculture and the rural economy to integral development; for its contribution to food security, energy security, supply of water, employment, the preservation of the environment and the preserving of social peace and social stability. I have noticed that the Africans have placed food security and agriculture at the top of their development agenda. The current development model in the Caribbean—the current model—is based on cheap food, cheap energy, preferential treatment of a few export commodities, consumption pattern based on what we do not produce, and peace and tranquility in our countries. We produce bananas, but we do not provide our children with a banana in their lunch kits per day. We try to sell the bananas to Europe.

Today we face a new reality: high food prices, high energy prices, no preferential treatment, and in some cases, we have been graduated from the World Bank and those hallowed institutions who now classify us as 'middle income'; so you do not have a right to any of the soft loans any longer. So, the totally new scenario: we need a new model. Sir Alfred Lewis, celebrated economist and the first person from the Caribbean to win a Nobel Prize in economics, recognized the importance of agricultural development in his celebrated work, "The Theory of Economic Growth" published in 1955. Recently, Professor Norman Gervin, in a lecture delivered on the 20th of February (2008) to mark the launch of the Year of Sir Arthur Lewis, and in commemoration of the first Caribbean Nobel Laureate, wrote, and I quote: "The second lesson that has continued relevance is the importance of effecting an agricultural revolution. By raising the productivity of domestic production, the supply-price of labor to the commodity sector would increase. This would counter the tendency for decline in terms of trade, raise rural incomes, creating a market for the goods produced by the industrial sector, and facilitating improvements in living standards."

Hence, Arthur Lewis regarded the agricultural revolution in developing countries as equally important as the industrial revolution. In that 1950 article of West Indian Industrialization, he was at pains to point out that industrial and agricultural development in the region were not alternatives, but had to proceed in tandem with one another. Unfortunately, governments in the Caribbean and parts of the developing world have completely ignored this fundamental truth. Everywhere today, we see the results of decades of neglect of the domestic agricultural sector in the form of rural poverty, rural urban migration, the growth of urban megacities, with the attendant social pathologies: youth gangs, antisocial behavior, drug use, and teenage pregnancies. Lewis' legacy calls on us to readjust the imbalance by raising the return to agricultural activity, by making the conditions of rural life more attractive, and by investing in human and physical

capital for the agricultural sector and providing other kinds of government support needed."

By focusing on food security of a nation, we should produce more of what we consume, create more employment opportunities in the food services sector and contribute to reducing unemployment. Someone said to me not so long ago, "How do you change consumption pattern?" When you have to change, you have to change. We need to start in the schools. We have to change the diet in the schools. We have school feeding programs. What do we give the children? In their recent book on the political economy of food and agriculture in the Caribbean, Belal Ahmed and Dr. Sultana Afroz wrote, and I quote, "Over the years, the population has been conditioned to accept imported food, which is supposed to be better, tastier, cheaper and trendier than locally produced food. Foreign cultural penetration and commercial advertisement by local and overseas media have led to the further development and the refinement of tastes. It is perhaps a legacy of slavery when cereals, salt fish and canned fish and meat and butter and cheese and flour were imported into the region free of any taxes or duties. And the import of basic food items strengthened monoculture and the creation of capital which was invested abroad. There may be more important exotics: caviar, frog legs, lobster tails, clams, mussels, oysters, ham, turkey, etc. on the supermarket shelves which are symbols of growth without development and food without security. Dislocation in the international trade and commodity prices and the devaluation of local currencies increases the vulnerable of our food security situation."

I believe that the Caribbean, whether we like it or not, is at a defining moment in its history where you must decide whether we will continue to depend on external supplies of food or whether we will seek to improve our own food security. To me, the global environment as it exists today is very simple. Now is the time to go back and brush off the Caribbean Food Plan which we developed some thirty years ago; the Caribbean Food and Nutrition Strategy, which we developed years ago, and to use it in the context of the Caribbean single marketing economy, to take advantage of national comparative advantages such as land in Guyana, Suriname, Belize, water, and markets based on a strategic partnership between governments and the private sector. Regional enterprises in livestock and poultry, cereals and legumes, root crops and vegetables, need to be looked at in the context of a Caribbean regional agricultural policy.

We have just seen a regional agricultural policy developed by the Central Americans. They decided to put up 80 million dollars as a first step in developing a common agricultural policy for Central America. Within the Caribbean common marketing economy, we need a strategy. Agro-processing industries to produce feed—animal feed—based on some of our local products; land reform to provide land for the landless farmers. And not only land for real estate, but land for food; land for recreation; land for water. Regional agricultural insurance programs: Some countries of the hemisphere are now putting in place agricultural insurance—something that is not common to the Caribbean; let's look at it, to protect our farmers against hurricanes and floods.

Regional agricultural transport systems: Those of us who are old enough remember the days when we had two boats—*The Federal Maple* and *The Federal Palm*—in the seas of the Caribbean. We need to relook at those things. The regional research institutions must be funded. The faculty of agriculture of the University of the

West Indies has almost disappeared, and yet we talk about revitalizing agriculture. Without technology, it cannot happen. The ministries of agriculture of the region should be converted to ministries of food, where food imports, food production, food safety, and food security are managed in one place. If you have a ministry managing food imports and another ministry managing food production, you have a serious structural problem, in which one ministry sometimes doesn't know what the other one is doing.

So, one ministry has the mandate to increase food production and the other ministry is importing food. Therefore, you have a conflict in policy. Until you have coordinated food policy, we are not going to move forward. It is impossible. One guy has a mandate to produce carrots and another one has a mandate to import carrots, and then one morning, the farmer can't sell his carrots because somebody has imported carrots. The policy—lack of coordination of policy—is critical. Regional storage facilities: We do not have any storage facilities for food. You remember when we had Ivan in Granada? There was no food.

We should focus on the production of organic products—vitally necessary. And I think we need a regional food security council. We need a regional food security council that has its pulse on the regional food security situation and can advise leaders as to where we are—or where we are going. If you don't put structures in place, it is difficult to implement policy. We know that and I think we can do something about it. Therefore, I recommend that within the context of the Caribbean common marketing economy, we should have a regional food security council that looks at food security in the region, does studies on the nature of food security, where our food supplies will come from in case of emergency, what policies we must put in place, what research we must do, etc., etc.

Susan George of the Institute for Policy Studies says food dependency conditions other forms of dependency. So long as a nation has failed to solve its food problems, there is little chance that it can practice truly independent policies. That's Susan George. I don't necessarily believe everything that Susan George says, but that is what she says. National sovereignty and national independence depends on having food.

In the current context of food and security in the Caribbean, I may ask you, therefore, what is the role of the Caribbean Food Crops Society? Or to place it in another context, are you ready to contribute to finance solutions to our current challenges in the context of the crisis which we face? And if the Society says yes, I would wish to ask the Society, "What do you plan to do as a Society?" I would think that one of the things you could do is to analyze the strengths, weaknesses, opportunities and threats of our plan for food security in the Caribbean. What are the opportunities? What are the weaknesses? What are the threats? What is the current food production capacity? Clearly we cannot produce everything. What's the potential capacity? What policy and institutional changes are necessary for the implementation of a Caribbean Food Plan?

Let us hope that in this meeting, we will be able to examine some of these issues and define the way forward for a new transformation paradigm for Caribbean agriculture in the 21st Century. Thank you very much.

DAVID SAMMONS:

Thank you for that summation of our discussion of today, Dr. Brathwaite. You have done a nice job of pulling together the threads that were presented through our

discussion of this entire plenary session. We have a few minutes, and if there are questions, Dr. Brathwaite has said he would be willing to respond to them.

Q. Dr. Brathwaite. You have eloquently put all these in order, but, as you know, we don't have a regional government in the Caribbean. I want to say, you put that challenge for the Crops Society, but how can the Crops Society act? What I will say now: the governments have a responsibility since they are in charge of agriculture. We will propose to convince them that they need a regional policy that focuses on the issues to satisfy the sectors in the diverse countries, since we don't have a regional government. How will you convince all these governments that they need to forward, since, you said we had a policy 50 years ago—they didn't do anything; we had a policy 30 years ago—they didn't do anything. How will you get them to do something today?

A. It seemed to me that we are in a different time and a different place. This is 2008. We have burgeoning societies; growing, young societies; young people who are looking to the future with hope, and looking to a future where they can live a life of happiness—what they call in this country, 'the pursuit of happiness.' If people are going pursue happiness, they do not want to go back to poverty. So we have to have societies that are growing, societies that are prosperous, and societies that provide opportunity for our people. It seemed to me that you, as an individual within your own society, have to marshal the will and the mechanism to treat the issues to the extent that they come to the attention of your Minister, so that your Minister, as part of the regional structure—because we do have a regional structure, which is CARICOM (there are meetings at all levels, ministerial levels in the community, meetings of ministers of foreign affairs, meetings of ministers of agriculture, meetings of health, etc.)—to take your concern to the level of regional ministers so that that can feed up through the system to COTED[25] and COTED can bring it to the attention of the leaders of the community. It seemed to me that the mechanisms are in place to do that. But we cannot sit down and do nothing. We have to make our voices heard.

Q. Can I do a follow-up? You mentioned tourism, which is a mainstay of most of the Caribbean countries right now, since they have obliterated the agriculture. I see, in some ways, where, as you mention about strategically putting agriculture on the map in the countries economically. If we produce the goods and service to serve all these different structures, all these sectors that are developing as we move toward pursuing happiness and all these things and the development economically in the country. So, the ministers who should take up this challenge should look at the various sectors we need to produce goods and services for, so agriculture can do that. In terms of doing that, they are going to create the jobs. If they do that and place those things, then don't worry about the

[25] COTED: Council for Trade and Economic Development, part of the Caribbean Community (CARICOM) organization

jobs—they will come. They'll get the bankers, the distributors and everybody on board. So they can play a part in their own development.

A. I couldn't agree with you more. One of the things that we must recognize is that our people are very creative. If the opportunities are available, and if the incentives are given, and if the investment capital is given, and if the credit is available, and if the structures are in place, people will take advantage of the opportunities and will move forward. I think it is critically important for us to begin to recognize that this is a new day. This is not sugar and bananas. Sugar and bananas had their own structures. The British organized the marketing, they organized the processing, they organized the shipping, they organized the sales, and they gave you what they thought was for you. Bananas almost the same. The structures for the development and production of these commodities were not developed internally; they were developed by others. What we have to do is to go back and develop the structures for the new agriculture. The new agriculture requires food safety, it requires marketing, it requires marketing intelligence, it requires a whole set of structures that we now have to put in place. It is the responsibility for our leaders to work with us—those who are of the technical fields—to begin to put these things into place. Twenty years ago, we heard nothing about food safety. Today food safety is a very important issue, because if our tourists do not get safe food in the hotels that they stay in, in our countries, they are not coming back. So there are several issues that have to be dealt with. We have to put food safety inspectors in place. We have to train people. We have to do good agricultural practices on the farms, etc., etc., things that were not necessary when you were producing sugar and bananas. So the new agriculture has to come to terms with new realities.

Q. From your address, which was very thought provocative, and you were talking both about food and the potential for fuel. I'm curious: do we have a good assessment in the Caribbean nations, as to the available arable acreage, and can we increase food production and fuel production? Is there underutilized capacity, which we are certainly seeing in Brazil? We see it in the United States. We see it in the former Soviet Union, where, for the last several decades, we have been in a food surplus scenario, and now, in this new regime, we are finding that there are actually opportunities for folks to move up by utilizing an underutilized land resource.

A. One of the things we recognize is that, in spite of the fact that the Caribbean is small, there is a significant amount of unutilized land. Even in some of the smaller territories, there is a significant amount of unutilized land and some lands that have been abandoned. Nothing is being produced on it. Go to a country like Jamaica. There is a significant amount of land where they are not producing anything. It used to be in sugar cane—now abandoned. But the countries that really have significant amounts of land—there is Guyana, Belize and Suriname—as part of a community, we must work together as a community with joint

ventures to take advantage of those larger tracts of land. In a country like Guyana there is a significant amount of land area available. There is no shortage of land in the Caribbean for producing alternative fuels. What we have to do is to rationalize it. A lot of that land that should have been in food production is currently not in food production anyhow. So there is need for some land policy and need for some land evaluation of current land use in a lot of our countries. I won't say the same for St. Vincent or Grenada or Dominica—that is a different ball game—but when we are talking about Guyana, Suriname or Belize, even of Jamaica, there is a significant amount of land that is currently not being used for anything that could be used for energy production.

DAVID SAMMONS:

Before I adjourn the meeting, I have several announcements that need to be made. First of all, I need to ask the question: Is there someone named Jorge Osuna-Garcia? May I speak to you after the meeting please?

As you know, this evening we have our cultural event, and this cultural event is going to be a cruise on the Intracoastal Waterway. I mentioned this, this morning, but I do want to remind you that it is important to board the ship beginning at 6:30. It will be available for boarding. Bring your ticket with you and allow about ten to fifteen minutes to walk from the hotel to where the boat will be waiting for us. To reach the boat, you walk out the hotel and turn to the left or to the south, and it will be about two blocks to the south, opposite the Eden Roc Hotel. The boat is called the *Biscayne Lady*, and there will be people from the Caribbean Food Crops Society staff to take your ticket and to make sure you get on the right boat. The boat will not wait, so do not be late. I want you to be sure to be there. It is going to be an enjoyable evening with dinner, with music, and with dancing.

Tomorrow you will have a choice to make; there are going to be concurrent sessions. In this room, we will have the TSTAR Invasive Species Symposium which will go on throughout the day. On the other side of the hall, in the Regency Ballroom, we'll have concurrent technical sessions dealing, in the morning, with issues related to forage and livestock and to food science and post-harvest technology. During the afternoon, in the Regency Ballroom, there will be a concurrent session on socioeconomic and policy issues in the greater Caribbean. Also, the CACHE board of directors meets tomorrow afternoon starting at 1:30 pm, and that is all detailed in the conference booklet. The PROCICARIBE and Ag. Experiment Station directors meet tomorrow afternoon as well.

Remember, at 5:00 pm, after the technical sessions and the TSTAR symposium are finished, we will convene in the poster room behind where we are sitting—the next room over—and in that room, we will have a poster session, cocktails, and hors d-oeuvres between 5:00 pm—7:00 pm. All poster presenters are asked to be present by their posters to interact with participants.

Amy Roda will be convening the Red Palm Mite meeting in the Regency Conference Room beginning at 7:00 pm and going until whenever it ends. We have it set for 7:00 pm—8:30 pm, but it may go longer.

Breakfast will open, as it did this morning, at 7:00 am in the room behind us. We call it morning refreshments, but I'm sure that those of you who took advantage of it today realize that it is more than morning refreshments, it is a full breakfast. There were eggs, pastry; there was yogurt; there was fruit; coffee; milk; various juices and so on. So don't spend your money going to breakfast; the breakfast is included and we look forward to seeing you at 7:00 tomorrow morning for breakfast, but before then, 6:30 pm on the boat down the street for a fun evening. Dress will be casual. You do not need to wear your jacket and tie, for the men, and women dress however you feel comfortable for an outing on the water.

Thank you all for a wonderful day.

TECHNICAL SESSIONS
PAPERS PRESENTED ORALLY
Tuesday, July 15, 2008
and
Wednesday, July 16, 2008

FORAGE AND LIVESTOCK

2008 Proceedings of the Caribbean Food Crops Society. 44(2):77-83. 2008

Production of Eastern Gamagrass Accessions Grown under Greenhouse Conditions.

Ronald J. Smith and Errol G. Rhoden. George Washington Carver Agricultural Experiment Station, Tuskegee University, Tuskegee, AL. Corresponding author: 308 Milbank Hall, Tuskegee Univ., Tuskegee, AL, 36088; (334) 727-8435; rhoden@tuskegee.edu

ABSTRACT.
The development of adapted acid-tolerant plants is important in the southeastern United States. Eastern gamagrass (*Tripsacum dactyloides*) is a warm-season perennial native to the Americas, capable of high potential productivity and moderate to high forage quality, for use as grazed or preserved forage. It produces peak growth during hot, dry weather when cool season plants are dormant. Eastern gamagrass has also been reported to penetrate acidic claypan by tolerating low Ca, high Al and low soil pH. As result, eastern gamagrass is being considered as a potential barrier and forage crop in the southeast United States. A study was conducted at the George Washington Carver Agricultural Experiment Station at Tuskegee University, to measure the performance of eastern gamagrass accessions of varying forage potential under greenhouse conditions. Accessions were chosen based on their probable suitability as forage crops, as well as to reflect a broad geographic and genetic spectrum of eastern gamagrass found in the southern US. Single shoots were transplanted and fertilized with 20-20-20 (NPK). After three months of establishment, plants were harvested to 25 cm height every 35 days and forage yield and quality measured. Data on plant height, dry matter yield, and regrowth was recorded. Crude protein, mineral composition, and fiber were used as quality factors. Data indicated that most accessions attained their greatest height at harvest 3. Florida 2 (FL2) produced the tallest plants on average (121.0 cm) prior to the first harvest. Texas 3 (TX3) had the highest daily growth rate before harvest two and produced the tallest plants on average prior to the second harvest (127.8 cm), while TX4 produced the shortest plants on average (95.7 cm). Plant dry weight for the various accessions ranged from 12.0 to 83.5 g/pot while crude protein ranged from 13.7 to 17.3%. These results indicate that the quality of these eastern gamagrass accessions were above the NRC requirements for finishing cattle. A comprehensive review of these eastern gamagrass populations could identify accessions that exhibit specific establishment and growth pattern that are suitable for the southern US.

KEYWORDS: eastern gamagrass, forage production, accession

INTRODUCTION

The development of adapted acid-tolerant forages is important in the southeastern United States. Eastern gamagrass [*Tripsacum dactyloides, L.*] is a warm-season perennial bunchgrass found in the Midwestern and eastern United States. Eastern gamagrass occurs naturally from Massachusetts on the Atlantic coast, west to Nebraska, Oklahoma, and Kansas, and south to Florida and Texas in the United States, Brazil in South America (Newell and deWet, 1974). Eastern gamagrass is capable of penetrating acidic claypan, tolerating low calcium (Ca), high aluminum (Al) and low soil pH (Foy et al., 1999). Due to high potential productivity of eastern gamagrass as well as its moderate to high forage quality, there is considerable interest in its use as cut and stockpiled forage (Rhoden et al., 2002). Reported traits of the species that would be valuable in a sustainable agriculture system include high protein content, high yields, high palatability and digestibility, and peak growth during hot, dry weather when cool season pasture plants are dormant. As result, eastern gamagrass is being considered as a potential barrier and forage crop in the southeast United States. According to Krizek et al. (1998), eastern gamagrass is capable of high productivity with moderate to high forage quality. Eastern gamagrass is a very versatile and widely adaptable grass, and could easily be incorporated into sustainable development programs for marginal lands for pasture as well as for preserved forage. One remarkable trait is that it closes canopy very rapidly after establishment and therefore, very effective as an erosion deterrent. Eastern gamagrass is considered to be tolerant of certain acidic soil types. It has been found to penetrate hardpans and claypans by tolerating acidic Al-toxic soil and/or nutrient solutions in both greenhouse and field studies (Foy, 1997; Foy et al., 1999; Rhoden et al., 2000a). Burns et al. (1996) compared eastern gamagrass with switchgrass and flaccidgrass when preserved as hay and found that the hay quality of eastern gamagrass was adequate to meet the energy and protein requirements of many ruminants. Rhoden et al. (2000a) obtained crude protein (CP) content as high as 19.6% in highly fertilized eastern gamagrass grown in the greenhouse. Furthermore, eastern gamagrass also shows promise as a dual-purpose grain and forage crop. Eastern gamagrass produces small kernels roughly 6 % the size of corn kernels. Bailey and Sims (1998) estimated the protein content of eastern gamagrass grain to be 30 % as well as having a 90 % digestibility. To this end, the Plant Material Centers in the southeast are making progress towards the selection and development of eastern gamagrass cultivars that are suitable for such conditions. These centers and universities are presently screening large populations of eastern gamagrass for suitable ecotypes that are capable of high-quality forage and productivity. Therefore, the objective of this study was to measure the performance of 12 eastern gamagrass accessions under greenhouse conditions and to evaluate their forage potential.

MATERIALS AND METHODS

This study was conducted in the greenhouse facilities of the George Washington Carver Agricultural Experiment Station, Tuskegee University, Tuskegee, Alabama. Twelve accessions of eastern gamagrass were vegetatively established and selected for uniformity within each accession. A day/night temperature of 30/25°C $\pm$ 2.5°C was

maintained in the greenhouse for the length of the study. A nutrient solution of 20-20-20 (NPK) was given at a rate of approximately 56 kg/ha. The initial harvest was made when plants were at the boot stage, and subsequent harvests every 35 days thereafter. The plants were cut back to 25 cm height, and data on plant height and vigor were recorded for all plants.

Data on shoot growth and regrowth were based on linear measurements and biomass collected for dry matter analysis. Weights were recorded for total dry matter yield, and divided into blade, sheath and stem yields. Each sample collected was separately ground and ashed. Ashing was done overnight and acid detergent fiber (ADF), neutral detergent fiber (NDF), CP, total digestible nutrients (TDN) determined.

RESULTS AND DISCUSSION

The data from Table 1 indicates that most accessions attained their greatest height at harvest 3. Plant height varied among accession lines based on locations, but not significantly. There was significant location ×accession × harvest interaction, however.

Table 1. Foliage height of 12 eastern gamagrass accessions prior to harvest (cm)

Accession	Harvest 1	Harvest 2	Harvest 3	Average
TX1	106.50	109.83	115.50	110.61
TX2	104.42	114.00	129.67	116.03
TX3	113.00	127.83	134.00	124.94
TX4	89.00	95.67	131.00	105.22
FL1	101.00	100.00	99.17	100.06
FL2	121.00	118.50	123.17	120.89
FL3	119.67	122.83	122.67	121.72
FL4	113.82	113.74	115.19	114.25
AR1	95.33	104.67	123.83	107.94
AR2	93.33	98.33	118.50	103.39
AR3	101.00	108.67	121.67	110.45
AR4	96.49	103.94	121.33	107.25

Arkansas accessions were shortest compared to those from Texas and Florida, which also showed greater variation among accession lines for plant height. Florida accessions showed little variation in plant height across harvest periods, with less than a 1% increase in height from harvest 1 to 3. Florida 1 declined in height as with passing harvest period. Florida 2 and FL 4 also achieved lesser height at harvest 2, while FL 3 was shorter at harvest 3 compared to harvest 2. Arkansas and Texas accessions, however, showed consistent increases in plant height from one harvest period to another, reaching maximum height at harvest three.

Prior to the first harvest, FL2 produced the tallest plants, averaging 121 cm, followed very closely by accession seven (FL3) (119.67 cm), while TX 4 had the shortest plants (89 cm). Accession three (TX3) had the highest daily growth rate before harvest two and produced the tallest plants on average (127.83 cm), while accession four (TX4)

produced the shortest plants on average (95.67 cm). Accession three (TX3) showed the highest daily individual growth rate (3.11 cm/day) between harvest two and three to produce the tallest plants on average (134 cm) prior to the third harvest. Accession five (FL1) produced the shortest plants on average (99.17 cm). When averaged over the three harvests, FL 1 produced the shortest plants and TX 3 produced the tallest (Table 1). Some of the plant heights achieved in this study are slightly less than some of the accessions reported in literature. Texas 1 achieved foliage height between 106 and 115 cm (110 cm avg.), over three harvests in this study. Snider (1995) reported peak foliage height of 122 cm for TX1, and AR3, which achieved foliage height between 96 and 121 cm (107 cm avg.) over three harvests in this study.

Florida accessions showed the most variation for dry matter production within accession. Arkansas accessions had the lowest dry matter production, for all three harvests, while Florida accessions had the highest production. Accessions irrespective to locations exhibited similar trends across the three harvest periods. The amount of dry matter produced on a per plant basis was lowest for harvest 3. The data indicated that for harvest 3, all accessions produced the significantly lower amount of dry matter, as compared to harvest 1 and 2 (Table 2). Texas and Arkansas accessions however, showed a larger reduction in dry matter production for harvest 3, than Florida accessions. The AR 1 plants had the lowest overall dry matter yield, while FL 2 out-yielded all the other accessions, followed closely by FL 3. This is consistent with of researchers who have noted that it is common that high yielding eastern gamagrass varieties are usually associated with tall plants (Rhoden et al 2000b).

Table 2. Dry matter production of 12 eastern gamagrass accessions grown under greenhouse conditions [kg/ha]

Accession	Harvest 1	Harvest 2	Harvest 3	Total Yield
TX1	3413.28	3338.88	2658.24	9410.40
TX2	3429.12	3428.16	1320.96	7998.24
TX3	3653.28	3436.32	1589.28	8678.88
TX4	3185.28	3002.40	1107.36	7295.04
FL1	3496.80	3217.92	2446.08	9160.80
FL2	4314.24	3508.80	3927.84	11750.88
FL3	4054.08	4229.28	3299.52	11582.88
FL4	3915.36	3654.72	3210.24	10780.32
AR1	3287.04	2792.16	746.88	6826.08
AR2	3134.40	3334.56	1691.04	8160.00
AR3	2952.00	3049.44	1593.12	7594.56
AR4	3126.72	3068.16	1348.32	7543.20

Dry matter production per pot was converted to hectare production equivalent. The yields in this study compared favorably with, and in fact are at the higher end of yields reported by Faix et al. (1980) in the establishment year in southern Illinois, except

AR1 and TX4 (Table 2). All accessions in this study produced higher DM yields than those reported for 'Pete' eastern gamagrass by Fine et al. (1990) during the establishment year, at Woodward, OK, and production by Foy et al (1999) after liming in an acid soil. All accessions compared favorably with 4-, 6-, 8-, and 10-week DM yields achieved by Mashingo et al. (2002). All accessions also yielded higher than reports given by McLaughlin et al (2004) over a three year period (4.76 metric tons/ha avg.).
While plant height and yield are essential criteria for evaluating eastern gamagrass, quality is critical to determining its worth as a forage. The CP content of forage samples in this study was high. Average reported crude protein ranged from 13.69 % (TX 2) to 17.31% (TX 1) (Table 3). These numbers were higher than those reported by Faix et al (1980) (11% avg. over 3 years), and McLaughlin et al. (2004).

Table 3. Crude fiber, neutral detergent fiber, acid detergent fiber and total digestible nutrients of eastern gamagrass accessions. (Harvest 3)

Accession	CP	Crude Fiber	NDF	ADF	TDN
	%	%			
TX1	17.31	33.22	74	33	49.14
TX2	13.69	32.12	71	33	50.90
TX3	14.88	32.92	73	34	49.73
TX4	13.81	33.72	75	34	48.55
FL1	16.69	32.92	73	34	49.73
FL2	13.88	33.32	74	34	49.14
FL3	15.50	32.92	73	36	49.73
FL4	15.36	33.05	73	35	49.53
AR1	16.75	32.52	72	35	50.31
AR2	17.00	34.52	77	38	47.38
AR3	16.19	35.32	79	36	46.21
AR4	16.65	34.12	76	36	47.97

In addition to protein, forages provide the fiber needed for cud chewing, rumination, and rumen health. At harvest 3, Arkansas accessions showed the most variation for percent crude fiber followed by those from Texas, and Florida accessions which showed very little variation (Table 3). Arkansas accessions had the highest percent crude fiber on average, followed by Florida and Texas accessions, which were very similar on average. Percent crude fiber ranged from 32.12 (TX 2) to 35.32 (AR 3) at harvest 3. The highest NDF of 79% was obtained from AR 3, and TX 2 the lowest NDF content (71%). AR 2 samples contained 38% ADF and TX 1 and TX2 contained 33% ADF. At harvest 3, Arkansas accessions showed the most variation for percent total digestible nutrients (TDN) followed by those from Texas, and then Florida accessions which showed very little variation. Arkansas accessions had the lowest percent TDN on average, as opposed to those from Florida and Texas, which were higher and very similar. Total digestible nutrients ranged from 46.21% (AR 3) to 50.90% (TX 2)

(Table3). Faix et al. (1980) found the total digestibility of eastern gamagrass to average approximately 50 % over a period of three years.

The results showed a decline in biomass with successive harvests consistent with limited fertilization. Even though satisfactory biomass was obtained in this study under limited resource conditions, the biomass potential of eastern gamagrass is even greater under optimal growing conditions. The CP content of all accessions used in this study was well above the 7% needed for brood cows or 10.5% minimum needed for finishing cattle. Therefore, none of the accessions would require protein supplementation in order to meet the nutritional requirements to maintain growth and development in cattle. Texas1 and AR 2 had the highest CP, and would be recommended for feeding, based solely on CP content. All accessions also met or exceeded crude protein requirements for maintaining mature horse and stallions, and for light- and moderate- working horses on a dry matter basis. Further comprehensive review of these populations could identify accessions that exhibit specific establishment and growth pattern that are suitable for different regions. Planting productive accessions would reduce the need for annual forage replanting especially on sloping croplands that would be prone to high rates of soil erosion. Those accessions possessing stiff, erect stems also show promise as vegetative hedges and/or barriers that could reduce runoff and the resultant sediment and nutrient losses.

REFERENCES

Bailey, D. W. and P. L. Sims. 1998. Comparison of eastern gamagrass grain and cotton seed meal as supplements for sheep fed mature eastern gamagrass hay. *Animal Feed Science and Technology* 76:95-102.

Burns, J. C., D. S. Fisher, and K. R. Pond. 1996. Quality of eastern gamagrass compared with switchgrass and flaccidgrass when preserved as hay. Postharvest Biology and Technology 7:261-269.

Faix, J.J., C.J. Kaiser, and F.C. Hinds. 1980. Quality, yield and survival of Asiatic bluestems and an eastern gamagrass in southern Illinois. Journal of Range Management 33(5): 388-390.

Fine, C.L., F.L. Barnett, K.L. Anderson, R.D. Lippert and E.T. Jacobson. 1990. Registration of 'Pete' eastern gamagrass. Crop Sci. 30(3):741-742.

Foy, C.D. 1997. Tolerance of eastern gamagrass to excess aluminium in acid soil and nutrient solution. Journal of Plant Nutrition 20: 1119-1136.

Foy, C.D., A. M. Sadeghi, J.C. Ritchie, D.T. Krizek, J.R. Davis and W.D. Kemper. 1999. Aluminium toxicity and high bulk density: Role in limiting shoot and root growth of selected aluminium indicator plants and eastern gamagrass in an acid soil. Journal of Plant Nutrition 22:1551-1566.

Krizek, D.T., C.D. Foy, J.B. Reeves III, A. Sadeghi and J.C. Ritchie. 1998. Root penetration, yield and forage quality of eastern gamagrass grown on an acid compact soil. p. 278. In: 1998 Agronomy Abstracts, American Society of Agronomy, Madison, WI.

Mashingo, M.S.H, D.W. Kellogg, W.K. Coblentz, and K.S. Anschutz. 2002. Influence of Harvesting Management on Regrowth Performance and Nutritive Value of Eastern Gamagrass (Tripsacum dactyloides L.). In: Animal Science Department Report 2002,

Zelpha B. Johnson and D. Wayne Kellogg, (eds.), Arkansas Agricultural Experiment Station. Arkansas Agricultural Experiment Station Research Series 499: 33-34.

Newell, C. and J. M. J. de Wet. 1974. Morphological and cytological variability in Tripsacum dactyloides (Gramineae). American Journal of Botany 61:652-664.

Rhoden, E.G., J.B. Reeves III, D.T. Krizek, J.C. Ritchie and C.D. Foy. 2000a. Influence of root removal and shoot growth and forage quality of greenhouse grown eastern gamagrass. Proceedings of the Eastern Native Grass Symposium, Baltimore, MD. 2:276-282.

Rhoden, E.G., J.B. Reeves III, D.T. Krizek, J.C. Ritchie and C.D. Foy. 2000b. Vegetative propagation of eastern gamagrass: effects of root pruning and growth media. Proceedings of the Eastern Native Grass Symposium, Baltimore, MD. 2:270-275.

Rhoden, E.G., J.R. Bartlett, R.J. Smith and M. McIntyre. 2002. Quality of stockpiled eastern gamagrass forage. Caribbean Food Crops Society 38:434-439.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):84. 2008

Relación Hoja-Tallo, Altura y Rendimiento de Seis Gramíneas Forrajeras, Tres Panicum y Tres Brachiarias, en un Suelo Ultisol

Birmania Wagner[1], Rodys Colón[1]. [1]Instituto Dominicano de Investigaciones Agropecuarias y Forestales, IDIAF. bwagoner@idiaf.org.do

RESUMEN.
La evaluación continua de especies con posibilidades forrajeras es tarea permanente para dar respuesta a la demanda de alimentación económica para el ganado. El objetivo fue medir el rendimiento de materia seca en kg/ha, la relación hoja–tallo y altura de seis gramíneas forrajeras. El estudio se realizó en la Estación Experimental Pedro Brand en el periodo 2006-2007. La precipitación promedio en la zona del estudio es 1800 mm y la temperatura media anual 25 oC. El suelo donde se hizo el estudio es del Orden Ultisol. Los tratamientos evaluados correspondieron a las gramíneas Panicum maximum (cultivares 'Aries', 'Atlas' y 'Mombaza') y Brachiaria brizantha (cultivares 'Xaraes', 'MG-4', 'MG-5'). Fueron sembradas por semilla a razón de 7 kg por ha, a chorrillo, y 0.50 m entre hileras. El diseño utilizado fue de bloques completos al azar con cuatro repeticiones. Las variables respuesta fueron altura de corte, rendimiento de materia seca, en kg/ha, y relación hoja-tallo. A los resultados se les aplicó un análisis de varianza al 5% de significancia. En los casos donde hubo diferencias significativas se procedió a la prueba de Duncan. Las muestras tomadas se separaron en hojas y tallos, para obtener la relación hoja/tallo. Se determinó el rendimiento de materia seca y se hicieron análisis de nutrientes. Los resultados indican diferencias estadísticas para las tres variables. 'Mombaza' resultó significativamente superior a los demás en altura de corte y relación hoja-tallo. Para el rendimiento, 'Mombaza', 'Atlas' y 'MG-5' resultaron significativamente mejores que los demás. Bajo las condiciones del experimento, estos tres cultivares representan las mejores forrajeras para ser integrados a los sistemas de producción animal en la República Dominicana.

PALABRAS CLAVES: Panicum, brachiarias, rendimiento de forrajes

2008 Proceedings of the Caribbean Food Crops Society. 44(2):85-95. 2008

Land Application of Food Processing Wastewater Residuals Effect on Dry Matter Yield of Tanner Grass

St. Luce, M.[1, 2], G. Gouveia[1], and G. Eudoxie[1]. [1]Department of Food Production, Faculty of Science and Agriculture, University of the West Indies, St. Augustine Campus, Trinidad and Tobago. [2]Caribbean Agricultural Research and Development Institute (CARDI), Roseau, Dominica.*
*Corresponding Author: Email: mstluce_79@hotmail.com; Fax: 1 767 448 5690

ABSTRACT.
Finding alternative avenues for disposal of food manufacturing waste has become important in the Caribbean Region due to increasing populations, concerns about environmental pollution, increased growth in the manufacturing sector, as well as limited land availability for disposal. Two field trials were conducted on a mixed loamy isohyperthermic Fluventic Eutropepts in the dry (Trial 1) and wet (Trial 2) seasons to evaluate the effect of adding food processing wastewater residuals on the crop productivity of Tanner grass (*Brachiaria arrecta*). The wastewater residual was compared to inorganic sources of nitrogen (N) and phosphorus (P) from urea and triple superphosphate, respectively at 0, 50 and 200 kg N/ha and 0, 50 and 100 kg P/ha respectively in a randomized complete block design. In the dry season, the inorganic N resulted in a Tanner grass dry matter (DM) yield of 4357 kg/ha, which was significantly ($P<0.05$) higher than that resulting from the wastewater residual N (1835 kg/ha). However, similar yields of 2898 kg/ha and 2610 kg/ha for inorganic N and wastewater residual N respectively were obtained in the wet season. The wastewater residual applied at 200 kg N/ha with no supplemented P resulted in a higher ($P<0.05$) DM yield of 2875 kg/ha compared to the yields of 1535 kg/ha from the unfertilized control in the wet season. Tanner grass dry matter yields for both seasons were higher in response to application of the wastewater residual at 50 and 200 kg N/ha versus the unfertilized control. Food processing wastewater residual can be used in pasture production as an organic soil amendment as an alternative to disposal since it is capable of supporting plant growth.

KEYWORDS: Wastewater residuals, dry matter yield, organic soil amendment

INTRODUCTION

In the Caribbean, particularly in Trinidad and Tobago, the manufacturing sector including the food processing industry has seen improved growth resulting in increased waste generation. Disposal of food processing waste is restricted to land filling after treatment, but this presents both economic and environmental concerns. Land filling of this waste, which is generally high in nitrogen (N) and phosphorous (P) can result in contamination of both ground and surface water supplies.

Globally, the food processing industry generates large volumes of wastewater (Zvomuya, et al., 2006). There are about 50 food and beverage manufacturing companies in Trinidad and Tobago, which produce waste as either wastewater residuals or filter

press. Nestlé Trinidad and Tobago Limited produces about 60,000 gallons (U.S) of wastewater residuals from its wastewater treatment facility per week. Hence, the combined total volume of wastewater residuals or liquid waste from all the food and beverage companies on a weekly basis is extremely high. Limited land availability for suitable landfills compounded by concerns about environmental pollution necessitates alternative avenues of waste disposal and or utilization.

One beneficial alternative to disposal is land application for agricultural production (Stehouwer, 2003). Research in developed countries such as the United States has indicated that when applied to agricultural land, biosolids supported crop production, especially pasture production, at levels similar to conventional artificial fertilizers (Michalk et al., 1996; Adjei and Rechcigl, 2002; Tiffany et al., 2003). Nestlé Trinidad and Tobago Limited provides technical support to the dairy farmers in various areas particularly in pasture management. Furthermore, Nestlé has been mandated by the Government of Trinidad and Tobago to purchase local milk. The wastewater residuals from the Nestlé wastewater treatment facility can be used by local farmers to support pasture production thereby recycling the waste.

Literature is scarce on alternative uses of food processing wastewater residuals such as application to agricultural land for crop production. A thorough understanding of effects of applying food processing wastewater residuals to agricultural land on crop productivity and nutrient dynamics is warranted. This usage may prove to be a sound alternative to land filling, especially for Small Island Developing States (SIDS) where land scarcity and economics are major concerns.

This study examined the effect of wastewater residual application on Tanner grass dry matter yield.

MATERIALS AND METHODS

Treatments and Experimental Design

The experiment compared inorganic nitrogen and phosphorous applied as urea and triple super phosphate (TSP) respectively, with food processing wastewater residuals. A randomized complete block design with three replicates per treatment was used. Tanner grass (*Brachiaria arrecta*) was the test crop and it was evaluated in dry (Trial 1) and wet (Trial 2) seasons. Nitrogen from both sources was applied at 0, 50 and 200 kg N ha^{-1}. Inorganic phosphorous was applied at 0, 50 and 100 kg P ha^{-1}. Wastewater residual application was based on nitrogen (N) concentration; therefore, application of wastewater residual phosphorous was dictated by the phosphorous concentration of the wastewater residual. Furthermore, TSP was used as a supplement for certain wastewater residual treatments to obtain final phosphorous application rates of 50 and 100 kg P ha^{-1}.

Site Establishment and Characteristics

The experiment was conducted at the University of the West Indies Field Station (latitude 10^0 38" N; longitude 61^0 23" W; 15.2 m above sea level) on a River Estate loam; a fine loamy, micaceous Fluventic Eutropepts (Smith, 1983). In March 2005, three adjacent beds were selected, brush cut and ploughed to a depth of 20 cm. Each bed was further sub-divided into plots measuring 2 m in length and 6m wide. Tanner grass was planted by stolons in designated plots in April 2005 and was maintained until the start of

the experiment in March 2006. A sample of the wastewater residual was taken for analysis prior to each of the two trials and the characteristics are indicated in Table 1. Tanner grass was brush cut to about 5 cm and the wastewater residual was applied the following day. Inorganic N and P were broadcast on the Tanner grass plots four days after wastewater residual application.

Table 1. Chemical and physical properties of the food processing wastewater residual.

Parameters	Trial 1	Trial 2	US EPA Pollutant Concentration Limit (mg/kg)*
pH	6.68	6.62	-
Moisture Content (%)	98	98	-
TSS (mg/L)	11360	N/A‡	-
OC (%)	0.65	0.38	-
NH_4^+-N (mg/L)	191.3	118.6	
NO_3^--N (mg/L)	43.24	14.4	
Total N (%)	0.21	0.14	-
Total P (mg/L)	400	372	-
Total K (mg/L)	74.8	64.8	-
Total Fe (mg/L)	23.8	N/A	-
Total Zn (mg/L)	42.75	3.01	2800
Total Cu (mg/L)	0.60	0.88	1500
Total Mn (mg/L)	0.73	0.69	-
Total Cr (mg/L)	1.96	0.76	1200
Total Ni (mg/L)	1.21	0.21	420
Total Cd (mg/L)	Undetected	Undetected	39
Total Pb (mg/L)	Undetected	Undetected	300

* Source: Pollutant concentration limits as defined in US Environmental Protection Agency (US EPA) (1993), Adjei and Rechcigl (2002).
‡: Not Available

Sample Collection and Preparation and Laboratory Analysis

Pre-plant composite soil samples were randomly collected at depths of 0-15 cm and 15-30 cm. Tanner grass was harvested six weeks after fertilization in a sampling area of 2 m^2. The samples were weighed immediately after harvesting, chopped and sub-samples taken. Soil samples at 0-15 cm were also collected from each plot. Tanner Grass sub-samples were oven dried at 80° C for three days, whilst soil samples were air dried and crushed to pass a 2-mm sieve. Tanner grass dry matter yield was determined gravimetrically after oven drying.

Statistical Analysis

An analysis of variance test was conducted to determine the presence of any significant treatments at 95 % probability level using the Minitab (2000) software. Treatment means were separated using the least significant difference (LSD) test at

P≤0.05. Further analysis was conducted to determine the effect of fertilizer source and rate.

RESULTS

Table 2. Dry matter yield of Tanner Grass as influenced by treatments in trials 1 and 2.

Treatments[1]	Trial 1	Trial 2
	kg/ha	
N_0P_0	1351c †	1535c
$N_0P^a_1$	1514c	1991bc
$N_0P^a_2$	1629c	1780bc
$N^a_1P_0$	3840b	2748ab
$N^a_1P^a_1$	4660ab	2947ab
$N^a_1P^a_2$	4024b	2769ab
$N^a_2P_0$	5429a	3026ab
$N^a_2P^a_1$	4028b	3088ab
$N^a_2P^a_2$	4163b	2809ab
$N^b_1P^s_1$	1596c	2342b
$N^b_1P^s_2$	1753c	2482b
$N^b_1P_3$	1530c	1924bc
$N^b_2P^s_1$	2442c	2890ab
$N^b_2P^s_2$	1529c	3236a
$N^b_2P_3$	2164c	2875ab
Mean	2777	2559
SEM	387.31	243.26
p value	<0.001	<0.001
LSD (0.05)	1121.77	705.93

[1] N_0: No nitrogen; P_0: No phosphorous; N^a: Urea; P^a: Triple Super Phosphate; N^b: Wastewater residual N; P_3: wastewater residual P; P^s: Supplemented phosphorus; $_1$: 50 kg/ha; $_2$: 200 kg/ha and 100 kg/ha for N and P, respectively.
LSD (0.05): Least significant difference at 5% probability level; SEM: Standard error of the mean.
†Values with the same letter in a column are not significantly different (P>0.05)

Table 2 shows there were significant differences (P<0.05) in dry matter yield of Tanner Grass among the treatments in the first and second trials. In the first trial, inorganic fertilizer at 200 kg N/ha (N^a_2 x P_0) gave the highest dry matter yield of 5428 kg/ha for Tanner grass, while the unfertilized control resulted in the lowest dry matter yield of 1350 kg/ha. Furthermore, among the wastewater residual treatments, the application rate of 200 kg N/ha with supplemented P at 50 kg P/ha (N^b_2 x P^s_1) resulted in the highest dry matter yield of 2441 kg/ha, while that applied at 200 kg N/ha with supplemented P at 100 kg P/ha (N^b_2 x P^s_2) resulted in the lowest yield of 1529 kg/ha. The wastewater residual treatments resulted in insignificantly higher dry matter yields than the unfertilized control. In contrast, only the inorganic N applied at 50 kg N/ha with 50

kg P/ha (N^a_1 x P^a_1), as well as that applied at 200 kg N/ha (N^a_2 x P_0) and 200 kg N/ha with 100 kg P/ha (N^a_2 x P^a_2) resulted in significantly higher dry matter yields than the unfertilized control.

Overall, mean dry matter yield in the second trial was lower than the first trial. The wastewater residual applied at 200 kg N/ha with supplemented P at 100 kg P/ha (N^b_2 x P^s_2) gave the highest yield of 3236 kg/ha, while the unfertilized control (N_0 x P_0) resulted in the lowest yield of 1535 kg/ha. However, wastewater residual applied at 200 kg N/ha with no supplemented P (N^b_2 x P_3) resulted in a significantly ($P<0.05$) higher dry matter yield than the unfertilized control, but the wastewater residual applied at 50 kg N/ha with no supplemented P (N^b_1 x P_3) was not significantly different ($P>0.05$) from dry matter yield of the unfertilized control (Table 2).

Dry matter yield increased for all the wastewater residual treatments from the first to the second trial, whereas, it decreased for the inorganic treatments except for the phosphorus treatments where no N was applied (Table 2). Furthermore, dry matter yield decreased by 33% from the first to the second trial in response to the inorganic N, whereas a 42% increase was observed in response to the wastewater residual (Table 3 and Figure 1).

Figure 1. Comparison of the effect of rate of application of N from two sources on dry matter yield of Tanner Grass

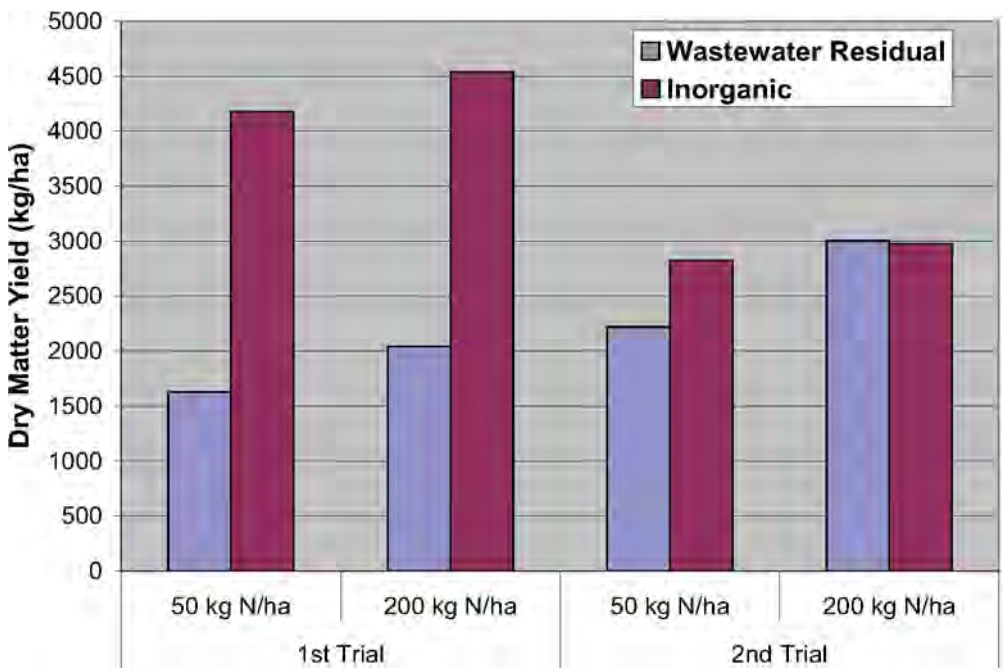


Table 3. Effect of nitrogen source on dry matter yield of Tanner Grass

	Trial 1	Trial 2
	kg/ha	
Nitrogen Source		
Inorganic	4357 (158.1)†	2898 (99.3)
Wastewater Residual	1835 (158.1)	2610 (102.2)
p value	<0.001	0.054
LSD (0.05)	457.96	293.20

†: SEM LSD (0.05): Least significant difference at 5% probability level

As shown in Table 3, inorganic N resulted in significantly ($P<0.05$) greater dry matter yield compared to the wastewater residual in the first trial, but no significant ($P>0.05$) difference was observed in the second trial. Figure 1 demonstrates that the inorganic N resulted in significantly ($P<0.05$) higher dry matter yield than the wastewater residual treatment at both N rates only in the first trial. Inorganic N resulted in a significantly ($P<0.05$) higher dry matter yield than wastewater residual N only at 50 kg N/ha in the second trial.

Table 4. Comparison of the effect of nitrogen rate and source on dry matter yield of Tanner Grass

	Wastewater Residual		Inorganic N	
	kg/ha			
N Rate	Trial 1	Trial 2	Trial 1	Trial 2
0 kg N/ha	1498 (223.6)†	1769 (140.5)	1498 (223.6)	1769 (140.5)
50 kg N/ha	1626 (223.6)	2226 (149.0)	4175 (223.6)	2822 (140.5)
200 kg N/ha	2045 (223.6)	3000 (140.5)	4540 (223.6)	2453 (140.5)
p value	0.214	<0.001	<0.001	<0.001
LSD (0.05)	647.67	420.02§; 407.58‡	647.67	407.58

†: SEM LSD (0.05): Least significant difference at 5 % probability level
§: LSD between 0 kg N/ha and 50 kg N/ha, and between 50 kg N/ha and 200 kg N/ha ‡: LSD between 0 kg N/ha and 200 kg N/ha

Table 4 shows that the rate of inorganic N applied had a significant ($P<0.05$) effect on dry matter yield during both trials whereas, the wastewater residual N rate had a significant effect ($P<0.05$) only in the second trial. Dry matter yield from both wastewater residual N rates in the second trial were significantly ($P<0.05$) higher than the control. The dry matter yield increased with increasing N rate in all cases except for the inorganic N rates in the second trial.

DISCUSSION

Several studies (Michalk et al., 1996; Tiffany et al., 2003) have reported that application of slurry biosolids to agricultural land supported crop production, especially pasture production, at a level similar to that of conventional artificial fertilizers. Adjei and Rechcigl (2002) reported that slurry biosolids supported Bahiagrass forage production at a similar rate and to the same extent as inorganic ammonium nitrate fertilizer.

The Tanner grass formed a thick thatched layer above the soil surface. The wastewater residual, with a moisture concentration of 98%, was applied to well established, recently brush-cut tanner grass plots. This method of application would have resulted in a reduced infiltration rate and thus increased runoff (Sanjari et al., 2006). This was more pronounced in the second trial due to the antecedent soil moisture conditions at the time of application resulting from high rainfall (Table 5). Furthermore, most of the solid material found in the wastewater residual adhered to the grass cover, particularly in the first trial, thereby increasing the exposure of the wastewater residual to the atmosphere and augmenting ammonia volatilization. Muñoz et al. (2003) in reviewing work by Thompson et al. (1987), noted that when manure or slurry contain appreciable amounts of urea or NH_4^+, N can be easily lost via NH_3 volatilization, especially if surface-applied. In this study, NH_4^+-N was substantially higher than NO_3^--N (Table 1). Bittman et al. (2005) stated that the amount of ammonia lost to the atmosphere is negatively related to the rate of infiltration of manure into the soil. In addition, ammonia losses are greater from crop residuals on the soil surface than from tilled exposed soil (Lorimor, 1998), or incorporation into the soil (Rochette et al., 2001). Epstein (2003) further stated that most N is volatilized during the first few days after application. Ammonia volatilization from the wastewater residual may have occurred in the first trial, particularly due to the grass cover, low humidity, high temperatures and higher evaporation (Table 5) in the first trial.

The fact that most of the N in wastewater residuals or biosolids is found in organic forms (Binder et al., 2002; Epstein, 2003) and therefore, has to undergo mineralization in order to supply nutrients for plant uptake may have also resulted in the difference in dry matter yield between the wastewater residual and the inorganic N in the first trial. The inorganic N concentration of the wastewater residual was 11 % and 9 % of the total N in the first and second trials respectively. The major processes for the release of organic N into inorganic forms when biosolids are applied to soil are well established (Stevenson, 1982, 1986; Petrovic, 1990; cited from Adjei and Rechcigl, 2002). The nitrogen mineralization process was too slow in the first trial due unfavorable conditions such as moisture limitations and temperature. Unlike urea, organic materials are mineralized slowly to NH_4^+ (Agehara and Warncke, 2005). In comparison, the N in the inorganic nitrogen source (urea) was readily soluble and available for crop uptake as

shown by the rapid yield response (Adjei and Rechcigl, 2002). Although the loss of N from the inorganic N source through ammonia volatilization could have occurred when applied on the soil surface and especially on plant residue (Teutsch et al., 2005) in the first trial, more N was available for plant uptake.

Table 5. Relevant climatic conditions during the field experiment at the University Field Station in Valsayn, Trinidad.

	Trial 1		Trial 2		
Parameters	March	April	July	August	September
Sunshine (mean hr/day)	8.01	9.18	6.04	6.83	6.98
Monthly Rainfall (mm)	101.1	23.9	330.4	201.8	229
Minimum Relative Humidity (%)	55	53.3	64	60.7	56.7
Minimum Air Temperature (^{0}C)	21.71	21.56	23.43	23.04	23.14
Maximum Air Temperature (^{0}C)	31.08	31.81	31.53	32.12	32.81
Mean monthly pan evaporation (mm)	172	186.7	122.2	135.9	248.3

Wastewater residual application resulted in higher Tanner grass dry matter yields than the no N control in the first trial, with a significantly higher dry matter yield occurring in the second trial (Table 4). This suggests that the wastewater residual, through mineralization, supplied nutrients to the crop for plant uptake and forage growth. The insignificant difference in tanner grass dry matter yield between the wastewater residual and the inorganic N source in the second trial was most likely due to more favorable conditions for mineralization. Air temperature and precipitation, which has a

direct influence on soil moisture, were higher in the second trial (Table 5). These climatic indices provided conditions necessary for increased mineralization. Among the factors controlling net N mineralization are soil temperature and water content (Kätterer et al., 1998; cited from Cabrera et al., 2005). This is evident in Table 4 where the rate of wastewater residual N had a significant ($P<0.05$) effect on dry matter yield in the second trial. Nitrogen fertilization and availability as well as soil moisture are two of the biggest factors limiting growth (Tranel, 2000). In addition, residual nitrogen from the wastewater residual applied in the first trial could have also resulted increased productivity in the second trial. Nitrogen mineralization is an on-going process, which is influenced by several factors, including temperature, moisture and aeration (Whitehead, 1985). Therefore, some of the wastewater residual may have not completely mineralized during the first trial such that the process continued during the second trial. The application of large amounts of organic amendments to the soil can influence soil N supply and crop yields for several years after application (Boyle and Paul, 1989; cited from Binder et al., 2002).

An increase in dry matter yield from the first to the second trial in response to the wastewater residual, in comparison to a decrease in response to inorganic N can be attributed to a greater N loss through NH_4^+ fixation (Eudoxie, 2003), and denitrification and volatilization (Whitehead, 1985) from the inorganic N source (urea) as well as increased N mineralization from the wastewater residual in the second trial. Eudoxie (2003) reported that apparent recovery of fertilizer N as fixed NH_4^+ at 14 and 28 days after fertilization in River Estate Series was 38% and 36% respectively. The organic nature and hence the slow release of N from the wastewater residual would decrease the percentage of fixed NH_4^+.

REFERENCES

Adjei, M.B., and J.E. Rechcigl. 2002. Bahiagrass production and nutritive value as affected by domestic wastewater residuals. Agronomy Journal 94 (6):1400-1410.

Agehara, S., and D.D. Warncke. 2005. Soil moisture and temperature effects on nitrogen release from organic nitrogen sources. Soil Science Society of America Journal 69:1844-1855.

Binder, D.L., A. Dobermann, D.H. Sander and K.G. Cassman. 2002. Biosolids as a nitrogen source for irrigated maize and rainfed sorghum. Soil Science Society of America Journal 66:531-543.

Bittman, S., L.J.P. van Velt, C. Grant Kowalenko, S. McGinn, D.E. Hunt, and F. Bounaix. 2005. Surface-banding liquid manure over aeration slots. A new low-distribution method for reducing ammonia emissions and improving yield of perennial grasses. Agronomy Journal 97:1304-1313.

Boyle, M., and E.A. Paul. 1989. Carbon and nitrogen mineralization kinetics in soils previously amended with sewage sludge. Soil Science Society of America Journal 53: 99-103.

Cabrera, M.L., D.E. Kissel, and M.F. Vigil. 2005. Nitrogen mineralization from organic residues: Research Opportunities. Journal of Environmental Quality 34:75-79.

Epstein, E. 2003. Land application of sewage sludge and biosolids. Lewis Publishers. CRC Press Company.

Eudoxie, G.D. 2003. Use of ^{15}N tracer techniques to evaluate factors affecting interlayer fixation of NH_4^+ and its subsequent release in Trinidadian soils. Ph.D. Thesis. Department of Food Production. Faculty of Agriculture and Natural Sciences, University of the West Indies, Trinidad.

Kätterer, T., M. Reichstein, O. Andren, and A. Lomander. 1998. Temperature dependence of organic matter decomposition: A critical review using literature data analyzed with different models. Biology and Fertility of Soils 27: 258-262.

Lorimor, J. 1998. Ammonia losses from broadcast liquid manure. In: Management /Economics. ISU Swine research report. Iowa State University Extension. Iowa State University. http://www.extension.iastate.edu/Pages/ansci/swinereports/asl-1597.pdf

Michalk, D.L., I.H. Curtis, C.M. Langford, P.C. Simpson, and J.T. Seaman. 1996. Effects of sewage sludge on pasture production and sheep performance. In: Proc. of the 8th Australian Agronomy Conference. The Regional Institute Ltd.

Muñoz, G.R., J. Mark Powell, and K.A. Kelling. 2003. Nitrogen budget and soil N dynamics after multiple applications of unlabeled or ^{15}Nitrogen-enriched dairy manure. Soil Science Society of America Journal 67: 817-825.

Petrovic, A.M. 1990. The fate of nitrogenous fertilizers applied to turfgrass. Journal of Environmental Quality 19:1-14.

Rochette, P., M.H. Chantigny, D.A. Angers, N. Bertrand, and D. Côté. 2001. Ammonia volatilization and soil nitrogen dynamics following fall application of pig slurry on canola crop residues. Canadian Journal of Soil Science 81: 515-523.

Sanjari, G., H. Ghadiri, and C. Ciesiolka. 2006. Grazing management and its effects groundcover and runoff control in Queensland, Australia. In: 14th International soil conservation organization conference. Water management and soil conservation in semi-arid environments. Marrakech, Morocco, May 14-19. http://www98.griffith.edu.au/dspace/bitstream/10072/11497/1/T3-Sanjari-Grazing_Mngt_paper_ISCO2006.pdf.

Smith, G.D. 1983. Soil and land use surveys. No. 27. Correlations of the soils of the Commonwealth Caribbean, Puerto Rico, the Virgin Islands and Guyana. Department of Soil Science. Faculty of Agriculture, University of the West Indies, Trinidad.

Stehouwer, R. 2003. Effects of biosolids on soil and crop quality. Agricultural Research and Cooperative Extension. College of Agricultural Sciences, Pennsylvania State University.

Stevenson, F.J. 1982. Origin and distribution of nitrogen in soil. In: Nitrogen in agricultural soils. Edited by F.J. Stevenson. p.155- 215. Agronomy Monograph 22. ASA, CSSA, and SSSA, Madison, WI.

Stevenson, F.J. 1986. The internal cycle of nitrogen in soil. In: Cycles of soil: Carbon, nitrogen, phosphorus, sulfur, micronutrients. p.155-182. John Wiley & Sons, New York.

Teutsch, C.D., J.H. Fike, G.E. Groover, and S. Aref. 2005. Nitrogen rate and source effects on the yield and nutritive value of Tall Fescue stockpiled for winter grazing. Forage and Grazinglands. Plant Management Network. http://www.plantmanagementnetwork.org/pub/fg/research/2005/winter/

Thompson, R.B., J.C. Ryden, and D.R. Lockyer. 1987. Fate of nitrogen in cattle slurry following surface application or injection to grassland. Journal of Soil Science 38: 689-700.

Tiffany, M., L. McDowell, G. O`Connor, F. Martin, N. Wilkinson, E. Cardoso, and P. Rabianksy. 2003. Effects of pasture-applied biosolids (municipal sewage sludge) on forage nutrient concentrations over a grazing season in North Florida. Florida Beef Report. University of Florida.

Tranel, L. 2000. Nitrogen fertilizer on grass pastures. ISU Fact Sheet LT-107. Cooperative Extension. Iowa State University. http://www.extension.iastate.edu/NR/rdonlyres/B090C051-8602-4456-B3D6-1ED769C2D495/46839/NitrogenFertilizeronGrassPastures.pdf

Whitehead, M.L. 1985. The effect of soil type and sludge source on the mineralization of nitrogen and determination of nitrogen mineralization potentials. M.S. Thesis. University of Florda.

Zvomuya, F., C.J. Rosen, and S.C. Gupta. 2006. Nitrogen and phosphorous leaching from growing season versus year-round application of wastewater on seasonally frozen lands. Journal of Environmental Quality 35: 324-333.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):96-100. 2008

El Ensilaje de Barbojo de Habichuela con Niveles de Melaza/Urea

J. Caridad[1], R. Silvestre[2] y G. García Lagombra[3]. [1]Investigador en producción animal, jcaridad@idiaf.org.do,[2]Encargado campo experimental ganade rsilvestre@idiaf.org.do, [3]Encargado nacional programa sistemas de producción animal, glagombrra@idiaf.org.do, Instituto Dominicano de Investigaciones Agropecuarias y Forestales, República Dominicana

RESUMEN.

El uso de los subproductos de cosecha en la región este es una alternativa para épocas de crisis de pastos, por lo que se planteó un experimento para usar el barbojo de habichuela, subproducto de la cosecha estacional de la zona después de cosechada y paleada. Se tomaron 15 fundas plásticas y se llenaron con 10 kg de barbojo de habichuela, con el objetivo de evaluar el efecto de diferentes niveles de melaza/urea sobre la calidad nutritiva del barbojo de habichuela, para lo cual se utilizó un diseño completamente al azar (DCA) con cinco tratamientos y tres repeticiones donde cada 10 kg de ensilaje era la unidad experimental, siendo los tratamientos T1: barbojo de habichuela solo (testigo), T2: barbojo de habichuela + 2 % melaza + 0 % urea, T3: barbojo de habichuela + 2 % melaza + 0.5 % urea, T4: barbojo de habichuela + 2 % melaza + 1.0 % urea y T5: barbojo de habichuela + 2 % melaza + 1.5 % urea. A los 21 días se tomaron muestras de los tratamientos y enviadas al laboratorio para el análisis bromatológico, resultando diferencias significativas en los tratamientos 1 y 2 con relación al 3, 4 y 5 ($P<0.05$) con respecto al contenido de proteína (7.56, 8.94 vs 17.88, 19.59 y 22.34). Tomando este resultado como referencia, podemos concluir que la presencia de urea en el ensilaje mejora la calidad del barbojo de habichuela por efecto del contenido de nitrógeno que aporta.

PALABRAS CLAVES: época de crisis de pastos, subproducto de cosecha, cosecha estacional

INTRODUCCIÓN

El ganado bovino es una de las especies más eficaces, por ser capaces de transformar los subproductos de cosechas y agroindustriales, pastos y forrajes en alimentos para los humanos. La alimentación es uno de los aspectos que incide de manera negativa en el desarrollo de las fincas ganaderas en época de sequía. Es por ello que para la época crítica y/o de escasez de alimento es importante conocer los recursos con los que se dispone, los materiales de pastos y forrajes que se pueden introducir de acuerdo a las condiciones existentes y su valor nutritivo.

La práctica del ensilaje contrarresta el efecto negativo que provocan los períodos secos en la producción bovina como es la pobre disponibilidad de forraje tanto en cantidad como en calidad creando disminución en la producción de leche y de carne (Bolsen, 1996). Aparte de la falta de adecuación y sistemas de conservación eficientes para la seguridad alimentaria del ganado durante esos períodos se han realizado ensayos tendentes a estudiar las diferentes alternativas de conservación de forrajes, tomando en

cuenta tanto la cantidad como la calidad de la misma para mantener los niveles de producción sin importar las épocas del año (Pérez, 1996; Rodríguez, 1983).

La mayoría de ganaderos olvidan durante el invierno que muy pronto vendrá una época difícil de ausencia de lluvia con poco pasto verde para sus vacas, y por lo tanto pérdidas por baja producción de leche y carne. La técnica de la preparación del ensilaje para favorecer el manejo y uso integral de los recursos (suelo-planta), promueve el uso de alimentos de la propia región reduciendo la importación de concentrados y por consiguiente la fuga de divisas nacionales, además de ser una alternativa para épocas de crisis en la producción de pasto (Moreno, 1982).

Las tecnologías de conservación adecuadas a las realidades tropicales, constituyen un ejemplo de tecnología apropiada que tienden a reducir la dependencia económica de la actividad pecuaria y desarrollar una producción constante durante todo el año. Por lo que el ganadero esta siendo inducido a practicar estos métodos y así desarrollar políticas de auto suficiencia (Fermín, 1983).

Si se hace un silo se pueden aprovechar diversos cultivos que su cosecha coincide con el inicio de la época crítica en la producción de pastos que pueden ser aprovechados a través del ensilaje, añadiéndoles elementos ricos en proteínas y energía para mejorar el producto ensilado. De igual forma, evitará las pérdidas y dispondrá de alimento, sosteniendo una producción normal durante todo el año. Como tal es el caso de la habichuela, rubro cultivado estacionalmente entre los meses noviembre – enero de cada año en la región este.

El objetivo de esta investigación es estudiar el efecto de diferentes niveles de melaza/urea sobre la calidad nutricional del ensilaje del barbojo de habichuela.

MATERIALES Y MÉTODOS

Este ensayo se realizó en el Campo Experimental Higüey, ubicado en el km 1 de la carretera Higüey – La Otra banda, Provincia La Altagracia. Localizada a 18°6´ latitud norte y 68° 7´ longitud oeste con una pluviometría anual promedio de 1431 mm y temperatura anual promedio de 27.4°C.

Se utilizó un diseño completamente al azar (DCA) con cinco (5) tratamientos y tres (3) repeticiones, donde cada funda de ensilaje era una unidad experimental para un total de quince (15) unidades experimentales.

Los tratamientos utilizados en este experimento fueron los siguientes: T1: barbojo de habichuela solo (tratamiento testigo), T2: barbojo de habichuela + 2 % melaza + 0 % urea, T3: barbojo de habichuela + 2 % melaza + 0.5 % urea, T4: barbojo de habichuela + 2 % melaza + 1.0 % urea, y T5: barbojo de habichuela + 2 % melaza + 1.5 % urea.

Se recolectó material desechado después de cosechada y paleada la habichuela procediendo a introducir el material en fundas de polietileno y los tratamientos fueron aplicados a medida que se llenaban las fundas. El porcentaje de urea y melaza se aplicó de acuerdo al contenido total del ensilaje que fue 10 kg por unidad experimental. Una vez completos todos los tratamientos fueron ubicados en un lugar estratégico y se tomaron muestras a partir de 21 días después de guardado. Se realizó un análisis de laboratorio (bromatológico solamente) a todas las unidades experimentales en el laboratorio de la Junta Agroempresarial Dominicana (JAD). El análisis de ácido láctico no fue posible realizarlo.

El análisis estadístico fue realizado con el programa SAS para el análisis de varianza y Duncan para la prueba de comparación de medias. Se determinaron los costos marginales para cada tratamiento (RD$/Tonelada).

Se evaluaron las siguientes variables: Materia Seca (MS), Humedad (Hum), Proteína (Prot.), Grasa (G), Ceniza (Cen), Calcio (Ca), Fósforo (P), y Fibra bruta (FB).

RESULTADOS Y DISCUSIÓN

En la Tabla 1 se muestra que el contenido de proteína entre los tratamientos fue significativamente diferente a P<0.05 (T1 y T2 frente a T3, T4 y T5). Esta diferencia se presentó cuando se incluyó la urea en el ensilaje, sin embargo, no hubo diferencias significativas entre los tratamientos T3, T4 y T5, lo que indica que cuando el ensilaje contiene urea a ciertos niveles, los porcentajes de proteína, como NNP, aumentan, mejorando la calidad del ensilado (ver Figura 1).

Tabla 1. Contenido nutricional del ensilaje de barbojo de habichuela como respuesta a diferentes niveles de melaza urea y el costo de los mismos

Tratamientos	**T1**	**T2**	**T3**	**T4**	**T5**
	%	**%**	**%**	**%**	**%**
MS	**84.16**	**83.96**	**77.28**	**82.91**	**79.80**
NS					
Humedad	**15.84**	**16.04**	**22.72**	**17.09**	**20.20**
NS					
Proteína	**5.78 c**	**6.39 bc**	**9.80 a**	**8.75 ab**	**9.57 a**
Grasa	**0.84 ab**	**1.04 ab**	**1.28 a**	**1.12 a**	**0.56 b**
Ceniza	**9.46**	**9.74**	**11.75**	**9.82**	**10.38**
NS					
Calcio	**0.97**	**1.08**	**1.22**	**1.08**	**1.05**
NS					
Fósforo	**0.06 b**	**0.08 ab**	**0.09 ab**	**0.09 ab**	**0.09a**
Fibra bruta	**-**	**-**	**-**	**-**	**-**
Costo/tonelada RD$*	**0**	**90.72**	**116.80**	**142.88**	**168.96**

*Dólar US$/RD$40.00; Letras similares, en la misma fila, no son significativamente diferentes a P<0.05, NS = no significativo.

Según se observa en la Figura 1 los tratamientos con melaza/urea surtieron efectos positivos en cuantos a los niveles de proteína (en base a valores de Nitrógeno). Estos resultados coinciden con los encontrados por Silvestre (2002) al estudiar la melaza/urea en el ensilaje de *Gliricidia sepium* combinada con *Pennisetum purpureum* (datos no publicados).

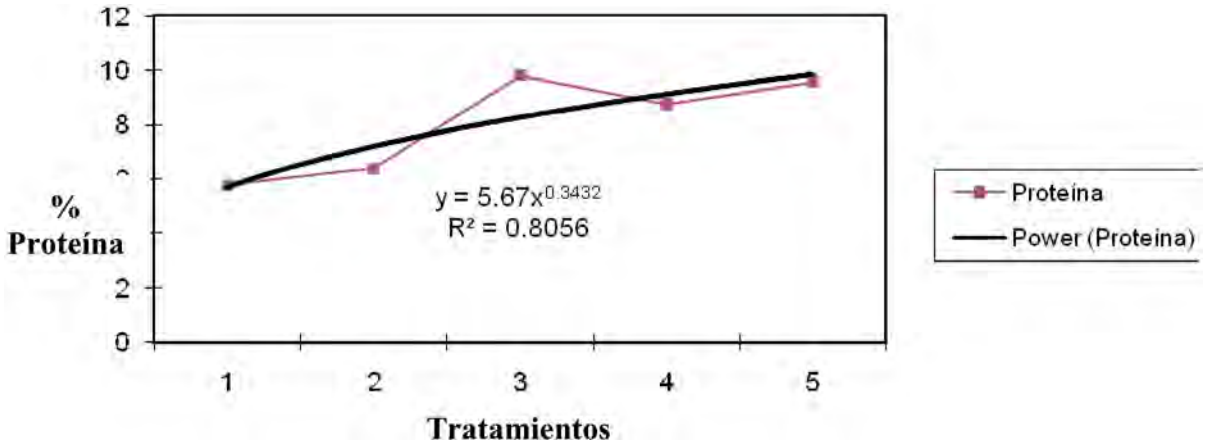


Figura 1. Comportamiento de la proteína como respuesta a diferentes niveles de melaza/urea en el ensilado del barbojo de habichuela.

En relación con los niveles de fósforo (P) hubo diferencias significativas, resultando un efecto directamente proporcional con respecto a los tratamientos estudiados porque a medida que se aumentaron los niveles de melaza/urea, aumentaron los niveles de fósforo. Estos resultados, también coinciden con los encontrados por Silvestre (2002) al estudiar el mismo efecto sobre el ensilaje de *Gliricidia sepium* combinada con *Pennisetum purpureum* (datos no publicados).

Según el análisis económico realizado para verificar la dominancia entre los tratamientos encontramos que el tratamiento T3 posee el costo más bajo, cuando se le adicionó melaza/urea, dominando sobre los demás, ya que sus niveles de proteína difieren significativamente de los demás tratamientos, haciendo al T3, el de menor costo con niveles de proteína óptimos, como podemos apreciar Figura 2.

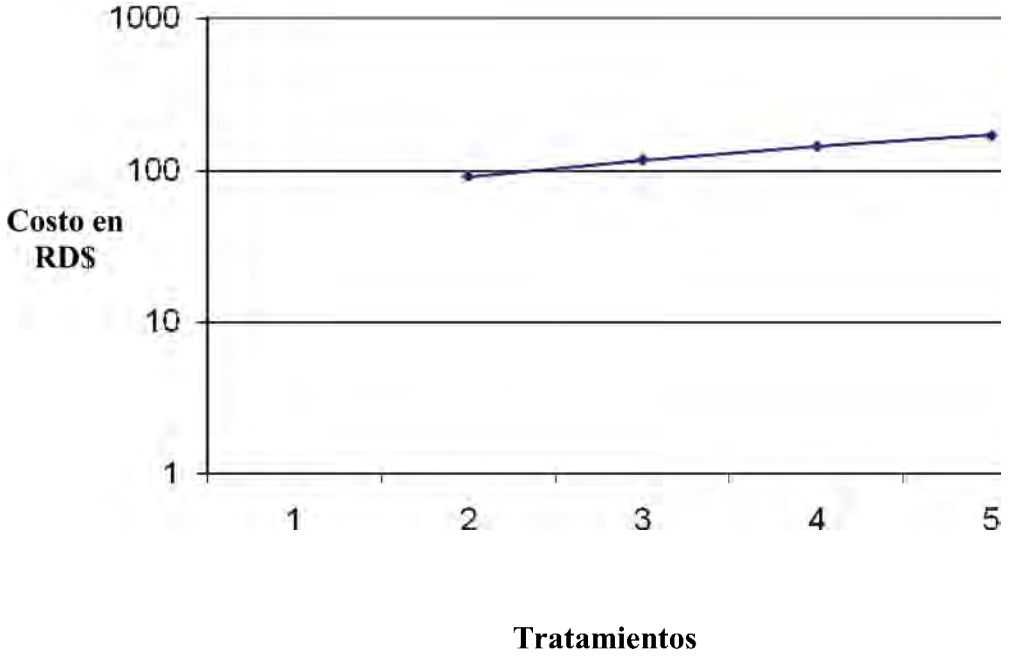


Figura 2. Costo en RD$ x Tonelada de la aplicación de los diferentes niveles de melaza/urea en el ensilado del barbojo de la cosecha de habichuela

La inclusión de melaza/urea en el ensilaje del barbojo de habichuela mejoró su calidad proteica con cualquiera de los niveles de melaza/urea aplicados. Los niveles de 0.5, 1.0 y 1.5 % de urea más 2 % de melaza, pueden usarse indistintamente como mejoradores de la calidad del ensilaje del barbojo de habichuela. Sin embargo, se recomienda usar 0.5% de urea y 2% melaza al tomar en cuenta el costo/tonelada en la preparación del ensilaje ya que no existen diferencias significativas entre los tratamientos cuando se aplica urea en el ensilaje del barbojo de habichuela, pero resulta ser el de menor costo.

REFERENCIAS

Bolsen, K. 1996. Manejo de ensilaje: con énfasis en merma. Ensilajes tropicales en producción de leche. Proteínas nacionales, CXA. Y RALSTON PURINA Internacional, Santo Domingo, R.D.

Fermín, A. 1983. Alternativas nutricionales para la época seca. Sistema de producción animal en el trópico. Curso corto. Secretaría de Estado de Agricultura, Centro Nacional de Investigaciones Pecuarias (CENIP), Centro de Agronomía Tropical Investigación y Enseñanza (CATIE), y W.K. Kellogs Fundation, Santo Domingo, R.D.

Moreno, A. 1982. Fundamentos de la conservación de forrajes en el trópico. Secretaría de Estado de Agricultura y Dirección General de Ganadería, Santo Domingo, R.D.

Perez, O. 1996. Conservación de pastos y forrajes. Manejo intensivo del pastoreo y conservación de forrajes como alternativa de alimentación para el ganado bovino en el trópico. Curso de capacitación. Seminario internacional sobre: Ensilajes tropicales en producción de leche. Proteínas Nacionales, CXA. Y RALSTON PURINA Internacional, Santo Domingo, R.D.

Rodríguez, S. 1983. Ensilaje. Fondo Nacional de Investigaciones Agropecuarias (FONAIAP) Vol. 1, año 2- no. 12, Caracas, Venezuela.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):101-113. 2008

Mucuna pruriens Detoxification through Ensiling

Christiaan M . Huisden [1], Adegbola T. Adesogan [1], and Nancy J. Szabo[2]. [1]Department of Animal Sciences, IFAS, University of Florida, USA; [2]Center for Environmental and Human Toxicology, University of Florida, USA.*
**Corresponding Author: Email: adesogan@ufl.edu; Fax: 1 352 392 7652*

ABSTRACT.

Mucuna pruriens is grown for food and feed despite its L-Dopa concentration (2-6% by wt), which is toxic to monogastrics. The aim of this study was to determine if the L-Dopa concentration of *Mucuna* could be reduced by ensiling. The objective of Experiment 1 was to examine how long it takes to decrease the pH of ensiled *Mucuna* to 4.5. Crushed *Mucuna* beans (6 mm) were ensiled in the dark at room-temperature (18 to 25°C) for 0, 3, 7, 14, 21, and 28 days in vacuum-sealed bags. A pH of 4.5 and an L-Dopa concentration of 1.3% (54% reduction) were recorded after 28 days. The objective of Experiment 2 was to study the effect of particle size of ensiled *Mucuna* on L-Dopa concentration and fermentation and nutritional characteristics. Ensiling *Mucuna* that had been ground to particle sizes of 2, 4 and 6 mm for 28 days decreased the L-Dopa concentration from 2.8% in the unesiled bean to 1.2, 1.6, and 1.1%, respectively. Ensiling also reduced the water-soluble carbohydrate (WSC) concentration and pH and increased the ammonia-N (NH_3N) concentration. Neither ensiling nor particle size affected concentrations of ether extract (EE; 5%), CP (23-25%), starch (38-40%), and neutral detergent fiber (NDF; 17-20%). Dry matter losses (< 1%) and mold or yeast counts were unaffected by particle size. Aerobic stability was maintained beyond 657 hours in all treatments and the lactate:acetate ratio of all samples exceeded 3.0. In conclusion, ensiling *Mucuna* bean for 28 days reduced the L-Dopa concentration by 43 to 61% while preserving most nutrients. Particle size had minimal effects on nutritional composition or fermentation indices.

KEYWORDS: *Mucuna pruriens*, detoxification, ensiling

INTRODUCTION

Mucuna pruriens is a legume indigenous to Asia that grows in many tropical regions including Africa and the West Indies. According to Ezeagu et al. (2003), *Mucuna* beans are high in crude protein (CP; 24-29%) and starch (39-41%). Adebowale et al. (2005) reported a higher CP range for *Mucuna* (33 to 38%), reflecting variation in composition due to growth environment. These nutritional attributes explain why various species of *Mucuna* are grown as a food crop in tropical countries despite their toxic properties. The major toxic component of *Mucuna* that limits its use as food for humans or monogastric livestock is 3,4-dihydroxy-L-phenylalanine (L-Dopa), the chemical precursor to the neurotransmitter dopamine. Szabo and Tebbett (2002) reported L-Dopa concentrations ranging from 4.47 to 5.39% L-Dopa in the bean, but wider ranges have been reported (3.1 to 6.7%; Daxenbichler et al., 1972).

Although ruminants are not adversely affected by ingestion of Mucuna (Burgos et al., 2002; Perez-Hernandez et al., 2003; Nyambati and Sollenberger, 2003; Castillo-

Caamal, 2003ab; Eilitta et al., 2003; Matenga et al., 2003; Mendoza-Castillo et al., 2003; Muinga et al., 2003; Chikagwa-Malunga et al., 2008), numerous publications report its toxic effects on monogastrics (Carew et al., 2002; Del Carmen et al., 2002; Flores et al., 2002). Some consequences of increased peripheral dopamine in humans include orthostatic hypotension resulting in dizziness and in some cases staggering; increased heart rate, nausea, vomiting, and anorexia are also common side effects of excess L-Dopa ingestion (Szabo and Tebbett, 2002). Safe levels of L-Dopa in monogastric livestock diets are considered to be 0.4% or less (Eilitta et al., 2003; Carew et al., 2002; Ferriera et al., 2003; Iyayi and Taiwo, 2003; Ukachukwu and Szabo, 2003).

Studies indicate that processing techniques can reduce the L-Dopa concentration of *Mucuna* beans to a safe level (Bressani, 2002). Processing methods that utilize heat decrease the L-Dopa concentration to or near a 1% level; permeation of the bean with hot water removes over 75% of the water-soluble L-Dopa, and boiling eliminates almost all (>99%) of the L-Dopa (Szabo and Tebbett, 2002). Extraction rates increase with increasing water temperature, allowing safe levels to be reached within 13 h at 40°C, 3 h at 66°C, and 40 min in boiling water (Teixeira and Rich, 2003). However, these methods are appropriate for many developing countries (Gilbert, 2002) because heating fuel is expensive and copious amounts of water are required. Acid-solvent extraction can be just as effective as boiling water extraction (Myhrman, 2002), but this method depends on the availability of acids which are corrosive and harmful. Little is known about strategic use of ensiling or fermenting as an L-dopa detoxification method.

Mucuna has been boiled and fermented to produce food products such as tempe (Egounlety, 2003), and mixtures of Mucuna and corn have also been ensiled (Matenga et al., 2003). In both instances the digestibility of the bean increased after fermentation but effects on L-dopa concentration were not measured. Matenga et al. (2003) ensiled various mixtures of *Mucuna* and maize grain for 21 days and reported that the L-Dopa concentration was reduced by 10% for a 100% *Mucuna* sample and by 47% for a 30% *Mucuna* 70% maize mixture. The decrease in L-Dopa concentration due to *Mucuna* fermentation might be a useful strategy for making *Mucuna* safe for feeding to non-ruminants. However, the ensiling duration that is required for fermentation of *Mucuna* alone has not been determined and little is known about the nutritive value of fermented *Mucuna.*

This study had two objectives. The first one was to determine the effect of ensiling duration on the fermentation characteristics of *Mucuna.* Removal of L-Dopa from *Mucuna* beans depends on the particle size because smaller particles have greater surface area and promote more interaction with extraction solvents (Teixeira et al., 2003). Therefore, a second objective was to study the effect of particle size of ensiled *Mucuna* on L-Dopa concentration, nutritive value and fermentation characteristics.

MATERIAL AND METHODS

Mucuna pruriens cv. Georgia bush, containing 25% CP, 4.6% EE, 17.3% NDF, 18.1% WSC, 38.2% starch, and 2.8% L-Dopa was obtained from the University of Georgia, Tifton, GA, USA.

Effects of ensiling duration (Experiment 1)

In the first of two experiments, beans were crushed in a roller mill (model 10004; Peerless International, Missouri, USA), collected in dark plastic bags, mixed thoroughly

and 1500 g sub-samples were weighed into individual vacuum mini silo bags (26.5cm x 38.5cm; VacLoc Vacuum Packaging Rolls, FoodSaver, Neosho, MO, USA; Figure 1) in quadruplicate. To provide sufficient moisture for the fermentation, 900 ml of double-distilled water was added to the beans in each bag. A vacuum sealer (V2220, FoodSaver, Neosho, MO, USA) was used to remove residual air from the bags. Individual mini-silos were wrapped in brown paper bags and kept in a dark room at room temperature (18 to 25°C) for up to 28 days. The dark ensiling conditions were used to prevent the degradation of light-sensitive L-Dopa.

The mini-silos were inspected daily and manually vented by pricking with a pin to remove excessive gas accumulation when necessary. Pin holes were immediately sealed with silo-tape after venting. Four bags containing *Mucuna* were opened after 0, 3, 7, 21, and 28 days of ensiling. After ensiling, the contents of each bag were analyzed for dry matter (DM), pH, and concentrations of volatile fatty acids (VFA), lactic acid, CP, and NH_3-N. A pH of 4.6 or lower was taken to indicate adequate fermentation because this pH represents the typical minimum value for ensiled legumes (Heinrichs and Ishler, 2000). Samples with a pH of 4.6 or lower were also tested for L-Dopa.

Effects of particle size of ensiled *Mucuna* (Experiment 2)

Crushed *Mucuna* beans were sieved through a 6-mm (coarse) screen (USA Standard Testing Sieve, Fisher Scientific) or ground in a Wiley mill to pass through a 4-mm (medium) or a 2-mm (fine) screen (Arthur H. Thomas Company, Philadelphia, PA, USA). Samples (1500 g) of each particle size were weighed into vacuum plastic bags in quadruplicate. Double-distilled water (900 ml) was added to each bag and the bags were sealed and ensiled for 28 days based on the results of Experiment 1.

Chemical analysis

Unensiled and ensiled bean samples were dried at 55 oC to 97% DM and ground to pass through a 1-mm screen in a Wiley mill (Arthur H. Thomas Company, Philadelphia, PA). Dry matter concentration was determined after drying at 60°C for 72 hours and ash was measured by combustion in a muffle furnace at 550°C overnight. Gross energy levels were determined by an adiabatic bomb calorimeter (1261 isoperibol bomb calorimeter, Parr Instrument Company, Moline, Illinois, USA. The following analyses were also conducted: NDF (Van Soest et al., 1991), EE (AOAC, 1984), WSC (MAFF, 1986), L-Dopa (Siddhuraju and Becker, 2001), CP (Noel and Hambleton, 1976), and starch (Hall, 2001).

Statistical analysis

Each experiment had a completely randomized design with four replicates. Data were analyzed with the MIXED procedure (SAS 9.1, SAS Inst. Inc., Cary, NC, USA). When the treatment effect was significant ($P < 0.05$), means were separated with a PDIFF statement. Tendencies were declared at $P > 0.05$ and ≤ 0.10. Orthogonal polynomial contrasts (linear, quadratic and cubic) were used to evaluate the effects of ensiling duration in Experiment 1 and increasing the particle size (2, 4, and 6 mm) in Experiment 2 on silage quality measures.

RESULTS

Effects of ensiling duration

A pH of 4.5 (Table 1) and an L-Dopa concentration of 1.3% (Figure 2) were obtained after 28 days of ensiling. During the fermentation, the pH decreased cubically, whereas concentrations of NH_3-N, lactate, isobutyrate and isovalerate increased non-linearly. The NH_3-N concentration remained below the threshold of 10% of total N throughout the ensiling period but lactate concentration had increased by 74% by day 28 and therefore lactate was the predominant fermentation acid. The lactate:acetate ratio increased cubically from 1.12 at day 0 to 3.60 at day 28. Dry matter losses were not detected in any treatment.

Table 1. Fermentation characteristics of *Mucuna* silage after various ensiling durations

	Days						
Item	0	3	7	21	28	SEM[A]	Polynomial contrasts
pH	6.2^{a}	6.1^{a}	5.4^{b}	4.7^{c}	4.5^{c}	0.1	C
NH_3-N, % DM	0.19^{a}	0.26^{a}	0.29^{a}	0.31^{a}	0.39^{b}	0.02	C
NH_3-N,% total N	4.9^{d}	6.8^{c}	8.1^{b}	7.8^{bc}	9.4^{a}	0.4	C
Lactate, % DM	0.66^{cd}	0.29^{c}	1.97^{bcd}	2.06^{bc}	2.57^{ab}	0.57	C
Acetate, % DM	0.73	0.43	0.61	0.53	0.85	0.17	NS
Propionate, % DM	0.15	0.93	0.64	0.09	0.21	0.33	NS
Iso-butyrate, % DM	0.47^{c}	0.26^{c}	0.32^{c}	0.84^{b}	1.35^{a}	0.10	C
Iso-valerate, % DM	0.23^{d}	0.61^{c}	0.95^{a}	0.59^{c}	0.64^{bc}	0.08	C
Total VFA, % DM	1.00	1.62	2.30	1.49	2.62	0.62	NS
Lactate:acetate	1.12^{bc}	0.65^{c}	3.09^{abc}	3.80^{ab}	3.60^{abc}	1.00	C

[A] SEM = standard error of mean; C = cubic; NS = not significant; within a row, means without a common superscript letter differ ($P < 0.05$).

Effects of particle size of ensiled *mucuna*

Ensiling reduced the L-Dopa concentration of coarse, medium, and fine particles to 64, 42 and 57%, respectively (Figure 3). Particle size did not affect CP, starch, fat, or NDF concentrations or DM losses (Table 2). The WSC concentrations of ensiled coarse or medium and fine particles were reduced by 45 and 73%, respectively. Gross energy values were unaffected by ensiling, but ensiled medium and fine particles had 6-7% less GE than ensiled coarse particles. The ash concentration of coarse and unensiled particles were similar but ash concentration increased by more than 44% by ensiling medium and fine particles. Ensiling decreased the pH by 22-26%, but particle size did not affect this reduction (Table 3). Ensiling increased lactate, isobutyrate, total VFA, valerate, and NH_3-N concentrations. Ensiling also increased acetate, propionate and isovalerate concentrations of fine and coarse but not medium particles. Lactate was the main fermentation acid and the lactate:acetate ratio exceeded 3.0 in all ensiled treatments. Among ensiled samples, coarse particles had less lactate and more NH_3-N than fine or medium particles, and a lower lactate to acetate ratio. Mold and yeast counts (Table 4) were unaffected by particle size and due to low numbers of these microbes, AS was maintained beyond 657 hours in all treatments.

Table 2. Chemical composition of unensiled *Mucuna* (CON) and *Mucuna* ensiled at various particle sizes for 28 days

Item	CON	Ensiled			SEM	Polynomial contrasts
		2 mm	4 mm	6 mm		
DM, %	91.2[a]	37.6[b]	39.8[b]	38.9[b]	1.0	NS
DM-loss, %	NA	1.1	0.9	0.8	0.4	NS
CP, % DM	25.0	23.2	23.7	24.4	0.4	NS
Ash, % DM	6.0[c]	13.4[a]	10.7[ab]	8.8[bc]	1.0	L
GE, cal/g	4055[ab]	3859[b]	3903[b]	4135[a]	71	NS
Starch, % DM	38.2	38.0	39.6	38.4	1.0	NS
WSC, % DM	18.1[a]	4.8[c]	10.1[b]	10.0[b]	1.2	L
Fat, % DM	4.6	4.8	4.7	4.9	0.2	NS
NDF, % DM	17.3	19.9	18.7	18.1	1.2	NS

SEM = standard error of mean; L = linear effect; NS = not significant; within a row, means without a common superscript letter differ ($P < 0.05$).

Table 3. Fermentation characteristics of unensiled *Mucuna* (CON) and *Mucuna* ensiled at various particle sizes for 28 days

Item	CON	Ensiled 2 mm	Ensiled 4 mm	Ensiled 6 mm	SEM[A]	Polynomial contrasts
pH	6.18[a]	4.58[b]	4.80[b]	4.73[b]	0.11	NS
Lactate, % DM	0.66[c]	6.40[a]	6.44[a]	4.42[b]	0.56	NS
Lactate, % total acids	42.33	53.66	57.57	46.23	13.62	NS
Acetate, % DM	0.73[b]	1.28[a]	1.05[ab]	1.30[a]	0.15	Q
Propionate, % DM	0.15[b]	0.46[a]	0.31[ab]	0.45[a]	0.09	NS
Iso-butyrate, % DM	0.47[b]	3.01[a]	2.76[a]	2.61[a]	0.21	NS
Butyrate, % DM	0.00[b]	0.47[a]	0.37[ab]	0.19[ab]	0.12	NS
Iso-valerate, % DM	0.23[b]	0.88[a]	0.73[ab]	1.07[a]	0.17	NS
Valerate, % DM	0.00[b]	0.01[a]	0.01[a]	0.01[a]	0.00	NS
Total VFA, % DM	1.00[b]	5.50[a]	4.70[a]	5.07[a]	0.36	NS
Lactate:acetate	1.12[c]	5.03[ab]	6.16[a]	3.41[b]	0.64	Q
NH_3-N,% DM	0.18[c]	0.51[b]	0.51[b]	0.56[a]	0.01	NS
NH_3-N,% total N	4.41[c]	11.56[b]	11.88[b]	13.03[a]	0.28	L

[A] SEM = standard error of mean; L = linear effect; Q = quadratic effect; NS = not significant; within a row, means without a common superscript letter differ ($P < 0.05$).

Table 4. Microbial counts and aerobic stability (AS) of unensiled *Mucuna* (CON) and *Mucuna* ensiled at various particle sizes for 28 days

Item	CON	Ensiled 2 mm	Ensiled 4 mm	Ensiled 6 mm	SEM
Yeasts, log cfu/g[A]	<1.0	3.0	<1.0	<1.0	N/A
Molds, log cfu/g[A]	<1.0	2.8	2.5	3.0	0.3
Aerobic stability, hours	N/A	>657	>657	>657	N/A

[A] cfu/g = Colony-forming units per g of *Mucuna* silage; within a row, means without a common superscript letter differ ($P < 0.05$).

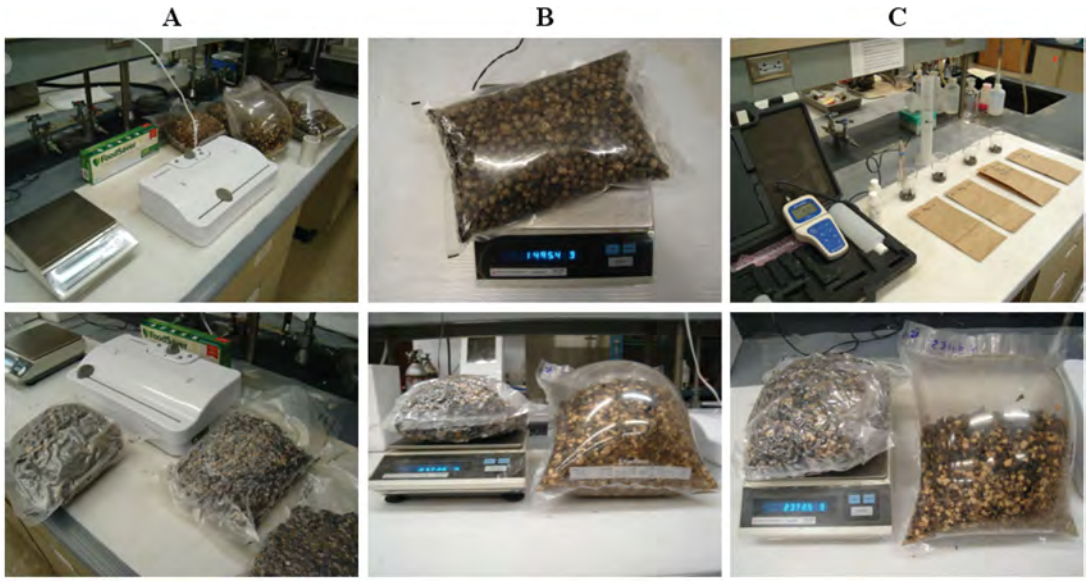


Figure 1. Ensiling *Mucuna* beans: A) vacuum sealing mini silos, B) weighing before and after ensiling, C) measuring the pH; gas accumulation in ensiled bags.

DISCUSSION

Characteristics of well preserved silages include a pH below 4.0, an NH_3-N concentration below 10% of total N, and a lactate:acetate ratio above 2.0 (Owens et al., 1999). Legume silages tend to have a pH range of 4.6 to 5.2 (Heinrichs and Ishler, 2000). Therefore, it took 28 days to achieve the minimum typical pH of legume silages. The NH_3-N concentration in Experiment 1 increased to 9.4% of total N after 28 days of ensiling, indicating that proteolysis was not excessive. The predominance of lactate in the total acid concentration indicates that a homolactic fermentation occurred and reflects the utilization of WSC by lactic acid bacteria. This lactate accumulation led to the 27% drop in pH to a value of 4.5 after 28 days of fermentation, which resulted in a 54% decline in L-Dopa concentration to 1.2% of DM. This level is higher than the generally accepted safety threshold ($\leq$ 0.4%) for consumption of *Mucuna* by monogastric livestock (Eilitta et al., 2003; Carew et al., 2003; Ferriera et al., 2003; Iyayi and Taiwo, 2003; Ukachukwu and Szabo, 2003).

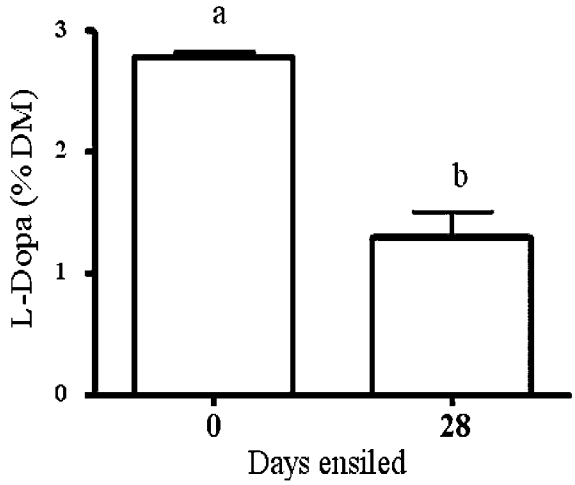
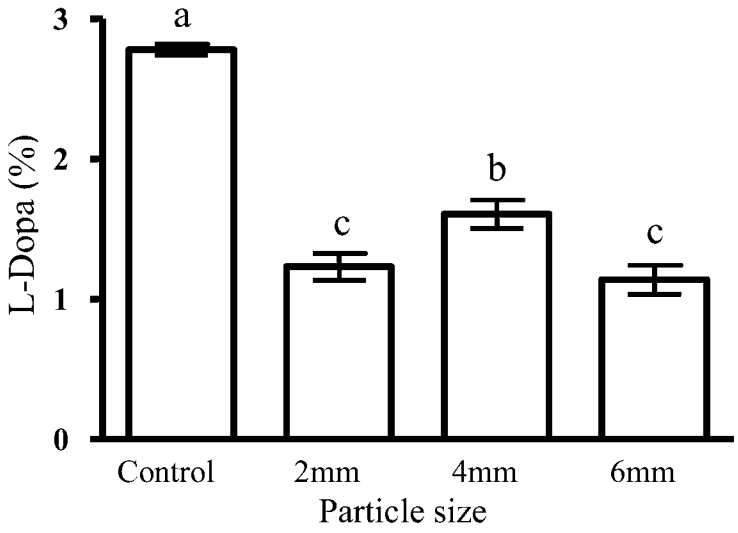


Figure 2. The L-Dopa concentration of unensiled and ensiled *Mucuna* bean. Means without a common superscript letter differ ($P < 0.05$); error bars denote standard error.

Figure 3. Effect of particle size on L-Dopa concentration of ensiled *Mucuna*. Means without a common superscript letter differ ($P < 0.05$); error bars denote the standard error.



In Experiment 2, concentrations of NH_3-N were slightly above the threshold of 10% indicating that minimal proteolysis occurred (Seglar, 2003). The relatively high lactate concentrations and lactate:acetate ratios beyond the critical value of 2.0 in all ensiled treatments indicate the predominance of efficient homo-fermentative pathways during ensiling of *Mucuna*. Ensiling decreased the L-Dopa concentration by 61% relative to the control, exceeding the 10 to 47% decrease reported by Matenga et al. (2003) after ensiling different mixtures of *Mucuna* with maize grain for 21 days. As in Experiment 1, the post-ensiling L-Dopa concentration of 1% was higher than the threshold of 0.4% considered safe for consumption by monogastric livestock. Therefore, ensiled *Mucuna* should be fed with other ingredients in diets of monogastrics to dilute the L-Dopa ingested and avoid excessive L-Dopa intake.

Particle size affected L-Dopa concentration of ensiled beans in a quadratic manner. Inexplicably, the medium sized particles had higher residual levels of L-Dopa relative to the fine and coarse particles. Nevertheless, L-Dopa concentration was markedly reduced by ensiling without affecting CP concentration at each particle size. Apart from that of Matenga et al. (2003), no published studies were found on the effects of ensiling *Mucuna* alone on its L-Dopa concentration.

The fact that ensiling produced normal fermentation characteristics and decreased the L-Dopa concentration without adversely affecting concentrations of most nutrients indicates that *Mucuna* silage can be of value as a food and feed component in the diet of monogastrics. However, care should be taken to ensure that total L-Dopa intake does not exceed levels associated with side effects. In humans, a daily L-Dopa intake of 0.25 g/day is used as a starting dose for Parkinson's patients in order to minimize side effects

(Szabo and Tebbett, 2002). The body progressively adjusts to ingested L-Dopa, therefore this starting dose could be increased by 0.5 g every 7-10 days up to a maximum therapeutic dose of 8 g L-Dopa/day.

Relative to other detoxification methods, such as solvent extraction at variable pH (Diallo et al., 2002 and Teixeira et al., 2003) and thermal processing (Wanjekeche et al., 2003), ensiling is a simpler, relatively inexpensive procedure that does not require purchasing heating fuel, acid or alkaline solvents, or using copious amounts of water. Furthermore, unlike solvent extraction, ensiling does not lower the CP concentration or make the bean much darker due to formation of melanin (Teixeira et al., 2003; Wanjekeche et al., 2003). However, ensiling for 28 days did not reduce the L-Dopa concentration as much as these more conventional detoxification methods. Future research should investigate if longer ensiling durations produce greater reductions in the L-Dopa concentration.

Coarse particles of *Mucuna* ensiled well and resulted in as much L-Dopa removal as fine particles. This implies that for ensiling, beans can be crushed to an approximate particle size of 6 mm and this can easily be achieved by applying a blunt force to crack the beans into a few pieces. Therefore, no mechanical grinders are required and this represents an additional advantage over the solvent extraction method where a fine particle size must be achieved for successful detoxification.

CONCLUSION

In the current study, the pH of ensiled *Mucuna* was reduced to 4.5 within 28 days, which is the typical minimum pH value for legume silages. This ensiling duration decreased the L-Dopa concentration from 2.8 to 1.3% (Experiment 1) or 2.8 to 1.2% (Experiment 2). Except for decreasing the WSC concentration, the chemical concentration of the bean was preserved during ensiling and the shelf life of the ensiled bean exceeded 657 hours. Based on the fermentation characteristics, good nutritional composition, extensive AS, and reduction of L-Dopa concentration, ensiling is a promising method of detoxifying *Mucuna* beans for monogastric consumption. Ensiled *Mucuna* should be fed with other dietary ingredients to moderate L-Dopa ingestion by monogastrics because ensiling does not completely reduce the L-Dopa concentration to safe levels. Future research should investigate if longer ensiling durations (>28 days) produce greater reductions in the L-Dopa concentration.

REFERENCES

Adebowale, Y.A., Adeyemi, A., and Oshodi, A.A., 2005. Variability in the physicochemical, nutritional and antinutritional attributes of six Mucuna species. Food Chemistry 89, 37–48.

Association of Official Analytical Chemists (AOAC), 1984. Official methods of Analysis, Fourteenth edition, Washington DC, Procedure 24.005.

Bressani, R., 2002. Factors influencing nutritive value in food grain legumes: Mucuna compared to other grain legumes. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew, R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), Tegucigalpa, Honduras, p. 164-188.

Burgos, A., Matmoros, I., Toro, E., 2002. Evaluation of velvetbean (Mucuna pruriens) meal and Enterobium ciclocarpum fruit meal as replacements for soybean meal in diets for dual-purpose cows. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew, R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), Tegucigalpa, Honduras, pp. 228-237.

Carew, L.B., Hardy, D., Weis, J., Alster, F., Mischler, S.A., Gernat, A., Zakrzewska, E.I., 2003. Heating raw velvetbeans (Mucuna pruriens) reverses some antinutritional effects on organ growth, blood chemistry, and organ histology in growing chickens. Tropical and Subtropical Agroecosystems 1, 267-276.

Carew, L.B., Valverde, M.T., Zakrzewska, E.I., Alster, F.A., Gernat, D., 2002. Raw velvetbeans (Mucuna pruriens) and L-Dopa have differing effects on organ growth and blood chemistry when fed to chickens. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew, R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), Tegucigalpa, Honduras, p. 272-287.

Castillo-Caamal, A.M., Castillo-Caamal, J.B., Ayala-Burgos, A.J., 2003a. Mucuna bean (Mucuna spp.) supplementation of growing sheep fed with a basal diet of napiergrass (Pennisetum purpureum). Tropical and Subtropical Agroecosystems 1, 107-111.

Castillo-Caamal, J.B., Jiménez-Osornio, J.J., López-Pérez, A., Aguilar-Cordero, W., Castillo-Caamal, A.M., 2003b. Feeding velvetbean to small ruminants of Mayan farmers in the Yucatan Peninsula, Mexico. Tropical and Subtropical Agroecosystems 1, 113-117.

Chikagwa-Malunga, S.K., Adesogan, A.T., Sollenberger, L.E., Phatak, S.C., Szabo, N.J., Kim, S.C., Huisden, C.M., Littell, R.C., 2008. Nutritional characterization of Mucuna pruriens: 4. Does replacing soybean meal with Mucuna pruriens in lamb diets affect ruminal, blood and tissue L-Dopa concentrations? Animal Feed Science and Technology, In Press, Corrected Proof, Available online 28 April 2008.

Daxenbichler, M.E., VanEtten, C.H., Earle, F.R., Tallent, W.H., 1972. L-Dopa recovery from Mucuna seed. Journal of Agriculture and Food Chemistry, 20, 1046-1048.

Del Carmen, J., Gernat, A.G., Myhrman, R., Carew, L.B., 2002. Evaluation of raw and heated Velvetbeans (Mucuna pruriens) as feed ingredients for broilers. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), Tegucigalpa, Honduras, p. 258-271.

Diallo, O.K., Kante, S., Myhrman, R., Soumah, M., Cisse, N.Y., Berhe, T., 2002. Increasing farmer adoption of Mucuna pruriens as human food and animal feed in the Republic of Guinea. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), Tegucigalpa, Honduras, pp. 60-72.

Egounlety, M., 2003. Processing of velvetbean (Mucuna pruriens var. utilis) by fermentation. Tropical and Subtropical Agroecosystems 1, 173-181.

Eilitta, M., Carsky, R.J., Mureithi, J., Szabo, N., Bressani, R., Myhrman, R., Sandoval, C., Muinga., R., Carew, L.B., Capo-chichi, L.J.A., Teixeira. A., 2003. Future agenda for research and promotion of Mucuna. Tropical and Subtropical Agroecosystems 1, 329-343.

Ezeagu, I.E., Maziya-Dixon, B., Tarawali, G., 2003. Seed characteristics and nutrient and antinutrient composition of 12 Mucuna accessions from Nigeria. In Eilittä, M., Mureithi, J., Muinga, R., Sandoval, C., & Szabo, N. (Eds.) Increasing Mucuna's Potential as a Food and Feed Crop [Proceedings of an international workshop held September 23-26, 2002, in Mombasa, Kenya]. Tropical and Subtropical Agroecosystems 1, 129-140.

Ferriera, H.A., Peňa, B.K., Gernat, A.G., Carew, L.B., Matamoros, I.A., 2003. Studies of the effect of heated, water extracted and extruded velvetbeans (Mucuna pruriens) and of methionine and lysine supplementation in diets for broilers. Tropical and Subtropical Agroecosystems 1, 277-286.

Flores, L., Esnaola, M.A., Myhrman, R., 2002. Growth of pigs fed diets with Mucuna bean flour (Mucuna pruriens) compared to soybean meal. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), April 26-29, 2000, Tegucigalpa, Honduras, pp. 288-305.

Gilbert, R.A., 2002. Mucuna pruriens in Malawi: A promising legume with a troubled history. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), Tegucigalpa, Honduras, p. 48-59.

Hall, M.B., 2001. Starch gelatinization and hydrolysis method. In: Neutral Detergent-Soluble Carbohydrates. Nutritional Relevance and Analysis, A Laboratory Manual. Bulletin 339, University of Florida, Department of Animal Sciences, Florida.

Heinrichs, J., and Ishler, V., 2000. Evaluating forage quality by visual appraisal, pH, and dry matter content. Pennsylvania State University Department of Dairy and Animal Science and Cooperative Extension. http://www.das.psu.edu/dairynutrition/documents/evalfor.pdf Accessed Dec. 14, 2007.

Iyayi, E.A. and Taiwo, V.O., 2003. The effect of diets incorporating Mucuna (Mucuna pruriens) seed meal on the performance of laying hens and broilers. In Eilittä, M., Mureithi, J., Muinga, R., Sandoval, C., & Szabo, N. (Eds.) Increasing Mucuna's Potential as a Food and Feed Crop [Proceedings of an international workshop held September 23-26, 2002, in Mombasa, Kenya]. Tropical and Subtropical Agroecosystems 1, 239-246.

Matenga, V.R., Ngongoni, N.T., Titterton, M., and Maasdorp, B.V., 2003. Mucuna seed as a feed ingredient for small ruminants and effect of ensiling on its nutritive value. Tropical and Subtropical Agroecosystems 1, 97-105.

Mendoza-Castillo, H., Castillo-Caamal, J.B., and Ayala-Burgos, A., 2003. Impact of Mucuna bean (Mucuna spp.) supplementation on milk production of goats. Tropical and Subtropical Agroecosystems 1, 93-96.

Ministry of Agriculture, Fisheries and Food (MAFF), 1986. The analysis of agricultural materials. Reference book 427, HMSO, London.

Muinga, R.W., Saha, H.M., Mureithi, J.G., 2003. The effect of Mucuna (Mucuna pruriens) forage on the performance of lactating cows. Tropical and Subtropical Agroecosystems 1, 329-343.

Myhrman, R., 2002. Detection and Removal of L-Dopa in Mucuna. In Food and Feed from Mucuna: Current Issues and the Way Forward. International Cover Crops Clearinghouse, Honduras, p. 142-162.

Noel, R.J. and Hambleton, L.G., 1976. Collaborative study of a semi automated method for determination of crude protein in animal feeds. Journal of the Association of Official Analytical Chemists 59, 134-140.

Nyambati, E.M. and Sollenberger, L.E., 2003. Nutritive value of top-canopy herbage of Mucuna and Lablab relay-cropped in maize in the sub-humid highlands of northwestern Kenya. Tropical and Subtropical Agroecosystems 1, 329-343.

Owens, V.N., Albrecht, K.A., Muck, R.E., and Duke, S.H., 1999. Protein degradation and fermentation characteristics of red clover and alfalfa silage harvested with varying levels of total nonstructural carbohydrates. Crop Science 39, 1873-1880.

Perez-Hernandez, F., Ayala-Burgos, A.J., Belmar-Casso, R., 2003. Dry matter in vivo digestibility of sheep with a basal diet of Napier grass (Pennisetum purpureum) supplemented with velvetbean (Mucuna Spp.). Tropical and Subtropical Agroecosystems 1, 329-343.

Statistical Analysis Systems (SAS), 2002. SAS User's guide: Statistics, Version 9.1. SAS Inst., Inc., Cary, NC.

Seglar, B. 2003. Fermentation analysis and silage quality testing. Pages 119-136 in Proceedings of the Minnesota Dairy Health Conference, University of Minnesota, Minneapolis, MN.

Siddhuraju, P. and Becker, K., 2001. Rapid reversed-phase high performance liquid chromatographic method for the quantification of L-Dopa (3,4-dihydroxyphenylalanine), non-methylated and methylated tetrahydroisoquinoline compounds from Mucuna beans. Food Chemistry 72, 389-394.

Szabo, N.J. and Tebbett, I.R., 2002. The chemistry and toxicity of Mucuna species. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO) Workshop, Tegucigalpa, Honduras, p. 120-141.

Teixeira, A.A. and Rich, E.C. 2003. Detoxification of velvetbean (Mucuna pruriens) by water extraction of L-Dopa. Document Title: Transactions of the ASAE 46, 1399-1406

Teixeira, A.A., Rich, E.C. and Szabo, N.J., 2003. Water extraction of L-Dopa from Mucuna bean. Tropical and Subtropical Agroecosystems 1, 159-171.

Tournas, V., Stack, M.E., Mislivec, P.B., Koch, H.A., and Bandler, R., 1999. Yeasts, molds and mycotoxins. In: Food and Drug Administration Bacteriological Analytical Manual. AOAC Intl., Gaithersburg, MD.

Ukachukwu, S.N. and Szabo, N.J., 2003. Effect of processing, additives and vitamin B6 supplementation of Mucuna pruriens var conchinensis on broilers. Tropical and Subtropical Agroecosystems 1, 227 – 237.

Van Soest, P.J., Robertson, J.B., Lewis, B.A., 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science 74, 3568-3597.

Wanjekeche, E., Wakasa, V., and Mureithi, J.G., 2003. Effect of alkali, acid and germination on nutritional composition and antinutritional factors of Mucuna (Mucuna pruriens). In Eilittä, M., Mureithi, J., Muinga, R., Sandoval, C., and Szabo, N. (Eds.) Increasing Mucuna's Potential as a Food and Feed Crop [Proceedings of an international workshop held September 23-26, 2002, in Mombasa, Kenya]. Tropical and Subtropical Agroecosystems 1, 183-192.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):114-122. 2008

Effect of Sonication and Two Solvent Extraction Methods on the L-dopa Concentration and Nutritional Value of *Mucuna pruriens*

Christiaan M. Huisden[1], Adegbola T. Adesogan[1], and Nancy J. Szabo[2],*
[1]Department of Animal Sciences, IFAS, University of Florida, USA
[2]Center for Environmental and Human Toxicology, University of Florida, USA
**Corresponding Author: Email: adesogan@ufl.edu; Fax: 1 352 392 7652*

ABSTRACT.

Mucuna pruriens beans are high in crude protein (CP; 25-30%) and starch (39-41%), but also contain toxic L-Dopa. Methods to reduce L-Dopa to a safe threshold (< 0.4%) are often costly and little is known about their impact on the nutritional value of the bean. The objective of this study was to examine effects of three extraction methods on L-Dopa concentration and nutritional composition of finely (1 mm) or coarsely (6 mm) ground beans. Methods evaluated included extraction in solutions of acetic acid (ACD, pH 3) or sodium hydroxide (ALK, pH 11) for 8 hours or sonication (SON) for 5 minutes. All extraction methods decreased the L-Dopa concentration of fine Mucuna particles from 2.8 to < 0.2%, decreased their CP and water-soluble carbohydrate (WSC) concentrations by 24-31% and 78-81%, respectively and increased their NDF and starch concentrations by at least 62 and 14%, respectively. Sonication reduced the ether extract (EE) concentration of fine particles from 5.5% to 4.2% but ACD and ALK did not. Sonication and ACD did not reduce the L-Dopa concentration of coarsely ground beans but ALK reduced it from 2.8 to 2%. Sonication also reduced CP, WSC, and ether EE concentrations of coarse particles by 6, 17, and 27%, respectively and ALK increased their starch concentration by 17%. Therefore, the extraction methods reduced L-Dopa of fine Mucuna particles to safe levels but increased their NDF and starch concentrations at the expense of WSC and CP concentrations. Extraction methods were less effective at reducing the L-Dopa in coarse particles and had fewer, less consistent effects on their nutritional composition.

KEYWORDS: *Mucuna pruriens*, solvent-extraction, sonication

INTRODUCTION

Malnutrition in developing countries is due in part to insufficient access to affordable protein sources. Diets of many children in such countries lack protein and instead consist mainly of cereal-based porridge that is bulky, low in energy and nutrients, and high in antinutrient concentration (Adebowale et al., 2005a). *Mucuna pruriens*, a legume indigenous to tropical regions, can be used to increase the supply of dietary protein to such children. *Mucuna pruriens* beans are high in nutrients including crude protein (25-38%), starch (39-41%), and fiber (4%; Ezeagu et al., 2003; Adebowale et al., 2005b). Adebowale et al. (2007) reported that the bioavailability and amino acid concentrations of Mucuna protein isolates exceeded levels recommended for humans by Food and Agriculture Organization, World Health Organization, and the United Nations for all amino acids except methionine and cysteine. The lysine concentration of *Mucuna*

is particularly high (Bressani, 2002), therefore *Mucuna* is a valuable supplementary protein source to cereal-based diets, which are known to be lysine deficient. The chemical composition of the beans varies with cultivar, geographical location, maturity at harvest, and bean color (St-Laurent et al., 2002; Ezeagu et al., 2003). However, *Mucuna* contains anti-nutritive factors (ANF) and the most potent and problematic ANF in the *Mucuna* bean is L-Dopa (Ukachukwu et al., 2002), the concentration of which ranges from 3 to 7% on a dry basis (Daxenbichler et al., 1972). Symptoms of *Mucuna* intake in humans and monogastric livestock include reduced feed intake, weight loss, diarrhea, vomiting, and skin lesions (Del Carmen et al., 2002; Flores et al., 2002; Szabo and Tebbett, 2002).

Some processing techniques can reduce *Mucuna*'s L-Dopa concentration to the safe threshold of < 0.4% (Eilitta et al., 2003). L-Dopa is readily soluble in dilute solutions of hydrochloric acid (Daxenbichler et al., 1972). Acidification of water to pH 3 allows extraction of the L-Dopa in *Mucuna* beans at 1-mm particle size to safe levels in less than 8 hours (Teixeira et al., 2003). However, this treatment could result in protein loss because of the increased protein solubility at pH less than the isoelectric point (pH 4.0-5.0) of *Mucuna* protein (Adebowale et al., 2007). Alkaline conditions may also facilitate inactivation of L-Dopa in *Mucuna* beans. Diallo et al. (2002) reported that a calcium hydroxide solution was more effective than water at removing L-Dopa from Mucuna bean. Soaking the beans in 4% calcium hydroxide solution for 48 hours reduced the L-Dopa concentration to 0.001%. Teixeira et al. (2003) also reported that extraction of *Mucuna* beans (1 mm particle size) in NaOH solution at pH 11 reduced L-Dopa to safe levels (<0.4%) in less than 8 hours. However, Teixeira et al. (2003) and Wanjekeche et al. (2003) reported that melanin is produced when Mucuna L-Dopa is extracted at alkaline pH and this makes the beans black. Melanin has been anecdotally associated with the formation of melanoma in some studies (Dollery, 1999; Letellier et al., 1999; Siple et al., 2000), but no evidence for this association was found in other studies (Weiner et al., 1993; Pfutzner and Przybilla, 1997; Fiala et al., 2002). Nevertheless, the black color of the alkali-extracted bean may reduce its acceptability. According to Wanjekeche, beans cooked in acid solutions are a lighter shade of black than beans cooked in alkaline solution, therefore they may be viewed as more acceptable. Effective L-Dopa detoxification methods that do not adversely affect the color or nutritional value of the bean are needed. Sonication is a method used in more recent laboratory L-Dopa extraction procedures and it is not associated with discoloration of the beans. St-Laurent et al. (2002) reported 5 minutes to be the most effective duration for sonication. However, effects of sonication on the nutritive value of Mucuna are unknown. Successful removal of L-Dopa from Mucuna beans with solvents depends on the particle size; smaller particles generally increase the surface area and the solid-liquid interaction, promoting the rate of L-Dopa transfer (Teixeira et al., 2003). In contrast, larger particles require less preparation and less expensive equipment such as grinders.

The objective of this study was to examine the effects of the method of extraction on the L-Dopa concentration and nutritional composition of finely (1 mm) or coarsely (6 mm) ground *Mucuna* beans. Methods examined included extraction in either acetic acid (pH 3) or sodium hydroxide (pH 11) for 8 hours or extraction by sonication (SON) in water (pH 7) for 5 minutes.

MATERIALS AND METHODS

Extraction methods

Mucuna pruriens cv. Georgia bush beans were crushed (Roller Mill model 10004, Peerless International, Missouri, USA) and either sieved to pass through a 6-mm screen (USA Standard Testing Sieve, Fisher Scientific, Pittsburgh, PA, USA) or ground in a Wiley mill to pass through a 1-mm screen (Arthur H. Thomas Company, Philadelphia, PA, USA). Twenty-four representative 50-g samples (8 per treatment) of fine (1 mm) or coarse (6 mm) particles were subjected to sonication (SON) in water (neutral pH) or soaked in acidic (ACD) or alkaline (ALK) solutions. The ACD solution was brought to pH 3 by diluting 0.8 ml of a 25% (v/v) acetic acid solution in 2 L of distilled water. The alkaline solution was brought to pH 11 by dissolving 0.1 g of sodium hydroxide in 2 L of distilled water. Each solution was shaken (Eberbach shaker, Michigan, USA) at room temperature for 8 hours (Figure 2), then sieved through four layers of cheesecloth and a Whatman #1 filter paper (1001-240, Fisher Scientific, Pittsburgh, PA, USA). The residue was subsequently rinsed with 1 liter of distilled-deionized water. Samples were also submerged in 2 L of water (pH 7.3) within a sonication bath (Branson Ultrasonics, Connecticut) and sonicated for 5 minutes at room temperature. For each treatment, pairs of replicate residues were composited to provide sufficient sample for chemical analysis (n=4).

Chemical analysis

Sonicated and solvent-extracted residues were dried at 55 oC to 97% DM and ground to pass through a 1-mm screen in a Wiley mill (Arthur H. Thomas Company, Philadelphia, PA). Dry matter concentration was determined after drying at 60oC for 72 hours and ash was measured by combustion in a muffle furnace at 550oC overnight. Gross energy levels were determined by an adiabatic bomb calorimeter (1261 isoperibol bomb calorimeter, Parr Instrument Company, Moline, Illinois, USA), using benzoic acid as a standard. The following analyses were also conducted: NDF (Van Soest et al., 1991), EE (AOAC, 1984) , WSC (MAFF, 1986), L-Dopa (Siddhuraju and Becker, 2001), CP (Noel and Hambleton, 1976), and starch (Hall, 2001).

Statistical analysis

The experiment had a completely randomized design involving 7 treatments: untreated control, and acid, alkali, or sonication treatments of 1- and 6-mm particle size beans. Each treatment had 4 replicates (n=4) and all values reported are least squares means. Data were analyzed with the MIXED procedure (SAS 9.1, SAS Inst. Inc., Cary, NC, USA). Significance was declared at $P < 0.05$ and means were separated with a PDIFF statement.

RESULTS

All processing methods reduced L-Dopa concentrations of fine Mucuna particles from 2.8% to less than 0.2% (Figure 1). Acid and alkali treatments made the solvents and extracted bean residues darker (Figure 2). All methods also reduced CP and WSC of fine particles by 24-31% and 78-81%, respectively (Table 1) and increased their NDF and starch concentrations by at least 62 and 14%, respectively. Fat concentration of fine particles was reduced from 5.5% to 4.2% by SON, whereas ACD and ALK reduced their

GE values by approximately 10%. The ash concentration of fine particles was increased by 88% and 35% by ALK and SON, respectively.

Sonication and ACD did not reduce L-Dopa concentration of coarsely ground beans but ALK reduced it from 2.8% to 2%. Sonication reduced CP, WSC, and fat concentration of coarse particles by 6, 17, and 27%, respectively. The ALK treatment increased their starch concentration by 17% but decreased their WSC concentration by 78%. The ACD treatment increased the NDF concentration of coarse particles by 35% but decreased their WSC and fat concentrations by 51% and 31%. Ash concentration and GE of coarse particles were not affected by any of the treatments.

Table 1. Effect of processing method on the chemical composition of fine (1 mm) and coarse (6 mm) *Mucuna* beans

Item	Unground ControlA	ACDB 1 mm	ALKC 1 mm	SOND 1 mm	ACDB 6 mm	ALKC 6 mm	SOND 6 mm	SEM
Dry matter, %	95.4	94.9	95.3	95.6	95.1	95.5	95.1	0.2
Crude protein, % DM	25.4a	19.3c	17.9cd	17.4d	25.3ab	24.6ab	23.9b	0.5
Ash, % DM	6.0c	7.9bc	11.3a	8.1b	6.6bc	6.9bc	7.3bc	0.7
Gross energy, Kcal/g	4.1a	3.6b	3.6b	3.8ab	4.0ab	3.9ab	3.9ab	0.13
Starch, % DM	38.2b	45.9a	46.2a	43.7a	36.8b	44.8a	34.6b	1.5
WSC, % DM	18.1 a	3.8 d	3.9 d	3.5 d	8.8 c	13.3b	15.0b	0.8
Fat, % DM	5.5a	5.9a	5.6a	4.2b	3.8c	3.6c	4.0b	0.4
NDF, % DM	17.3 e	32.0 b	38.0a	28.1bc	23.4c	21.0de	20.3de	1.9

Within a row, means without a common superscript letter differ ($P < 0.05$); A untreated beans; B acid-treated beans; C alkali-treated beans; D sonicated beans; WSC = water-soluble carbohydrate; NDF = neutral detergent fiber.

Figure 1. Effect of acid extraction (ACD), alkali extraction (ALK), or sonication (SON on the L-Dopa concentration of fine (1 mm) or coarse (6 mm) Mucuna particles. Means without common letters differ ($P < 0.05$); error bars denote standard error.

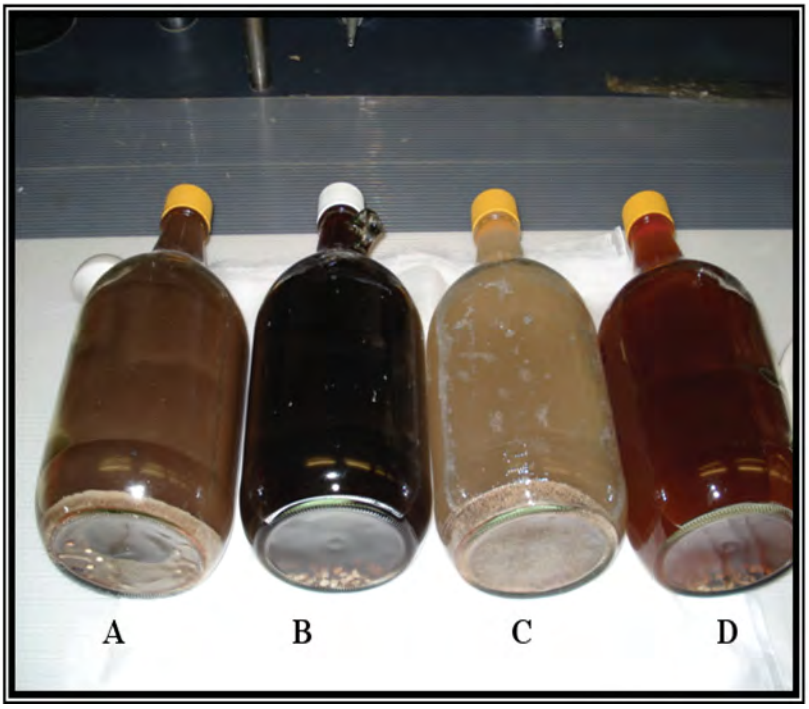
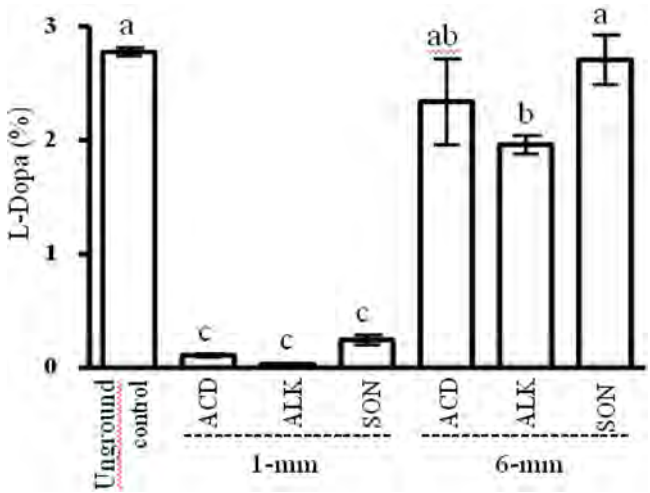


Figure 2. Color changes after detoxification of *Mucuna* bean through A) Alkaline extraction at 1-mm particle size, B) Alkaline extraction at 6-mm particle size, C) Acid extraction at 1-mm particle size, D) Acid extraction at 6-mm particle size.



DISCUSSION

Safe L-Dopa levels in Mucuna beans destined for monogastric livestock consumption are considered to be 0.4% or less (Eilitta et al., 2003). All extraction methods were equally effective in reducing the L-Dopa concentration of fine Mucuna particles to < 0.2% and thus making them safe for consumption by monogastrics. However, the L-Dopa concentration of coarse Mucuna particles was not decreased by ACD and SON and the 29% reduction by ALK treatment was inadequate to make the bean safe for consumption by monogastrics. These particle-size dependent responses are in agreement with Teixeira et al. (2003), who showed that L-Dopa removal at pH 3 or 11

depended on particle size; it was more effective in beans ground to a 1-mm particle size versus that ground to 2-, 4-, and 8-mm sizes. The efficacy of the acid and alkali-treatment of fine particles also agrees with the observations of Teixeira et al. (2003).

The CP concentration of fine particles was reduced by 24-31% in all treatments but that of coarse particles was only reduced by SON. The latter was likely because of the cell rupturing effect of sonication, which would have exposed more of the protein to the solvent and thus increased solvent penetration. Most (67.5%) of the protein in Mucuna is water-soluble (Adebowale et al., 2007). Greater CP and WSC losses in finer particles were because of the greater surface area exposure. This is in agreement with Myhrman (2002) and Teixeira et al. (2003) who reported CP losses of 11% and up to 50%, respectively due to leaching after soaking of finely ground bean samples in acid or alkaline solutions. Losses of CP from ACD and ALK-treated fine particles were also facilitated by the solubility of Mucuna protein. For unknown reasons, the alkaline extraction of Mucuna did not lead to greater CP losses than the acidic extraction. More work should be done on effects of these extraction methods on the true protein concentration of Mucuna.

The increased starch concentration of fine particles due to ACD, BAS or SON treatments of fine particles agrees with responses to acid or alkali extraction of Mucuna reported by Siddhuraju and Becker (2005). The increased starch concentration was due to partial loss of soluble components including WSC, protein, and L-Dopa, all of which decreased with solvent extraction relative to CON. The reduction in concentration of these components and the energy value of the bean, and the concomitant increases in starch and fiber concentration imply that solvent extraction and sonication modified the nutritive value of the bean and resulted in losses of key components. Further research should determine effects of the processing methods employed in this experiment on concentrations of amino acids in Mucuna.

The pH of the solvent is an important factor that can affect the success of L-Dopa removal from Mucuna and the residual nutritional quality. Several authors mention that due to formation of melanin, Mucuna beans are darker after acid or alkali extraction (Teixeira et al., 2003; Wanjekeche et al., 2003). Melanin is a metabolite of L-Dopa characterized by its dark color and conversion of L-Dopa into melanin is most evident at alkaline pH (Teixeira et al., 2003; Wanjekeche et al., 2003). The darker color of the alkali versus acid extracts in this study (Figure 2) agrees with these observations.

Diallo et al. (2002) successfully reduced the L-Dopa concentration to 0.001% after 48 hours of soaking cracked Mucuna beans in calcium hydroxide solution, but noted the remarkably dark coloration upon treatment. Beans cooked in acid solutions are lighter in color than beans cooked in alkaline solutions (Wanjekeche et al., 2003). Adebowale et al. (2007) noted that darker colors occurred in sodium hydroxide solutions of pH 11 relative to less alkaline solutions. This causes concern because the effects of melanin on health are controversial. Melanin has been anecdotally associated with the formation of melanoma in some studies (Dollery, 1999; Letellier et al., 1999; Siple et al., 2000), but no evidence for this association was found in other studies (Weiner et al., 1993; Pfutzner and Przybilla, 1997; Fiala et al., 2002). Discarding the solvent residue may reduce this concern. Nevertheless, the darker color of the extracted bean indicates the need for further investigation of concentrations of melanin residues in the detoxified bean.

CONCLUSION

Particle size affected the efficacy of L-Dopa removal in the solvent extracts. Both acidic and alkaline solvents performed equally well at detoxifying fine particles of Mucuna bean to safe levels (<0.4% L-Dopa) but also reduced their WSC and CP concentrations and increased their starch and NDF concentrations. However, these methods were not effective at detoxifying coarse Mucuna particles and they had less consistent effects on their nutritive value. Acidic and alkaline solvent extraction darkened the bean, suggesting that they increased the formation of melanin, a metabolite of L-Dopa characterized by its dark color. Future research should determine melanin concentrations in acid- or alkali-extracted beans as well as their concentrations of true protein and amino acids.

Sonication did not cause discoloration of Mucuna , yet it was also an effective method of detoxifying fine but not coarse particles of Mucuna to safe levels (<0.4% L-Dopa). Sonication generally resulted in similar modifications to the nutritive value of the bean as acid or alkali solvent extraction but caused greater losses of fat from fine particles.

REFERENCES

Adebowale, Y.A., Adeyemi, I.A., and Oshodi, A.A., 2005a. Functional and physicochemical properties of flours of six Mucuna species. African Journal of Biotechnology 4, 1461-1468.

Adebowale, Y.A., Adeyemi, A., and Oshodi, A.A., 2005b. Variability in the physicochemical, nutritional and antinutritional attributes of six Mucuna species. Food Chemistry 89, 37–48.

Adebowale, Y.A., Adeyemi, I.A., Oshodi, A.A., and Niranjan, K., 2007. Isolation, fractionation and characterisation of proteins from Mucuna bean. Food Chemistry 104, 287–299.

Association of Official Analytical Chemists (AOAC), 1984. Official methods of Analysis, Fourteenth edition, Washington DC, Procedure 24.005.

Bressani, R., 2002. Factors influencing nutritive value in food grain legumes: Mucuna compared to other grain legumes. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew, R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), Tegucigalpa, Honduras, p. 164-188.

Daxenbichler, M.E., VanEtten, C.H., Earle, F.R., Tallent, W.H., 1972. L-Dopa recovery from Mucuna seed. Journal of Agriculture and Food Chemistry, 20, 1046-1048.

Del Carmen, J., Gernat, A.G., Myhrman, R., Carew, L.B., 2002. Evaluation of raw and heated Velvetbeans (Mucuna pruriens) as feed ingredients for broilers. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), Tegucigalpa, Honduras, p. 258-271.

Diallo, O.K., Kante, S., Myhrman, R., Soumah, M., Cisse, N.Y., Berhe, T., 2002. Increasing farmer adoption of Mucuna pruriens as human food and animal feed in the Republic of Guinea. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way

Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), Tegucigalpa, Honduras, pp. 60-72.

Dollery, C., 1999. Therapeutic drugs, Second Edition. Churchill Livingstone Publishing, Edinburgh, UK, p. 39-42.

Eilitta, M., Carsky, R.J., Mureithi, J., Szabo, N., Bressani, R., Myhrman, R., Sandoval, C., Muinga., R., Carew, L.B., Capo-chichi, L.J.A., Teixeira. A., 2003. Future agenda for research and promotion of Mucuna. Tropical and Subtropical Agroecosystems 1, 329-343.

Ezeagu, I.E., Maziya-Dixon, B., Tarawali, G., 2003. Seed characteristics and nutrient and antinutrient composition of 12 Mucuna accessions from Nigeria. In Eilittä, M., Mureithi, J., Muinga, R., Sandoval, C., & Szabo, N. (Eds.) Increasing Mucuna's Potential as a Food and Feed Crop [Proceedings of an international workshop held September 23-26, 2002, in Mombasa, Kenya]. Tropical and Subtropical Agroecosystems 1, 129-140.

Fiala, K.H., Whetteckey, J. and Manyam, B.V., 2002. Malignant melanoma and levodopa in Parkinson's disease: causality or coincidence? Parkinsonism and Related Disorders 9, 321-327.

Flores, L., Esnaola, M.A., Myhrman, R., 2002. Growth of pigs fed diets with Mucuna bean flour (Mucuna pruriens) compared to soybean meal. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), April 26-29, 2000, Tegucigalpa, Honduras, pp. 288-305.

Hall, M.B., 2001. Starch gelatinization and hydrolysis method. In: Neutral Detergent-Soluble Carbohydrates. Nutritional Relevance and Analysis, A Laboratory Manual. Bulletin 339, University of Florida, Department of Animal Sciences, Florida.

Letellier, S., Garnier, J.P., Spy, J., Stoltchkov, K., Le Bricon, T., Baccard, M., Revol, M., Kerneis, Y. and Bousquet, B., 1999. Development of metastasis in malignant melanoma is associated with an increase in the plasma L-Dopa/L-tyrosine ratio. Melanoma Research, 9, 389-394.

Ministry of Agriculture, Fisheries and Food (MAFF), 1986. The analysis of agricultural materials. Reference book 427, HMSO, London.

Myhrman, R., 2002. Detection and Removal of L-Dopa in Mucuna. In Food and Feed from Mucuna: Current Issues and the Way Forward. International Cover Crops Clearinghouse, Honduras, p. 142-162.

Noel, R.J. and Hambleton, L.G., 1976. Collaborative study of a semi automated method for determination of crude protein in animal feeds. Journal of the Association of Official Analytical Chemists 59, 134-140.

Pfutzner, W. and Przybilla, B., 1997. Malignant melanoma and levodopa: Is there a relationship? Two new cases and a review of the literature. Journal of the American Academy of Dermatology 37, 332-336.

Siddhuraju, P. and Becker, K., 2001. Rapid reversed-phase high performance liquid chromatographic method for the quantification of L-Dopa (3,4-dihydroxyphenylalanine), non-methylated and methylated tetrahydroisoquinoline compounds from Mucuna beans. Food Chemistry 72, 389-394.

Siddhuraju, P. and Becker, K., 2005. Nutritional and antinutritional composition, in vitro amino acid availability, starch digestibility and predicted glycemic index of differentially processed Mucuna beans (Mucuna pruriens var. utilis): An under-utilized legume. Food Chemistry, 91, 275-286.

Siple, J.F., Schneider, D.C., Wanlass, W.A. and Rosenblatt, B.K. 2000. Levodopa therapy and the risk of malignant melanoma. The Annals of Pharmacotherapy 34, 382-385.

St-Laurent, L., Livesey, J.T., Arnason, J.T., Bruneau, A., 2002. Variation in L-Dopa concentration in accessions of Mucuna pruriens (L) DC. and in Mucuna beachyarpa Rech. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO) Workshop, Tegucigalpa, Honduras, p. 352-373.

Szabo, N.J. and Tebbett, I.R., 2002. The chemistry and toxicity of Mucuna species. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO) Workshop, Tegucigalpa, Honduras, p. 120-141.

Teixeira, A.A., Rich, E.C. and Szabo, N.J., 2003. Water extraction of L-Dopa from Mucuna bean. Tropical and Subtropical Agroecosystems 1, 159-171.

Ukachukwu, S.N., Ezeagu, I.E., Tarawali, G., and Ikeorgu, J.E.G., 2002. Utilization of Mucuna as food and feed in West Africa. In: Food and Feed from Mucuna: Current Issues and the Way Forward. International Cover Crops Clearinghouse, Honduras, p. 189-217.

Van Soest, P.J., Robertson, J.B., Lewis, B.A., 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science 74, 3568-3597.

Wanjekeche, E., Wakasa, V., and Mureithi, J.G., 2003. Effect of alkali, acid and germination on nutritional composition and antinutritional factors of Mucuna (Mucuna pruriens). In Eilittä, M., Mureithi, J., Muinga, R., Sandoval, C., and Szabo, N. (Eds.) Increasing Mucuna's Potential as a Food and Feed Crop [Proceedings of an international workshop held September 23-26, 2002, in Mombasa, Kenya]. Tropical and Subtropical Agroecosystems 1, 183-192.

Weiner, W.J., Singer, C., Sanchez-Ramos, J.R., Goldenberg J.N., 1993. Levodopa, melanoma, and Parkinson's disease. Neurology 43, 674-67

2008 Proceedings of the Caribbean Food Crops Society. 44(2):123-131. 2008

Physiological and Performance Effects on Rats Fed Detoxified *Mucuna pruriens*

Christiaan M. Huisden[1], Adegbola T. Adesogan[1], Veronika Butterweck[2], Nancy J. Szabo [3], Jack M. Gaskin[4], Ademola Raji[1], Lv Yongning[2] and Elizabeth Maxwell[1].*
[1]Department of Animal Sciences, IFAS, University of Florida, USA. [2]Department of Pharmaceutics, University of Florida, USA. [3]Center for Environmental and Human Toxicology, University of Florida, USA. [4]Department of Infectious Diseases and Pathology, University of Florida, USA.
**Corresponding Author: Email: adesogan@ufl.edu; Fax: 1 352 392 7652*

ABSTRACT.
L-Dopa (3, 4 dihydroxy-L-phenylalanine), a toxic compound in *Mucuna pruriens*, causes reduced feed intake, anorexia, diarrhea, vomiting, skin lesions and potential mortality when consumed by humans and monogastric livestock. Processing the bean can reduce L-Dopa in *Mucuna* beans to safe levels (< 0.4%), but few studies have examined the effects of feeding detoxified *Mucuna* to monogastrics. The objective of this study was to examine the effect of feeding detoxified *Mucuna* bean on the performance, behavior, and health of rats. Sixty Sprague-Dawley rats were randomly assigned to five treatments (n=12). Dietary treatments consisted of a commercial rat chow (CON) or diets in which 10% of a customized rat chow was replaced with either undetoxified *Mucuna* (MUC), or *Mucuna* detoxified by acetic acid extraction (pH 3), sodium hydroxide extraction (pH 11), or ensiling for 28 days (SIL). During the 14-day trial, behavior, physiological development, and signs of clinical pathology were evaluated. Necropsy revealed that MUC caused splenomegaly and monocytosis, and reduced phosphorus concentrations relative to CON. These effects were not observed in rats fed detoxified diets, which alkaline phosphatase concentrations 11-17% greater than those of MUC, but similar to those of CON. No abnormalities in behavior, performance, or physiology were observed in any of the rats on the detoxified diets. Compared to those fed CON, rats fed *Mucuna*-based diets had similar feed intake, weight gain, and behavioral results in the open field. It can be concluded that at the 10% level of dietary inclusion, there were fewer measurable adverse effects due to feeding the detoxified *Mucuna* bean compared to untreated *Mucuna* bean.

KEYWORDS: *Mucuna pruriens,* detoxification, monogastric

INTRODUCTION
The major problem that has compromised the usefulness of *Mucuna pruriens* as a food source is its concentration of antinutrients. According to Szabo and Tebbett (2002) and Ukachukwu et al. (2002), 3,4-dihydroxy-L-phenylalanine (L-Dopa) is the most potent toxic compound in the Mucuna bean, which contains between 3.1 and 6.7% L-Dopa (Daxenbichler et al., 1972). Consequences of excessive L-dopa intake in humans can include nausea, vomiting, and anorexia, orthostatic hypotension resulting in dizziness, staggering, increased heart rate, and psychiatric disturbances such as nervousness, anxiety and agitation, insomnia, vivid dreams, confusion, delirium,

depression and psychotic reactions with hallucinations (Szabo and Tebbett, 2002). Symptoms of Mucuna intake in broilers and pigs include weight loss, reduced feed intake, and feed conversion efficiency (Flores et al., 2002; Del Carmen et al., 2002).

Despite the health hazards caused by L-Dopa, the Mucuna bean's high protein concentration makes it an important part of the diet in Asia, Africa, and South/mid-America. According to Ezeagu et al. (2003), Mucuna beans are not only high in protein (25-30%), but also in starch (39-41%). Adebowale et al. (2007) showed that except for methionine and cysteine, concentrations of bioavailable amino acids in Mucuna protein isolates exceeded the values for human diets recommended by the Food and Agricultural Organization (FAO), World Health Organization (WHO), United Nations (UN/ONU). Mucuna's high lysine concentration makes it a suitable supplementary protein to cereal-based diets, which are known to be lysine deficient (Adebowale, 2007). Therefore, Mucuna could be used to alleviate malnutrition in developing countries, if its L-Dopa concentration is effectively reduced (Bressani, 2002; Teixeira et al., 2003). The safety threshold is a bean L-Dopa concentration of less than 0.4% (Eilitta et al., 2003; Carew et al., 2003; Ferriera et al., 2003; Iyayi and Taiwo, 2003; Ukachukwu and Szabo, 2003). Processing techniques have been evaluated that reduce the Mucuna L-Dopa concentration to safe levels (Bressani, 2002), but few studies have examined the residual nutritional value of detoxified Mucuna bean and the effects of feeding it to monogastrics.

The objective of this study was to evaluate the effect of feeding Mucuna beans detoxified by acid or alkali extraction or ensiling on the performance, physiology and behavior of Sprague-Dawley rats.

MATERIALS AND METHODS

Mucuna Detoxification

Mucuna pruriens cv. Georgia bush, were obtained from Dr. Sharad Phatak at the University of Georgia, Tifton, GA, USA and detoxified using the following methods.

Detoxification through acid or alkali solvent extraction: Mucuna beans were ground in a Wiley mill to pass through a 1-mm screen (Arthur H. Thomas Company, Philadelphia, PA, USA). An acidic solution was brought to pH 3 by diluting 0.8 ml of a 25% (v/v) acetic acid solution in 2 L of distilled water. The alkali solution was brought to pH 11 by dissolving 0.1 g of sodium hydroxide in 2 L of distilled water. Suspensions (25 g/l) of Mucuna in the acid and alkaline solutions were shaken (Eberbach shaker, Michigan, USA) at room temperature for 8 hours, then filtered through four layers of cheesecloth and a Whatman #1 filter paper (1001-240, Fisher Scientific, Pittsburgh, PA, USA). The residue was subsequently rinsed with 1 L of distilled-deionized water and dried at 55oC to 97% DM.

Detoxification through ensiling: Mucuna beans were ground in a Wiley mill to pass through a 6-mm screen (Arthur H. Thomas Company, Philadelphia, PA, USA). Ground beans were weighed (1500 g) into individual vacuum bags (26.5 x 38.5 cm, VacLoc Vacuum Packaging Rolls, FoodSaver, Neosho, MO, USA) and 900 ml of double distilled water were added to provide sufficient moisture for fermentation. A vacuum sealer (V2220, FoodSaver, Neosho, MO, USA) was used to remove residual air from the bags and to heat seal them. Bags were placed in brown paper bags and kept in the dark at room temperature (18 to 25oC) for 28 days. The bags were inspected daily and manually

vented by pricking with a pin to remove excessive gas accumulation when necessary. Pin holes were immediately sealed with silo-tape after venting. After ensiling, the concentrations of each bag were dried at 55oC to 97% DM. All procedures were performed under conditions of limited lighting since L-Dopa is light sensitive. Upon detoxification, representative samples were analyzed for L-Dopa and nutritional value (Table 1).

Table 1. Chemical composition of undetoxified (control) and detoxified *Mucuna* beans

Item	Control	Detoxification method		
		Ensiling	Acid extraction	Alkaline extraction
Crude protein, % DM	25.0	23.2	19.3	18.1
Ash, % DM	6.0	13.4	7.9	11.3
Gross energy, Kcal/g	4.1	3.9	3.6	3.6
Starch, % DM	38.2	38.0	45.9	46.2
WSC, % DM	18.1	4.8	3.8	3.9
Fat, % DM	4.6	4.8	5.9	5.6
NDF, % DM	17.3	19.9	32.0	38.0
pH	6.2	4.5	3.0	11.0
L-Dopa, % DM	2.8	1.2	0.1	0.0

WSC = water-soluble carbohydrate; NDF = neutral detergent fiber.

Chemical analysis

Ensiled and solvent-extracted residues were dried at 55 oC to 97% DM and ground to pass through a 1-mm screen in a Wiley mill (Arthur H. Thomas Company, Philadelphia, PA). Dry matter concentration was determined after drying at 60oC for 72 hours and ash was measured by combustion in a muffle furnace at 550oC overnight. Gross energy levels were determined by an adiabatic bomb calorimeter (1261 isoperibol bomb calorimeter, Parr Instrument Company, Moline, Illinois, USA), using benzoic acid as a standard. The following analyses were also conducted: NDF (Van Soest et al., 1991), EE (AOAC, 1984) , WSC (MAFF, 1986), L-Dopa (Siddhuraju and Becker, 2001), CP (Noel and Hambleton, 1976), and starch (Hall, 2001).

Rat feeding study

Dietary treatments: The diets for each of the five treatments were prepared by Harlan Teklad (Madison, WI, USA) and contained 25-26% CP, 9% ash, 37% carbohydrates, 4% fat and 2.7 Kcal/g GE. The treatments consisted of one control diet (CON) consisting of a commercial rat chow (8604 rodent diet, Harlan Teklad, Madison, WI, USA) and four Mucuna-based diets in which 10% of the commercial rat chow was replaced with either untreated Mucuna (MUC), or Mucuna beans detoxified by acetic acid extraction (ACD), sodium hydroxide extraction (BAS), or ensiling (SIL).

Animals and Measurements: Sixty 6- to 8-week-old male Sprague-Dawley rats with an initial body weight of 200 grams were purchased from Harlan (Indianapolis, IN, USA). Rats were individually-housed in 40 x 30 x 20 cm cages and randomly assigned to the five treatments (n=12). All animals had an ad libitum water and food supply.

Performance and physiological analysis: Feed intake during the first 10 days of the trial was calculated on a daily basis. Animals were also weighed daily during the first 12 days of the trial and growth records used to determine average daily gain and total weight gain. After 14 days the rats were necropsied and the heart, liver, kidneys, spleen, and gonads were weighed. Organ weights were normalized to reflect percent of body weight.

Clinical pathology analysis: At the end of the trial (day 14), blood was collected post-anesthesia through cardiac puncture and stored in serum and EDTA vacutainer tubes (Vacuette, Greiner Bio-One NA, Inc, Monroe, NC, USA) for testing in a clinical pathology laboratory that performed a blood chemistry panel and complete blood counts (CBC).

Statistical analysis Statistical analysis was performed with GraphPad Prism (version 4.00, GraphPad Software Inc., San Diego, CA, USA) and one-way analysis of variance (ANOVA) followed by Student–Newman–Keul's multiple comparison test. In all cases differences were considered significant if $P < 0.05$.

RESULTS

Performance: Table 2 shows that dietary treatments did not affect DM intake or weight gain. However, rats fed MUC had numerically ($P > 0.1$) lower values than those fed other diets.

Physiology: Necropsy revealed that in all treatments the heart, liver, kidney and testicular weights remained unchanged relative to CON (Table 3). Levels of red blood cells were not different among treatments. Feeding MUC increased spleen weight (splenomegaly) and monocyte occurrence (monocytosis) relative to CON, but feeding the detoxified beans did not (Figure 1). Concentrations of alkaline phosphatase were increased by 11-17% due to feeding detoxified beans instead of MUC, but all Mucuna treatments resulted in similar alkaline phosphatase concentrations as CON. Blood phosphorus concentration was decreased by feeding MUC relative to CON (9.78 vs 10.74 mg/dl) but it was similar in rats fed CON and detoxified diets.

Table 2. Effects of feeding unprocessed or detoxified *Mucuna pruriens* on dry matter intake and growth of rats

	CON[a]	MUC[b]	ACD[c]	BAS[d]	SIL[e]
Feed intake, g/11d	228.1 ± 6.3	212.4 ± 5.8	224.6 ± 3.4	230.8 ± 7.2	223.4 ± 6.2
Daily DM intake, g	20.7 ± 0.6	19.3 ± 0.5	20.4 ± 0.3	21.0 ± 0.7	20.3 ± 0.6
Feed intake, % BW	86.1 ± 2.1	81.9 ± 1.4	84.6 ± 1.1	85.6 ± 2.2	82.1 ± 2.0
Daily DM intake, % BW	8.6 ± 0.2	8.2 ± 0.1	8.5 ± 0.1	8.6 ± 0.2	8.2 ± 0.2
Weight gain, g/10d	59.5 ± 3.3	58.2 ± 5.3	61.8 ± 2.6	65.7 ± 2.2	66.9 ± 2.5
Daily weight gain, g	5.9 ± 0.3	5.8 ± 0.5	6.2 ± 0.3	6.6 ± 0.2	6.7 ± 0.2

Mean ± standard error; within a row, means without a common superscript letter differ ($P < 0.05$); [a] control diet, standard rat chow without *Mucuna*; [b] untreated *Mucuna* diet; [c] *Mucuna* beans detoxified by acetic acid extraction; [d] *Mucuna* beans detoxified by sodium hydroxide extraction; [e] *Mucuna* beans detoxified by ensiling; BW = body weight; DM = dry matter.

Table 3. Effects of feeding unprocessed or detoxified *Mucuna pruriens* on organ weights and concentrations of monocytes, alkaline phosphatase, and phosphorus in the blood

	CON[A]	MUC[B]	ACD[C]	BAS[D]	SIL[E]
Heart, % BW	3.84 ± 0.04	3.76 ± 0.05	3.88 ± 0.06	3.68 ± 0.05	3.71 ± 0.07
Liver, % BW	45.2 ± 0.6	44.8 ± 1.6	45.1 ± 1.1	44.2 ± 1.0	44.6 ± 0.9
Kidney, % BW	7.7 ± 0.4	7.6 ± 0.3	7.6 ± 0.2	7.2 ± 0.1	7.6 ± 0.2
Testicles, % BW	12.4 ± 0.7	13.6 ± 0.3	13.2 ± 0.2	12.9 ± 0.3	12.8 ± 0.3
Spleen, % BW	2.48^{b} ± 0.05	2.79^{a} ± 0.08	2.67^{ab} ± 0.05	2.54^{b} ± 0.06	2.64^{ab} ± 0.06
Red blood cells, $x10^6$/ul	7.4 ± 0.1	7.3 ± 0.1	7.4 ± 0.1	7.3 ± 0.1	7.1 ± 0.1

Mean ± standard error; within a row, means without a common superscript letter differ ($P < 0.05$); [A] control diet, standard rat chow; [B] untreated *Mucuna* diet; [C] *Mucuna* beans detoxified by acetic acid extraction; [D] *Mucuna* beans detoxified by sodium hydroxide extraction; [E] *Mucuna* beans detoxified by ensiling.

DISCUSSION

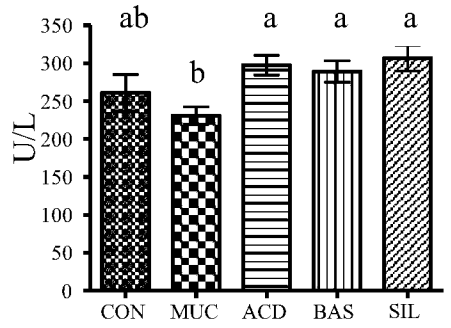
Mucuna-based diets have reportedly been associated with a decrease in acceptability and intake compared to soybean based diets (Del Carmen et al., 1999; Flores et al., 2002). Feed intake and weight gain did not differ among treatments suggesting that acceptability and nutrient bioavailability of control and Mucuna-based diets were similar, though the relatively low Mucuna inclusion rate (10% of diet DM) may also be implicated. Although the detoxification methods resulted in different L-Dopa and CP concentrations, similar performance and clinical data suggest the CP bioavailability and food safety were comparable among detoxified treatment diets. Solvent extraction typically disrupts the protein structure and degrades AA in Mucuna (Adebowale et al., 2007), nevertheless, feeding BAS and ACD did not adversely affect growth and performance.

Adverse effects due to MUC consumption evidenced by splenomegaly and monocytosis were not evident when detoxified diets were fed. The splenomegaly caused by MUC agrees with studies where spleen enlargement occurred when poultry were fed Mucuna beans (Iyayi and Taiwo, 2003; Iyayi et al., 2005; Pugalenthi et al., 2005; Carew and Gernat, 2006). The spleen is the largest collection of lymphoid tissue in the body and splenomegaly resulting from feeding MUC probably reflects increased workload or hyper-function of the organ. Splenomegaly is associated with red blood cell destruction in the spleen, congestion due to portal hypertension and infiltration by leukemias and lymphomas, obstruction of blood flow or antigenic stimulation, and infection (Grover et al., 1993). Carew et al. (2003) observed lymphoid necrosis, macrophage proliferation and lympho-phagocytosis of the spleen at a 12% Mucuna inclusion in the diet of broilers. Iyayi et al. (2005) reported that lymphoid depopulation in the spleen is indicative of the degenerative effects associated with feeding raw Mucuna beans.

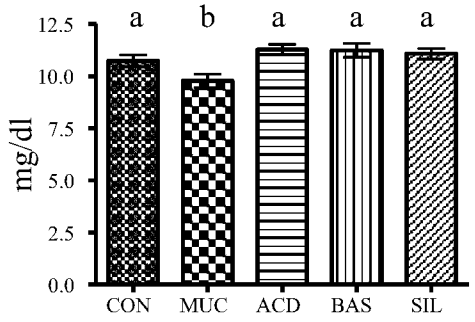
Relative to CON, the dietary inclusion of undetoxified Mucuna bean (MUC) also caused monocytosis, a state of excess monocytes in the peripheral blood indicative of

various disease states. Monocytes are leukocytes that replenish macrophages and dendritic cells and elicit an immune response at infection sites.

A. Alkaline phosphatase



B. Phosphorus



C. Monocytes

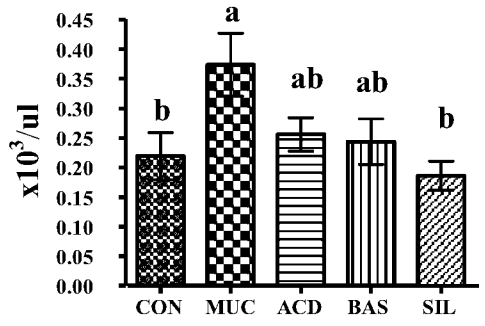


Figure 1. Effects of feeding detoxified *Mucuna pruriens* on blood levels of A) alkaline phosphatase; B) phosphorus; and C) monocytes. CON = control diet; MUC = untreated *Mucuna* diet; ACD = *Mucuna* beans detoxified by acetic acid extraction; BAS = *Mucuna* beans detoxified by sodium hydroxide extraction; SIL = *Mucuna* beans

detoxified by ensiling. Means without a common superscript letter differ ($P < 0.05$); error bars denote standard errors.

In the tissues, monocytes mature into different types of macrophages that are responsible for phagocytosis of foreign substances in the body. Monocytosis can indicate inflammation, stress due to disease, hyperadrenocorticism, immune-mediated disease, and malignant tumors (Meuten, 2008).

The immediate causes of splenomegaly and monocytosis in the current study are not clear. Interestingly, differences with respect to spleen weight and concentrations of phosphorus and monocytes counts between rats fed MUC versus CON were not evident when those fed CON versus detoxified diets were compared. Since the detoxified diets contained reduced levels of L-Dopa, the main toxic compound of concern in Mucuna, it is likely that L-Dopa toxicity was at least partially responsible for these clinical conditions in rats fed MUC.

Alkaline phosphatases remove phosphate groups by dephosphorylation, and they are most effective in an alkaline environment (Coleman, 1992). Phosphatases are involved in signal transduction because they regulate the action of proteins to which they are attached (Steelman et al., 2008; Yi and Lindner, 2008). Feeding undetoxified Mucuna resulted in lower plasma alkaline phosphatase (hypophosphatasemia) and phosphorus concentrations relative to detoxified Mucuna treatments partly suggesting that detoxification reduced adverse effects of L-dopa on signaling.

CONCLUSION

Dietary inclusion of detoxified or undetoxified Mucuna at 10% of diet DM did not affect any performance measure. Compared to feeding CON, feeding MUC decreased blood phosphorus concentration and caused splenomegaly and monocytosis but feeding detoxified Mucuna-based diets did not have these effects. Feeding MUC also decreased alkaline phosphatase levels relative to feeding detoxified Mucuna diets. Therefore, the detoxification processes improved the safety of Mucuna. Follow up research should also focus on long term effects of feeding the detoxified diets to multiple monogastric species.

REFERENCES

Adebowale, Y.A., Adeyemi, I.A., Oshodi, A.A., and Niranjan, K., 2007. Isolation, fractionation and characterisation of proteins from Mucuna bean. Food Chemistry 104, 287–299.

Association of Official Analytical Chemists (AOAC), 1984. Official methods of Analysis, Fourteenth edition, Washington DC, Procedure 24.005.

Bressani, R., 2002. Factors influencing nutritive value in food grain legumes: Mucuna compared to other grain legumes. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew, R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), Tegucigalpa, Honduras, p. 164-188.

Carew, L.B., Hardy, D., Weis, J., Alster, F., Mischler, S.A., Gernat, A., Zakrzewska, E.I., 2003. Heating raw velvetbeans (Mucuna pruriens) reverses some antinutritional effects on organ growth, blood chemistry, and organ histology in growing chickens. Tropical and Subtropical Agroecosystems 1, 267-276.

Carew, L.B. and Gernat, A.G., 2006. Use of velvetbeans, Mucuna spp. as a feed ingredient for poultry: a review. World's Poultry Science Journal 62,131-143.

Coleman, J.E., 1992. Structure and mechanism of alkaline phosphatase. Annual Review of Biophysics and Biomolecular Structure 21, 441-483.

Daxenbichler, M.E., VanEtten, C.H., Earle, F.R., Tallent, W.H., 1972. L-Dopa recovery from Mucuna seed. Journal of Agriculture and Food Chemistry, 20, 1046-1048.

Del Carmen, J., Gernat, A.G., Myhrman, R., and Carew, L.B., 1999. Evaluation of raw and heated velvetbeans (Mucuna pruriens) as feed ingredients for broilers. Poultry Science 78, 866-872.

Del Carmen, J., Gernat, A.G., Myhrman, R., Carew, L.B., 2002. Evaluation of raw and heated Velvetbeans (Mucuna pruriens) as feed ingredients for broilers. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), Tegucigalpa, Honduras, p. 258-271.

Eilitta, M., Carsky, R.J., Mureithi, J., Szabo, N., Bressani, R., Myhrman, R., Sandoval, C., Muinga., R., Carew, L.B., Capo-chichi, L.J.A., Teixeira. A., 2003. Future agenda for research and promotion of Mucuna. Tropical and Subtropical Agroecosystems 1, 329-343.

Ezeagu, I.E., Maziya-Dixon, B., Tarawali, G., 2003. Seed characteristics and nutrient and antinutrient composition of 12 Mucuna accessions from Nigeria. In Eilittä, M., Mureithi, J., Muinga, R., Sandoval, C., & Szabo, N. (Eds.) Increasing Mucuna's Potential as a Food and Feed Crop [Proceedings of an international workshop held September 23-26, 2002, in Mombasa, Kenya]. Tropical and Subtropical Agroecosystems 1, 129-140.

Ferriera, H.A., Peňa, B.K., Gernat, A.G., Carew, L.B., Matamoros, I.A., 2003. Studies of the effect of heated, water extracted and extruded velvetbeans (Mucuna pruriens) and of methionine and lysine supplementation in diets for broilers. Tropical and Subtropical Agroecosystems 1, 277-286.

Flores, L., Esnaola, M.A., Myhrman, R., 2002. Growth of pigs fed diets with Mucuna bean flour (Mucuna pruriens) compared to soybean meal. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO), April 26-29, 2000, Tegucigalpa, Honduras, pp. 288-305.

Grover, S.A., Barkun, A.N., Sackett, D.L., 1993. The rational clinical examination. Does this patient have splenomegaly? Journal of the American Medical Association 270, 2218-2221.

Hall, M.B., 2001. Starch gelatinization and hydrolysis method. In: Neutral Detergent-Soluble Carbohydrates. Nutritional Relevance and Analysis, A Laboratory Manual. Bulletin 339, University of Florida, Department of Animal Sciences, Florida.

Iyayi E.A., Taiwo V.O., and Fagbohun, A.O., 2005. Performance, carcass characteristics, aemotological and histopathological studies of broilers fed Mucuna (Mucuna utilis) bean meal based diets. Israel Journal of Veterinary Medicine 60, 2.

Iyayi, E.A. and Taiwo, V.O., 2003. The effect of diets incorporating Mucuna (Mucuna pruriens) seed meal on the performance of laying hens and broilers. In Eilittä, M., Mureithi, J., Muinga, R., Sandoval, C., & Szabo, N. (Eds.) Increasing Mucuna's Potential as a Food and Feed Crop [Proceedings of an international workshop held September 23-26, 2002, in Mombasa, Kenya]. Tropical and Subtropical Agroecosystems 1, 239-246.

Ministry of Agriculture, Fisheries and Food (MAFF), 1986. The analysis of agricultural materials. Reference book 427, HMSO, London.

Meuten, D.J. 2008. Monocytosis. https://www.vetconnect.com.au/5min/data/02500251.htm# BASICS. Accessed June 2008.

Noel, R.J. and Hambleton, L.G., 1976. Collaborative study of a semi automated method for determination of crude protein in animal feeds. Journal of the Association of Official Analytical Chemists 59, 134-140.

Pugalenthi, M., Vadivel, V., and Siddhuraju, P., 2005. Alternative food/feed perspectives of an underutilized legume Mucuna pruriens var. utilis—a review. Journal of Plant Foods for Human Nutrition 60, 201-218.

Siddhuraju, P. and Becker, K., 2001. Rapid reversed-phase high performance liquid chromatographic method for the quantification of L-Dopa (3,4-dihydroxyphenylalanine), non-methylated and methylated tetrahydroisoquinoline compounds from Mucuna beans. Food Chemistry 72, 389-394.

Steelman, L.S., Abrams, S.L., Whelan, J., Bertrand, F.E., Ludwig, D.E., Bäsecke, J., Libra, M., Stivala, F., Milella, M., Tafuri, A., Lunghi, P., Bonati, A., Martelli, A.M., McCubrey, J.A., 2008. Contributions of the Raf/MEK/ERK, PI3K/PTEN/Akt/mTOR and Jak/STAT pathways to leukemia. Leukemia 22, 686–707.

Szabo, N.J. and Tebbett, I.R., 2002. The chemistry and toxicity of Mucuna species. In: B. M. Flores, M. Eilitta, R. Myhrman, L.B. Carew and R. J. Carsky (Eds), Food and Feed from Mucuna: Current Uses and the Way Forward. Proceedings of the Centro Internacional de Informacion sobre Cultivos de Cobertura (CIDICCO) Workshop, Tegucigalpa, Honduras, p. 120-141.

Teixeira, A.A., Rich, E.C. and Szabo, N.J., 2003. Water extraction of L-Dopa from Mucuna bean. Tropical and Subtropical Agroecosystems 1, 159-171.

Ukachukwu, S.N., Ezeagu, I.E., Tarawali, G., and Ikeorgu, J.E.G., 2002. Utilization of Mucuna as food and feed in West Africa. In: Food and Feed from Mucuna: Current Issues and the Way Forward. International Cover Crops Clearinghouse, Honduras, p. 189-217.

Ukachukwu, S.N. and Szabo, N.J., 2003. Effect of processing, additives and vitamin B6 supplementation of *Mucuna pruriens* var conchinensis on broilers. Tropical and Subtropical Agroecosystems 1, 227 – 237.

Van Soest, P.J., Robertson, J.B., Lewis, B.A., 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science 74, 3568-3597.

Yi, T. and Lindner, D., 2008. The role and target potential of protein tyrosine phosphatases in cancer. Current Oncology Reports 10, 114-21.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):132. 2008

Estudio del Tiempo de Almacenamiento Sobre la Eclosión del Huevo del Pato Pekinés

Patricia Valerio[1], Gregorio García Lagombra[2], Walkiria Cruz[2]. [1]Universidad Autónoma de Santo Domingo y [2]Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF). glagombra@idiaf.org.do

RESUMEN.
Este estudio se realizó en la Estación Experimental Pedro Brand del IDIAF. En vista de que la información sobre el manejo reproductivo de patos pekineses en los trópicos es limitada, se hace necesario investigar sobre los parámetros técnicos de estos patos. Las condiciones geo-climáticas son: 18º 34' latitud Norte y 70º 05' longitud Oeste, a 90 m sobre el nivel del mar. La temperatura media anual es de 25 ºC y la precipitación media anual es de 1800 mm. El propósito fue estudiar el efecto del tiempo de almacenamiento sobre la eclosión de huevos del pato pekinés. El estudio se realizó en galpón a temperatura ambiente. Se utilizó un diseño completamente al azar con siete tratamientos y cuatro repeticiones. Cada tratamiento equivalía a un día de la semana y cada repetición fue el % de eclosión de huevos de las relaciones macho/hembra. Los tratamientos fueron 1, 2, 3, 4, 5, 6 y 7 días de almacenamiento. Las relaciones macho: hembras usadas para este estudio, las cuales a su vez eran las unidades experimentales, fueron 1:3, 1:4, 1:5 y 1:6. Las variables evaluadas fueron tasa de eclosión, temperatura y humedad. El experimento duró 60 días. Los análisis estadísticos indicaron que los tiempos de almacenamiento no tuvieron efecto significativo sobre la tasa de eclosión de huevos. Se observaron mejores tasas de eclosión los días 3, 4 y 5 de almacenamiento. Además no se pudo establecer ningún efecto negativo de la temperatura y la humedad del sobre la tasa de eclosión de los huevos. En vista de que el tiempo de almacenamiento bajo condiciones naturales no afectó la tasa de eclosión, se considera que se puede utilizar el almacenamiento de huevos en condiciones naturales y obtener resultados satisfactorios.

PALABRAS CLAVES: tiempo de almacenamiento, tasa de eclosión, nacimientos.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):133. 2008

The Effects of Synchronization Treatments on Estrous Response in Seasonal Does

Angela McKenzie-Jakes, G. Nurse, G. Byrant. Research and Cooperative Extension Programs, Florida A&M University. angusboer34@hotmail.com

ABSTRACT.
Reproduction efficiency is one of the most important economic traits in terms of livestock production. Maintaining good reproductive functions in the herd is pivotal to the success of any livestock production system. Productivity and profitability in the goat herd is measured by ovulation rate, conception rate, the number of kids born, the number of kids weaned and the frequency in which they are produced. Theoretically, a gestational period (pregnancy) of five months should support more than one kidding interval per doe per year. However, the seasonal breeding behavior of goats in the U.S. has seriously limited the ability of the producer to increase herd productivity and to access markets that bring about the highest economic returns. In recent years, estrus synchronization has become a valuable reproductive tool for controlling and manipulating the breeding period in goats. Studies have shown that differences exist in the onset and duration of estrus between various breeds of goats and even among individuals within the same breed. The objective of this study was to determine efficacy of different treatment regimens on inducing cyclic heat in breeding does. Sixty does were randomly assigned among three treatment groups. Goats in group A (n=20) were the control group (no treatment). Goats in group B were synchronized using CIDR, (Controlled Internal Releasing Device) in combination with lutalyase (1ml) and goats in group C were exposed to a vasectomized buck for 21 days. Blood samples were collected after the does were observed in standing heat. Immunoassays test were used to determine serum progesterone concentrations in the experimental does. Cyclic heat was observed in 85% of the does within 24 hours after the implants were removed (treatment B), 24 hours after the vasectomized buck was remove from the pen (treatment C) and 40% of the does were in heat in the control group 24 hours after being exposed to an intact buck.

Key words: goats, reproduction, synchronization, CIDR

2008 Proceedings of the Caribbean Food Crops Society. 44(2):134. 2008

Poisonous Plants in the Pasture

Mudge, D.M., Extension Agent III, Livestock and Natural Resources, University of Florida, Orange County Cooperative Extension Service, 6021 S. Conway Rd., Orlando, FL 32812. E-mail: dmmudge@ifas.ufl.edu

ABSTRACT.
Livestock producers in sub tropical and tropical climates always have to deal with the issue of toxic plants. Acute poisoning always brings attention and often pain or panic. While chronic poisoning is much more common, it is just as serious and yet goes unnoticed. Many pastures offer livestock nothing but weeds as the only green forage available. What approach should goat farmers, cattle producers, horse owners and even the back yard farmers implement? Here is offered a successful educational approach developed by an experienced agent who specializes in "poisonous plants in the pasture." Educational Objectives: Resources were intended to educate by increasing the producer's knowledge, lowering the risks to livestock and the saving of actual animal's lives. Program Activities: Included are educational classes, on-site ranch visits, website live plant collection, local TV (16,000 viewers), PowerPoint presentation, newsletters, media, a national media appearance (18 million viewers), and a resource guide notebook including identification DVD. The guide includes significance of the problem, practical guidance, animals at risk, symptom identification, natural deterrents, problem animals, risk in hay, drought problems, and weed identification. A special section on herbicide weed control and information on invasive exotic plants is included as well. This program has been presented to the thoroughbred industry in Ocala; Deseret Ranch, the largest cow/calf beef operation in the United States; Grand Cypress Equestrian Center, located adjacent to Disney World; the Arabian Nights attraction; Orlando Carriage Company, and many hundreds of large and small livestock producers across Florida. Impact: The resources are used and endorsed by an impressive list of agriculture operations. Deseret Ranch used these materials to develop an employee incentive program related to poisonous plant identification and eradication. Evaluation: Feedback indicated numerous extremely valuable animals have been spared poisoning. There has been an estimated savings of $800,000 in livestock, with uncounted thousands save by equine operators who own very valuable horses.

KEYWORDS: risks to livestock, toxic plants, practical guidance

2008 Proceedings of the Caribbean Food Crops Society. 44(2):135. 2008

Effect of Omega 6-3 and 9 Fatty Acids Plus Vitamin E on Egg and Human Blood Triglycerides and Cholesterol Levels

P*ablo de la Mota, Ginecologo-Obstetra, Investigador Independiente,*
angelsuazomateo@hotmail.com

ABSTRACT.
Human deaths caused by cardiovascular problems are usually associated with high cholesterol; and triglyceride levels. A study was carried out to evaluate the cholesterol profile in laying hen eggs and human blood. Four hens were fed with normal diet or the same diet with omega 6-3 and 9 fatty acids plus vitamin E. At 12 days of receiving the treatment, the eggs were sent to the HB1 lab to investigate the cholesterol profiles in the eggs, and the cholesterol on triglycerides, HDL and LDL in the human blood of twenty people between 17 and 74 years old of both sexes consuming those eggs. The cholesterol levels of the eggs were reduced from 219.15 mgs/dl to 184.3 mgs/dl (-18.90%). In addition triglyceride and the LDL were reduced from 192.75 mgs/dl to 153.3 mgs/dl (25.73%) and from 132.0 mgs/dl to 116.00 mgs/dl, respectively. The HDL was increased from 46.45 mgs/dl to 51.1 mgs/dl (9.09%). Neither the liver morphology nor the enzyme functions changed. To our understanding, an egg from the above treatment is the only food product, which reduces cholesterol, triglycerides and LDL, and which increases HDL profiles. Therefore, the consumption of such eggs may increase human life expectancy as a result of the beneficial effects of omega fatty acids in reducing arteriosclerosis and cardiovascular diseases.

KEYWORDS: egg, omega fatty acids, cholesterol, human blood

2008 Proceedings of the Caribbean Food Crops Society. 44(2):136-143. 2008

Huevos sin Colesterol: Paracol, su Efecto en la Lipidemia

Pablo de la Mota, Ginecologo- Obstetra, Investigador Independiente. Instituto Superior de Agricultura de la República Dominicana. angelsuazomateo@hotmail.com

RESUMEN.
Motivado por la alta incidencia en gran parte de los paises del mundo, de muertes producidas por las enfermedades cardiovasculares (arteriosclerosis, infartos del miocardio, derrame cerebral, Alzheimer y otros), producto de la alimentación con un alto contenido de colesterol y grasas saturadas y buscando la forma de ayudar a la humanidad, nos decidimos a realizar un trabajo científico en lo que respecta a las gallinas ponedoras de huevos y los alimentos especiales que estas ingieren a los fines de lograr una fórmula en base a los ácidos grasos omegas. Obteniendo óptimos resultados de nuestra investigación, lo que coadyuvará a una sana alimentacion y aumento de la calidad de vida de la población. Un huevo contiene según autores 213, 275 y 500 mg/dl de colesterol, escogiéndose 275 mg/dl de colesterol como la cantidad promedio. Preparamos una alimentación especial basándose en ácidos grasos omegas 6-3-9 y vitamina E agregándose a la alimentación de gallinas ponedoras. Obtuvimos un huevo que contiene 0.58 mg/dl de colesterol representando un 0.073% del mismo. Luego escogimos al azar 20 personas, con edades comprendidas entre 17 a 74 años de edad, incluyendo una mujer embarazada con 17 semanas de gestacion, les hicimos un perfil lipídico (colesterol, trigliceridos, HDL y LDL) antes y después de la ingesta de huevos. Un grupo ingirió 1 huevo diario por 10 dias, otro grupo 2 huevos diarios, una sola persona ingirio 3 huevos diarios por 10 dias. Con el objetivo de demostrar el efecto de estos huevos sobre la lipidemia, encontrando una notable disminución en los maracadores lipídicos antes mencionados, siendo la acción de las cuatro sustancias más efectiva sobre los triglicéridos, lo que concuerda con todas las investigaciones realizadas hasta el momento. Obteniendo una disminución de 95% de colesterol y triglicéridos, 90% de LDL y aumento de 75% de HDL. El porcentaje mínimo y máximo de reducción de los marcadores del perfil lipídico fue: Colesterol de 4.1% a 65.3%, triglicéeridos de 3.6% a 89.4%, HDL de 0.0% a 25.0% y el LDL de 0.0% a 60.4%. Estos datos y otros más se lograron ingiriendo las 20 personas en 9.9 días, 14.5 huevos.

PALABRAS CLAVES: enfermedades cardiovasculares, Lipidemia, colesterol, triglicéridos, LDL y HDL.

INTRODUCCIÓN

Clasificación de los Lípidos

- La grasa neutra también conocida como triglicedos.
- Los Fosfolípidos.
- El Colesterol.
- Otros de menor importancia.

MATERIALES Y MÉTODOS

Triglicéridos

- Se usan en el organismo para proporcionar energía en los procesos metabólicos.
- Pequeñas cantidades de Triglicedos junto con el colesterol y Fosfolípidos, son utilizados en el organismo para formar la membrana de las células, y para realizar otras funciones celulares.
- Los ácidos grasos de cadena larga están unidas a una molécula de glicerol. Los mas frecuentes son.
- Acido Esteárico con cadena de 18 carbonos, completamente saturada con átomos de hidrogeno.
- Acido Oleico, con 18 cadenas de carbono, con doble enlace en la mitad de este.
- Acido Palmitico, con 16 átomos de carbono y está completamente saturado.
- La cantidad total de Triglicéridos en el hígado esta determinada por la intensidad global con que se están utilizando los lípidos para obtener energía.

Fosfolípidos

- Los principales tipos de Fosfolípidos son: 1. Lecitinas, 2. Cefalinas y Esfingomielinas.
- Los Fosfolípidos siempre contienen una o más moléculas de ácidos grasos un radical de acido fosforico y una base nitrogenada. también son liposolubles y se utilizan por todo el cuerpo con diferentes propósitos estructurales.
- Se sintetizan en casi todas las células del cuerpo. El 90% se forma en el hígado, también en células epiteliales intestinales durante la absorción intestinal de lípidos.
- La intensidad de la formación de estos esta gobernada por los factores habituales que controlan la intensidad del metabolismo de las grasas, pero cuando se depositan triglicéridos en el hígado se reduce la formación de Fosfolípidos.

Tabla de alimentos de América Latina. Edición preliminar. Centro Sub-regional para América del Sur, universidad de Chile. Santiago de Chile, 1997.

- Huevo de Codorniz 844 Mgs / Dl.
- Huevo de Pata 844 Mgs / Dl.
- Huevo de Pava 933 Mgs / Dl.
- Huevo Deshidratado 1918 Mgs / Dl.
- Huevo entero crudo 548 Mgs / Dl.
- Huevo 430 Mgs / Dl.
- Yema de Huevo 1602 Mgs / Dl.
- Yema de Huevo cocida 1315 Mgs / Dl.

Ingesta diaria de colesterol

300 Mgs / Dl.

Concentración de colesterol en Huevos.

- Huevos normales 213 – 275 – 500 Mgs / Dl.
- Huevos PARACOL 0.58 Mgs / Dl.
- Otros 1.00 Mgs / Dl.

Beneficios del consumo de ácidos Omegas.

- Disminuye la muerte cardiovascular repentina.
- Alzheimer y la falta de atención se relaciona con deficiencia en el consumo de ácidos omegas.
- Mejora la Oxigenación Sanguínea.
- Ayuda a regular el nivel de los Triglicéridos.
- Protección y Flexibilidad de las Arterias.
- Reduce el envejecimiento de los tejidos.
- Ayuda a mejorar lesiones de la piel, incluyendo psoriasis.
- Tienen capacidad antiflamatoria.
- Previene los Coágulos en la sangre.
- Son útiles en enfermedades respiratorias.

Beneficios de la vitamina E.

- Es un antioxidante que preserva de la destrucción que provocan los radicales libres.
- Retrasa el envejecimiento.
- Conserva el buen estado de la célula.
- Ayuda a mantener la salud de los nervios, músculos, la circulación y el corazón.
- Estimula el organismo a defenderse contra el cáncer.
- Ejerce efectos positivos sobre el sistema reproductor.
- Aumenta la resistencia al esfuerzo y al trabajo.
- Disuelve coágulos de la sangre.
- Protege a los pulmones de la contaminación.
- Acelera curación de las heridas y quemaduras.
- Permite que las funciones del hígado y tejido muscular se realicen adecuadamente.

Efectos colaterales de las Estátinas y Fibratos.

Constipación, flatulencia, dispepsias, dolor abdominal, dolor de cabeza, nauseas, astenia, mialgias, disneas, insomnio, calambres, miositis, miopatias, parestesia, neuropatía periférica, pancreatitis, hepatitis, ictericia colestásica, anorexia, vómitos, alopecia, prurito, rash, impotencia, hiperglucemia, hipoglucemia, perdida de peso, aumento de las aminotransferasas serica.

Contenido nutricional del huevo.

- Calorías (kcal.) 75

• Proteínas	(g.)	625
• Lípidos Totales	(g.)	5.01
• Carbohidratos Totales.	(g.)	0.6
• Ácidos Grasos	(g.)	4.33
• Grasa Saturada	(g.)	1.55
• Grasa Monoinsaturada.	(g.)	1.91
• Grasa Poliinsaturada	(g.)	0.68
• Colesterol	(mgs)	213
• Vitamina B1/Tiamina	(mgs)	0.031
• Vitamina B2/Riboflavina	(mgs)	0.254
• Niacina (Acido Nicotínico)	(mgs)	0.036
• Vitamina B6 / Piridoxina	(mgs)	0.070
• Acido Folico	(mcg)	23.5
• Vitamina B12 / cianocobalamina	(mgs)	0.50
• Vitamina A	(IU)	317.5
• Vitamina E	(mgs)	0.70
• Vitamina D	(IU)	245
• Colina	(mgs)	215.1
• Biotina	(mcg)	9.98
• Calcio	(mgs)	25
• Hierro	(mgs)	0.72
• Magnesio	(mgs)	5.0
• Cobre	(mgs)	0.007
• Yodo	(mgs)	0.024
• Zinc	(mgs)	0.55
• Sodio	(mgs)	63
• Manganesio	(mgs)	0.12

Niveles de colesterol en las gallinas, antes y después del consumo de ácidos omegas.

171 mgs / dl.
100 mgs / dl.

Objetivo del trabajo.
Verificar si los huevos producidos por una gallina alimentada con ácidos grasos omegas, Vitamina E, tienen el mismo efecto sobre el perfil lipídico que un huevo normal.

Huevos sin colesterol, PARACOL, su efecto en la lipidemia.

Nombre	Edad	S	Perfil Lipidico Antes mgs/dl.	Perfil Lipidico Después mgs/dl.	HTA	TGO	TGP	Cantidad de huevos	% ALBO	ALBS	Fibrinogeno	TP	TPT	TC	TS
PM	56	M	C320 T452	C224 T272	SI	7	6	3X10	42.8/66						
			40 / 198	48/150					16.6/32						
CEM	28	F	C204 T180	C193 T95		8	10	2X10	5.6/89.4						
			67/118	72/90					6.9/31.1						
MV	29	F	C229 T200	C213 T125		9	7	2X10	7.5/60						
			63/125	70/120					10/4.1						
MDE	38	F	C221 T200	C209 T140		6	8	2X10	5.7/42.8						
			38/143	48/137					20.8/4.3						
NM	39	F	C240 T292	C200 T205		6	6	2X 10	20/42.4						
			39/143	47/138					17/3.6						
AM	38	F	C300 T208	C248 T146		7	9	1X10	20.9/42.4						
			39/140	49/134					20.4/4.4						
JM	58	F	C276 T257	C257 T185		10	6	1X10	7.3/38.9						
			42/143	50/135					16/5.9						
MD	49	F	C205 T200	C190 T192		7	8	8-10	7.8/4.1						
			40/139	48/130					16.6/6.9						
PM	33	F	C210 T127	C127 T122		8	6	2-8	65.3/4.0						
			38/144	45/135					15.5/6.6						

Relación de edad en personas del estudio.

Edades	**Personas**
10-20	2
20-30	2
30-40	5
40-50	2
50-60	5
60-70	3
70-80	1

Porcentaje de sexo.

- Hombres 40%
- Mujeres 60%

Relación de porcentaje de ingesta de huevos. Cantidad y Días.

Cantidad	**Días**	**Personas**	**%**
3	10	1	5
2	10	8	40
1	10	9	45
8	10	1	5
2	8	1	5

Porcentaje de reducción de niveles de lípidos en 20 personas que consumieron huevos PARACOL.

Marcadores	Personas	%		
Colesterol	19	95		
Triglicéridos	19	95		
HDL	15	75	15%	10%
LDL	18	90	5%	5%

Promedio de perfil lipidico antes y después, y promedio de días y de huevos PARACOL.

Marcadores	Antes	Después	Días	Huevos	%
Colesterol	219.15 mgs/dl.	184.3 mgs/dl.			18.90
Triglicéridos	192.75 mgs/dl.	153.3 mgs/dl.			25.73
HDL	46.45 mgs/dl.	51.1 mgs/dl.			9.09
LDL	132.00 mgs/dl.	116.0 mgs/dl.			13.79
			9.9	14.5	

Porcentaje de reducción de los marcadores.

Marcadores	Mínimo	Máximo
Colesterol	4.1%	65.3%
Triglicéridos	3.6%	89.4%
HDL	0.0%	25.0%
LDL	0.0%	60.4%

Indicadores de los Marcadores	Promedio	Desviación Típica	Coeficiente de Variación Marcadores
Colesterol antes	219.15	51.6	23.5%
Colesterol después	184.30	40.7	22.1%
Triglicéridos antes	191.75	93.9	49.0%
Triglicéridos después	153.30	70.0	45.7%
HDL antes	46.45	9.0	19.4%
HDL después	51.25	8.2	16.0%
LDL antes	132.00	43.0	32.6%
LDL después	116.00	29.0	25.0%

RESULTADOS Y DISCUSIÓN

Suministrándole a la gallina ácidos grasos omegas logramos que en vez de aumentar el colesterol o de mantenerse igual se observo que las personas incluidas en el estudio presentaron una disminución marcada de los marcadores en la investigación que conforman lo que se conoce como perfil lipídico.

- Con un promedio de colesterol de 219.15 mgs/dl. Ingiriendo 14.5 huevos en 9.9 días se logro una reducción del colesterol serico a 184.3 lo que representa un 19%.
- Con un promedio de triglicéridos de 192.75 mgs/Dl. ingiriendo 14.5 huevos en 9.9 días se obtuvo una reducción a 153, que significa un 26%.
- Un efecto beneficioso se observa en el HDL al comenzar con un promedio de 46.45 elevándose de manera favorable a 51.1 para una cantidad porcentual de 10.
- En lo que respecta al LDL de un promedio al inicio de 132 y luego de ingerir los

huevos bajo a un promedio de 116 que representa un 14%.

- A 40% de la población investigada, le practicamos un perfil de coagulación con indicadores superficiales y profundos para determinar su acción en la osmolaridad sanguínea y no se encontró ningún tipo de reacción de importancia.
- Luego de la ingesta de los huevos PARACOl, no se encontró alteraciones de enzimas hepáticas.

CONCLUSIONES.

Nuestra investigación presentó resultados similares a lo establecido en otras investigaciones sobre los ácidos grasos omegas, sobre el colesterol y triglicéridos, siendo mas eficaz en este ultimo.

Paracol

- Contraindicaciones
- Efectos colaterales
- Recomendaciones.

Frase Celebre.

El mejor placer en la vida es hacer lo que la gente te dice que no puedes hacer.

Walter Bagehot.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):144-154. 2008

Evaluating Hass Avocado Maturity Using Hyperspectral Imaging.

D. Girod[1], J.A. Landry[1], G. Doyon[2], J.A. Osuna-Garcìa[3], S. Salazar-García[3] and R. Goenaga[4] [1]Department of Automated Production Engineering, École de technologie supérieure, Université du Québec, Montréal, Canada. [2]Food Research and Development Centre, Agriculture and Agri-Food Canada, Saint-Hyacinthe, Canada. [3]INIFAP-Santiago Ixcuintla Experimental Station, Nayarit, Mexico. [4]USDA-ARS, Tropical Agriculture Research Station, Mayagüez, Puerto Rico.

ABSTRACT.

The maturity of avocado fruit is usually assessed by measuring its dry matter content (DM), which is a destructive and time consuming process. The aim of this study is to introduce a non-destructive and quick technique that can estimate the DM content of an avocado fruit. 'Hass' avocado fruits at different maturity stages and varying skin color were analyzed by hyperspectral imaging in reflectance and absorbance modes. The DM ranged from 19.8% to 42.5%. The hyperspectral data consist of mean spectra of avocados in the VIS/NIR region, from 400nm to 1000nm, for a total of 163 different spectral bands. Relationship between spectral wavelengths and DM content were carried out using a chemometric partial least squares (PLS) regression technique. Calibration and validation statistics, such as correlation coefficient (R^2) and prediction error (RMSEP) were used as means of comparing the predictive accuracies of the different models. The results of PLS modeling, over several different randomizations of the database, with full cross validation methods using the entire spectral range, resulted in a mean R^2 of 0.86 with a mean RMSEP of 2.45 in reflectance mode, and a mean R^2 of 0.94 with a mean RMSEP of 1.59 for the absorbance mode. This indicates that reasonably accurate models (R^2>0.8) could be obtained for DM content with the entire spectral range. Also this study shows that wavelengths reduction can be applied to the problem. Starting with 163 spectral bands, the DM could be predicted with identical performances using 10% of the initial wavelengths (16 spectral bands). Thus the study demonstrates the feasibility of using VIS/NIR hyperspectral imaging in absorbance mode in order to determine a physicochemical property, namely DM, of 'Hass' avocados in a non-destructive way. Furthermore it gives some clues about which spectral bands could be useful for that purpose.

KEYWORDS: Non-destructive, dry matter, avocado, spectroscopy, imagery

INTRODUCTION

Avocado's (*Persea* Americana Mill.) maturity is indicated by it's oil content and is commercially measured using dry matter (DM) analysis, both of which were shown to be highly correlated (Charles, 1978; Lee et al., 1983). The measurement of both is long and destructive for the fruit. Finding a non-destructive mean of evaluating the maturity of an avocado could prove useful in a production context. Rapid, accurate and easy measurements in the field to monitor produce maturity, allowing for timely harvest would be very valuable, both to the producer (economics) and to the consumer (quality).

The field of spectroscopy is an emerging technology in the agro-food industry and is seeing new applications in the assessment of produce quality and safety. The use of spectrometry may provide fast and reliable methods to this industry and more research is definitely in order.

MATERIAL AND METHODS

Fruits

A total of 21 avocados of the Hass variety were bought from a local market. It is known that there is a DM gradient repartition within the fruit (Woolf et al., 2003). In consequence, dry matter content of fruit was determined by taking thin flesh slices lengthwise, over the 4 cardinal points with respect to the peduncle of the fruit. The slices were peeled and stoned to form 10±1g samples. Dry matter was determined by weight loss following 5 hours drying in a laboratory oven at 105°C.

Hyperspectral imagery

Visible/Near Infrared (VIS/NIR) spectra of intact avocados were collected over the 400nm-1000nm range of the electromagnetic spectrum, with a 2.5nm resolution in reflectance mode, resulting in 163 spectral bands. The hyperspectral imaging system consists of a 12 bits CCD camera (Imperx IPX-2M30), a V10E spectrograph (Specim, FI), a Schneider Kreuznah 23mm achromatic lens, and four (4) 300W Tungsten halogen spots (Ambico V-100). Each reflectance spectrum was then calibrated using dark and white references in order to convert it to reflectance values. The dark reference was obtained by covering the lens with a cap, in order to prevent light from reaching the sensor. The white reference, measured for every 6 fruits, was a Spectralon tile, widely used in spectroscopy (Springsteen, 1999) . Data acquisition and storage was achieved with a PC running in-house software (SpectralCube v2.72, Autovision, USA).

Measurements

In order to match the spectral data to the DM content measured, 4 regions of interest upon the fruit were identified, corresponding to the 4 regions where the DM content was measured. For each region, the corresponding spectrum was obtained by averaging the spectra of this region. Each spectrum is then composed of 163 reflectance values.

Statistical dry matter content analysis

Statistical analysis of the DM database was performed in order to analyze the adequacy of the sampling (number of intra-fruits measures: 4), and repetition rates (number of inter-fruits measures: 21). It is important to select an acceptable variability for a given error level (α), which leads to a sample size and or a number of repetitions suitable for the experiment. Calculating the coefficient of variation (Equation 1), with σ the standard deviation, and $\overline{x}$ the mean, and evaluating what coefficient of variation is desirable, the target (wished) standard deviation can be computed (Equation 2). Knowing the actual (obtained) and the desired (wished) standard deviations for given sampling and repetition rates, the desired (wished) sample size and number of repetitions can therefore

be calculated (Equation 3) where t is the student distribution and α the error level (typically 0.05 corresponding to 95% confidence).

$$CV_{obtained} = \frac{\sigma_{obtained}}{\overline{x}_{obtained}} \times 100 \ (\%) \qquad \text{(Equation 1)}$$

$$\sigma_{wish} = \frac{\overline{x}_{obtained} \times CV_{wish}}{100} \qquad \text{(Equation 2)}$$

$$N = \left(t_{\frac{\alpha}{2}, N_{obtained}-1} \times \frac{\sigma_{obtained}}{\sigma_{wish}} \right)^2 \qquad \text{(Equation 3)}$$

Modeling the relation between NIR data and dry matter

Analysis of the NIR and DM data involved 50 separate modeling/test exercises. Each exercise required a different random split of the database into 2 subsets: a calibration/modeling set (*n=55* fruits), and a validation/test set (*n=29* fruits). The minimum error of cross validation (RMSECV, 5 subsets) was used to choose the number of latent variables in the model, up to a maximum of 40. Once the modeling completed, the calibration model was applied to the test subset, and regression analysis between predictions and known physical measurements was used to judge the predictive abilities of the model. The statistics used were the correlation coefficient R^2, (Equation 4), and the root mean square error (Equation 5) over the calibration set (RMSEP) and validation set RMSEP. In these equations $\hat{y}_i$ is the predicted value by the model and $\overline{\mathbf{y}}$ is the mean value of the actual measurements. Performing 50 different exercises of modeling/testing allowed us to gauge the stability of the models against measurements variations.

$$R^2 = 1 - \frac{\sum_{i=1}^{N} (y_i - \hat{y}_i)^2}{\sum_{i=1}^{N} (y_i - \overline{\mathbf{y}})^2} \qquad \text{(Equation 4)}$$

$$RMSE = \frac{1}{N} \sqrt{\sum_{i=1}^{N} (\hat{y}_i - y_i)^2} \qquad \text{(Equation 5)}$$

The principal modeling tool was the Partial Least Squares regression (Matlab R2007b, Mathworks, USA) with the PLS toolbox (v4.1.1, Eigenvector Research, USA). The DM content is modeled as a linear combination of spectral reflectance/absorbance (Equation 7) values weighted by the regression vector coefficients β (Equation 6). Apart from absorbance transformation, no other spectral pretreatments were applied.

$$\%DM = \sum_{i=1}^{163} \beta_i \lambda_i + e \qquad \text{(Equation 6)}$$

$$Absorbance = \log\left(\frac{1}{Reflectance}\right) \qquad \text{(Equation 7)}$$

Band reduction

Variable selection is an important step in the prediction process. In situation where the number of wavelengths (variables) is large, the reduction of this number by using the ones that carry most information may give a safer and easier model to interpret, with fewer factors and better performances. Thus wavelengths not useful to the model are put aside, leaving only the ones that are important. The difficulty then resides in the selection of a relevant variable subset of a reasonable size. The evaluation of all possible models ($2^{163}-1$) being impossible, it is necessary to use a method for the selection of relevant variables.

We selected the PLS approach (Lima, Mello and Poppi, 2005). The pruning approach intends to promote an ordered and selective PLS regression coefficient (variable) elimination based on a specific criterion, trying to reach an improvement in the prediction capability of the model. PLS pruning is an iterative technique of variable elimination. Starting from the total set of variables (163), the aim of the method is the deletion of unimportant PLS spectral bands by minimizing the error variation (saliency calculation) following the deletion of a particular variable. It can be summarized as follows:

(1) Start from a PLS model with the total set of variables (*m=163*)

(2) Eliminate just one variable according to the saliency calculation that estimate the error variation following the exclusion of this band.

(3) Compute a new PLS model with the *m-1* remaining variables.

(4) Execute steps (2) and (3) until there is one variable remaining.

Using this procedure it is possible to collect a set of *m* models, the first one with *m* variables, the second one with *m-1* variables… until the last one with 1 variable. For each model there is an associated error value (RMSECV), the best model is the one that will offer the minimum error with the minimum variables at the same time.

RESULTS

Dry matter measures

DM content values are within 19.8% and 42.5%, with a lack of data around 30% (Figure 1). The coefficient of variation for the sampling number is 2.55%, and 23.36% for the repetitions. A value of 5% is acceptable for the sampling corresponding to a sampling wished equal to 4. But for the repetition a value of 10%, even 5%, would be

acceptable; corresponding to a number of repetitions of 24 fruits (10%), and 95 fruits (5%), instead of 21 fruits.

Prediction of dry matter using all spectral bands

Calibration and validation statistics for the DM prediction are listed in Table 1. These are the means over the 50 random subsets of the entire database. The absorbance mode results in better predictive performances with R^2=0.94 and RMSEP=1.65, whereas in reflectance mode we obtained R^2=0.86 and RMSEP=2.41. Typical spectra in absorbance and reflectance modes can be observed on Figure 2.

Figure 1 . Dry matter content sorted by avocado, with 95% confidence intervals

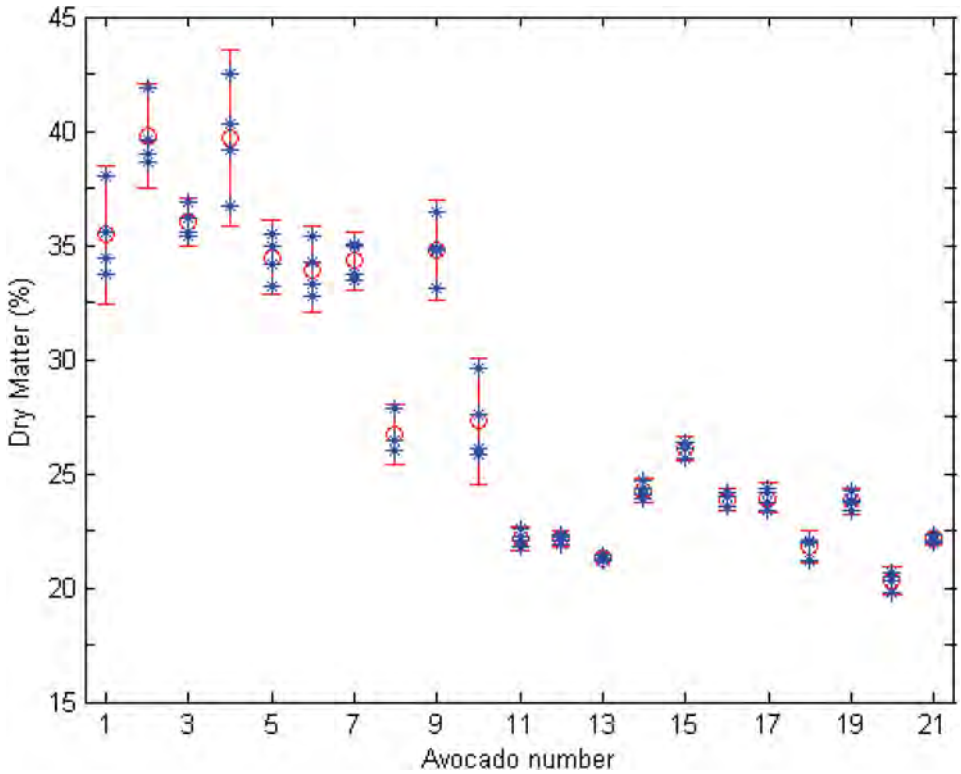


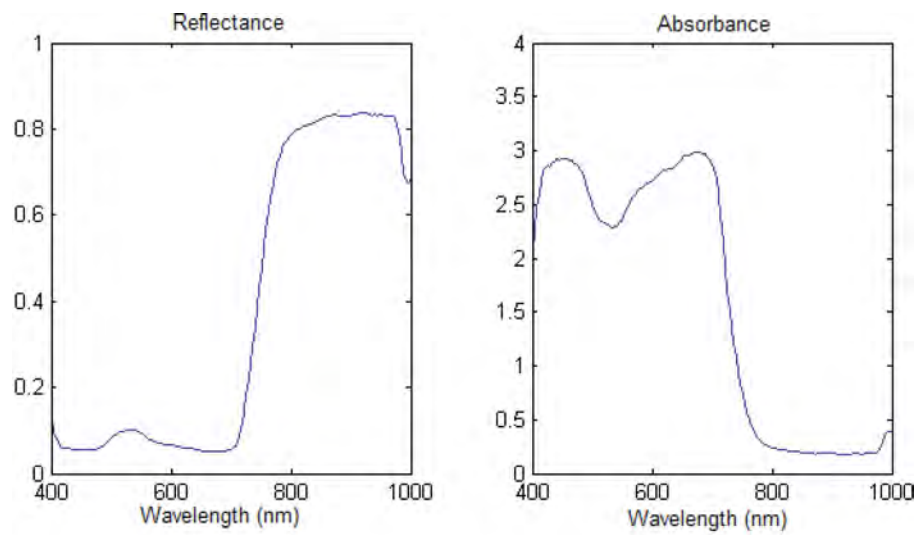
Table 1 . Calibration and validation statistics

	LV	RMSEC	RMSEP	R^2
Reflectance	17	1.10	2.41	0.86
Absorbance	13	0.80	1.65	0.94

The shape of these curves can be explained by the response of the pigments present in the fruit skin. The main pigments responsible for the color of vegetables (skin and flesh) are the chlorophyll (α and β), the anthocyanin and the carotenoid. In the avocado skin, we

find mainly both chlorophylls and carotenoïds (lutein and β-carotene) which absorption spectra can be observed on Figure 3 (Ashton et al., 2006). To analyze the differences obtained in the performances between reflectance mode and absorbance mode, the DM data was divided in 4 groups based upon their DM content. The fist group has DM contents inferior to 25%, the second group has DM contents comprised between 25% and 31%, the third one has DM contents between 31% and 37.5%, and the last group has DM content superior to 37.5% (Figure 4). The appearance of mean spectra is conforming to the absorption spectra of the pigments (Figure 5). Poor reflectance around the two absorption peaks at 450nm and 650nm, and after near 700nm at the so-called 'red edge', leading to a plateau of high reflectance in the near-infrared, where pigments no longer absorb radiation (Blackburn, 2007). Comparison of the mean spectra given by those 4 groups shows that the differences between the spectra in the 400-700nm is more important in absorbance mode than in reflectance mode.

Figure 2 . Typical absorption and reflection spectra from avocado



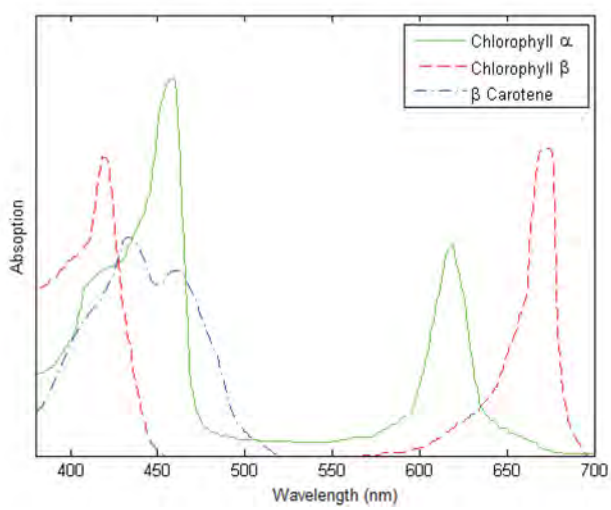


Figure 3 . Absorption

spectra of pigments in avocado skin, adapted from (Ashton et al., 2006)

Band reduction

The PLS pruning method was applied to the 50 random subsets of the database leading to 50 band selection subsets. Therefore, one can compute the number of times each band had been chosen (Figure 6). The 16 bands that obtained the largest number of votes are listed in

Table 2. 14 of these bands are in the visible range (400nm-700nm), which seems to confirm the pigment analysis. With those 16 bands, the most interesting combination can be determined by computing the performances given by all possible combination of those 16 bands (Table 3).

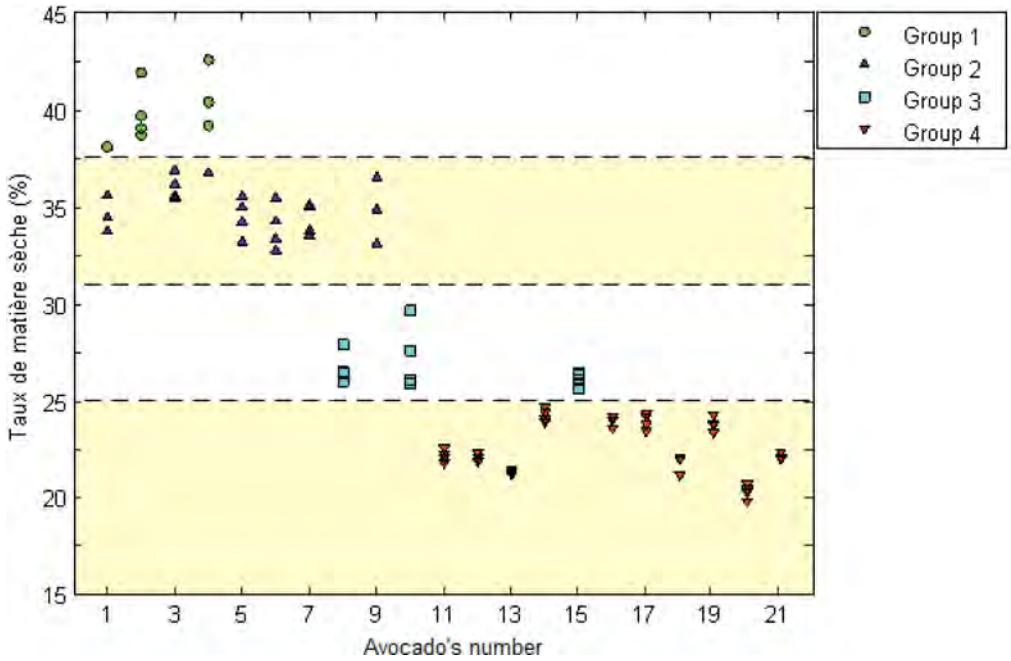


Figure 4 . DM content groups

Band reduction is possible and can even offer better performance than while using all bands. Modeling with 16 bands (10% of the initials set) resulted in R^2=0.96 and RMSEP=1.35. Using as few as 8 bands (5% of the initials set) the performances are equal to that of using the full number of bands (R^2=0.94, RMSEP=1.60). Finally, with only 5 bands (3% of the initials set) performances are still very acceptable (R^2=0.90, RMSEP=2.04). The retained bands can be observed on Figure 7.

DISCUSSION

Using hyperspectral imagery to evaluate the maturity of fresh avocado is possible. There is a strong correlation between the dry matter content of Hass avocado, and its skin color (as perceive by spectroscopy). As there is still uncertainties concerning the origin, transport and storage of the fruits between their harvest and the measurements in the laboratory, as well as a lack of DM samples around 30%, conclusion of this study cannot be definitive, but can lead to effective recommendations for future work.

Figure 5 . Mean spectra of each of the 4 avocado groups

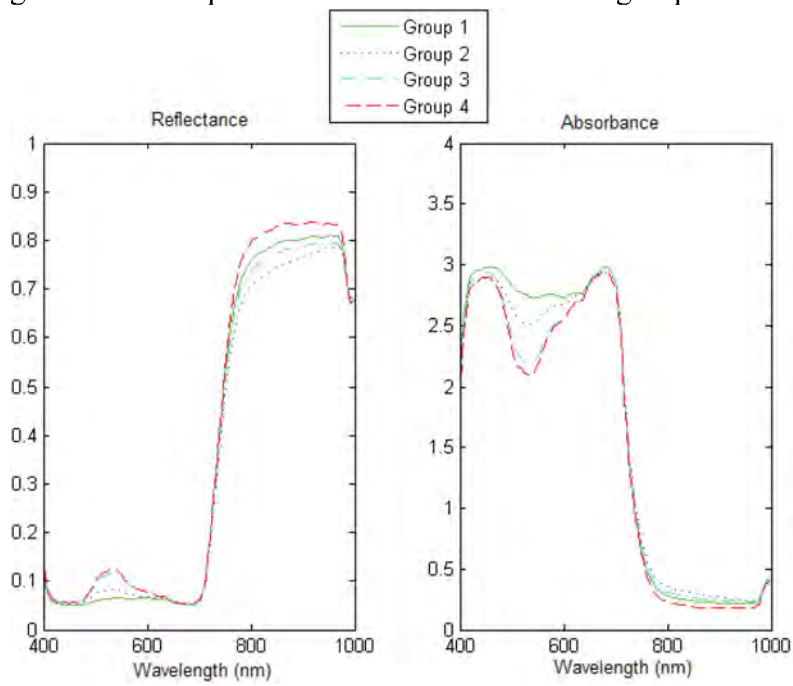


Figure 6 . Pruning votes

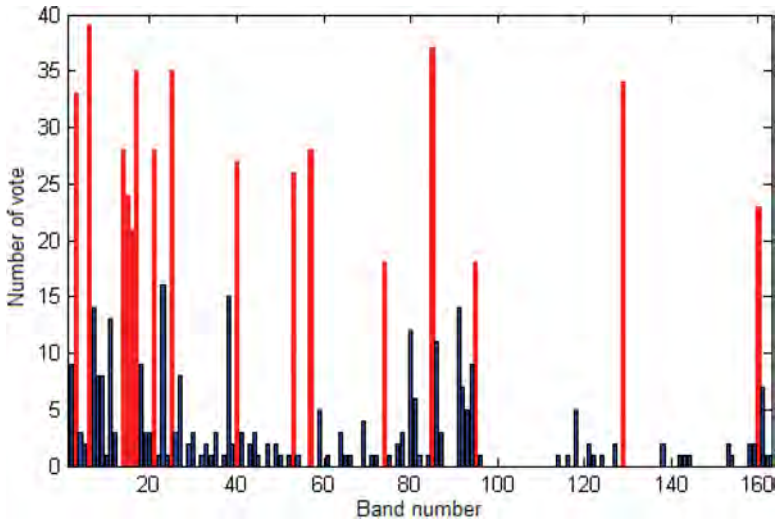


Table 2 . Selected bands and their wavelengths

Selected bands	3	6	14	15	16	17	21	25
Wavelength (nm)	425.58	458.97	486.35	489.27	492.19	495.110	506.88	510.69
Selected bands	40	53	57	74	85	95	129	160
Wavelength (nm)	563.08	601.40	613.16	663.09	695.41	724.83	825.74	959.81

Table 3 . Mean performance of band combinations

Number of bands	RMSEP	R^2	Wavelength of selected bands
5	2.04	0.90	40 57 85 95 129
8	1.60	0.94	16 21 25 40 57 85 95 129
16	1.35	0.96	3 6 14 15 16 17 21 25 40 53 57 85 95 129 160

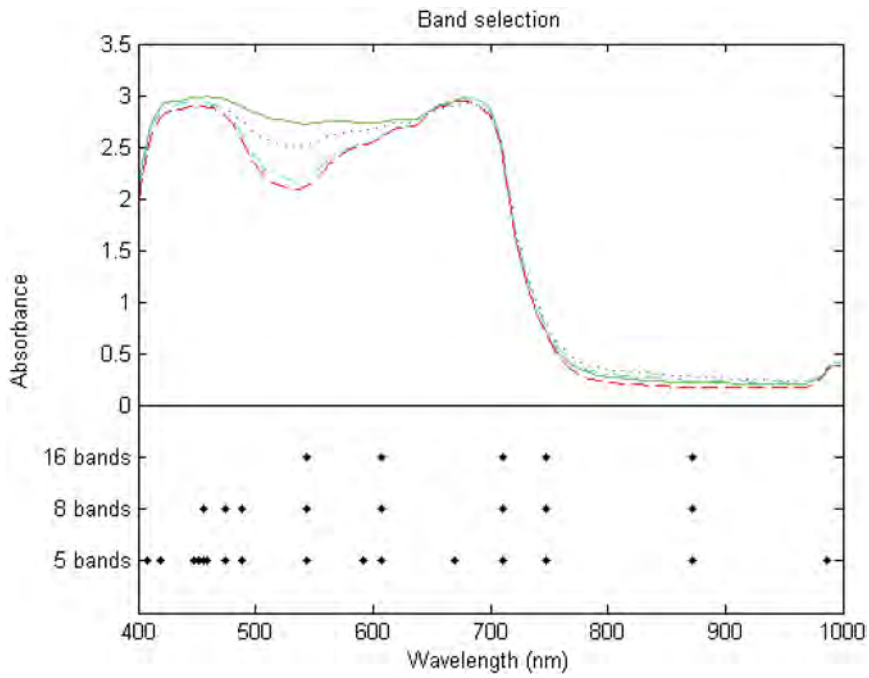


Figure 7 . Band selection

It is necessary to have maximum variability along with an adequate DM content repartition over the dataset. To accomplish that, one need to have a reliable avocado

source to satisfy the same condition for storage and transport between harvest and analysis. On site study would be preferable. A study with 24 fruits can lead to a variability coefficient of 10%, if the goal is 5%, 95 fruits are needed. Measuring DM content of each avocado over the 4 cardinal points with respect to the peduncle of the fruit, combined to the acquisition of 4 spectra of the same areas will ensure that the DM content variability is respected.

Following those recommendations, a full study can be carried on, leading to more conclusive results.

REFERENCES

Ashton, O. B. O., M. Wong, T. K. McGhie, R. Vather, Y. Wang, C. Requejo-Jackman, P. Ramankutty et A. B. Woolf. 2006. « Pigments in Avocado Tissue and Oil ». *J. Agric. Food Chem.,* vol. 54, n° 26, p. 10151-10158.

Blackburn, George Alan. 2007. « Hyperspectral remote sensing of plant pigments ». *Journal of Experimental Botany,* vol. 58, p. 855-867.

Charles, E. Lewis. 1978. « The maturity of avocados - a general review ». *Journal of the Science of Food and Agriculture,* vol. 29, n° 10, p. 857-866.

Lee, S. K. , R. E. Young, P. M. Schiffman et C. W. Coggins. 1983. « Maturity Studies of Avocado Fruit Based on Picking Dates and Dry Weight ». *Journal of the American Society for Horticultural Science,* vol. 108, n° 3, p. 390-393.

Lima, Silvio L. T., Cesar Mello et Ronei J. Poppi. 2005. « PLS pruning: a new approach to variable selection for multivariate calibration based on Hessian matrix of errors ». *Chemometrics and Intelligent Laboratory Systems,* vol. 76, n° 1, p. 73-78.

Springsteen, Art. 1999. « Standards for the measurement of diffuse reflectance - an overview of available materials and measurement laboratories ». *Analytica Chimica Acta,* vol. 380, n° 2-3, p. 379-390.

Woolf, Allan, Chris Clark, Emma Terander, Vong Phetsomphou, Reuben Hofshi, Mary Lu Arpaia, Donella Boreham, Marie Wong et Anne Whit. 2003. « Measuring avocado maturity; ongoing developments ». *The Orchadist*, p. 40-45.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):155. 2008

An Integrated Approach to Increasing Food Safety Awareness at the Farm Level among Small and Limited Resource Goat Producers in Florida

A. McKenzie-Jakes[1], R. Mobley[1], DVM, T.E. Peterson[1], DVM, P. Hunter[2], DVM, G. Nurse[1], J. Beaudouin[1], G. Bryant[1], G. Queeley[1], S. Thompson[1], N. Tillman[3], and L. Anderson[1]. [1]Florida A&M University, Research and Cooperative Extension Program, 2Florida Department of Agriculture (DOACS) and [3]Southeastern Small Farmer's Network. angusboer34@hotmail.com

ABSTRACT.
Many researchers today agree that most food borne illnesses start on the farm. The Center for Disease Control and Prevention (2007) estimated that 76 million food borne illnesses occur each year in the United States. In 2007, the Master Goat Producers Program was initiated through Florida A&M University's Research and Cooperative Extension program to address increasing incidents of food borne illness and herd health issues linked to goat production. The goal of this program was to educate producers about the real threat of food borne illnesses. Furthermore the program was established to ensure that producers took strides in protecting their animals and consumers from microbial ford borne contaminations and other infectious diseases. In view of this a 5 day comprehensive training program was developed for small and limited resource goat producers followed by on-farm inspections. The program emphasized training on food safety and associated heard health problems with small ruminants. A survey conducted revealed that prior to attending the program most of the participants were unfamiliar with HACCP (77.78%), biosecurity (66.67%), quality assurance (68.00%) and bioterrorism (57.69%). These results may explain why only 3% of the participants passed the pre-examination. Contrastingly, 89% of the producers passed the post-examination with a score of 70% or greater. From the pool of producers that applied for certification status, 64.3% passed their initial farm inspection and adopted 5 or more sustainable goat production practices on their farm. These results provide convincing evidence that extension programs of this nature are highly warranted.

KEYWORDS: food borne illness, food safety, Master Goat Program

2008 Proceedings of the Caribbean Food Crops Society. 44(2):156. 2008

Innovative Strategies for Strengthening the Agricultural Sector of Puerto Rico

Javier Rivera-Aquino[1] and Wilfredo Colón-Guasp[2], [1]President Agricultural Commission, House of Representatives, Commonwealth of Puerto Rico, [2]Professor and Dean, School of Science and Technology, Universidad del Este, Carolina, Puerto Rico, ue_wcolon@suagm.edu

ABSTRACT.
During the past decade the agricultural sector of Puerto Rico has experienced a decrease in the amount of land under production, number of farmers, number of farms, and contribution of this economic activity to the gross domestic product. The major challenges to this sector are competition of land resources for urban use, increase in land value, increase in production costs, and lack of farm laborers. To further augment this situation, the budget earmarked for the Department of Agriculture has been reduced significantly. The increased consumption of agricultural commodities by emerging markets, increase in the prices of feeds due to the expansion of ethanol production, and increased gas prices are also altering the prices of agricultural commodities. These global factors are making policymakers aware of the huge potential that lies in strengthening the agricultural sector. In order to strengthen the agricultural sector various strategies need to be implemented. These are: to secure the availability of agricultural lands; to secure the availability of water resources; to recognize the right to farm; to provide adequate capital investment; to restructure the Department of Agriculture; to implement a holistic economic development strategy for the rural areas; to develop an agribusiness mentality; to guide the agricultural sector towards increasing its share of institutional markets; and to make sure the resources assigned to the sector are properly accounted for. We will discuss the specific strategies needed to strengthen the agricultural sector of Puerto Rico in light of the local and global threats and opportunities.

KEYWORDS: competition for land resources; holistic economic development strategy

2008 Proceedings of the Caribbean Food Crops Society. 44(2):157-165. 2008

Finding an Agricultural Development Model for St. Thomas, USVI – Adapting an Extension Approach to a Small, Densely Populated, Caribbean Island

Richard W.H. Pluke, Fintrac Inc., St Thomas, US Virgin Islands
richard@fintrac.com; (340) 776 7601

ABSTRACT.

St. Thomas, the busiest island of the US Virgin Islands, is small (81km^2) but has a population of 53,000 people (population density: 654.3 people/km^2) that does not include the 1.5 million annual tourists. While steep slopes make for attractive seascape views, it means that there is little suitable land for agriculture. Land zoned for agriculture is under constant threat of re-classification to make room for more lucrative residential/tourist/commercial developments. Agricultural inputs are scarce and costly. Water resources are limited and unreliable. Agricultural productivity is low and even though markets are strong and prices high, very few people can commit to full-time farming. Establishing a productive agricultural base that can economically support producers and justify continued government support may require the institutional support of non-traditional producers. These producers include small-scale, home gardeners. The fact that they outnumber full-time farmers reflects the urban characteristics of the island and helps understand the particular farming system found on St Thomas. Extension efforts that rely on full-time farmers as vehicles of change do not acknowledge the limitations of the St. Thomas farming system. Adapting to a different client type may be the best way of spending extension dollars. Broad, educational initiatives, community programs and an appropriate scaling of technological packages will feed into the general interest on the island for food security, lowered grocery bills and better food quality. Fundamental to these extension efforts is to make non-traditional producers believe that they can be active participants in the island's food economy.

KEYWORDS: Extension; St. Thomas, US Virgin Islands; urban agriculture

INTRODUCTION

All agricultural extension models are designed to create the highest level of productivity for the region and the farmers being served by the extension service. In most countries, the agricultural sector is well established and the extension service has evolved with agricultural development. The effectiveness of an extension approach will depend on its compatibility and familiarity with the farming sector. It must be noted that within a country or region's farming sector, there are a number of farming systems. The Food and Agricultural Organization (Dixon et al., 2001) classifies farming systems based on a number of key factors that include:

1. the available natural resource base;
2. the dominant pattern of farm activities and household livelihoods, including relationship to markets; and
3. the intensity of production activities.

It is important to recognize that there will be different extension programs that serve different farming systems. An extension package designed for a large, commercial farm growing only maize will be different than an extension package for a small, mixed-activity, family farm.

In 2005, Fintrac Inc. moved its headquarters to St. Thomas, US Virgin Islands. This international agribusiness development company began a small extension program alongside the territorial Department of Agriculture and the University of the Virgin Islands. The company has successfully used an extension model on its projects whereby a group of lead clients are selected to be agents of change within their community. The main focus is to position the farmer's production activities within a market-led value chain to get the most benefit out of market opportunities (Figure 1). This requires the orientation of the farm as a business and the development of excellent production capabilities to guarantee the timely delivery of produce to the market at the quantity and quality required. There is also a multiplier effect due to a network of beneficiary clients that observe and participate in the development of the lead clients' agricultural activities.

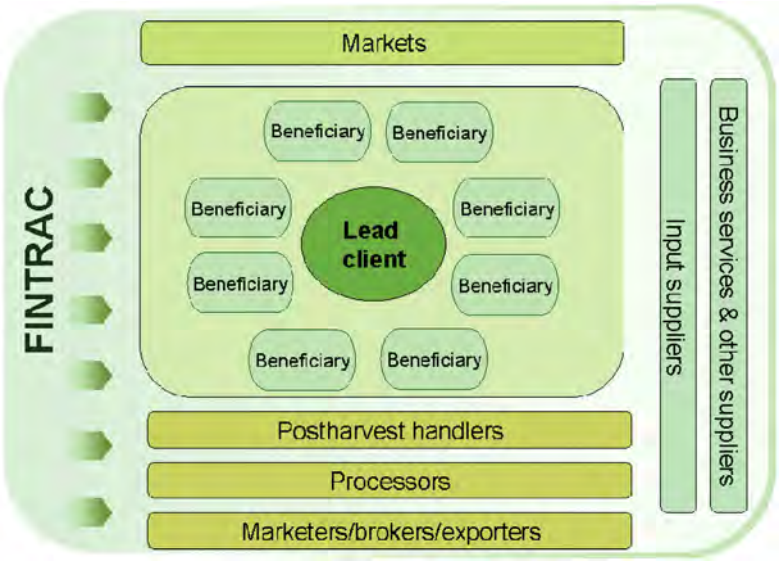


Figure 1. A market-led, value chain extension model

ANALYSIS

Market opportunities on St Thomas, USVI

This extension approach was brought to St Thomas in 2006 in the full knowledge that market opportunities on this island were very strong. While St Thomas is small at 83 km^2, it has a population of 53,000 and many more tourists. In 2007, there were 561,300 air visitors and 1,917,400 cruise ship passengers. (USVI Bureau of Economic Research, 2008). The economy of the US Virgin Islands is relatively strong, in part due to its ties with the United States of America. In terms of its gross domestic product (GDP) per capita, the US Virgin Islands is ranked fifth, behind the USA, the Bahamas, Puerto Rico and Trinidad & Tobago. Residents on St Thomas are able to buy a wide range of food products although high food prices do have an impact on food choices.

These high food prices do however strengthen market opportunities for island farmers. Early in 2008, a 63-item food basket survey was done comparing St Thomas supermarkets and supermarkets in Washington DC, USA. It was found that the price of the shopping basket came out at 50% higher in St Thomas than in Washington DC. Table 1 gives some of the price differences.

These food prices will continue to rise with the rising cost of fuel as the US Virgin Islands imports most of its food. This puts local farmers in a stronger position to compete against imports and to obtain higher income on sales. It is interesting to note that this study also found that tomatoes were cheaper in St Thomas. This attests to another market opportunity for local farmers. Wholesalers purchase relatively low quality produce to balance the high import costs. This creates a large quality differential between local and imported produce. This creates further leverage that local producers can use to improve their position in the market.

Table 1: Some selected price differences in the 2008 shopping basket survey

Product	Washington DC	St Thomas, USVI
Orange juice (half gallon)	$1.58	$5.09
Coffee (11.5 oz.)	$3.29	$5.59
Milk (half gallon)	$2.39	$ 3.47
Eggs (dozen)	$2.14	$2.27
Flour (5 lbs)	$2.79	$3.44
Dave Barber (retired head of the V.I. Labor Department's Bureau of Labor Statistics)		

The farming sector on St Thomas

Using the latest agricultural census data from 2002 (USDA, 2005) it quickly becomes apparent that the agricultural sector in St Thomas and St John (the census data lumps the two island's data together) is very weak. In 2002, there were 52 farm operators. 40 of these operators worked more than 200 days off the farm and only 5 of them were full time farmers. There are a total of 52 farms on the 2 islands than cover 460 acres (the total land area of St Thomas and St John is 35,410 acres). Of these 460 acres, there were only 44 acres that were considered harvested cropland. The revenue created by the islands' farms is also limited. Table 2 gives the market value of produce by crop type. These low incomes are largely due to the low yields being obtained on the farms. For all reported crops, yields were less than 30% of the average yields found in the USA.

Table 2: Market value of produce by crop type

Crop type	# of farms that grow them	Total market value ($)	Average market value/ farm ($)
Vegetables	26	120,623	4,639
Fruits & nuts	23	29,155	1,268
Horticultural specialties	8	77,727	9,716

Farming system characteristics of St Thomas

Agriculture needs land and it needs labor to work the land. The shortage of both greatly limits agriculture on St Thomas. Table 3 presents the population density of countries in the region and St Thomas' 643 people per square kilometer puts the island at the top of the list. Even without the influence of a high population, St Thomas does not have much prime agricultural land. The island is dominated by steep hills rising out of the sea. The soils are shallow and water resources are minimal. Land zoned for agriculture is under constant threat of being rezoned and developed for residential or commercial purposes. Labor costs are another feature of this farming system, where hourly wages exceed $12 an hour and where most day laborers expect to receive $100 for 8 hours of work. Even if farmers were able to afford these rates, there are also problems with availability - agricultural work is considered difficult and there are other options that are considered 'easier'. There is also little direct experience of agricultural labor on the island, the unfamiliarity of which makes acceptance more difficult.

SVI Bureau of Economic Research, 2008. http://www.usviber.org/publications.htm.

Table 3: Population densities of some states in the Caribbean region

Country	Population (k)	Physical Size (km2)	Pop. Density (per km2)
USVI: St. Thomas	53	83	643
Barbados	277	431	643
Puerto Rico	3,957	9,104	435
Martinique	402	1,128	356
Grenada	106	345	308
Haiti	8,558	27,748	308
St. Lucia	171	616	277
Trinidad & Tobago	1,340	5,128	261
St. Vincent	102	392	261
USVI: St. Croix	55	212	260
Guadeloupe	441	1,780	248
Jamaica	2,688	10,991	245
Dominican Republic	9,680	48,734	199
Antigua & Barbuda	85	435	196
St. Kitts	49	267	183
USA: FL	18,467	139,697	132
Cuba	11,237	109,886	102
Dominica	71	738	96
USVI: St. John	5	52	94
Turks & Caicos	35	497	71
Bahamas	335	13,962	24
Guyana	780	215,083	4
Suriname	518	163,820	3

There are also few agricultural inputs available on St Thomas. There are no dedicated agricultural input stores and so farmers have to buy products on-line and absorb high shipping costs or they buy them from garden centers. The problem with buying from home garden centers is that selection is limited and there are issues of suitability. Many products are only labeled for ornamental uses, which legally, makes them unavailable for horticultural purposes. Many of the island's farmers are also organic, which further restricts their agricultural input options. There is no organic premium paid for organic produce in the local market and so farmers are not compensated for the losses sustained under an organic production system.

Finally, the high food prices mentioned earlier attest to a high cost of living on St Thomas. A full time farmer has to be productive enough to cover most of the living costs of a family. As an indication of living costs, a person earning a salary of $50,000 in Miami, USA would have to earning a salary of $67,000 in St Thomas (SalaryExpert, 2008). As the data from Table 2 indicate, farms on St Thomas are presently not generating that kind of revenue.

Opportunities for the farming community of St Thomas

The farming system of St Thomas is a challenging one. It is difficult to make money growing traditional crops using traditional production systems. Agriculture, in the sense of a specialized group of citizens mass producing food for the greater population, may not be appropriate for St Thomas.

For example, the average per capita consumption of tomatoes in the USA is around 20 pounds a person. The 2002 production of tomatoes on St Thomas and St John was 18,245 pounds. Based on the U.S. average consumption figure, the tomato production in 2002 would have fed 912 people or 1.6% of the population. This is far short of providing food security for the island. At least tomato production in 2002 was better than 1997, where tomato production (3,280 pounds) would have only supplied about 164 people. While the efforts to grow a wide range of fresh foods for the island are commendable, they may be counter productive to the development of a viable agricultural sector. Most of these crops do not generate adequate profits. True sustainability of an agricultural system occurs when the farming activities create enough income to sustain the operation and the operators. This attracts others to farming and the sector develops. How then, can a farmer be profitable on St Thomas?

There first has to be adequate resources – land and water. The selection of agricultural activities has to be compatible with the constraints of the farming system. The following activities have characteristics that may circumvent the local constraints:

- High value, niche crops
- Activities with low labor requirements
- Mix of activities (year round income)
- Activities that have an intensive use of land (e.g. greenhouses)
- Value-added activities (but needs the production base)

It may be that the number of suitable activities is limited but that may be what it takes. One successful farmer in the 1990s grew nothing but basil under a shade house but he was successful enough to export to New York. This farm also created sufficient income to rebuild the shade house after a major hurricane.

Growing food locally

Having an agricultural sector that is focused on a small number of profitable activities does not mean that St Thomas should relinquish what food security it already has. In fact, there are many opportunities that would allow for an increase in food production. This can be accomplished by focusing in on the opportunities of the St Thomas farming system in the same way that acknowledging the constraints allows us to identify areas of weakness. The greatest resource St Thomas has is people. According the Economic Research Service of the USDA, urbanized areas "must have a core with a population density of 1,000 persons per square mile and may contain adjoining territory with at least 500 persons per square mile". The population density of St Thomas is 1,654 persons per square mile, which makes it an urbanized area. This urbanization is one of the constraints to traditional agriculture. It can also be an opportunity for an alternative production model – urban or peri-urban agriculture.

Urban agriculture fits the constraints of St. Thomas for a number of reasons. Most importantly, there is no need for large areas of land dedicated to agriculture. Urban agriculture can fit itself within urban development. Because of the scale of production, there is also no need to hire laborers as care of the plots can be done on an individual basis. The technology levels will also be relatively low, without the need of specialized agricultural machinery. At the most a rototiller and some spray equipment would be needed. Water is one of the main problems on St Thomas. Farmers have difficulty finding and storing the large quantities of water needed. Small scale operations are more able to

access the water needed. There are already many home gardeners who use house water, whether it comes from the municipal supply or from rain water captured from the roof. There are also grey water possibilities, where water from hand basins and showers can be used to water the garden.

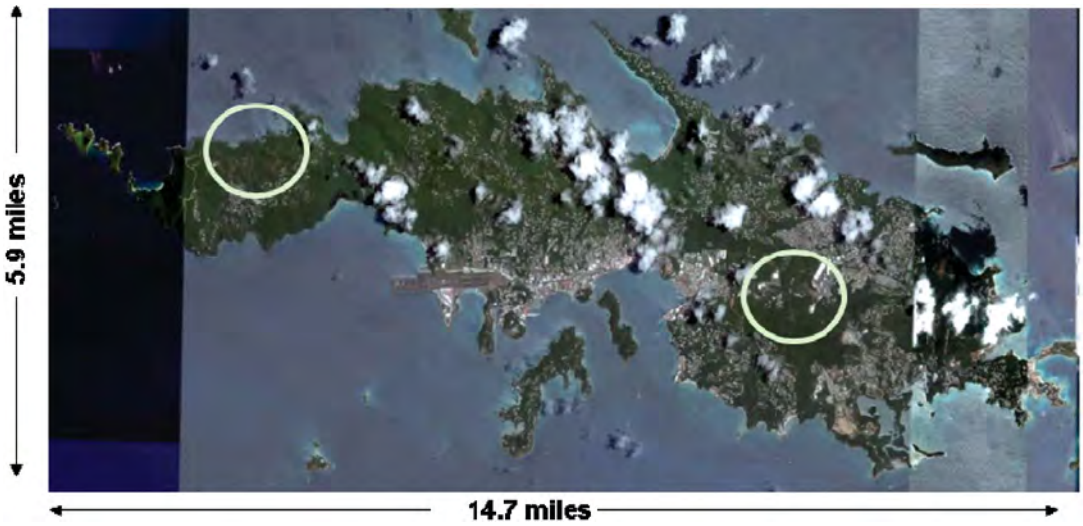


Figure 2. Satellite image of St Thomas showing urban development & the 2 main areas of agriculturally zoned land (circled)

The agrochemical inputs found in garden retail stores are more appropriate for urban agriculture – smaller packaging and easier instructions. Urban gardeners also have the advantage, when it comes to pest and disease control, of being able to give more attention to individual plants. This allows for more intensive control options such as hand picking and pruning.

Urban agricultural programs

The development of urban agricultural schemes in St Thomas is strengthened by the large number of home gardeners that already exist on the island. These people can be organized into a network of growers where extension and marketing initiatives can be directed. When developing an urban agricultural program there are a number of alternatives to consider. Some of the alternatives are given below:

1. Home gardens vs. cultivated urban plots
2. Individual vs. community gardening groups
3. Government supported vs. private
4. Organic vs. conventional
5. Sales orientated vs. personal consumption
6. Crop farming vs. livestock

Caribbean examples

There are already a number of examples of urban agriculture in the Caribbean. The best know example is the urban agricultural program in Cuba. This program arose as a response to the food shortages and economic problems that followed the loss of the Soviet Union's support after 1989. The period after 1989 is known as the 'Special Period'

and the promotion of urban agriculture began in 1991. The 'huertos populares' are the most obvious manifestation of the program and by 1995 there were an estimated 26,600 public garden lots. The Ministry of Agriculture, alongside the Havana city government created a Department of Urban Agriculture that provides extension support to these urban initiatives. The government also manages seed houses ('casas de semillas') that provide all the inputs. In addition to 'huertos populares', there are also 'organopónicos', 'huertos intensivos', 'autoconsumos' & 'campesinos particulares' that span the range of possible urban and peri-urban activities. It has been reported that these production technologies have proved themselves to be more productive, per unit piece of land than the large state farms (Caridad Cruz & Sánchez Medina, 2003).

In addition to Cuba, there are other examples of urban agriculture in the Caribbean region although information on the larger impact of these programs is difficult to come by. Many urban agricultural initiatives, such as those in Jamaica and Haiti, were instigated as part of larger urban development projects. Puerto Rico has had a well established urban agricultural program and recently celebrated the tenth Home Garden festival.

Urban agricultural extension packages

The extension materials for the urban agricultural activities will need to be tailored for the intended clients. This will include community groups, schools, churches, horticultural clubs, as well as individuals. A wider impact is expected when working with groups. The most important feature of an urban agriculture extension package is that all the relevant technological information is bundled so that a person can have quick success. The focus is to make it easy for busy, part-time growers to build a complete production system without going through a long establishment period. With so many other requirements for their time, early success strengthens initial enthusiasm, which then promotes sustainability and success for the urban agricultural program as a whole.

The information that is included in the extension material must be carefully chosen and presented in a way that does not confuse. It must be appropriate for urban requirements – urban landscapes are unique and traditional agricultural information must be adapted. Listed below are the broad areas of information that should be included in the extension packages:

- **Site planning** (plot layouts, terraces, storage, sun, light/shade, security)
- **Land preparation** if planting directly in the soil
- Construction of **specialist growing containers** (e.g. planting boxes & tires)
- **Planting medium** (soil mix, compost, free of contaminants)
- **Irrigation system** (flow requirements, pressure regulation, filters, pipe sizes)
- Production of **planting material** (nurseries, selection of healthy material)
- **Pest and disease** identification & control. Basic control toolkit.
- **Plant nutrition** & **water management**
- **Crop planning** (market reasons and ecological considerations)
- **Budgeting** & **record keeping**

DISCUSSION

There are significant constraints to traditional agriculture in St Thomas that have prevented the full development of an agricultural sector on the island. The main constraints to this development are a lack of suitable land, high labor costs, water shortages and a lack of inputs. Farmers need to assess potential activities and focus on those that will succeed, despite the inherent difficulties. It is thought that successful activities will either be niche, high value crops or alternatively, those crops that have low labor requirements such as fruit trees. The design of farm activities also needs to be carefully planned so that the farm is generating income throughout the year.

The realignment of the agricultural sector on St Thomas will probably mean that the successful farmers will have a narrower activity base and will not offer the wide range of food crops that they now plan for. This does not mean that food security on St Thomas needs to be compromised. St Croix shows immense agricultural potential and with dependable transport links between the two islands, quantities of locally produced food on St Thomas could be far higher than it is now. Even closer to home, food crops could be produced in an urban agricultural program.

Urban agriculture is a realistic approach to St Thomas. With a population density of 1,654 persons per square mile, St Thomas should be considered an urban location. There are successful urban agricultural examples in the Caribbean, most notably in Cuba, which can be used to help direct efforts in St Thomas. Home gardeners, already active on the island, can be recruited to spearhead the efforts. Extension materials developed for urban activities must be tailored and bundled to ensure early success. In conclusion, the establishment of an energetic urban agricultural program will stimulate local production of food crops, increasing food security and so freeing the traditional agricultural sector to find a profitable, sustainable set of activities that best fit the constraints and opportunities found on St Thomas.

REFERENCES

Caridad Cruz M. & R. Sánchez Medina, 2003. "Agriculture in the city: a key to sustainability in Havana, Cuba". International Development Research Centre (IDRC): http://www.crdi.ca/prma/ev-31574-201-1-DO_TOPIC.html

Dixon J., Gulliver A. & Gibbon D. 2001. Farming systems and poverty: Improving farmers' livelihoods in a changing world. Food and Agriculture Organization & the World Bank. Rome, Italy.

SalaryExpert 2008: http://www.salaryexpert.com/?FuseAction=COLCalculator.USCOL

USDA, 2005. 2002 Census of Agriculture: http://www.agcensus.usda.gov/Publications/2002/Outlying_Areas/usvi.pdf.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):166-169. 2008

Linking Agriculture and Tourism: Constraints and Opportunities with a Focus on Local Food Chains in the U.S. Virgin Islands

Stafford Crossman[1], Carlos Robles[1], Louis Petersen[2], Eric J. Wailes[3], and Francis A. Mwaijande[3]. [1]University of the Virgin Islands Cooperative Extension Service, RR1, Box 10,000, Kingshill, St. Croix, Virgin Islands 00850; scrossm@uvi.edu; [2]Virgin Islands Department of Agriculture, Estate Lower Love, Kingshill, St. Croix, Virgin Islands, 00850, louis.petersen@doa.vi.gov [3]Department of Agricultural Economics and Agribusiness, 217 Agriculture Building, University of Arkansas, Fayetteville, AR 7270; ewailes@uark.edu

ABSTRACT:
The linkage between tourism and agriculture in the US Virgin Islands is limited by production, marketing and institutional constraints. A study was conducted to identify and evaluate policy constraints and opportunities to improve this linkage. Focus group analyses of farmers, hospitality personnel, and policy decision-makers were conducted to develop a formal survey questionnaire. Each group was then surveyed in order to identify current and potential production/purchase constraints and opportunities for local food by restaurants in the islands. Seventy percent of restaurants' food purchases originate less than 10% of local food, 35% of restaurants make no purchases of local foods. However, 97% indicated willingness to purchase if available. In addition to availability constraints, quality, prices, consistency and other factors were determined to be constraints. Lack of producer knowledge of quality and product demand by farmers, and lack of knowledge of availability and outlets by chefs are key constraints. Development of educational exchange and information systems and a pilot project for production/market contracts for local foods are recommended and are being pursued.

KEYWORDS: Agritourism, local foods, constraints, community supported agriculture

INTRODUCTION

While tourism is the greatest contributor to the economy of the U.S. Virgin Islands, there is great concern about the decline in local agricultural production and the need to revitalize the agricultural industry. Agritourism is viewed as one of the ways to reinvigorate the agricultural economy of the U.S. Virgin Islands. The term "agritourism" has many meanings including farm visits, short and long-term farm stays, farm tours, farm bed and breakfasts, agricultural fairs and festivals, living history farms, and restaurants serving local cuisine using local produce. This study explores the constraints of this last meaning for the agricultural and tourist/hospitality sectors of the U.S. Virgin Islands. The objectives of this study include: assess of current food chain linkages between agriculture and tourism in the U.S. Virgin Islands, identify constraints on local food production and marketing, assess stakeholder (farmers, restaurant owners/chefs, and policy decision-makers) perspectives on constraints and barriers, assess stakeholder perspective on opportunities and finally develop recommendations to strengthen linkages of local food to the tourism/hospitality sector.

MATERIALS AND METHODS

Three focus group discussions (FGD) were conducted in the U.S Virgin Islands between September and October, 2005 as part of data collection on the project "Trade, Tenure and Tourism in the U.S Virgin Islands: Understanding the Policy Frameworks that will increase Success for Sustainable and Organics Agriculture". The project is funded by the United States Department of Agriculture SARE Southern Region (USDA/SSARE) for the creation of new opportunities within the Island's agriculture sector and the creation of new opportunities to link producers with the tourism industry, which has become the leading economic sector of the Islands.

The current study employed the purposeful sampling method for recruiting participants (Patton, 1990). The participants for each group discussion were recruited to represent what could be explained as well-informed people with rich information and the ability to provide critical perspectives. For this reason the farmer group, hospitality group and policy makers group were purposefully selected and became the units of analysis. The primary criterion for selection for the farmers group was based on the participant engagement in the agricultural activities (farming or livestock) as a major activity. For the hospitality group the primary consideration was based on the provision of hotel or restaurant services to tourists. Selection criteria for the policy-makers group were based on current and previous involvement in policy making or analysis. Four questions were asked of all focus groups in the following sequence.

1. What are the pertinent issues that need to be addressed in order to develop a successful, sustainable agricultural industry in the US Virgin Islands?
2. What are the constraints or barriers that inhibit the development of a successful, sustainable agricultural industry in the US Virgin Islands?
3. What recommendations would you make to address the barriers identified in the previous question?
4. How would you prioritize these recommendations?

The focus group data analysis involved content analysis based on transcriptions from three videotapes of the recorded participants' responses to the four questions. Analysis of the focus group discussions was done with computer assisted qualitative data analysis software (CAQDAS) called NUD*IST version 6 (N6). This software has sophisticated tools for handling non-numerical and unstructured data collected through qualitative methods such as interviews or focus group discussions. The software enables the qualitative data analyst to index data and identify and merge codes that are closely related (Weitzman, 2000).

Based on content analysis of the focus group discussions, questionnaires were developed and administered to the three stakeholder groups. The three groups for which questionnaires were developed included:1) local farmers/producers, 2) restaurant/hotel owners/chefs, and 3) policy decision-makers. The producer/farm questionnaire included questions about production and interest in production of specific products, concerns about production constraints, concerns about marketing constraints, marketing methods, participation or interest in participation in farmer associations and pilot projects with hotels/restaurants, methods to encourage local food/hospitality linkages, and the role of government policy. The hospitality sector questionnaire included questions about

purchasing and interest in purchasing locally produced foods by specific products, methods of purchase, methods of promoting use of local foods in the establishment's cuisine, concerns about ability to purchase local foods, interest in participating in a pilot project with local farmers, methods to encourage local food/hospitality linkages, and the role of government policy. The policy decision-maker questionnaire included questions about perceptions of local food production and marketing constraints, methods to encourage local food/hospitality linkages, and the role that government policy should have. The objective of questionnaires and surveys of study stake-holders was to collect in-depth information to be used as the basis for characterizing attitudes, perceptions and interest in policy and technical constraints and solutions to integrating a sustainable local agriculture with the hospitality sector.

The questionnaires were pre-tested and after final revision were administered spring 2007 to random samples of complete population lists of all relevant stakeholder groups. Analysis was conducted using SPSS statistical software to test congruence of responses to same questions across stakeholder groups. The study results were presented at stakeholder meetings to report the survey findings and to engage stakeholders in a discussion of recommendations to improve linkages.

RESULTS AND DISCUSSION

Seventy percent of U.S. Virgin Islands restaurants' purchase less than 10% of their food products from local sources and 35% of restaurants make no purchases of local foods. However, 97% of the island restaurants indicated their willingness to purchase local foods if available. Less than one-third of the restaurants purchase local foods at farmers markets or directly from farmers on a weekly basis. Although given a choice of suppliers among wholesalers, grocery stores, farmers markets, and direct purchase from farmers, restaurants indicated the most preferred method (over 70%) would be directly from farmers. The constraints perceived by the restaurant owners/chefs in developing the local farm to tourist restaurant linkage by importance included: lack of sufficient and consistent quantities of local foods, lack of market outlets and linkage to farmers, lack of local product quality and market information including availability and price. Farmers tended to agree as they listed by importance the lack of sufficient and consistent supply. However they believed that the price of imported products places them at a disadvantage and that there is a general lack of interest by restaurant owners/chefs in local food products. This study found that lack of producer knowledge about food product quality and product demand is an important constraint. Similarly, the lack of knowledge of availability and outlets by restaurant owners/chefs are also key constraints.

To address the constraint of adequate and consistent supplies, farmers and policy-decision makers were asked to rank the most important production constraints. Both groups agreed that lack of irrigation water infrastructure was most important. That was followed by lack of local government support, labor availability and land allocation.

With respect to identifying ways to improve linkages, farmers indicated that improving water and land resources and extension education were most important. The restaurant sector indicated that improving market information on local food was most important along with developing improved market infrastructure and farmer-chef exchanges. Policy decision-makers indicated that the most important way to improve linkages was to teach agricultural science in the school curriculum but that was followed

with improving market information on local foods, improving land and water resources and facilitating farmer-chef exchanges.

Recommendations to improve the agriculture – tourism linkage that were based on study findings included 1) the U.S. Virgin Island government should develop fiscal policies to improve land, water and labor availability, 2) a market information service should be developed by the U.S. Virgin Island Department of Agriculture, and 3) the Department of Agriculture should initiate a pilot project between farmers and restaurant owners/chefs to provide for educational exchange and to develop food supply chains for local foods that will meet the quantity and quality interests of the island restaurants.

Actions being taken by stakeholders as a result of this project include: a pilot project has been initiated to strengthen business and personal relationships between farmers and restaurant owners/chefs; a directory that identifies suppliers and purchasers of local foods is developed and planned activities include farm visits for chefs and food demonstrations by chefs for farmers using local foods.

REFERENCES

Patton, M. 1990. Qualitative Evaluation and Research Methods, Sage Publications, Newbury Park, London.

Weitzman, E. 2000. "Software and Qualitative Research" in Denzin, N. K and Lincoln, Y. S. Handbook of Qualitative Research, Sage Publications, Inc, Thousand Oaks, London

2008 Proceedings of the Caribbean Food Crops Society. 44(2):170. 2008

Impact of Various Interventions on Revitalization of the Vital Agricultural Sector in Grenada Following the Destruction by Hurricanes Ivan and Emily in 2004 and 2005, Respectively.

Daniel Lewis, Agronomist, Ministry of Agriculture, Grenada. ddclewis@spiceisle.com

ABSTRACT.

Hurricanes Ivan in 2004 and Emily in 2005 severely devastated the vitally important agricultural sector in Grenada. All the major agricultural sub-sectors suffered significant damages. The island's most important export crop, nutmeg (Myristica fragrans), lost > 90% of its trees. Prior to Hurricane Ivan, Grenada was the second largest producer of nutmeg accounting for 23% of world production. Severe losses impacted in the cocoa and banana industries, forest lands, vegetables production, roots and tubers crops, citrus and minor fruit orchards, ornamental horticultural crops and minor spices (i.e. clove, cinnamon, tonka beans, etc.). The livestock industry, farm and feeder roads, agriculture infrastructure such as agro-industry buildings, warehouses and nurseries suffered substantial damages. Given the critical importance of the agriculture industry, the Government, with technical and financial support from friendly Governments and international organizations, has expended enormous financial resources in implementing programmes and projects to resuscitate this vital sector. The main interventions have been soft loans credit schemes for farm investments, rehabilitation of nurseries, farmers' training, capacity building of Ministry of Agriculture technicians, subsidized inputs, implementation of irrigation schemes, transfer of protective culture technology, etc.

The interventions have had varying degrees of success across the different sub-sectors. Impact in vegetable production has been very strong and production has been surpassing pre-hurricanes levels. Irrigation technology has been a major factor for the increase in vegetable production as the high levels of production persist even during the dry season. Egg and pork production have grown considerably, in part, because of the soft loan scheme accessed by many pig and poultry farmers. Extensive training of farmers has contributed to growth. Growth in banana production has been restricted despite significant injection of resources into that sub-sector. The incidence of the black sigatoka (*Mycosphaerella fijiensis*) disease, identified in Grenada for the first time in November 2005 has impacted negatively on the growth of that crop. Cocoa export has been increasing and is expected to reach 750,000 thousand pounds in 2008. Present production of nutmeg is about 10 % of the pre-hurricanes level and is not expected to increase significantly in the short term since the crop takes 7 to 10 years to attain optimal production.

KEYWORDS: soft loans credit schemes, training, irrigation, black sigatoka

2008 Proceedings of the Caribbean Food Crops Society. 44(2):171. 2008

Agriculture and CARICOM Development: Millstone or Panacea?

Timothy G. Taylor[1] and Brian Francis[2], [1]Food and Resource Economics Department, University of Florida and [2]Department of Economics, University of the West Indies, Cave Hill, Barbados. tsquare@ufl.edu

ABSTRACT.
Over the past several decades, there have been numerous policies devised to enhance economic growth and development in CARICOM countries. Many of these policies have emphasized the role of agriculture and have been conceived within the context of the smallness of CARICOM countries. Examination of real GDP per capita data over the 1970 to 2007 period suggests that smallness may not be as significant in limiting development as is commonly argued, that agriculture may not be as important to economic growth as often believed and that other factors may be at play. Indeed, those countries which placed less emphasis on agriculture and more emphasis on other elements of their economies seem to have grown faster, despite differences in size. Although these data are anecdotal they point directly to the question: why is it that some CARICOM countries, especially some of the smaller ones, have grown more rapidly in terms of per capita GDP than others? One possibility is the manner in which various CARICOM countries have treated agriculture and how agriculture has influenced their overall development strategies. This paper provides an initial exploration into the hypothesis that the historical production of "traditional" crops such as sugar and bananas, and policies that emphasized agricultural diversification and export promotion as a key component of development strategies have served to inhibit rather than enhance economic growth.

KEYWORDS: CARICOM agricultural policy, smallness, economic growth, per capita GDP

2008 Proceedings of the Caribbean Food Crops Society. 44(2):172-178. 2008

Gleaning After Citrus Mechanical Harvesters – Labor Productivity

Fritz Roka and Barbara Hyman, Food and Resource Economics Department, University of Florida, Institute of Food and Agricultural Sciences, Southwest Research and Education Center,2686 Hwy 29 N, Immokalee, FL34142-9515. fmroka@ufl.edu

ABSTRACT.

Canopy and trunk shakers in properly prepared Florida orange groves recover between 85 and 93 percent of the available fruit. Whether a grower should "glean" the remaining fruit depends on if the unit cost of gleaning is less than the on-tree fruit value. Labor productivity of gleaners is an important component in determining the unit cost of gleaning. Previous work by Polopolus and Emerson indicates that worker productivity of orange harvesters averages between 8 and 10 boxes per hour. Their data, however, are restricted to hand crews working in blocks averaging between 300 and 500 boxes per acre. Workers, or gleaners, who follow mechanical harvesting systems have access to far less fruit, perhaps only between 25 and 75 boxes per acre. The objectives of this paper are to test the hypothesis that worker harvest productivity is positively correlated with crop yield, and if true, estimate the overall effect of crop yield on worker productivity. A data set was assembled from 47 Hamlin orange blocks harvested in southwest Florida between 27 November 2007 and 10 January 2008. Each block was characterized by its total production (boxes per acre), the total boxes harvested by either hand crews or mechanical systems, and the average hourly productivity of hand harvesting crews. A linear model of worker productivity as a function of the log-transformed value of fruit availability was estimated by OLS. The estimated parameter coefficient on fruit availability was positive and statistically significant. The model predicts that worker productivity falls from ten to nearly five boxes per hour when fruit availability decreases from 500 to 25 boxes per acre. In order to for all workers to earn at least $8 per hour, the harvesting piece rate must increase from 80-cents for hand harvesters to $1.50 per box for gleaners.

KEYWORDS: gleaner productivity, citrus mechanical harvesting

INTRODUCTION

Problem Statement and Research Objectives

Citrus harvesters, like most workers who harvest fruit and vegetable crops, are paid on the basis of a piece rate. A worker's daily earnings are calculated by multiplying the piece rate by his productivity. Productivity of citrus harvesters is measured as the average number of 90-pound boxes collected per hour. For example, if the piece rate is 70-cents per box and the worker picks 80 boxes during the course of one day, total earnings will be $56. If the same worker spends 8 hours harvesting, his average productivity is 10 boxes per hour and his average hourly earnings is $7. The harvester's responsibility is to strip the tree of its fruit and collect the fruit into tubs positioned among the trees being harvested.

Harvest piece rates are influenced by grove conditions and the requirement that workers earn at least minimum wage. Florida's minimum wage, as of January 1, 2008, is $6.79 per hour. Therefore, if the piece rate is 70-cents per box, a harvester must collect 9.7 boxes an hour to earn the minimum wage. If grove production (defined as boxes per tree or boxes per acre) in a particular block is lower than average, productivity may suffer as a worker must travel farther to collect the same amount of fruit. If a harvesting crew, which can pick 10 boxes per hour in an average yielding block, can only pick 6 boxes per hour in a poorly producing block, the piece rate must be adjusted from 68-cents to $1.14 per box just to ensure that the average worker earns minimum wage.

Previous work by Polopolus et.al (1996) indicated that productivity of citrus hand harvesters averaged between eight and ten (90-pound) boxes per hour. These data were based on 1992-95 payroll records of harvesting crews during the first week of February, defined to be the peak harvesting period for citrus in Florida. Payroll records provided Polopolus et.al with a daily accounting of total boxes picked by a specific crew along with the total number of hours the crew worked. Average productivity by crew was calculated by dividing total boxes by total hours of labor. The Polopolus study documented differences in worker productivity by variety. Average worker productivity while harvesting Hamlins (early variety) was higher than while harvesting Valencia (late variety). While the authors speculated that worker productivity differences could be related to grove productivity, the payroll data to which they had access did not allow any testable hypothesis.

The purpose of this paper is to develop a model predicting worker productivity as a function of available yield per acre. A model that predicts worker productivity would provide a basis to estimate the piece rate needed to meet minimum wage requirements, or any other hourly earnings goal. This paper extends the previous work of Polopolus et.al by estimating a functional relationship between worker productivity and available citrus yield by including citrus blocks that were "gleaned" after mechanical harvesting.

MATERIALS AND METHODS

Trunk and canopy shakers, which collect removed fruit, have been shown to "recover" between 80 and 95 percent of the on-tree fruit (Roka, 2004). Hence, a block that yields 500 boxes per acre will have between 25 and 100 boxes of fruit remaining in the grove after a mechanical harvesting operation. An important question associated with mechanical harvesting is whether the remaining fruit should be harvested or "gleaned" by manual labor. As with harvesters who work in hand-picked blocks, gleaners must earn at least minimum wage. More importantly, in order to entice workers to shift from hand-picking to gleaning after a mechanical system, they must be assured that expected hourly earnings would remain the same. If productivity in a gleaned block is less than the productivity in a hand-picked block, a higher piece rate would be needed to maintain equal expected hourly earnings across the blocks. Before a reasonable piece rate can be established, there needs to be a reliable estimate of worker productivity under "gleaning" conditions and extent to which productivity is less than under "hand-picked" conditions.

The model to be estimated for this paper can be represented as,

$$P = f(Y),$$

where Y are the boxes per acre of oranges available for hand harvest and P is a measure of a worker's average hourly productivity. It is expected that the productivity (P) varies directly with available yield (Y), or,

$$\Delta P/\Delta Y > 0.$$

Available Yield Data for Hand Harvest

Yield data were collected from 47 Hamlin (early season orange variety) blocks in southwest Florida harvested between November 27, 2007 and February 3, 2008. On 17 blocks, the oranges were harvested completely by hand. On the remaining 30 blocks, a mechanical system (continuous canopy shake and catch, Oxbo Inter. Corp.) initially harvested the block. Fruit prices during the early 2007-08 season were in excess of $1.50 per pound-solid, providing growers with the financial incentive to pay hand crews to glean all fruit not harvested by the mechanical system. Grower records identified the method of harvest on each block (i.e. hand or machine pick). For those blocks mechanically picked, yield records separated the boxes harvested by gleaners from boxes harvested by the mechanical system. The total quantity of gleaned boxes divided by the net tree acreage of a block provided the per acre estimate of "available yield" for manual labor to glean.

Hand picked blocks averaged 331 boxes per acre, while machine picked blocks averaged 394 boxes per acre. Given the yield variability among the blocks, the difference in yield between hand and machine picked blocks was not statistically different (Table 1). As expected, "available yield" was significantly different between hand and machine picked blocks. On average, mechanical systems harvested 83-percent of the crop, leaving an average of 65.8 boxes per acre to be gleaned. For hand picked blocks, it was assumed the average yield equaled available yield (Table 1).

Worker Productivity Data

Growers typically hire a labor contractor to harvest their fruit. A contractor records all information relevant to worker productivity on daily payroll sheets. A payroll sheet is specific to an individual crew and indicates the grove and block where the crew was assigned. The daily payroll sheet lists the name of the crew leader and the names of all crew members working that day. For each worker, total boxes harvested and their respective work hours are recorded. Usually, all members of the crew start and stop at the same time on a given day. Hence, from the daily payroll sheet, total hours worked and the total boxes harvested by the entire crew can be tabulated.

Demographic data by individual worker were not available. Therefore, worker productivity was calculated as a crew average, total hours divided by total harvested boxes. Blocks ranged in size from 16 to 151 net tree acres. If a block required several days to complete its harvest, payroll sheets of all days when the crew exclusively worked in that particular block were combined to calculate average worker productivity. A daily payroll sheet of a crew working in more than one block was excluded from the data set because hours worked and boxes harvested could not be allocated to their respective blocks.

Worker productivity among the 17 hand-picked blocks averaged 9.9 boxes per hour. Worker productivity to glean behind the 30 mechanically picked blocks averaged 6.6 boxes per hour (Table 1). The difference of 3.3 boxes per hour was statistically significant at the 90-percent confidence level.

Data Analysis

A data plot suggests a nonlinear relationship between available yield and worker productivity. An analysis of residuals suggested a logarithmic transformation of the independent variable, available yield to linearize the relationship (Neter, et.al, 1989). OLS was performed on the transformed data using the Linear Model function within the SAS statistical package (SAS Institute, Cary, NC). The "no-intercept" option forced worker productivity to be zero with zero available yield.

RESULTS AND DISCUSSION

The parameter estimate on the transformed values of available yield was positive and significantly different from zero (Table 2). Nearly 95-percent of the change in worker productivity was explained by the model.

Table 3 presents a numerical example of how worker productivity is predicted as available yield increases from 25 to 500 boxes per acre. Piece rates, roadside charges, total harvesting costs, and break-even prices are all dependent upon predicted values of worker productivity. Piece rates are determined by dividing a wage goal ($8/hr) by the predicted value of worker productivity (column 4, Table 3).

If a mechanical system harvest 90-percent of a lock yielding 500 boxes per acre, workers have 50 boxes per acre available to be gleaned. Their estimated productivity is slightly more than 6.5 boxes per hour. If their wage goal is $8 per hour, the piece rate must be $1.23 per box. As the recovery efficiency of a mechanical system increases from 90 to 95 percent, predicted productivity of gleaners declines by more than 1 box per hour to 5.36 boxes per hour. In order to maintain the same hourly earnings ($8/hr), piece rates must increase by more than 20% to $1.49 per box.

A reliable estimate of worker productivity has important economic implications in deciding whether gleaning should occur after mechanical harvesting. Typically, a piece rate equals 40-percent of total hand harvesting cost including hauling charges to a processing plant. If gleaners are paid $1.50 per box, then an estimate of total harvest costs to deliver gleaned fruit to a processing plant is $3.75 per box. Assuming there is 6.0 pound-solids per box, a grower would have to receive at least $0.63 per pound-solid as a delivered-in price. While the current market for processed oranges is in excess of $1 per pound-solid, the market price for early season fruit in 2003 was below 60-cents. Under those market conditions, a grower would have been advised to leave unharvested fruit in the grove after mechanical harvesting.

REFERENCES

Neter, J.W., Wasserman, W., and Kutner, M.H. 1989. Applied Linear Regression Models, Second Edition, Irwin Publishing Co., Boston, MA.

Polopolus L, Emerson R, Chunkasut N, and Chung R. 1996 The Florida Citrus Harvest: Prevailing wages, labor practices, and implications. Final report to the Florida Dept.

of Labor and Employment Security, Division of Labor, Employment and Training. 297pp.

Roka F and Hyman B (2004). Evaluating performance of citrus mechanical harvesting systems – 2003/04. Report to the Citrus Harvesting Research Advisory Council, Lakeland, FL, August 2004.

Table 1. Summary statistics of study blocks by harvest method. A different letter indicates that average values corresponding to harvest method (Hand and Machine/Glean) are significantly different.

		Hand	**Machine/Glean**
Number of blocks	(n)	17	30
Average Yield (std deviation)	(bx/ac)	331.5 **(a)** (130)	394.0 **(a)** (123)
Available Yield (std deviation)	(bx/ac)	331.5 **(a)** (130)	65.8 **(b)** (24.7)
Worker Productivity (std deviation)	(bx/hr)	9.9 **(a)** (1.184)	6.6 **(b)** (2.036)

Table 2. Parameter estimate, standard error, and model statistics for the predicted model of labor productivity.

Independent variable	Ln(AvailYield)
Parameter Estimate	1.66734
Standard Error	0.0568
Adj. R2	0.9482
F-value	861.37

Table 3. Predicted hourly worker productivity and implied piece rates to meet hourly earnings of $8. Productivity Model: P' = 1.666 * (LnY)
Wage goal: $8.00/hr

Yield	**Transformed yield**	**Estimated Productivity (P')**	**Implied Piece Rate**
Box/ac	**Ln(Y)**	**Box/hr**	**$/box**
25	3.219	5.36	$1.49
50	3.912	6.52	$1.23
75	4.317	7.19	$1.11
100	4.605	7.67	$1.04
150	5.011	8.35	$0.96
200	5.298	8.83	$0.91
250	5.521	9.20	$0.87
300	5.704	9.50	$0.84
400	5.991	9.98	$0.80
500	6.215	10.35	$0.77

2008 Proceedings of the Caribbean Food Crops Society. 44(2):179. 2008

Sweetpotato Export Market Development to the European Union

D.H. Picha, School of Plant, Environmental and Soil Sciences, Louisiana State University Agricultural Center, Baton Rouge, Louisiana. dpicha1@lsu.edu

ABSTRACT.
Sweetpotatoes (*Ipomoea batatas*) are significantly increasing in import volume and consumer demand in the E.U. The leading suppliers of sweetpotatoes to the E.U. are the U.S. and Israel, with lesser volumes originating from Egypt, Jamaica, Brazil, Honduras, and China. The principal European importing country is the U.K., in which the per capita consumption of sweetpotatoes currently is experiencing one of the most rapid increases among all fresh produce items. Although sweetpotatoes are still a minor vegetable in other E.U. nations, demand is rising as the major supermarket retailers throughout Europe now stock sweetpotatoes throughout the year. Orange-skin and orange-flesh roots are preferred among all the major supermarket retail chains. Smaller independent grocers, particularly in demographically diverse urban areas, offer a range of orange, cream, and white-flesh roots. The vast majority of sales are for conventionally-grown product, although there is a steadily increasing market demand for organically-grown sweetpotatoes. All sweetpotato suppliers selling product to the major European retail chain stores must comply with GlobalGap requirements. Large size roots (350 to 450 gm) are preferred for bulk displays, while medium size (150 to 200 gm) roots are preferred for pre-weighed 500 gm to 1 kg consumer packs. Three to 5 roots are typically put in a perforated polyethylene bag, depending on total pack weight. Blocky shaped roots are preferred over elongated ones. The principal constraints in sweetpotato arrival quality in the E.U. are root shrivel, surface mold, root skinning, bruising injury, dull skin coloration, Rhizopus soft rot, and Penicillium surface mold. The carbohydrate composition and nutrient content was determined from the roots of the leading sweetpotato cultivars marketed in the E.U. A wide range in individual sugars, carotenoid, and mineral content was found between cultivars. Significant market opportunities exist for those suppliers who can provide the E.U. market with consistent supplies of high quality sweetpotatoes.

KEYWORDS: *Ipomoea batatas*, postharvest care, marketing channels

2008 Proceedings of the Caribbean Food Crops Society. 44(2):180-181. 2008

4-H Munchy Adventures Project Book

Nancy J. Gal[1], Natasha Masciarelli[2] and Norma Samuel[3]. [1]Family and Consumer Sciences, Extension Agent IV; [2]Marketing and Public Relations Specialist and [3]Urban Horticulture Agent II. University of Florida/IFAS Marion County Extension Service, 2232 NE Jacksonville Road, Ocala, Florida 34470-3615. nsamuel@ufl.edu

ABSTRACT.

The *4-H Munchy Adventures* project book is a healthy lifestyles curriculum for youth ages eight to ten. It teaches youth how to balance healthful eating with regular physical activity to support normal growth and development, prevent disease, and encourage a lifetime of wellness. Youth journey through fun and engaging activities promoting consumption of healthy snacks and participation in physical activity as part of an appropriate healthy lifestyle plan. The curriculum follows the experiential learning model and contains five eye-appealing chapters plus a creative pre/post test crossword puzzle. Chapters provide a logical flow of information supported by thought provoking and reflective written activities. Chef Nicky, the fruit and vegetable loving guinea pig mascot, guides youth through activities designed to be done individually as well as with family, club and community members. Activities can be easily adapted for use by all cultures and ethnic audiences. The Take Charge section focuses on goal setting and community involvement, encouraging youth to identify local needs to help others make healthy lifestyle changes. The final chapter, set up as a board game, is an additional tool reinforcing healthy lifestyle behaviors. It combines the concepts learned throughout the curriculum for the ultimate learning experience. The curriculum has been pilot tested and internally and externally reviewed by Extension curriculum specialists and agents. The *4-H Munchy Adventures* Project book will be available from the University of Florida/IFAS bookstore in early 2009.

KEYWORDS: youth, kid, children, nutrition, physical activity, exercise

INTRODUCTION

Youth are faced with many lifestyle choices which can impact their health throughout their lives. The key to health promotion and disease prevention is early intervention in adopting positive lifestyle behaviors which support normal growth and development, disease prevention, and wellness. Consuming healthy foods in appropriate amounts coupled with regular physical activity are foremost to a child's well-being. Overeating accompanied with a sedentary lifestyle can lead to overweight and related health problems that can follow children into their adult years. Health problems of concern include increased risk of type 2 diabetes, high blood pressure, high cholesterol, asthma, joint problems, and overall poor health status. The early acceptance and implementation of healthy eating and physical activity behaviors can have a positive impact on helping youth and their family's practice healthy living.

MATERIALS AND METHODS

This project was initiated in 2005 and has been pilot tested three times to determine the effectiveness of the curriculum in relation to knowledge gain and practice change. Authors provided the subject matter instruction through groups and individual instruction in cooperation with trained adult Extension volunteers.

A total of forty-six youth ages eight to ten years participated. The pilot tests were conducted in one week intervals based on summer day camp schedules and school holiday intermissions. Youth received the project book at the start of the study and were returned for scoring at completion. Family involvement was encouraged by having youth take materials home each evening for return the next day.

The *4-H Munchy Adventures* project book is a comprehensive thirty-eight page multi-generational, multi-disciplined curriculum that follows the experiential learning model and contains five eye-appealing chapters including MyPyramid, Fuel Up, Fill Up Your Tank, Nutrition Facts, and the Ultimate Challenge, plus a creative pre/post test crossword puzzle. The chapters provide a logical flow of information supported by thought provoking and reflective written activities including refrigerator find, menu planning, label reading, time to get moving, and nutritious snack recipes. The three evaluation tools built into the curriculum include the pre/post crossword puzzle, the Ultimate Challenge board game and the pre/post Did You Take Charge? reflection activity. The crossword puzzle and board game serve to measure knowledge gain and the Did You Take Charge reflection activity serves to measure practice change.

RESULTS AND DISCUSSION

All forty-six youth who began in one of the three pilot tests completed the project book. All youth demonstrated an increase in knowledge (at-least-four-nutrition and one physical-activity item) and 91.3% reported intent to change at least two nutrition and/or physical activity behaviors.

The *4-H Munchy Adventures* project book supports an identified statewide curriculum need in childhood obesity, nutrition, and fitness. The outcome of these positive results, as well as supportive internal and external curriculum reviews, has led to the conclusion of the development stage and the beginning of project marketing and distribution.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):182-192. 2008

La Regencia Agropecuaria en Costa Rica

Rojas-Cabezas, E. Fiscalía Ejecutiva. Colegio de Ingenieros Agrónomos de Costa Rica. erojas@ingagr.or.cr; erojascabezas@gmail.com

RESUMEN

Hace más de 40 años el Colegio de Ingenieros Agrónomos de Costa Rica realiza una importante contribución al desarrollo del modelo de Regencias Agropecuarias costarricense que se refleja a nivel nacional en aspectos como legislación, capacitación, implementación, seguimiento y fiscalización del proceso.

El análisis del sistema de la "Regencia Agropecuaria Costarricense", representa una excelente oportunidad para examinar y comprender no sólo el proceso que lleva a cabo el Colegio de Ingenieros Agrónomos, sino también la figura técnica misma del Regente, encargada de velar porque las actividades del establecimiento regentado se sujeten a la normativa vigente en su relación con la sociedad.

En el sistema Regencial Costarricense hay inscritos un total de 763 establecimientos, que agrupados en 7 categorías regenciales diferentes brindan empleo a 518 profesionales, en quienes recaen las responsabilidades técnicas del regentado.

El caso "Costa Rica" en materia de Regencias Agropecuarias, corresponde a un modelo consolidado a lo largo del tiempo, que es mejorable, y que también se desea difundir para que otros países del área, lo tomen como guía que, adaptada a sus necesidades sirva para subsanar vacíos técnicos y legales presentes en la actividad agropecuaria local, para lo cual el Colegio de Ingenieros Agrónomos de Costa Rica pone a disposición regional su experiencia, de más de 4 décadas en la implementación del sistema.

PALABRAS CLAVE: Regencia agropecuaria, Fiscalización, Regente, Costa Rica

INTRODUCCION

Conocer el sistema de Regencias Agropecuarias Costarricense, es una excelente oportunidad para analizar, comprender y eventualmente implementar una figura técnica que permite -en el caso de la actividad agropecuaria de Costa Rica-, concatenar un gran número de actividades interrelacionadas bajo la tutela de un profesional que asume la responsabilidad técnica del establecimiento que requiere de sus servicios.

Dicho profesional no sólo asume la responsabilidad técnica indicada, sino que por delegación del Estado también es responsable de velar porque las actividades del establecimiento regentado, se sujeten a todas las leyes y reglamentos que rigen su relación con la sociedad.

El caso "Costa Rica" en materia de Regencias Agropecuarias, es un buen parámetro para que otros países del área, puedan subsanar algunos vacíos técnicos y legales que se presentan en la actividad agropecuaria local.

EL REGENTE AGROPECUARIO

Para definir el concepto "Regente", es necesario tomar en cuenta varios aspectos:

a) Diccionario de la Real Academia de la Lengua Española: Del latín *regens*, *regentis*, que rige o gobierna. / En la antigüedad, sujeto que estaba habilitado, mediante examen, para ejercer un cargo ostentando superioridad.
b) Definición conceptual: "El que sin ser dueño, dirige técnicamente una empresa."
c) Definición legal costarricense (Reglamento de Regencias Agropecuarias): "Profesional en Ciencias Agropecuarias incorporado al Colegio de Ingenieros Agrónomos, que de conformidad con las leyes, este Reglamento y la debida autorización de la Junta Directiva del Colegio, asume la regulación, supervisión, control y asesoría técnica de las personas físicas o jurídicas que requieren sus servicios, en las actividades establecidas en el mismo."

Se desprende de las definiciones anteriores, que el regente es un asesor sobre diversos aspectos en aquellos locales comerciales que mantienen actividades agropecuarias. Asimismo, le corresponde al regente la fiscalización de un gran número de puntos referidos al comercio, transporte, almacenamiento, adecuada identidad y buen estado de los agroquímicos, alimentos concentrados, material genético de origen vegetal o animal, pero ante todo la asesoría técnica para el buen manejo de esos productos.

Siendo las funciones del regente de asesoría técnica y fiscalización, el mismo no está supeditado -en el criterio técnico- al patrono o empleador, sino que por ser funciones de interés público, la empresa está obligada al acatamiento de lo que dicte el profesional en materia técnica; tal y como lo establece la legislación costarricense en la "Ley de Protección Fitosanitaria", que en su artículo 28 dice:

"...Las recomendaciones del regente serán vinculantes para la persona física o jurídica a la cual presta sus servicios...."

Las condiciones anteriores, establecen una situación especial en el contrato de trabajo, principalmente en el aspecto de subordinación y acatamiento del patrono a las recomendaciones técnicas hechas por el profesional.

Al comprender el concepto del regente en sí mismo, podemos vislumbrar entonces la existencia de un compromiso tripartito, pues:

El *Regente Agropecuario* del Colegio de Ingenieros Agrónomos debe representar fielmente a la Institución, a sí mismo como profesional y al Estado costarricense.

PERFIL DEL REGENTE AGROPECUARIO

En algunas actividades comerciales que tienen matices técnicos la figura del Regente es fundamental, por ejemplo las empresas químicas, farmacéuticas y veterinarias.

Tradicionalmente en Costa Rica el Regente Agropecuario se conceptualizó como un profesional que debía asesorar a los clientes de los agronegocios en el manejo técnico de los agroquímicos, circunscribiendo su labor únicamente a la atención en mostrador, por lo que la figura se convirtió en la de un funcionario con amplio conocimiento teórico de su ámbito de acción, pero alejado de la realidad práctica del campo, y por ende muy separado de la vivencia diaria de los agricultores.

En la actualidad, -luego de la promulgación del Reglamento de Regencias Agropecuarias vigente, (Decreto Nº 26503-MAG) publicado en octubre de 1997, y que derogó el primer reglamento de Regencias, publicado en noviembre de 1980-, las diferentes funciones que tiene el Regente fueron tipificadas claramente, permitiendo proyectar una adecuada luz sobre la figura misma del Regente, y a la vez ayudar a la comprensión del rol que debe jugar en el quehacer agrícola, es precisamente la definición del perfil básico conceptual del "Regente" y la interiorización de dicho concepto por parte del profesional que asume este rol, lo que le harán comprometerse con el quehacer cotidiano de la empresa regentada.

Inserción del Regente en el organigrama empresarial

1) Área administrativa

El nuevo concepto de la figura Regencial exige, sin lugar a dudas al profesional que la ejerce, una función más agresiva en la empresa para la cual labora, no sólo en aspectos técnicos, los cuales de hecho debe asumir, sino que su capacidad personal y profesional le hará ingresar en ámbitos administrativos que normalmente el agrónomo no asumía.

La formación académica y la cultura general de los profesionales en Agronomía les permite asumir o capacitarse para posicionarse en aspectos de administración como manejo de personal, manejo de recursos financieros, planeamiento estratégico, entre otros.

2) Área técnica

Sin embargo en Regente Agropecuario no debe olvidar al verse inmerso en la vorágine de actividades administrativas (situación muy común), que su razón fundamental de ser es el segmento tecnológico de la empresa, de cuya dirección es responsable, temática en la cual tiene la obligación profesional de mantenerse al día, mediante la acuciosa lectura e información constante.

Algunas de las áreas específicas del saber tecnológico que deben ser objeto de actualización continua son:

a) Cultivos de la zona

El conocimiento técnico agrícola es muy amplio, pero el Regente tiene la obligación de mantener un nivel adecuado de conocimientos sobre los cultivos predominantes en su zona de influencia, aspectos que son básicamente los que van a demandar la mayor parte de las consultas.

b) Plagas, enfermedades y nutrición

El manejo de los cultivos de la zona específica en la que se desempeña el regente, reviste particular importancia para su función, debe conocer de modo práctico los principales problemas que enfrentan los cultivos en su producción rentable.

c) Agroquímicos y fertilizantes

Las diferentes opciones tecnológicas que se tienen al alcance, para la atención eficaz de los problemas enunciados en el punto anterior deben ser también dominio del regente, y así podrá atender adecuadamente consultas y sugerencias.

d) Dosis y recomendaciones

Las recomendaciones en el campo y el agronegocio deben no sólo incluir los productos a utilizar, sino también un adecuado conocimiento de dosis, métodos de aplicación y consejos de seguridad para el manejo adecuado de los productos

e) Alternativas técnicas

Otro de los criterios para saber si se está haciendo una adecuada recomendación es el conocimiento y dominio de las alternativas técnicas que se tienen a la solución recomendada, algunas de las cuales pueden ser incluso más rentables para el agricultor, razón por la que el regente deberá dominar conceptos básicos de manejo integrado de plagas, alternativas orgánicas y biológicas entre otras.

3) Otras áreas:

Dependiendo del grado de inserción que el regente tenga en la empresa a la cual brinda sus servicios, así podrá tener influencia en otros aspectos empresariales de gran importancia, lo anterior adquiere particular importancia cuando las empresas regentadas son relativamente pequeñas, pues el aporte que el regente pueda hacer en estos campos influirá decisivamente en el crecimiento futuro de la empresa, algunas de ésta áreas son:

a) Ventas
b) Economía y administración
c) Extensión agrícola
d) Asistencia técnica y transferencia de tecnología

Todos los conceptos anteriores permiten concluir que definitivamente dentro de los elementos principales del perfil profesional que tipifica al Regente Agropecuario deben incluirse, no solo aspectos relativos a agroquímicos, sino elementos de administración y ventas que tienen importancia fundamental.

FUNCIÓN SOCIAL DEL REGENTE AGROPECUARIO

El Regente Agropecuario en los múltiples agronegocios que existen a nivel nacional debe, ante todo, ser un ente multiplicador de buenas prácticas agrícolas, que aseguren a los productores mayor rentabilidad en sus cultivos y a los consumidores un producto final de mejor calidad y menor nivel de contaminantes.

En un país eminentemente agrícola aquellas recomendaciones técnicas que busquen maximizar eficiencia en la utilización de insumos y formas de producción tienen, necesariamente, un reflejo directo en lo social, pues permiten a nuestros campesinos producir de forma más eficiente y sin dañar su entorno; el Regente agropecuario desde su cercana posición al agricultor puede convertirse en agente de cambio que permita mejorar con su influencia la comunidad a la que sirve.

En Costa Rica hay múltiples ejemplos de poblados donde el Regente cumple funciones que van más allá de las paredes del establecimiento para el que labora, técnicos que frecuentemente son buscados por el agricultor para recibir consejos que le permitan salir adelante con su producción, personas que al vivir en dichas comunidades, se insertan también en aspectos sociales que fortalecen el desarrollo local.

El Regente Agropecuario que se ubica en zonas rurales hace importantes aportes a la agricultura y al medio ambiente, velando porque las prácticas agrícolas no afecten las áreas protegidas, mantos freáticos ni ríos, minimizando así los efectos negativos al ambiente, y logrando a la vez dar sostenibilidad al proceso productivo, para que las generaciones futuras puedan seguir disfrutando de los beneficios que brinda la tierra a quien la trabaja.

El Regente Agropecuario que participa día a día con los agricultores y sus problemas tiene gran poder de convocatoria en los grupos de productores, por lo que su

posibilidad de transmitir conocimientos mediante charlas, actividades o medios de comunicación es ilimitada, pudiendo explotarla siempre en beneficio del agricultor.

Debido a la constante relación que el regente tiene con los agricultores durante su desempeño profesional, debe tener especial cuidado en complementar su accionar técnico, con las normas éticas fundamentales de la profesión, sin lugar a dudas este aspecto le hará crecer en credibilidad de parte de los agricultores y cualquier otra persona con la que deba relacionarse en lo cotidiano.

CONSOLIDACIÓN LEGAL DE LA FIGURA DEL REGENTE AGROPECUARIO

La figura costarricense del regente fue creada hace muchos años, la Ley de Sanidad Vegetal N°2852, de 1961, obligaba a las casas comerciales que importaban, fabricaban, distribuían o expendían productos de uso agrícola a contar con los servicios de un regente en la materia. Esta disposición se mantuvo en la Ley de Sanidad Vegetal N°6248 de 1978, sólo que esta última establecía sanciones más fuertes para aquellos establecimientos que incumplieran ese requisito. Esta legislación fue modificada por la Ley de Protección Fitosanitaria N°7664, de 1997, la cual mantiene y amplía los aspectos atinentes a las regencias agropecuarias y ratifica la creación del Registro de Establecimientos Agropecuarios del Colegio.

A nivel de la legislación atinente al Colegio de Ingenieros Agrónomos de Costa Rica, se puede mencionar que la regencia fue creada en su ley constitutiva (Ley N°3855), que fue derogada por la Ley N°7221 del 6 de abril, 1991, en la cual se amplían las actividades objeto de regencia, ya que se establecen nuevos campos que anteriormente no estaban conceptuados para ello.

En lo que a reglamentación se refiere, al delegar el Estado en el Colegio de Ingenieros Agrónomos el ejercicio de las Regencias a través de sus miembros, la Fiscalía se dio a la tarea de elaborar la normativa necesaria para la regulación de este campo del ejercicio profesional, creándose en 1980 el Reglamento de Regencias (Decreto N°12060-A). No obstante con la promulgación de la actual Ley del Colegio (N°7221), se hizo indispensable modernizar dicha normativa, para lo cual se trabajó por espacio de varios años en la estructuración, análisis y discusión de un nuevo reglamento, proceso en el que participó un considerable número de colegiados, regentes y organizaciones relacionadas con la materia, lográndose promulgar el ***REGLAMENTO DE REGENCIAS AGROPECUARIAS DEL COLEGIO DE INGENIEROS AGRONOMOS***, (Decreto N°26503-MAG), del 24 de octubre de 1997, el cual fue reformado por el Decreto N°27914-MAG del 24 de junio, 1999.

Este Reglamento fue concebido y estructurado como un instrumento de ayuda práctica para todos aquellos profesionales que ejerzan la actividad Regencial en sus diferentes formas, por lo que en el mismo puede encontrarse de modo claro no sólo las obligaciones e implicaciones para el Regente, sino también las funciones básicas a la cuales está obligado a dar seguimiento durante la operación del establecimiento regentado, pues aún y cuando existen diferentes tipos de funciones, -dependiendo de la categoría regencial del establecimiento que le contrata-, las principales funciones incluyen responsabilidad en los campos de:

a) Etiquetado. Velar porque los productos cuenten:
   - con etiqueta y panfleto en español

- en buen estado y adherida al envase
- productos registrados en el MAG
- concordancia entre contenido del envase y lo indicado en la etiqueta

b) almacenamiento y trasiego de productos
- Velar por cumplimiento de normas
- Prohibir almacenamiento junto a medicinas, alimentos, ropas.
- Que no se presente peligro de derrame, ruptura, deterioro
- Que los productos no se contaminen unos con otros

c) condiciones de local y seguridad
- Velar por cumplimiento de normas
- Permisos de funcionamiento al día
- Botiquín de primeros auxilios
- Personal cumpla con disposiciones del Ministerio de Trabajo
- Exámenes y controles médicos para el personal de la empresa

d) recetas profesionales
- Velar porque los productos de mayor toxicidad y restringidos se vendan bajo receta profesional
- Que se cuente con libro de inventario
- Velar por el archivo y custodia de las recetas
- Revisar las recetas que llegan al local

e) asesoría técnica y capacitación
- Brindar asesoría técnica a los usuarios en el local y en campo
- Asesorar y capacitar al personal
- Programar actividades de capacitación para usuarios, personal
- Asesorar sobre productos a vender
- Efectuar validación de productos
- Recomendar productos solo para usos y cultivos permitidos

f) reenvase y reempaque
- Permisos respectivos al día
- Llevar control de productos reenvasados y reempacados
- Tratamiento de aguas y residuos
- Descontaminación o desecho de envases y empaques
- Solo productos autorizados y en tamaños y pesos aprobados

g) Registro
- Que no se distribuyan productos con registro cancelado
- Recopilar y avalar la información para el registro de los productos
- Brindar seguimiento al proceso de registro
- Llevar control de los productos registrados por la empresa

h) control de calidad
- Velar porque se practiquen a los productos, previo a su distribución, los controles de calidad requeridos.
- Velar porque solo se distribuyan productos que cumplan las normas de calidad, tanto en características físicas como químicas.
- Interpretar los resultados derivados de los controles de calidad y brindar las instrucciones necesarias para que a los productos que no cumplan las normas

mínimas, se les realice el tratamiento requerido o se les de el destino pertinente.

En el Reglamento de Regencias Agropecuarias es posible encontrar un mejor detalle de los aspectos mínimos que deben cubrirse en cada uno de estas áreas.

Debe el regente poner todo su empeño y conocimiento profesional para cumplir cada una de las funciones que le corresponden, no sólo para desarrollar una eficiente labor en beneficio de la empresa regentada, de los usuarios de los servicios y del país en general, sino también porque una inadecuada ejecución de las mismas podrían acarrearle serias consecuencias en su carrera profesional, debido a las fuertes sanciones que establece la legislación por su incumplimiento.

PARTICIPACION DEL COLEGIO DE INGENIEROS AGRÓNOMOS EN LAS REGENCIAS AGROPECUARIAS

El Colegio de Ingenieros Agrónomos de Costa Rica al cabo de varios años ha tenido y tiene en la actualidad una importante participación en materia de Regencias Agropecuarias, por lo que es necesario referirse a algunos aspectos en los que el Colegio interviene por medio de la Fiscalía.

1. Capacitación del profesional regente

El Colegio, consciente de la gran importancia que tiene para el gremio y para el país en general el desempeño de la regencia agropecuaria, se ha preocupado por dar capacitación a los profesionales que ejercen tal actividad.

Es así como el Colegio por si mismo, estableció el "Curso de Regencias Agropecuarias", requisito obligatorio para todos los que deseen ejercer en el campo de las Regencias Agropecuarias, curso con duración de cuatro días que se imparte dos veces al año, también se realizan cursos de actualización para Regentes Agropecuarios en diferentes partes del país sobre esta materia y el Departamento de Capacitación del Colegio ha incluido dentro de sus programas de formación permanente, diversas conferencias vinculadas con el tema.

Por otra parte la Fiscalía del Colegio en coordinación con el Ministerio de Agricultura y Ganadería y el Ministerio de Salud, toma parte activa, en las actividades de capacitación y divulgación que se realizan sobre la materia realizando varios seminarios sobre aspectos Regenciales en distintas regiones, dándose cobertura casi total del país en lo que compete a información sobre Regencias.

2. Seguimiento del programa regencial

Al delegar el Estado en el Colegio de Ingenieros Agrónomos de Costa Rica y sus miembros, la ejecución, control y seguimiento del programa de Regencias Agropecuarias, el Colegio a través de su Fiscalía, ejecuta diversas acciones para el cumplimiento de esa responsabilidad. Para ello, se destina personal a la atención de los distintos aspectos que involucra el programa, entre los que se citan: recepción y revisión de solicitudes de nombramiento, de informes, apertura de Libros de Protocolo, consultas, atención directa, etc.

Los funcionarios de la Fiscalía ejecutan inspecciones periódicas a los establecimientos regentados, ante lo cual el regente o asesor técnico y los dependientes del negocio, están en la obligación de brindar la colaboración requerida para que éstos realicen la labor que les corresponde. Asimismo deben mostrar los documentos y

suministrar la información que dichos funcionarios soliciten para la verificación del cumplimiento de las disposiciones reglamentarias. También deben coadyuvar los regentes en la corrección de las anomalías que detecten los miembros de la Fiscalía o los Inspectores Oficiales de las Autoridades Competentes y en el acatamiento de sus recomendaciones. Todas las inspecciones de la Fiscalía son respaldadas con informes técnicos derivados de los aspectos observados en las mismas.

Cuando la Fiscalía detecta irregularidades en el cumplimiento de la labor regencial, tiene la potestad de dar inicio e implementar diferentes procesos administrativos y legales como los siguientes:

- llamadas de atención (verbales o escritas)
- amonestaciones escritas
- comparecencias
- procesos disciplinarios
- revocatorias de nombramiento
- traslado a otras instancias (Tribunal de Honor, Junta Directiva, Asesoría Legal)
- suspensiones

Además se investigan las denuncias que se presentan en este campo, a efecto de adoptar las acciones que procedan o elevar las recomendaciones a los órganos competentes del Colegio.

En lo que a sanciones se refiere, es necesario indicar que el Reglamento contempla la revocatoria del nombramiento de la regencia, cuando se compruebe que el profesional ha cometido alguna de las faltas tipificadas, en cuyo caso no se le autorizará una nueva regencia por un período de seis meses a tres años, de acuerdo a la gravedad y consecuencias de la falta.

Debe resaltarse además que la Ley de Protección Fitosanitaria, indica que será sancionado con prisión de tres meses a tres años e inhabilitación especial para ejercer sus funciones profesionales durante un máximo de tres años, el profesional que en el desempeño de sus labores, incumpla con las responsabilidades regenciales y los procedimientos de venta de productos restringidos.

Debido a las anteriores circunstancias, el regente debe asumir su labor de manera profesional, responsable y ética, con el propósito de no verse involucrado en situaciones problemáticas o conflictivas que podrían perjudicar seriamente su accionar, por aspectos que pudo haber previsto mediante un correcto y oportuno cumplimiento de sus obligaciones.

OTROS ASPECTOS IMPORTANTES DE LA REGENCIA AGROPECUARIA

1. Categorías y funciones regenciales

Se presenta a continuación un resumen de las categorías regenciales que estaban establecidas en el Reglamento de Regencias Agropecuarias y sus modificaciones, así como su correspondiente horario mínimo:

CATEGORIA	ACTIVIDAD	HORARIO MINIMO
A	Venta al público de plaguicidas, fertilizantes, hormonas y otros	½ tiempo (24 horas/semana)
B	Venta, importación, registro, etc de plaguicidas, fertilizantes, etc para venta a distribuidores	Tiempo complete (48 horas/semana)
B (R,I)	Registro representación de plaguicidas, fertilizantes y otros	8 horas/mes
D	Fábrica de concentrados y venta al por mayor de concentrados	8 horas/mes
E	Venta y distribución de productos biológicos y material genético vegetal	8 horas/mes
F	Venta y distribución de productos biológicos y material genético animal	8 horas/mes
H	Otras actividades no contempladas en las categorías anteriores	8 horas/mes

2. Nombramiento del regente

De acuerdo con el Reglamento de Regencias Agropecuarias, corresponde a la Junta Directiva del Colegio de Ingenieros Agrónomos de Costa Rica, autorizar a los profesionales para que puedan ejercer la actividad regencial respectiva, previo cumplimiento de los requisitos definidos al efecto, reservándose dicha Junta la potestad de denegar aquellas solicitudes que considere improcedentes, de acuerdo con las normas establecidas.

Por cada nombramiento regencial el Colegio entregará al profesional un certificado, que es el documento probatorio de que el establecimiento cumple con la normativa vigente en esta materia, el cual debe ser colocado en un lugar visible dentro del local y, una vez que la regencia quede sin efecto por cualquier motivo, deberá ser devuelto al Colegio.

Es potestad de la Junta Directiva del Colegio, tramitar las renuncias, cierres de establecimientos, sustituciones temporales y ceses de funciones, por lo que ningún profesional o establecimiento puede arrogarse la potestad de nombrar o rescindir el nombramiento de regente, sin que la Junta Directiva del Colegio haya implementado el trámite respectivo.

3. Informes regenciales

Todo regente o asesor técnico debe elaborar durante los primeros cinco días hábiles de cada mes, un informe de las labores regenciales efectuadas el mes anterior y remitirlo a las entidades competentes, en el formulario que para tal fin diseñó el Colegio.

Los informes deben ser elaborados de la forma más detallada posible, utilizando si es del caso hojas adicionales, anotando las irregularidades encontradas y las recomendaciones para corregirlas. Recordemos que el Informe Regencial es el documento mediante el cual el regente delega la responsabilidad en el regentado y que sus observaciones técnicas son de acatamiento obligatorio para el mismo.

4. Receta profesional

Uno de los aspectos operativos a los cuales debe brindar mucha atención la Regencia en los almacenes distribuidores de insumos agrícolas es la emisión, recepción y control de recetas profesionales.

La legislación vigente en Costa Rica establece que los plaguicidas clasificados en las categorías de mayor toxicidad (1A y 1B) y aquellos otros que se declaren de uso restringido, solo podrán ser comercializados y utilizados bajo receta profesional, y también que todo establecimiento comercial que expenda estos productos, debe llevar un libro oficializado para el control de venta e inventario de los mismos, el cual debe ser revisado periódicamente por el Regente o asesor técnico.

La emisión de receta profesional requiere necesariamente de visita previa al campo, o al menos del conocimiento del profesional que va a emitir la receta acerca de las condiciones reales de aplicación en las cuales se manipulará el producto.

La receta puede ser emitida por cualquier profesional inscrito en el Colegio de Ingenieros Agrónomos, que solicite el respectivo formulario, en la receta deben ser incluidos aspectos como: cultivo, área a aplicar, dosis, medidas de protección y seguridad exigidas y cantidad de producto a vender bajo el respaldo de la receta.

En el caso de clientes que solicitan la receta para su venta inmediata, es responsabilidad del regente evaluar si el cliente está en capacidad teórica y práctica de manipular el producto en cuestión, ante la menor duda es preferible no emitir la receta, abstenerse de vender el producto y ofrecer al cliente otras alternativas menos riesgosas.

Lo ideal es que el regente reciba recetas previamente emitidas por otro profesional, al hacerlo revise que ésta cumpla con todos los requisitos necesarios antes de expender el producto, pero en la práctica también es común que el establecimiento brinde como parte de sus servicios la posibilidad de confeccionarlas por su regente.

Bajo ningún concepto deben dejarse recetas firmadas en blanco, para ser completadas cuando el cliente llegue a adquirir el producto, ni deben efectuarse ventas sin receta, para pedir al regente que emita la receta "a posteriori".

5. Libro de Protocolo

Todo regente o asesor técnico deberá contar con un Libro de Protocolo inscrito en el Colegio de Ingenieros Agrónomos, en el que anotará un resumen por día o por visita de los principales aspectos atinentes a la regencia, debiendo acatar para ello las normas y procedimientos definidos por la Junta Directiva. Este libro puede ser adquirido directamente en las oficinas del Colegio.

El libro deberá permanecer siempre al día, ya que podrá ser solicitado en cualquier momento por la Fiscalía para su respectiva revisión, existiendo sanciones para quienes no lo tengan o lo lleven en forma inadecuada.

6. Horarios regenciales

El Regente debe desarrollar su labor en estricto apego al horario establecido y está en la obligación de hacer saber al representante o dependientes del establecimiento sus ausencias dentro del local regentado, cuando tenga que salir a cumplir funciones regenciales fuera del mismo, en aspectos tales como capacitación, asesoría técnica, visitas a productores, etc., de tal manera que en todo momento se tenga conocimiento de la ubicación del profesional. Debe ser honesto y ético para tomar la decisión adecuada, cuando por motivo de otras ocupaciones no pueda dar efectivo cumplimiento al horario establecido, ya que de comprobarse faltas en este sentido la regencia puede ser revocada por la Junta Directiva.

Es conveniente resaltar que el profesional debe ser muy cuidadoso al momento de convenir el horario con el regentado, de forma tal que cuente con suficiente tiempo para cumplir a cabalidad todas las funciones, obligaciones y responsabilidades que le establece la legislación vigente. Debe recordarse que la Junta Directiva del Colegio de Ingenieros Agrónomos tiene la potestad de improbar aquellas solicitudes de regencia que no se ajusten a las normas establecidas.

7. Salarios, honorarios y cuotas regenciales

El profesional debe convenir con el regentado la remuneración que recibirá por la prestación del servicio, para lo cual debe tener presente que el pago no puede ser inferior al salario mínimo definido por el Poder Ejecutivo para el ejercicio de la profesión o al valor mínimo de la hora profesional, dependiendo de la modalidad de contratación.

Desde el punto de vista ético y de responsabilidad profesional, el regente debe tomar como base de cobro las tarifas de salarios y honorarios mínimos definidos para cada caso, ya que de no ser acatadas se entraría en competencia desleal con el resto de la comunidad de colegiados, con graves consecuencias para sí mismo y para el sistema regencial.

El Código de Ética Profesional del Colegio de Ingenieros Agrónomos establece, que el colegiado será correcto en la estimación de sus honorarios y hará el cobro de los mismos de conformidad con las tarifas que el Colegio estipule, sin que pueda cobrar honorarios menores que los señalados y que existen sanciones disciplinarias, aplicables para aquellos profesionales que se les compruebe que están faltando a las normas establecidas.

Todo Regente deberá pagar al Colegio a más tardar el último día de cada mes, una cuota mensual por el ejercicio de la actividad, cuyos fondos serán destinados a cubrir los gastos que demande la participación del Colegio de Ingenieros Agrónomos en esta materia y que el no pago puntual de las mismas, conlleva a la anulación de la regencia correspondiente.

8. Conclusión

El Modelo Regencial Agropecuario Costarricense, puede ser analizado y adoptado por otros países del Caribe, para lo cual el Colegio de Ingenieros Agrónomos de Costa Rica pone a disposición regional su experiencia, de más de 4 décadas en la implementación del sistema.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):193-194. 2008

4-H Garden Project Builds Positive Life Skills in Youth

Nancy Gal, Family and Consumer Sciences Agent IV, and Norma Samuel, Urban Horticulture Agent II; University of Florida/IFAS Marion County Extension Service, Ocala, Florida 34470, USA

ABSTRACT.
A vegetable garden project is an excellent way to develop life skills including decision making, record keeping, enhanced self-esteem, and good work ethic in youth. It also promotes a healthy lifestyle by developing an enjoyment in gardening and consumption of fresh vegetables. The objectives of this project are to teach youth: basic horticulture skills to implement a garden plan; how to make educated decisions in the care of their gardens based on knowledge gain; utilization of grown vegetables as part of a healthy nutrition plan; and to encourage a sense of citizenship through donations of vegetables to those in need. Over the last two years summative evaluations of 148 youth participants were collected from garden judging, vegetable exhibits, and record book scores. Results found: 98% completed the project; 75% received a blue ribbon score of 90% or higher on their record book; 100% prepared at least one recipe from the vegetables grown, and a follow-up survey of ten youth indicated 100% knowledge gain and reported developing record keeping, time management, decision making, and problem solving skills and enhanced self esteem.

KEYWORDS: vegetable garden, life skills, youth

INTRODUCTION

Since the 1890's, 4-H has been the premier youth development program, helping young people become healthy, problem solving, constructive adults. The essential elements which serve as guiding principles are positive relationships, engagement in learning, self determination and service to others. The subject matter used for meeting the needs of youth and building life skills is numerous. This vegetable garden project increases competency in youth horticulture and nutrition skills.

MATERIALS AND METHODS

The garden project begins each year with interested youth attending a mandatory workshop to receive instruction on garden site selection, soil sampling, proper soil preparation, correct fertilizing techniques, appropriate irrigation techniques, and cultural practices to care for a spring vegetable garden. Each youth enrolled in the project plant a 20 by 26 feet garden in mid-March according to a specified garden plan with ten vegetables: radish, turnips, snap beans, yellow squash, zucchini, cucumbers, tomatoes, sweet corn, onions, and bell peppers. Throughout the project instructional newsletters are distributed providing pertinent and timely information. Youth are encouraged to keep a garden record book, present a demonstration to their club members, research nutrition information on vegetables grown and prepare a dish to serve family and friends. Towards the end of May youth submit their project books and a group of Master

Gardeners visit and judge each garden. The last Monday night of May is Exhibit and Awards Night. Youth bring in four different types of vegetables for display according to guidelines. Awards are given to: the top five overall gardeners, best garden, best project book, best exhibit, best first year gardener, best scarecrow in each category, and the best cucumber in a bottle.

RESULTS AND DISCUSSION

Over the last two years (2006 and 2007) summative evaluations of 148 youth participants were collected from garden judging, vegetable exhibits, and record book scores. Results found: 98% completed the project; 91.9% received a blue ribbon score (≥ 90%) or red ribbon score (80 - 89%) on project books (111 blue, 25 red); 100% prepared at least one recipe from the vegetables grown, and a follow-up survey of ten youth indicated 100% knowledge gain and reported developing record keeping, time management, decision making, and problem solving skills and enhanced self esteem. Parents of youth participating in the project indicated that their families benefited from the project in the following ways: quality family time together, saved money on grocery bill, increased their consumption of vegetables, and youth developed marketable life skills.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):195. 2008

Biotechnology: Prospects for Development in Emerging Economies, the Case of the Caribbean

Malachy Dottin, Biotechnologist, PhD, UN BCH Regional Advisor for Biotechnology and Biosafety in the Caribbean. Ministry of Agriculture, Lands, Forestry and Fisheries, Ministerial Complex, Botanical Gardens, Tanteen, St. George's, Grenada, West Indies. malachyd@hotmail.com

ABSTRACT.
Biotechnology has rapidly emerged as a top priority on the CARICOM agenda. The fast pace of development in the field of biotechnology has given rise to two challenges in the Caribbean region to convince producers and consumers of its benefits, and to assess its potential risks and impact. Despite the apparent controversy, the appropriate application of advances in biotechnology can contribute to food security and to the sustainable use of natural resources in the Caribbean. Both agricultural technology and biosafety have become important issues for the Caribbean Region. On the one hand, food must be produced for a growing population, and on the other, food production must comply with environmental regulation, such as the Cartagena Protocol on Biosafety, the Convention on Biological Diversity and the trade rules being enforced by the World Trade Organization (WTO). Modern biotechnology provides both opportunities and challenges, provided Caribbean countries increase the capacity of their national research systems. Biotechnology has the potential to support national efforts towards food security, increase exports and achieve sustainable development in the region. The countries of the region require appropriate infrastructures that permit them to acquire, absorb, develop and efficiently manage biotechnologies. The creation of enabling conditions must be addressed to obtain the potential benefits of these new technologies and to minimize any possible adverse effects on the environment, on human health or on agricultural productive systems. The first step to be taken by a government wishing to create a suitable environment to benefit from the potential of biotechnology, improve agricultural productivity and mitigate concerns about potential adverse effects is to implement its regulatory framework to ensure the safe use of biotechnology products in an opportune and effective manner. This presentation is intended to outline the wealth of biodiversity in the Caribbean and to present an overview of the current biosafety regulations in the region.

KEYWORDS: Cartegena Protocol, regulatory framework, biodiversity

2008 Proceedings of the Caribbean Food Crops Society. 44(2):196. 2008

The University of Florida IFAS Center for Tropical Agriculture

Richard E. Litz, Director, Center for Tropical Agriculture, Tropical Research and Education Center, University of Florida, 18905 SW 280 St., Homestead FL 33031-3314. relitz@ufl.edu

ABSTRACT.
The Center for Tropical Agriculture aspires to be a major interdisciplinary center for tropical agriculture with expertise in capacity building, technical assistance, and research related to agriculture and agro-ecosystems in the humid tropics and subtropics. The Center provides capacity building for degree-seeking students and trainees who seek professional, leadership, and executive positions in tropical agriculture. Students can obtain postgraduate minors in Tropical Agriculture at the M.S. and Ph.D. levels. The Center addresses issues that impact tropical agriculture and agro ecosystems of Florida and of the humid tropics and subtropics worldwide. The major focus areas include: 1) production agriculture for crops and livestock; 2) invasive species; 3) conservation and utilization of genetic resources and biodiversity; 4) effects of climate change on tropical agriculture; 5) environmental and economic sustainability of tropical agriculture; 6) food security and nutrition; and 7) food technology and safety.

KEYWORDS: interdisciplinary, humid tropics and subtropics, capacity building

2008 Proceedings of the Caribbean Food Crops Society. 44(2):197-203. 2008

Green Genetic Engineering Technology: The Use of Endogenous Genes to Create Fungal Disease-Resistant Grapevines

D.J. Gray[1], S.A. Dhekney[1], Z.T. Li[1] and T.W. Zimmerman[2], [1]Mid-Florida Research and Education Center, University of Florida/IFAS, 2725 Binion Rd., Apopka, FL 32703, USA and [2]Biotechnology & Agroforestry, University of the Virgin Islands, RR# 1, Box 10,000, Kingshill, St. Croix, VI 00850, USA djg@ufl.edu

ABSTRACT.

Use of genetic engineering technology to add disease resistance to otherwise desirable varieties is an attractive approach to establishing a *Vitis vinifera* L.-based agriculture in the Caribbean. Endogenous genes isolated directly from grapevine were engineered for enhanced expression and transformed into *V. vinifera* 'Merlot', 'Shiraz' and 'Thompson Seedless', plus *Vitis* hybrid 'Seyval Blanc'. Transgenic plant lines were selected via greenhouse screening based on resistance to powdery mildew. Outstanding lines were vegetatively propagated and established, along with non-transgenic controls, into USDA APHIS-approved field test sites at UVI St. Croix and UF/IFAS Florida in 2007. Vines grew rapidly and began to fruit in 2008. Based on preliminary results, certain transgenic lines exhibited significant resistance to black rot and anthracnose diseases compared to non-transgenic control lines. Because these are three of the most serious tropical/sub-tropical fungal diseases of *V. vinifera*, availability of resistant lines will provide new opportunities for production in the region. Our adaptation of endogenous genes to modulate disease resistance is a first step in creating "green transgenic plants" that contain only genetic elements from grapevine, thus eliminating concerns about incorporation of foreign genes in GMOs.

KEYWORDS: Grape, genetic engineering, disease resistance, *Vitis vinifera*

INTRODUCTION

Although established in the 1500s in the Caribbean region, *Vitis vinifera* L. grape has not become a major crop due to its susceptibility to tropical and sub-tropical diseases. However, consumption of grape is high. The US Virgin Islands imported 102,686 kg of fresh grapes worth $236,000 in 2004. Florida is the 2nd largest consumer of grape products in the US but imports nearly all of this commodity because the market prefers varieties of *V. vinifera*.

Grape is grown in the Caribbean region both as a small farm crop and in commercial plantings. Accurate data for acreages planted are not available because some production occurs in small farm settings that are not surveyed. Grape production in Florida is estimated to be about 2,000 acres, although the extent of many small farm plantings and U-picks have not been evaluated. Both Florida, located roughly between

25° and 30° N latitude, and the Greater Antilles at nearly 20° N latitude share similar growing conditions for grape production (Watlington, 1990).

Grape is a high-value crop, prized for its multiple uses as a fresh fruit and processed food products (jelly, juice, raisins & wine). A host of anti-oxidants and vitamins found in grape and its products help prevent heart disease and cancer. Physicians now recommend drinking a glass of wine each day as a health supplement. The health attributes of grape have become increasingly well documented. For example, grape is an excellent source of soluble fiber. These attributes have contributed to make grape the world's most important fruit crop, including a major crop in the United States (FAOSTAT, 2002). In particular, wine represents the single most valuable product produced from a fruit crop, where as little as a pound of fruit can be converted into a bottle of wine.

In Florida, the average price for a bottle of locally-produced wine is $9.00. There have never been "wine gluts" of locally-produced product and our existing market is so large as to accommodate significant growth. Along with the over-demand for existing local varieties, there is continual interest expressed by vintners and consumers in local production of conventional *V. vinifera* varieties to take advantage of the Florida market.

There currently exists an immense potential for increased cultivation of conventional grape products in the Caribbean region if improved varieties suitable for the region are developed. For example, Florida's wine market has an annual turnover of $1.5 billion and the state is typically ranked *second* to California in wine consumption (Business Wire, 2003). Other than the very small amount of local production (well under 1% of total consumption), all grape products sold in Florida and the rest of the Caribbean must be imported. This is due to the severe obstacle to local cultivation and production imposed by diseases (see below). In the Caribbean region, wine consumption by locals and tourists is high with most of the wine and other grape products imported from the United States and Europe. In the Virgin Islands, with a population of 100,000, fresh grape imports have been steadily increasing. Agriculture and tourism are the backbone of many economies in the Caribbean region and there exists a need for the expansion of high income agri-industrial crops such as grape, which grows well under permanent minimal tillage cultivation, even on degraded hilly terrain (Olmo, 1979). In addition to providing impetus for increase in grape-related industries, expansion of grape cultivation could provide supplementary income for many families that subsist in marginal rural areas and/or depend on irregular low wage jobs in urban-centered economies (Lewis and Thiele, 1979).

Although several thousand grape varieties are known, only about 50 comprise the majority of plants cultivated for production (Winkler, 1962). With few exceptions, these varieties originated in antiquity; they are highly prized for specific varietal qualities (i.e., genetically-fixed phenotypic traits), whether it be for fresh fruit (e.g., 'Thompson Seedless' is responsible for 40% of US grape acreage) or wine (e.g., numerous varieties like 'Cabernet Sauvignon', 'Chardonnay', 'Merlot'). Improvement via genetic transformation offers the possibility of adding only desirable traits to existing varieties without disturbing phenotypic attributes. It is not possible to utilize breeding to introgress single traits into elite varieties.

Genetic transformation allows transfer of single or a few genes into existing varieties without otherwise altering the genetic milieu of the plant and is particularly

useful in grape due to the aforementioned genetic constraints and needs. Transfer of genes across phylogenetically divergent organisms has resulted in creation of transgenic crops with high agronomic value but has also raised concerns because of their ecological and evolutionary novelty including the following: 1) Movement of transgenes to unwanted species and landraces and their impact on native ecology, 2) Potential health issues stemming from use of antibiotic resistance markers, and 3) Possible unforeseen allergenic qualities of transgenic protein.

Certain concerns about implementation of GMO technology might be allayed if endogenous genes from the grape genome itself were used for genetic improvement through over-expression strategies. Recent advances in plant molecular biology have greatly facilitated efforts to isolate plant genes associated with agronomic traits. Such native endogenous genes already exist in a plant's genome and can be recovered and analyzed. The re-engineered genes then are placed in a construct with a promoter chosen to provide desired expression characteristics and the construct is re-inserted into the desired plant. Such genes often modify metabolism in a manner similar to natural or induced mutations without causing genetic contamination (Strauss, 2003). The improvements achieved should be similar qualitatively to those obtained via traditional breeding approaches, but significantly better quantitatively, due to the ability to over-express desired proteins, both temporally and spatially. The present report provides progress to date of inserting such endogenous genes into grape and testing the resulting GM grapevines for disease resistance in field plots.

MATERIALS AND METHODS

Genetic engineering of grapevine was accomplished as previously described (Dhekney et al. 2008; Li et al. 2006, 2008). Two different endogenous genes were inserted into into *V. vinifera* 'Merlot', 'Shiraz' and 'Thompson Seedless', plus *Vitis* hybrid 'Seyval Blanc'. Gene *vvtl-1* is the *Vitis vinifera* thaumatin-like protein gene 1, and *eg*-2 is a proprietary endogenous gene, both cloned from grapevine via standard techniques.

All genes were placed into a proprietary bi-directional duplex promoter (BDDP) system (Li et al. 2004) that also contained an enhanced green fluorescent protein gene (*egfp*) for visual detection of transformed cells, tissues and plants. The *egfp* gene was fused to a neomycin phosphotransferase gene (*nptII*), which confers resistance to the antibiotic kanamycin for selection of transgenic cells. The resulting *egfp/nptII* fusion gene was previously described by Li *et al.,* (2001).

Transformed plants were recovered and independently transformed lines were evaluated in a greenhouse for resistance to powdery mildew disease. Plants that were most resistant to disease were selected, cloned to produce replicates and established in field plots in Florida and the US Virgin Islands.

RESULTS AND DISCUSSION

Transgenic grapevines and non-transgenic controls were placed into USDA APHIS approved field plots at the University of the Virgin Islands (UVI), St. Croix campus in January 2007 and at the UF/IFAS Mid-Florida Research and Education Center (MREC) at Apopka Florida in April 2007. All plants grew rapidly. Minimal fungal disease control was administered. In particular, Ridomil™ was applied as needed to

control downy mildew, an oomycetous fungal disease that the subject genes would not control. At the UVI site, a significant problem encountered in larger vines was chlorosis, which was inferred to be cause by pH imbalance due to a limestone under layer. In 2008, certain vines at both sites produced fruit, which was somewhat unexpected because grapevine typically requires 2 – 3 years of growth for maturation to fruiting stages. At the MREC site, resistance to black rot and anthracnose diseases was observed in 2 out of 5 lines tested, when compared to controls. During this time, the vines had received only Ridomil™ control. However, as summer progressed, resistance under conditions of no fungal disease control began to break down. In August 2008, we instituted a typical broad spectrum disease control regime and will continue to evaluate resistance for the remainder of the 2008 season. Several seasons will be required to properly evaluate the plants over time. Unfortunately, TSTAR funding was curtailed for non-invasive pest research in Florida, such that renewed support will come from other sources.

It is important to note that the genes used in this study to control fungal diseases are native to grapevine. For example, VVTL-1 belongs to a group commonly known as PR (pathogenesis related) protein genes, several of which have been cloned and expressed in plants. They have been grouped (PR 1 to PR 5) based on their structure and mode of action (Punja 2001). A number of PR proteins exhibit antifungal properties, which variously cause inhibition of fungal cell wall synthesis and/or a disruption in cell wall structure leading to cell lysis (Seliterennikoff 2001). PR proteins are classified into different groups including cysteine rich antimicrobial peptides (Broekaert et al. 1992; Cammue et al.1995; Epple et al.1997; Thevissen et al. 2000), glucanases and chitinases (Nielsen et al.1997), chitin binding proteins (Van Damme et al.1999) and thaumatin like (TL) proteins (Selitremmikoff 2001). The PR proteins have been cloned from a number of commercial crop plants like rice (Agrawal et al. 2000), wheat (Rauscher et al.1999), barley (Byrngelsson et al.1994), tobacco (Ponstein et al. 1994), tomato (Van Damme et al.1999) and other plants.

The PR 5, or thaumatin like (TL) proteins, share significant amino acid homology to thaumatin (Selitremmikoff 2001). TL proteins inhibit a wide range of plant pathogens *in vitro* (Selitremmikoff 2001) and have been cloned from several plant species (Huynh et al. 1992; Hu and Reddy 1997; Cheong et al. 1997; Koiwa et al. 1998). TL proteins are known to be differentially expressed in reproductive tissues such as pistils and ripening fruits (Neale et al. 1990; Vu and Huynh 1994; Fils-Lycaon et al. 1996; Barre et al. 2000). The UF/IFAS grape biotechnology laboratory cloned *V. vinifera* thaumatin-like protein (VVTL-1) from grapevines derived from embryogenic cultures that were subjected to *in vitro* selection with the culture filtrate of *Elsinoe ampelina*, the causal agent of grapevine anthracnose (Jayasankar et al. 2003). Protein produced from VVTL-1 significantly inhibited *E. ampelina* spore germination and hyphal growth *in vitro*. Plants regenerated from *in vitro* selected cultures similarly inhibited fungal growth in leaf assays. Similar results have been obtained with VVTL-2 cloned from grape, which was expressed in leaves and ripening berries in response to powdery mildew infection (Jacobs et al.1999; Tattersall et al. 1997) and exhibited antifungal properties (Salzman et al. 1998).

Gene *eg-2* is another endogenous gene from grape that produces a naturally-occurring protein. We recorded resistance to powdery mildew in greenhouse screening studies of plants transformed with vvtl-*1* or eg-*2*, which led to the current field trials.

Both VVTL-1 and EG-2 proteins occur naturally in ripened berries of grape. As such, there is no reason to believe that there are any human health-related toxicological issues associated with its expression in transgenic grapevines.

As techniques of molecular biology have developed and become refined, so has our knowledge of genomics (Li, 2005). In particular, our understanding of how genes function and regulate plant growth and development has increased immensely. This has led to our ability to identify the endogenous genes that render disease resistance to plants. Our use of endogenous genes in this manner is novel for grape, but not for other plants. However, their over-expression in a bi-directional duplex promoter system does constitute a new approach to re-engineering plants that contain only native DNA and proteins. This "green" approach should alleviate many concerns expressed by producers and consumers regarding the use of plants modified with molecular techniques vs. traditional plant breeding.

REFERENCES

Agrawal, G.K., Jwa, N.S., and Rakwal, R. 2000. A novel rice (*Oryza sativa* L.) acidic PR1 gene highly responsive to cut, phytohormones, and protein phosphatase inhibitors. Biochememical Biophysical Research Communications, 274:157-65.

Barre, A., Peumans, W.J., Menu-Bouaouiche, L., Van Damme, E.J.M., May, G.D., Herrera, A.F., Van Leuen, and H.F., Rouge, P. 2000. Purification and structural analysis of an abundant thaumatin like protein from ripe banana fruits. Planta211:791-799.

Broekaert, W.F., Terras, F.R., Cammue, B.P., and Osborn, R.W. 1992. Plant defensins: novel antimicrobial peptides as components of host defense systems. Plant Physiology, 108:1353-1358.

Bryngelsson, T., Sommer-Knudsen, J., Gregersen, P.L., Collinge, D.B., Ek, B., and Thordal-Christensen, H. 1994. Purification, characterization, and molecular cloning of basic PR-1 type pathogenesis-related proteins from barley. Molecular Plant Microbe Interactions, 7:267-275.

Business Wire 2003. Wines from around the world to be introduced for the first time at the 2nd Annual Miami International Wine Fair Sept 17th 2003.

Cammue, B.P.A., M.F.C. De Bolle, F.R.G. Terras, P. Proost, J. Van Damme, S.B. Rees, J. Vanderleyden, and W.F. Broekaert. 1992. Isolation and characterization of a novel class of plant antimicrobial peptides from *Mirabilis jalapa* L. seeds. Journal Biological Chemistry, 267: 2228-2233.

Cheong, N.E., Choi. Y.O., Kim, W.Y., Bae, I.S., Cho, M.J., Hwang, I., Kim, J.W., and Lee, S.Y. 1997. Purification and characterization of an antifungal PR 5 protein from pumpkin leaves. Molecular Cells, 7:214-219.

Dhekney, S.A., Li, Z. T., Dutt, M. and Gray, D. J. 2008. *Agrobacterium*-mediated transformation of embryogenic cultures and regeneration of transgenic plants in *Vitis rotundifolia* Michx. (muscadine grape). Plant Cell Reports 77: 865-872.

Epple, P., Apel, K., and Bohlmann, H. 1997. Overexpression of an endogenous thionin enhances resistance of *Arabidopsis* against *Fusarium oxysporium*. Plant Cell, 9: 509-520.

FAOSTAT 2002. Faostat.fao.org

Fils-Lycaon, B.R., Wiersma, P.A., Eastwell, K.C., and Sautiere, P. 1996. A cherry protein and its gene, abundantly expressed in ripening fruit have been identified as thaumatin like. Plant Physiology, 111:269-273.

Hu, X. and Reddy, A.S. 1997. Cloning and expression of a PR-5 like protein from *Arabidopsis*. Plant Physiology, 107:305-306.

Huynh Q.K., Borgmeyer, J.R., and Zobel, J.F. 1992. Isolation and characterization of a 22kDa protein with antifungal properties from maize seeds. Biochemical Biophysical Research Communications, 182:1-5.

Jacobs, A.K., Dry, I.B., and Robinson, S.P. 1999. Induction of different pathogenesis-related cDNAs in grapevine infected with powdery mildew and treatment with ethephon. Plant Pathology, 48: 325–336.

Jayasankar, S., Li, Z., and Gray, D.J. 2003. Constitutive expression of *Vitis vinifera* thaumatin like protein after *in vitro* selection and its role in anthracnose resistance. Functional Plant Biology, 30:1105-1115.

Koiwa, H., Kato, H., Nakatsu, T., Oda, J., Yamada, Y., and Sato, F. 1998. Crystal structure of tobacco PR 5d protein at 1.8A resolution reveals a conserved acidic cleft structure in antifungal thaumatin like proteins. Journal Molecular Biology, 286:1137-1145.

Lewis, I.R., and Thiele, G.F. 1979. Vineyards in the year 2000. Socio economic pressures. Acta Horticulturae, 104, 33-48.

Li, Z.T. 2005. Software databases as tools for analyzing nucleic acids and protein sequences. In: Plant Development and Biotechnology Ed. Gray, D.J., Trigiano, R.N., CRC Press, Boca Raton, 101-118.

Li, Z.T., Dhekney, S. A., Dutt, M., Van Aman, M. Tattersall, J., Kelley, K. T. and Gray, D. J. 2006. Optimizing *Agrobacterium*-mediated transformation of grapevine, In Vitro Cellular Developmental Biology Plant. 42: 220-227.

Li, Z.T., Dhekney, S. A., Dutt, M. and Gray, D. J. 2008. An Improved Protocol for *Agrobacterium*-Mediated Transformation of Grapevine. Plant Cell Tissue Organ Culture 93: 311-321.

Li, Z., Jayasankar, S. and Gray, D. J. 2001. Expression of a bifunctional green fluorescent protein (GFP) fusion marker under the control of three constitutive promoters and enhanced derivatives in transgenic grape (*Vitis vinifera*), Plant Science 160: 877-887.

Li Z.T., Jayasankar S., and Gray D.J. 2004. Bi-directional duplex promoters with duplicated enhancers significantly increase transgene expression in grape and tobacco. Transgenic Research, 13:143-154.

Neale, A.D., Wahleithner, J.A., Lund, M., Bonnett, H.T., Kelly, A., Meeks Wagner, D.R., Peacock, W.J., and Dennis, E.S. 1990. Chitinase, β-1,3-glucanase, osmotin, and extensin are expressed in tobacco explants during flower formation. Plant Cell, 2:673-684.

Nielsen, K.K., Nielsen, J.E., Madrid, S.M., and Mikkelsen, J.D. 1997. Characterization of a new antifungal chitin-binding peptide from sugar beet leaves. Plant Physiology, 113:83-91.

Olmo, H.P. 1979. Vineyards in the year 2000: Technical pressures. Acta Horticulturae., 104, 11-19.

Ponstein, A.S., Bres-Vloemans, S.A., Sela-Buurlage, M.B., van den Elzen, P.J.M., Melchers, L.S., and Cornelissen, B.J.C. 1994. A novel pathogen- and wound-inducible tobacco (*Nicotiana tabacum*) protein with antifungal activity. Plant Physiology, 104:109–118.

Punja, Z. 2001. Genetic Engineering of plants to enhance resistance to fungal pathogens-a review of progress and future prospects. Canadian Journal of Plant Pathology, 23:216-235.

Rauscher, M., Adam, A.L., Wirtz, S., Guggenheim, R., Mendgen, K., and Deising, H.B. 1999. PR-1 protein inhibits the differentiation of rust infection hyphae in leaves of acquired resistant broad bean. Plant Journal, 19:625–633.

Salzman, R.A., Tikhonova, I., Bordelon, B.P., Hasegawa, P.M., and Bressan, R.A. 1998. Coordinate accumulation of antifungal proteins and hexoses constitutes a developmentally controlled defense response during fruit ripening in grape. Plant Physiolology, 117: 465–472.

Seliterennikoff, C.P. 2001. Antifungal Proteins. Applied Environmental Microbiology, 7:2883-2894.

Strauss, S.H. 2003. Genomics, Genetic Engineering and Domestication of Crops. Science, 300:61-62.

Tattersall, B.D., van Heeswijck, R., Bordier, and Hoj, P. 1997. Identification and characterization of a fruit-specific, thaumatin-like protein that accumulates at very high levels in conjunction with the onset of sugar accumulation and berry softening in grapes. Plant Physiolology, 114:759-769.

Thevissen, K., Ghazi, A., Smablanx, C., Bownlee, R., Osborne, R.W., and Broekaert, W. F. 2000. Specific binding sites for an antifungal plant defensin from Dahlia (*Dahlia merckii*) on fungal cells are required for antifungal activity. Molecular Plant Microbe Interactions, 13:54-61.

Van Damme, E.J., Charels, D., Roy, S., Tierens, K., Barre, A., Martins, J.C., Rouge, P., Van Leuven, F., Does, M., and Peumans, W.J. 1999. A gene encoding a heavein like protein from elderberry fruits is homologous to PR-4 and class V chitinase genes. Plant Physiology, 119:1547-1566.

Vu, L. and Huynh, Q.K. 1994. Isolation and characterization of a 27 kDa antifungal protein from the fruits of *Diospyros texana* . Biochemical Biophysical Research Communications, 202:666-672.

Watlington F.L. 1990. Adaptive viticulture in the Caribbean basin. A PhD dissertation submitted to the University of Florida, 1990.

Winkler, A.J. 1962. General Viticulture, University of California Press, Berkley, California.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):204-211. 2008

El Virus de la Tristeza de los Cítricos (CTV) en Plantaciones Comerciales y Viveros de la República Dominicana

Luís Matos[1] y Julio Borbón[2]. [1]Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF) y [2]Facultad de Ciencias Agronómicas y Veterinarias, Universidad Autónoma de Santo Domingo (UASD), Santo Domingo, República Dominicana. lmatos@idiaf.org.do

RESUMEN:
El Virus de la Tristeza de los Cítricos (CTV) es la principal limitante de la producción citrícola en la República Dominicana. En el período marzo a octubre del 2007 se realizaron muestreos en viveros y plantaciones comerciales para determinar el estatus actual del CTV. Se muestrearon nueve viveros tomando entre 1 y 2% del total de plantas para un total de 700 plantas muestreadas. A nivel de campo se muestrearon 42 plantaciones en 18 provincias del país, tomando 3200 muestras. Se usaron bloques de 400 plantas con una configuración de 20 hileras x 20 plantas, tomando 100 muestras en cada uno. Seis diferentes cultivares fueron muestreados, los cuales fueron, naranjas dulces (cv. 'Valencia' y 'Washington Navel'), limón 'Persa', mandarinas, toronjas y limón 'Criollo' ('Lima Mexicana'). Se utilizó la técnica serológica de impresión directa del tejido (DTBIA) sobre membranas de nitrocelulosa de 0.45 µm. Se usaron dos tipos de anticuerpos monoclonales, uno de los cuales (MCA-13) reconoce las razas severas y el otro compuesto de la mezcla de dos anticuerpos (3DF1-3CA5), que reconocen todas las razas del CTV. Los análisis indican que siete de los nueve viveros muestreados reaccionaron a ambos anticuerpos, mientras que en las muestras de campo todas fueron positivas a ambos anticuerpos. Estos resultados muestran que el CTV está ampliamente distribuido en las diferentes regiones productoras de cítricos del país. Los resultados de viveros presentan altos niveles de contaminación, indicando que las fuentes de yemas utilizadas por los viveristas están contaminadas. No hubo diferencias en los resultados entre los diferentes anticuerpos utilizados, por lo que las razas severas y no severas están interactuando juntas en la citricultura dominicana.

PALABRAS CLAVES: CTV, anticuerpos monoclonales, análisis serológicos.

The Citrus Tristeza Virus (CTV) in Commercial Orchards and Nurseries in the Dominican Republic

Luis Matos[1] & Julio Borbón[2] [1]Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF), and [2] Facultad de Ciencias Agronómicas y Veterinarias, Universidad Autónoma de Santo Domingo (UASD), Santo Domingo, Dominican Republic. lmatos@idiaf.org.do

ABSTRACT:
The Citrus Tristeza Virus (CTV) represents the most important disease in Dominican citrus production. From March to September 2007, a survey was carried out to determine the actual status of the CTV. Nine nurseries were sampled taken consisting of 1 or 2 % of

total trees according their size; in total, 700 samples were collected. During the field sampling, 42 orchards were sampled in 18 provinces around the country, with 3200 trees sampled. A plot design of 400 trees (20 rows x 20 trees) was used taking 100 samples from each one. Six different cultivars were sampled: sweet oranges (cv. 'Valencia' and 'Washington Navel'), Persian lime, grapefruit, mandarin and Criollo lime ('Mexican lime'). Direct Tissue Blot Immunoassay (DTBIA) using nitrocellulose membranes 0.45 µm was used for serological test. Two types of different monoclonal antibodies were used, one of them (MCA-13) to detect severe strains of the CTV, and a mixture of two antibodies (3DF1-3CA5) for general strains. The nursery surveys showed that seven out of nine were positive to both antibodies, while in the field samples all of them were positive to both antibodies. At the same time the results of the nurseries showed, that budwood used in different nurseries are highly infected with CTV. There were no differences between both antibodies used in these test. These results suggest a relatively homogeneous population of severe and mild strains of CTV dispersed throughout the Dominican Republic.

KEYWORDS: CTV, monoclonal antibodies, serological tests

INTRODUCCION

En la República Dominicana el cultivo de cítricos es uno de los principales rubros frutícolas. Las áreas en producción de los diferentes cultivares de cítricos rondan las 30 mil hectáreas (Prodefrut, 2003), con una producción que supera las 450 mil toneladas métricas por año (*H. Puello, comunicación personal*). De la superficie destinada a la producción de cítricos, más del 50% es cultivada con naranjas dulces (*Citrus sinensis* [L.] Osb.), principalmente de la variedad 'Valencia'. En orden de importancia les siguen el limón Persa (*C. latifolia* Tan.), las mandarinas (*C. reticulata* Blanco), y las toronjas (*C. paradise* Macf.), entre otros.

El sector citrícola nacional, ha tenido grandes dificultades ya que el cultivo es atacado por un gran número de enfermedades, que reducen la producción considerablemente. Los cítricos normalmente son propagados de forma asexual con el uso de injertos, y esta es la principal vía de entrada de patógenos intracelulares cuando los materiales de propagación, que se utilizan, no están libres de enfermedades.

El Virus de la Tristeza de los Cítricos (CTV, por sus siglas en inglés) es una de las principales enfermedades transmitidas por injerto. El CTV, después de haber sido reportado por primera vez en el país por Lee (1990), se ha convertido en la principal limitante en la producción nacional de este rubro motivado principalmente por la presencia del vector *Toxoptera citricida* Kirkaldy (Hemiptera: Aphididae) (Abud, 1992). La interacción de estos dos eventos produjo una rápida dispersión de las razas suaves del CTV en plantaciones comerciales (Garnsey, 1996). En zonas tradicionales de producción como las provincias de Hato Mayor y Monte Plata y en otros lugares donde se ha usado el patrón de Naranja agria (*C. aurantium* L.), los daños ocasionados por la enfermedad han sido significativos.

Durante la década de los 90's se realizaron en el país monitoreos tendentes a evaluar el desarrollo de la enfermedad con la presencia del vector *T. citricida*. Estos muestreos indicaron una amplia diseminación de un aislamiento suave del CTV, muy similar al existente en Florida. Entre 1996 y 1997 se reportaron dos razas del CTV en

zonas específicas de campos de producción localizados en la provincia de Hato Mayor y una pequeña área de la provincia Monte Plata (Garnsey *et al.,* 2000). Con el objetivo de conocer el estatus del CTV en plantaciones comerciales y viveros en la República Dominicana, fue realizado un muestreo a nivel nacional, en las principales zonas productoras de cítricos del país.

MATERIALES Y METODOS

Ubicación y Alcance del Estudio:

Para la presente investigación se realizaron muestreos en 18 provincias del país, haciendo mayor énfasis en aquellas donde se concentran las principales plantaciones de cítricos. Además, otras provincias donde no existe un gran desarrollo de este cultivo también fueron muestreadas, entendiendo que en estas últimas existe un alto potencial de producción. Los análisis de muestras fueron realizados en el laboratorio de Virología del Centro de Tecnologías Agrícolas (CENTA), del Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF) ubicado en Pantoja, Los Alcarrizos, Provincia de Santo Domingo.

Provincias, Cultivares Muestreadas y Número de Muestras:

Las diferentes provincias, cultivares muestreados y el numero de muestras colectados a nivel de campo y de viveros se indican en el Cuadro.1.

Cuadro. 1. Provincias, cultivares y número de muestras.

Región/provincia	Cultivares muestreados	No. total de muestras
REGION ESTE		
Hato Mayor	Valencia/Limón Persa/Toronjas/Mandarinas	750
La Altagracia (Higüey)	Mandarinas/Limón Persa	150
El Seybo	Washington Navel	75
San P de Macorís	Limón Persa / W. Navel	100
REGIÓN SUR		
Bahoruco	Limón Criollo	25
Peravia (Baní)	Limón Persa	150
San José de Ocoa	Limón Persa	75
San Juan	Limón Persa	25
San Cristóbal	Valencia/Mandarinas/Limón Persa	250
Azua	Limón Persa	200
REGIÓN CENTRAL		
Santo Domingo	Limón Persa	250
Monte Plata	Valencia/Mandarina/Limón Persa, Toronjas	650
Sánchez Ramírez	Valencia	200
REGIÓN NORTE Y NOROESTE		
Santiago	Limón Persa	90
San Fco. Macorís	Limón Persa	175
La Vega	Limón Persa	110

Monte Cristo	Limón Persa	125
Total muestras de campo		3,200
Muestras de viveros	Valencia, Pineaple, Washington Navel, Limón Persa, Mandarinas	700
Total de muestras		3,900

Muestreos en Viveros:

Los viveros muestreados son representativos de la producción y comercialización de plántulas de cítricos en cada región del país. En los viveros muestreados se seleccionaron el 1% ó 2 % del total de las plantas, de acuerdo al tamaño del vivero los cuales estuvieron en un rango aproximado de 2000 plantas los pequeños y 40,000 los mas grandes, a mayor número de plantas se tomó el 1% y en los viveros pequeños el 2% aproximadamente. En total se muestrearon nueve viveros localizados en las provincias Santo Domingo, San Cristóbal, Monseñor Nouel, y Hato Mayor. El número total de muestras colectadas fue de 700.

Muestreos de Campo:

En plantaciones mayores de 5 ha, las muestras fueron colectadas en bloques de 400 plantas en 20 hileras de 20 plantas. Se tomaron cuatro plantas adyacentes, dos de cada hilera, luego de seis pares de plantas se tomaron cuatro plantas de la misma manera. De esta forma se recolectaron 100 plantas en cada bloque de 400 plantas siguiendo la metodología descrita por (Gottwald *et al.,* 2000 y Hughes *et al.,* 1998). Las muestras consistieron en un brote tierno por planta, y cuando no fue posible obtenerlos se tomó un pedúnculo de frutos nuevos o tiernos por planta. Los cultivares o variedades muestreadas fueron 'Valencia', 'Washington Navel', limón Persa, mandarinas, toronjas y limón Criollo. Los muestreos fueron realizados desde el mes de marzo a septiembre del 2007.

Procesamiento de las Muestras:

Los brotes tiernos colectados como muestras se les quitaron las hojas dejando solo los tallos, los cuales fueron cortados en los dos extremos y se realizó la impresión de ambos cortes en las membranas de nitrocelulosa. Las membranas de nitrocelulosa fueron cortadas en tamaños de 42 cm^2 (6 cm x 7 cm) y sub-divididas en 110 cuadrículas de 0.36 cm^2 (0.8 cm x 0.8 cm). De cada muestra se tomaron impresiones en membranas dobles, una para los análisis de las razas severas con el anticuerpo MCA – 13 y otra para CTV en general con los anticuerpos 3DF1 y el 3CA5. En total se colectaron 3900 muestras en dieciocho provincias del país, donde 3200 corresponden a plantaciones de campo y 700 de viveros.

Análisis de las Muestras:

Los análisis fueron realizados usando la técnica de Impresión Directa del Tejido sobre Membranas de Nitrocelulosa (DTBIA, por sus siglas en Inglés) y conocida también como inmunoimpresión (Garnsey *et al.,* 1994). En este caso se usaron membranas de nitrocelulosa de 0.45 μm (micrones) (Bio-Rad Corp. Missouri, EE.UU.). Se colocaron 110 muestras por cada membrana de nitrocelulosa de 42 cm^2 descrita previamente. Para los análisis se usaron dos tipos de anticuerpos monoclonales, el MCA-13 (Nokomis Corp,

Florida, EE.UU.), que solo reconoce las razas severas del CTV (Permar *et al.,* 1990), y otro tipo que reconoce cualquier raza del virus, compuesto por la mezcla de anticuerpos contenidos en un kit comercial (Ingenasa, España). Estos anticuerpos son 3DF1 y el 3CA5 que reconocen cualquier raza del CTV (Vela *et al.,* 1988).

Las membranas de nitrocelulosa que contienen las impresiones de las muestras se colocaron en una placa Petri de 9 cm de diámetro, donde se les adicionó la leche descremada al 2 % por 45 minutos (Sigma Corp., Missouri, EE.UU.) disuelta en un búfer fosfatado salino (PBS por sus siglas en Inglés). Luego se les adicionó el anticuerpo MCA-13 por dos horas, seguido de la adición del antiespecie por una hora, según ha sido descrito por Garnsey *et al*., 1994. Las muestras fueron leídas después de la adición de Nitro Blue Tetrazolium/ Bromo-Cloro- Indopenil Fosfato (NBT/BCIP, Sigma Corp. Missouri, EE.UU.) en 10 ml de agua destilada. Para facilitar esta reacción, se colocaron las membranas en la oscuridad por cinco minutos y con la ayuda de un estereoscopio se leyeron los resultados tomando como parámetros un testigo positivo y uno negativo colocado al inicio del análisis. Esta coloración desarrollada en las muestras debía coincidir con la del testigo positivo (Garnsey *et al.,* 1994). Para los anticuerpos 3DF1 y 3CA5 que reconocen cualquier raza del CTV, se siguieron las especificaciones del fabricante del kit (Ingenasa, Madrid, España).

RESULTADOS Y DISCUSION

Análisis de muestras de viveros:

Los resultados de los viveros muestreados indican que las fuentes de yemas usadas por la mayoría de los viveristas nacionales están infectadas del CTV. Es preciso señalar, que solo las plántulas procedentes de plantas madres traídas de Martinica en el año 2000 y que son preservadas en túneles anti-insectos no reaccionaron a ninguno de los anticuerpos usados. Borbón *et al.,* (1995) realizaron muestreos en bancos de yemas y de viveros y no reportaron la presencia del CTV en los viveros muestreados. Según los resultados obtenidos en el presente estudio la presencia del CTV en los viveros se ha incrementado en más de un 80% en los últimos diez años. Esta situación de alta contaminación en los materiales de propagación puede considerarse como uno de los principales factores del movimiento y dispersión del CTV en el territorio nacional.

Análisis en muestras de campo:

Los resultados de los análisis serológicos se obtuvieron a partir de los anticuerpos monoclonales MCA-13 y 3DF1 - 3CA5. Todas las muestras colectadas a nivel de campo analizadas con los diferentes anticuerpos fueron positivas al CTV. En ese sentido no hubo diferencias en los resultados obtenidos por anticuerpos utilizados. Es decir, las 1075 plantas muestreadas en la Región Este fueron positivas a la mezcla de anticuerpos 3DF1 y el 3CA5, los cuales reconocen cualquier raza del CTV, mientras que igual número de muestras resultaron positivas al anticuerpo MCA-13 que solo reconoce las razas severas.
En la Región Central compuesta de las provincias de Santo Domingo, Monte Plata, Sánchez Ramírez (Cotuí), donde se colectaron 1100 muestras en total, todas fueron positivas a la mezcla de anticuerpos 3DF1 y 3CA5, y además al MCA-13. Igual situación se registró en la Región Sur en las provincias de Peravia, Azua, San Juan de la Maguana, San Cristóbal, Neyba y San José de Ocoa. En total, 675 muestras dieron positivos en ambos análisis serológicos realizados. En la Región Norte y Noroeste donde

se tomaron en conjunto 450 muestras de limón Persa todas fueron positivas a los anticuerpos usados.

La incidencia en áreas tradicionales de producción donde previamente se habían reportados las razas severas del CTV en comparación con las áreas no tradicionales no mostraron diferencias, indicando que tanto los efectos del áfido vector, *T. citricida*, como el uso de material de propagación contaminado pueden ser las principales causas de la dispersión del CTV. En estudios previos, publicados en 1995, Gottwald *et al.,* no reportaron la presencia de razas severas del CTV en cuatro bloques de estudios localizados, dos en Hato Mayor, uno en Bayaguana y otro en Villa Altagracia. No obstante, después de la aparición en 1996 y 97, de los primeros focos con razas que reaccionaron al anticuerpo monoclonal MCA-13, la incidencia fue relativamente baja hasta el año 2000. Por ejemplo, en la sección Sabana Grande, Hato Mayor, la incidencia fue menor al 8% al MCA-13, mientras que en el municipio de Villa Altagracia la incidencia estuvo entre 1 y 4 % (Garnsey *et al*., 2000). Los niveles de incidencia en ambas plantaciones en este estudio fueron de un 100%. Estos resultados coinciden con los obtenidos por Gottwald *et al.,* 1995, que indican que la incidencia de la raza suave del CTV, en un período de seis años, alcanzaron más del 90% de incidencia.

Desde el año 1998 no se habían realizado nuevos muestreos del CTV, por lo que, los efectos de este han sido muy notorios en aquellas zonas donde previamente se reportó el virus. En áreas como Hato Mayor un gran número de productores han abandonado la actividad citrícola; igual ha ocurrido en algunas áreas de la provincia de Monte Plata. En este estudio, en total se analizaron 3,900 muestras colectadas en 42 plantaciones y nueve viveros de cítricos localizadas en 18 provincias del país, donde se concentra más del 90% de los cítricos del país. De todas las muestras analizadas solo 180 de las 3,900 muestras no reaccionaron a los anticuerpos usados, lo que representa en términos porcentuales, que el 95.4 % de las plantas están contaminadas, ya sea con la raza severa, con la suave o con ambas.

Todas las muestras de campo fueron positivas a los diferentes anticuerpos utilizados, indicando que la dispersión se ha incrementado considerablemente, si tomamos como referencia los resultados obtenidos por Garnsey *et al.,* (2000), donde se registraron niveles de incidencia entre un 4 y 8 % en diferentes campos de producción. De estos resultados puede inferirse que el *T. citricida* ha sido el principal factor en la dispersión del CTV en el país. Esta inferencia confirma lo expresado por Gottwald *et al.,* (1998), de que el *T. citricida* puede realizar la dispersión del CTV con mayor eficiencia que cualquier otra especie de áfidos. Por ejemplo, en un muestreo inicial realizado en 1992, en un campo de producción de Villa Altagracia en un bloque de 400 plantas (20 hileras x 20 Plantas), 32 de estas plantas resultaron positivas a la razas suaves para una incidencia del 8 %. Este bloque fue muestreado de manera secuencial hasta el año 1998, registrando para ese entonces una incidencia de alrededor 90 %; es decir, 359 de las 400 plantas evaluadas reaccionaron positivamente a las razas suaves.

Los efectos del CTV han sido mayores en plantaciones establecidas sobre el patrón agrio; no obstante, cuando se usan patrones tolerantes la producción de naranjas no es afectada considerablemente. Por otra parte en cultivares como el limón Persa y toronjas los efectos se manifiestan sin importar el patrón utilizado, por lo que la acción del virus en estos cultivares es más notoria que en cualquier otro cultivar. Por su parte las

mandarinas representan uno de los cultivares mas tolerantes al CTV, aún estando injertadas sobre patrones de baja tolerancia al virus, como el *C. macrophylla* Webster.
El Virus de la Tristeza de los Cítricos, (CTV), está distribuido a nivel nacional, basado en los resultados de los análisis serológicos realizados a las muestras colectadas en 18 provincias donde se encuentran los principales viveros y plantaciones de cítricos del país. Los niveles de incidencia y distribución del CTV en la República Dominicana indican una clara necesidad de implementación de un programa de certificación de yemas y semillas de patrones de cítricos que garantice la calidad fitosanitaria de los materiales de propagación. El programa de certificación debe estar sustentado en saneamiento de las variedades comerciales a través del uso de microinjertos de ápices caulinares y una base legal que sustente las regulaciones requeridas para el correcto funcionamiento del programa.

AGRADECIMIENTOS

Agradecemos al Consejo Dominicano de Investigaciones Agropecuarias y Forestales (CONIAF) por aportar parte de los fondos utilizados en esta investigación. Además agradecemos a los citricultores y viveristas nacionales, especialmente al Consorcio Citrícola del Este (CCE), Consorcio Cítricos Dominicanos (CCD) y a la Asociación de Viveristas Dominicanos (AVIDO), por su colaboración.

REFERENCIAS

Abud, A. J. 1992. Áfido vector de la Tristeza de los Cítricos en República Dominicana. Naturalista Postal. Herbario Universidad Autónoma de Santo Domingo (UASD). NP 2/92.

Borbón, J. C., Matos, L., Garnsey, S M. y Gottwald, T. 1995. Muestreos del Virus de la tristeza de los cítricos en bancos de yemas y viveros de producción en la República Dominicana. *In:* Proceeding of the Third International Workshop. Citrus Tristeza Virus and the Brown citrus Aphid in the Caribbean Basin, Management Strategies. Lake Alfred, Florida. pp 127-132.

Garnsey S.M., Gottwald, T. R. and Borbón, J. C. 1996. Rapid Dissemination of Mild Isolates of Citrus Tristeza Virus Following introduction of Toxoptera citricida in the Dominican Republic. *In:* Proceeding of Thirteenth International Organization of Citrus Virologist Conference Riverside California. pp. 92-103.

Garnsey S. M, Permar, T. A., Cambra, M. and Herderson C. T. 1994. Direct Tissue Blot Immunoassay (DTBIA) for Detection of Citrus Tristeza Virus (CTV). *In:* Proceeding of Twelfth IOCV Conference. Riverside, California. pp. 39- 50.

Garnsey S. M. Gottwald, T. R.,. Hilf M E ,Matos, L. and. Borbón, J. C. 2000. Emergence and Spread of Severe Strains of Citrus Tristeza Virus in the Dominican Republic. *In*: Proceeding of Fourteenth IOCV Conference.Riverside, California. pp. 57-68.

Garnsey S. M., Cambra, M.. 1991. Enzyme – Linked Immunosorbent assays for Citrus Pathogens.p. 193-216, *In*: Roistacher, C. Graft-transmissible diseases of citrus. - Handbook for detection and diagnosis of graft-transmissible diseases of citrus. Food Agriculture Organization, Roma. 286 p.

Gottwald T. R., Garnsey, S. M. and Borbón, J.. 1998. Increase and Patterns of Spread of Citrus Tristeza Virus Infections in Costa Rica and Dominican the Republic in the

Presence of the Brown Citrus Aphid, Toxoptera citricida. In: The American Phytopathologycal Society (No. 1998. 0504-01R. Vol.88. No 7: 621-636.

Gottwald,T.R., and Hughes, G. 2000. A new survey method for citrus Tristeza diseases assessment. In: Proceeding of 14th Conference of IOCV, 77-87. IOCV, Riverside, CA.

Hughes, G., and Gottwald, T. R. 1998. Survey methods for assessment of citrus tristeza virus incidence when Toxoptera citricida is the predominant vector. Phytopathology 89: 487-494.

Lee, R. F. 1990. A survey for virus and virus-like diseases of tropical fruit in the Dominican Republic. Report to Junta Agroempresarial de Consultoría y Coinversiones (JACC), June 3-8, 1990, pp. 7.

Vela, C., Cambra, M. Sanz, A. and Moreno, P.. 1988. Use of specific monoclonal anti-bodies for diagnosis of citrus tristeza virus. *In*: Proc. 10th Conference International Organization of Citrus Virologist, Riverside. CA. pp. 55-61.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):212-216. 2008

Acibenzolar-S-Methyl and PGPR Increases Host Resistance in Squash to Phytophthora Blight Under Greenhouse Conditions

Shouan Zhang[1], Thomas L. White[1], Miriam C. Martinez[1], Joseph W. Kloepper[2], and Waldemar Klassen[1]. [1]Tropical Research & Education Center, University of Florida, IFAS, Homestead, FL, and [2]Department of Entomology and Plant Pathology, Auburn University, AL.

ABSTRACT.

Phytophthora blight disease caused by *Phytophthora capsici* Leonian threatens vegetable production worldwide. It is imperative to develop practical and cost-effective alternatives to methyl bromide in order to sustain production of vulnerable vegetables including squash in Florida. Greenhouse studies have been conducted to evaluate the potential of the use of Acibenzolar-S-methyl (ASM; Actigard 50WG) and plant growth-promoting rhizobacteria (PGPR; SE34 and IN973b) for control of Phytophthora blight on squash. Actigard at 30 and 3 mg/l and PGPR strain SE34 at 10^7 CFU/ml significantly ($P<0.05$) reduced disease severity of Phytophthora blight of squash compared to the nontreated control. Actigard at 30 mg/l provided the greatest protection in squash against *P. capsici*. No disease symptom developed on squash plants treated with Actigard at 30 mg/l while nontreated inoculated plants collapsed due to the infection of *P. capsici*. The results suggest that ASM and PGPR are effective against *P. capsici* in squash and may be incorporated in integrated management strategies for control of Phytophthora blight of squash.

KEYWORDS: *Phytophthora capsici*, induced disease resistance, squash

INTRODUCTION

Phytophthora blight, caused by the oomycete *Phytophthora capsici*, is one of the most serious threats to cucurbit production in the United States and worldwide (Babadoost 2004; Hausbek and Lamour 2004). *P. capsici* is a soil-borne pathogen and survives as oospores for many years in soil or as mycelia in plant debris. *P. capsici* infects a wide range of plant taxa involving a total of more than 50 species (Tian and Babadoost 2004), including major vegetable crops and weeds. Recently, the incidence of Phytophthora blight has dramatically increased in many cucurbit-growing areas, causing up to 100% yield loss (Babadoost 2004; Hausbek and Lamour 2004). Summer squash in south Florida is highly susceptible to *P. capsici* causing foliar blight and fruit rot (Roberts *et al.* 2001), and winter squash is also of concern to Florida producers.

P. capsici can infect squash plants at any stage of growth. Symptoms of Phytophthora blight include seed rot, seedling damping-off, leaf and vine blight, and fruit rot. Considering the pathogen's tremendous ability to reproduce, and given the optimal conditions of warm, wet weather in south Florida, *P. capsici* can devastate a whole field of squash within several days. In 2007, several squash growers in Miami-Dade County, Florida, who produced calabaza for the Florida and New Jersey markets for many years,

have ceased this line of operation because of disastrous crop losses from Phytophthora blight (Julian Guillarte, personal communication).

Practices available for management of soil-borne pathogens such as *P. capsici* in the field include cultural practices, crop rotation, fungicide applications, pre-plant fumigation and the use of resistant or tolerant varieties. At present, there is no single method which can provide adequate control of *P. capsici* (Babadoost 2004; Hausbek and Lamour 2004). Highly resistant varieties with ideal horticultural traits are not available for Florida (Olson *et al.* 2007). Crop rotation is an important component of integrated disease management; however, the long-term survival of *P. capsici* oospores even in the absence of a host limits the effectiveness of this strategy (Hausbek and Lamour 2004). There is a limited number of fungicides registered for use on cucurbits and no fungicides are highly effective against *P. capsici* (Babadoost 2004; Hausbek and Lamour 2004). More importantly, *P. capsici* has been reported to develop resistance to some fungicides applied for Phytophthora blight control (Hausbek and Lamour 2004).

Methyl bromide, a fumigant used extensively to control soil-borne pathogens, is effective against the mycelia and the long-term persistent oospores of *P. capsici* in the soil. However, agricultural emissions of methyl bromide have been shown to be a significant source of ozone depletion (EPA 2008; Spreen *et al.* 1995). Therefore, the phase-out of the use of methyl bromide has been ongoing under the 1989 Montreal Protocol. Consequently, many tomato and pepper growers in Florida are replacing the use of a mixture of methyl bromide and chloropicrin with a combination of 1, 3-dichloropropene (a nematicide) and herbicides; however, 1, 3-dichloropropene cannot be used in counties with karst geography, such as Miami-Dade County. Metam sodium and chloropicrin have been registered for control of *P. capsici* (Hausbek and Lamour 2004), but are less reliable than methyl bromide and chloropicrin mixtures. Methyl iodide and chloropicrin mixtures are highly effective against *P. capsici* and have been tested extensively for protection of tomato (Rosskopf *et al.* 2005). Recently, a 50:50 mixture of methyl iodide (MIDAS®) has been registered in Florida for use on ornamentals, strawberries, tomatoes, peppers, tree fruit, nuts and vines, as well as turf. (Arysta LifeScience Corp., 2008). However, the high cost of methyl iodide is likely to be a prohibitive factor for use of this product in squash production. Spreen *et al.* (1995) estimated that the loss of methyl bromide would result in a $1 billion impact on the US winter vegetable industry, mostly borne by Florida producers. The objective of this study was to evaluate acibenzolar-S-methyl (ASM) and plant growth-promoting rhizobacteria (PGPR) for their effect on Phytophthora blight of squash in the greenhouse.

MATERIALS AND METHODS

Greenhouse experiments were conducted with squash F1 hybrid HMX 5703 (provided by R. See, Seedway-SE Florida). Seeds of squash were planted in transplant flats containing potting mix. Two applications of the inducing agents were performed by soil drench at 1 and 2 weeks after planting (WAP), respectively. The treatments were ASM (Actigard® 50 WG, Syngenta, Inc.) at 30 and 3 mg/l, PGPR strains SE 34 and IN937b each at 1×10^7 CFU/ml, and silicic acid at 1.5 and 0.5 mM. Nontreated plants served as the blank control. Five milliliters of the cocktail inoculum (2×10^4 spores/ml), which contains equal number of zoospores for each of the three isolates (#121, #146 and #151, provided by Dr. P. Roberts) were applied to each plant at the time of inoculation by

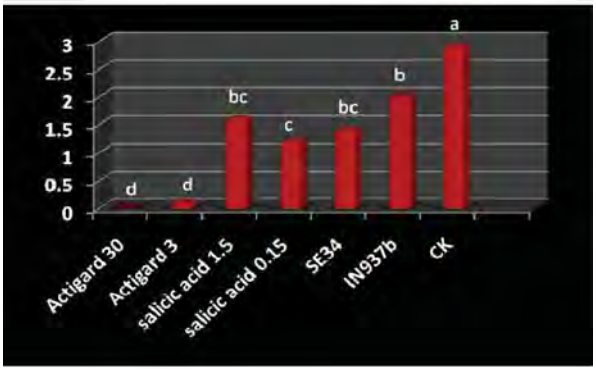
adding to the soil around the stem. Inoculated plants were placed on benches for 7 days when disease was rated according to a disease rating scale of 0-5. In this rating scale, 0 = no visible symptoms, 1 = small brownish lesion at the base of stem, 2 = stem lesions extend to cotyledons or the lesion has girdled the stem causing plant collapse, 3 = plants have collapsed with all leaves wilted or turned yellow except for the young leaves, 4 = plants have completely collapsed, and 5 = plants are dead. Treatments were arranged as randomized complete blocks with five replications and two plants per replication.

In other greenhouse assays, Actigard® was evaluated for the effect on Phytophthora blight of squash at various concentrations of 30, 20, 10, 1 and 0.1 mg/l. In an experiment to evaluate the potential of improved effect by combining Actigard® and PGPR strain SE34, Actigard® was applied at 10 and 3 mg/l alone and in combination with SE34. Actigard® at 30 mg/l served as the positive control, and nontreated squash plants served as the blank control. The experimental design and application method were the same as described above.

Data from greenhouse and field experiments were analyzed by analysis of variance using JMP software (SAS Institute Inc., Cary, NC). The significance of effects of treatments was determined by the magnitude of the F value (P = 0.05). When a significant F test was obtained for treatments, the separation of means was accomplished by Fisher's protected Least Significant Difference (LSD).

RESULTS AND DISCUSSION

In the repeated greenhouse assays, Actigard® at 30 and 3 mg/l and PGPR strain SE34 at 10^7 CFU/ml significantly ($P<0.05$) reduced disease severity of Phytophthora blight of squash compared to the nontreated control (Figure 1). ASM at 30 mg/l provided the greatest protection in squash against *P. capsici*. No disease symptoms developed on squash plants treated with SAM at 30 mg/l whereas nontreated inoculated plants collapsed due to the infection of *P. capsici*.



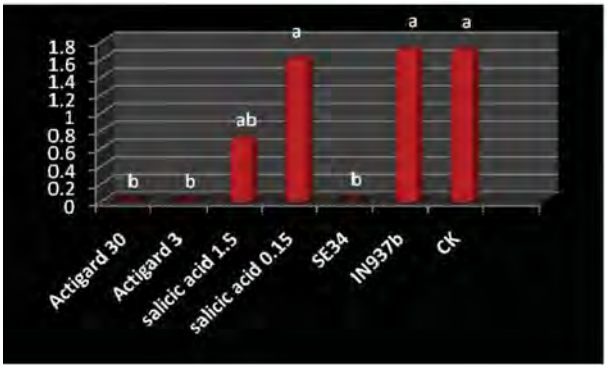


Figure 1. Effect of ASM and PGPR treatments on Phytophthora blight of squash in the greenhouse. Data presented are from two repeated greenhouse experiments. Values of disease severity with the sameletter are not statistically different (P=0.05, LSD).

Squash plants treated with Actigard® at 10 mg/l or higher concentrations consistently had less disease severity when compared with the nontreated plants (Figure 2). Treatments with Actigard® at 3 mg/l and 10 mg/l in combination with SE34 significantly reduced disease severity of *P. capsici* compared to the nontreated control, as well as to the treatment with SE34 alone (Figure 3). This indicates that improved control of Phytophthora blight in squash can be achieved in the greenhouse by combining ASM and PGPR strain, and field trials should be conducted to confirm this effect under field conditions.

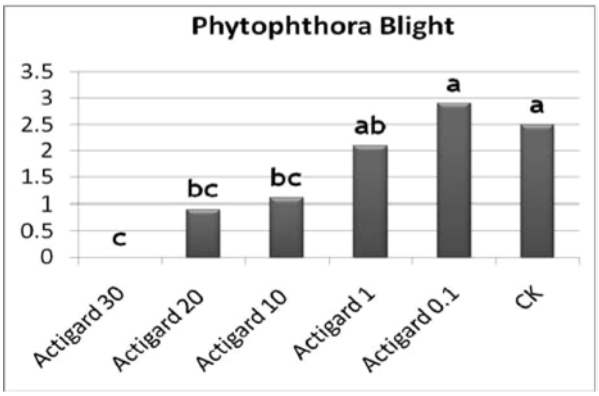


Figure 2. Effect of ASM on Phytophthora blight of squash in the greenhouse. Results from the repeated experiments were same. This is a representative from three repeated experiments. Values of disease severity with the same letter are not statistically different (P=0.05, LSD).

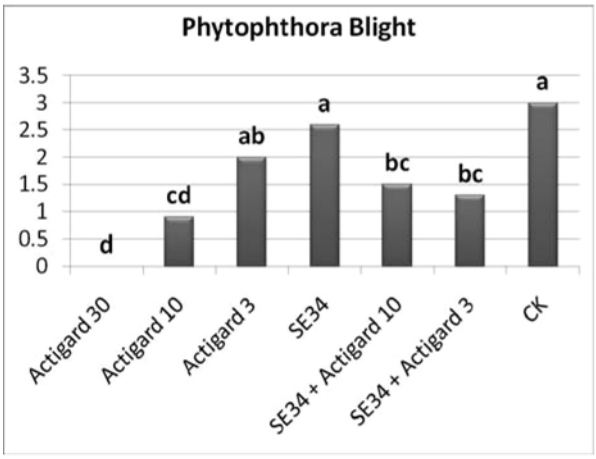


Figure 3. Combined effect of ASM and PGPR strain SE34 on Phytophthora blight of squash in the greenhouse. Results from the repeated experiments were similar. This is a representative from repeated experiments. Values of disease severity with the same letter are not statistically different (P=0.05, LSD).

REFERENCES

Arysta LifeScience Corporation. 2008. Florida registers MIDAS® for commercial use; now available in 45 states. Available at http://www.arystalifescience.com/default. asp?V_DOC_ID=1893.

Babadoost, M. 2004 Phytophthora blight: a serious threat to cucurbit industries. Available at http://www. apsnet.org/online/feature/cucurbit/links.asp.

Environmental Protection Agency. 2008. The Phaseout of Methyl Bromide. Available at http://www.epa.gov/ozone/mbr/.

Hausbek, M. K., and Lamour, K, H. 2004. *Phytophthora capsici* on vegetable crops: Research progress and management challenges. Plant Dis. 88: 1292-1303.

Olson, S.M., Simonne, E. H., Stall, W. M., Roberts, P. D., Webb, S. E., Talor, T. G., Smith, S. A., and Freeman, J. H. 2007. Cucurbit production in Florida. http://edis.ifas.ufl.edu / pdffiles/CV/CV12300.pdf.

Roberts, P. D., McGovern, R. J., Kucharek, T. A., Mitchell, D. J. 2001. Vegetable disease caused by *Phytophthora capsici* in Florida. University of Florida. EDIS SP 159, pp1-4. 14.

Rosskopf, E. N., Chellemi, D.O., Kokalis-Burelle, N., and Church, G.T. 2005. Alternatives to Methyl Bromide: A Florida Perspective. Available at http://www.apsnet.org/ online/feature/ methyl bromide.

Spreen, T. H., VanSickle, A. E., Moseley, M. S., Deepak, M. S., and Mathers, L. 1995. Use of methyl bromide and the economic impact of its proposed ban on the Florida fresh fruit and vegetable industry. University of Florida Bulletin 898.

Tian, D., and Babadoost, M. 2004. Host range of *Phytophthora capsici* from pumpkin and pathogenicity of isolates. Plant Dis. 88: 485-489.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):217. 2008

Management of Watermelon Vine Decline Caused by Squash Vein Yellowing Virus in South Florida.

P.D. Roberts[1], P.A. Stansly[1], S. Adkins[2], and W.W. Turecheck[2], [1]University of Florida, Southwest Florida Research and Education Center, Immokalee, FL and [2] USDA-ARS, U.S. Horticultural Research Laboratory, Fort Pierce, FL USA. pdr@ufl.edu

ABSTRACT.
Watermelon vine decline (WVD) causes plant decline and death and was first reported in Florida the spring of 2003. Squash vein yellowing virus (SqVYV), the causal agent of WVD in Florida, is vectored by the silverleaf whitefly Bemisia tabaci (Biotype "B"). Two seasons of field trials were conducted to investigate management of WVD by applications of insecticides, systemic acquired resistance (SAR) inducers, biological control agents, and other materials. Applications were made at weekly intervals throughout the growing season. Disease incidence (percentage of symptomatic plants per plot) was initially lower in plots receiving some of the some treatments but was not different at the end of the season from untreated plants. However, disease severity, rated on a 0-5 scale where 0= no symptoms and 5=plant dead, was significantly decreased for plants receiving insecticidal regimes without or with SAR inducers. Yield and marketable fruit were increased by these same treatments. Similarly, whitefly population counted as adult whitefly/leaf was decreased compared to untreated plants. In 2007, Cucurbit leaf crumple virus also vectored by the same whitefly was seen for the first time on watermelon in south Florida. Growers have increased their usage of insecticides to manage whiteflies but remain in need of effective management options for the dual threat represented by these two virus diseases of watermelon.

KEYWORDS: plant disease management, cucurbit virus

2008 Proceedings of the Caribbean Food Crops Society. 44(2):218. 2008

Comparison of Performance of Different Plastic Films for Soil Solarization

Harsimran K Gill[1], Robert McSorley[1], Gaurav Goyal[1], [2,] Jeffery E. Pack[3], and Heidi Hanspetersen[1,] [1]Entomology and Nematology Department, University of Florida, Gainesville, FL, [2]Everglades Research and Education Center, Belle Glade, FL, [3]Plant Medicine Program, University of Florida, Gainesville, FL. simgill@ufl.edu

ABSTRACT.
Soil solarization, an important practice for home and vegetable gardens, is also used commercially in areas with very high solar radiation and air temperatures during summers. This is a common technique using clear polyethylene sheets to manage harmful insects, diseases, nematodes, fungi, and weeds in soil. Five different kinds of plastic sheets commonly available to growers were evaluated for durability, weather tolerance, and effectiveness in reducing soil weeds. The experiment was conducted for six weeks beginning in first week of July 2007, which is the best time for soil solarization due to high temperature and light intensity. Various parameters were evaluated including tolerance of plastic sheets to sunlight, their durability, weed growth under different kinds of plastic sheets, and their comparative availability to growers. Soil temperatures at different depths, viz. 5 and 15 cm, were recorded in each treatment. Results allow comparison of efficacy of different kinds of plastic sheets with respect to their weather tolerance and effectiveness in reducing weeds.

KEYWORDS: soil solarization, plastic sheets, durability, weed control

2008 Proceedings of the Caribbean Food Crops Society. 44(2):219-232. 2008

Policy Implications of the Entry of Black Sigatoka (*Mycosphaerella fijiensis*) into Puerto Rico

E. A. Evans[1] and C. I Alamo[2]. [1]Tropical Research and Education Center, University of Florida, Homestead, FL, and [2]Department of Agricultural Economics and Rural Sociology, University of Puerto Rico, Mayaguez, PR. eaevans@ufl.edu

ABSTRACT.

Plantains and bananas are the principal crops in Puerto Rico, with the 2004 crop valued at US $89.8 million, representing 29 percent of the total annual Gross Agricultural Crops Income (GACI). After many years of being free of black sigatoka, the disease was detected in Puerto Rico in August 2004. The disease, which is caused by the fungus Mycosphaerella fijiensis, affects plantains and bananas and can reduce yields by as much as 90 percent. Government agencies have been funding research and assisting growers with the cost of treating the disease, but budgetary constraints may force the government to substantially scale back on funding these programs. The presence of the disease and the fact that eradication is highly improbable has also raised concerns over whether the current trade policy that restricts, the importation of plantains and bananas is no longer warranted. Consequently, this paper addresses two questions:

1. Should the government continue to subsidize the cost of treating the disease while maintaining strict prohibitions on plantain and banana imports? 2. Should the government remove the prohibitions on plantain and banana imports while still providing assistance to growers to treat the disease? The research utilizes an Equilibrium Displacement Model (EDM) to assess the effects of the proposed policy changes on plantain and banana prices, production, consumption, and revenue and welfare.

The results suggest that it make sense for the government to continue to assist growers with treating the disease. The results also suggest that the modest gains to be made from opening of the market to imports of these commodities might not be sufficient to outweigh the potential losses that could arise from inadvertently introducing other invasive pests and diseases such a Moko disease and Papaya Fruit Fly which are sometimes transmitted via banana imports and can cause serious damage to the agriculture and ornamental industries.

KEYWORDS: invasive species, equilibrium displacement model, black sigatoka (*Mycosphaerella fijiensis*)

INTRODUCTION

The plantain and banana commodities are the principal crops in Puerto Rico. In 2004, the Agricultural Sector in Puerto Rico reported an annual Gross Agricultural Income (GAI) at the farm level of $803.0 million (Puerto Rico Department of Agriculture (DAPR, 2005). At $89.8 million, plantains and bananas represent approximately one-third of the total crop GAI. The gross income generated from plantain and banana production was $62.1 million and $27.7 million, respectively. In 2002, the Census of

Agriculture reported 6,340 plantain farms, covering 25,582 "cuerdas" (1 acre = 0.97 "cuerda"), and 3,958 banana farms, covering 11,071 "cuerdas." Plantains are cultivated on 35.9 percent of the total farms of the island and bananas are cultivated on 22.4 percent.

Although plantains and bananas are grown throughout the island, their main production areas are located in the mountain regions in close proximity to high population areas. In the central mountain regions, plantains and bananas are intercropped with coffee, where they provide shade for the coffee plants and most importantly a steady source of income for growers during the early stages of coffee production. Because the mountain regions are the main water sources for the island, they have high humidity conditions that are very conducive to the spread of the black sigatoka disease (discussed below). In contrast, the south coastal region has dry weather conditions.

Plantains and bananas constitute a major part of the Puerto Rican cultural diet. Between 1995 and 2004, total plantain consumption increased from 73,920 tons to 118,907 tons, and per capita consumption increased from 39.7 pounds to 60.9 pounds (Figure 1). In the case of bananas, consumption decreased slightly over the corresponding period from 43,400 tons to 41,465 tons, and per capita consumption decreased from 23.3 to 20.1 pounds (Figure 2). The relatively high per capita consumption of plantains as compared to other starchy foods is a common feature among Latin American and Caribbean countries where plantain and green banana consumption features prominently in the national diets.

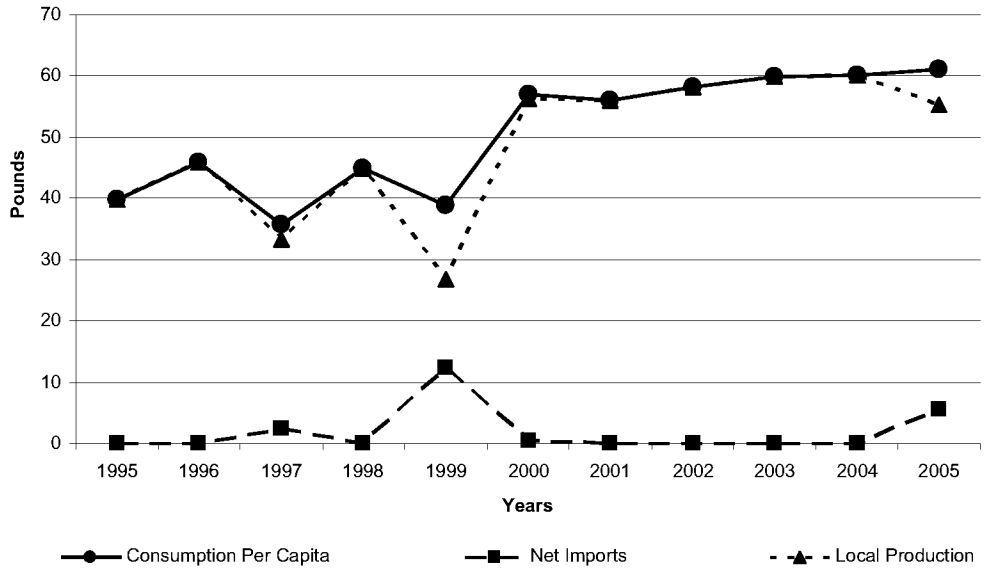


Figure 1. Plantain: Per Capita Consumption, Imports, and Local Production, 1995-2005

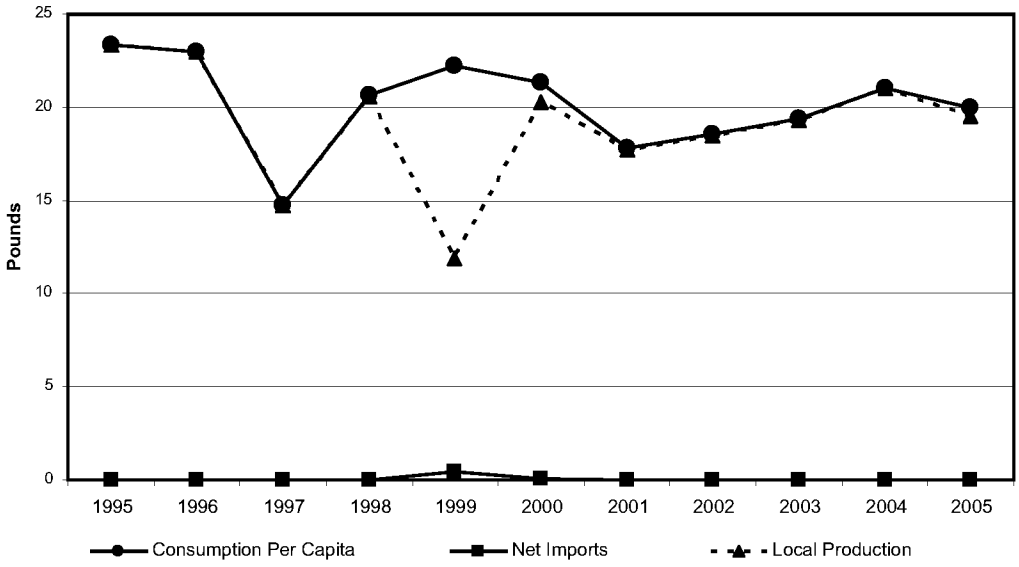


Figure 2. Bananas: Per Capita Consumption, Imports, and Local Production, 1995-2005

Plantain consumption increases with population growth, product availability, and the consumer preferences for ethnic dishes. Outside-of-home consumption of plantains has increased because of restaurants and fast-food places including them on their menus. In Puerto Rico, for example, "mofongo" (a ball of fried green plantain mashed with fried pork rinds and seasoned with thickened stock, garlic, and other condiments) is a favorite ethnic dish on the menus of restaurants, including those in the tourist areas. Moreover, technological advances have greatly facilitated the processing of various plantain and banana products. Between 1990 and 2006, plantain per capita consumption increased while other starchy crops, such as sweet potato, tannier, and taro, decreased (Departamento de Agricultura de Puerto Rico, 2007). This was due to changes in consumer preferences (Cortés, 2006).

As can be seen from Figures 1 and 2, the domestic market for plantains and green bananas is currently supplied entirely by domestic producers as a result of phytosanitary restrictions on imports of such commodities. Imports are only allowed in the years when domestic production is interrupted by hurricanes. When this occurs, the Department of Agriculture in Puerto Rico issues licenses to a number of importers to source the products from areas of countries certified to be free of black sigatoka and moko disease (*Ralstonia solanacearum*). The importers sell to the domestic retailers and processors. On the few occasions when the country must import these commodities, they are sourced mainly from the Dominican Republic, Venezuela, and Ecuador. As mentioned earlier, in light of confirmation of the disease in Puerto Rico, there is a growing debate as to whether trade restrictions should be lifted to supply the local market if production decreases significantly due to the disease.

Black Sigatoka Disease in Puerto Rico

Black sigatoka is considered worldwide as the most devastating disease of plantains and bananas. The disease, which was first reported in Sigatoka Valley in Fiji in 1963, is known to exist in almost every region around the globe where banana is cultivated. Within the Western Hemisphere, it is established in Honduras (1972), Belize (1975), Guatemala (1977), Cuba (1990), Venezuela (1991), Peru (1994), Jamaica (1995), the Dominican Republic (1996), Florida in the United States (1998), and Trinidad and Tobago (2003). In August 2004, the fungus was detected in Añasco, Puerto Rico, a municipality in the western part of the island. By December 2005, it had been identified in 25 municipalities (32.1%) of the island.

The disease, which is also known as black leaf streak, is a pathogenic fungus that significantly reduces leaf area and results in yield loss and premature fruit ripening. Severe infestation has been reported to result in an 80 to 100 percent yield reduction (Orozco, 1998). Black sigatoka is more damaging and difficult to control than the related yellow sigatoka (*Mycosphaerella musicola)* disease, and has a wider host range that includes plantains as well as dessert and ABB-cooking bananas, which are not usually affected by yellow sigatoka. High temperatures and humidity contribute significantly to the introduction and spread of the disease into previously uninfected areas.

The most important vectors of the disease are contaminated plant material, wind, and travelers. International legal and illegal travel and trade (particularly from the Dominican Republic) and weather conditions have been identified as possible pathways by which the disease was introduced into the island.

Once the disease has been introduced and detected, efforts to stem the spread involve a combination of local quarantine and chemical and cultural treatments. Attempts are usually made to isolate affected fields and all unauthorized personnel are prohibited from the area. However, on an island such as Puerto Rico, restricting the movement of people is very limited.

In terms of chemical treatment, a variety of fungicides are recommended for aerial application. On the large export plantations such as those found in Central America, applications are usually done via airplane/helicopter. As Ploetz (2001) points out, this form of application usually accounts for as much as 20 percent of the purchase price of the exported fruit. However, given the average size of plantain and banana farms in Puerto Rico and their close proximity to residential areas and the fact that most of the farms are intercropped with coffee, this form of application is not recommended.

The more common methods of applying the fungicides in Puerto Rico are via motorized tractor implements and backpacks. The general recommendations for treatment frequency of fungicide application in Puerto Rico (Diaz, 2006) and tropical regions, such as Mexico (Orozco, 1998) and Ecuador (Ministerio de Agricultura y Ganadería, 1995), are 14 to 21 days for systemic fungicides. Considering the application recommendations, the number of treatments per year is between 17 and 26. The mean number of treatments per year in Puerto Rico is 18, which is in the lower application range.

However, because there is a tendency for resistance or tolerance in *M. fijiensis* towards systemic fungicides, many farmers use a combination of fungicides mixed with petroleum oil sprays (Ploetz, 2001). Fungicides of the chemical groups of triazoles, pyrimidines, morpholines, and strobilurines should not have back-to-back applications

and no more than eight applications per year. This application number consists of a rotation of systemic and protectant fungicides to prevent pesticide resistance. The registered fungicides most frequently applied in Puerto Rico for black sigatoka are Propiconazole, Tebuconazole, Azoxystrobin, and Banana Spray Oil (Díaz, 2006). These are systemic fungicides, with Azoxystrobin being the only one in the pyrimidin chemical group.

Ploetz (2001) notes that although such "cocktail" mixtures usually provide an effective control, their effect on the environment is a cause for concern. The risk factors associated with the use of fungicides are related to potential ground water contamination and harm to farm workers. Potential harm to farm workers covers a spectrum from eye and skin irritations to possible carcinogenic diseases.

Further complicating the matter is the fact that the fungicides approved for the treatment of black sigatoka in Puerto Rico are not approved for use in farms intercropped with coffee. Because Puerto Rico is controlled by the United States Environmental Protection Agency (EPA), the pesticides used for crop protection must be registered for specific crops. The effective registered fungicides that control black sigatoka are not allowed on coffee, which is the principal crop in the intercropping system. Therefore fungus control must be limited to cultural practices in such circumstances. The cultural practices recommended are usually labor-intensive and costly. They include manual removal of affected leaves and infected plants, burning, and field sanitation to ensure adequate spacing of plants and efficient drainage within plantations. Although burning the entire field is quite effective against the spread of the disease, it has limited application where there is intercropping.

To ensure the proper application of fungicides, the government of Puerto Rico subsidizes the operation by providing the spray equipment and crews for the fungicides purchased by the growers. The DAPR has a general labor subsidy program that reimburses participant growers a maximum of 50 percent of the cultural practices cost. These programs have limited budgets, thereby limiting the services they provide to the growers.

METHODOLOGY

Economic Analysis

To assist with quantifying the effects of the introduction of the disease and the supply shocks, we utilized an equilibrium displacement model (EDM), following the general approach adopted by Choi et al. (2003). In this model, a system of demand and supply conditions is laid out in log-linear form to determine how the equilibrium quantities, prices, and other variables respond to shocks (e.g., yield reductions and increased production costs). The model is parameterized with a range of economic and biological data, focusing on the intermediate-run impact without examining the path of adjustment.

The following set of equations in log-linear form characterizes the situation:

(1) $d \ln Y = \delta$

(2) $d \ln A = \varepsilon d \ln P - \varepsilon d \ln C$

(3) $d\ln S = \varepsilon d\ln P - \varepsilon d\ln C + \delta$

(4) $d\ln D = -\eta d\ln P$

(5) $d\ln S = d\ln D$

In equation (1), Y represents the yield of plantain and banana per acre, and δ denotes the actual percentage amount by which yield can be expected to change as a result of the disease. In equation (2), A represents the acreage of plantains and bananas as a function of price (P) and production costs (C), where ε is the price elasticity of supply (area planted). As pointed out by Choi et al. (2003), the elasticity of the area with respect to marginal costs per acre is the negative value of ε under the assumption of constant returns to scale. In equation (3), S denotes the percentage change in market supply of plantains and bananas and is obtained by summing the percentage change in yield (equation 1) and the percentage change in acreage (equation 2). In equation 4, D represents the demand for plantains and bananas, and η represents the absolute value of price elasticity of demand. Equation 5 reflects the market clearing condition and implies that the percentage change in quantity demanded will equal the percentage change in quantity supply.

The above set of equations can be solved by giving formulas for changes in price, acreage, equilibrium quantity, and revenue as shown in equations 6 to 9 below:

(6) $d\ln P = \left(\frac{1}{\varepsilon+\eta}\right)(\varepsilon d\ln C - \delta)$

(7) $d\ln A = \left(\frac{-\varepsilon}{\varepsilon+\eta}\right)(\delta + \eta d\ln C)$

(8) $d\ln Q(= d\ln S = d\ln D) = \left(\frac{-\eta}{\varepsilon+\eta}\right)(\varepsilon d\ln C - \delta)$

(9) $d\ln(PQ) = d\ln P + d\ln Q = \left(\frac{1-\eta}{\varepsilon+\eta}\right)(\varepsilon d\ln C - \delta)$

The welfare effects of the disease in terms of changes in the surpluses for both the producers and the consumers can be approximated by using the following equations:

(10) $\Delta PS = P_0 Q_0 (K - Z)(1 + 0.5Z\eta)$

(11) $\Delta CS = P_0 Q_0 Z(1 + 0.5Z\eta)$

where

$$Z = K\left(\frac{1}{\varepsilon+\eta}\right) = -d\ln P, \qquad K = -(\varepsilon d\ln C - \delta),$$

and P_0 and Q_0 are the initial equilibrium price and quantity before the supply shifts. Using the above framework and parameters and data (discussed below), we estimated the impact on plantains and bananas caused by yield and cost shocks (i.e., the likely reduction in yield and increased cost of production).

Biological and Economic Data

Data used in the analysis were based on the result of a 2005 survey of plantain and banana growers conducted by the Agricultural Experiment Station in collaboration with the Agricultural Extension Service of the University of Puerto Rico, Mayaguez Campus, and extensive discussions held with industry experts and agricultural extension agents. Secondary data were obtained from the Department of Agriculture of Puerto Rico, Statistical Office (DAPR, 2006 and 2005). Regarding the 2005 survey, a total of 91 farms were surveyed to determine, among other things, the distribution of the disease, impact on yield, control methods employed, and additional costs of such treatments.

The survey results indicated that approximately 50 percent of the total plantain and banana acres were infected with the black sigatoka as of December 2005. As stated earlier, the disease affects yield in two ways: directly by reducing the number of bearing plants, and indirectly by affecting the quality of the fruit in terms of number (hands and fingers), size, and weight of marketable fruits. The extent to which yields are affected depends on several factors: variety (plantain or banana), disease severity, location, humidity, plant growth stage at time of infestation (before or after flowering), and whether treatment had been applied. On the basis of discussions with the industry experts, it was noted that if the disease infected the plant during the pre-flowering stage and no control treatments were applied, overall yield was likely to decrease by as much as 90 percent. If attempts were made to control the disease during this stage, losses could be lowered by as much as 75 percent (i.e., yield would be reduced by only 25 percent). If, on the other hand, infestation occurs after the pre-flowering stage, the impact would be less severe (yields would decrease by about 50 percent). Applying treatments during the pre-flowering stage would further reduce expected losses to about 15 percent (Diaz, personal communication).

Further discussions with extension agents and industry specialists, and findings in the literature review indicated that the average yield reductions experienced in cases where no controls were applied were 50 percent for plantains and 80 percent for bananas. Given that the survey results indicated that approximately 50 percent of the acres were infected, the industry-wide yield impact if growers did not control the disease would be about 25 percent for plantains (50% of 50%) and 40 percent for bananas (50% of 80%).

As mentioned earlier, controlling the disease involves using a combination of chemical and cultural methods. The survey results indicated that growers with black sigatoka control programs reported an increased average annual control cost of about $582 per acre. The mean cost for control application was about $33 per acre, and there were approximately 18 treatments per year. Given that the average annual costs of plantain and banana production in situations where the disease is not present have been estimated as $5,273 and $6,744, respectively (Ortiz, unpublished), control of the disease can be expected to add 11.0 percent and 8.6 percent to production costs of plantains and bananas, respectively. Since a 75 percent efficacy of the treatment can be assumed, the estimated national impact on yield, if all affected growers were to treat the disease, is

estimated at 6.25 percent for plantains (25% of 25%) and 10 percent (25% of 40%) for bananas.

With respect to economic data and parameters, the average price, quantity, and industry values of plantains and bananas over the three-year period of 2001 to 2003 were used as the initial equilibrium values (Table 1). Since imports of plantains and bananas are restricted except when the domestic supply is interrupted by hurricanes, we had to construct estimates of the import prices for plantains and bananas during the period. Our estimate was determined on the basis of information provided by the importers and phytosanitary inspectors regarding farm gate prices for plantains and bananas in Ecuador (one of the overseas suppliers), transportation and insurance costs, and costs of inspection and certification. Based on such information and the allowance for a 10 percent profit margin, we estimated an import price of around 19 cents per pound for plantains and 17 cents per pound for bananas.

Table 1. Price and Quantity Variables

Commodity	Price(dollars/pound)	Quantity (million pounds)
Banana	$0.18	84.0
Plantain	$0.25	237.8

We use acreage supply elasticities of 0.25 and 0.1 to reflect the inelastic nature of the supply response of both plantains and bananas. Most of the agricultural lands are currently under production. Although there are pure stands of plantains and bananas, most are usually grown as shade crops for coffee. In addition, both plantains and bananas are considered as cash crops, providing a source of weekly income for many of the growers. A review of the literature found only one study that had attempted to estimate the acreage supply elasticity. The study, which is somewhat dated, indicated a supply elasticity of .01 (Cortés, 2005) for banana. The economic model also requires that we provide estimates of the demand elasticity. In view of the fact that a reliable data series was unavailable for estimating the demand elasticity and searching the literature proved unsuccessful, the data estimates supplied were based on discussions with consumers and what is known with respect to the consumption of the commodities. Numerical values assigned for the demand elasticity were in the range of -0.25 to -0.5 and -0.5 to -0.75 for plantains and bananas, respectively. The demand for plantains is assumed to be more inelastic than that for bananas since there are only a couple of imperfect substitutes available, namely cassava and potatoes (Cortés and Gayol, 2006). In the case of banana demand, there is a wide range of local fruits and vegetables that can be substituted; however, bananas are still the favorite fruit in Puerto Rico.

RESULTS

Using the above discussed estimates and data, we estimated the economic welfare consequences of introducing the disease in situations where import prohibitions for plantains and bananas are maintained and farmers treat the disease with some assistance from the government. Under this scenario, the average production costs were estimated to have increased by 11 percent and 8.6 percent for plantain and banana cultivation, respectively. Yields, on the other hand, were estimated to have decreased by 6.25 percent

and 10 percent respectively. Tables 2 and 3 provide the simulated effect, given the range of economic parameters for plantains and bananas, respectively.

Table 2. Plantains: Estimated Impacts Assuming Treatment with Ban on Imports

Yield Loss (%)	Change in Costs (%)	Acreage elasticity	Demand elasticity	Price ($/lb)	Production (million pounds)	Revenue ($m)	Δ PS ($m)	Δ CS ($m)
- 6.25	11.0	0.1	-0.25	0.30	225.32	68.16	7.90	-12.16
		0.1	-0.50	0.28	223.23	62.65	2.82	-7.06
		0.25	-0.25	0.30	227.10	66.99	5.23	-10.46
		0.25	-0.50	0.28	223.53	62.59	1.73	-6.92
Average				0.29	224.80	65.10	4.42	-9.15

Source: Authors, estimates.

Table 3. Bananas: Estimated Impacts Assuming Treatment with Ban on Imports

Yield Loss (%)	Change in Costs (%)	Acreage elasticity	Demand elasticity	Price ($/lb)	Production (million pounds)	Revenue ($m)	Δ PS ($m)	Δ CS ($m)
-10.0	8.6	0.10	-0.50	0.21	76.41	16.24	1.05	-2.61
		0.10	-0.75	0.20	75.95	15.42	0.28	-1.84
		0.25	-0.50	0.21	77.21	16.15	0.59	-2.35
		0.25	-0.75	0.20	76.35	15.41	0	-1.75
Average				0.21	76.48	15.81	0.48	-2.14

Source: Authors, estimates.

Information in Table 2 suggests that with pest control treatments, plantain production would be expected to decrease by a maximum of about 6 percent, or from 237.8 million pounds to 223.2 million pounds. The reduction in the availability of plantains induces a price increase of between 12 percent and 21 percent (prices increased from 25 cents per pound to between 28 cents and 30 cents per pound). Because of the moderate increase in prices, acreage would increase only slightly by about 1 percent. The surplus (welfare) for producers would increase in the range of $1.7 million to $7.9 million, depending on the responsiveness of consumers and producers. On the other hand, the surplus (welfare) for the consumers would decrease in the range of $6.9 million to $12.16 million. The overall net economic welfare would decrease (cost to society) by approximately, $5 million.

The information contained in Table 3 suggests that in the case of bananas, prices would increase from 18 cents per pound pre-infestation to about 21 cents per pound. Quantities produced would decrease about 9 percent, or from 84.0 million pounds pre-infestation to about 77 million pounds. Acreage response would be marginal, with an increase of about 1 percent. Despite the increased price, the surplus for the producers would only rise slightly (by at most $1 million) due to increased production costs and lower yields. The increased price facing consumers would cause a decline in the surplus for the consumers between $1.75 million and $2.61 million. On average, there would be a slight reduction in welfare of about $1.5 million (U.S. dollars).

However, as discussed earlier, the presence of diseases has called into question the rationale for maintaining import restrictions. Given the existence of the disease, the simulated production, consumption, trade, and welfare effects of moving from a ban to free trade are presented in Tables 4 and 5 for plantains and bananas, respectively. With respect to Table 4, the results indicate that removing the ban on plantains would cause producer price to fall by about 24 percent from the pre-infestation price, or a decrease from 25 cents per pound to about 19 cents per pound. Depending on the elasticities, the consumption of plantains would increase from 237.8 million pounds to between 252.07 million pounds and 266.34 million pounds. As a consequence of lower prices, higher production costs, and reduced yield, domestic production would decrease to between 205.6 million pounds and 216.9 million pounds, implying self-sufficiency of between 77 percent and 86 percent. The corresponding fall in the revenues for producers would be much higher than the drop in volume due, in part, to the larger proportionate fall in price. On average, the value of production would decline to about $40 million dollars, compared to the pre-infestation value of almost $60 million. The welfare of the producers would fall by up to $17.58 million while the welfare of the consumers would increase by about $13.88 million. Overall, economic welfare would decline by approximately $3.4 million.

Table 4. Plantains: Estimated Impacts Assuming Treatment with Import Ban Removed

Index	Unit	With Import Ban				Average
Import Price	$/lb	0.19	0.19	0.19	0.19	0.19
Producer Price	$/lb	0.19	0.19	0.19	0.19	0.19
Supply Elasticity	n/a	0.10	0.10	0.25	0.25	-
Demand Elasticity	n/a	0.25	0.50	0.25	0.50	-
Consumption	mil. lbs	252.07	266.34	252.07	266.34	259.20
Consumption expenditure	$ mil.	47.89	50.60	47.89	50.60	49.25
Production Marketed	mil. lbs	216.94	216.03	206.89	205.57	211.36
Value at Farm Gate	$ mil.	41.22	41.04	39.31	39.06	40.16
Imports	mil. lbs	35.13	50.31	45.18	60.77	47.85
Value of Imports	$ mil.	6.68	9.56	8.58	11.55	9.09
Self-Sufficiency	(%)	86.06	81.1	82.08	77.18	81.61
Change in Producer Surplus	$ mil.	-16.98	-17.08	-17.55	-17.58	-17.3
Change in Consumer Surplus	$ mil.	13.89	13.83	13.95	13.84	13.88
Net Change in Econ. Welfare	$ mil.	-3.09	-3.25	-3.6	-3.74	-3.42

Source: Authors, estimates.

Table 5. Bananas: Estimated Impacts Assuming Treatment with Import Ban Removed

Index	Unit	Without Import Ban				Average
Import Price	$/lb	0.17	0.17	0.17	0.17	0.17
Producer Price	$/lb	0.17	0.17	0.17	0.17	0.17
Supply Elasticity	n/a	0.1	0.1	0.25	0.25	-
Demand Elasticity	n/a	0.5	0.75	0.5	0.75	-
Consumption	mil. lbs	86.33	87.50	86.33	87.5	86.92
Consumption expenditure	$ mil.	14.68	14.88	14.68	14.88	14.78
Production Marketed	mil. lbs	74.87	74.72	73.58	73.33	74.12
Value at Farm Gate	$ mil.	12.73	12.70	12.51	12.47	12.6
Imports	mil. lbs	11.47	12.78	12.75	14.17	12.79
Value of Imports	$ mil.	1.95	2.17	2.17	2.41	2.17
Self-Sufficiency	(%)	86.72	85.39	85.00	83.81	85.29
Change in Producer Surplus	$ mil.	-2.17	-2.21	-2.36	-2.39	-2.28
Change in Consumer Surplus	$ mil.	0.8	0.8	0.81	0.81	0.81
Net Change in Econ. Welfare	$ mil.	-1.37	-1.41	-1.55	-1.58	-1.48

Source: Authors, estimates.

In the case of bananas, the data in Table 5 indicate a somewhat similar pattern to that obtained for plantains. With the removal of the ban, the domestic price could be expected to fall to about 17 cents per pound, slightly below the pre-infestation price of 18 cents per pound. In that case, consumption would increase slightly from 84.0 million pounds to about 87.5 million pounds, or by a maximum of about 4 percent. The volume of production would decrease to between 73 million and 75 million pounds, satisfying 85 percent of the demand. Reflecting the drop in price and reduction in volume, farm gate revenues would decline to about $12.6 million, or by about 16.7 percent. These changes and the higher costs of production reduce the welfare of the producers by an amount ranging from $2.17 million to $2.39 million. The welfare of the consumers would increase marginally by about $0.8 million. Overall, economic welfare would decline by about $1.5 million annually.

DISCUSSION

The foregoing analysis provides estimates of the economic and trade effects of the introduction of black sigatoka under two scenarios: (1) prohibiting imports of plantains and bananas while providing assistance to the growers to treat the disease and (2) lifting import restrictions to allow for free trade of plantains and bananas while providing assistance to the growers to treat the disease. The results indicate that in the first scenario, prices could be expected to increase by as much as 20 percent for plantains and by about 17 percent for bananas when compared to the pre-infestation prices. Production of both plantains and bananas would be expected to decrease by a maximum of about 6 percent and 9.5 percent, respectively. In the case of plantains, the welfare of the producers would increase by about $4.4 million while the welfare of the consumers would decrease by about $9.2 million, given a net economic loss to society of around $4.7 million. For bananas, the welfare of the producers would increase by about $0.5

million while the welfare of the consumers would decrease by about $2 million. Overall, there would be a cost to society of about $1.7 million.

Removing the trade restrictions and opening import markets would prevent the upward adjustment of prices caused by the reduction in domestic supplies. Under this scenario, prices would decline by around 24 percent and 6 percent for plantains and bananas, respectively. While consumption of plantains and bananas would increase, domestic production would decrease, on average, by 11 percent and 12 percent, respectively. In the case of plantains, the surplus for the producers would decline by an average of $17.3 million while the welfare of the consumers would increase by $13.9 million, or a net change in economic welfare of loss of about $3.4 million. For bananas, the welfare of the producers would decline on average by $2.3 million while the welfare of the consumers would increase by less than $1.0 million. Overall net economic welfare would decline by about $1.5 million.

Although the two scenarios considered above reflect relatively small overall changes in cost to society, the distribution of benefits and costs among producers and consumers differs considerably. Under the first scenario, the producers would benefit largely at the expense of consumers due to the upward adjustment of prices. As the results indicate, despite the increased costs and reduced yield, the surplus for the producers would still increase but would be insufficient to outweigh the fall in the welfare of the consumers.

With free trade, the situation is reversed, with the welfare of the producers declining and the welfare of the consumers increasing. Of interest is the fact that overall net economic welfare would remain negative. Because import prices are not significantly lower than pre-infestation prices, gains to consumers are insufficient to outweigh losses to producers. Producers are disadvantaged in terms of facing lower prices, higher production costs, and lower yields. Such a situation could create economic hardships for growers who depend on these crops for a steady stream of income. Moreover, removing the phytosanitary restrictions on plantain and banana imports is likely to increase the probability of introducing other invasive pests and diseases, which might affect other agricultural crops. The Moko disease and Papaya Fruit Fly are sometimes transmitted via banana imports and can cause serious damage to the agriculture and ornamental industries. If such a situation were to be realized the costs to society could be further increased.

Also, there is no guarantee that relaxing import restrictions would lead to any significant reduction in prices, as the past events of 1998 have clearly shown. Due to damages caused by the hurricane in that year, most of the total demand had to be satisfied from overseas sources. Prices were observed to remain virtually the same despite being supplied by imports because importers and retailers were not compelled to pass on any cost savings to the consumers. Such a policy could be effective if the system were redesigned to establish a research and promotion authority that could collect a portion of the rent from imports which could be used to support research towards control of the disease. Specific research for resistant cultivars and biological controls could reduce fungicide application. A portion of the rent from imports could be assigned to "incentive control programs" to reduce costs and enable growers to implement cultural practices that benefit the environment.

Another consideration on which the above results are predicated is the assumption that the affected growers would apply fungicides in a judicious manner which would minimize any adverse impact on the environment. As mentioned earlier, the bulk of the plantain and banana farms are located in mountainous areas which are important watershed areas. In addition, some of the farms are in close proximity to residential areas. Indiscretion in the use of such fungicides could lead to undesirable runoffs and contamination of important water sources. This analysis did not take into consideration possible adverse environmental impacts from the improper use of chemicals, given that the government has taken steps to oversee chemical applications by providing the required equipment and trained crews to apply the chemicals (discussed below). Hence, it is important that assistance continue and that growers be provided the necessary incentives to limit the use of fungicides and chemicals and to employ cultural practices. These incentives should be accompanied by educational programs to inform the growers about the potential adverse environmental impacts from improper chemical use.

Currently, the government of Puerto Rico assists growers with controlling the spread of black sigatoka. Our calculation implies that in spite of government assistance, production costs are likely to increase by 11.0 percent and 8.6 percent for plantains and bananas, respectively. Unconfirmed reports indicate that the government may reduce or eliminate their support because of budgetary constraints. This would further increase the cost to the growers and could undermine efforts to limit chemical use through more expensive cultural practices. Given the need of reducing control costs, increasing society's welfare, providing safe drinking water, and minimizing harm to the environment, government support should not be decreased or eliminated.

There could be a significant payoff in investing in research to develop plantain and banana varieties that are resistant to black sigatoka. Such research is currently underway but only to a limited extent in Puerto Rico. Support should be given to intensify efforts at developing resistant agronomically-acceptable cultivars, and organoleptic evaluations should be conducted to ensure that resistant cultivars possess the desirable characteristics that are essential in preparing ethnic dishes and have consumer acceptance.

CONCLUSION

A critical decision facing the government of Puerto Rico is whether in light of the presence of the diseases the current restrictions on the import of plantains and bananas should be removed. Our analysis did not find conclusive evidence that society would be made better off by removing such restrictions. Moreover, given that such actions are likely to create economic hardships for growers who depend on these crops for a steady stream of income as well as increase the probability of introducing other invasive pests and diseases, which might affect other agricultural crops, the decision to do so needs to be considered carefully. Governments have a key role to play in limiting the spread of invasive species. In that regard the Government of Puerto Rico has taken steps to assist the growers manage the disease. Currently, with assistance from the government, growers are employing a combination of cultural and chemical control methods to combat the spread of the disease. The judicious use of chemicals is crucial to the environment. Removal of government assistance could cause the growers to use cheaper combinations of chemicals that are more damaging to the environment. The potential gains to society of

providing safe drinking water and a safe environment suggest the need for the government to continue its support in restricting the spread of diseases and promoting research to develop resistant cultivars.

REFERENCES:

Choi, Jung-Sup, Daniel A. Summer, Robert K. Webster, and Christopher A. Greer "Economic Consequences of a New Exotic Pest: The Introduction of Rice Blast Disease in California". *Exotic Pests and Diseases: Biology, Economics, and Public Policy for Biosecurity*. Ames, IA: Iowa State University Press, 2003.

Cortés M. and R. Villagómez. "Estimados de la Elasticidad de la Oferta para el Cultivo de Guineo en Puerto Rico". *Journal of Agriculture of the University of Puerto Rico* 89 3-4 (July-October 2005): 181-192. 2005

Cortés M. and L. Gayol. "Componentes de la Empresa de Platanos en Puerto Rico" *Journal of Agriculture of the University of Puerto Rico* 90 (3-4): 237-244.

Departamento de Agricultura de Puerto Rico. Consumo de Alimentos Farináceos, Hojas de Cómputos de Malanga (Fólder 16-57B24) Batata (Fólder 16-57B21y Apio (Folder16-57B14). Oficina de Estadísticas Agrícolas, San Juan, Puerto Rico, 2007.

Departamento de Agricultura de Puerto Rico. Consumo de Alimentos Farináceos, Hojas de Cómputos de Plátano (Folder 16-57B24) y Guineos Verdes (Folder16-57B25). Oficina de Estadísticas Agrícolas, San Juan, Puerto Rico, 2006.

Departamento de Agricultura de Puerto Rico. Ingreso Bruto Agrícola de Puerto Rico 2003/04–2004/05. Oficina de Estadísticas Agrícolas, San Juan, Puerto Rico, 2005.

Díaz, M. Personal Communication. Agricultural Extension Service, College of Agricultural Sciences University of Puerto Rico, Mayaguez Campus., September 2006.

Diaz, M. Sigatoka Negra y su Manejo Integrado en Puerto Rico, Servicio de Extensión Agrícola, Colegio de Ciencias Agrícolas, Recinto Universitario de Mayagüez, Universidad de Puerto Rico, disco compacto, 2006.

Ministerio de Agricultura y Ganadería de Ecuador. Programa Nacional de Banano, El Cultivo del Plátano en Ecuador, Guayaquil p 57, 1995.

Orozco-Santos, Mario. *Manejo Integrado de Sigatoka Negra del Plátanos*. Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias INIFAB, Colima, México, Technical Bulletin, No. 1 ISSN 1405, 1998.

Ortiz, J., M. Díaz, M. Cortés, y R. Martínez. Presupuestos Modelos para la Producción de Plátano y Guineo. Unpublished manuscript, Estación Experimental Agrícola, Colegio de Ciencias Agrícolas, Recinto Universitario de Mayagüez, Universidad de Puerto Rico, Mayagüez, Puerto Rico, 2006.

Ploetz, R. 2001. The Most Important Disease of a Most Important Fruit. Internet site: http://www.apsnet.org/education/feature/banana/Top.html

United States Department of Agriculture. Census of Agriculture: Puerto Rico, National Agricultural Statistics Services, United States Department of Agriculture, Vol 1, Geographic Area Series Part 52, 2002.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):233. 2008

Use of Hay, Green, and Plastic Mulches to Suppress Nutsedge in Horticultural Crops

Shabana, Yasser[1], Rosskopf, E.[2], Morales-Payan J.P.[3], Abou Tabl, A.H[1], Klassen, W.[4], and Charudattan, R.[1] [1]Department of Plant Pathology, University of Florida, 1453 Fifield Hall, PO Box 110680, Gainesville, FL 32611; [2]USDA, ARS, USHRL, 2001 South Rock Road, Fort Pierce, FL 34945; [3]Department of Horticulture, University of Puerto Rico - Mayaguez Campus, PO Box 9030, Mayaguez, PR 00681; [4]Tropical REC, 18905 SW 280 St., PO Box 111569, Homestead, FL 33031. yassershabana2@yahoo.com

ABSTRACT.
Purple and yellow nutsedges (*Cyperus rotundus* and *C. esculentus*, respectively) are among the most serious weed problems in Florida, Caribbean, and other parts of the world. They have been reported to cause yield losses of 20-89% in various horticultural crops. Production systems based on plastic mulch and methyl bromide soil fumigation are used for nutsedge suppression in many conventional vegetable cropping systems. When methyl bromide has been totally phased out, the losses due to nutsedges are expected to increase in conventional horticultural crops. Organic production will continue to suffer due to a lack of effective weed control measures. Thus, 10 organic hays (shoot straw of bahiagrass, cogongrass, cowpea, millet, nutsedge, sorghum Sudangrass, sunnhemp, rye, corn, and sugarcane bagasse), four green mulches (cowpea, millet, sorghum Sudangrass, and sunnhemp), and two plastic mulches (black and IRT) were tested for their efficacy in suppressing purple and yellow nutsedge growth in a raised bed tomato (cv. Tygress) field. The black plastic mulch consistently reduced nutsedge emergence and growth more than the organic mulches and the IRT plastic mulch. All green organic mulches, except the green sunnhemp, were more suppressive to nutsedge emergence and growth than hay mulches. Among the organic mulches, the greatest suppressive effect on nutsedge was found when using green sorghum, green millet, and congongrass hay. Although cogongrass hay did not enhance the total yield, it influenced the proportion of larger fruits. The highest yield of extra large tomatoes per plant was obtained when cogongrass hay was used as mulch. However, the use of black plastic increased the total yield and the proportion of larger fruit.

KEYWORDS: Nutsedge, organic mulch, tomato

2008 Proceedings of the Caribbean Food Crops Society. 44(2):234. 2008

Mortality to Giant African Snail *Achatina Fulica* Bowdich and Non-Target Snails Using Select Molluscicides

Matthew A. Ciomperlik[a], David G. Robinson[b], Ian H. Gibbs[c], Angela Fields[d], Timothy Stevens[e], and Bret M. Taylor[c] [a] USDA, CPHST, Pest Detection and Management Laboratory, Edinburg, TX 78541. [b]USDA PPQ NIS, Academy of Sciences, 1900 Ben Franklin Pkwy Philadelphia, PA 19103. [c]Ministry of Agriculture and Rural Development, Christ Church, Graeme Hall, Barbados. [d]University of the West Indies, Cave Hill Campus, P.O. Box 64, Bridgetown, Barbados. [e]USDA APHIS PPQ Eastern Region, 1815 Gardner Dr., Wilmington, NC 28405. Matt.A.Ciomperlik@aphis.usda.gov

ABSTRACT.
Laboratory bioassays and caged field trials were conducted to compare molluscicide effects on the neonate, juvenile, and adult development stages of giant African snail (GAS) (Achatina fulica) and three non-target snail species in Barbados. Nine commercially available molluscicides, diatomaceous earth, and a kaolin clay product (Surround WP) were evaluated. High levels of mortality to neonate GAS were seen in all the laboratory molluscicide bioassays except for Surround and diatomaceous earth. Highest mortalities to neonate GAS occurred during field trials testing Durham granules and Slugfest. Deadline, Durham granules, Metarex, and Orcal pellets caused the highest rates of mortality to juvenile GAS in field trials. For adult GAS several molluscicides including Blitzem, Deadline, Durham Granules, Mesurol 75W, Metarex, Orcal pellet, and Slugfest caused greater than 95% mortality in laboratory bioassays. Field trials showed Durham granules and Slugfest yielded the highest mortality rates. Sluggo pellet did not cause significant mortality to juvenile and adult GAS in our field trials, but did cause significant mortality to neonate GAS. The majority of the molluscicides tested in our trials were equally or more lethal to Pleurodonte isabella, Bulimulus guadalupensis, and Zachrysia provisoria than GAS. Our results identify several effective commercially available molluscicides that can be used to control incipient populations of GAS. However, our results show that the potential impact on non-target snail species during control or eradication programs may be significant, causing substantial mortality regardless of what brand, active ingredient, or formulation is used. Mention of a proprietary product does not imply endorsement by USDA.

KEYWORDS: Giant African snail, molluscicides, non-target effects

2008 Proceedings of the Caribbean Food Crops Society. 44(2):235-248. 2008

The Presence and Distribution of the Red Palm Mite, *Raoiella indica* Hirst (Acari: Tenuipalpidae) in Trinidad

C. Shripat, F. Hosein, P. Siew and Y. Ali., Ministry of Agriculture, Land and Marine Resources, Central Experiment Station, Research Division, Centeno, Trinidad, c_shripat@yahoo.com

ABSTRACT.

The red palm mite, *Raoiella indica* Hirst (Acari: Tenuipalpidae) is an Invasive Alien Species (IAS), which was first detected in the Western Hemisphere in the island of Martinique in 2004. It has since spread to Dominica (2005), Dominican Republic (2006), Puerto Rico (2006), Trinidad (2006), St. Vincent (2007), Jamaica (2007), and Grenada (2007). The pest has the potential to quickly spread to new locations by wind currents or human activities. Raoiella indica was first detected in Trinidad in March 2006. Surveillance activities revealed that the pest was rapidly dispersing to new areas. From July-September 2007, a survey was conducted to detect the presence and distribution of red palm mite and native natural enemies in Trinidad. Ten coconut farms were randomly selected from each of the eight counties and two trees were sampled from each farm. In each case, samples were collected from the 3rd and 9th fronds and examined in the laboratory for red palm mite and natural enemies. The data were analyzed using the Statistical Package for Social Science (SPSS), Version 7.5. Red palm mite was present in all counties, but the numbers observed in each county were varied. Nariva/Mayaro and St. Andrew/St. David had significantly ($p<0.05$) more mites than the other counties. The predominant natural enemy was Amblyseius largoensis (Acari: Phytoseiidae); however, predatory mite populations were low ranging from only nine in theSt. Patrick East samples to 81 in St. George West. Counties with higher populations were those with large coconut farms >20.0 hectares. Because the red palm mite was found to be widespread, surveys should also be conducted in the dry season and long term population dynamics studies should be initiated. Amblyseius largoensis should be reared and mass produced in the laboratory for augmenting field populations,and classical biological control also should be investigated to manage the pest.

KEYWORDS: *Raoiella indica*, natural enemy, Trinidad

INTRODUCTION

Red palm mite *Raoiella indica* Hirst (Acari: Tenuipalpidae) is an important pest of coconuts (*Cocos nucifera* L.) and areca palm (*Areca catechu* L.) in India, Pakistan and Mauritius. It is also present in Iran, Egypt, Israel, Sudan, Russia, Oman United Arab Emirates, Sri Lanka, Philippines and Reunion. In the Western Hemisphere, *R. indica* was first observed in Martinique in 2004. It has now spread to St. Lucia (2005), Dominica (2005) and Dominican Republic (2006) (Kane et al., 2006). *R. indica* also was detected in Puerto Rico in 2006 (Calero-Toledo et al., 2006). In 2007, it was reported from St. Vincent, Jamaica and Grenada. Other countries affected in the region are Guadeloupe, Haiti, US Virgin Islands and USA (Florida).

*Raoiella indica*is of Asian origin. It was described by Hirst in 1924 from coconut leaves in Coimbatore, India (Flechtmann and Etienne, 2004). All stages, including eggs, are red in color; however, adult females can be easily distinguished by the presence of black patches on their backs. *R. indica* has long spatulate setae and flattened bodies in comparison to spider mites (Tetranychidae) (Kane and Ochoa, 2006).

The Presence of *R. indica* in Trinidad

In March 2006, *R. indica* was first detected at San Quintin Estate, Icacos in the southwestern peninsula of Trinidad. Samples of pinnae of coconut palm fronds taken to the Entomology laboratory were preliminarily diagnosed to be infested with *R. indica*. Specimens were later confirmed to be this species by Dr. Ronald Ochoa of the Insect and Mite Identification Service of the USDA-ARS Systematic Entomology Laboratory. This service was facilitated through CARINET.

In May 2006, a rapid reconnaissance program undertaken by the Ministry of Agriculture, Land and Marine Resources (MALMR) and assisted by the USDA officials (Dr. Ronald Ochoa and Ethan Kane) confirmed the presence of red palm mite found in coconuts (*C. nucifera*), indigenous heliconias (*Heliconia* spp.) and bananas (*Musa* spp.) at Icacos and Guayaguayare. Subsequent surveillance activities showed that the red palm mite was rapidly spreading to new locations.

Economic Impact of *R. indica*

Raoiella indica is a pest of quarantine importance. Its presence could have a negative impact on international trade as restrictions have already been implemented by USDA to reduce the risk of entry of red palm mite into the United States. The pest was first detected in Florida in December 2007.

Raoiella indica has the potential to quickly establish and spread to new areas. It can be dispersed by wind currents and also through trade (Welbourn, 2006) and human activities (Mendonca *et al.*, 2005), which may have been the pathway of entry into this country. The pest has a high reproductive rate with a life cycle of 33 days and it can reproduce both by sexual and parthenogenetic means (Mendonca *et al.*, 2005). Although the red palm mite predominantly attacks palms (Arecaceae) (Kane *et al.*, 2006), it also has been reported from a number of host plants in six other families.

Natural/Biological control of *R. indica*

In many countries where red palm mite is present, natural regulation often occurs. Nageshachandra and Channabasavanna (1984) reported an increase in population levels of red palm mite during periods of low relative humidity, high temperatures and long periods of sunlight, whereas high rainfall had a negative impact. In Mauritius, the predatory mite, *Typhlodromus caudatus* Berlese (Acari: Phytoseiidae) was reported to be an important natural enemy of eggs of *R. indica* (Moutia, 1958). In Trinidad, several natural enemies have been observed in association with red palm mite.

Objectives of the study

Investigations on *R. indica*, its host range, distribution, biotic and abiotic factors affecting populations in Trinidad would form the basis for adoption of management strategies for the pest.

This study was conducted to confirm the presence and distribution of *R. indica* in Trinidad. It is also expected to identify associated natural enemies and their distribution.

MATERIALS AND METHODS

Site/tree Selection

A list of coconut farms was obtained from each of the eight County Agricultural Offices in Trinidad. From each county ten locations/farms were randomly selected. At each location/farm two trees were sampled.

Leaf Sampling

In each selected tree, the 3rd and 9th fronds were cut and gently lowered to the ground by the tree climber using a rope. Intotal, six leaflets were taken from each frond; one each, 60 cm from both the leaftip and leafbase and four from the intermediate portion of the leaf, i.e. two leaflets from both sides of the rachis. The samples were placed in plastic bags, labelled, stored in coolers and transported to the Entomology laboratory.

Laboratory Examination

Leaflets from each sample were passed through a mite-brushing machine. The mite-brushing machine sweeps mites and natural enemies off the leaflets into a spinning disc which is divided into twelve sections from the center radiating towards the circumference. Direct visual counts of mites and natural enemies were made on the disc under a binocular stereo microscope at a magnification of150 x.

Data Collection

Data on variety of coconut (tall, short, yellow, green), height of tree and location using the Global Positioning System (GPS) were recorded n the Field Data Sheet (Appendix 1.)

The number of leaflets examined, number of red palm mites and the number of natural enemies were recorded in the Laboratory Data Sheet (Appendix II).

Data Analysis

The data were analysed using the Statistical Package for Social Sciences (SPSS) Version 7.5. Because the data were not normally distributed, they were also logarithm transformed and subjected to analysis of variance (ANOVA).

RESULTS AND DISCUSSION

The number of coconut farms by county is shown in Figure 1. The majority (71.9%) of coconut farms in all counties except Nariva/Mayaro were small scale/backyard situations less than 1 hectare in size. Medium sized farms (> 1.0 ha –20.0 ha) were located in all counties comprising (26.2 %) of the total number while large farms (>20.0 ha) comprised 1.9%. The eight large farms were located in the counties St. Andrew/St. David, St. Patrick West and Nariva/Mayaro. (Table1). The distribution of small, medium and large coconuts farms is given in Figure 2.

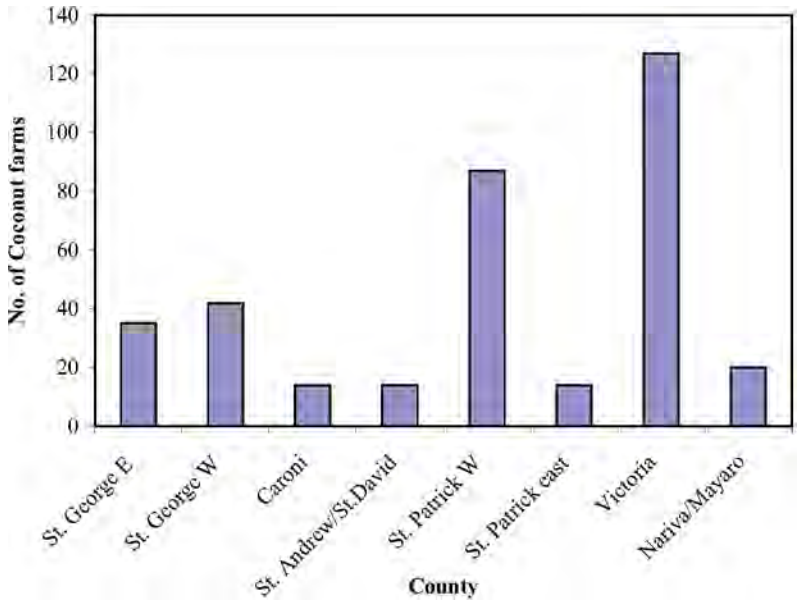


Figure 1. Distribution of coconut farms by county

Source: County Agricultural Offices

Overall, red palm mite was present in all counties (Appendix III). In most situations were red palm mite was found natural enemies also were present. Natural enemies consisted of two species of predatory mites in the families Phytoseiidae and Cunaxidae and lacewings (Chrysopidae). In general, natural enemy populations were low for all counties (Figure 3) ranging from nine in St. Patrick East to 81 in St. George West.

Table 1. The distribution of coconut farms by size of holdings for all counties

County	Small farms < 1.0 ha	Medium farms > 1.0 to < 20 ha.	Large farms > 20 ha	Total no. of farms
St. George East	35	1	0	36
St. George West	41	1	0	42
Caroni	12	2	0	14
St. Andrew/St. David	9	4	1	14
St. George East	13	1	0	14
St. George West	72	11	4	87
Victoria	112	6	0	172
Nariva/Mayaro	0	27	3	30
Total	294	107	8	409
%	71.9	26.2	1.9	100

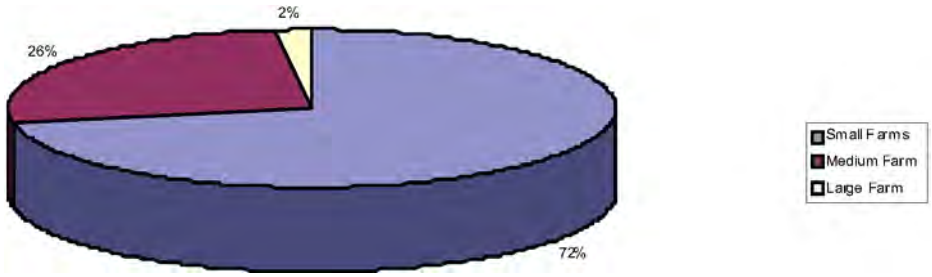


Figure 2. The Distribution of Small, Medium and Large coconut farms in Trinidad

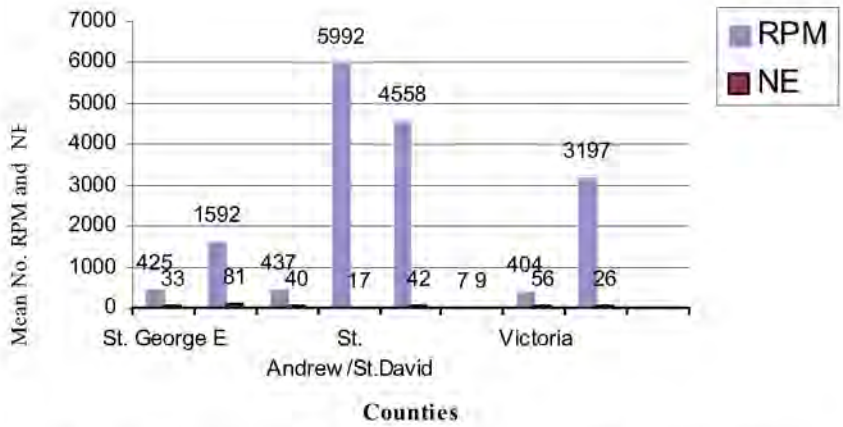


Figure 3. The Mean No. of Red Palm Mite(RPM) and Natural Enemies (NE) by County

Table 2. The mean number (log transformed) of red palm mite on leaf 3 by county [1]

County	Mean	Std. Error
St. George East	3.468	.767
St. George West	4.419	.548
Caroni	3.316	.525
St. Patrick West	4.802	.500
St. Andrew/ St. David	6.388[a]	.533
St. Patrick East	.169	.548
Nariva / Mayaro	6.629[a]	.641
Victoria	3.350	.467

1 Means within the column followed by similar letter do not differ significantly ($p<0.05$)

Table 3. The mean No. of red palm mite by month for leaf 3[1]

Month	Mean	Std. Error
7	4.316 [a]	.311
8	4.560 [a]	.337
9	4.235 [a]	.421

1 Means within the column followed by similar letter do not differ significantly ($p<0.05$)

Table 4. The mean number (log transformed) of red palm mites on leaf 9 by counties[1]

County	Mean	Std. Error
St. George East	3.918	.820
St. George West	5.476	.587
Caroni	2.879	.562
St. Patrick West	4.929	.535
St. Andrew / St. David	6.655 [a]	.570
St. Patrick East	.949	.587
Nariva / Mayaro	6.835 [a]	.685
Victoria	3.201	.500

1 Means within the column followed by similar letter do not differ significantly ($p<0.05$)

Table 5. The mean No. of RPM for leaf 9 by month[1]

Month	Mean	Std. Error
7	4.823 [a]	.333
8	4.705 [a]	.360
9	4.257 [a]	.451

1 Means within the column followed by similar letter do not differ significantly ($p<0.05$)

Table 6. The mean number (log transformed) of natural enemy by county[1]

County	Mean	Std. Error
St. George East	3.655 [a]	.420
St. George West	4.159 [a]	.301
Caroni	3.245	.288
St. Patrick West	3.428	.274
St. Andrew/ St. David	1.963	.292
St. Patrick East	1.539	.301
Nariva / Mayaro	3.482	.351
Victoria	3.640 [a]	.256

1 Means within the column followed by similar letter do not differ significantly ($p<0.05$)

Table 7. The mean number (log transformed) of natural enemy by month[1]

Month	Mean	Std. Error
7	3.472 [a]	.171
8	2.521	.185
9	3.144 [a]	.231

1 Means within the column followed by similar letter do not differ significantly ($p<0.05$)

The mean number of red palm mite and natural enemy by county and month is summarized in Tables 2-7 respectively.

The ANOVA showed highly significant ($p<0.000$) county and month effects for mite and natural enemy populations on both leaf 3 and leaf 9. These effects also were noted in surveys conducted in St. Lucia where differences in mite populations were found between regions and months (Bruce Lauckner, palmmite@cardi.org).

Population Dynamics

For both leaves 3 and 9, the county Nariva/ Mayaro had significantly ($p<0.05$) more mites than the other counties except St. Andrew/St. David. Nariva/Mayaro had the highest number of mites followed by St. Andrew/St. David, St. Patrick West, St. George West, St. George East, Victoria, Caroni and St. Patrick East for leaf 3. The counties with higher mite populations also were those with large (>20.0ha) coconut farms except for St. George West, which is densely populated (people) and has numerous backyard situations with trees clustered together like large estates. In most situations, Leaf 9 had more mites than Leaf 3, which is expected because symptoms of mite infestations are always more pronounced on the lower leaves.

On large farms, once the infestation occurs it is expected that populations would increase exponentially given the high reproductive rate and potential to quickly establish and disperse to new locations (Mendonca et al, 2005). In May 2006, surveillance activities revealed no evidence of red palm mite in St. Andrew/St. David however high populations were observed further south in Nariva/Mayaro at Guayaguayare. By September 2006, red palm mite was first observed at Manzanilla in St. Andrew/St. David and at the time of the survey, one year after, the population had exploded. This quick spread and establishment to Andrew/St. David may be attributed to wind movements and commerce in green coconuts because workers/ coconut vendors move from area to area in search of green/immature coconuts transporting with them infested leaves as packing

material. The high populations of red palm mite in St. Andrew/St. David is not unexpected since this county had large numbers of available host and one of the lowest number of natural enemies. In the absence of density dependent factors, e.g. predators, there is exponential growth of a (pest) population in newly infested areas. However, exponential growth of a population is followed by large fluctuations (Murray, 1979). Welbourn (2006) reported that red palm mite can be dispersed by wind currents and through trade whereasMendonca et al, (2005) indicated that dispersal is also through human activity where people contribute to infestation. St. Patrick East had few (14) coconut farms, the majority of which were backyard situations sparsely distributed which may attribute to low red palm mite populations as compared to St. George West, which has many backyard farms forming clusters of coconut trees.

Regarding natural enemies, several predators were found associated with red palm mite in the field. These include *Amblyseius largoensis* Muma, an unidentified species in the family Cunaxidae, ladybird beetles (Coccinellidae) and lacewings (Chrysopidae). The predominant one was *A. largoensis*. The population was significantly ($p < 0.05$) greater in St. George West than in St. Andrew/St. David, St. Patrick East, Nariva/Mayaro, Caroni and St. Patrick West. Although they were present in all counties there was no correlation between the natural enemy complex and red palm mite populations. However, indigenous natural enemies found attacking red palm mite are expected to provide some control of the pest. At present, there seems to be very little or no impact on the pest populations. According to Cornell and Hawkins (1993), indigenous natural enemy complexes on exotic species…"are too young to be considered fully integrated associations" as compared to indigenous species and … "may require between 100 – 10, 000 years." Therefore intervention is required by way of rearing and multiplication of natural enemies to augment the natural enemy population or the implementation of a classical biological control strategy to manage the pest.

Varietal Influence

The varieties surveyed were dwarf green, dwarf yellow, tall green and tall yellow. Since a varietal effect was not observed it suggests that all varieties are susceptible. However, dwarf green coconuts at Constance Estate, Icacos observed during routine surveillance, although highly infested displayed little or no typical symptoms of red palm mite infestation. A varietal effect observed in St. Lucia suggests that varieties displaying only minor symptoms of mite damage actually were highly infested, which may indicate varietal tolerance (Bruce Lauckner, palmmite@cardi.org)

Weather Influence

Regarding time of the year, the survey was conducted from July to September 2007 during the rainy season. Although a temporal effect was observed and populations of red palm mite were highest for leaves 3 and 9 in August and July, respectively, and natural enemy populations were significantly ($p <0.05$) greater in July than in August, it is too early to suggest seasonal influence. However, it is expected that populations would peak and fluctuate from time to time as weather has an impact on red palm mite populations (Moutia, 1958., Nageshachandra and Channabasavanna, 1984). This phenomenon can be investigated by conducting long-term population dynamics studies and surveys during the dry season.

CONCLUSION

Red palm mite is distributed in all counties in Trinidad (Appendix III). Although the population is low in St. Patrick East, it is expected to increase with time. Natural enemies were also present in all counties surveyed, which suggests that they have an active role in regulating red palm mite populations. The presence of red palm mite is now widespread and confirmed to be in Trinidad.

RECOMMENDATIONS

Based on the high populations of red palm mite in St. Patrick West, St. Andrew/St. David and Nariva/Mayaro, it is recommended that long-term population dynamics studies of red palm mite and their natural enemies be conducted in these counties. Because the presence of natural enemies is expected to regulate red palm mite populations, these should be reared and mass produced in the laboratory for augmenting populations in the environment in a biological control program. Mite surveys also should be repeated during the dry season to investigate differences (if any) in populations due to abiotic factors. Finally, a survey should be conducted in Tobago to determine the status of red palm mite on the island.

REFERENCES

Calero-Toledo, L. M., Perez, J., Gil de Rubio, Y., Medina, R., Benitez, L., Guzman, B., Hewrnandez, R., Jimenez, S., Martinez, N., Millan, P., Romero, L., Rosario, N., Zaleski, C., Rodriguez, Cruz, B., Crespo C. and F. 2006. *Raoiella inidca* Hirst (Acari: Prostigmata: Tenuipalpidae) a new menace to *Musa* sp. Industry in Puerto Rico. USDA/APHIS/PPQ-PHIS San Juan.

Cornell, H. V. and Hawkins, B. A. 1993. Accommodation of native parasitoid species on introduced herbivores: a comparison of hosts as natives and hosts as invaders. Amer-Nat. (Chicago). 141: 847 – 865.

Flechtmann, C.H.W. and Etienne, J. 2004. The red palm mite, Raoiella indica Hirst, a threat to palms in the Americas. J. Systematic and Applied Acarology 9: 109-110.

Kane, E.C. and Ochoa, R. 2006. Detection and identification of red palm mite Raoiella indica Hirst (Acari Tenuipalpidae)
http.//www.sel.barc.usda.gov/acari/PDF/indica Guide.pdf

Kane, E. C., Ochoa, R., Mathurin, G. and Erbe, E.F 2006. Raoiella indica Hirst (Acari: Tenuipalpidae): An island hopping mite pest in the Caribbean. USDA-ARS, Baltimore.

Mendonca, R.S., Navia, D. and Flechtmann, C.H.W. 2005. Raoiella indicates Hirst (Acari: Prostigmata: Tenuipalpidae), O-mite vermelho das palms Uma ameaça for as Americas. Brasilia: Embrapa Genetic Resources and Biotechnology (Document 146). Available at:
http://www.cenargen.embrapa.br/publish/works/doc146.pdf

Moutia, L.A 1958. Contribution to the study of some phytophagous acarina and their predators in Mauritius. Bull. Ent. Res. 49 (1) 59-75.

Murray, Jr. B. G. 1979. Population Dynamics. Academic Press, INC. New York, 212 pp.

Nageshachandra, B. K. and Channabasavanna, G. P. 1984. Development and Ecology of Raoiella indica Hirst (Acari: Tenuipalpidae) on coconuts. In. Griffiths, D. A. and C. E. Bowman. Acarology Vl: 2, 785-798.

Welbourn, C. 2006. Red Palm Mite Raoiella indica (Acari: Tenuipalpidae). Pest Alert. DPI-FDACS; 4pp. (http://www.doacs.state. fl.us/pi/enpp/ento/r.indica.html).

ACKNOWLEDGEMENTS

The authors are grateful to Mr. Bruce Lauckner, Biometrician at CARDI for statistical consultations and data analysis. The assistance of the on-the-job (OJT) trainees, Messrs. Keston Harradan and Nehru Haynes and Ms. Sasha Maraj, (students of the University of the West Indies), in laboratory processing of the samples is greatly appreciated. Thanks to Ms. Marlene Roberts for data entry and typing of the manuscript.

Appendix I

Appendix I

MINISTRY OF AGRICULTURE LAND AND MARINE RESOURCES

RED PALM MITE SURVEY - Field Data Sheet

Name of Officer: _____ **County:** _____

Date:_____ **Site Sampled:** _____

				GPS			
Tree	**Ref#**	**Variety**		**N**	**W**	**Altitude**	**Height**

Appendix II

Appendix II												
MINISTRY OF AGRICULTURE LAND AND MARINE RESOURCES												

RED PALM MITE SURVEY - Laboratory Data Sheet

Name of Officer: _____ **County:** _____

Date:_____ **Site Sampled:** _____

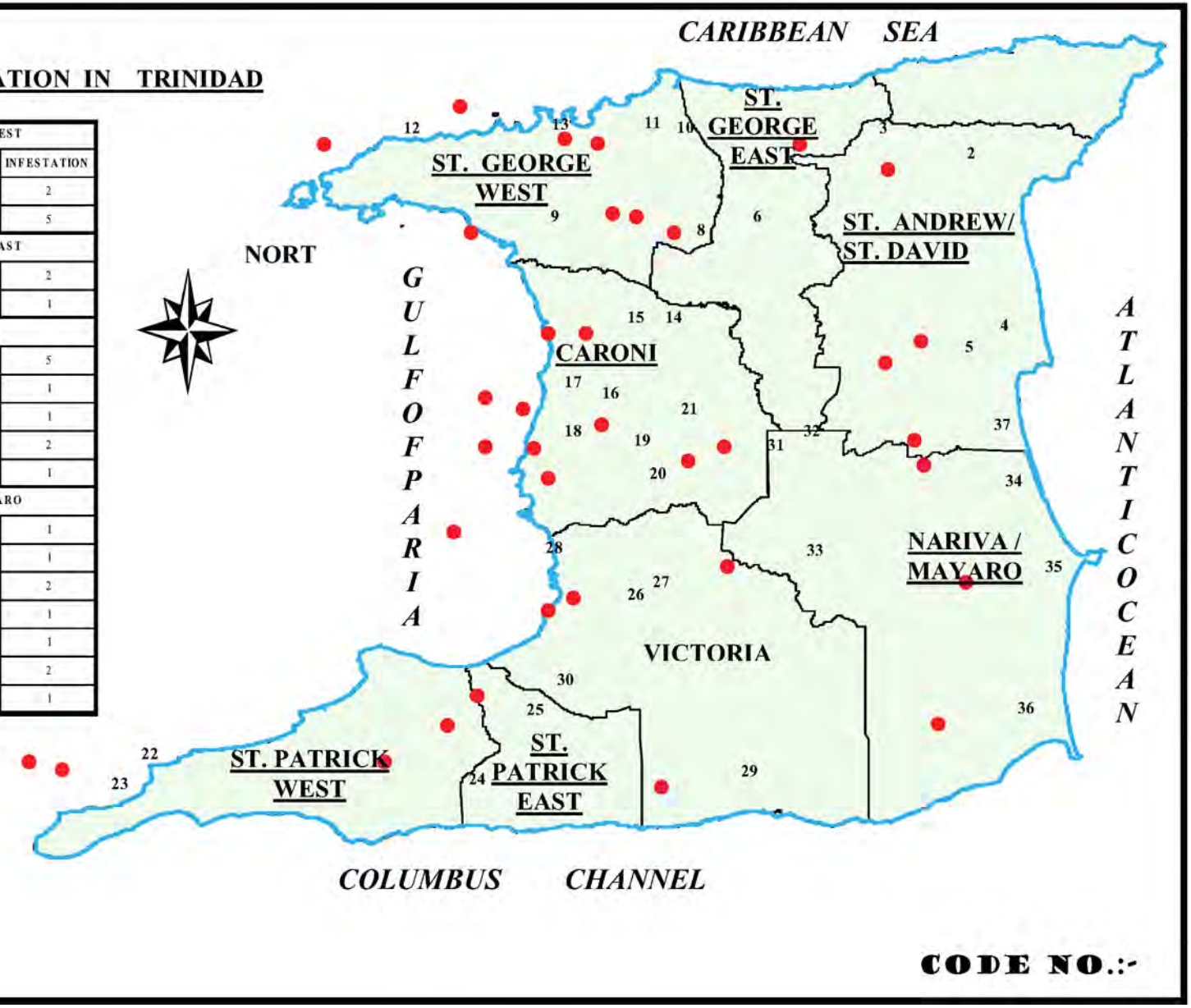
Ref.	**Variety**	**Leaf 3**				**Leaf 9**					**GPS**	
		No. of mites			**Leaflet**	**No. of mites**			**Leaflet**	**Natural**		
		E	**I**	**A**	**length (cm)**	**E**	**I**	**A**	**length (cm)**	**enemies**	**N**	**W**

Appendix III: Distribution of Red Palm Mite in Trinidad, July – September 2007

RED PALM MITE INFESTATION IN TRINIDAD

T. DAVID / ST. ANDREW	
LOCATION	INFESTATION
CUMANA	2
MATHURA	1
VALENCIA	3
PER MANZANILLA	2
PLUM RD.	2
ST. GEORGE EAST	
WALLERFIELD	2
ARIMA	3
MALONEY	5
ST. GEORGE WEST	
BAMBOO #1	5
LOPINOT	2
CAURA	1
DIEGO MARTIN	1
MARACAS	1
CARONI	
LAS LOMAS	1
ENTERPRISE	1
FREEPORT	2
CARAPICHAIMA	2
COUVA	1
PREYSAL	1
TORTUGA	1
MAMORAL	1

ST. PATRICK WEST		
CODE	LOCATION	INFESTATION
22	GRANVILLE	2
23	CEDROS	5
ST. PATRICK EAST		
24	SIPARIA	2
25	CLARKE ROCHARD	1
VICTORIA		
26	PRINCESS TOWN	5
27	NEW GRANT	1
28	CLAXTON BAY	1
29	MORUGA	2
30	BARRACKPORE	1
NARIVA / MAYARO		
31	TABAQUITE RD.	1
32	NAVET VILLAGE	1
33	LIBERTVILLE	2
34	LOWER MANZANILLA	1
35	MAYARO	1
36	GUAYGUAYARE	2
37	ORTOIRE VILLAGE	1



2008 Proceedings of the Caribbean Food Crops Society. 44(2):249-260. 2008

Establecimiento de *Doryctobracon Areolatus* (Szépligeti) (Hymenoptera: Braconidae), Parasitoide Exótico de *Anastrepha* Spp. (Diptera: Tephritidae), en la República Dominicana;

Establishment of the Exotic Parasitoide of *Anastrepha* Spp. (Diptera: Tephritidae), *Doryctobracon Areolatus* (Szépligeti) (Hymenoptera: Braconidae), in the Dominican Republic

Colmar A. Serra[1], Mileida Ferreira[1], Socorro García[1], Loeny Santana[1], Maira Castillo[2], Caridad Nolasco[3], Paula Morales[4], Timothy Holler[5], Amy Roda[5] & John Sivinski.
[1]Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF), [2]Universidad Autónoma de Santo Domingo, [3]DSV-Secretaría de Estado de Agricultura, [4]USDA-APHIS, Santo Domingo, Dominicana; [5]USDA-APHIS, [6]USDA-ARS, Florida, E.U.A. cserra@idiaf.org.do

RESUMEN:
En dos zonas con alta prevalencia: Hato Damas (HD, Suroeste) y Mata Larga (ML, Noreste) se desarrolló un programa de control biológico clásico con parasitoides exóticos criados en México. Entre junio y diciembre del 2005, se liberaron 14,690 (HD) o 2,182 (ML) avispitas, respectivamente en alrededor de 20 árboles de *Spondias* spp. u otros hospederos en cada área. Durante tres períodos consecutivos de fructificación hasta Octubre del 2007, se recogieron periódicamente frutos de árboles hospederos. En laboratorios del IDIAF se registraron las cantidades de frutos, pesos, larvas/pupas obtenidas, emergencia de moscas (especie y sexos), parasitoides nativos y exóticos. En 2007, en la zona de HD se recuperaron parasitoides exóticos en 16 de los 18 lugares muestreados con 1.1 a 100% de parasitismo, variando este último en combinación con la especie nativa entre 11.1 y 87.5%. Los exóticos dominaron temporalmente en más del 50% de los lugares muestreados. Emergieron de jobo, ciruela, manzana de oro, guayaba, vinagrillo, carambola, manzana malaya, y almendro tropical. En ML se confirmó el establecimiento de *D. areolatus* recién finalizando el estudio, posiblemente debido a la insuficiente disponibilidad de plantas hospederas de *Anastrepha* durante el año entero y la mucho menor cantidad de parasitoides liberados. Se detectaron *D. areolatus* a 6 km (Suroeste), 7 km (Sureste) y 50 km (Noroeste) desde los lugares de liberación más cercanos de HD. Un muestreo realizado en una plantación comercial de guayaba, indica un incremento de parasitismo por *D. areolatus* durante la temporada húmeda y reducción de infestación de frutos.

PALABRAS CLAVES: Control biológico clásico, moscas de las frutas, *Spondias* spp., *Psidium guajava*

ABSTRACT:
Two zones: Hato Damas (HD, South) and Mata Larga (ML, Northeast), were selected to develop a program on classical biological control with exotic parasitoids reared in Mexico. Between June and December 2005, a total of 14,690 (HD) or 2,182 (ML)

parasitic wasps, respectively, were released in about 20 selected trees of *Spondias* spp. or other hosts in each zone. During three consecutive fructification periods until October 2007, fruits were sampled periodically from host trees. In laboratories of IDIAF were registred amounts of fruits, weights, obtained larvae/pupae, emergence of fruit flies (species and sexes), native and exotic parasitoids. In 2007, in the HD zone, exotic parasitoids were obtained in 16 of 18 monitored localities with between 1.1 and 100% parasitism, varying the latter in combination with the native species between 11.1 and 87.5%. The exotics dominated temporarily in more than 50% of the monitored places. They emerged from hogplums, ambarella, guava, Malayan apples, pickle fruit, carambola, and tropical almond. In ML, the establishment of *D. areolatus* was only confirmed finishing the study, possibly due to an reduced disponibility of *Anastrepha*-host plants during the whole year and the much lower amount of released parasitoids. *D. areolatus* were detected at 6 km (Southwest), 7 km (Southeast) and 50 km (Northwest) from the nearest spots of liberation of HD. A survey carried out in a commercial guava plantation indicates an increase of parasitization by *D. areolatus* during the humid season and reduction of fruit infestation.

KEYWORDS: Classical biological control, fruit flies, *Spondias* spp., *Psidium guajava*

INTRODUCCIÓN

Las moscas de la fruta (Diptera: Tephritidae) provocan daños cuantiosos a la producción de mangos, guayabas, cerezas, carambolas y otras frutas en la República Dominicana. Constituyen una limitante seria para el desarrollo de la fruticultura, especialmente para el sector del mango. Éste ha experimentado un auge en las áreas de producción, tanto para el consumo interno (frutos frescos y agroindustrias) como para la exportación, incluyendo mangos orgánicos hacia la Comunidad Europea y recientemente también hacia los EE.UU. Esto último es posible a partir de la certificación de una planta de tratamiento de frutos con agua caliente ubicada en Moca (zona Norte) y otra por construirse en Baní (zona Sur). *Anastrepha obliqua* (Macquart), la Mosca de las Frutas de las Indias Occidentales, constituye la principal amenaza para el desarrollo del sector de los mangos, mientras que la Mosca de las Frutas Caribeña (*A. suspensa* (Loew) lo es para la guayaba, cítricos y otras frutas. Estudios realizados por Ventura *et al.,* 1990 y Cuevas *et al.,* (2002) han demostrado la distribución y abundancia relativa de éstas y otras especies del mismo género.

La importancia de la temática para el sector frutícola nacional se ve reflejada en las actividades de diferentes instituciones durante los últimos años. De esta manera, el Depto. de Sanidad Vegetal (DSV-SEA) está realizando trampeos periódicos para detectar la eventual introducción de tefrítidos exóticos no reportados para el país (mosca del mediterráneo [*Ceratitis capitata* (Wied.)], *Bactrocera* spp., *Dacus* spp. y diversas *Anastrepha* spp. como *A. ludens* (Loew), *A. fraterculus* Wied., y *A. serpentina* Wied., entre otras, en diferentes zonas del país con trampas McPhail y trampas Jackson en diferentes zonas del país.

La Universidad Autónoma de Santo Domingo (UASD) estudió el rango de plantas hospederas y distribución de moscas de la fruta (Castillo *et al.*, 2006). En el IDIAF y en algunos trabajos con apoyo de la Universidad Nacional Pedro Henríquez Ureña (UNPHU) y en otros del USDA/ARS, se realizaron estudios comparativos de atrayentes

líquidos y sintéticos sólidos y/o para capturas de moscas de las frutas y organismos no meta; se incluyeron comparaciones de trampas modificadas de McPhail multicebos (MultiLure®, Better World Manufacturing, Inc, Fresno, CA) con bases de diferentes colores y la versión amarilla con trampas Easytrap® (Soligor, España) y 'caseras' en plantaciones comerciales de mango, guayaba y una mixta de guayaba y carambola en el sur de la República Dominicana (Ogando y Serra 2006, Serra *et al.,* 2005a,b y 2007, Thomas *et al.,* 2008).

A partir de Junio del 2004, un equipo del IDIAF realizó muestreos de frutas atacadas por moscas de las frutas del género *Anastrepha*, especialmente de mango (*Mangifera indica* L.), 'jobo' (*Spondias mombin* L.) y 'ciruela' (*S. purpurea* L. var. *flava*) en los municipios de la Región Sur Hato, Damas (Provincia San Cristóbal) y Matanzas (Prov. Peravia), así como en la Región Nororiental, en Mata Larga, San Francisco de Macorís (Prov. Duarte) y en Las Terrenas (Prov. Samaná). Como resultado se obtuvieron parasitoides larval-pupales nativos identificados por Robert A. Wharton, Texas A&M University, como *Utetes anastrephae* (Viereck) (Hymenoptera: Braconidae) (Ver imagen 1) con niveles de parasitismo determinados entre 6 y 90% en *Spondias* spp. asociado a *A. obliqua*, siendo el primer reporte de este parasitoide en el país (Serra *et al.* 2005c). Sin embargo, no se pudo obtener *U. anastrephae* emergidos de frutas de mangos, ni guayaba muestreadas, aún cuando hubo una relativamente alta infestación con larvas de *Anastrepha* spp. Razones morfológicas relacionadas con el corto ovipositor de la especie parasitoide son discutidas para explicar la limitación en el rango de frutales hospederos (ver Imagen 1). La ausencia de otros parasitoides importantes, podría subrayar, que la así llamada Mosca de las frutas de las Indias Occidentales (*A. obliqua*) sea originaria de México y/o Centro América, donde si abundan. Se llegó a la recomendación de realizar un proyecto de Control biológico clásico de moscas de las frutas liberando masivamente en las zonas estudiadas a uno o diferentes parasitoides exóticos con fines de su establecimiento y evaluación.

Basado en estos resultados, completados posteriormente por otro muestreo realizado por un grupo multi-institucional, inició el programa de control biológico clásico con el envío semanal de hasta 1000 parasitoides bracónidos *Doryctobracon areolatus* (Szépl.) (Ver imagen 1) desde México y liberación en *Spondias* spp. en las provincias San Cristóbal y Duarte con la participación de las instituciones listadas. Como objetivos, el programa tiene entre otras metas lograr el establecimiento de este parasitoide en el país para apoyar el programa de control biológico de la mosca de la fruta y complementar las especies nativas, para reducir las poblaciones de moscas de las frutas. La reducción de las poblaciones de moscas de las frutas sería de mucha importancia para obtener y mantener zonas de baja prevalencia de estos especimenes y así poder cumplir con los requisitos de la USDA-APHIS para la exportación de mangos hacia los E.U.A. Las frutas para exportación a Estados Unidos no pueden contener ninguna larva viva. Además permitiría la integración del control biológico con otras técnicas de manejo de moscas de las frutas como el uso de trampas y atrayentes efectivos, la aplicación de insecticidas biológicos, métodos culturales y legales, entre otros.

MATERIALES Y METODOS

Los estudios fueron realizados en las dos zonas seleccionadas a partir del período de liberación de parasitoides entre el de parasitoides entre el 17 de Junio y 15 de

Diciembre del 2005 y concluido durante el período de fructificación de *Spondias* spp. en Octubre del 2007. Las zonas de liberación fueron seleccionadas con los siguientes criterios: altas densidades de *Anastrepha* spp., datos sobre parasitismo nativo existentes, presencia de numerosos árboles hospederos de moscas de las frutas y buena accesibilidad y cercanía relativa a laboratorios para monitorear la emergencia de moscas y parasitoides. La zona de Hato Damas, perteneciente al municipio y la provincia de San Cristóbal, se encuentra a alrededor de 17 km de Santo Domingo y 20 km de los laboratorios del Centro de Tecnologías Agrícolas (CENTA) del IDIAF, mientras que la zona de Mata Larga, paraje rural de San Francisco de Macorís, provincia Duarte, comprendió parte de la finca de la Estación Experimental Mata Larga (EEML), quedando el punto de liberación y estudio más lejano a menos de cuatro km de los laboratorios. Alrededor de la primera zona, se establecieron 10 puntos de monitoreo fuera del área de liberación hacia el Sur y Sureste, que fueron periódicamente muestreados para obtener informaciones sobre la dispersión de los parasitoides exóticos liberados.

Liberación masiva de D. areolatus (Hymenoptera: Braconidae): Los parasitoides fueron criados y enviados en 26 ocasiones durante el período de liberación de medio año (17/6 al 15/12/2005). En el Laboratorio de Post-entrada en el Aeropuerto Internacional de Las Américas de Santo Domingo (AILA), los parasitoides fueron recibidos por personal del DSV y se registró la mortalidad y las cantidades de hembras y machos recibidos y su estado. Pasaron por el Laboratorio de Cuarentena por mínimo 24 horas y fueron alimentados con una solución de miel para su recuperación antes de ser transferidos a los contenedores en número de 20 para su transporte en una nevera transportable a los puntos de liberación en el campo.

En total se soltaron en la R.D. en 26 jornadas 16,973 parasitoides (58.2% hembras, 41.8% machos). En la zona de Hato Damas se soltaron en 21 fechas (17/6-15/12) un total de 14,791 parasitoides (87.1% del total), correspondiendo alrededor de un 57% a hembras. En la zona de Mata Larga, se liberaron en cinco fechas (22/7-30/9) 2,182 parasitoides perteneciendo un 67% a hembras. La menor proporción de machos liberados se debió a una mayor mortalidad de los mismos durante y después del transporte desde el laboratorio de cría hacia el laboratorio para aclimatarse y se incrementaba a medida que aumentaba la duración del traslado a los puntos de liberación, encontrándose la segunda zona a casi tres horas de viaje (170 km) desde el AILA.

De los originalmente seleccionados puntos para el estudio, no se liberaron parasitoides en los árboles enumerados 5, 6, 7, 11, 13, 15 en Hato Damas y 6 y 13 en Mata Larga por diferentes razones como la reducida presencia de frutas maduras, podas o cortes realizadas por lugareños, y otras. Sin embargo, en algunos de ellos como el # 13 de HD se realizaron colectas de frutos.

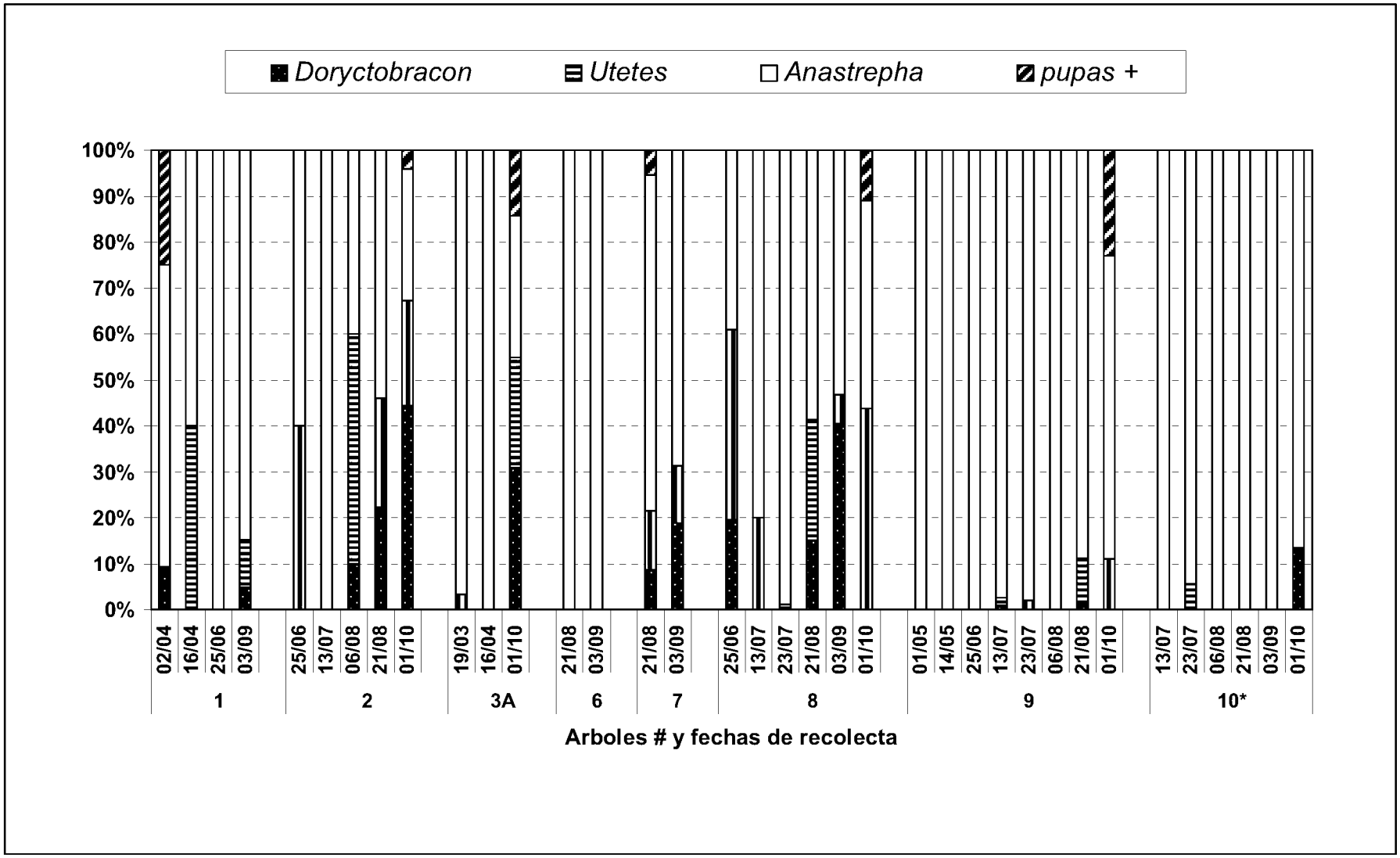
Recolección de frutas: Los frutos fueron colectados desde el suelo o en caso de necesidad de ramas inferiores alcanzables. En formularios de recolección se registraron los números de los árboles muestreados, cantidad y pesos de los frutos recolectados, fechas de inspección (inicial, 2da y final) y las pupas o larvas que abandonaron los frutos para empupar en el suelo obtenidas al momento de desecharse los mismos, 10 días después de su colecta. De la arena que cubría el fondo de unos recipientes de 50 cm de diámetro (10 l) se colectaron las pupas al éstas salir a flote cuando se realizaba un lavado de la arena. Las pupas fueron luego transferidas a frascos plásticos (3.75 l) con una fondo de 6 cm de arena mantenida humedecida durante un mes. En éste período se monitoreaba

la emergencia de moscas de las frutas y/o parasitoides, las cuales fueron identificadas y la mortalidad de pupas. Los datos de emergencia y especies fueron confirmados en laboratorios de la UASD.

RESULTADOS Y DISCUSION

La Figura 1 contiene los resultados obtenidos en el 2007 de la zona de Hato Damas, dos años después de las liberaciones. Está representada la mortalidad porcentual de pupas debido a factores probablemente climáticos y la emergencia porcentual a partir de frutas procedentes de 17 árboles de *Spondias mombin* o *S. purpurea* de moscas, parasitoides nativos y exóticos (géneros *Anastrepha*, *Utetes, Doryctobracon*, respectivamente). Se recuperaron parasitoides exóticos en 16 de los 17 lugares representados, excepto en arbol # 6 y apenas en los árboles # 9 y 10. El parasitismo correspondiente varió desde 1.1 a 100% de parasitismo, según el lugar (árbol) y momento del muestreo. En combinación con la especie nativa, el porcentaje varió entre 11.1 y 87.5% (Fig. 1). La especie exótica llegó a dominar temporalmente en más del 50% de los lugares muestreados, en la mayoría de los casos hacia el final del período de evaluación. De esta manera en, el arbol # 20 se obtuvo una emergencia del 100% en el último muestreo, aunque también los demás puntos, excepto los # 1, 7, 9, 10 y 19, se registraron parasitismos de mayor o igual de un 30%, que pueden considerarse como relativamente eficientes. Esto tiene una especial importancia tomando en cuenta que los hospederos alternativos de la *A. obliqua* como las *Spondias*

spp.


Doryctobracon
Utetes
Anastrepha
pupas +
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
02/04
16/04
25/06
03/09
25/06
13/07
06/08
21/08
01/10
19/03
16/04
01/10
21/08
03/09
21/08
03/09
25/06
13/07
23/07
21/08
03/09
01/10
01/05
14/05
25/06
13/07
23/07
06/08
21/08
01/10
13/07
23/07
06/08
21/08
03/09
01/10
1
2
3A
6
7
8
9
10*
Arboles # y fechas de recolecta

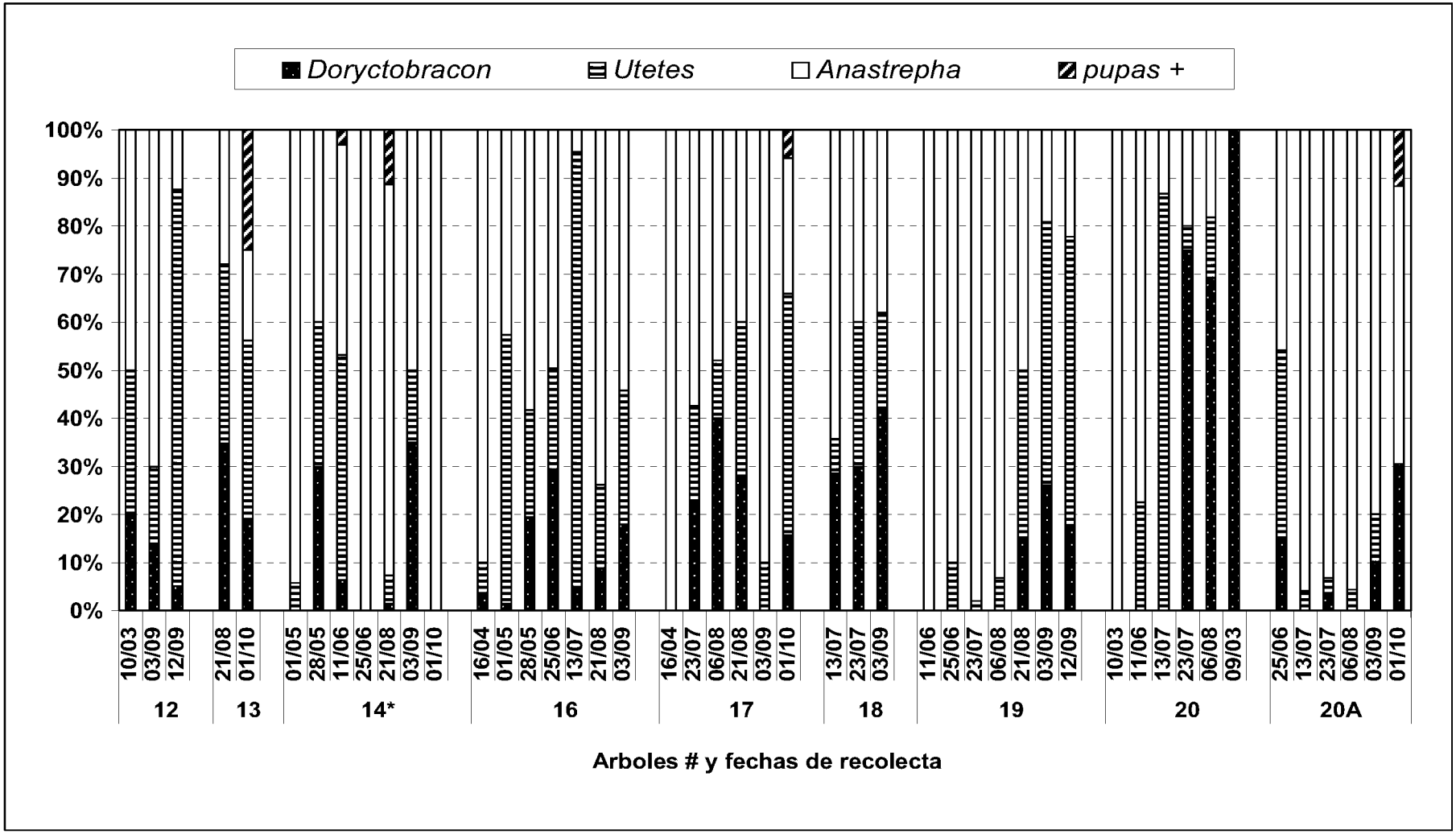

Doryctobracon
Utetes
Anastrepha
pupas +
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10/03
03/09
12/09
21/08
01/10
01/05
28/05
11/06
25/06
21/08
03/09
01/10
16/04
01/05
28/05
25/06
13/07
21/08
03/09
16/04
23/07
06/08
21/08
03/09
01/10
13/07
23/07
03/09
11/06
25/06
23/07
06/08
21/08
03/09
12/09
10/03
11/06
13/07
23/07
06/08
09/03
25/06
13/07
23/07
06/08
03/09
01/10
12
13
14*
16
17
18
19
20
20A
Arboles # y fechas de recolecta

Figura 1. Mortalidad de pupas y emergencia de los géneros *Anastrepha*, *Dorytobracon* y *Utetes* de frutos de *Spondias mombin* y *S. purpurea** (Hato Damas, San Cristóbal, 2/4-1/10/07).

y otros permiten un mantenimiento de los parasitoides asociados durante períodos de no presencia de frutas de hospederos importantes como el mango. Sin la presencia de controladores biológicos eficientes, las poblaciones de moscas aumentan a niveles altos para posteriormente atacar plantaciones de cultivos susceptibles pudiendo causar daños económicos de consideración.

Ejemplares de *D. areolatus* emergieron durante el estudio de frutos de jobo (*Spondias mombin* L.), ciruela (*S. purpurea* L. var. flava y var. purpurea), manzana de oro (*S. cytherea* Sonn., todas Anacardiaceae), guayaba (*Psidium guajava* L.), manzana malaya (*Syzygium malaccense* (L.) Merril & Perry), todos Myrtaceae), vinagrillo (*Averrhoa bilimbi* L.), carambola (*A. carambola* L., ambas Oxalidaceae), y almendro tropical (*Terminalia catappa* L., Combretaceae). Cabe mencionar, que con excepción de las dos principales *Spondias* spp. y guayaba, fueron reducidas las recuperaciones. De los frutales hospederos de *A. obliqua* de numerosas muestras tomadas de mango, así como reducidas de cereza antillana (*Malpighia glabra* L., Malpighiaceae) y cajuilito Sulimán (*Syzygium samaragnense* (Blume) Merril & Perry no se obtuvo parasitoides.

Finalizando el estudio, se detectaron *D. areolatus* a 6 km (Suroeste), 7 km (Sureste) y posteriormente en una plantación comercial de guayaba a 50 km (Noroeste) desde los lugares de liberación más cercanos de HD.

Cuadro 1: Recuperación de *D. areolatus* en *S. mombin* en la zona de Mata Larga en 2007

Arbol	Fechas	Pupas	% de emergidos			
#	recolectas	emergentes	*D. areolatus*	*Utetes*	*Anastrepha*	Parasitismo
2	21/8	70	1.4	11.4	87.1	12.9
3	21/8	39	2.6	15.4	82.1	17.9
4	21/8	65	3.1	0.0	96.9	3.1
4	3/9	32	9.4	6.3	84.4	15.6
9	3/9	69	6.3	25.0	68.8	31.3
9	26/9	32	5.0	0.0	95.0	5.0
12	21/8	44	4.5	4.5	90.9	9.1
15	21/8	83	7.3	0.0	92.7	7.3

En ML, durante muestreos realizados en el 2006, solamente en fecha del 21/8 se habían recuperado 14 parasitoides exóticos de 125 pupas obtenidas de 35 jobos del arbol # 9 en contra de las expectativas, se pudo sin embargo confirmar el establecimiento de *D. areolatus* finalizando el estudio en seis puntos de 16 muestreados hacia el final, aunque con porcentajes de emergencia relativamente bajos entre 1.4 y 9.4 % para la especie exótica y entre 3.1 y 31.3 % para el parasitismo total (Cuadro 1). Posiblemente, la baja presencia se debió a la insuficiente disponibilidad de plantas hospederas de *Anastrepha* durante el año entero y la mucha menor cantidad de parasitoides liberados que en HD. Sin embargo, es de suponer, que *D. areolatus* haya podido mantenerse en la zona en

reducidos números cuando los frutales hospederos principales no tenían frutos. Comparado con la zona de HD, ésta no presentaba el misma diversidad de especies hospederas. Un estudio futuro podría determinar la importancia de las algunas especies y posiblemente permitir la detección de otras plantas hasta la fecha no tomadas en consideración.

Cuadro 2: Grado de infestación y emergencia de moscas de las frutas y parasitoides de frutas colectadas fuera del área de liberación

	Rumbo Km,*	Fecha 2007	Frutos		Infest.		% Emergencia			
Lugar, hospedero^			#	g	Pupas/kg	Pupas	MF	*D.a.*	*U.a.*	Parasitismo
La Cruz B, *Sp*	3,SO	21/08	25	155	97	15	68.0	4.0	28.0	32.0
La Cruz D, *Sp*	6,SO	1/10	25	198	250	40	100.0	0.0	0.0	0.0
Los Cocos, *Sm*	2.5,SE	3/09	85	335	314	85	45.9	2.4	51.8	54.1
Los Mameyes, *Sp*	4.5,SE	21/08	16	400	100	40	90.0	10.0	0.0	10.0
Feliciano, *Sp*	5.5,SE	21/08	20	155	452	70	78.6	8.6	12.9	21.4
La Pared, *Sp*	7,SE	21/08	20	240	146	35	94.3	0.0	5.7	5.7
Piedra Blanca, *Pg*	50,NO	18/10	1	300	83	25	72.0	28.0	0.0	28.0

^*Sm*: *S. mombin*, *Sp*: S. *purpurea, Ac= A. carambola, Pg= P. guajava*;

*Distancia directa estimada y dirección desde el punto de liberación más cercano.

Los datos que muestran la dispersión de *D. areolatus* desde las áreas de liberaciones del parasitoide exótico en la zona de HD están contenidos en Cuadro 2. Los muestreos, que durante más de dos años cubrieron puntos hacia el Sur, Suroeste y Sureste hasta a seis o siete Km desde el punto de liberación más cercano, recién al finalizar el estudio dieron con positivos en seis lugares y una distancia máxima de 6 km hacia el Suroeste.

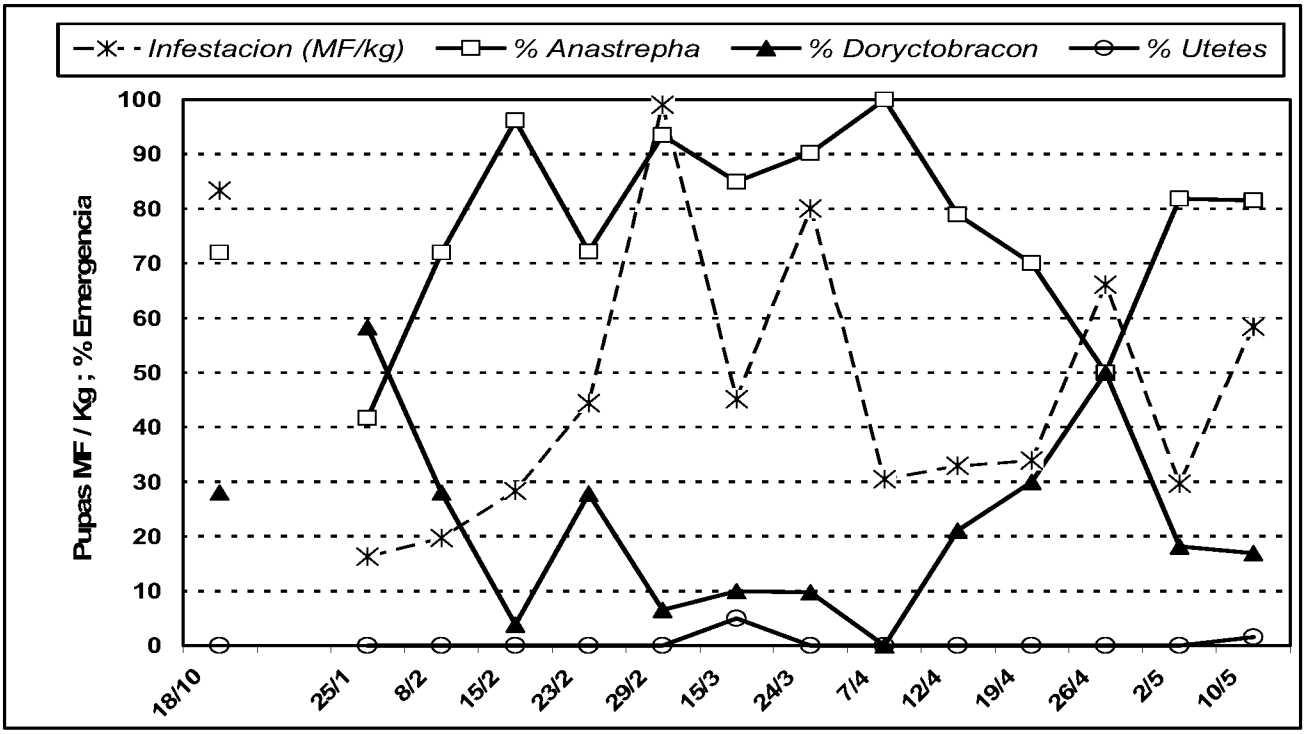


Figura 2. Infestación de guayabas tipo 'Cubano' y emergencia de *Anastrepha suspensa* o parasitoides (Piedra Blanca, Monseñor Nouel: 18/10/07-10/5/08)

Sin embargo, se detectó la presencia de *D. areolatus* durante un muestreo rutinario con frutos colectados el 18/10/2007 en una plantación comercial de guayaba tipo 'Cubano'. La finca está ubicada en Piedra Blanca, provincia Monseñor Nouel, a 50 km desde el punto de liberación más cercano hacia el Noroeste. No se pudo constatar la manera como el parasitoide pudo trasladarse de manera activa o pasiva y establecerse en esta zona. En Figura 2 se representaron datos de monitoreo dentro de la plantación fuertemente atacada por la mosca *A. suspensa.*

En el gráfico está representado el nivel de infestación medido en pupas de moscas de las frutas obtenidas por kg de fruta y en el momento del primer muestreo, el nivel fue alto al igual que el nivel de parasitismo por el parasitoide exótico. Los niveles variaron a través del período observado. A partir de mediados de febrero, con el inicio de la temporada relativamente más seca en esta zona de alta pluviometría, los niveles de infestación aumentaron, posiblemente debido al descenso de las poblaciones del parasitoide y la reducción en la fructificación en la plantación. A partir de la primera semana de abril se registró un fuerte aumento de las densidades de *D. areolatus* al mismo tiempo de la menor emergencia de moscas de los frutos. Los niveles de infestación se redujeron, en parte también debido a una reducción de frutos lo suficientemente desarrollados fisiológicamente para ser atacados por las moscas. Hacia el final de la serie representada se repite el efecto de un incremento de la infestación ante la reducción de poblaciones del parasitoide.

Durante el período completo solamente emergieron dos avispitas de la especie nativa, *U. anastrephae*, lo que sugiere una mayor limitante morfológica de esta especie para parasitar a larvas de moscas dentro de la pulpa de frutas cuyo grosor permite a las

mismas evadir al corto ovipositor (largo: ~1-1.2 mm) de las avispitas en el caso de frutas como la guayaba, carambola, manzana malaya y otras que sirven de plantas hospederas para *D. areolatus* con un ovipositor más largo (l: ~3.5-4 mm), mientras que el rango de frutales hospederos de la especie nativa se restringe a especies con escasa pulpa como *Spondias* spp. y el almendro tropical, entre otras.

Se sugiere dar continuidad a los estudios para actualizar los datos sobre la dispersión de *D. areolatus* en el país y analizar su impacto en zonas, donde está establecido comparado con otras, donde aún no ha sido detectado. Además, consideramos como muy oportuno la realización de liberaciones masivas en diferentes regiones, donde no ha sido liberado, especialmente en cercanía a áreas con presencia de plantaciones comerciales de frutales. Los parasitoides deberían preferiblemente ser producidos masivamente en el país. Si no se ejecutara un proyecto en este sentido o si resultara más económico o viable, se debería tomar en consideración la adquisición periódica de los parasitoides de laboratorios de cría de México u otros, que produzcan esta especie. Finalmente, también se sugiere realizar los estudios para determinar la existencia de otra u otras especies asociadas a moscas de las frutas del género *Anastrepha*, para eventualmente intentar establecerlas en el país y lograr complementar la acción de las especies actualmente existentes y lograr una reducción importante y sostenible de los niveles de daños en mangos, guayaba y otros frutales dentro de un paquete de manejo integrado de moscas de las frutas.

AGRADECIMIENTOS

A Robert A. Wharton , Departamento de Entomología, Texas A&M University por la identificación de parasitoides, Martín Aluja y su equipo del Instituto de Ecología, Xalapa, Veracruz, México, por el envío de los parasitoides; Daniel Virgil, Eugenio Rodríguez, José Asiático, Pedro Marte, Raúl Nina, José Volquez (todos DSV-SEA), Xiomara Cayetano, Teofila Reinoso (CENTA), Lucía Silverio, Juan de Dios Moya, José Luis González y Luis Antonio Cabrera (EEML), por el apoyo durante las colectas, procesamiento y/o evaluaciones de las muestras.

REFERENCIAS

Castillo, M., L. López & R. Guzmán. 2006. Prospección de moscas de las frutas en la República Dominicana. Reporte final para el Consejo Nacional de Investigaciones Agropecuarias y Forestales (CONIAF), Universidad Autónoma de Santo Domingo, (UASD), Santo. Domingo, R.D.

Cuevas, R., A. Abud & P. Alvarez. 2002. Informe preliminar sobre detección de moscas de fruta llevada a cabo en diferentes regiones de producción de frutales de la República Dominicana. SEA, Subs. de Investigación Extensión y Capacitación Agropecuarias, Depto. de Sanidad Vegetal, Santo Domingo, Rep. Dominicana, 17 pp.

Ogando, F.R. & C.A. Serra. 2006. Desarrollo de un atrayente de material disponible en la República Dominicana para capturar Moscas de las Frutas. Memoria *Caribbean Food Crops Society* (CFCS) 42: 102-112.

Serra, C., S. García, M.A. Ferreira, O. Batista, N.D. Epsky & R.R. Heath. 2005a. Comparación de atrayentes para el trampeo de moscas de las frutas, *Anastrepha*

spp. (Diptera: Tephritidae) en frutales en la República Dominicana. Memoria *Caribbean Food Crops Society* (CFCS) 41(2):524-532.

Serra, C.A., S. García, M. Ferreira & O. Batista. 2005b. Comparación de tipos de trampas para el trampeo de moscas de las frutas, *Anastrepha* spp. (Diptera: Tephritidae) en frutales en la República Dominicana. Resúmenes 51 Reunión Anual, Sociedad Interamericana para Horticultura Tropical (ISTH), 10-14/10/05, Boca Chica, República Dominicana.

Serra, C.A., S. García & M. Ferreira. 2005c. Evaluación de *Mangifera indica*, *Spondias* spp. (Anacardiaceae) y *Psidium guajava* (Myrtaceae), hospederos de Moscas de las frutas, *Anastrepha* spp. (Diptera: Tephritidae), en cuanto a la presencia de parasitoides en diferentes zonas de la República Dominicana. Resúmenes 51 Reunión Anual, Sociedad Interamericana para Horticultura Tropical (ISTH), 10-14/10/05, Boca Chica, República Dominicana.

Thomas, D.B., N.D. Epsky, C.A. Serra, D.G. Hall, P.E. Kendra & R.R. Heath. 2008. Ammonia formulations and capture of *Anastrepha* fruit flies (Diptera: Tephritidae). J. Entomol. Sci. 43(1): 76-85.

Ventura T., L, H. Mercedes Rivas & T. Rojas. 1990. La mosca de las frutas del género *Anastrepha* (Diptera: Tephritiidae) en la República Dominicana. Tesis de Ingeniería Agronómica, Universidad Autónoma de Santo Domingo (UASD), Santo Domingo, República Dominicana, pp.53.

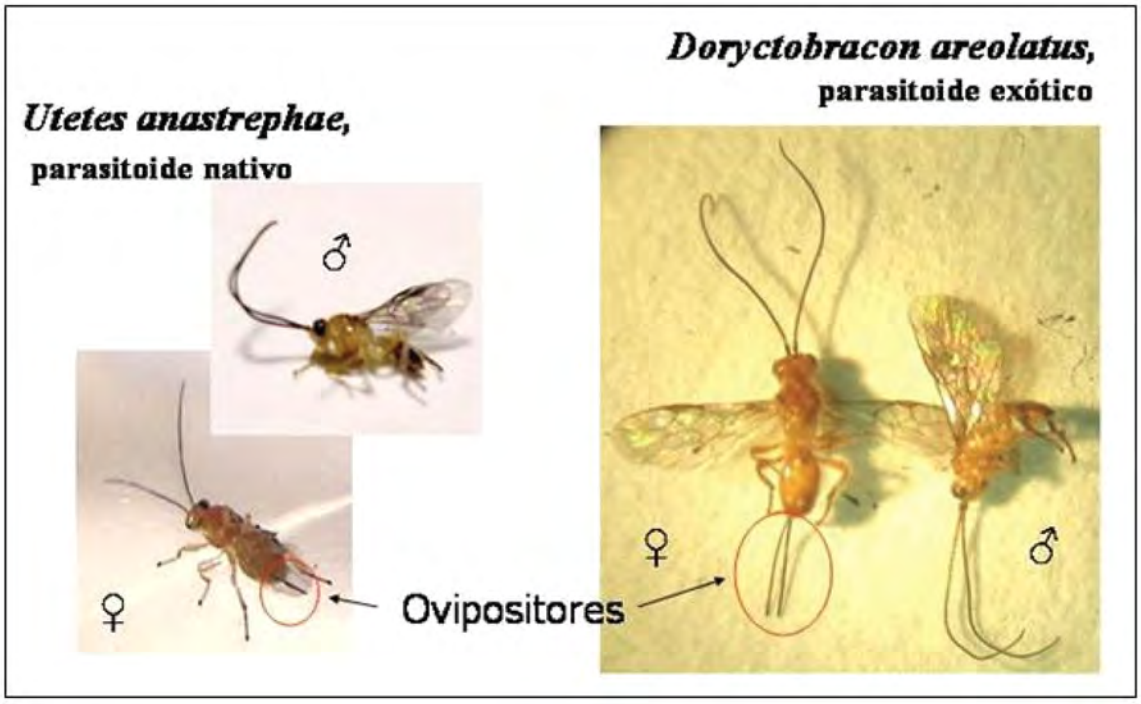


Imagen 1. Comparación ampliada (~x3) de ambas especies de parasitoides nativos y exóticos mostrando la diferencia en cuanto a los ovipositores (hembras izq., machos der., respectivamente)

2008 Proceedings of the Caribbean Food Crops Society. 44(2):261. 2008

Four Corn Silk Fly Species and Counting: Which Ones Are Primary Pests?

Gaurav Goyal[1], Gregg S. Nuessly[1], and Harsimran K. Gill[2]
[1] Everglades Research and Education Center, 3200 East Palm Beach Road, PO Box 8003, Belle Glade, FL 33430-8003; and [2]Dept. of Entomology and Nematology, University of Florida, Bldg. 970 Natural Area Drive, PO Box 110620, Gainesville, FL Gainesville. goyalgau@ufl.edu

ABSTRACT.
Corn silk fly is considered a serious pest of sweet corn, Zea mays L., in Caribbean countries (e.g., Dominica, St. Vincent, Jamaica, Puerto Rico, Antigua) as well as in many South, Central and North American states. We have identified four species of picture-winged flies from corn in Florida: Euxesta eluta Loew, E. annonae (F.), E. stigmatias Loew, and Chaetopsis massyla (F.) (Diptera: Ulidiidae). Infestation by some lepidopteran larvae is usually found in corn ears along with larvae of these flies. Thus, it is not known which species primarily attack otherwise healthy ears, and which are only found in ears inhabited or previously damaged by other dipterous or lepidopterous species. Greenhouse studies were conducted in which undamaged as well as damaged corn ears were enclosed with flies of each species. Field experiments were also conducted to support the results from green house experiment. Evidence of any of these species being secondary only can influence grower's control decisions.

KEYWORDS: Corn silk fly, primary, secondary

2008 Proceedings of the Caribbean Food Crops Society. 44(2):262. 2008

Developing Surveillance Systems for Pests and Invasive Species- Lessons Learnt from the Jamaican Perspective and Implications for the Wider Caribbean

P. Chung[1] and D. Clarke-Harris[2], 1Rural Agricultural Development Authority (RADA), Jamaica; and 2Caribbean Agricultural Research and Development Institute (CARDI) Jamaica Unit. Chung p2@yahoo.com; dclarkeharris@yahoo.com

ABSTRACT.
Food safety and food security issues have gained heightened importance during the current millennium, attaining a global peak in recent months. The continued growth in international travel and trade from globalization along with security and environmental threats, further exacerbate these issues. In today's knowledge-driven economy, the generation and dissemination of information is vital to their successful management. Surveillance programmes are significant in this respect, particularly in assessing pest and invasive alien species dynamics, agricultural production practices, support systems and outputs. Capability in temporal and spatial data collection, reporting, analysis and information delivery will facilitate timely response. However, onerous trade requirements overburden the human, physical and technological infrastructure of resource-challenged Caribbean states, threatening the stability and sustainability of their economies to seemingly unprecedented levels. Towards meeting these challenges, collaborative public-private sector efforts continue within and among such states, to optimize utilization of their collective resource base. Experiences of national, regional and international pest and invasive alien species management efforts are presented. From a series of initiatives aimed at tackling a growing number of threats, introductions and established invasive pest populations within the last decade, the Jamaican experience offers lessons which could provide a useful base on which to build an effective regional system.

KEYWORDS: surveillance programmes, invasive alien species, collaboration, trade, environment.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):263-266. 2008

DDIS and Diagnostic Networks: Building Partnerships for Safer Trade

Carrie Lapaire Harmon[1], Jiannong Xin[2], and Timur Momol[3], [1]Department of Plant Pathology, [2]IFAS Information Technology, and [3]IFAS Extension Administration, University of Florida, Gainesville, Florida 32611, USA

ABSTRACT.

Movement of agricultural products is one of the primary means of introduction of new diseases and pests. The agricultural inspections that take place at the ports of entry target higher-risk commodities, but inspect only an estimated 1-2% of total shipments. According to the Department of Commerce (U.S. Census Bureau, Foreign Trade Statistics), U.S. agricultural exports increased 26.72% from 2006 to 2007 and imports increased 10.12% over the same period. Imports from the Caribbean alone totaled $451,098,000 in 2007. The economic impact of trade cannot be underestimated, and neither should the possibilities for newly introduced pests. Early detection and accurate diagnosis of diseases and other pests is vital to any eradication efforts. In addition, communication between countries regarding pest detections increases awareness and allows for targeted survey programs. These efforts cannot happen without robust diagnostic capability and communication systems in place. The National Plant Diagnostic Network (NPDN) was developed by the USDA-CSREES in 2002 to quickly detect and accurately diagnose plant pests and initiate communications, and has become the standard for creation of similar systems such as the International Plant Diagnostic Network (IPDN) and the Caribbean Region Diagnostic Network (CRDN). The CRDN represents this effort in the Caribbean basin, tying diagnostic laboratories and personnel together via technical training and the Digital Diagnostic and Identification System (DDIS). Participants in this network utilize a secure online system to log and share diagnostic data in a confidential environment. This coupled with technical training increases the availability of expertise in the region, and helps to establish a baseline of pest knowledge that will support phytosanitary and trade decisions.

KEYWORDS: Diagnostic network, diagnostics, DDIS

INTRODUCTION

It is well-known that invasive organisms do not respect political borders. Therefore, diagnostic and detection efforts must be organized on a collaborative, international scale. The goals of the Plant Diagnostic networks include 1) Detection of pathogens/pests in an exporting country so the management of those pests will improve export quality and quantity, 2) Detect and accurately diagnose new or introduced pests/pathogens in-country to minimize impact, and 3) train diagnosticians and plant professional in a standardize but customizable way and encouraging international cooperation.

The plant protection puzzle can be broken down into a progression of four activities: preparation, early detection, delimitation, and management. These four interlocking puzzle pieces represent four major aspects of plant pathology: preparation

and education, early detection of new pathogens, delimitation of pathogen existence, and management once the pathogen is beyond eradicative measures. We'll use this as a framework for this paper, keeping in mind that this is an incomplete look at a complex issue.

Part of preparation is having people ready to detect and diagnose new/introduced organisms. Networks of diagnostic personnel and extensionists are working towards an era of international cooperation and preparedness. The International Plant Diagnostic Network (IPDN) established regional plant disease diagnostic clinic networks which empower rural individuals by giving communities their own capability to accurately diagnose plant diseases and to develop a working media library of plant and insect issues (2). The IPDN was developed based on the model of the National Plant Diagnostic Network (NPDN), developed in the U.S. in 2002 (3). The network is comprised of five regions, each centered at Land-Grant Universities. Satellite triage laboratories exist in the surrounding states, creating a hub-and-spoke system. It is no accident that the hubs and triage labs are mostly at land-grant universities; these institutions have a long history of involvement with Extension. Truly, a network of people involved with agriculture was already in place and the NPDN is a supplement to that effort, concentrating on diagnostics and detection. The NPDN funding from USDA-CSREES has been critical to the stability and development of our land-grant laboratory system.

One of the responsibilities of the NPDN is education and training of First Detectors, as part of preparation and early detection. UF serves as the hub of the Southern Plant Diagnostic Network, one of the five regions, and is responsible for leading the NPDN in national education and training efforts. First detectors see something out of the ordinary and report it to their county extension agent. The county agent performs triage, using his/her training to rule out normal disorders for their area. In Florida, the county agent sends a digital or real sample of unusual or possibly high-risk disorders to the Plant Diagnostic Clinic, where a diagnostician performs expert-level tests on it. The sample information is stored in a regional database, housed at UF, and select data are sent forward to the national data repository, housed at Purdue University. As part of the NPDN First Detector training program, standardized training modules (presentations, handouts, tests) are available online for regional customization by extension educators.

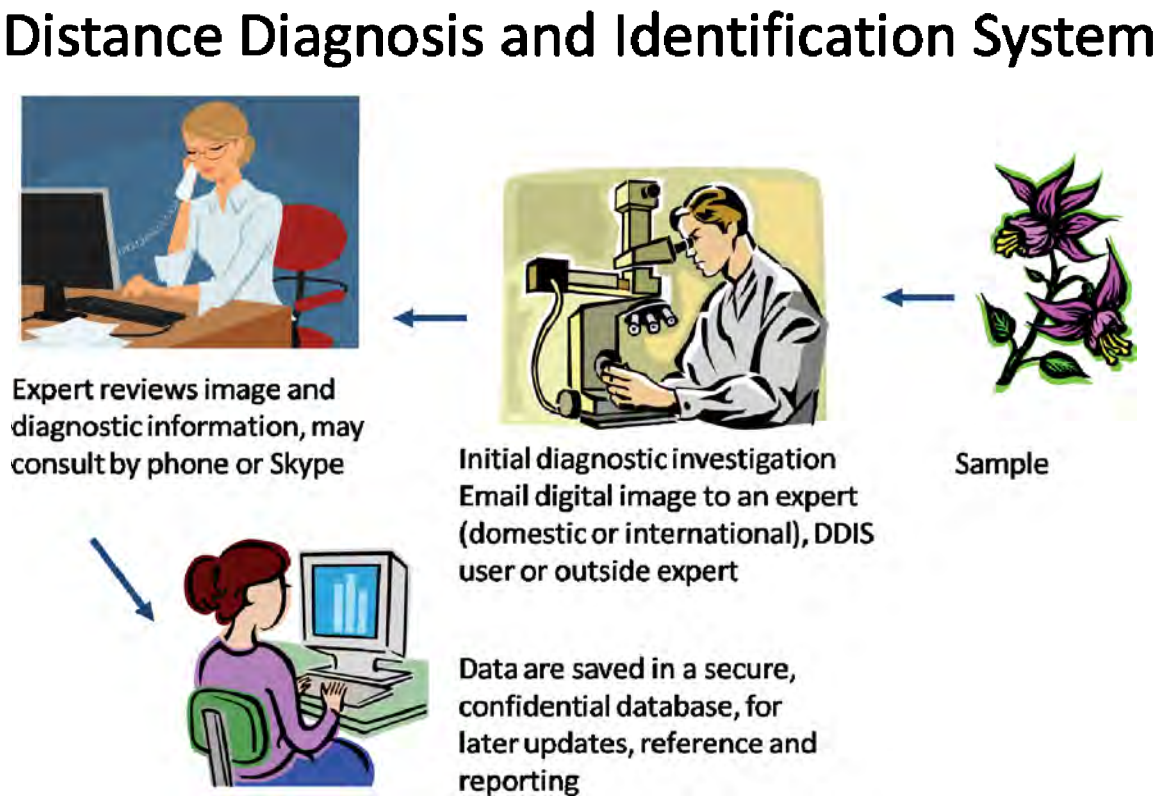
Diagnosticians also require preparatory training in detection and diagnosis of new and exotic pests and pathogens, so a collaborative effort with APHIS has allowed for hands-on diagnostic training by APHIS experts. Training in identification of regulatory pathogens has occurred in Beltsville APHIS facilities for sudden oak death, *Ralstonia solanacearum* Race 3 biovar 2, citrus greening, plum pox virus, soybean rust, and others. Further training support is available for NPDN diagnosticians to attend training in specific fungi, bacteria, viruses, nematodes, arthropods, PCR technology, etc.

MATERIALS AND METHODS

NPDN Standard Operating Procedures (SOPs) are written by diagnosticians, in collaboration with subject matter experts and regulatory authorities. They include background information, symptoms, sampling protocols, triage expert-level confirmatory diagnostic protocols, communication information, and necessary forms. The idea behind the SOPs is to have all the needed information at the diagnostician's fingertips should the need arise for its use. NPDN personnel practice the NPDN chain of custody and

communication protocols during non-emergency periods to ensure that all personnel involved know what to do if they suspect a high-impact pathogen detection. University, regulatory, and clientele groups are involved and these exercise scenarios allow for trouble-shooting of the protocols on a state-by-state basis, to ensure that the protocols are accurate and complete, including contact information in the event of a detection.

Diagnostic tools include online database-driven systems such as the Distance Diagnosis and Information System (DDIS, http://ddis.ifas.ufl.edu)(4), the Plant Disease Information System (PDIS, http://www.pdis.org), and others. These systems allow diagnosticians to consult with each other and subject-matter experts, reducing turn-around time for diagnostic services and leveraging diagnostic knowledge worldwide (1). Additionally, distance diagnostic systems allow digital samples to be sent in cases where "live" samples cannot be shipped due to regulatory or other constraints. These systems



often house media libraries of pests and diseases. The DDIS media library is open to the public. Media submissions are reviewed by subject-matter experts for content and accuracy, so the library becomes an integral part of diagnostic education.

The last two pieces of the puzzle, delimitation and management, are not part of the NPDN responsibilities, but the detections and diagnoses feed into those pieces. Delimitation is usually the responsibility of the state and federal regulatory authorities (state departments of agriculture and USDA-APHIS). Delimitation can be the first step in regulatory response, sometimes leading into eradication and quarantine measures, which is why it is part of the regulatory authorities' responsibilities. Management recommendations generally are developed by land-grant university extension specialists

with responsibilities in certain commodity areas. Management is the step after delimitation, and is generally part of the response once the pathogen/pest becomes established. Often, those management recommendations become part of the documentation the diagnostician sends to a client once a diagnosis has been made, increasing the value of the diagnosis and generating a teachable moment with the extension client.

RESULTS AND DISCUSSION

As the National Plant Diagnostic Network continues to interact with other networks internationally, there are a few things that will facilitate growth and interaction. Diagnosticians will share diagnostic protocols with their colleagues around the world. The networking available within the global diagnostic community, coupled with the power of the internet, allow for incredible information exchange with international and domestic partners, facilitates connections between experts, fosters continuing education in extension, and encourages trust in each others' diagnostic results, regulatory findings and efforts, and overall international information flow.

REFERENCES

Holmes, G., Brown, E. and Ruhl, G. 2000. What's a picture worth? The use of modern telecommunications in diagnosing plant diseases. *Plant Dis.* 84:1256-65.(1)

Miller et al. 2009. Plant Disease Diagnostic Capabilities and Networks. Annu. Rev. Phytopathol. Volume 47. In Press (2).

Stack, J.P., Cardwell, K.C., Hammerschmidt, R., Byrne, J, Loria, R. et al. 2006. The National Plant Diagnostic Network. *Plant Dis.* 90:128-36 (3).

Xin, J., H. W. Beck, L. A. Halsey, J. H. Fletcher, F. S. Zazueta, T. Momol. 2001. Development of a Distance Diagnostic and Identification System for Plant, Insect, and Disease Problems. *Applied Engineering in Agriculture.* Vol. 17(4): 561–565 (4).

2008 Proceedings of the Caribbean Food Crops Society. 44(2):267-278. 2008

Impact of Elevated Carbon Dioxide and Temperature on Fresh Weight and Sugar Yield of Sugar Cane

Leon Hartwell Allen, Jr.[1], Joseph C. V. Vu[1], Joan C. Anderson[1], and Jeffery D. Ray[2], [1]U.S. Department of Agriculture, Agricultural Research Service, Center for Medical, Agricultural, and Veterinary Entomology, 1700 SW 23rd Drive, Gainesville, Florida 32608, USA and [2]U.S. Department of Agriculture, Agricultural Research Service, Jamie Whitten Delta States Research Center, Stoneville, Mississippi 38776, USA.

ABSTRACT.

Rising atmospheric carbon dioxide (CO_2) concentration can change crop productivity directly by increasing photosynthesis, and indirectly by positive or negative modifications of growth responses to predicted global warming and changes in rainfall. The purpose of this experiment was to determine the effects of CO_2, temperature, soil type, and water table depth on growth of four cultivars of sugar cane, a C_4 photosynthetic pathway species (*Saccharum officinarum* L.). Studies were conducted in paired temperature-gradient greenhouses at ambient and enriched levels of CO_2 [≈ 360 and ≈ 710 μmol (CO_2) mol^{-1} (air), respectively] with four temperature zones along the length of each greenhouse: baseline, +1.5, +3.0, and +4.5°C. These 1.5°C steps were maintained by a combination of heat inputs (electric heaters and sunlight) and ventilation by computer-controlled fans. Other treatments were soil type (mineral vs. organic), water table depth (constant water table of 20 cm vs. ≈50-cm drained profile). The four cultivars were CP72-2086, CP73-1547, CP88-1508, and CP80-2086. Doubled CO_2 increased the following components of plant growth of the first sampling in late June-early July of 1997: leaf number = 7%; leaf area = 15%; leaf fresh weight = 13%; leaf dry weight = 8%; mainstem length = 32%; mainstem fresh weight = 31%; mainstem dry weight = 23%; juice volume = 40%; total fresh weight = 25%; juice dry weight = 36%; total dry weight = 21%. However, total fresh weight increase of that whole-crop harvest was somewhat less at 16%. Increasing temperatures caused a slight downward trend in sugar cane yield regardless of cultivar or CO_2 treatment. The order of cultivar yields for the first harvest was: CP73-1547 > CP80-1827 > CP88-1508 > CP72-2086. Doubling CO_2 appeared to benefit sugar cane productivity more than the anticipated 10% increase for a C_4 species. The apparent increase in sugar cane dry weight, fresh weight, and juice volume indicates greater yields as global atmospheric CO_2 continues to rise.

KEYWORDS: sugar cane, carbon dioxide, temperature, climate change, global warming

INTRODUCTION

Atmospheric carbon dioxide (CO_2) concentration is rising annually at the rate of about 1.5 to 2.0 μmol (CO_2) mol^{-1} (air). The CO_2 concentration was 315 μmol mol^{-1} in 1958 and it was more than 380 μmol mol^{-1} in 2008. The CO_2 concentration may increase

to somewhere between 485 to 1000 μmol mol^{-1} before the end of the 21st century depending on CO_2 emissions scenario (IPCC 2001). Most of the increase is caused by burning of fossil fuels, although biomass burning and oxidation of biomass and soil organic matter as a consequence of land clearing also contribute CO_2 to the atmosphere. Since CO_2 is a greenhouse effect gas, many atmospheric scientists have predicted that a doubling of atmospheric CO_2 concentration could cause a global warming of 1.4 to 5.8°C (depending on scenario), and regional changes in patterns and amounts of cloudiness and rainfall (IPCC 2001).

A large amount of research has shown clearly that elevated CO_2 increases photosynthesis, growth, and productivity of C_3 photosynthetic pathway plants such as rice and soybean. Much less research has been conducted on CO_2 effects on plants with the C_4 photosynthetic pathway (such as sugar cane) because these plants have a biochemical/molecular mechanism of concentrating CO_2 in leaves at the chloroplastic site of CO_2 fixation, and these types of plants generally exhibit only small responses to elevated CO_2. Within the context of global climate change, little research has been conducted on high temperature, or the combination of elevated CO_2 and high temperature, on plants. Limited research has shown that warm-season species are not adversely affected by elevated temperatures up to a point.

In Florida, most sugar cane has been grown on organic soils (Stephens and Johnson, 1951; Stephens and Stewart, 1976; Stephens et al., 1984; Snyder, 2005). However, federal, state, and local programs oriented toward restoration of the South Florida ecosystem are seeking methods to ameliorate the impact of agriculture, especially in the Everglades Agricultural Area, on organic soil subsidence (Shih et al., 1979, 1998; Tate 1979, 1980; Tate and Terry, 1980) with concomitant emissions of CO_2 to the atmosphere (Allen, 2007; Knipling et al., 1971; Volk, 1973) and on nutrient outflows to natural and less managed parts of the ecosystem. One management option is to produce sugar cane on organic soil with shallow water tables maintained over a large part of the cropping cycle, using adapted cultivars (Allen, 2007; Gilbert et al., 2007; 2008; Glaz et al., 2005; Glaz and Gilbert, 2006; Glaz and Morris, 2006; Glaz, 2007; Glaz et al., 2008; Morris et al., 2004; Morris, 2005). Holding water on the fields rather than allowing rapid flow through the upper soil profile and subsequent drainage from the field should also decrease nutrient outflows from the farms. Given restoration policies, sugar cane production in South Florida might move in part from organic soils to mineral soils. With appropriate management of water and nutrients (especially nitrogen), yields should be as good on mineral soils as those on organic soils (Obreza et al. 1998).

Because of both global and local environmental questions, our purpose was to study effects of the combination of elevated CO_2, high temperatures, soil type (organic vs. mineral), and water table depths on growth and yield of several cultivars of sugar cane. This paper reports the early fresh weight and sugar yield results of this study.

MATERIALS AND METHODS

Temperature-gradient greenhouses. Four sugar cane cultivars were grown at CO_2 concentrations of ≈ 360 or ≈ 710 μmol (CO_2) mol^{-1} (air) in two temperature-gradient greenhouses (or TGGs) at four temperatures above ambient. The TGGs were 27.43 m in length and 4.27 m in width at the base. Semicircular arcs covered with greenhouse polyethylene with a center-line ridgepole height of 2.2 m formed the structure itself.

These TGGs have been described in general by Sinclair et al. (1996), Vu et al. (2002, 2006, 2009), and Allen et al. (2006; 2009). One TGG was equipped with a computer-controlled CO_2 injection system to maintain CO_2 concentration at 710 μmol (CO_2) mol^{-1} (air). The other TGG received only ambient air with a concentration of about 360 μmol (CO_2) mol^{-1} (air). Temperature gradients were maintained by a combination of electrical resistance heaters, sunlight, and computer-controlled ventilation fans along the length of each TGG within four 5.49-m sections or zones. The baseline temperature of the first working zone averaged 1.5°C above outside ambient conditions. Therefore, average temperatures above outside ambient were +1.5°C, +3.0°C, +4.5°C, and +6.0°C for Zone 1, Zone 2, Zone 3, and Zone 4, respectively at baseline temperature, +1.5, +3.0, and +4.5°C. A 3.66-m-long entry section and a 1.83-m-long exit section were not planted to sugar cane. Systems for measurements of temperatures and control of temperature gradients were controlled by a Supervisory Control and Data Acquisition (SCADA) system computer. The controller/data logger was a Keithley Metrabyte "Workhorse" system (Keithley Instruments, Boston MA USA) operated by a PC using FIX DMACS Version 3.03 software program (Intellution, Norwood, MA USA).

A 40.6-cm diameter fan with thermostat was placed at the top of the exit end of each TGG as a fail-safe device. The thermostat setting ranged from a minimum of 35°C during the winter to a maximum of 45°C during the summer.

Soil containers, soil treatments, and cultural practices. Thirty-two 150-gallon containers for soil were placed in each TGG, with 8 soil containers in each of the 4 temperature zones along the TGG length. Each temperature zone had a cluster of four soil containers that had been filled with topsoil of an onsite mineral soil (Arredondo fine sand, a loamy, siliceous, hyperthermic Grossarenic Paleudult of the Order Ultisol) and a cluster of four soil containers that were filled with an organic soil from a site near Florahome, Florida (Okeechobee muck, a euic, hyperthermic Hemic Medisaprist of the Order Histosol) during the first week of March 1997. Before planting and throughout the period of growth, fertilizers containing major and micro elements were applied generally at doses recommended for commercial sugar cane production in Florida (Obreza et al., 1998).

Stems of each of the sugar cane cultivars were provided by Dr. Jimmy Miller, USDA-ARS, Canal Point, Florida USA. On January 13, 1997, the stems were cut at the midpoint of each internode to provide vegetative propagules at each node (vegetative seed-pieces). The seed-pieces were then pre-treated for 30 min in water at 52°C to break dormancy and ensure more uniform regeneration and were planted in a seedbed of 12-cm depth of potting soil in a greenhouse with temperature controlled to 30°C. The seedbed was watered frequently during the growth of the seed-pieces. On March 21, 1997, the top growth was trimmed back to prevent excessive transpiration, and the seedlings were transplanted to the soil containers in the TGGs. Seven plants of four cultivars were transplanted to each soil container and labeled as follows: 1A + 1B, 2A + 2B, 3A + 3B and 4; (cultivar 1 = CP72-2086; cultivar 2 = CP73-1547; cultivar 3 = CP88-1508; cultivar 4 = CP80-1827). Eight similar soil containers were also set up outside the TGGs. There were insufficient seed-pieces of cultivar CP80-1827; therefore only one seed-piece was transplanted to each soil container.

Watering procedures. For convenience in the water treatments, the soil containers that extended toward the east side of the TGGs were selected for the drained soil treatment and the soil containers that extended toward the west side were selected for the high water table treatment (20 cm depth). The water levels of each of the containers of each of the 32 high water table treatments of each TGG were controlled with individual constant water level buckets equipped with float valves. The height of each bucket was adjusted to provide the constant water table level of each soil container as controlled by the float valve. The drained soils were watered manually with a garden hose two to three times weekly. An in-line water meter at the spray nozzle was used to meter water precisely to each soil container. Clear plastic sight tubes were installed on each soil container to avoid overwatering. The amounts of irrigation increased with increasing distance into the TGG to compensate for the increase of evapotranspiration requirements with increasing temperature. Furthermore, the amount of water applied in the high-CO_2 TGG was slightly less to account for the decreased stomatal conductance induced by elevated CO_2. Adjustments to the amount of water applied were made by inspection of the sight tubes before each irrigation. If any residual water was observed, then the amount of irrigation water applied was decreased in quantitative proportion to the level of the water above the bottom of the soil container. This treatment was called ≈ 50 cm drained profile treatment.

Sampling and harvesting. For several purposes beyond the scope of this paper, the detailed sampling of the sugar cane plant-crop beginning in June 1997 was revised with a simpler sampling of subsequent ratoon-crop harvests. On June 24-27, 1997, plants of each sugar cane cultivar in eight of the 32 soil containers in each TGG were harvested for detailed measurements of mainstems and leaves. The mainstem cane was cut about 3 cm above the soil surface and transported immediately to a field laboratory. The leaves were cut from the mainstems for measurements of number of green leaves, leaf area, and leaf fresh weight. The measurements on the mainstems were length of the cane to the top leaf ligule, mainstem fresh weight, and length of sequential internodes. The leaves from each mainstem were bagged and dried for at least one week at 80°C for determination of dry weights. The mainstems were juiced by crushing the canes in a small rolling cylinder mill and subsequently the crushed mainstems were dried at 80°C for dry weight determinations. Juice volume was recorded and both hydrometer and Brix measurements made. Juice dry weight was computed from juice volume and sucrose concentration. Total fresh weights of the remaining stems plus leaves for each cultivar in these eight soil containers were collected over the period June 30 to July 3, 1997. The juice was crushed from the stems and juice volume measured.

For fresh weights only, on July 9-11, 1997, the sugar cane in the remaining 24 of the 32 soil containers was cut and weighed for determination of total fresh weight of stems plus leaves. After weighing the plant materials were discarded. From these complex samplings, all sources of fresh weights were summed to provide data for total aboveground fresh weights of each cultivar in soil container within each combination of TGG (CO_2 treatment), temperature zone, type of soil, and water treatment.

For subsequent harvests, (December 1997, June 1998, and December 1999) total fresh weights of stems plus leaves were measured for each cultivar in eight of the 32 soil containers. Then the leaves were separated from the stems and stems were juiced by

crushing in a small rolling mill for juice volume and Brix measurements. Dry matter components of leaves, crushed stems and sugar were determined. The total plant fresh weights in the remaining 24 soil containers of each TGG were determined. For overall aboveground fresh weight analyses, all data were assembled for statistical analyses.

Statistical Analysis. An analysis of variance ANOVA was conducted on various components of the data as presented in the results and discussion section. In many cases, data were pooled across one or more treatments or across the four cultivars or across the four individual harvests. A Duncan's multiple range test was applied to infer statistical differences. The general linear model (GLM) procedure of SAS was used in the data analyses. Interactions were not prevalent and are not reported.

RESULTS AND DISCUSSION

Sugar cane total above-ground fresh weight data were pooled for all cultivars, CO_2 concentrations, temperatures, soil types, and water table depths at the plant crop harvest (June 1997) and for the subsequent three ratoon crop harvests in December 1997, June 1998, and December 1998 (Fig. 1). The fresh weight yield was greatest for the plant crop, but the subsequent harvests were somewhat similar. Since 3/4 of the fresh weights of the plant-cane harvest were not obtained until July 9-11, this delay might have caused higher values in the "June harvest" and lower values in the December 1997 harvest.

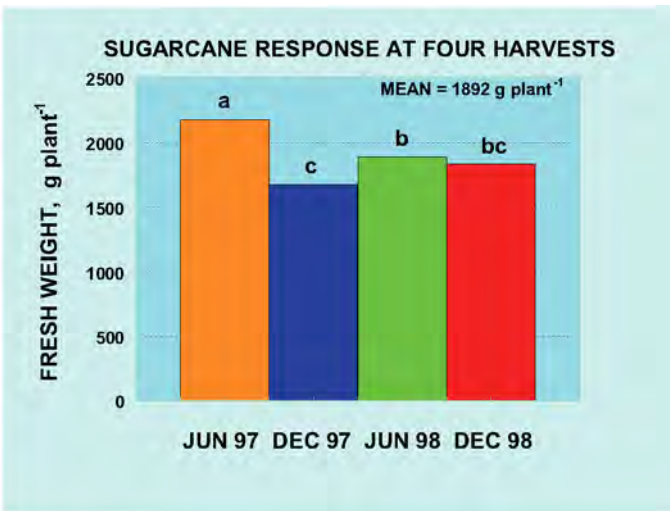


Figure 1. Sugar cane total above-ground fresh weight pooled for all cultivars, CO_2 concentrations, temperatures, soil types, and water table depths at the plant harvest (June 1997) and at three subsequent ratoon harvests. Means of columns with the same letter are not significantly different.

Since none of the four harvests showed a significant response to temperature over the four levels (1.5, 3.0, 4.5, and 6.0°C) above Gainesville ambient, all the fresh weight harvest data were pooled as shown in Fig. 2. Potential global warming would not likely be detrimental to vegetative productivity of sugar cane.

With data pooled across all four harvests, sugar cane fresh weight showed a response to CO_2 concentration, soil type (mineral versus organic), and water treatment

(20-cm water table versus ≈ 50 cm drained profile (Fig. 3). The CO_2-enriched sugar cane had both a larger fresh weight (16% greater) and a larger dry weight (21% greater, data not shown) than the sugar cane exposed to ambient CO_2 concentrations. Plants that were grown in mineral soil rather than organic soil had a greater fresh weight (27% greater) likely because more nitrogen fertilizer had been added to the mineral soil than the organic soil. Plants grown at the controlled water table depth of 20 cm had about 11% greater fresh weight.

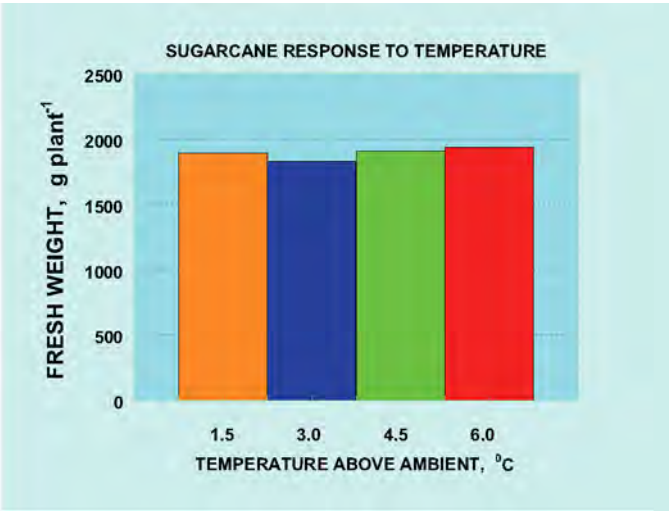


Figure 2. Sugarcane total above-ground fresh weight at four temperatures (above Gainesville ambient temperatures) pooled for all cultivars, CO_2 concentrations, soil types, and water-table depths for the first four harvests. There were no significant differences among temperature treatments.

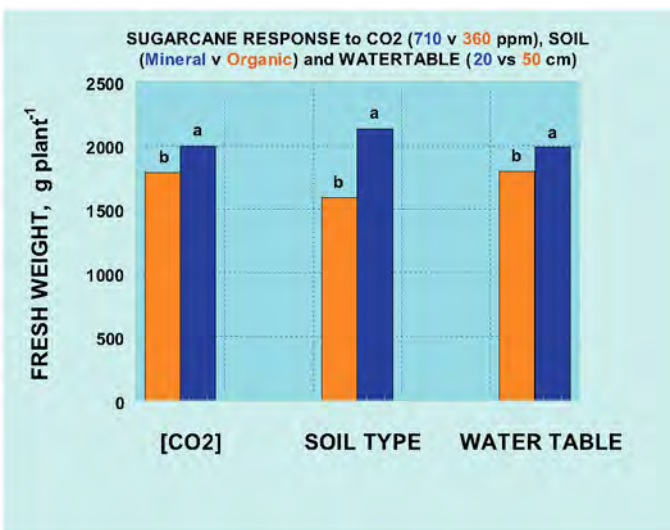


Figure 3. Sugar cane total above-ground fresh weight (pooled across temperatures and four harvests) responses to CO_2 concentration, soil type (mineral vs. organic), and water table depth. Within each treatment, different letters indicate significant differences of mean values.

Sugar cane total above-ground fresh weight responses of each of the four cultivars pooled across all treatments of the first four harvests are shown in Fig. 4. Productivity and survivability of the cultivar CP88-1508 declined continuously after the first plant cane harvest, whereas most of the plants of the other three cultivars survived.

Fresh weight responses to CO_2 enrichment were significant for the first two harvests, but not for the second two harvests (Fig. 5). However, the mean fresh weight responses to CO_2 across all four harvests were significant.

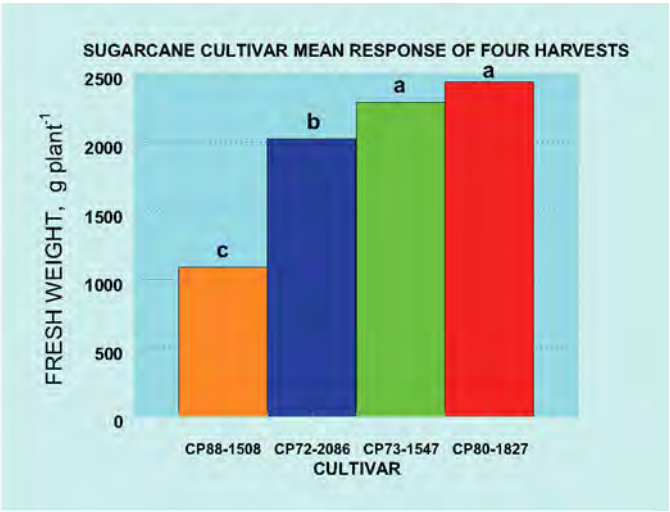


Figure 4. Sugar cane total above-ground fresh weight response of each cultivar pooled across all treatments of the first four harvests. Means of columns with the same letter are not significantly different. Many plants of Cultivar CP88-1508 had failed to survive after the four harvests.

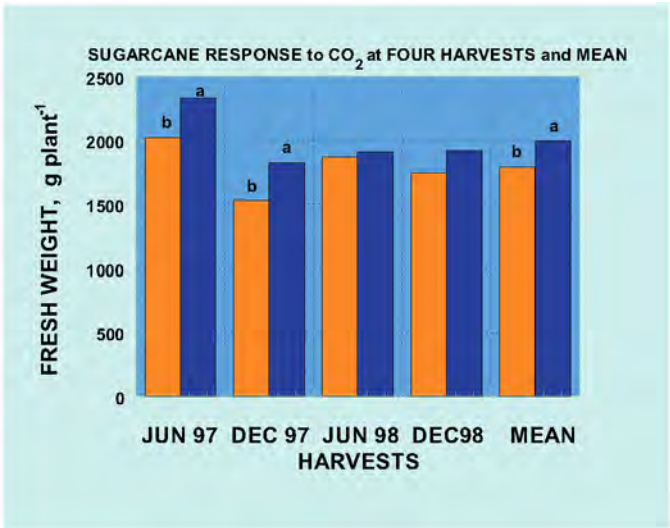


Figure 5. Sugar cane total aboveground fresh weight responses to CO_2 concentration (pooled across all other treatments) for the first four harvests and for the mean of the first four harvests. Paired columns with different letter had significantly different means.

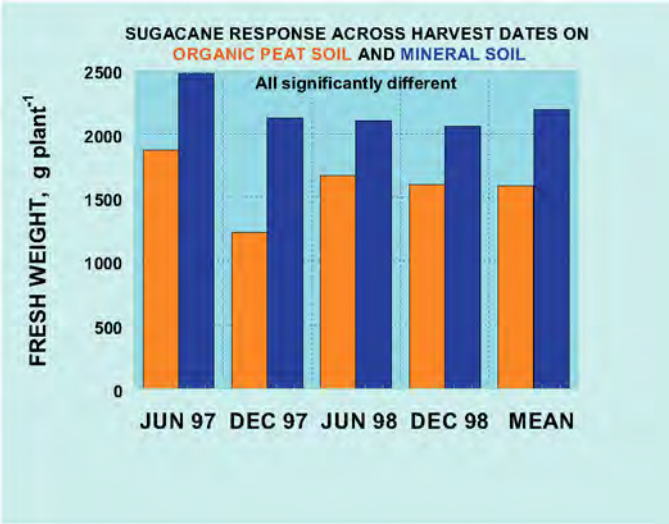


Figure 6. Sugar cane total aboveground fresh weight responses of plants grown in organic peat soil compared with plants grown in sandy mineral soil (pooled across all other treatments) for the four harvests. Mean values of all paired columns were significantly different.

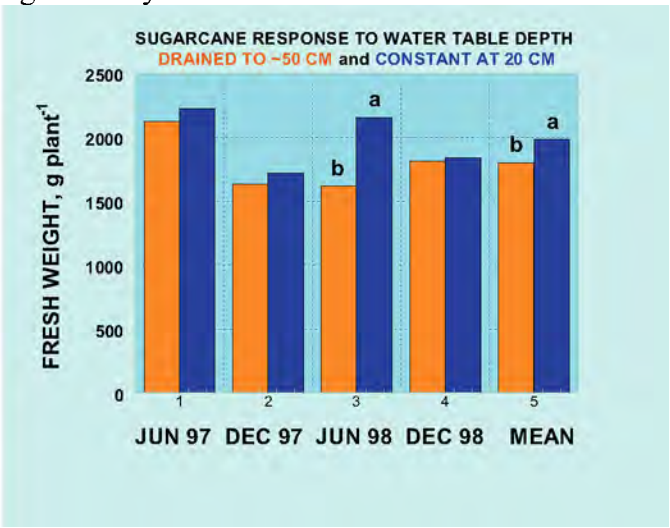


Figure 7. Sugar cane total aboveground fresh weight responses of plants to water table depths. Mean values within paired columns with different letters were significantly different.

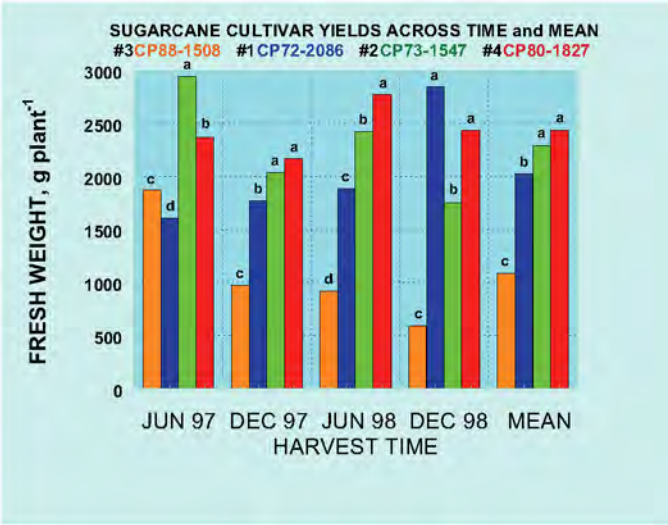


Figure 8. Sugar cane total aboveground fresh weights of the four cultivars compared at each of the four harvest dates and compared for all harvest dates pooled. Within dates, columns with the same letter are not significantly different. Cultivar CP88-1508 declined with each succeeding harvest.

All sugar cane harvests showed significantly larger fresh weight responses of plants grown in sandy mineral soil compared to plants grown in organic peat soil, with data pooled across all other treatments (Fig. 6). This occurred despite the fact that we added equivalent nitrogen to the organic peat soil after the first two harvests. However, it should be pointed out that the organic soil was obtained from sources near Florahome, Florida and the peat might be quite different from the sugarcane producing Histosols of the Everglades Agricultural Area in southern Florida.

Within individual harvests, only the June 1998 harvest showed a significant difference between water treatments, wherein the 20-cm constant water table plants had a higher fresh weight yield (Fig. 7). However, the tendency across all four harvests resulted in the mean data for the four harvests also showing a significantly higher fresh weight yield for the 20-cm constant water table treatment. This finding indicates that sugar cane could be produced in relatively high water table soil, which would be beneficial in ameliorating the microbial oxidative subsidence or organic soils.

Fresh weight yields of the four cultivars across the four harvests are compared in Fig. 8. Growth and fresh weight yields of cultivar CP88-1508 declined sharply after the plant crop. This cultivar did not survive well or compete well with other cultivars. The relative performance of the other three cultivars was somewhat variable but they all survived well after the plant crop harvest.

The final figure shows many of the percentage increase responses of various components of sugar cane growth to elevated CO_2 concentration for the first (plant-crop) harvest (Fig. 9). These responses are pooled across all cultivars and other treatments. Note that percentage increase of juice dry weight (column #11) was greater than percentage increase of stem dry weight (column #6) which in turn was greater than percentage increase in leaf dry weight (column #4). Percentage increase of stem length (column #9) probably contributed to the percentage increase of stem fresh weight

(column #5) and percentage increase of juice volume (column #10) which led to the large percentage increase in juice dry weight (column #11), the economically valuable yield product.

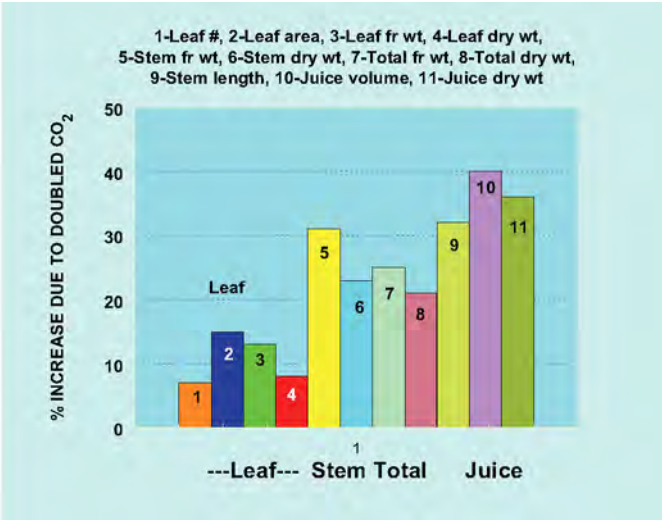


Figure 9. Percentage increases of components of sugar cane in response to elevated CO_2 concentration for the first harvest in June 1997 pooled across all cultivars and other treatments. Note that percentage increase of juice dry weight (column #11) was greater than percentage increase of stem dry weight (column #6) which in turn was greater than percentage increase in leaf dry weight (column #4). Percentage increase of stem length (column #9) probably contribute to the percentage increase of stem fresh weight (column #5) and percentage increase of juice volume (column #10) which led to the large percentage increase in juice dry weight (column #11), the economically valuable yield product.

CONCLUSIONS

Several conclusions can be drawn from the results of this study. First, fresh weight of sugar cane, a C4 crop, responds slightly to a doubled CO_2 concentration. Second, sugar cane did not respond to temperature over the range of treatments in this study. Global warming should not be a problem for this crop. Third, fresh weight production was consistently greater on sandy mineral soil than on organic peat soil in this study. The reason is not known, but it might be related to the source of the peat soil. Fourth, fresh weight productivity was slightly greater in soil with the water table maintained at 20 cm depth than in a drained profile to 50 cm. This finding implies that sugar cane could be grown at high water table in organic soils which would reduce subsidence by microbial oxidation of organic matter. Fifth, cultivars differed in their ability to compete with each other, at least in this system of soil containers in TGGs.

Finally, and most importantly, juice and sugar production appeared to respond more to elevated CO_2 concentration than did the fresh weight (and overall dry weight). This is an important finding, and if confirmed to be generally true, would mean that sugar cane productivity should be enhanced by rising atmospheric CO_2 concentration. This would be even more important since higher temperatures did not adversely affect fresh weight production.

ACKNOWLEGMENTS

The assistance of Sara E. Clendenin, W.W. Wynn, H.F. McGraw, R.A. Horton, A.W. Frenock, and Z. Chen is greatly appreciated. We especially thank Dr Wilfredo Colón-Guasp for presenting the paper for the authors on short notice.

REFERENCES

Allen, L.H., Jr. 2007. Carbon balance of sugarcane agriculture on Histosols of the Everglades Agricultural Area: Review, analysis, and global energy perspectives. Soil and Crop Science Society of Florida Proceedings 66:00-00 (in press).

Allen, L.H., Jr., S.L. Albrecht, K.J. Boote, J.M.G. Thomas, Y.C. Newman and K.W. Skirvin. 2006. Soil organic carbon and nitrogen accumulation in plots of rhizoma perennial peanut and bahiagrass grown in elevated carbon dioxide and temperature. Journal of Environmental Quality. 35:1405-1412.

Allen, L.H., Jr. and J.C.C. Vu. 2009. Carbon dioxide and high temperature effects on growth of young orange trees in a humid, subtropical environment. Agricultural and Forest Meteorology. 149:820-830.

Gilbert, R.A., C.R. Rainbolt, D.R. Morris, and A.C. Bennett. 2007. Morphological responses of sugarcane to long-term flooding. Agron. J. 99:1622-1628.

Gilbert, R.A., C.R. Rainbolt, D.R. Morris, and J.M. McCray. 2008. Sugarcane growth and yield responses to a 3-month summer flood. Agric. Water Manage. 95:383-291.

Glaz, B. 2007. Sugarcane response to month and duration of preharvest flood. J. Crop Improve. 20:137-152.

Glaz, B., J.C. Comstock, P.Y.P. Tai, S.J. Edme, R. Gilbert, J.D. Miller, and J.O. Davidson. 2005. Evaluation of new Canal Point sugarcane clones - 2003-2004 harvest season. USDA, ARS, ARS-165, 32 pp.

Glaz, B., and R.A. Gilbert. 2006. Sugarcane response to watertable, periodic flood, and foliar nitrogen on organic soil. Agron. J. 98:616-621.

Glaz, B., and D.R. Morris. 2006. Sugarcane morphological, photosynthetic, and growth responses to water-table depth. J. Sustainable Agric. 28:77-97.

Glaz, B., S.T. Reed, and J.P. Albano. 2008. Sugarcane response to nitrogen fertilization on a Histosol with shallow water table and periodic flooding. J. Agron. & Crop Sci. 194:369-379.

IPCC. 2001. Climate Change 2001: The Scientific Basis. Cambridge University Press, UK.

Knipling, E.B, V.N. Schroder, and W.G. Duncan. 1971. CO_2 evolution from Florida organic soils. Soil Crop Sci. Soc. Florida Proc. 30:320-326.

Morris, D.R. 2005. Dry matter allocation and root morphology of sugarcane, sawgrass, and St. Augustinegrass due to water-table depth. Soil Crop Sci. Soc. Florida Proc. 64:80-86.

Morris, D.R., B. Glaz, and S.H. Daroub. 2004. Organic soil oxidation potential due to periodic flood and drainage depth under sugarcane. Soil Sci. 169:600-608.

Obreza, T.A., D.L. Anderson, and D.J. Pitts. 1998. Water and nitrogen management of sugarcane grown on sandy, high water table soil. Soil Science Society of America Journal. 62:992-999.

Shih, S.F., E.H. Stewart, L.H. Allen, Jr., and J.W. Hilliard. 1979. Variability of depth to

bedrock in Everglades organic soil. Soil Crop Sci. Soc. Florida Proc. 38:66-71.

Shih, S.F., B. Glaz, and R.E. Barnes, Jr. 1998. Subsidence of organic soils in the Everglades Agricultural Area during the past 19 years. Soil Crop Sci. Soc. Florida Proc. 57:20-29.

Snyder, G.H. 2005. Everglades Agricultural Area soil subsidence and land use projections. Soil Crop Sci. Soc. Florida Proc. 64:44-51.

Stephens, J.C., L.H. Allen, Jr., and E. Chen. 1984. Organic soil subsidence. pp. 107-122. In: T.L. Holzer (ed.). Reviews in Engineering Geology, v. VI. Geological Soc. of America.

Stephens, J.C., and L. Johnson. 1951. Subsidence of organic soils in the upper Everglades region of Florida. Soil Crop Sci. Soc. Florida Proc. 11:191-237.

Stephens, J.C., and E.H. Stewart. 1976. Effect of climate on organic soil subsidence. Proceedings of the Second International Symposium on Land Subsidence, Anaheim, CA, 13-17 December 1976. IAHS-AISH Pub. No. 121, pp. 647-655.

Tate, R.L. III. 1979. Microbial activity in organic soils as affected by soil depth and crop. Appl. Environ. Microbiol. 37:1085-1090.

Tate, R.L., III. 1980. Microbial oxidation of organic matter of Histosols. pp. 169-201. In: M. Alexander, (ed.) Advances in Microbial Ecology, vol. 4, Chap. 5. Plenum Publishing Corp.

Tate, R.L.III, and R.E. Terry. 1980. Variations in Microbial activity in Histosols and its relationship to soil moisture. Appl. Environ. Microbiol. 40:313-317.

Volk, B.G. 1973. Everglades Histosol subsidence: 1. CO_2 evolution as affected by soil type, temperature and moisture. Soil Crop Sci. Soc. Florida Proc. 32:132-135.

Vu, J.C.V., Newman, Y.C., Allen, L.H., Jr., Gallo-Meagher, M. and Zhang, M.Q. 2002. Photosynthetic acclimation of young sweet orange trees to elevated growth CO_2 and temperature. Journal of Plant Physiology. 159:147-157.

Vu, J.C.V., Allen, L.H., Jr. and Gesch, R.W. 2006. Up-regulation of photosynthesis and sucrose metabolism enzymes in young expanding leaves of sugarcane under elevated growth CO_2. Plant Science 171:123-131.

Vu, J.C.V. and Allen, L.H., Jr. 2009. Growth at elevated CO_2 delays the adverse effects of drought stress on leaf photosynthesis of the C4 sugarcane. Journal of Plant Physiology. 166:107-116.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):279. 2008

Crop Water Stress Index and Yield Components for Common Bean (Phaseolus vulgaris L.) Genotypes in Greenhouse and Field Environments

V. H. Ramirez Builes[1], E. W. Harmsen[2], and T. Porch[3]. [1]Assistant Professor, Agronomy Program. University of Santa Rosa de Cabal, Risaralda-Colombia, victorhugorb@gmail.com; [2]Professor, Dept. of Agr. and Biosystems Eng., Univ. of Puerto Rico. Mayagüez, PR 00681, harmsen1000@hotmail.com, (787)832-4040; [3]USDA-ARS, Mayagüez Puerto Rico, Timothy.Porch@ARS.USDA.GOV

ABSTRACT.
Methods to detect and characterize the magnitude of drought stress are an area of active research. With the development and increased popularity of the infrared thermometer, a thermal stress index has been proposed and applied. One of the most popular and useful is the crop water stress index (CWSI). The principal objective of this research was to develop baselines for CWSI for four common bean genotypes, and relate the index with yield components and soil available water under field and greenhouse environments. Trials were conducted during three years (2005, 2006 and 2007) in two environments (greenhouse and field) in western and southern Puerto Rico. Three water levels were applied in the greenhouse and two water levels were applied in the field using the randomized complete block design. Four common bean genotypes were studied: Morales, with an unknown drought response; and BAT477, SER16 and SER 21, which are drought tolerant. The CWSI was derived for a total of five growing seasons (two field and three greenhouse experiments). The results indicate differences in drought tolerance between genotypes. Wind induced an additional "physiological stress" which was detected by the CWSI. The differences in the CWSI between genotypes were correlated with the root available water, and yield components.

KEYWORDS: common bean, canopy temperature, crop water stress index, air temperature, drought stress.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):280. 2008

Response of Common Bean (*Phaseolus vulgaris* L.) to Rhizobium Inoculation and Nitrogen Fertilization

A.O. Ramírez-Madera[1], J.S. Beaver[1], D. Sotomayor-Ramírez[1], and C. Estévez de Jensen[2]; [1]Department of Agronomy and Soils and [2]Department of Crop Protection, University of Puerto Rico, Mayagüez Campus. axelramirez@hotmail.com

ABSTRACT.
Beans (*Phaseolus vulgaris* L.) in Puerto Rico need greater efficiency in the use of inputs such as N in order to increase yield and control production costs. Two field experiments were conducted at the University of Puerto Rico Isabela Substation. The N-NO_3^- content in the soil was low (11 ppm) with organic matter content of 4%. Fertilization included 50 kg/ha of N-P_2O_5-K_2O at planting. During the rainy season on February 2007, the field trials were planted using a RCB design with 6 replications. Ninety-six dry bean lines of different seed types (black, red/pink, white, pinto/cream, and Andean) were evaluated. Lines R-99 OAC Rico and NOD-125 were non-nodulating lines used as controls. At planting, all lines were inoculated in the soil with *Rhizobium* at a rate of 3.33 g of inoculant per 3.8 L of water. Nodulation was evaluated using the CIAT 1-9 scale. VAX 3 (3.5 and 1,859 kg/ha), Cardenal (4.0 and 1,509 kg/ha) and RAB 655 (4.5 and 1,723 kg/ha) had the best nodulation and the greatest mean seed yields. The second experiment was planted in June 2007 during the dry season. Treatments were arranged in a split plot design within a RCB with 5 replications. Whole plots were N levels (0 and 25 kg/ha) and sub-plots were the best 40 bean lines. Two non-nodulating lines were used as controls. Inoculant was applied to the furrow during planting. There was no interaction between lines and level of fertilization on nodulation score. The best nodulating lines were: Salagnac 90A (2.7), Arroyo Loro Negro (2.8) and PR 0427-7 (3.5). The best nodulation scores were observed in the low N plots (0 kg/ha). There was a significant interaction between lines and levels of fertilization on seed yield. VAX 3, A 774 and RAB 655 were the most productive lines under low N conditions.

KEYWORDS: *Phaseolus vulgaris* L., nodulation score, low N fertility

2008 Proceedings of the Caribbean Food Crops Society. 44(2):281-289. 2008

The Effects of Humus of Earthworm on Ivy Gourd Growing; Sustitución de Fertilizantes Químicos por Lombriz Compost en el Cultivo de la Tindora (*Coccinia grandis* L.)

Martin F. Tolentino, Jacquelin Daphinis, Jorge L. del Villar[1], José B. Nuñez[1], Carlos M. De Jesús Arias[2], Rafael A. Vásquez Martínez[3]*

Departamento de Agronomía[1]; Departamento de Ciencia Animal[2]; Facultad de Ciencias Agroalimentarias y del Ambiente[3]; Universidad ISA, La Herradura, Santiago, República Dominicana

ABSTRACT.

The organic growing production is increasing in the Dominican Republic due to a higher demand of healthier foods. A trial was set at Universidad ISA to evaluate the effects of the combination of chemical fertilizer and humus from earthworm on Ivy Gourd (Coccinia grandis L.). The experimental design was a randomized complete blocks design with five treatment combinations and four repetitions. The treatment combination were 0 chemical fertilizer-3612.39 kg/ha of humus; 118.3 kg/ha chemical fertilizer-2708.33 kg/ha humus; 237.91 kg/ha chemical fertilizer -1805.55 kg/ha humus; 356.22 kg/ha chemical fertilizer-902.77 kg/ha humus; 475.82 kg/ha chemical fertilizer-0 kg/ha humus. The chemical fertilizer formula was N (12)-P(24)-K(12). It was applied to the crop eight times during the growing period while the humus from earthworm was applied once at 30 day after the planting. The evaluated variables were fruit yield, length (cm), diameter (cm), number of fruit per plant, fruit weight and profit. The results show that the fruit yield had higher at 15days with 3612.39 kg/ha of humus and 0 chemical fertilizers, however, the total production of Ivy gourd fruit was no significantly different among the treatments. The fruit diameter was increased by the application of 237.91 kg/ha chemical fertilizer and 1805.55kg/ha of humus of earthworm. The data of this study suggest that the humus of earthworm may substitute the chemical fertilizer in the Ivy gourd production.

KEYWORDS: Tindora, Earthworm Compost, Fertilizer.

INTRODUCCION

En la República Dominicana se está incrementando la producción de vegetales orientales, entre estos, el cultivo de tindora (*Coccinia grandis*), que ocupa el primer lugar entre los vegetales de exportación. El cultivo de tindora (*Coccinia grandis* L.), es un vegetal oriental que se introdujo en República Dominicana a mediado de los años 90. Este se cultiva, principalmente, para la exportación a diferentes países como son: Canadá, Estados Unidos, Inglaterra y Holanda (Rodríguez, 2005).

En el año 2004 se exportaron 2,999.77 toneladas para un ingreso de 6,599,490.00 dólares. Así mismo en el año 2003 se exportaron 2,211.70 toneladas por un valor de 4,865,737.25 dólares (Rodríguez, 2005).

Su importancia radica en la generación de mano de obra y las divisas que genera para el país. Para el año 2004 generó unos 923,928.60 dólares (Rodríguez, 2005).

En los países del Caribe, especialmente en la República Dominicana, se carece de información sobre este cultivo rubro, debido a que no se han realizado investigaciones sobre el mismo, por esta razón se hace necesario realizar investigaciones relacionadas al manejo de este cultivo a fin de desarrollar nuevas técnicas y/o tecnologías de producción orientadas a lograr un uso más eficiente de los recursos.

No se conoce con exactitud la diferencia entre el uso de fertilizantes químicos, abonos orgánicos o la combinación de ambos sobre la productividad y condiciones para el desarrollo optimo de este cultivo, aunque algunos productores de las zonas de La Canela, Licey, pertenecientes a Santiago de los Caballeros, y La Vega utilizan regularmente dicha combinación, pero no ha sido tema de evaluación científica. Por tanto, los productores no saben la proporción de enmienda (Lombriz Compost y fertilizantes químicos) que debe agregarse y cuál es la dosis de fertilizantes que debe aplicarse a dicho cultivo.

Debido a esto, el Departamento de Agronomía de Universidad ISA, conjuntamente con la Asociación de Exportadores de Vegetales Orientales, propusieron la realización de esta investigación, la cual se ejecutó en el campo experimental de la Universidad ISA de La Herradura, con el objetivo de evaluar diferentes dosis combinadas de fertilizante químico y Lombriz Compost sobre la producción del cultivo de Tindora (*Coccinia grandis* L.).

MATERIALES Y METODOS

Área de Estudio

La fase experimental fue desarrollada en el área del la universidad ISA, durante el período de noviembre del 2003 hasta abril del 2004. Las condiciones geo-climáticas del área experimental es 19 º 26´ N, 70 º 44´ O y una altura de 160 msnm, con una temperatura media anual de 26 ºC; Precipitación media anual de 970 mm; Humedad relativa 84.28 %(Memorias de ISA, 2004)

Diseño Experimental

En esta investigación se utilizó un diseño de bloques completos al azar, compuesto por 5 tratamientos y 4 repeticiones, (Tabla. 1). Las parcelas experimentales tuvieron una longitud de 7.2 m de ancho por 10.8 m de largo. Cada unidad experimental tuvo un tamaño de 77.8 m². La separación entre bloques fue de 3.6 m y 2.0 m entre parcelas. La separación entre plantas fue de 1.2 m mientras que la separación entre hileras fue de 1.8 m con un total de 45 plantas por parcelas. El área total fue de 2,455.2 m².

Tabla .1. Tratamientos Evaluados en el Experimento Sustitución de Fertilizantes Químicos por Lombriz Compost en el Cultivo de la Tindora (*Coccinia grandis* L.).

Tratamientos (Q-LC)	Lombriz Compost (kg/ha)	Químico (kg/ha)
0-100%	3613.74	0
25-75%	2709.66	118.31
50-50%	1806.89	237.91
75-25%	906.78	356.22
100-0%	0	475.82

Variables Evaluadas

Las variables evaluadas durante el estudio fueron:

Rendimiento (kg/ha) de los Frutos: Se obtuvo el peso de los frutos de cada cosecha (15 cortes) del área útil de 77.8 m^2 en cada tratamiento y su rendimiento en kg/ha.

Número de Frutos por Planta: se determino el en numero promedio de frutos cosechados por plantas. Los frutos cosechados correspondieron a las doce (12) plantas seleccionadas al azar en las unidades experimentales

Diámetro de los Frutos : Esta variable se midió utilizando un pie de rey calibrado en centímetros y en cada cosecha se midió el diámetro (cm) en la parte mas ancha de quince (15) frutos escogidos al azar, y luego se sacó el promedio de todas las cosechas.

Longitud de los Frutos: Se utilizo el mismo método de la variable anterior, con la diferencia de que se midió la longitud desde el ápice hasta la inserción del pedúnculo.

Consistencia de los Frutos: Se determinó ejerciendo peso sobre los frutos en gramos por cm^2, con el cual penetró al interior de los frutos con un tornillo de 0.5 cm de diámetro con la punta plana. El tornillo estaba adherido a una cápsula de aluminio. Para este procedimiento se colocaron quince (15) frutos por tratamientos sobre una superficie plana de madera, el tornillo sostenido por un soporte el cual permitía su libre desplazamiento, fue colocado sobre el fruto y luego se colocó pesas conocidas dentro de la cápsula, hasta observar el momento en el cual el tornillo penetra el interior del fruto a evaluarse.

Relación Beneficio / Costo: Se calculó con el propósito de saber la ganancia por cada peso invertido por cada tratamiento y se obtuvo mediante la fórmula RB/C= (Ingreso-Costo)/Costo.

Análisis Estadístico

Se realizó un análisis de varianza según el sistema de análisis estadístico SAS V.8.0 para las variables en estudio, con una probabilidad de 0.05. En caso de observarse diferencia significativa en algunas de las variables en estudio, se realizó para aquellos tratamientos estructurados se hizo un análisis de regresión. Los datos se sometieron a un análisis estadístico, cuyo modelo es el siguiente:

$$y_{ijk} = \mu + \beta_j + T_j + £_{ijk}$$

Donde:

Y_{ijk} = es la observación del tratamiento i en el bloque j.
μ = es el efecto verdadero de la media general.
T_j = es el efecto de i_j – ésimo tratamiento (i = 1,2...n)
$ß_i$ = es el efecto de i – ésimo bloque.
$£_{ij}$ = es el error experimental.

Manejo del Cultivo

Obtención de las Estacas: Las estacas son provenientes de la finca de la Exportadora de Vegetales Orientales Isidro, ubicada en La Canela en la provincia de Santiago.

Siembra: Los esquejes sembrados tenían cuatros nudos cada uno, a dos esquejes por golpe, para lograr un mayor número de estacas prendidas y al final dejando una para lograr una buena plantación. Una vez sembrados los esquejes se observo que a los 12 días estaban enraizados. La siembra se realizó manualmente el día 24 de noviembre del 2003 con un marco de siembra de 1.20 m entre plantas y 1.80 m entre hileras, para una densidad de 5,787 plantas por hectárea.

Riego: Para suplir las necesidades de agua del cultivo, Se utilizó un sistema de riego por goteo. El primer riego se realizó dos días antes de la siembra de los esquejes, durante dos horas; y el segundo se realizó el mismo día de siembra y los siguientes se realizaron de forma cada dos días, excepto en tiempo de lluvia. El tiempo de riego fueron dos horas, lo que representó 5 mm de lámina de agua.

Tutores: Debido a que la Tindora es una planta trepadora, para lograr que ellas trepen, se usaron 5 tutores por hileras a una distancia de 2.16 m entre ellos. Se utilizaron 25 tutores por parcela para un total de 500. Se utilizó alambre dulce una línea arriba y otra abajo sobre los tutores. La primera línea, estaba a 40 cm de distancia del suelo y la otra 140 cm entre un alambre y otro. También encima de los alambres se colocó tejido hilo de nylon en forma de Zig- Zag a 31 cm de distancia (de quien) para que de esa forma las ramas de las plantas pudieran trepar con facilidad.

Aplicación del Lombriz Compost: Todo el Lombriz Compost se aplicó de forma incorporada el 26 de diciembre del 2003, después de que el cultivo estaba establecido de manera uniforme (Cuadro 1). Por la característica que presenta el abono orgánico (lombriz compost) de que sus efectos se observan a largo plazo (3-5 meses), se esperó un mes para realizar la aplicación del producto químico. La aplicación del fertilizante 12-24-12 fue realizada un mes después de los tratamientos que conllevaban Lombriz Compost. Se hicieron ocho aplicaciones del granulado 12-24-12, una cada siete días (Cuadro 3.3 y 3.4) de acuerdo al análisis de suelo realizado antes del experimento (Anexo 4). La primera aplicación fue diferente en proporción de las otras aplicaciones la primera aplicación fue 30 % y las otras aplicaciones fueron 10 %. Para que exista un buen aprovechamiento de fertilizantes por parte de la planta es necesario aplicar este en varios momentos de aplicación siendo la primera la mas fuerte ya que es un cultivo perenne y se realizan varias cosechas.

Control de Malezas: El control de malezas se realizó mecánicamente con azada al principio de la plantación. Después (en que momento) el control se realizó manualmente en los troncos de las plantas para luego (cuando) hacer el control total con producto químico. En total con los métodos manual y químico se realizaron siete actividades de control de malezas.

Control Fitosanitario: Las especies encontradas en el cultivo de tindora fueron: Ácaros (*Tetranichus sp*), gusano cortador (*Agrotis ipsilon*), hiede vivo (*Nasara viridula*), diafania (*Diafania hyanilata*), minador (*Tetranichus sp*).

Cosecha: La primera cosecha se realizó a los 97 días después de la siembra, el 2 de febrero del 2004 de forma manual, iniciándose cuando los frutos alcanzaron un tamaño comercial (4.5 cm). Para la cosecha se seleccionaron 12 plantas al azar que representaron el área útil (30.24 m^2) de los tratamientos. El Cuadro 3.6 muestra la cantidad cortes realizados durante el experimento, con una frecuencia cada 5 días.

RESULTADOS Y DISCUSION

Rendimiento (kg/ha) de Frutos

Al evaluar el rendimiento de frutos en la cosecha total no hubo diferencias significativas (Ver Cuadro 2), con rendimientos similares a pesar de las diferentes proporciones de fertilizantes sustituida por Lombriz compost. El análisis de regresión (Ver figura 2) para la variable rendimiento en kg/ha de Tindora de la cosecha total, se aprecia una tendencia cuadrática que es explicada por la siguiente fórmula $y = 250.96 X^2 - 1688.3 X + 6940.4$ con un $R^2 = 0.252$.

Tabla 2. Parámetros productivos de Tindora en la Sustitución de Fertilizantes Químicos por Lombriz Compost en el Cultivo de la Tindora (*Coccinia grandis* L.).

Tratamientos (Q-LC)	Químico	Lombriz Compost	Rendimiento (kg/ha)	Numero de frutos/planta
0-100%	3613.74	0	15,350.53	1083
25-75%	2709.66	118.31	14,078.82	1055
50-50%	1806.89	237.91	12,249.19	1155
75-25%	906.78	356.22	14,048.70	1080
100-0%	0	475.82	13,513.50	1136

Los resultados indican que a medida en que disminuye la proporción de lombriz compost se reducen los rendimientos. También se observa que alta proporción de fertilizantes químicos tiende a aumentar el rendimiento, pero sin llegar a los niveles observado con alta dosis de lombriz compost (Ver Figura 1).

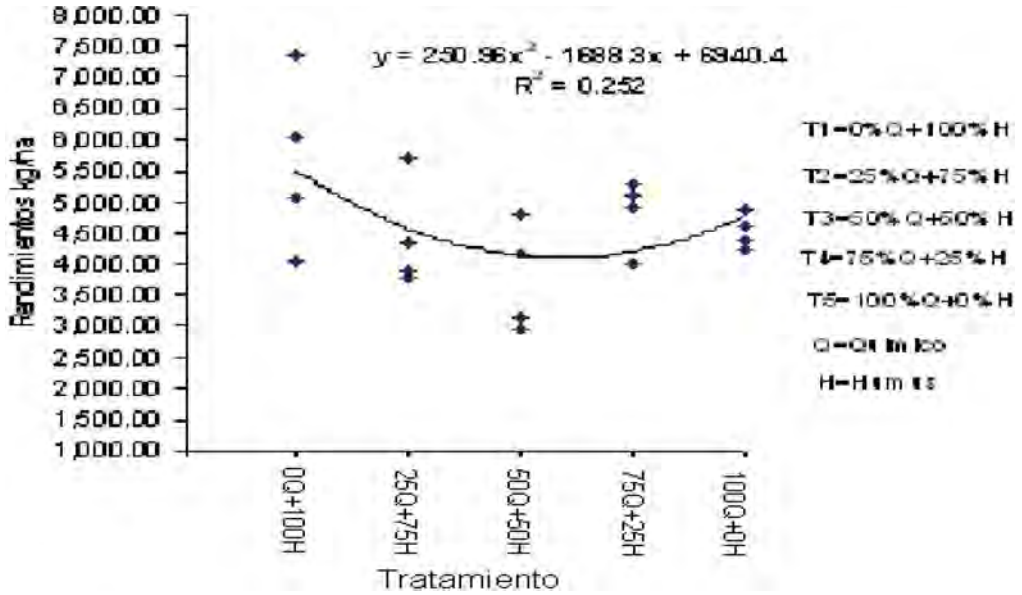


Figura 1. Análisis de Regresión del Rendimiento Total de los Frutos en el Experimento Sustitución de Fertilizantes Químicos por Lombriz compost en el Cultivo de la Tindora (*Coccinia grandis* L.).

Peso (g) Promedio de los Frutos

No se observó diferencias significativas en el peso promedio de los frutos en los distintos tratamientos durante la cosechas de Tindora. Aunque al observar las medias (Ver Tabla 2) se aprecia que el mayor peso se encontró cuando se aplicó 75 % de fertilizantes químicos y 25 % de lombriz compost, con un peso promedio de 8.32 g, y el peso más bajo al aplicar 100 % de fertilizantes químicos con 7.10 g de humus.

Número de Frutos por Planta

Al evaluar las medias del número de frutos totales por planta, no se encontró diferencia significativa entre sus tratamientos. Al observar las medias aritméticas (Ver Tabla 3) se aprecia que, el mayor número de frutos por plantas se encontró cuando se aplicó 50 % de fertilizantes químico y 50 % de lombriz compost con 1,155, seguido por el tratamiento con el porcentaje más alto de fertilizantes químico (100 %) con 1,136, los más bajos resultados se obtuvieron cuando se aplicó 75 % de lombriz compost y 25 % de fertilizantes químicos con 1055 frutos.

Tabla 3. Parámetros de los frutos de Tindora en la Sustitución de Fertilizantes Químicos por Lombriz Compost en el Cultivo de la Tindora (*Coccinia grandis* L.).

Tratamientos (Q-LC)	Químico	Lombriz Compost	Diámetro (cm)	Longitud (cm)	Consistencia (g/cm^2)
0-100%	3613.74	0	1.47	5.19	13,477.56
25-75%	2709.66	118.31	1.45	5.25	13,161.08
50-50%	1806.89	237.91	1.49	5.17	13,425.51
75-25%	906.78	356.22	1.52	5.28	13,289.54
100-0%	0	475.82	1.46	5.21	13,395.65

Diámetro de los Frutos

Al realizar la comparación de media (Ver Tabla 3) se observó que el mayor diámetro promedio se obtuvo en el tratamiento 4 con la combinación de (75 % fertilizante químico y 25 % lombriz compost) con 1.52 cm, seguido del tratamiento 3 con 1.49 cm siendo estadísticamente diferentes entre ellos. Mientras que el menor se obtuvo cuando se aplicó 25 de fertilizantes químico +75 % de lombriz compost con un valor de 1.44 cm.

Longitud de los Frutos

La mayor longitud de frutos de la cosecha total fue observada (ver Tabla 3) al aplicar 75 % de fertilizantes químico y 25 % de lombriz compost con un promedio de 5.28 cm, y donde la aplicación de 25 % de fertilizantes químico y 75 % de lombriz compost con un promedio de 5.25 cm y la menor longitud promedio se registró en plantas donde se aplicó 50 % lombriz compost y 50 % de fertilizantes químico con 5.17 cm.

Consistencia (g/cm^2) de los Frutos

Al observar las medias promedio de consistencia de los frutos, la aplicación de 50 % de fertilizantes químico + 50 % de lombriz compost (ver Tabla 3) registró la mayor consistencia con 13,425.51 g/cm^2, mientras que los frutos con menor consistencia registrada fue cuando se aplicó 25 % de fertilizantes químico + 75 % de lombriz compost que para su penetración se necesitó 13,161.08 g/cm^2.

Relación Beneficio / Costo

Aplicar una fertilización total con abono orgánico de lombriz compost, resulta el más rentable con ganancias de 54.66 pesos por cada peso invertido (ver Tabla 4) que los demás niveles de sustitución de Lombriz Compost por fertilizantes químico. Se observó que la segunda mejor relación beneficio-costo fue con la aplicación el 100 % de fertilizantes químico con 50.45 por cada peso invertido y la más baja relación fue con el 50 % de fertilizantes químico y 50 % de lombriz compost con 42.69.El rendimiento más alto se encontró cuando se aplicó el 100 % de lombriz compost con 61,702.76 kg, mientras que el más bajo rendimiento fue cuando se aplicó 50 % de fertilizantes químico + 50 % de lombriz compost con 49,389.67 kg.

Tabla 4. Relación beneficio-costo de los diferentes niveles de Sustitución de Fertilizantes Químicos por Lombriz Compost en el Cultivo de la Tindora (*Coccinia grandis* L.)

Tratamientos (Q-LC)	Rendimiento (kg)	Precio kg (RD$)	Ingreso (RD$)	Costo de Producción (RD$)	Beneficio (RD$)	Relación B/C
0-100%	61,702.76	52.80	3257905.72	58524.81	3199380.91	54.66
25-75%	55,986.65	52.80	2956095.12	59674.81	2896420.31	48.53
50-50%	49389.67	52.80	2607774.57	59674.81	2548099.76	42.69
75-25%	57987.99	52.80	3061765.87	59674.81	3002091.06	50.30
100-0%	55228.53	52.80	2916066.38	56674.81	2859391.57	50.45

CONCLUSIONES Y RECOMENDACIONES

De acuerdo a los resultados del análisis estadístico de las variables, se puede concluir que la aplicación del lombriz compost no combinada, produjo los mejores rendimientos (15,350.53 kg/ha), además resultó lo más rentable con ganancia de 54.66 pesos por cada peso invertido en el cultivo de Tindora y además la calidad de los frutos (longitud, diámetro, consistencia y peso promedio por fruto) no cambia con la sustitución de fertilizante químico por lombriz compost

REFERENCIAS

Alcé, P. y Michel, G. 2000. Evaluación de Dos tipos de Fertilizantes y Una Combinación de Ellos en la Producción a Raíz Dirigida de *Pinus caribea* Var. Caribea Morolet y *Swietenia mahagoni,* L. Jacp. Bajo Tres Frecuencias de Fertilización. Tesis Ingeniero Forestal (ISA) República Dominicana.

Asís del Rio. J. y Bornemiga, E. 1987. Importación de los Fertilizantes Orgánicos e Inorgánicos

Balasch, D. 1998. Fertilidad de los Suelos Abonos Y Materia Orgánica. Idea Book. Barcelona. España. 82.85

Bernard S., y Meyer, D. 1960. Introducción a la Fisiología Vegetal. Editorial Universidad. Buenos Aires, Argentina.

Beer, F.. 1998. Los Suelos en Relación con Crecimientos de los Cultivos. Traducción del Ingles por José Albbeijon Veloso. Barcelona. España.

Bello, E. 1995. Diferentes Dosis de Humus y Fertilizantes Químicos en Tabaco. Cuba.

Bravo, R. y Radick, R. 1986. Centro de Investigación y Desarrollo de Lombriz Cultura. México.

Biblioteca de la Agricultura. 1997. Suelos, Abonos, y Materia Orgánica. Idea Book. Barcelona. España pp. 82.85

Burkill, H. 1985. The Usefull Plants the West Tropical. Africa.

Casseres, E. 1996. Producción de Hortalizas. IICA. Lima, Perú.

Cliffor, W. 1998. Fruit Goard. Botany Department. Universidad de Hawai.

Devlin, R. 1980. Fisiología Vegetal. Ediciones Omega, S.A. Barcelona. España.

Diaz, R. y Hunter, A. 1989. Informe sobre el Uso de los Fertilizantes. IDEA Books, España.

Fuentes, J. 1994. El Suelo y los Fertilizantes. Ediciones Mundi - Prensa. Madrid, España.

Guerrero, A. 1969. El Suelo, los Abonos y la Fertilización de los Cultivos. Editorial Mundi Prensa. España.

Howard, R. Wuman P. 1995. Plantas Medicinales de la Familia Cucurbitáceas. Pakistán.

Millar, V. 1967. Fisiología Vegetal. Traducción al Español por el Dr. Francisco Latone. UTHEA, México

Pérez, A. 1999. Repuestas del Cultivo de Ají (*Capsicum annum*) a la Fertilización con Nitrógeno. Tesis Ingeniero Agrónomo Pontificia Universidad Católica Madre y Maestra. República Dominicana

Rodríguez, F. 1983. Fertilizantes. AGT. Editorial 3A. México.

Rodríguez V. 2005. Información Anual de Vegetales Orientales. No 83. Santo Domingo República Dominicana.

Suquilanda, M. 1995. Componentes del Humus y su Modo de Acción. México.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):290. 2008

Challenges of Using Greenhouse Technologies in the Caribbean to Grow Food Crops

Kimberly Moore and Luci Fisher. University of Florida, Fort Lauderdale Research and Education Center, 3205 College Ave., Davie, FL 33314; klock@ufl.edu

ABSTRACT.
The Caribbean has the potential to become self-sufficient by producing more vegetable crops than they import. However, during the rainy season, vegetable production outdoors is hindered. One technique that can be employed is the use of greenhouse structures in order to grow plants year-round. However with the use of any new technology, training is essential. During training sessions in Barbados and Nassau Bahamas, I observed several common challenges growers were facing in both of these countries as they worked to use greenhouse structures to grow vegetables. This poster presentation will outline several of the challenges observed and potential solutions.

KEYWORDS: greenhouse, vegetable production, controlled environment

2008 Proceedings of the Caribbean Food Crops Society. 44(2):291-303. 2008

Organic Agriculture in Trinidad and Tobago: Approaches and Successes of Grassroots Networks and Governmental Policies

Mitra E. Sticklen[1] and Dr. David Dolly[2], [1]US Fulbright Program, and [2]Agricultural Economics and Extension, University of West Indies, St Augustine Campus, Trinidad

ABSTRACT.

In response to mounting environmental, human health, social and economic problems in conventional agriculture, farmers and consumers in Trinidad and Tobago have started to support more organic farming. Within this movement, grassroots actions and networks have created more organic farming and marketing than have governmental policies. There is a lack of legislation regarding organic agriculture, despite the formulation of a draft policy document by a government-appointed committee. Without such legal framework, the definition, standards and methods remain open to interpretation. Between August 2007 and May 2008 the authors studied the development and philosophy of the local organic agriculture movement by conducting interviews, surveys, and engaging in participant observation. Several dispersed networks were identified, and included farmers, marketers, consumers, students, researchers, and policy-makers. Notably, there are opportunities to be certified organic through external certifiers, but the process is often too expensive for farmers selling nationally and there are no local certification alternatives. A few export-focused farms are going through the certification process, but currently there are no certified organic farms in Trinidad and Tobago. This research reveals a number of trends about successful farmer strategies, perceived motivations for organic farming, and obstacles facing this industry. Future recommendations for growth include coupling grassroots actions with formal policy measures. With a focus on public awareness and education, research and demonstration, policy intervention, and incentive creation, Trinidad and Tobago could move towards greater food security via organic food production.

KEYWORDS: Trinidad and Tobago, organic agriculture, legal framework

"We have all the potential to do amazing things. We have water, we have fertile land, but we just don't have the leadership and we're not working in the right direction."

- Tobago farmer who recently lost his organic farm to land tenure issues

INTRODUCTION

The two-island nation of Trinidad and Tobago lies at the southern tip of the Caribbean island chain. Trinidad's agricultural development was largely shaped by its colonial history under Spanish rule in the sixteenth century and under British rule in the seventeenth and eighteenth centuries (Tobago changed hands over twenty times and was not incorporated with Trinidad until 1889). Until the emancipation of slavery in 1838, the majority of agricultural land was in large plantations of crops grown for export, particularly sugar and cocoa. In the years directly following emancipation, the number of small land holdings dramatically increased, most of which were used to grow a variety of

crops for domestic markets. During this period, Trinidad and Tobago was exporting vast quantities of commodity crops while growing enough domestic crops to nearly maintain self-sufficiency in food.

In the early twentieth century, the discovery of oil in Trinidad "led to the decline of the relative importance of agriculture," wherein agricultural output was "inversely related to the performance of the oil sector: depressed during the oil boom, stimulated during oil's decline" (Dolly 2007, IICA 2005). Called the "Dutch disease" effect, the vast large oil and natural gas reserves off the coast of Trinidad drew workers and resources into this industry and out of the agricultural sector. The Dutch disease effect explains why the 1970s brought an oil boom and consequent drop in agricultural production (with Agriculture's share of GDP dropping from 6% in 1970 to 2% in 1980), and why during the 1980s oil decline the nation's economy "was led by strong performance of domestic agriculture, especially small-scale farming," (IICA 2005). Throughout the last decade there has been another oil boom, and a resulting exodus from agriculture, particularly domestic markets. Largely due to the lucrative oil and gas industry, many farmers and agricultural workers are leaving the industry, and agriculture today barely contributes to the gross domestic product.

In addition to the effects of Dutch disease, the decline of agriculture in Trinidad and Tobago was largely in response to international trade regimes. In the early 1990s, a government briefing explained that promoting self-sufficiency and food security "will cost the economy dearly and will impose excess investments," so they announced new policies for "development guided by free market regime," (Republic 1991). Yet with the benefit of hindsight a decade later, the government reflected upon the consequences of free market policy actions: "With respect to WTO rules, developed countries (in particular the USA and the EU) have significantly increased their support to agriculture since 1995 while developing countries are being pressured to reduce support…This imbalance has grown in recent years creating further distortions in trade and unfair competition against exports from developing countries" (Specialists 2004). The government has created many initiatives to diversify agriculture and reinvigorate farming for local and international markets, among which are a handful of organic agriculture programs. These top-down governmental projects have very different goals and values from the grassroots organic farming organizations and markets that have bloomed throughout the nation. While the organic farming practices in Trinidad and Tobago may seem similar at a glance, closer investigation reveals the differences in the various ways organic agriculture has grown.

This research aims to understand the complex history and current status of sustainable agriculture in Trinidad and Tobago. The authors posit that it is ideal for a grassroots organic agriculture movement to continue growing at the same time as a policy-driven movement. By describing the history and current state of organic farming networks, the authors illustrate the approaches, successes, and challenges of organic agriculture in Trinidad and Tobago. This manuscript contributes to the international discourse on organic agricultural movements, particularly at the intersection between global forces and local initiatives. Furthermore, what can be expected, or suggested, for the future of organic agriculture in Trinidad and Tobago?

MATERIALS AND METHODS

Between August 2007 to May 2008, through support of a US Student Fulbright Grant, Ms. Sticklen researched the development and current state of the local organic agriculture movement in collaboration with Dr. David Dolly at the University of the West Indies. The authors first reviewed the agricultural history and policies of Trinidad and Tobago. For the remainder of the grant period, the authors studied the history, values and practices of the organic agriculture movement in the field. Several principal networks were identified including farmers, marketers, consumers, students, researchers, and policy-makers.

The authors spent a great deal of time locating appropriate communities, which at times proved problematic as many organic agriculture groups were operating independently of one another, and little previous research had been done on the current state of local sustainable agriculture. They worked with four main organizations to develop case studies of sustainable agriculture networks. This included: 1. A group of organic farmers in a valley along the East-West Corridor (a densely populated and agriculturally fertile stretch of Trinidad) organized by an older Rasta farmer with a PhD in Horticulture; 2. A for-profit organic food business in Port of Spain (the capital city of Trinidad) that imported various organic items and organized delivery from organic farms in Trinidad and Tobago; 3. The Trinidad and Tobago Organic Agriculture Movement; and 4. A working organic research farm in Tobago, funded by an international agriculture organization.

Methods to understand the historical and political background included research in university and national libraries, and archival research with various professors and policy-makers. Field research methods included interviews and surveys, and most significantly spending weeks at a time with these communities, engaged in participant observation.

To disseminate the research findings, the authors organized a few networking events to discuss and share information about local sustainable agriculture and presented a paper at the Caribbean Food Crops Society's 2008 meeting. Pamphlets and informational flyers are being developed for distribution among members of these communities, and future ethnographic and participatory research is a promising possibility.

RESULTS AND DISCUSSION

Perceived incentives for local organic agriculture

The sweeping trends at the production and consumption ends of agriculture in Trinidad and Tobago mirror the patterns of free-market industrial agriculture throughout the developing world. On the production end, farms in Trinidad and Tobago became fewer and larger, and increasingly utilized green revolution technologies including mechanization and intensive use of synthetic chemicals. On the consumption end, cheaper imported foods have largely replaced the Trinidadian domestic products, and Trinidadian food preferences (and consequent health issues) are increasingly reflecting American diets. The growing awareness among Trinidadians about the various threats of industrial agriculture has lead to a number of grassroots sustainable agriculture organizations. Most small-scale producers selling to domestic markets do not have access

to governmental resources (including from TTOAM), and most have alternative sources of income to supplement their organic food sales.

The compounding of environmental problems provides many measurable reasons to move away from conventional agriculture. In a 2005 report from the Inter-American Institute for Cooperation on Agriculture (IICA), authors noted that many areas of Trinidad and Tobago that were fertile have been degraded due to "soil erosion, salinisation, and/or a general loss of soil fertility due to the pervasive use of agrochemicals," and furthermore, "[f]reshwater resources have been polluted or overexploited through intense use of agrochemicals and excessive irrigation, particularly in rice production" (IICA 2005). This has also been scientifically measured by CABI: "Over the past few decades, pesticide abuse has been increasing in many Caribbean countries particularly in short-term and high-value crops. This has had negative effects on farm family income, farmer and farm worker health, and consumer health…A socioeconomic survey of vegetable farmers' practices in Trinidad carried out by CAB International and the Ministry of Agriculture, Land and Marine Resources (MALMR) in 1995 on three short-term vegetable crops (cabbage, tomato, eggplant) documented excessive and unwarranted pesticide applications," (CABI 2004). Additionally, the prevalence of monocrop agriculture decreases biodiversity and leads to loss of important regional crop species as well as wildlife. Environmental concerns aside, conventional agriculture poses many risks to human health.

The government of Trinidad and Tobago has acknowledged that "[p]esticide abuse is an important issue because of its effects on the farmers who use the chemicals as well as on the consumers of the products. It is also of concern because pesticide residues in products can prevent access to export markets," (Ministry 1995-1997). In our field observations and conversations with farmers and extension workers, the authors found that most farmers use more than the recommended amounts of pesticides and fertilizers, assuming incorrectly that this will solve their various agricultural problems. A 2005 IICA report confirms the risks of heavy chemical usage, and warns that pesticide residues in drinking water is a large health risk to the health of farmers and consumers. (IICA 2005). Beyond chemical health risks, there are many health issues associated with diet. A 2003 report by the World Health Organization and the Food and Agriculture Organization outlines the high prevalence of diseases which could be prevented by better nutrition, including obesity; diabetes; cardiovascular diseases; cancers; osteoporosis and bone fractures; and dental disease" (Lang 2004). These diseases are becoming epidemics throughout the world, including in the population of Trinidad and Tobago, particularly children. The environmental and health concerns of conventional agriculture provide citizens in Trinidad and Tobago alarming reasons to seek healthier alternatives for food. The threats of conventional agriculture are motivation for many to join the organic food movement, but many others are drawn to the movement's economic and social benefits.

In Trinidad and Tobago, the government has outlined food security as a priority in their 2020 vision, and the imperative was highlighted during the food crisis in early 2008. One main incentive for the government to pursue organic agriculture is economics. According to a governmental report, agriculture has changed over the last 30 years and its relative importance in the economy has gone down. "Globalisation and international trade development pose a more recent challenge to the growth of the agricultural sector. Agricultural development in Trinidad and Tobago over the past 30 years highlight the

need for increased rates of productivity and competitiveness to maintain profitability and attract investment into the sector," (Ministry 2001). Organic agriculture is one way to strive towards competitiveness, because it is (on international markets) viewed as a niche commodity item. Beyond food security and economics, organic agriculture also creates a number of jobs. For example, organic farmers in the East-West Corridor are starting to utilize the government's Community Environmental Protection and Enhancement Programme workers, who usually do road maintenance, to work on organic farms. In doing so, these workers are gaining a lifelong skill and also reconnecting with the land. Organic production is a way to diversity agriculture that creates alternative markets and priority commodities. In this same farming community, many of the farmers are Rastas, and working on organic farms and eating organic food is just one more way to connect to the earth and each other and life an ital, or natural, lifestyle. Many consumers are drawn to the connectedness of a food system where they know where their food comes from, and in Trinidad and Tobago an organic store in the capital city promoted their local organic fresh fruits and vegetables, as well as prepared meals, to a wide variety of customers. The idea of local organic food is very appealing to many consumers, wherein they can contribute to their local economy and a healthy livelihood for a local farmer, while eating chemical-free food and promoting better environmental practices.

While the organic agriculture movement takes many forms in Trinidad and Tobago, its main goal is to achieve sustainability within and across environmental, human health, economic and social sectors.

Organic agriculture: Definitions and legal framework

While there has been a growing interest in organic food and farming in Trinidad and Tobago, there is still no legal definition or infrastructure to regulate and monitor the specific "organic" practices on farms and in processing. The authors researched the growth and obstacles of the organic movement's legal infrastructure in other nations and in Trinidad and Tobago.

Many international organizations have sought to standardize and streamline the definition and processes of organic horticulture. The International Federation of Organic Agriculture Movements (IFOAM) developed the definition that many countries and organizations throughout the world have adopted: "a holistic production management system, which enhances agro-ecosystem health, utilizing both traditional and scientific knowledge. Organic agricultural systems rely on ecosystem management rather than external agricultural inputs," (IFOAM 2005). Similarly and more specifically, IICA describes "organic" as having a few major technical features: soil fertility, mulching, intercropping, and composting (IICA 2005). Each country has the option of defining the word legally and regulating the use of its labeling to ensure certain qualities. In the United States, the USDA launched these definitions with the 1990 Organic Food Productions Act, and in the 2002 National Organic Program. Similar legislative processes had begun in Trinidad and Tobago but have not yet been codified into law.

In 2002, Trinidad and Tobago's Ministry of Agriculture, Land and Marine Resources established a committee to develop a draft organic agriculture policy. This committee helped create the Trinidad and Tobago Organic Agriculture Movement (TTOAM), a branch of IFOAM. The main goal of this committee was to identify, assess and prioritize the socio-economic potential of organic agriculture to make Trinidad and

Tobago a regional leader in organic agriculture. To do this, the executives and members of TTOAM focused on defining "organic" and creating certification options for the exportation of large-scale commodity crops.

By 2006, TTOAM and the committee had written a Draft Sector Policy for Organic Agriculture. This included notably a definition of organic agriculture, a review of the local and global agriculture sector (see **Figure 1**), the costs of conventional agriculture and the benefits of organic agriculture, a proposed legal framework for certification and networking, and an ambitious action plan. Yet in 2006, after four years of deliberation, only seven of the ten committee members had signed the draft policy (Government 2006). As described by TTOAM's chairman and founder in February 2008, the draft policy was completed and awaiting legislative approval. As of May 2008, TTOAM's draft policy still had not been codified into law. Due to this lack of legislation, the definition, standards and methods of organic agriculture production and marketing remain open to interpretation in Trinidad and Tobago.

Figure 1. Import/Export vs domestic money spent on the world market for organic foods in 1994, 1999 and 2004. (Government 2006)

Grolink AB	1994	1999	2004
Import/Export	0,5	1,5	8
Domestic	5	11	32

During the development of the draft policy in 2005, IICA recommended a number of short- and long-term actions to create a viable organic sector. First and foremost they called for a national organic agriculture policy through legislation in a short timeframe (IICA 2005). Furthermore, they prompted the Ministry to establish an institutional platform, to appoint competent authorities within the government, to establish a clear legal framework, to network with organic sectors in other countries like Jamaica and the Dominican Republic, and finally to create "National Organic Agriculture Board" with members from official and private institutions (IICA 2005). Yet with the stagnation of this policy legislation, these suggestions as yet go unfulfilled.

The Ministry of Agriculture, Land, Marine Resources (MALMR) in May 2008 did not have a specific program on organic agriculture. Today, there is still no legal definition of organic agriculture in the country, nor is there a specifically regulated

certification procedure or governmentally-promoted organic infrastructure. Despite this legislative stagnation, there are a growing number of organic farmers in Trinidad and Tobago.

Figure 2: Obstacles facing organic farmers in Trinidad and Tobago

PROBLEMS	SOLUTIONS
1. Lack of physical & political infrastructure	Governmental policies, public awareness, partner with grassroots organizations
2. Contamination in the field	On-site monitoring, farmer awareness
3. Counterfeiting	Food testing, certification or farmer-buyer trust
4. Co-mingling	Market and transportation standards, farmer/transporter/marketer awareness
5. Lack of public awareness	Local media, educational programs in schools and communities
6. Labor issues and work ethic	Governmental programs, clear incentives, training
7. Extension, research and training	Partner with research institutions, farmer field schools, expand governmental courses, distribute information through markets
8. Lack of organic inputs	Locally produced compost, natural pesticides/insecticides/fungicides, seed-saving
9. Land tenure	Governmental policies, land trusts
10. Skepticism about organic farming	Public demonstration sites, education and media outreach
11. Access to credit and funding (loans and grants)	Governmental policies, tax breaks, partner with local and international institutions
12. Certification issues	Local certification options for domestic organic food and food destined for exportation
13. Lack of markets	Partner with existing markets, create specific organic markets
14. Praedial larceny	More farmstead land, better policing, clear disincentives for criminals
15. Lack of young farmers	Educational and governmental programs, clear incentives and demonstration

Trinidadian farmers who claim to be farming organically have many definitions of "organic," most of which are based on concepts of naturalness or defined by the absence of synthetic chemicals. When asked about organic agriculture, a worker on an organic farm in Trinidad said, "it's healthier to use for the farmers who work the land, and healthier for the family who eats the food too." On a different farm that promotes itself as organic, in reflecting on the government's involvement in the organic movement, one farmer said, "A lot is being said, but little is being done." He went on to explain that much more was happening at the grassroots level, that the bureaucratic process was only slowing the growth of the organic movement. This sentiment is echoed throughout the main actors in the local organic movement, particularly among farmers and market owners. Many farmers insisted that the government moves too slowly and wastes too

many resources, and generally privileges large-scale export-focused organic farms. While it is important to develop this infrastructure and standardize the techniques required to call a product "organic," the authors assert that the government should listen to the needs and obstacles of the farmers and consumers in the local small-scale organic network.

Organic Farms: Certification

For the purposes of this manuscript, the word "organic" generally refers to farms that claim to be organic, and the term is not limited to a legal definition. Yet in 2008, there were still no certified organic farms in Trinidad and Tobago. According to a 2005 report from IICA, there were "no support mechanisms for organic production at both the governmental and farm levels particularly in the production of the required inputs such as fertilizer, weed, disease and pest management, and the delivery of extension services," (IICA 2005). The IICA recommended that the first step in developing organic agriculture in Trinidad and Tobago would be creating the infrastructure for legal certification and to make organic inputs available to farmers.

In 2007, TTOAM began to receive training from TTOAM and from the International Organic Inspectors Association. TTOAM officials began to lay the groundwork for certification and inspections, which was a long process. In the certification options of 2007, farmers could choose an inspection agency and pay independent agents for inspection. This process entails keeping close records on their practices and their farms, profiling insects, mapping plots, and planning for future soil fertility. However, TTOAM's Technical Director said the annual certification costs can be extremely variable, and that certification is only necessary when the market is far away: "It could be expensive depending on how far it's going, so it's unnecessary for farmers who are selling to a local market." In other words, farmers selling to local markets would not find it profitable to seek organic certification. Many local farmers reflected this sentiment, agreeing that it was far too expensive for their income level. Of the farms seeking certification, the authors found that the farms seeking certification were all large-scale and export focused, or run by an international organization and intended to serve as a demonstration site. Interestingly, IFOAM statistics for 2005 claimed Trinidad and Tobago had 67 hectares under organic agricultural land, all in one organic farm, which accounted for 0.05% of total agricultural land (IFOAM 2008). Yet the authors of this manuscript could not account for this farm or the IFOAM method for measuring organic farms. During the conclusion of this research, a number of large-scale farms were transitioning to become certified. TTOAM's Chairmain told the authors that, "within six months, ten to fifteen inspected organic products will be on the market, including fresh produce." Yet in May 2008, there were no certified organic farms in Trinidad and Tobago.

Organic movement: Governmental resources and local organizations

There are a few governmental resources available to organic farmers and consumers. In 2007, MALMR held a short one-day workshop on organic agriculture, and in 2008 this was expanded to a two-day short course. The authors interviewed a number of the 2008 participants, and noted that most were not organic farmers selling to markets but rather home gardeners interested in growing organic food for the family. It is important to offer resources to home gardeners, but the government has not reached out

to many farmers wishing to transition to organic practices. Because many farmers do not have the ability to attend courses, many extension resources are available to conventional farmers. Yet unfortunately, in 2008 there were no organic specialists on staff in the state's extension department.

Organic farmers also have the option of utilizing the National Agriculture Marketing Development Corporation's (NAMDEVCO) farmers markets and marketing resources. In an interview, the Corporate Manager of Marketing said NAMDEVCO was "willing to make facilities in Debe and in Macoya available separate from the conventionally produced things in the market. But there was only one farmer in Macoya, and he backed down…" These false claims about the naturalness of organic food are not uncommon in Trinidad and Tobago. The authors observed two farms that were claiming to be organic, but continued using "salts," or conventional fertilizers, on many of their plants during certain stages of growth. Without codified procedures for certification or testing, many farmers who claim to be organic would not meet the requirements of many national standards for organic food.

CABI, an international organization, recommends various solutions to the technical problems facing organic farmers, particularly a Farmers Field School approach to educating farmers: "Farmer Participatory [FP] methods are widely recognised as key components for more sustainable and environmentally friendly approaches to crop production...FP approaches aim to build farmers' capacity to make their own crop management decisions based on a better understanding of the agroecology of their own field, and according to their own unique set of circumstances and priorities," (CABI 2004). In a valley in Trinidad's agriculturally fertile East-West Corridor, farmers participated in this methodology in 2003 to not only collectively gain technical knowledge about organic farming, but also to provide farmers with new skills and insights in ecological principles. Through these FP methods, farmers were more empowered and research became more farmer-driven. One of the main farmers in the valley is a Rasta man with a PhD in horticulture, and his value and passion for naturalness and the environment extends to his farming practices and into his community.

While the governmental resources regarding organic agriculture are limited, many groups of people have organized around these issues to create a local organic movement in Trinidad and Tobago. Some of these groups work through private funding, others are non-profits, and some are international organizations. Each group offers different resources, has a unique membership structure, and some groups have more success in creating and promoting organic farms than others.

TTOAM, as aforementioned, is the largest and most recognized organic organization in Trinidad and Tobago. This private organization funds all their expenses except attending conferences, which is paid through grant funding. In 2008, TTOAM had 120 members, including individuals and groups. While many farmers and local organizers question their closed membership structure, lack of open information, and slow speed of effecting change, this group has organized more organic legislation and action than any other group. They offer support services to organic farmers, and invite many conventional farmers to consider changing their practices and join the organic movement.

An organic shop in Trinidad's capital city, Port of Spain, was one of the main sites for this research. The store had been open for a few years and experienced

exponential growth and interest in organic food. In 2007 and 2008, this for-profit business was selling local and important organic products including dry goods, fresh fruits and vegetables, and prepared meals. The business also began a "box scheme" program in 2007 to organize a number of local organic farmers to provide enough food for customers to buy an entire box of local organic foods. Furthermore, the owner of the business hosted a number of events, discussions, and educational experiences to help raise public awareness about issues facing the organic movement.

A handful of other groups were working towards similar goals, particularly a permaculture organization, the Agricultural Society of Trinidad and Tobago, a number of farmers associations, and a student group on campus at the University of the West Indies, St. Augustine. Furthermore, international groups IICA, CARDI, and FAO worked in Trinidad and Tobago to provide educational, research, training and outreach resources.

Global and Local Organic Agriculture: Differences in Values

A 2007 CABI report explains the early organic farming movement "as an alternative to agribusiness as usual...this movement started out not to produce expensive niche-market foods for rich people, but rather to offer a model for all of agriculture…The real promise of organic agriculture is to provide credible production systems that can aid the world's poor and strengthen local food security" (CABI 2007). And yet it is clear that the global paradigm is that of a free market trade system, where the priority is the bottom dollar.

Laura T. Raynolds describes the early organic movement's "domestic and civic values of trust, place-based knowledge, ecological diversity, and social justice, upheld through networks involving small-scale organic farms, face-to-face exchanges, and conscientious consumers," (Raynolds 2004). As organic trade becomes more globalized, distancing production from consumption and farmers from consumers, these original values and networks have been increasingly replaced by free-market economic values of competition and control.

In an example from Mexico, where the organic agriculture infrastructure is older and more larger, the corporate agribusiness networks are taking control of the organic sector. Only 2% of Mexican certified organic producers in the nation are large private agroindustrial organic producers, but they are cultivating 16% of the certified organic farmland, on farms that average ten times larger than small certified organic producers, and gain 31% of the returns in the certified organic market (Tovar 2005). The authors of this study show how traditional economic forces privilege large-scale organic producers, who can "can capitalize on economies of scale and guaranteed contracts." This situation is becoming more common throughout the world, including in Trinidad and Tobago. However, there is an alternative movement within this new globalized organic agriculture movement.

Raynolds asserts that while the original social and environmental organic agriculture values are increasingly dominated by the global free-market trade of organic food, many alternatives would maintain these values. "To socially and environmentally re-embed agricultural production would thus appear to require not just alternative products, but alternative marketing links," (Raynolds 2000). Through this research in Trinidad and Tobago, the authors would posit that many organic farmers and consumers

have created these alternatives, with underlying values that are closely aligned with those of the original organic movement.

Local organic farmers: Problems and solutions

Through a series of interviews, claims of other organizations, and extensive participant observation, the authors noted a number of similar obstacles and a variety of solutions to these stumbling blocks. This list is summarized in **Figure 2**.

1. Lack of physical infrastructure including insufficient road access, water supply and adequate resources for organic farmers pose a large obstacle. Additionally, without any legislation regarding organic agriculture, there is a lack of political infrastructure necessary to support a vibrant organic sector. Solutions included on-site infrastructure (such as water collection and marketing), governmental policies (especially to provide adequate road access and resources to organic farmers and marketers), public awareness (through media, schools, and at markets), partner with grassroots organizations
2. Contamination in the field can be from pesticide drift from neighboring land, or from a mistake of a farmer who isn't aware of the regulations. Solutions include on-site monitoring and farmer awareness and education
3. Counterfeiting is false claims made at the marketplace. This can be due to lack of farmer understanding, from a blatant lie about the production of the organic food, or from poor communication during shipping. These issues can be overcome with food testing, certification standards (whether local or otherwise) or from trust between the farmer and consumer
4. Co-mingling (organic food being in contact with conventionally produced items) is not acceptable for most organic standards. Solutions include clear transportation and marketing standards as well as promoting farmer/transporter/marketer awareness
5. There is an overall lack of public awareness about organic agriculture. Public awareness can be raised through local media outlets and educational programs in schools and communities
6. Labor issues and work ethic are Governmental programs, clear incentives, training
7. Organic agriculture resources in extension, research and training are inadequate. To solve this, the authors recommend partnerships with research institutions, farmer field schools, expansion of governmental courses, distribution of information through markets
8. Lack of organic inputs can be solved with locally produced compost, natural pesticides, insecticides, fungicides, and local seed-saving
9. Land tenure issues can effectively be addressed with governmental policies and land trusts
10. Skepticism about organic farming is widespread, as many farmers in Trinidad and Tobago don't believe agriculture is viable without chemical use. This can be overcome with public demonstration farms as well as outreach and demonstration through various media (radio, internet, television, billboards) and schools
11. Access to credit and funding (loans and grants) creates a huge obstacle for organic farmers. This can be addressed with governmental policies, tax breaks, partner with local and international institutions

12. Certification issues mentioned above include the extremely high cost of certification for local producers. The authors recommend separate local certification options for domestic organic food (the word "organic" could be replaced), and organic certification for the foods destined for exportation
13. To address the lack of markets, the government and farmers could partner with existing markets and create specific organic markets
14. Praedial larceny, or agricultural theft, is becoming a huge problem that can be devastating to farmers. The authors propose more farmstead labor (living on the farm), better policing, and clear disincentives for criminals
15. Lack of young farmers is the biggest problem for the future of the organic movement in Trinidad and Tobago. To address this, the authors recommend more educational and governmental programs, outreach through schools including school gardens and mandatory agricultural education, clear incentives and appropriate demonstration

Future recommendations

Future recommendations for growth of the organic agriculture sector include coupling grassroots actions with formal policy measures. With a focus on public awareness and education, research and demonstration, policy intervention, and incentive creation, Trinidad and Tobago could move towards greater food security via local organic food production.

A number of problematic issues arose during this research that could be better explored in future investigations. In particular, most of the actors in this research who engaged in organic agriculture were financially secure from other funds or income sources. None of them were making their living 100% on organic agriculture. This poses a question of the viability of the sector, or how the farmers must engage in many activities to create viability. Furthermore, the consumers who regularly purchased organic food at the store in Port of Spain were generally mid-upper class Trinidadians, ex-patriots from America or Europe, and/or people with deep health/environmental/spiritual beliefs that guide their lifestyle and food choices. What implications does this have for the future of organic agriculture? How can the organic movement include people from lower economic backgrounds in the consumption and production end of farming? More research on these complex issues within organic farming in Trinidad and Tobago would contribute to the regional and global body of sustainable agriculture literature, but more importantly would support this important local movement in an increasingly globalized world.

REFERENCES

CABI (2004) *Discovery Learning Manual for Pest Management in the Caribbean – cabbage and tomato*. European Union. Caribbean Agriculture and Fisheries Programme.

CABI (2007) Organic Farming: An International History. W. Lockeretz. Oxfordshire, UK.

Dolly, David (2007) *Agriculture Gender and Trends in Rural Labour in Caribbean Economies: Changing Patterns*. University of the West Indies.

Government of the Republic of Trinidad and Tobago (2006) *Draft Sector Policy for Organic Agriculture 2002-2006*. National Committee for Policy Formulation for Organic Agriculture.

IFOAM (2008). The World of Organic Agriculture: Statistics and Emerging Trends 2008. Edited by Helga Willer.

IFOAM (2005). "The Principles of Organic Agriculture." Retrieved 11-11-2006, 2006, from http://www.ifoam.org/

IICA (2005) *Organic agriculture in Trinidad and Tobago: Prospects and opportunities*. Pilar Emilio Ramirez, Joseph Peltier.

Lang, Tim, Michael Heasman (2004). *Food Wars: The Global Battle for Mouths, Minds and Markets.* Sterling, VA, Earthscan.

Ministry of Agriculture, Land and Marine Resources (1995-1997). Food and Agriculture Policy, Republic of Trinidad and Tobago.

Ministry of Food Production and Marine Resources (January 2001). "Sector Policy for Food Production and the Marine Resources, Agricultural Sector Policy, 2001-2005."

Raynolds, Laura T. (2000) "Re-embedding global agriculture: The international organic and fair trade movements." *Agriculture and Human Values* (17) 297-309.

Raynolds, Laura T. (2004). "The Globalization of Organic Agro-Food Networks." *World Development* **32**(5): 725-743.

Republic of Trinidad and Tobago, Ministry of Food Production and Marine Exploitation (1991) *Basic Agricultural Studies First Stage Report – Diagnosis*. TAHAL Consulting Engineers Ltd, AGROCON Ltd.

Specialists from the University of the West Indies in collaboration with the Ministry of Agriculture, Land and Marine Resources (2004) *Strategic Intervention for the Ministry of Agriculture, Land and Marine Resources*.

Tovar, Laura et al (2005). "Certified organic agriculture in Mexico: Market connections and certification practices in large and small producers." *Journal of Rural Studies* **21**: 461-474.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):304-312. 2008

An Evaluation of Factors Influencing Successful Grafting of Breadfruit on Chataigne Rootstock.

F. Solomon Jr. and L. B. Roberts-Nkrumah, Food Production Department, Faculty of Science and Agriculture, University of the West Indies, St. Augustine Campus, Trinidad and Tobago WI

ABSTRACT.

The potential for expanding the availability of breadfruit (*Artocarpus altilis*) as a food source in the Caribbean by establishment of commercial orchards is limited by its being vegetatively propagated. One of the disadvantages of this propagation method is a shallow rooting system, which results in limited distribution of the tree mainly to wetter regions, susceptibility to root-inhabiting diseases and proneness to hurricane damage. Chataigne (*A. camansi*), a close seed producing relative, produces a tap root and exhibits these disadvantages to a lesser extent. Therefore, grafting breadfruit on chataigne can potentially benefit commercial establishment. Poor success in grafting these species has been reported. This experiment aimed to evaluate the effect of grafting techniques, scion cultivars and ages of rootstock on grafting success. Grafting techniques were top wedge, side, and whip and tongue; the scions were the 'Yellow' and 'White' breadfruit cultivars and chataigne and ages of chataigne rootstocks were 47, 67and 130 days old. A three-factor, factorial arrangement in a complete random design was used with 10 plants per treatment. Data were collected on the condition and length of survival of grafted scions and analysed using ANOVA, General Linear Model. Variety was the only factor with significant ($p < 0.001$) effect on success of grafting. Six weeks after grafting, there was 71% survival of grafts of chataigne scion grafted on chataigne rootstock, compared with 28% of 'Local Yellow' scion and 18% of 'Local White' breadfruit. The results suggest a genetic influence and a possible physiological effect on the success of grafting.

KEYWORDS: *Artocarpus altilis, Artocarpus camansi*, rootstock age, grafting technique, variety

INTRODUCTION

For commercial establishment of seedless breadfruit focus has to be placed on a propagation method for successfully producing a large number of plants. Ragone (1991) reported that the seedless types are sterile because of triploidy and that fruit development is due to parthenocarpy, therefore, the seedless breadfruit can only be propagated vegetatively. There are several reports on vegetative propagation of the seedless breadfruit (Galang and Elayda 1924; Padolina 1931; Narasinga 1957; Rowe-Dutton 1976; Roberts-Nkrumah 1993; Rouse-Miller and Duncan 1999; Nandwani and Kuniyuki 2005; Murch et al 2007). Propagation methods include stem cuttings, root cuttings with suckers, excised adventitious shoots cuttings, grafting, air layering and most recently micropropagation.

Propagation by root cuttings with or without suckers present major disadvantages with respect to large scale commercial production of planting material due to limited

availability of root pieces. Additionally, frequent removal of roots damage trees and the exposed cut surfaces create entry points for pathogens (Narasinga 1957; Rowe-Dutton 1976; Roberts-Nkrumah 1993). There has been very limited successful propagation of stem cuttings (Hamilton et al, 1983). In the Bahamas, Russell (1953) reported that attempts to propagate breadfruit on a large scale by air layering, using a covering of air-wrap, did not prove very successful. Additionally, in India Narasinga (1957) reported that air layering of aerial shoots has not been successful, even with the aid of root-inducing hormones and plastic films. Padolina (1931) reported that there is greater difficulty in rooting branches of old breadfruit trees than young seedlings. Apparently, due to the upright growth habit of the breadfruit tree it would be difficult to find many branches suitable for air-layering. However, early reports from India indicated that air-layering root suckers have been used quite successfully on a commercial scale (Rowe – Dutton 1976).

Grafting is one vegetative method of propagation that minimises the problem of damage to parent trees. Galang and Elayda (1924) reported successfully approach grafted breadfruit onto jackfruit, *A. heterophyllus, A. elastica* and chataigne, but gave no details. Similarly, Padolina (1931) briefly stated that breadfruit was inarched successfully on chataigne. Thomas (1969) reported young shoots of breadfruit being grafted on wild jackfruit, also gave no further details. Medagoda and Chandrarathna (2007) grafted breadfruit onto chataigne rootstock with 83% success. They however, did not highlight some factors that may influence the outcome of a successful graft union. These include varieties used, type of scion wood and the location on the parent plant which they were collected.

Grafting of the seedless breadfruit has a limitation with respect to choice of rootstock. Because the production of root stock from these breadfruit types relies on vegetative propagation, the methods discussed previously that are not suitable for large scale production. The seeded breadfruit types produce seeds that are short-lived and very highly variable due to cross fertilization but the seedlings grow quickly (Narasinga 1957; Ragone 1997). These types are not available in the Caribbean, and would not be considered as rootstock at present with respect to commercial establishment.

However, chataigne or breadnut which is seeded is a parent of the breadfruit (Zerega et al 2004) and may have greater potential as a rootstock for breadfruit, than both seeded and seedless breadfruit. The authors have observed that fresh mature chataigne seeds germinate quickly and have high germination rates. Due to its taproot system, chataigne is better adapted to drier regions than breadfruit, which because of vegetative propagation, has a shallow rooting system.

The factors associated with successful grafting of breadfruit require evaluation. The objective of this study was to evaluate the effect of age of rootstock, grafting technique and breadfruit variety of the scion on successful grafting of breadfruit on chataigne rootstock.

MATERIALS AND METHODS

The study was conducted at the University Field Station (UFS) of the University of the West Indies St. Augustine Campus, Trinidad from August 13 2005 to February 23, 2006.The experiment consisted of three factors - age of rootstock, grafting technique and

scion variety, each with three levels, arranged in a completely random design. There were 10 plants for each of the treatment combinations.

The methods used to generate scion material included manipulation of lower branches, propagation of stem cuttings, heavy pruning of donor plants and shoots of young seedling plants.

(i) Manipulation of branches - Six weeks prior to grafting, the distal end of lower branches of approximately three trees each of 'Yellow' and 'White' breadfruit cultivars and chataigne from the UFS *Artocarpus* germplasm collection were manipulated by bending to approximately 30 - 60 cm from the ground level with the use of stakes and twine. Horizontal cuts 15 cm apart were placed along the upper part of these branches from the proximal to the distal end.

(ii) Stem cuttings approximately 30 – 38 cm long, and 3 – 6 cm in diameter were cut from chataigne branches, dipped in Benlate solution (2.5g/L), and then placed to a depth of 1½ - 2 cm in propagation bins containing sharp sand. (iii)Terminal shoot cuttings of young chataigne seedling plants were taken from seedlings that were not required for use as rootstocks.

(ii) Epicormic shoots that emerged after pruning trees in the Crop Museum of the UFS consisting only of 'Yellow' breadfruit were used as scion material for the 9 week old rootstock.

Because suitable scion material for breadfruit cultivars was inadequate, 'Yellow' scion was grafted only on 7 and 9 week old rootstock, and 'White' scion only on 7 and 18 week old rootstock.

Two days prior to the grafting the leaf blades of the potential scion shoots were cut in half. Scion materials ranged from 9 - 12 cm in length and were matched as closely as possible to the diameters of respective rootstocks. Chataigne seeds with approximately 0.5 cm of the embryo emerging were selected from freshly harvested ripe fruits and soaked in Mankocide solution (7g/L) for 5 to 7 minutes. The seeds had an average weight, length and width of 7.7g, 3 cm and 2 cm, respectively. One seed per potting bag (10 cm L x 15 cm W x 25 cm D) was planted to a depth of 2.5 cm into a 3:2:1 mixture of soil, decomposed cow manure and sharp sand, respectively. On August 13, 2005 chataigne seeds for the 13 wk old rootstocks were planted. The seeds for the 7 wk and 9 wk old rootstocks were planted on November 3, 2005. The grafting of the 7 wk and 9 wk old rootstocks was done on December 20, 2005 and January 10, 2006, respectively while the 13 wk old rootstocks were grafted on December 21, 2005. The average diameters of the 7 wk, 9 wk and 13 wk old chataigne rootstocks at time of grafting were 0.72 cm, 0.89 cm and 1.45 cm respectively.

Three grafting techniques were used at approximately 30 cm from the base of the rootstock stem. (i) Whip and tongue - the length of the cut ranged from 2.5 to 4 cm due to the variability in diameter of the rootstocks. The cut end of the scion was cut to match with the cut on the rootstock. (ii) Side graft - a straight, downward cut was made at 30 º angle on the rootstock. (iii) The top wedge graft - the top of the chataigne rootstock was cut off at an internode using a grafting knife a horizontal cut. Then a vertical cut 2.5 to 4.5 cm long was made downwards at the top cut. The base of the scion was cut to a wedge-shape using an angled cut on the two opposite sides. This ensured that the cambium of the scion would line up with the cambial surface of the rootstock. All grafts were tied with plastic strips and the entire plant covered with a plastic bag. The plants

grafted on the 9 wk old rootstock were observed for six weeks and those on the 7 wk and 18 wk old rootstock, were observed for 10 weeks. The condition of all graft unions was scored subjectively over a six and ten week period. The score ranged from 0 – 5 representing - death (0), >90% necrosis (1), 70 - 90% necrosis (2), 40-69% necrosis (3), < 40% necrosis (4) and healthy (5) receptively. Length of survival in weeks of the grafted scions was recorded and statistically analysed using ANOVA, general linear model. The statistical program, Minitab 15 was used to analyse this data.

RESULTS

Scion material production

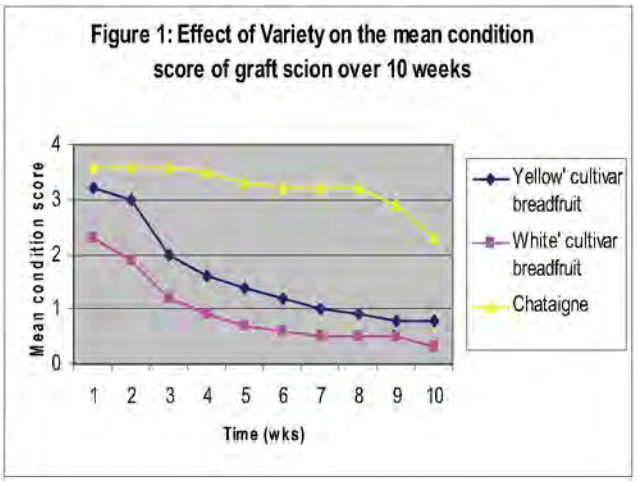
Breadfruit and Chataigne trees were in the reproductive phase when the branches were manipulated, when stem cuttings were taken and when the trees were pruned. On the branches of the 'Yellow' and 'White' breadfruit cultivars that were tied downwards, approximately 5 to 8 epicormic buds /branch were released. These buds were used as scion materials for grafting 7 and 18 week old rootstock, with the exception of 'Yellow,' which produced many shoots at the proximal end of the branches with diameters that were too large for grafting (Plate 1). As a result, 18 week old rootstock was not grafted with scion from this variety. Pruned 'Yellow' trees produced in excess of 50 epicormic buds/tree which provided scion material for grafting 9 week old rootstocks. Chataigne branches that were tied downwards released only 2 to 4 epicormic buds/branch which was insufficient for use as scion in this experiment. Attempts to produce epicormic buds on chataigne stem cuttings failed since the cuttings either decayed or failed to produce new buds.

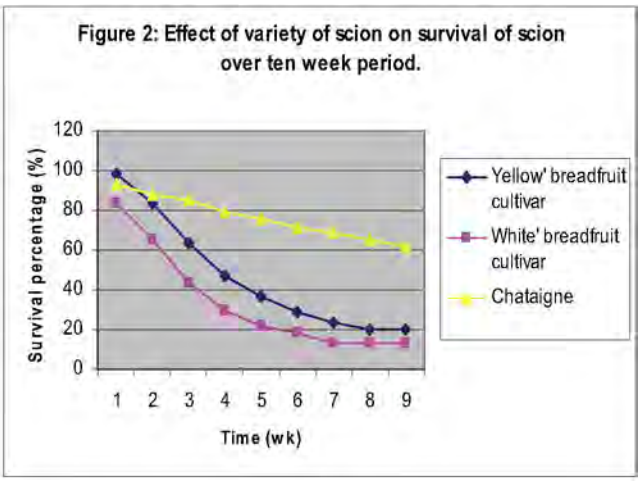
Plate 1: Epicormic shoot emergence on lower branches as a result of branches bending. (a) newly emerging shoots (b) shoot used as scion material. Note size difference.

Survival of grafted plants

Effect of variety:

Plants grafted with the chataigne scion appeared to maintain the best condition, up to Week 8 but declined thereafter. Those grafted with 'Yellow' scion were of intermediate condition and declined noticeably until week 4, after which, the condition score fell to 1 (Fig. 1). At the end of six weeks the survival rate of grafted chataigne scion

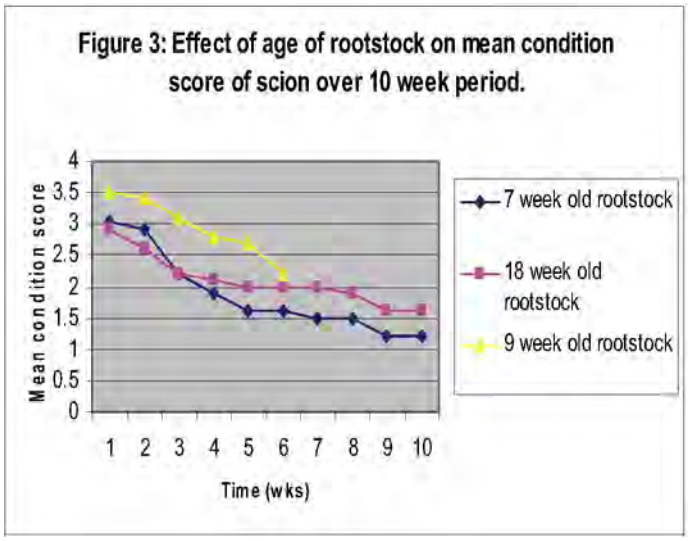


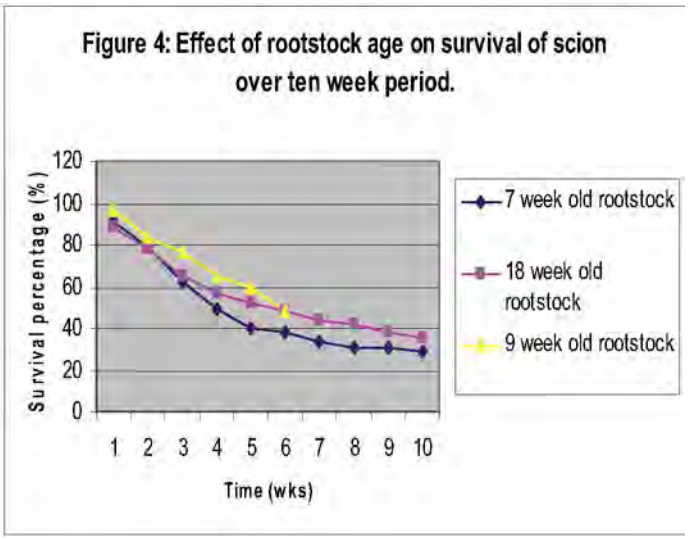


was 71% compared with 28% for 'Yellow' and 18% for 'White' breadfruit cultivar scions grafted on chataigne rootstock (Fig. 2). At six weeks after grafting, the variety of the scion significantly ($p < 0.001$) affected the length of survival of grafted scion. There was no significant interaction observed among factors. Although scions died, the rootstocks survived and showed regrowth.

Effect of rootstock age:

Plants grafted on 9 wk old rootstock appeared to maintain the best condition, followed by those on the 18 wk old rootstock over the first six weeks after grafting (Fig. 3). The condition of the plants declined over time regardless of rootstock age, but the rate





of decline slowed from week 5 for those plants grafted on 7 and 18 wk old rootstocks. At the end of week 6, the survival rate of graft unions on the 9 and 18 wk old root stock was 48%, while it was 39% on the 7 week old rootstock. At the end of week ten, the survival rate on the 7 and 18 week old rootstock was 29% and 35% respectively, indicating a steady decline over the experimental period (Fig. 4). Age of rootstock, did not have any significant effect on survival of the grafted unions (Table 1).

Effect of grafting technique:

With respect to the effect of the grafting technique on the condition of the grafted scion, the plants with the side graft appeared to maintain a better condition than those grafted by other techniques (Fig. 5). The survival percentage of grafted scions showed a steady decline over the period with all grafting techniques (Fig. 6). Grafted scion with top wedge and whip and tongue grafting technique accounted for 31% and 35% respectively at six weeks. The grafting technique did not affect the survival of grafted scion at six weeks after grafting (Table 2).

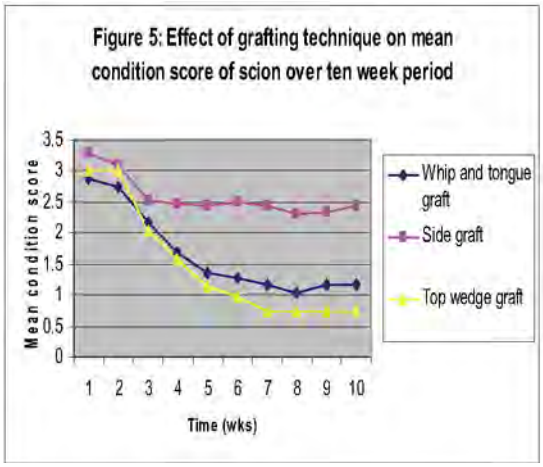
Table 4: Effect of variety of the scion on the length of survival of grafted scions on rootstock of different ages.

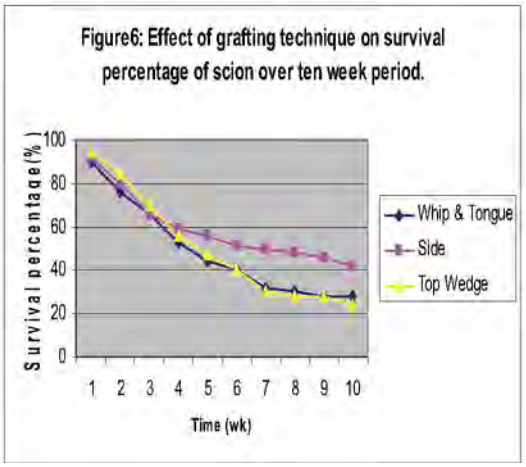
ROOTSTOCK AGE (WEEKS)	LENGTH OF SURVIVAL (WK)			ROOTSTOCK AGE (MEANS) (P = NS)
	Variety of scion			
	'Yellow' breadfruit	'White' breadfruit	Chataigne	
7	3.3	2.7	4.8	3.6
9	3.9	-	4.7	4.3
18	-	2.6	5.2	3.9
Variety Mean ($p < 0.001$)	3.6b	2.65c	4.9a	

Average LSD value for the variety of scions is = 0.92 NS: Not significant.

Table 5: Effect of grafting technique on the length of survival of grafted scions on rootstocks of different ages.

Rootstock Age	Length of survival (wk)			Rootstock Means
	Grafting Technique			
	Whip and Tongue	Side	Top wedge	
7 wk	3.40	4.10	3.30	3.56
9 wk	4.05	4.25	4.60	4.3
18 wk	3.75	3.70	4.22	3.89
Grafting technique means (p = NS)	3.7	4.02	4.04	





DISCUSSION

Scion material availability is a key consideration in the grafting of breadfruit and chataigne. Pruning the donor tree produced the most scion material due to the emergence of epicormic shoots because apical dominance was removed. However, bending the lower branches to disrupt the basipetal movement of auxins responsible for apical dominance generated the required quantities of scion material from breadfruit varieties but the materials were not of uniform size, especially, in 'Yellow'. The dormant buds at the proximal end of the bent branches, emerged, grew and became woody faster due to less apical dominance exerted on these buds than on those at the distal end. This made selection of scion material difficult as the large, woody shoots produced closer to the proximal were unsuitable for grafting. Chataigne branches were less responsive to bending as a means of forcing emergence of epicormic shoots and there was no success with stem cuttings. This poor response may be a result of the trees being in a reproductive state between late August and early November. The overall result was that breadfruit scion materials of varying size and hardness from mature branches were grafted on to the chataigne rootstocks. After branch manipulation and stem cuttings failed to produce sufficient chataigne scion, the material for grafting on chataigne rootstock material was then sourced from seedlings and was very juvenile in comparison with the breadfruit scion material.

Variety significantly affected the survival of the grafted scions. Although breadfruit is closely related to chataigne (Zerega et al 2004), the 'Yellow' and 'White' breadfruit scion material did not do as well as the chataigne scion on chataigne rootstock. While this may be partly the result of differences in the genetic make up of both species, other factors may be responsible. Since scion materials were not uniform, the size of the scion and rootstock might not have been properly matched. The scion materials used for both breadfruit cultivars were mature, which might also have contributed to the poor success of their graft unions.

The chataigne scion materials grafted onto chataigne rootstock achieved the highest length of survival period among variety of scion material on chataigne rootstock. These chataigne scions were genetically more similar and closer in size and age to their respective rootstock. Additionally, these scions were of juvenile material with very active cambium. All these factors might have contributed to the high success rate reported for the chataigne scion on chataigne rootstock. Given these factors, an even higher percentage of success was expected than was obtained in this study and there may be a need to improve execution of the grafting procedures. Nandwani and Kuniyuki (2005) reported 80% success grafting various cultivars of breadfruit together. Since the species of the scion and rootstock were identical, there may be in fact a genetic influence on grafting success with breadfruit. Additionally, they reported that the scion materials used were juvenile, which suggests that juvenility of the scion might be required for successful grafting of breadfruit. However, Medagoda and Chandrarathna (2007) reported a 83% success rate when grafting mature breadfruit scion material onto chataigne rootstock.

There was no significant effect of rootstock age on the length of survival of grafted scions in this study. Medagoda and Chandrarathna (2007) reported that 45 day old rootstocks performed better than younger and older rootstock and attributed the differences to the relative hardness of the rootstock stems. 30 day old rootstocks were too soft while, 60 day old rootstocks were too hard. Nandwani and Kuniyuki (2005) achieved

success on one year old plantlets that they used as rootstocks. These successes on varying rootstock age may suggest that rootstock age may not be a contributing factor to successful grafting.

Grafting technique did not have any significance with this experiment. Medagoda and Chandrarathna (2007) reported using only wedge grafting. On the other hand, Nandwani and Kuniyuki (2005) used approach grafting and side grafting and found that the former was much more successful (80%) than the latter (20%), which confirms earlier reports of successful grafting of breadfruit . Successful results were also obtained when breadfruit was inarched to chataigne (Padolina, 1931) an approach grafted to jackfruit, chataigne and *A. elastica* (Galang and Elayda 1924). This suggests that grafting of breadfruit may require that the scion remains attached to its parent as is the case in approach grafting and inarching.

CONCLUSIONS

The study emphasizes a critical need for a method of generating adequate scion material of uniform size to facilitate a commercial scale. Additionally, it emphasizes the need for generation of standardised and uniform scion material to match respective rootstock diameter and need for longer term evaluation of unions. While genetic compatibility may play a role in the success of the graft union between breadfruit and chataigne, other important factors may include the hardness of the scion wood and the physiological state of the parent plant. While age of the of the chataigne rootstock may not be critical for successful grafting of breadfruit, grafting technique needs to be evaluated further, especially methods in which the scion remains attached to a parent source, example, approach grafting.

REFERENCES

Galang, F.G. and Elayda, A.R, .1924. Experiments on vegetative propagation of tropical fruit at Lamao Experimental station, Lamo, Bataan. Philippians agriculture Review 17: 203-205.

Hamilton, R. A., Criley R. A., and Cia, C.L. 1983. Rooting of stem cuttings of breadfruit under intermittent mist. Combined Proceedings of the International Plant Propagators Society. 32, 347 – 350.

Hartmann, H.T., D.E. Kester and F.T. Davies, Jr. 2002. Plant Propagation: Principles and Practices. Seventh edition. Prentice-Hall, Englewood Cliffs: NJ.

Murch, S., J., Ragone, D., W., Lei Shi, A., R., Alan and P., K., Saxena. 2007. In vitro conservation and sustained production of breadfruit: modern technologies for a traditional crop. Naturwissenschaften: 95: 99-107.

Nandwani, D., and A.H. Kuniyuki. 2005. Grafting and improvement of breadfruit production in Micronesia. Acta Hort. (ISHS) 694: 307-310.

Narasinga U.R. 1957. The Breadfruit in India (Farm bulletin). New Delhi: Indian Council of Agricultural Research.

Padolina, F. 1931. Vegetative propagation experiments and seed germination. Philippians Journal of Agriculture 2: 347-355

Ragone, D. 1997. Breadfruit. Artocarpus altilis (Parkinson) Fosberg. Institute of Plant Genetics and Crop Plant Research, Gatersleben/International Plant Genetic Resources Institute, Rome, Italy

Roberts-Nkrumah, L.B. 1993. Breadfruit in the Caribbean: a bicentennial review. Extension Newsletter Dept. of Agric., University of the West Indies (Trinidad and Tobago) 24(2):1-3.

Rouse-Miller, J and Duncan, E., J. 1999. In-vitro propagation of Artocarpus altils (Park) (Breadfruit) from mature plant material. In-vitro Cell development- Plant: (36) 115-117.

Rowe-Dutton, P. 1976. Breadfruit. In: (Eds. R.J. Garner and S.A. Chandri). The Propagation of Tropical Fruit Trees. Horticultural Review No. 4. Commonwealth Agriculture Bureau, Pt. 2, 248-266.

Thomas, C. A. 1969. You can grow breadfruit in your garden. Indian Hort., 50: 83.

Zerega, N., Ragone, D., and Motley, T. 2004. Complex origin of breadfruit (Artocarpus altilis, Moraceae): Implication for human Migration. Amercian Journal of Botany. 9(5): 760 – 766.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):313-316. 2008

Analysis of External Coloration of the Low-Chill Peach 'Tropicbeauty' Grown in Puerto Rico.

María C. Padilla-Páez and J. Pablo Morales-Payan, Department of Horticulture, College of Agricultural Sciences. University of Puerto Rico, Mayagüez Campus. P.O. Box 9030, P.R. 00681-9030. Morales.payan@upr.edu, josepablomorales@yahoo.com

ABSTRACT.
Research was conducted in 2007 and 2008 to assess the external coloration components in fruits of the low–chill peach [*Prunus persica* (L.) Batsch] 'Tropicbeauty' grown in Adjuntas, Puerto Rico. Fruits were harvested at three apparent maturity stages (AMS) (50, 70, and 90% change in ground color) and external (peel) color was determined shortly after harvesting (fruits kept at 20°C) or after storage at 0°C for two weeks followed by ripening at 20°C. Peel color was determined with a Hunter Lab-MiniScan XE spectrocolorimeter calibrated with white and black standards (X=79.8, Y=84.6, Z=90.4) in the L* a* b* uniform color space, assessing values for L* (lightness of the color), a* (green to red), b* (blue to yellow), Chroma (color saturation or intensity), and hue (red, yellow, green, blue, purple, or intermediate colors between adjacent pairs of the basic colors). Chroma values increased as AMS was higher, whereas Hue values tended to decrease as AMS increased. L* values increased slightly as AMS was higher and after storage.

KEYWORDS: Fruit crops; low-chill requirement; post-harvest color.

INTRODUCTION

Fruit crops are an important crop group in Puerto Rico, worth $48.6 million in 2005 (Mejia, 2006). In many countries, peach [*Prunus persica* (L.) is a traditional and well established fruit crop; worldwide, peach was commercially grown in approximately 1.45 million hectares in 2006, with a global production of 17.2 million tons that year (FAO, 2008). In contrast, in Puerto Rico, peach is a relatively recent introduction. Peach varieties with low chill requirement developed by the University of Florida (Andersen et al., 2001) were introduced in Puerto Rico in January 2002, to assess their performance in the highlands of Adjuntas and Corozal, as a potential alternative for highland growers willing to diversify from more traditional crops such as citrus (*Citrus* spp.) and coffee (*Coffea* spp.).

So far, flowering and yield of low-chill peaches under normal conditions in Corozal (at 190 meters above sea level) has not been satisfactory. However, when grown with a relatively low input management in Adjuntas (at 594 meters above sea level), the low-chill peach varieties Tropicbeauty, Flordaglo, and Flordaprince have flowered and set fruits of adequate size and quality (Librán et al., 2006).

For commercial orchards, peach fruits for the fresh market should be harvested at an early stage in the fruit development process that allows the fruit to escape (or have significantly lower) damage by birds and fruit flies (*Anastrepha* spp.), provides a long

transit and shelf life, and when fully ripe still attains good quality at the consumer level. It is still unknown which is the earliest adequate maturity stage to harvest low-chill peaches grown in Puerto Rico. One of the easiest harvest indicators available to growers is the change in fruit peel color, usually from green (ground color) to yellow or orange. The objective of this research was to assess the external coloration components in fruits of the low–chill peach 'Tropicbeauty' grown in Adjuntas as a factor in the relationship between apparent maturity stages (as ascertained by peel color) and fruit quality after short-term postharvest time and after cold storage of fruits.

MATERIALS AND METHODS

'Tropicbeauty' fruits were harvested in 2007 from orchards at the Research Substation of the University of Puerto Rico-Mayaguez located in Adjuntas, Puerto Rico. Fruits deemed marketable as fresh fruit (adequate size and blemish-free) were collected at three apparent maturity stages (AMS) based on external (peel) ground coloration: 90% ground color change (= 10% of the peel was still green), 70% ground color change (= 30% of the peel was still green), and 50 % ground color change (= 50% of the peel was still green).

Color was analyzed with a HunterLab - MiniScan XE spectrocolorimeter (Hunter Associate Laboratory, Inc., Reston, Virginia, USA) calibrated with white and black standards (X=79.8, Y=84.6, Z=90.4) in the L* a* b* uniform color space, assessing values for L* (lightness of the color, where black =0 and white =100), a* (green to red), b* (blue to yellow), Chroma (color saturation or intensity), and hue (red, yellow, green, blue, purple, or intermediate colors between adjacent pairs of the basic colors). L*, a*, and b* were measured on the fruit cheeks. Chroma (C*) and Hue (H*) were derived from the resulting data with the statistical software SAS. The results were submitted to analysis of variance and separation of means with the Tukey test at the 5% level (SAS). Peel color was analyzed the same day the fruits were harvested and then again 5 days after harvest having kept the fruit at 20ºC (no cold storage) or having placed the fruit in cold storage (14 days at 0ºC) followed and then allowing 5 days at 20ºC. Results were expressed as values of L*, C*, and H* (McGuire, 1992).

RESULTS AND DISCUSSION

L* values determined 5 days after harvest (stored 20°C) or 19 days after harvest (stored at 0°C for 2 weeks and then at 20°C for 5 additional days) tended to be slightly higher than L* values taken at harvest (Tables 1 and 2). Cold storage had little additional effect on L* values (Table 2). In fruits harvested at the 90% AMS and then kept at 20°C for 5 days, L* values tended to decline after harvest, which was associated with fruit deterioration due to pathogens, injury, and/or excessive ripening (Kader, 2002; Lurie and Crisosto, 2005).

Chroma values tended to be higher as fruits were harvested at more mature stages (Table 1), and increased between 10 and 14% when fruits were kept for 5 days at 20°C. After cold storage followed by ripening at 20°C, fruit peel chroma values were 16-19% higher than right-after-harvest values (Table 2).

Hue values also tended to be higher (more in the green-yellow range) as AMS was lower. When fruits were harvested at the 90% AMS, hue values were closer to those indicative of the reddish-yellowish range, with H* values approximating 64 (Table 1).

Regardless of the AMS at fruit removal from the trees, hue values decreased after harvest. However, there was a tendency of lower hue reduction as fruits were harvested in more mature stages, with 11, 9, and 5% reductions in hue values for fruits harvested at 50, 70, and 90% AMS, respectively, for fruits kept at 20°C for 5 days without cold storage (Table 1), as well as 14, 11, and 7% reductions in hue values for fruits harvested at the 50, 70, and 90% AMS, kept in cold storage and then ripened at 20°C (Table 2).

'Tropicbeauty' is a low-chill peach variety with good yield performance in the highlands of a tropical island such as Puerto Rico. Our findings helped establish values for the peel color components of 'Tropicbeauty' harvested at three AMS based on peel coloration and their changes in postharvest in two different storage regimes. Having quantified L*, H*, and C* values, we aim at determining possible correlations between peel coloration components and fruit quality that may be useful to better determine adequate harvesting time for low-chill peaches in Puerto Rico and similar locations, as has been done with other fruits (Berger & Galleti, 2005).

ACKNOWLEDGEMENTS

This research was funded by the T-STAR Program, and it is part of the University of Puerto Rico-Mayagüez Campus Research Project ZTS-34.

REFERENCES

Andersen, P. C., W. B. Sherman, and J. G. Williamson. 2001. Low Chill Peach and Nectarine Cultivars from the University of Florida Breeding Program: 50 Years of Progress. Proc. Fla. State Hort. Soc. 114: 33-36

FAO (Food and Agriculture Organization of the United Nations). 2008. http://faostat.fao.org/site/567/default.aspx. Last accessed August 31, 2008.

Kader, A. A. 2002. Postharvest Biology and Technology. In: A. Kader (ed.) Postharvest Technology of Horticultural Crops. Pages 39-48. University of California, Oakland.

Gerber, H. and L. Galleti. 2005. Color as a harvest index for cherimoya. Acta Horticulturae 682:1471-1474.

Librán, C., R. Rouse. E. Hernández, and L. Cardona. 2005. Melocotones Tropicalizados (Prunus persica L.): Cultivo Alterno Para la Zona Montañosa de Puerto Rico. ISTH. Resumen Oral # 41.

Lurie, S. and C. H. Crisosto. 2005. Chilling Injury in Peach and Nectarine. Postharvest Biology and Technology. 37. p 195 – 208.

McGuire, R. G. 1992. Reporting of Objective Color Measurements. HortScience 27:1254-1255.

Mejía, L. R. 2006. La Empresa de Producción de Frutas. Informe Anual de la Empresa de Frutales. Estación Experimental Agrícola. Universidad de Puerto Rico. 6 pages. http://estacion.cca.uprm.edu/formularios/EmpFrutales/FRUTAS-Mejia.pdf. Accessed August 30, 2008.

Table 1. Influence of apparent maturity stage (based on percentage of ground color change) of 'Tropicbeauty' peach on lightness, chroma y hue values at harvest and in fruit kept at 20°C for 5 days after harvest.

Apparent maturity stage at harvest	Time of evaluation	L* (Lightness)	C* (Chroma)	H* (Hue)
50%	At harvest	63.1	42.4	78.4
50%	After storage	65.4	48.1	70.4
70%	At harvest	64.3	45.1	71.5
70%	After storage	66.2	50.2	66.3
90%	At harvest	65.0	46.3	65.2
90%	After storage	64.5	51.0	62.2

Table 2. Influence of apparent maturity stage (based on percentage of ground color change) of 'Tropicbeauty' peach on lightness, chroma y hue values at harvest and in fruit kept at 0°C for 14 days followed by 5 days at 20°C.

Apparent maturity stage at harvest	Time of evaluation	L* (Lightness)	C* (Chroma)	H* (Hue)
50%	At harvest	66.3	45.0	79.8
50%	After storage at 0°C followed by 5 days at 20°C	70.3	46.9	78.5
50%	After storage at 0°C	71.1	55.3	69.5
70%	At harvest	65.9	46.1	72.3
70%	After storage at 0°C	68.1	48.3	69.6
70%	After storage at 0°C followed by 5 days at 20°C	68.7	56.5	64.7
90%	At harvest	63.6	46.5	65.2
90%	After storage at 0°C	67.1	49.0	64.7
90%	After storage at 0°C followed by 5 days at 20°C	66.3	54.6	63.5

2008 Proceedings of the Caribbean Food Crops Society. 44(2):317-332. 2008

Microbial Population in Guyana Soils.

Subramanian Gomathinayagam, Lecture-II, Faculty of agriculture and forestry, University of Guyana,_Berbice Campus, Johns, Guyana, South America, Phone No; +592 337 1415, 1416, 6103345 (mobile), Fax No: +592 337 2280, Email Id:goms70@yahoo.com

ABSTRACT.

Microorganisms are fundamentally important in the soil habitat. They key roles in the ecosystem by controlling nutrient cycling reactions essential for maintaining soil fertility. Microbes are also active in nitrogen transformation during the cold winter season. Soil structure depends on the association between mineral partials (sand, slit, and clay) and organic matter. Although the chemistry of organic matter, total microbial biomass, and different enzymes activities in different soil size fractions have been well studied, little information is available on the structure of microbial population in microhabitats. All natural soils contain vast populations of microscopic plants and animals present in a state of dynamic equilibrium and changing balances. It has been estimated that within the top one to three feet of soil as much as 17000 pounds fungi and 40 pounds bacterial exist per acre. All soil microorganisms compete with each other for food and space. Any changes in environmental conditions such as food supply, temperature, moisture, oxygen supply etc., can result in changes which cause one or many types of soil microbes to become temporarily dominant over the others. The majority of fungi and bacteria present in soils are considered to be beneficial to higher plants. Mineral soil represents a complex of inert and living organisms. By maintaining good organic matter content in mineral soils an increased population's level of beneficial soil microorganism can be maintained. These non-pathogenic fungi and bacteria help promote well developed healthy root systems, by releasing essential elements and suppressing disease causing microorganisms. Preliminary work in this study has been done, pertaining to screening of soil microorganism such as bacteria, fungi and actinomycetes from soil in Guyana within Berbice. Additionally, calculations were done on the number of colonies of bacteria, fungi and actinomycetes in different soils.

KEYWORDS: Nutrient cycling, dynamic equilibrium, population density

INTRODUCTION

Scientists define soil and water microorganisms as organisms in the soil and water which can not be observed by naked eyes required a microscope to observe [1]. These organisms permeate soil, water and air of our planet and Guyana is no exception.

The biodiversity of these organisms is not evenly distributed, thus enumeration and identification serve as a measurement to indicate the health of the ecosystem. Two of the major groups of mineral indicators are the Bacteria and the Fungi. They existed

billions of years before plants and animals and continue to be the most abundant form of life on earth; as such they play an important role in the sustainability of life on earth [1].

Land management practices can alter the number of functional groups in the soil and water. Intensively managed systems, such as crop land, have varied numbers of functional mini groups. The characters and complicity of soil organisms are altered by crop selections, tillage practices, residue management, pesticide use, and irrigation. Biological complexity of a soil system can affect processes such as nutrient cycling, the formation of soil structure, pest cycles, and decomposition rates [2]. Researchers have yet to define how much and what kind of complexity in managed ecosystem is optimal for these processes.

To fully harness the possible use of theses microorganisms, we must first ascertain the wonders of Guyana`s microbial community. As such arose a desire to explore the diversity of microorganisms in Guyana soils and use this information to indicate the health and productivity of our country`s ecosystem particularly in the agriculture sector.

MATERIALS AND METHODS

Location and Description of Study Area. East Berbice-Corentyne (Region 6) is a region in Guyana covering the whole of the east of the country. Guyana borders are the Atlantic Ocean to the north, Suriname to the east, Brazil to the south and Venezuela to west the regions of Mahaica-Berbice, Upper Demerara-Berbice, Potaro-Siparuni and Upper Takutu-Upper Essequibo to the west. Soil samples were taken from 33 areas in the coast of the region extending from Molsen Creek to New Amsterdam. The region 6 has at its limitation Suriname on the East. Atlantic on North Region 5 on West and Region 10 on South. The areas are as follows;

Molsen Creek	Number 41
Number 76	Brighton
Number 72	Friendship
Number 69	Bushlot
Number 68	Black bush polder
Number 67	Johns
Number 65	Miss phobe
Number 64	Port mourant
Number 62	Hampshire
Number 59	Willamsburg
Number 57	Belvedare
Number 55	Nigg
Number 52	Guava Bush
Number 49	Albion
Number 47	Fyrish
Number 46	Number 1
Number 43	New Amsterdam

Collection of soil samples

A map was drawn of the sampling area and the areas for sampling were identified. From each unique area a sample was taken consisting of 5 slices of soil; one from each of the 4 corners of the area and one from the center. They were all thoroughly mixed together and placed in a clean plastic container. The core samples were used as a representative of the area. The slices were taken from a depth of 10 inches below the surface of the soil. The soil bag was filled with about one pound of soil The soil bag was labeled clearly and the numbers on the bag were recorded on the soil information sheet. The sampling procedure was repeated on each area identified on the map. The samples were then air dried and ground into powdered form separately.

Sterilization

All glassware were soaked in chromic acid cleaning solution (10% potassium dichromate in 25% sulphuric acid) for 3 hours .These were then soaked in soap water for 15 minutes then washed under running tap water: They were rinsed in distilled water and dried in a hot air oven.

Preparation of media – Potato dextrose agar (PDA)

Water (500 ml) was filled in a one liter beaker and placed on the heater. 200 g of washed, peeled and sliced potatoes were added to the beaker. The potatoes were boiled gently for 30 minutes or by the time they are easily penetrated by a glass rod. The solution was filtered through a cheese cloth squeezing out all the liquid. 500 ml of water was placed in another beaker and it was heated. 25 g of agar was placed in the hot water ($96^{o}C$ degree) to dissolve it. The agar was mixed with potato extract and the volume was brought up to 1000 ml. Dextrose (25g) was added to the solution. PDA (in 200 ml aliquots) was sterilized in an autoclave at $121^{o}C$ for 20 minutes at 15 psi. The flasks were cooled until it could be held by hand. The medium was poured 10 ml each in to Petri dishes quickly under aseptic condition. The medium was allowed to solidification.

Enumeration of bacteria and fungi by plate count – agar plating technique for soil sample.

Dilution banks were labeled as 10 and 10^{-1} The initial or mother sample (10) was made by adding to 10ml of sterile water and 1g of soil sample. This was mixed by rolling the test tube back and forth between hands to obtain uniform distribution of organism. The dilution 10^{-1} was prepared by transferring 1ml of suspension to this test tube containing 9ml of sterile water (10^{-1}) thus diluting original sample 10 times. The content was mixed by rolling the test tube back and forth between hands. Suspensions (1 ml of 10^{-1} dilution) were transferred to a sterile Petri plate containing PDA medium. The inoculations were left for 24 hours after which bacteria were counted and after 48 hours the fungi were counted using a colony counter (Quebec). The above method was repeated for the other 49 samples of soil.

Identification of fungal colonies in soil

Each plate that was used for counting was again used for identification. A clean glass slide was used for mounting where it was passed over flame to sterilize. The cover of the Petri plate containing the fungi was gently removed and a drop of sterile water was placed on the slide and then the fungi after which a cover slip. The specimen was placed

under the microscope and the features were drawn. The drawing was used as a guide to indentify the fungi using the key from the book titled "Compendium of soil fungi''. The above method was repeated for all the different fungi recognized in each plate.

Gram staining for the samples a preliminary procedure for identification

Preparation of LB broth (Luria Bertani broth containing 1g of LB powder and 200ml of water) was done. 10ml of sterilized broth was placed in a test tube and covered with a cotton plug. All samples were cultured in PDA medium once again and the samples of the unknown bacteria were placed in LB broth using inoculating needle. After 24 hours a smear was made of each culture on separate glass slides. The remaining culture in LB was left in the refrigerator for further work. The smears were left to air dry. The smear was held using slide rack or clothes pin. Each smear was covered with crystal violet for 30 seconds. Each slide was washed with distilled water for a few seconds using wash bottle. Each smear was covered with iodine solution for 30 seconds. The iodine solution was washed off with 95% ethyl alcohol. Ethyl alcohol was added drop by drop until no more colour flows from the smear. (The gram positive bacteria are not affected while all gram negative bacteria are completely decolourized. The slides were washed with distilled water and drained. Safranin was applied for 30 seconds (counter stain).This was then washed with distilled water and blotted dry with absorbent paper.

The stained slides were left to air dry. The slides were examined microscopically using oil immersion objective and it was identified based on the colour. The above method was done for all the samples.

Identification of an unknown bacterial culture

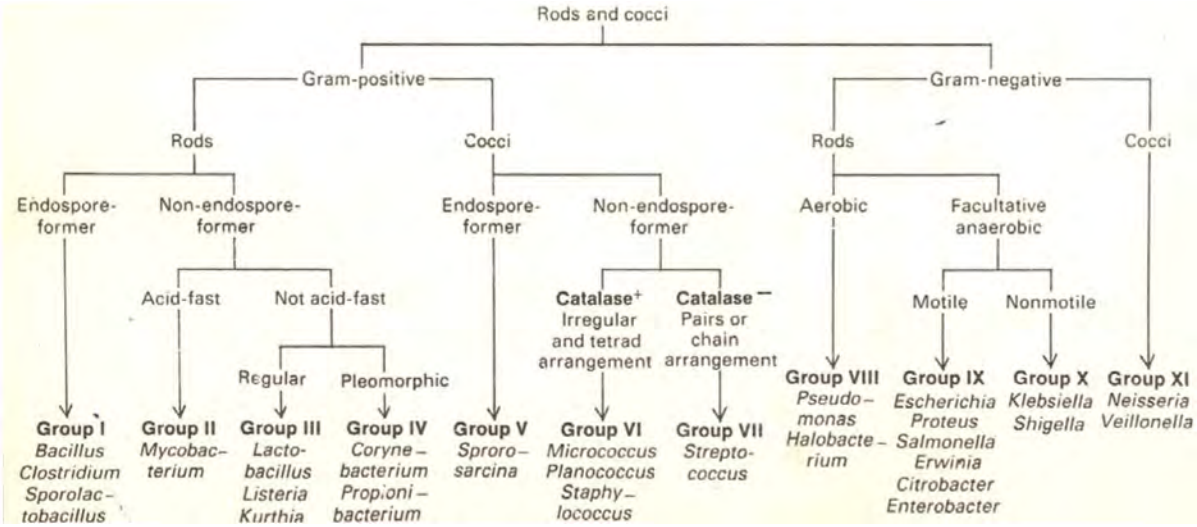
The bacterial from the stock culture was used. The culture was separated into gram positive and gram negative following the guide below after observing its staining and morphological characteristics, the following tests were done;

Acid Fast test

The smears were prepared on separate slides. The smears were flooded with carbol fuchsin. The slides were heated to steam 3-5 minutes. From time to time more stain was added to prevent smears from drying. The slides were cooled and washed with distilled water. The smear was decolourizes with acid-alcohol for 10-30 seconds or until the smears is a faint pink colour. The slide was washed with distilled water. The smear was countered with methylene blue for 1-2 minutes. This was washed with distilled water and then blotted dry with blotting paper. Observations were then made.

Catalase test

A capillary tube was dipped into 3%H_2O_2. The colony is touched there were observations that indicated bubbling in the tube for a positive reaction. This was done on for all the samples using the table below as a guide.



RESULTS AND DISCUSSION

Table 1: Showing soil sample data with physical description and pH

Sample Number	Village	Cultivated/Uncultivated	Colour	pH
1	Molsen Creek	Uncultivated	Light Brown	4.3
2		Cultivated	Light Brown	4.9
3	Number 76 Village	Uncultivated	Dark Brown	5.1
4		Cultivated	Brown	4.6
5		Cultivated	Reddish Brown	5.1
6	Number 2 Village	Cultivated	Black	6.6
7	Number 69 Village	Cultivated	Brown	6.5
8	Number 68 Village	Cultivated	Brown	6.5
9	Number 67 village	Uncultivated	Brown	3.6
10		Cultivated	Brown	5.4
11	Number 65 Village	Uncultivated	Dark Brown	6.1
12		Cultivated	Black	5.9
13	Number 64 Village	Uncultivated	Brown	6.3
14	Number 62 Village	Uncultivated	Reddish Brown	5.5
15		Cultivated	Black	7.0
16	Number 59 village	Cultivated	Black	7.2
17	Number 57 Village	Cultivated	Grey	6.5
18		Uncultivated	Light Brown	4.7
19	Number 55 Village	Cultivated	Brown	5.5
20	Number 52 Village	Cultivated	Dark Brown	6.0
21	Number 49 Village	Uncultivated	Brown	6.5

22		Cultivated	Brown	5.8
23	Number 47 Village	Cultivated	Brown	4.5
24	Number 46 Village	Cultivated	Brown	5.0
25	Number 43 Village	Uncultivated	Reddish Brown	6.8
26		Cultivated	Dark Brown	6.9
27	Number 41 Village	Cultivated	Black	5.6
28	Briton	Cultivated	Black	6.1
29	Bush Lot	Cultivated	Brown	5.8
30	Friendship	Cultivated	Dark Brown	4.7
31	Black Bush Polder	Cultivated	Black	5.1
32		Cultivated	Blackish Brown	4.9
33		Cultivated	Grayish Brown	5.2
34		Cultivated	Dark Brown	6.7
35	Johns	Cultivated	Grayish Brown	6.3
36	Miss Phobe	Cultivated	Grayish Brown	5.8
37	Port Mourant	Cultivated	Grayish Brown	5.7
38		Uncultivated	Grayish Brown	7.1
39	Hampshire	Cultivated	Light Brown	7.6
40	Willamsburg	Cultivated	Grayish Brown	6.9
41		Uncultivated	Light Brown	5.9
42	Belvedare	Cultivated	Grayish Brown	5.8
43	Nigg	Cultivated	Brick red Brown	4.6
44	Guava Bush	Cultivated	Grayish Brown	6.1
45	Albion	Uncultivated	Reddish Brown	8.2
46	Fyrish	Cultivated	Dark Brown	6.8
47		Uncultivated	Dark Brown	7.4
48	Number 1	Cultivated	Dark Brown	7.6
49		Uncultivated	Dark Brown	6.0
50	New Amsterdam	Cultivated	Reddish Brown	6.8

Table 2: Bacteria and fungal colonies in cultivated soil

Sample	Medium	Dilution Factor	NO. Of bacterial colonies	No. Of Fungal colonies
1	PDA	101	10000	1501
3	PDA	101	60	1051
6	PDA	101	480	4500
10	PDA	101	5000	1000
11	PDA	101	300	1900
13	PDA	101	50000	31
14	PDA	101	70000	80
18	PDA	101	25000	11000
21	PDA	101	4000	1400
25	PDA	101	125	3000
38	PDA	101	480	701
41	PDA	101	1000	3115
45	PDA	101	780	300
47	PDA	101	3000	3000
49	PDA	101	8000	4

Table 3. Bacteria and fungal colonies in uncultivated soil

Sample	Medium	Dilution Factor	NO. Of bacterial colonies	No. Of Fungal colonies
2	PDA	101	800	1986
4	PDA	101	1498	747
5	PDA	101	740	679
7	PDA	101	3000	4500
8	PDA	101	15000	600
9	PDA	101	3000	700
12	PDA	101	48000	20
15	PDA	101	65000	31
16	PDA	101	33000	410
17	PDA	101	20000	3000
19	PDA	101	4000	1500
20	PDA	101	1000	5100
22	PDA	101	300	4000

23	PDA	101	1100	6740
24	PDA	101	500	2000
26	PDA	101	1200	1180
27	PDA	101	1000	2000
28	PDA	101	4300	9400
29	PDA	101	290	348
30	PDA	101	300	5300
31	PDA	101	1000	30400
32	PDA	101	2340	4900
33	PDA	101	3400	4800
34	PDA	101	400	3800
35	PDA	101	4000	850
36	PDA	101	1500	4000
37	PDA	101	9000	3211
39	PDA	101	6300	800
40	PDA	101	1900	1646
42	PDA	101	2500	2055
43	PDA	101	1900	1300
44	PDA	101	8000	100
46	PDA	101	6000	5000
48	PDA	101	10000	1200
50	PDA	101	190	1300

Table 4.The types of fungi found in the soil samples

Samples	Fungus
1	*A. niger, A, fumigatus, Hypomyces completus*
2	*A.niger, A.fumigatus*
3	*A.niger, A.fumigatus, H.completus*
4	*A.niger, A.fumigatus, A. flavus, H.completus, Cladosporium*
5	*A.niger, A.fumigatus, A. flavus, H.completus, Cladosporium*
6	*A.niger, A. flavus, Absidia cylindospora, Hypomyces completus*
7	*A.niger, A.fumigatus, A. flavus, Absidia cylindospora, Cladosporium, Hypomyces completes*
8	*A.niger ,A.fumigatus, A. flavus, Absidia cylindospora, Hypomyces completes*
9	*A.niger, A.fumigatus, A. flavus, Absidia cylindospora, Hypomyces completes*
10	*A.niger, A. flavus, Hypomyces completes*
11	*A.niger, A. flavus, Absidia cylindospora, Hypomyces completus*
12	*A.niger, A.fumigatus, A. flavus, Hypomyces completus*
13	*A.niger, A. flavus, Absidia cylindospora, Hypomyces completus*
14	*A.niger, A. flavus, Hypomyces completes*
15	*A.niger, A. flavus*
16	*A.niger, A. flavus*
17	*A.niger, A. flavus, Absidia cylindospora, Hypomyces completus*
18	*A.niger, A.fumigatus, Absidia cylindospora, Hypomyces completus*
19	A.*niger, A.fumigatus, A. flavus, Absidia cylindospora, Hypomyces completes*
20	*A.niger, A. flavus, Hypomyces completus*
21	*A.niger, A. flavus, Hypomyces completus*
22	*A.niger, A. flavus*
23	*A.niger, A.fumigatus, A. flavus, Hypomyces completes, Trichoderma*
24	*A.niger, A. flavus, Hypomyces completus*
25	*A.niger, A. flavus, Hypomyces completus*
26	*A.niger, A. flavus, Absidia cylindospora, Hypomyces completus*
27	*A.niger, A.fumigatus, A. flavus, Absidia cylindospora, Hypomyces completes, Trichoderam*
28	*A.niger ,A.fumigatus, A. flavus, Absidia cylindospora, Trichoderma*
29	*A.niger, A. flavus, Absidia cylindospora,Trichoderma*
30	*A.niger, A. flavus, Absidia cylindospora, Hypomyces completus*
31	*A.niger, A. flavus, Hypomyces completus*
32	*A.niger, A. flavus, Hypomyces completus*
33	*A.niger, A.fumigatus, A. flavus, Hypomyces completus*
34	*A.niger*

35	*A.niger*
36	*A.niger, Hypomyces completes*
37	*A.niger, A. flavus, Absidia cylindospora, Trichoderma*
38	*A.niger, A. flavus*
39	*A.niger, A. flavus*
40	*A.niger, Hypomyces completes*
41	*A.niger, A.fumigatus, A. flavus, Hypomyces completus*
42	*Absidia cylindospora, Trichoderma*
43	*A.niger, A. flavus*
44	*A.niger, A.fumigatus, A. flavus, Absidia cylindospora, Hypomyces completes*
45	*A.niger, A. flavus, Absidia cylindospora, Hypomyces completes*
46	*A.niger, A.fumigatus, A. flavus, Hypomyces completus*
47	*A.niger, Absidia cylindospora*
48	*A.niger, A.fumigatus, A. flavus, Absidia cylindospora*
49	*Absidia cylindospora*
50	*A.niger, A. flavus, Rhizopus*

Table 5. Identification for Gram positive and Gram negative bacteria in the soil samples

Soil samples	Gram positive (Purple colour)	Gram negative(red colour)
1	√	-
2	√	-
3	√	-
4	√	√
5	√	√
6	√	√
7	√	√
8	√	-
9	-	√
10	-	√
11	√	√
12	√	√
13	√	-
14	√	-
15	-	√
16	-	√
17	-	√
18	-	√
19	√	-
20	√	√
21	-	√

22	-	√
23	√	-
24	√	√
25	√	-
26	-	√
27	√	√
28	-	-
29	√	√
30	√	√
31	√	√
32	√	√
33	-	√
34	√	√
35	√	√
36	-	√
37	-	√
38	-	√
39	-	√
40	-	√
41	-	√
42	-	√
43	-	√
44	-	√
45	-	√
46	-	√
47	-	√
48	-	√
49	-	√
50	-	√

Table .6 The various groups of bacterial found in selected soil samples

Samples	Bacterial group
5	Group 6
10	Group1
15	Group 6
20	Group4
25	Group1
30	Group 6
35	Group1
40	Group11
45	Group11

50	Group 5

Analysis of data

Micro-Organisms	Number of Observations	Mean	Standard Error of Mean	95% Confidence Interval for Means	
				Lower Bound	Upper Bound
Bacteria	50	8813.66	2306.325	4178.93	13448.39
Fungi	50	2963.72	651.922	1653.63	4273.81

Table 7: Grand Means for Bacteria and Fungi Counts in Soil Samples

Table 7 shows the average numbers of bacteria and fungi found in the fifty soil samples that were used in this study. It also shows the standard errors of the respective means and a 95% confidence interval for the average counts.

This shows that the mean for bacteria is not present within the confidence interval for bacteria thus is indicative of the existence of a significant difference between the means for the two variables. Since the lower bound on the interval for bacteria is higher than the mean for fungi it can be concluded that on average a larger number of bacteria than fungi can be expected in the soil.

While this initial data is useful, it does not give information on the effect of soil diversity (cultivated or uncultivated) on the prevalence of bacteria and fungi. In order to explore this, the analyses of the conditional distributions of the mean counts should be done.

Micro-organisms	T	Degrees of freedom	2-tailed P-value	Mean Difference	Standard Error of Mean Difference	95% Confidence Interval of the Mean Difference	
						Lower Bound	Upper Bound
Bacteria	-.869	48	.389	-4382.867	5045.463	-14527.450	5761.717
Fungi	.792	48	.432	1130.743	1428.058	-1740.560	4002.045

Table 8: t-test for Equality of Means for Cultivated vs. Uncultivated Soil

The results for the t-test shown were computed under the assumption of equal variances for the means for cultivated and uncultivated soil. This assumption is reasonable but the data substantiating this is not shown as it could be easily arrived at by the reader.

In both the case of bacteria and fungi, the results indicate that at the 5% level of significance, there is not difference in the average counts in cultivated and uncultivated soil (the 2-tailed P-value is larger than 5%). In particular, the 95% confidence for the difference estimate indicates that the mean difference for bacteria ranges from approximately -14527.45 to approximately 5761.717.

This interval contains zero (0) and therefore it cannot be disregarded as a possible result for the difference between the means for bacteria in cultivated and uncultivated soil. For fungi, the 95% confidence interval for the difference estimate ranges from approximately -1740.56 to approximately 4002.045. This interval also contains zero and therefore the difference in the mean number of fungi in cultivated and uncultivated soil is not significantly different from zero.

Type of soil	Fungi	Bacteria	Ratio (approx)
Cultivated	3302.94	7498.80	2.3 : 1
Uncultivated	11881.67	2172.20	1 : 5.5

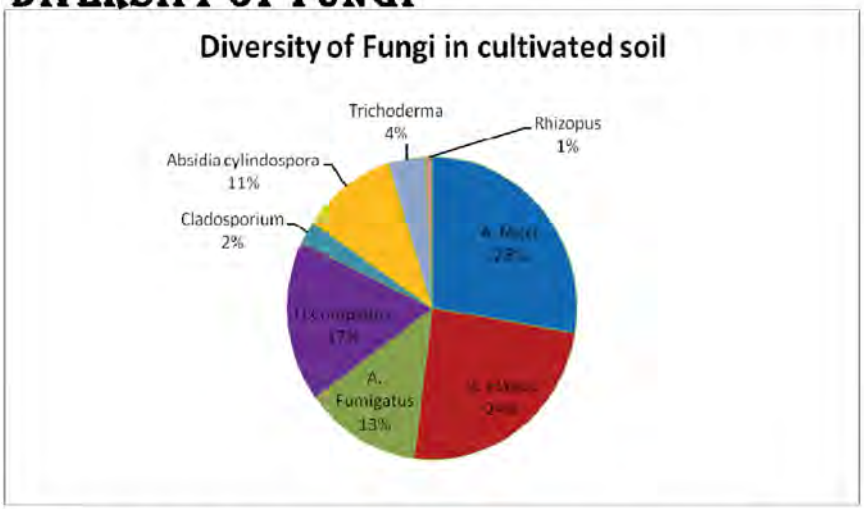
Table 9: Ratio of fungi to bacteria in cultivated and uncultivated soils.

This data indicates that there is higher amount of bacteria in the cultivated soil and a lower amount in the uncultivated soil.

University of Guyana Berbice Campus

FACULTY OF AGRICULTURE & FORESTRY

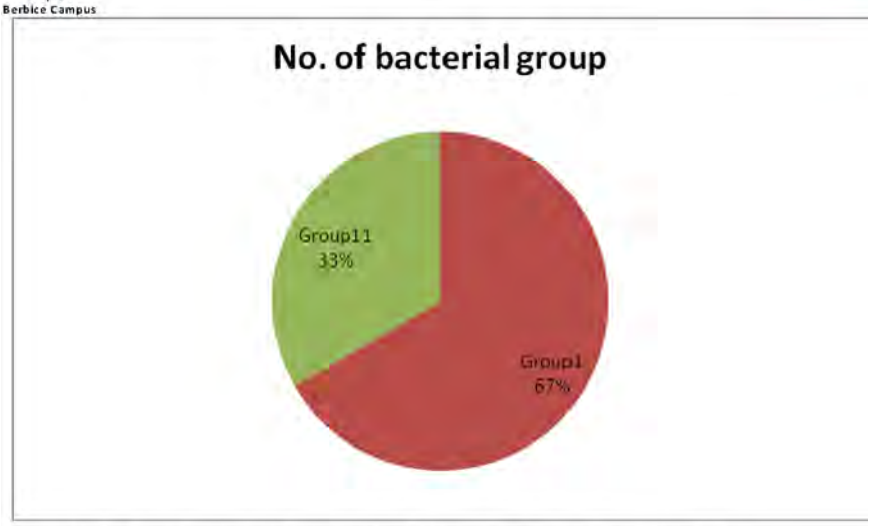
DIVERSITY OF FUNGI



Graph showing the diversity of fungi in the cultivated soil

University of Guyana Berbice Campus

FACULTY OF AGRICULTURE & FORESTRY



Graph showing diversity of bacteria in the uncultivated soil

REFERENCES

1. Aneja,K.R.1996. Experiments in Microbiology, Plant pathology, Tissue culture and Mushroom cultivation, Wishwa Prakasha, New age International (P) Limited, New Delhi, India, pp 111-138
2. Bollen, Walter B. 1959. Microorganisms and Soil Fertility. Oregon State College. Oregon State Monographs, Studies in Bacteriology.
3. Bowman, G. 1994. Why soil health matters. The New Farm. January.
4. Chambers, R. 1991. Farmer first: a practical paradigm for the third agriculture. In: M. Altieri and S.B. Hecht (eds.), Agro ecology and small farm development. CRC Press, Boca Raton, USA.
5. Domsch.K.D., Gams,W and Traute-Heidi A 1980. Compendium of Soil Fungi, Volume -1, Academic Press, London, pp 10-450.
6. Fravel, D. R., 1988. The role of antibiosis in biocontrol of plant diseases. Annu. Rev.Phytopathol. 26:75-91.
7. Frick, S 2000. Results from a 21 year old field trial, Research Institute of Organic Farming (FiBL), August issue.
8. Gershuny G and Smillie J. 1995. The soul of soil: A guide to ecological soil management. . agAccess, Davis, CA
9. Lynch, J. M., 2002. Resilience of the rhizosphere to anthropogenic disturbance. Biodegradation
10. Pankhurst, C.E., B.M. Doube and V.V.S.R. Gupta 1997. Biological indicators of soil health. CAB International, Wallingford, U.K.
11. Nielsen, M.N. and Winding, A. 2002. Microorganisms as indicators of soil health. National Environment Research Institute, Denmark. Technical Report No. 388.
12. Torsvik, V., Sorheim, R., and Goksoyr, J. 1996. Total bacterial diversity in soil and sediment communities – A review. Journal of Industrial Microbiology. 17: 170-178.
13. Turco, R. F., Kennedy, A. C., and Jawson, M. D. 1994. Microbial indicators of soil quality. In Defining soil quality for a sustainable environment. Doran, J. W., Coleman, D. C., Bezdicek, D. F., and Stewart, B. A. (eds.). Soil Science Society of America, Inc., Madison, pp. 73-90.
14. Whipps, J. M. 2001. Microbial interactions and biocontrol in the rhizosphere. J. Exper. Botany

WEB REFERENCES

1. http://aehsmag.com/issues/2002/january/microroganism.htm-
2. http://www.urbanex.uiuc.edu/soil/soil Biology//fw7Soilhealth.htm
3. www.saburchill.com/chapters/chap059.htm
4. www.pedosphere.com
5. www.extension.umn.edu/distribution/cropsystem/components/7403_02.htm
6. Soil health.com/newsletter/saa_vol3_no3.pdf
7. htt://www.biodiversityreporting.org/article.sub?docld=533c=Guyana
8. http://en.wikipedia.org/wiki/Aspergillus niger
9. http://en.wikipedia.org/wiki/Aspergillus flavus
10. http://en.wikipedia.org/wiki/Aspergillus fumigatus

11. http://en.wikipedia.org/wiki/Cladosporium
12. http://en.wikipedia.org/wiki/Rhizopus

2008 Proceedings of the Caribbean Food Crops Society. 44(2):333-345. 2008

Soil Biological Community Structure in Coffee (*Coffea arabica* L.) Agroecosystems in Puerto Rico

David Sotomayor-Ramírez[1], Veronica Acosta-Martínez[2], Yusmary Espinoza[3], Eduardo Schröder[1], José Amador[4]

*[1]UPR – Mayagüez; Agronomy and Soils Department, Mayagüez, Puerto Rico, [2]USDA-ARS; Wind Erosion and Water Conservation Unit, Lubbock, Texas, [3]INIA-CENIAP, Maracay Venezuela, [4]Laboratory of Soil Ecology and Microbiology, University of Rhode Island, Kingston, RI * Contact author: dsotomayor@uprm.edu*

ABSTRACT.

Coffee production in the Caribbean and Latin America is an important commodity in terms of economic, ecological and social value. Coffee production in Puerto Rico was intensified in the 1960s, with a shift to higher-yield varieties, increased use of pesticides and fertilizers, increased mechanization, higher-density planting patterns, with production under full sunlight. There is concern that long-term, intensive coffee production under full sunlight may have a negative impact on agroecosystem sustainability. Soil physical, chemical and biological attributes from representative major coffee production regions in Puerto Rico under partial shade and full sunlight were quantified. Soils from secondary forests at least 25 years old were included for comparison. Soil fertility differed between forest and coffee agroecosystems with favorable soil reaction, improved nutrient reserves and availability in forested systems; coffee under shade had a tendency towards improved soil fertility. The soil physical structure was significantly affected by coffee production, with a greater proportion of large macroaggregates in forested sites than in coffee agroecosystems. Coffee under both partial shade and full sunlight had a lower proportion of macroaggregates and a higher proportion of microaggregates which may have important implications for the capacity of soils under coffee production to store C and release N for crops. Soil organic carbon and nitrogen, microbial biomass and fungal groups were negatively affected by coffee production, with few observed differences between coffee under shade and full sunlight. The soil biological community structure was negatively influenced by coffee production relative to secondary forested sites, with coffee under shade having slight improvement relative to coffee under sun.

KEYWORDS: soil biological community structure, coffee, microbial ecology, soil quality

INTRODUCTION

Technological advances promoted by the College of Agricultural Sciences of the University of Puerto Rico and the Puerto Rico Department of Agriculture brought several improvements in coffee production in the mid 20th Century, including increased yields, improved pest management practices, expansion of planting areas, and improvements in the organizational market structure (Vicente-Chandler et al. 1968). Forty years after the introduction of these practices, it is becoming important to evaluate the effects of sunlight

vs. shade coffee production management practices on coffee yields, as well as coffee quality, system sustainability and soil quality. Long-term, intensive coffee production under full sunlight may decrease orchard longevity, lower fruit quality, and increase plant pest vulnerability. Soils in coffee under full sunlight, which have lower overstory vegetative canopy cover and decreased surface litter, are more vulnerable to erosion (Smith and Abruña, 1958) and nutrient runoff losses (Semidey et al., 2002; Sotomayor-Ramírez et al., 2008), which in turn affect soil functioning and ecosystem sustainability. Coffee under shade has been suggested as a more sustainable option, but quantitative information on soil parameters related to soil quality and functioning is lacking.

Shade for coffee production in Puerto Rico has traditionally been provided by an overstory of mature forest and introduced leguminous (N-fixing) trees such as *Inga spp.* and *Gliricidia spp* (Arango et al. 2004). Trees used for shade in coffee orchards are probably an important component of N cycling, primarily through leaf litter-fall, root exudates, and N fixation (Aranguren et al., 1982). Leaf litter decomposition plays an important role in the cycling of nutrients and energy transfer between plant and soil, especially in agricultural systems with low soil fertility and low fertilizer inputs. The underlying causes of the hypothesized differences in nutrient cycling between shaded and sun coffee agroecosystems need to also be ascertained by studying the biological component, since soil functioning and its long term sustainability depends on soil biota. However, information about the size, composition and function of soil microorganisms is scant for tropical agroecosystems, especially those under coffee production. We quantified selected soil chemical, physical, biological attributes in coffee agroecosystems, coffee under partial shade and full sunlight, to explain differences in C and N cycling patterns among different agroecosystems and secondary forests.

MATERIALS AND METHODS

Study sites. Three study sites were selected based on soil order, vegetation and climatic factors within the municipalities of Las Marías, Lares, and Jayuya (Table 1). Each site had soil from a different order (Ultisol, Inceptisol, and Oxisol) which are representative of soils used for coffee production in Puerto Rico (Arango et al., 2004). Within each site, experimental plots were established in areas with coffee under partial shade (coffee shade) and coffee under full sunlight (coffee sun), as well as a secondary forest (forest) control area. Each of the agroecosystems and the control area were replicated three times, with plot sizes of about 400 m^2.

Sampling. Soil samples were collected in mid-November 2007. Soils were collected using an auger (5 cm dia.) to a depth of 0-15 cm. A portion of the sample was kept refrigerated for microbiological analyses, a second portion was dried and sieved to pass a 2mm-mesh sieve, and a third portion was dried and sieved to pass a 6mm-mesh sieve.

Physicochemical properties. Soil moisture was determined gravimetrically. Soil pH and other soil chemical properties associated with fertility were determined (Page et al., 1982) by a commercial laboratory (MDS Harris Inc.). Soil organic C (OC) and total N (TN) contents were determined on the air-dried soil (sieved to <180 μm) by automated dry combustion. Aggregate size separation was performed by wet sieving air-dried soil (100 g soil) through a series of sieves (2000, 250 and 53 μm) (Elliot, 1986; Cambardella and Elliot, 1994). Four aggregate fractions: (i) >2000 μm (large macroaggregates), (ii)

250 to 2000 μm (small macroaggregates), (iii) 53 to 250 μm (large microaggregates), and (iv) 20 to 53 μm (small microaggregates) were obtained. Aggregate mass was corrected for sand and expressed as sand-free aggregate.

Biological properties. Microbial biomass carbon (MBC) and nitrogen (MBN) were determined by the chloroform-fumigation-extraction method (Brookes et al., 1985; Vance et al., 1987). Fatty acids methyl ester (FAME) profiles were used to describe the microbial community structure and were extracted from soil samples following the MIDI (Microbial ID, Inc., Newark, DE, USA) protocol as previously applied to soil analyses (Acosta-Martínez et al., 2004a,b). In brief, soils were subjected to saponification, methylation, FAME extraction, and the extract analyzed by gas chromatography with flame ionization detector.

Statistical analyses. The treatments were arranged in the field in a randomized complete block design with three replicates. A two-way analysis of variance was performed with ecosystem and site as the two factors using the MIXED procedure on measured and estimated parameters in SAS (SAS Institute Inc., Carey, NC). Means separation was performed using the LSMEANS procedure with a significance level of $P<0.05$, unless specified otherwise, with treatment differences assessed using Tukey's test. Since the treatments and the site were previously established, the inferences are strictly observational in nature. When interaction was significant, the treatments were sliced across site using the LSMEANS option to examine treatment effects within a site. Principal component analysis (PCA) was performed for selected soil FAME markers (Frostegård and Bååth, 1996) for fungal (18:1ω9c, 18:2ω6c, 18:3ω6c and 16:1ω5c) and bacterial (15:0, *a*15:0, i15:0, *a*17:0, *i*17:0, 17:1ω9c, cy17:0, cy19:0, 10Me16:0, and 10Me17:0) populations using the PCORD statistical software (version 4) to examine treatment effects in the microbial community structure.

RESULTS AND DISCUSSION

A total of forty-five parameters were either quantified or calculated to quantify the effects of land use, soil type and their interactions. In most cases the interaction site x treatment was significant, and only the most important ones are discussed here.

Soil fertility indicators. Soil C and N in Jayuya were significantly lower in both coffee production systems (sun and shade) relative to that in forest (Figure 1A and 1B). Soil C and N in Lares were significantly lower in coffee sun relative to forest, but only total C was different between the two coffee production systems. Soil C and N were similar among the three systems in Las Marías.

Soils under forest had higher pH, significantly lower exchangeable Al, and % Al saturation than both coffee production systems in Las Marías; this pattern, although non-significant, was also observed in Jayuya soil (Figure 2A, 2B, and 2C). Soil pH, exchangeable Al, and % Al saturation values were similar among coffee production systems and forest in Lares.

Soil exchangeable NH_4^+-N was significantly higher in forest soil than in coffee production systems, with no difference between coffee production systems (Figure 3A). Soil NO_3^--N was higher in forest soil than in coffee production systems only in Lares (Figure 3B). Soil mineralizable N was significantly higher in forest than the coffee under sun in Jayuya and Lares but not in Las Marías, where it was only greater than coffee under shade (Figure 3C). Coffee under shade had significantly greater mineralizable N

than coffee under sun in Jayuya and Las Marías. Extractable inorganic N followed the order: of forest > coffee shade > coffee sun.

Soil aggregate size distribution. The site x treatment x aggregate size interaction was only marginally significant (F=1.84, $P< 0.059$) and only the treatment x aggregate size interaction was considered important (F=18.34, $P<0.01$) (Figure 4). The forest soil had the greatest proportion of large macroaggregates (>2000 μm). The proportion of large macroaggregates decreased at the expense of an increase in small macroaggregates (250 – 2000 μm) in coffee shade and coffee sun and possibly large microaggregates (<50-250 μm) in coffee shade.

Soil microbial communities. Microbial biomass C and N were lower in both coffee agroecosystems when compared to forest in all sites (Figure 5A). The MBC was higher under shade compared to sunlight coffee in Jayuya, not affected by coffee agroecosystems in Lares, and it was lower under shade compared to sunlight in Las Marías soil. The MBN was higher in coffee under shade for Jayuya soil, but it was not affected by coffee production system for the other two soils (Figure 5B). Thus, effects of coffee management on microbial biomass depended on the soil order or other climatic and management conditions within each of the different sites.

Principal component analysis was used to evaluate the microbial community composition only as a function of coffee production systems, since forest soil clearly showed higher microbial biomass and fungal populations than the agroecosystems (Figure 6). Generally, higher fungal populations were found in Jayuya and Lares under coffee production with shade, and in Jayuya with coffee production with sunlight compared to the other systems. Thus, Las Marías soil under both shade and sunlight coffee production tended to have lower fungal populations and higher bacteria populations compared to the other soils. These trends depended on comparisons based on combined data from all soils; however, two of the three soils showed higher fungal populations with coffee production under shade, mostly likely due to higher litter accumulation and substrate availability compared to sunlight production. The soil microbial community shifts to larger populations under shade were in agreement with higher C content and N mineralization compared to sunlight coffee production systems.

CONCLUSIONS

Soil fertility differed between forest and coffee agroecosystems with improved soil reaction, organic matter (C and N) and extractable ammonium-N, nitrate-N and mineralizable N in forested systems; only in some cases were these parameters influenced by the manner in which coffee is grown, with coffee under shade showing a tendency towards generally improved properties. The soil physical structure was significantly affected by coffee production as forested sites had greater proportion of large macroaggregates than coffee agroecosystems. Coffee under both partial shade and full sunlight had a lower proportion of large macroaggregates and a greater proportion of small macroaggregates, which may have important implications in the capacity of soils under coffee production to store C and release N for crops. Soil biological parameters were negatively affected by coffee production, with few differences observed between coffee under shade and full sunlight. In some cases (parameters) coffee under shade was better for the soil, but the trend was not consistent among the biological parameters measured. It was of ecological significance to find that two of three soils showed higher

fungal populations with coffee production under shade, mostly likely due to higher litter accumulation and decreased rates of C cycling compared to coffee under sunlight.

REFERENCES

Acosta-Martínez, V., Upchurch D.R., Schubert, A.M, Porter, D., Wheeler, T., 2004a. Early impacts of cotton and peanut cropping systems on selected soil chemical, physical, microbiological and biochemical properties. Biology and Fertility of Soils 40, 44-54.

Acosta-Martínez, V., Zobeck, T.M., and V. Allen 2004b. Soil microbial, chemical and physical properties in continuous cotton and integrated crop-livestock systems. Soil Science Society America Journal 68, 1875-1884.

Arango, M., Santana, M., and Schröder, E.C. 2004. Reintroduction of shade for sustainable coffee production in Puerto Rico. Memorias Reunión Científica Anual, SOPCA 2004, Arroyo, Puerto Rico. P. 49.

Aranguren, J., Escalante, G. and Herrera, R. 1982. Nitrogen cycle of tropical perennial crops under shade trees. I. coffee. Plant and Soil. 67: 247-258.

Brookes, P.C., Landman, A. Pruden G. and Jenkinson, D.S. 1985. Chloroform fumigation and the release of soil nitrogen: A rapid direct extraction method to measure microbial biomass nitrogen in soil. Soil Biol Biochem 17:837–842.

Cambardella, C.A., y E.T. Elliott. 1994. Carbon and nitrogen dynamics of soil organic matter fractions from cultivated and grassland soils. Soil Sci. Soc. Am. J. 58: 123-140.

Elliott, E.T. 1986. Aggregates structure and carbon, nitrogen, and phosphorous in native and cultivated soils. Soil Sci. Soc. Am. J. 50:627-633.

Frostegard, A, Bååth, E., 1996. The use of phospholipid fatty acid analysis to estimate bacterial and fungal biomass in soil. Biology and Fertility of Soils 22, 59-65.

Page, A.L., R.H. Miller, and D.R. Keeney. 1982. Methods of soil analysis. Part 2. Chemical and microbiological properties. 2nd edition. American Society of Agronomy, Soil Science Society of America, Madison, WI.

Parham, J.A., Deng, S.P., 2000. Detection, quantification and characterization of β-glucosaminidase activity in soil. Soil Biology & Biochemistry 32, 1183-1190.

Semidey, N. E., Orengo-Santiago, and E.G. Más. 2002. Weed suppression and soil erosion control by living mulches on upland coffee plantations. J. Agric. Univ. P.R. 86: 155-157.

Smith, R.M., and F. Abruña. 1955. Soil and water conservation research in Puerto Rico. 1938 to 1949. Bulletin 124. University of Puerto Rico. Agricultural Experiment Station. Rio Piedras, PR. 51 pp.

Sotomayor-Ramírez, D., J. Ramírez-Avila, E. Mas, and G. Martínez. 2007. An alternative planting method for erosion and nutrient loss reduction in coffee (*Coffea Arabica*) plantations. J. Agric. Univ. P.R. (To be submitted for publication).

Tabatabai, M.A., 1994. Soil enzymes. In: Weaver, R.W., Angel, G. S., Bottomley, P.S. (Eds.), Methods of Soil Analysis: Chemical and Microbiological Properties, Part 2. Soil Science Society of America Book Series No. 5, Madison. pp. 797-798.

Vance, E.D., Brookes, P.C., Jenkinson, D.S., 1987. An extraction method for measuring microbial biomass C. Soil Biology & Biochemistry 19, 703-707.

Vicente-Chandler, J., F. Abruña, F. Bosque-Lugo, and S. Silva. 1968. Intensive coffee culture in Puerto Rico. Bulletin 211. University of Puerto Rico – Mayagüez Campus. Agricultural Experiment Station. Rio Piedras, PR. 53 pp.

Tables

Table1. General information from study sites.

Site	Series	Taxonomic classification [1]	Altitude above mean sea level (m) [2]
Jayuya	Los Guineos	Very-fine, kaolinitic, isothermic Humic Hapludox	789
Lares	Alonso	Very-fine, parasesquic, isohyperthermic Oxic Dystrudepts	604
Las Marías	Humatas	Very-fine parasesquic isohyperthermic Typic Haplohumults	286

1 Beinroth et al. (2003)

2 Represents the mean value of nine plots (three treatment combinations).

Figures

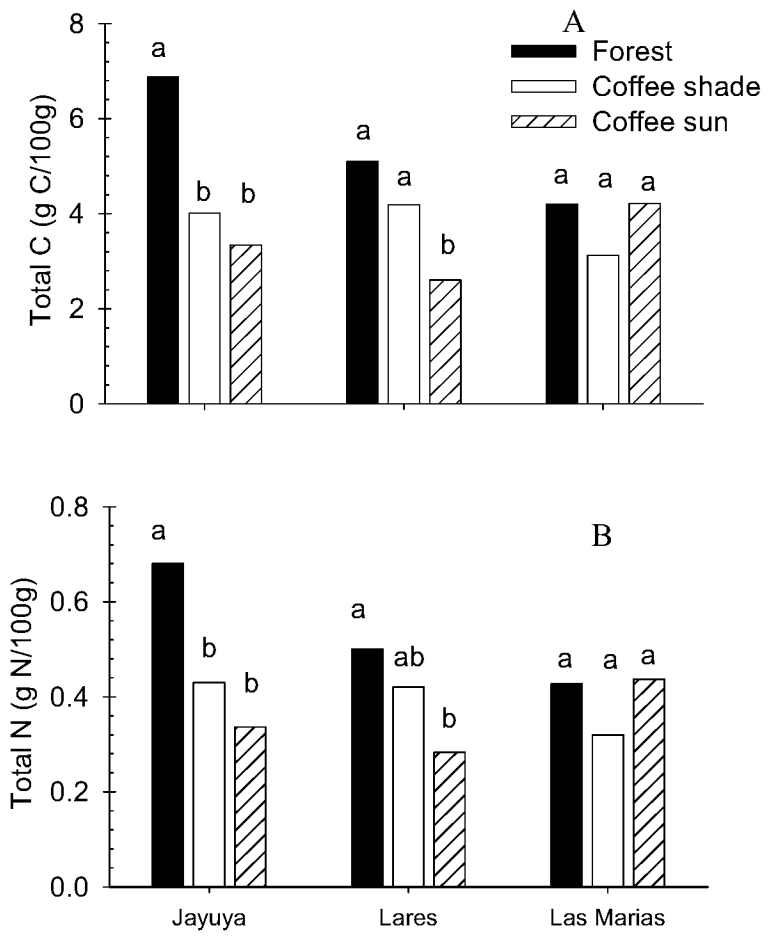


Figure 1. Soil total C (A) and total N (B) in secondary forest and in coffee production under partial shade and full sunlight in Jayuya, Lares, and Las Marías sites. Values followed by the same letter within a site were not significantly different.

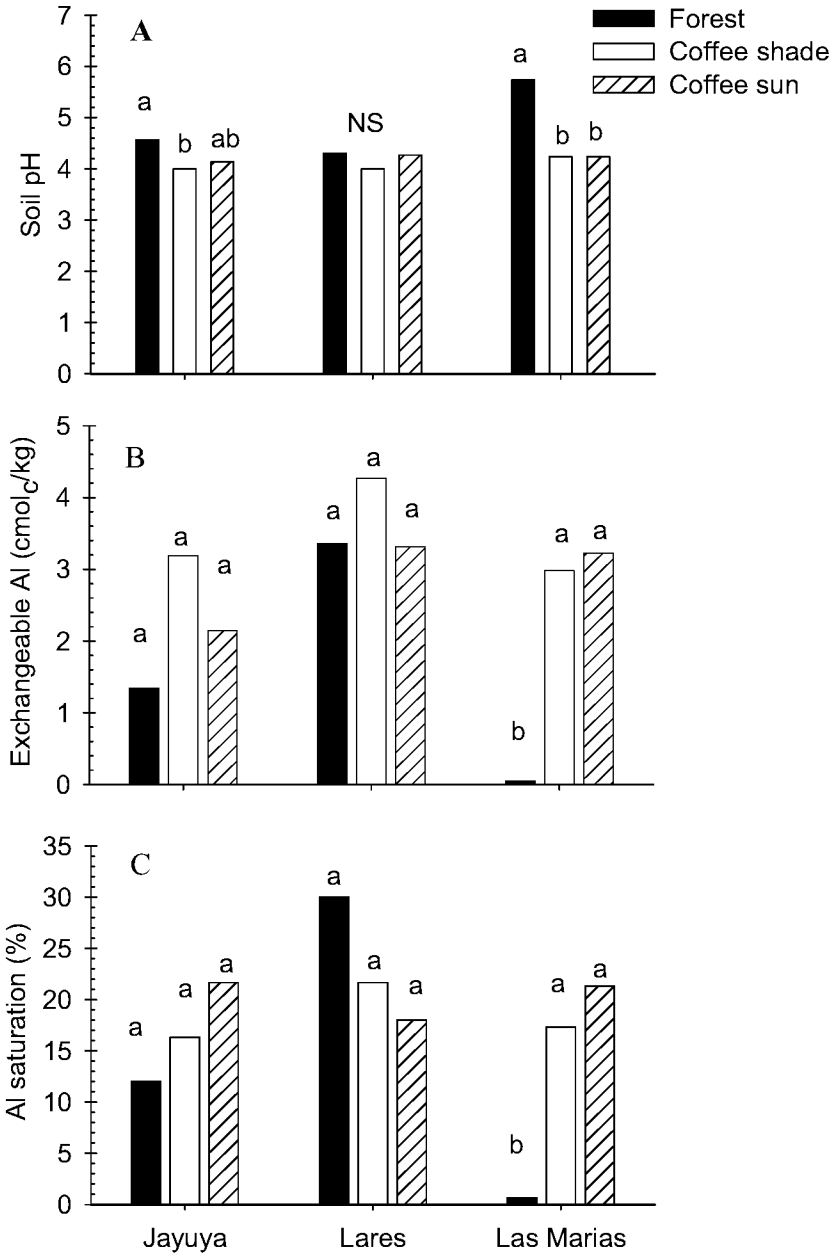


Figure 2. Soil pH (A), exchangeable Al (B), and Al saturation (C) in secondary forest and in coffee production under partial shade and full sunlight in Jayuya, Lares, and Las Marías sites. Values followed by the same letter within a site were not significantly different.

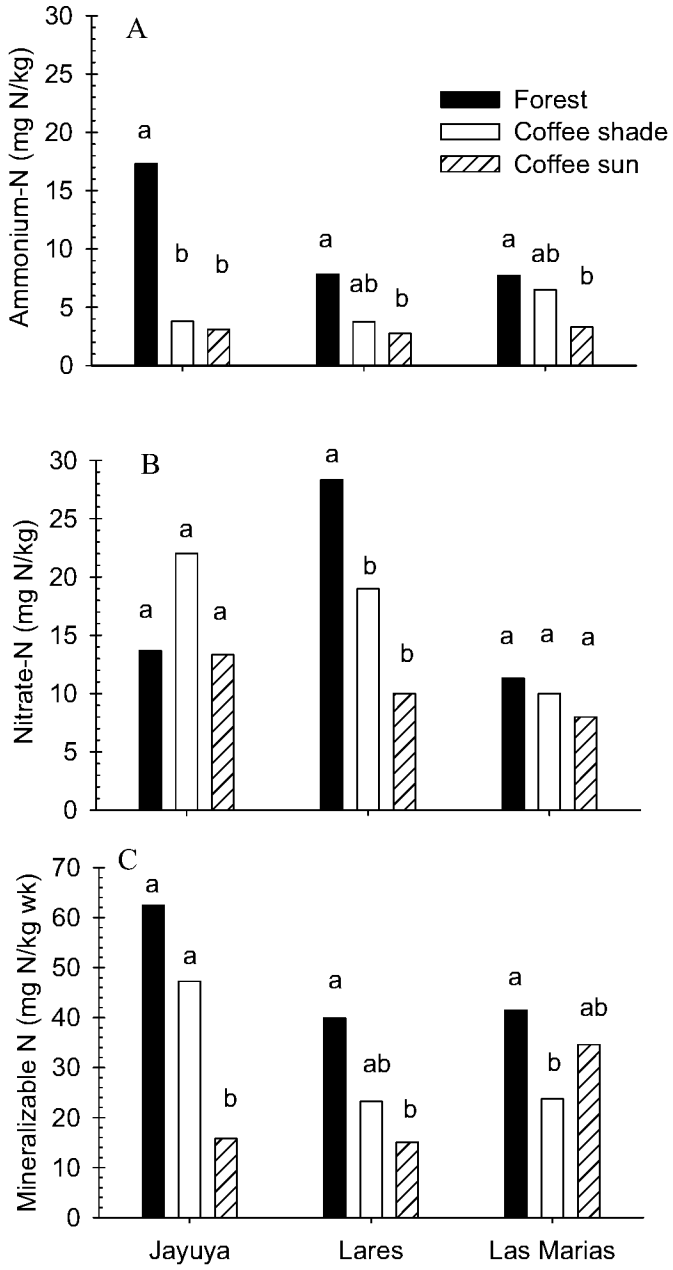


Figure 3. Soil ammonium (A), nitrate (B), and mineralizable nitrogen (C) in secondary forest and in coffee production under partial shade and full sunlight in Jayuya, Lares, and Las Marías sites. Values followed by the same letter within a site were not significantly different.

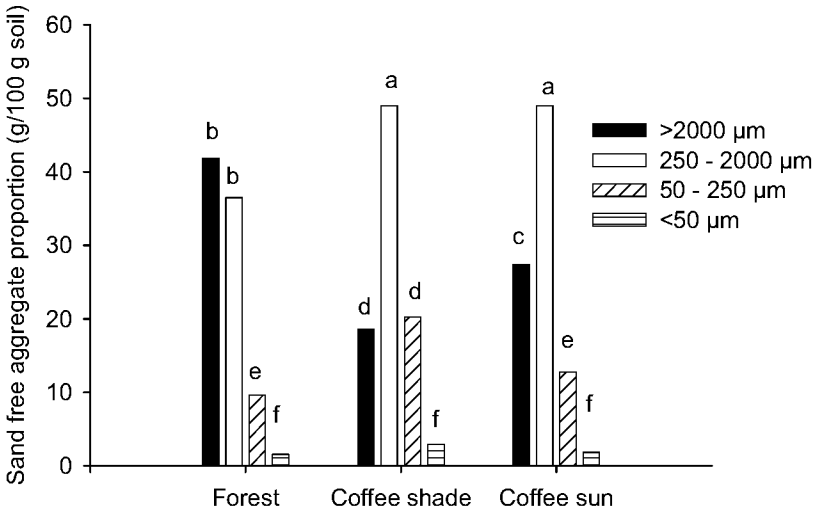


Figure 4. Aggregate size distribution as influenced by secondary forest and coffee production under partial shade and full sunlight in Jayuya, Lares, and Las Marías sites. Values followed by the same letter were not significantly different.

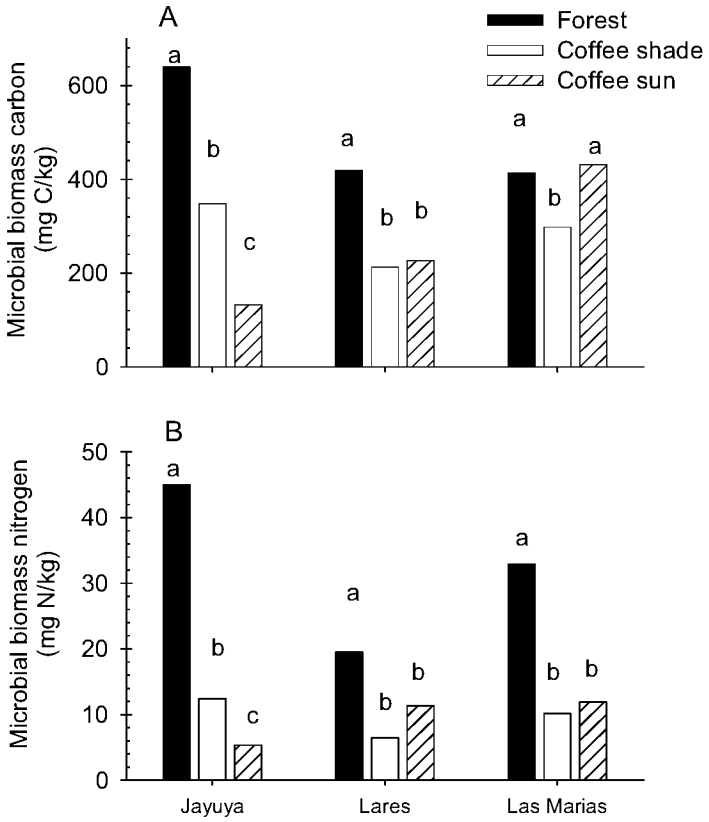


Figure 5. Soil microbial biomass carbon (A) and nitrogen (B) in secondary forest and in coffee production under partial shade and full sunlight in Jayuya, Lares, and Las Marías sites. Values followed by the same letter within a site were not significantly different.

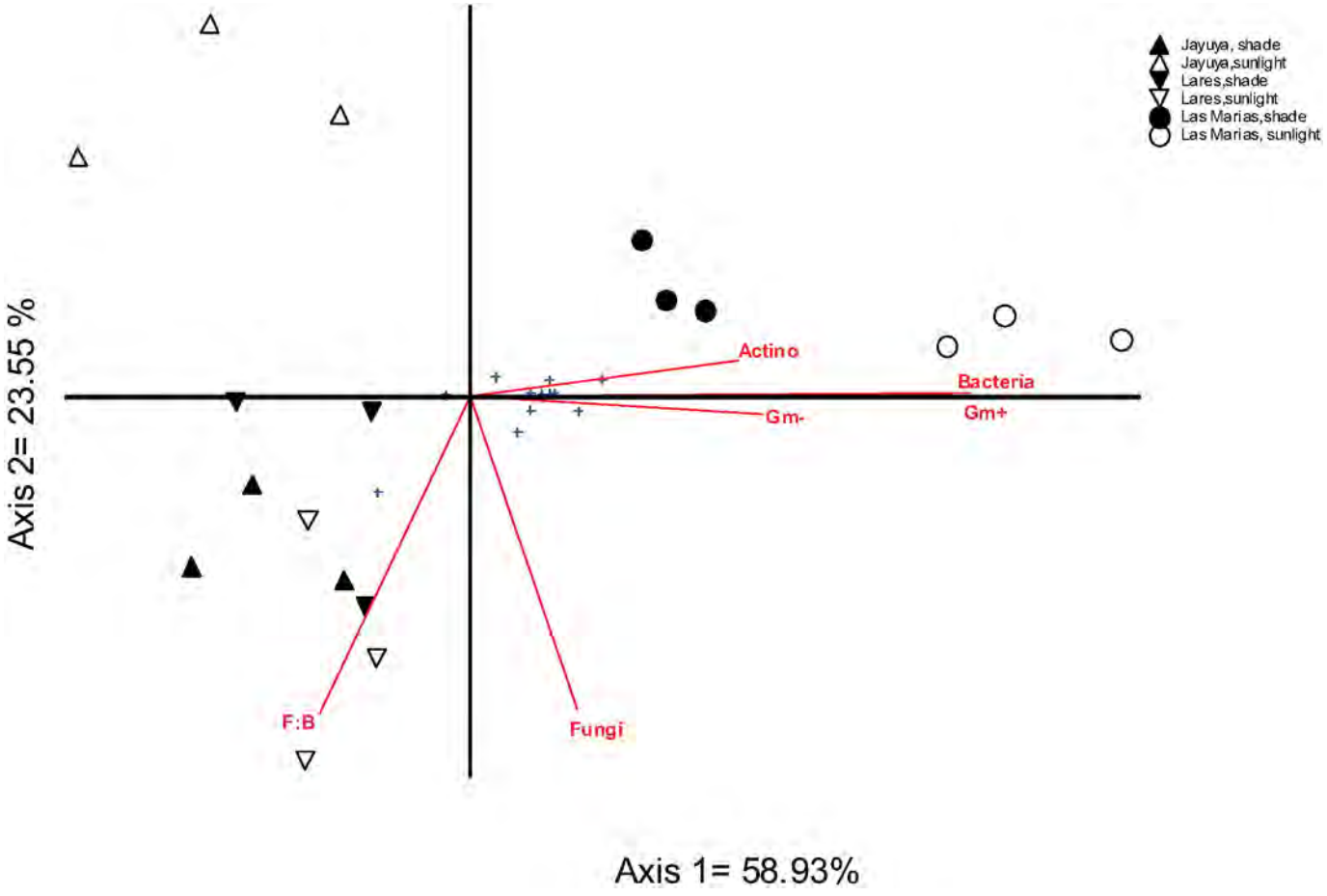


Figure 6. Principal Component Analysis (PCA) for selected soil FAME markers for fungal and bacterial populations to examine differences in soil microbial community structure in coffee under partial shade compared to coffee under full sunlight. Forest soil was not included in this analysis. In this PCA, higher abundance of fungi or bacteria populations are characterized when soil samples align to the vectors designated for those microbial groups.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):346. 2008

Training in Water Quality Concepts, Sampling and Analysis.

Yuncong Li[1], Kati Migliaccio[1], Teresa Olczyk[2], Ed Hanlon[3], Qingren Wang[1], and Pamela Fletcher[4] [1]Tropical Research and Education Center, [2]Miami-Dade County Extension Office, [3]Southwest Florida Research and Education Center, [4]Florida Sea Grant and NOAA, University of Florida. yunli@ufl.edu

ABSTRACT.
Considerable interest in environmental issues within southern Florida has generated a need for qualified individuals to conduct water quality sampling complying with stringent sample collection and analysis programs. We will present our experiences on water quality workshops, which were conducted during the last 3 years. The objectives of water quality workshops were to introduce (i) water regulations, (ii) monitoring and sampling techniques, (iii) Best Management Practices (BMPs) program initiatives, and (iv) laboratory methods related to water quality of surface and ground waters. The training focused on basic concepts of water chemistry and hydrology related to water sampling and analysis, instrumentation, water quality data analysis, and evaluation and reporting. The training sessions were each a combination of lectures, hands-on field and lab activities, and field and agency tours. Pre- and post-testing of participants showed effective learning was achieved despite diversity in educational backgrounds. In 2008, 11 participants demonstrated a 73% knowledge gain. After the course, a follow up handout was used to explain both correct and incorrect answers on the multiple choice pre/post tests, and it was sent to all participants.

KEYWORDS: water quality, monitoring and sampling, chemical analysis, data analysis

2008 Proceedings of the Caribbean Food Crops Society. 44(2):347-355. 2008

Nutrients in Dairy Manure Sludge in Puerto Rico: Management and Implications

David Sotomayor-Ramírez[1], Teodoro Ruiz[2], Yamil Quijano[1], Gustavo Martínez[1], Carlos Saavedra[3], and Alexander Recamán-Serna[1] [1]University of Puerto Rico (UPR) – Mayagüez; Agronomy and Soils Department, Mayagüez, Puerto Rico, [2]UPR – Mayagüez; Animal Husbandry Department, Mayagüez, Puerto Rico, [3]Agricultural Extension Service, UPR - College of Agricultural Sciences Mayagüez, Puerto Rico.
Contact author: dsotomayor@uprm.edu

ABSTRACT.

Dairy manure sludge (DMS) application to grazed forage pastures is a widespread agronomic practice. Unfortunately, the quantitative benefits of DMS application to improved pastures still has not been shown in the Caribbean. On-going application of DMS based on estimated nitrogen (N) content is unsustainable, and in many areas presents a threat to water quality, because the excess phosphorus (P) in dairy sludge is usually not extracted by plants and remains in soil until removed in runoff. Application of DMS based on P content of the material may be a better alternative, but pastures may need to be supplemented with N. The nutrient concentration of DMS sludge in various farms of Puerto Rico was assessed. The mean (standard deviation in parenthesis) nutrient concentration of DMS (n=17) was 233 (120), 122 (77), 232 (123) mg/L for total N, total P, and total K, respectively. The economic benefit of DMS application, in terms of substitution for the price of nutrients in mineral fertilizer, could be from $79 to $158 per ha-cm (acre-in) of application, but the excess volume of DMS application from the improper application could offset potential agronomic and economic gains. Farmers applying DMS to fields should take every precaution to ensure that the infiltration rate of the soil is not exceeded and that during the application the volumes are kept to levels in which the nutrients applied do not exceed crop nutrient requirements. Further precautions include reducing the number of applications during the year and spreading the material to other areas of the farms. A case study demonstrated that there is an excess of nutrients generated on-farm which originate primarily from grazing animals, and is exacerbated by high animal densities, improper distribution of N and P from DMS and fertilizer. Excess nutrients generated result in unsustainable nutrient rates to fields which could result in a waste of resources and environmental degradation.

KEYWORDS: dairy manure sludge, forage production, nutrients in pastures

INTRODUCTION

Modern milk production facilities in Puerto Rico have grown increasingly dependent on feed-concentrate for the maintenance of milk production levels (Welch et al. 1997). Increased concentrate feeding with reduction in feed from grazing, high quality haylage or fresh-cut pasture results in higher production costs, greater on-farm nutrient input (especially phosphorus, P) and can compromise animal health (Vicente-Chandler et al. 1984; Torres, 2005). The dairy industry in Puerto Rico has benefited from the implementation of state programs that strengthen the infrastructure base, such as

dairy-waste-holding lagoons (DWHL) combined with irrigation systems for pasture. Farmers with DWHL are USDA-NRCS clients and follow their recommendations for dairy manures sludge (DMS) to fields which is based on an empirically-based model. There are concerns because DMS application is based on theoretical DMS nitrogen (N) and P concentration and plant nutrient extraction book values. There is no quantitative information to guide farmers as to how they should combine DMS application with commercial fertilizers for pasture production. Further, farmers spread DMS to fields without considering the nutrient value of the material. The objective of this work was to quantify nutrient inputs from DMS in four farms. One farm was selected as a case study to quantify nutrient inputs to fields from individual and combined sources (fertilizer, DMS, and direct excretion) at the dairy farm level.

MATERIALS AND METHODS

Four dairy producing facilities in Puerto Rico were selected (Table 1). Quantification of nutrients in DMS was performed by monitoring nutrients in the lagoon and in the fields during the farmers' regular application schedule during 2007 and 2008.

Table 1. General characteristics of farms used in the study.

Producer	Soil type	Mean slope	Number of lactating cows	Area available for grazing	Farm area that receives sludge
		%		----------ha--------	
Isabela	Coto (Typic Eutrostox)	1 to 5	150	123	9
San Sebastian	Humatas (Typic Haplohumults)	15 to 45	96	39	4
Camuy	Bayamón (Typic hapludox), Almirante (Plinthic hapludox)	5 to 25	300	53	13
Hatillo	Espinoza (Typic Kandiudults)	5 to 25	750	81	32

The rates and form of application varied among the farms as these had varying irrigation spraying equipment, nominal working pressures, speed of sprayer movement, nozzle size, spraying distance and irrigator type among other factors. The DMS in the DWHL were sampled prior to its application to the fields using standard methods (Peters and Combs, 2003). A regular grid pattern was established within each field and 20-L buckets were placed to gather DMS applied. At the end of the DMS application, the volume within buckets was measured and a composite sample taken for analysis for total N and total P in a commercial laboratory. Information was gathered from two (Hatillo and Camuy) of the four farms, related to number and frequency of applications and annual nutrient inputs to fields were estimated. Soils were sampled (0-15 cm) from fields and analyzed for extractable P using Bray1 (soil pH <7.2) or Olsen (soil pH ≥ 7.3 procedures (Page et al., 1982).

One of the farms (Camuy) was selected as a case study for the quantification of nutrient inputs from the individual and combined sources (i.e. fertilizer, liquid sludge, direct excretion) on a field by field basis. The farm has an area available for grazing of 53 ha of which 25 ha are used by milking cows and 28 ha are used by heifers and dry

cows. The farm has had an average standing stock of approximately 300 milking cows, 2 bulls and 96 heifers and 85 dry cows. The daily mass of nutrients generated by animal excretion and total generation within the farm was computed (Table 2).

Table 2. Nutrient amounts generated by animal excretion and annual on an on-farm basis, in the selected dairy producing facility of Camuy.

	N [1]	P_2O_5	K_2O	N	P_2O_5	K_2O	$N:P_2O_5$
	----------kg/animal/day--------			----------kg/farm/yr----------			
Cows [1]	0.15	0.18	0.22	16923	19262	23891	0.88
Bulls [2]	0.08	0.08	0.15	60	55	106	1.09
Calves and heifers	0.05	0.02	0.06	1911	589	2230	3.24
Dry (fields only)	0.07	0.08	0.20	2115	2327	6064	0.91
Sum				21009	22233	32291	0.94

[1]Milking cow N production estimate is based on daily 17 kg feed intake with 18.6% protein; 18 kg milk with 2.9% protein. The P production estimate was obtained from C. Torres (2005) and feed intake data.

[2] Heifer estimate is based on 550 lb animal, 2% live-weight forage consumption of forage

The theoretical nutrient amounts combined from milking cows, bulls and heifers (allocation) (i) going into the lagoon, (ii) going as manure solids within the milking area and (iii) excreted directly by the animals to the field was calculated (Table 3).

Table 3. Allocation of nutrients that are potentially generated by milking cows, bulls and heifers, excluding dry cows in the selected dairy producing facility of Camuy.

	Lagoon	Manure solids	Excreted to fields	Total
	----------kg/yr----------			
N[1]	5105	2482	11282	18868
P_2O_5	3533	3496	12841	19870
K_2O	5920	4336	15925	26181

[1]N amounts do not consider any losses by volatilization or denitrification.

We estimated that the animals as a group spend 13 hours (54%) of the day grazing and 11 hours (46%) of the day being milked or waiting to be milked (milking process). Of the 11 hours in the milking process, the average time that each cow actually spends in the milking parlor is about 8 hours. Of the total amount of manure generated by each animal, approximately 33% is generated in the milking parlor and 66% of the manure is excreted to the fields. We estimated that about 55% of the excreted manure in the milking parlor (or 18% of the total) is scraped in a semi-solid state and is eventually spread to fields.

All of the estimates of P and potassium (K) excreted by the animals is based on the above-mentioned proportions, but the N is partitioned differently based on the fact that 60% of the N that is excreted occurs through urine and 40% occurs through solid feces (Van Horn et al. 1991). It is estimated that all of the urine-N generated in the milking process is directed to the waste holding lagoon. Of the feces-N generated in the

milking parlor, 20% goes to the waste-holding lagoon, with the remaining 80% is scraped in semi-solid state and handled as mentioned previously. As a check comparison, the $N:P_2O_5$ theoretical ratio of semi-solid manure based on this assumption is 0.71 and the value quantified was 0.76. Therefore, the amount of N that goes into the lagoon corresponds to that generated in the milking parlor and part of that from the waiting area. The theoretical annual nutrient distribution is shown in Table 3.

The farmer has kept a record of the rates and dates of fertilizer application to particular fields since 2002. He has also recorded dates and duration of DMS application to particular fields. The annual nutrient contribution from fertilizer to each field was quantified from the sum of the amounts of fertilizer with the formulation 15-5-10 ($N-P_2O_5-K_2O$) applied to each field.

To compute the nutrient contribution from DMS application, we assumed that 1.9 ha-cm (0.75 acre-inch) of DMS was applied each time. The nutrient concentration in the DMS sludge from the DWHL was quantified by us at various times throughout the year. The product of DMS volume, field area, and nutrient concentration in sludge was used to quantify nutrient inputs. The annual DMS nutrient contribution to each field was computed from the sum of the applications to each field, and the nutrient contribution to the farm was computed from the sum of all the applications to all of the fields during the year.

To calculate the nutrient contribution from direct excretion to each field, we estimated that the cows are rotated into each pasture every 21 days and thus enter each field about 15 to 19 days of the year (depending on climatic conditions and on whether the field receives DMS or not). The animals spend about 16 hours of the day in the field (55% of the time). The grazing time within each field depends on the size of the field. For example, a field of 2.4 ha, the animals spend about 2 days grazing, whereas in a field of 0.81 ha, the animals spend 1 day grazing (our best professional judgment was used for consideration of the time that animals spend within each field). Animal annual nutrient excreta allocation was calculated from the product of the number of animals, days spent in the field, fraction of time spend in the field, daily animal nutrient excretion and number of days per year the field is used.

RESULTS AND DISCUSSION

The mean (standard deviation in parenthesis) nutrient concentration of DMS was 233 (120), 122 (77), 232 (123) mg/L for total N, total P, and total K, respectively. The mean $N:P_2O_5$ ratio was 1.2 (0.66). The four farms evaluated differed in terms of the quantity and quality of animal feed, dilution of the lagoon due to rainfall or excess wash, and frequency of emptying or application, and thus represent the wide range of possible conditions found in Puerto Rico. The values presented are lower than those presented for other sites in Minnesota and Wisconsin (Peters and Combs, 2003) and in Arkansas (Daniels et al. undated) yet $N:P_2O_5$ ratios were similar. The values presented could be used as book-values for Puerto Rico and other areas with similar herd management practices in the absence of site-specific information. Typical forage crops extract from 2.5 to 4 times more N than P_2O_5 (Vicente-Chandler et al. 1983), which demonstrates that long-term N addition of DMS based on solely on N content, will lead to P buildup in soil. Soil testing for P should be a regular management practice in manure application areas to

avoid excess P accumulation in soil which can increase P concentrations in runoff and negatively impact surrounding water bodies (Sharpley et al. 2000).

USDA-NRCS suggests that up to 70% of the N in the nutrient holding lagoon is denitrified or volatilized prior to plant uptake (USDA-NRCS, 2001). It was not possible for us to ascertain at what stage of the N transformation processes the lagoons were when sampled. Also, P concentrations have been shown in some instances to be greater when the lagoon is stirred because particulate P is suspended in the water column (Dou et al. 2001), but not in others (Torres, 2005). In the lagoons studied (n=17), we did not observe differences in P concentrations between stirred and un-stirred samples. The potential economic value of DMS in relation to fertilizer was estimated in the four farms studied assuming between 30 and 100% availability for N and between 70 and 80% availability for P of the quantified nutrient concentrations in the DWHL, and a substituting the costs of urea ($0.88/lb N), triple-superphoshate ($1.26/lb P_2O_5) and muriate of potash ($0.71/lb K_2O) during 2005 for N, P_2O_5, and K_2O, in the DMS, respectively. Estimates range between $113 to $162 per ha-cm (0.97 acre-in) of application, and with a typical annual application of 50 ha-cm (49 acre-in) could range between $5,500 to $8,000/farm/yr.

Table 4. Dairy manure sludge nutrient application rates.

Field	Time of application	Irrigation depth median	Nutrient application rate			N/P_2O_5
		cm	----------kg/ha----------			
Isabela (static irrigator)						
	min		N	P_2O_5	K_2O	
1	45	0.5	13.9	16.9	18.7	0.82
2	50	0.8	16.4	15.3	25.6	1.06
San Sebastian (static irrigator)						
3	75	1.4	21.8	17.9	27.2	1.22
4	75	0.72	8.9	7.2	11.5	1.20
Camuy (movable irrigator)						
5	NA	0.42	20.9	7.1	25.5	2.9
6	NA	1.41	69.6	23.6	85.0	2.9
7	NA	1.91	94.0	31.8	114.7	2.9
Hatillo (movable irrigator)						
8	NA	4.5	162	85.6	190.2	1.9
9	NA	3.2	114.6	60.5	134.5	1.9
10	NA	3.75	135.0	71.3	158.4	1.9

Nutrient loads based on measured concentrations and volumes of DMS applied to different fields are shown in Table 4. The data demonstrate the wide range of values with a 15-fold range for N and a 12-fold range for P. For example, N application rates ranged from 8.9 kg N/ha in San Sebastián to 135 kg N/ha in Hatillo. The biggest determinant influencing nutrient loads to fields was the depth of application. The mean nutrient rates for each site were used to extrapolate annual nutrient application rates (Table 5).

Annual application of N and P exceeded crop nutrient requirements by 4.1 and 5.7 times, respectively, of those extracted by forage in Hatillo and 0.34 and 0.44 times in Camuy. Soil test P (Bray1) was on average 341 ppm in Hatillo and 235 ppm in Camuy, which are in the extremely high environmental category (Sotomayor et al. 2004) and well in excess of values considered sustainable. Therefore, farmers applying DMS to fields should take every precaution to ensure that the infiltration rate of the soil is not exceeded and that during the application the volumes are kept to levels in which the nutrients applied do not exceed crop nutrient requirements. Further precautions include reducing the number of applications during the year and spreading the material to other areas of the farms.

Table 5. Annual nutrient loading to fields in Hatillo and Camuy farms from dairy manure sludge and annual estimation based on documented farmers' practices.

	Nutrients per application	Nutrients per year	Application / extraction ratio [1]
	----------kg/ha----------		
----------Hatillo----------			
N	162	1616	4.1
P_2O_5	85	853	5.7
K_2O	190	1897	3.4
----------Camuy----------			
N	66	132	0.34
P2O5	33	65	0.44
K2O	110	220	0.39

[1]Assuming crop extraction values of 350, 133, and 500 lbs/acre of N, P_2O_5, and K_2O, respectively.

Nutrient inputs to fields from individual and combined sources (fertilizer, DMS, and direct excretion) at the dairy farm level were quantified for the farm in Camuy. The mean nutrient rates from the individual sources (i.e. fertilizer, liquid sludge and direct excretion) demonstrate that the biggest source is direct excretion by the animals (Table 6). The data demonstrate that about one-third of the N and about one-fifth of the P that is excreted by animals is applied via fertilization or from DMS application. The high standard deviation observed demonstrates the high spatial variability to different fields in the application of the nutrients from the varying sources.

Table 6. Nutrient contribution from individual sources in the dairy producing facility in Camuy.

Contribution from:	N		P_2O_5		K_2O	
	mean	sd	mean	sd	mean	sd
	----------kg/ha/yr----------					
Fertilizer	109	74	36	25	73	49
Liquid sludge	121	88	60	45	202	148
Direct excretion	341	290	376	343	482	408

A large portion of the farm was grazed with lactating cows and received regular nutrient inputs via direct excretion. The fields that received direct animal excreta were also supplemented with complete fertilizer (15-5-10), DMS, or both. Nutrient loads from combined sources of direct excretion with fertilizer, sludge or both ranged from 423 to 733 kg N/ha and from 386 to 629 kg P_2O_5/ha (Table 7). Clearly the biggest nutrient contribution originates from direct excretion due to grazing animals.

Table 7. Nutrient contribution from combined sources in the dairy producing facility in Camuy.

Areas that received:	N		P_2O_5		K_2O	
	mean	sd	mean	sd	mean	sd
	----------kg/ha/yr----------					
Fertilizer + sludge	269	146	111	62	271	197
Fertilizer + excretion	428	381	385	399	529	513
Sludge + excretion	590	354	588	392	874	495
Fertilizer + sludge + excretion	731	480	627	475	970	615

Key knowledge gaps related to nutrient management of manures include: (i) how much of the N and P added to fields via DMS and animal excretion is actually available to crops, (ii) how much of the N and P going into lagoon stays within or is lost via other microbial and chemical transformation processes, and (iii) how much N and P is needed to achieve maximum forage yield and quality during grazing conditions. Vicente-Chandler et al. (1983) suggested that that forage under grazed conditions could receive up to 375, 125, and 250 kg/ha of N, P_2O_5 and K_2O as a complete fertilizer 15-5-10. But, the conclusions were not based on plant response to individual nutrient sources, but rather based on animal weight gain. Further work should be centered towards quantification of forage response (biomass and quality) to individual nutrient sources under grazing conditions.

CONCLUSIONS

The DMS generated in dairy producing facilities is an important commodity that can provide generous nutrient amounts when properly applied to grazed forage pastures. There is an excess of nutrients generated on-farm which originate primarily from grazing animals, and is exacerbated by high animal densities, improper distribution of N and P from DMS and fertilizer. As observed in the case study, some farms fertilize with complete fertilizer formulation of 15-5-10 whereas a large proportion of P and K

requirements can be provided by direct excretion and DMS. Soil and plant tissue testing should be used to guide when only N need be applied to supplement nutrient from animal sources. Better spatial distribution of manure should help distribute nutrients to specific fields which are not grazed as intensively.

REFERENCES

Daniels, M., T. Daniel, D. Carman, R. Morgan, J. Langston, and K. VanDevender. 2005. Soil phosphorus levels: Concerns and recommendations. University of Arkansas, Extension Service Publication. Available at: http://www.sera17.ext.vt.edu/Documents/soil_testing_for_manure.pdf

Dou, Z., D.T. Galligan, R.D. Allshouse, J.D. Toth, C.F. Ramberg, and J.D. Ferguson. 2001. Manure sampling for nutrient analysis: Variability and sampling efficacy. J. Environ. Qual. 30: 1432-1437.

Page, A.L., R.H. Miller, and D.R. Keeney. 1982. Methods of soil analysis. Part 2. Chemical and Microbiological Properties. Second edition. Agronomy monograph no. 9. American Society of Agronomy, Soil Science Society of Agronomy. Madison, WI.

Peters, J. and S.M. Combs. Sampling livestock waste for analysis. 2003. In Peters, J., S.M. Combs, B. Hoskins, J. Jarman, M.E. Watson, A.M. Wolf, and N. Wolf (eds). P. 1-4. Recommended methods of manure analysis. University of Wisconsin Extension Service. Cooperative Extension Publishing, University of Wisconsin, WI.

Sharpley, A., B. Foy, and P. Withers. 2000. Practical and innovative measures for the control of agricultural phosphorus losses to water: An overview. J. Environ. Qual. 29-1-9.

Sotomayor-Ramírez, D., G. A. Martínez, R. S. Mylavarapou, O. Santana and J. L. Guzmán, 2004. Phosphorus soil tests for environmental assessment in subtropical soils. *Comm. Soil Sci. Plant Anal.* 35: 1485-1503.

Torres, C. 2005. Balance de fósforo en vaquerías de Puerto Rico. M.S. Thesis. Animal Husbandry Dept. University of Puerto Rico. 152 pp.

USDA-NRCS, 2001. National conservation practice standard. Code 633, Waste Utilization. Field Office Technical Guide, Caribbean Area. USDA-NRCS. Washington, D.C.

Van Horn, H.H., R.A. Nordstedt, A.V. Bottcher, E.A. Hanlon, D.A. Graetz, and C.F. Chamblis. 1991. Dairy manure management: Strategies for recycling nutrients to recover fertilizer value and avoid environmental pollution. FL Coop Ext. Serv. Circ. 1016.

Vicente-Chadler, J., F. Abruña, R. Caro-Costas, and S. Silva. 1983. Producción y utilización intensiva de las forrajeras en Puerto Rico. Bulletin #271. UPR-College of Agricultural Sciences, Agricultural Experiment Station.

Welch, S.A., L.E. Sollenberger, T.M. Ruiz, and C.R. Staples. 1997. Current management of tropical pastures to feed lactating dairy cattle in Puerto Rico. Proc. Carib. Food Crops Soc. 33: 151-163.

2008 Proceedings of the Caribbean Food Crops Society. 44(2):355. 2008

Fertilizer Prices and Controlled Release Fertilizers.

Yuncong Li[1], Edward Evans[1], Sikavas Na-Lampang[1], Xiahui Fan[1], Min Zhang[2], and T. Obreza[3] [1]Tropical Research and Education Center, [3]Soil and Water Science Department, University of Florida, USA, [2]College of Resources and Environment, Shandong Agricultural University, China. yunli@ufl.edu)

ABSTRACT.
World fertilizer prices have shot through the roof over the last year and are rising even more in 2008. From January 2007 to January 2008, diammonium phosphate (DAP) prices rose from $252 to $752/ton. Urea rose from $272 to $415/ton; and muriate of potash (MOP) rose from $172 to $352/ton. Higher fertilizer prices impact farmers greatly. How can we cope with the high cost of fertilizer? We will discuss various approaches. One of our recommendations is to use controlled release fertilizers (CRFs). We will present research data on CRFs and their performance.

KEYWORDS: fertilizer price, controlled release fertilizers, best management practices, soil testing, plant analysis

NOTES:

Caribbean Food Crops Society
Sociedad Caribeña De Cultivos Alimenticos
Societé Caraibe Des Plantes Alimentaures

44TH ANNUAL MEETING
REUNION ANUAL
CONGRÈS ANNUEL

HOSTING ORGANIZATION

University of Florida
Institute of Food and Agricultural Sciences

CO-SPONSORS

Florida A&M University
Florida Cattlemen's Association
IICA
UF/IFAS International Programs
UF/IFAS T-STAR
(Tropical-Subtropical Agricultural Research)
USDA
USDA/APHIS
USDA/CSREES

Miami, Florida
July 13-17, 2008

CARIBBEAN FOOD CROPS SOCIETY 44

Forty Fourth Annual Meeting 2008

Miami, Florida, USA

Vol. XLIV – Number 1

T-STAR Invasive Species Symposium

MEETING HOST:

UF UNIVERSITY of FLORIDA IFAS

PROCEEDINGS
OF THE
44th ANNUAL MEETING

Caribbean Food Crops Society
44th Annual Meeting
July 13-17, 2008

Miami Beach Resort and Spa
Miami Beach, Florida, USA

"Repositioning Caribbean Agriculture:
Challenges and Opportunities for Sustainability"

Reposicionando la Agricultura Caribeña:
Retos y Oportunidades para la Sostenibilidad

Repositionner l'agriculture de la Caraïbe:
Défis et opportunités pour la durabilité

United States Department of Agriculture,
T-STAR Sponsored Invasive Species Symposium

THE ROLE OF THE CARIBBEAN INVASIVE SPECIES SURVEILLANCE AND INFORMATION PROGRAM (CISSIP) IN THE REGIONAL AGRICULTURE REPOSITIONING STRATEGY

Special Symposium Edition
Vol. XLIV – Number 1
Edited by
Waldemar Klassen, Carlton G. Davis,
Edward A. Evans, and Sikavas Na-Lampang

Published by the Caribbean Food Crops Society

ISSN 95-07-0410

Copies of this publication may be obtained from:

Secretariat, CFCS
P.O. Box 40108
San Juan, Puerto Rico, 00940

or from:

CFCS Treasurer
Agricultural Experiment Station
Botanical Garden South
1193 Guayacán Street
San Juan, Puerto Rico 00926-1118

2007-2008 CFCS BOARD OF DIRECTORS AND OFFICERS

BOARD OF DIRECTORS

Chair:	Dr. Hector Santiago, University of Puerto Rico
Vice Chair:	Dr. Kwame Garcia, University of the Virgin Island
Secretary:	Mr. Wilfredo Colon, Universidad del Este, PR
Treasurer:	Dr. Alberto Beale, University of Puerto Rico
President 2007- 2008:	Dr. Jimmy Cheek, University of Florida

REGIONAL REPRESENTATIVES

English:
Mr. Kwame Garcia, UVI, University of the U.S. Virgin Islands
Dr. William F. Brown, University of Florida
Mr. Bruce Lauckner, CARDI, Trinidad and Tobago

Spanish:
Dr. Wilfredo Colon, Universidad del Este, PR
Mr. Jerry Dupuy, Private Sector, Dominican Republic
Dr. Hector Santiago, University of Puerto Rico

French:
Mr. Marceau Farant, INRA, Guadeloupe
Dr. Jean Louis Diman, INRA, Guadeloupe
Dr. Isabelle Jean-Baptiste, AMADEPA, Association Martiniquaise por le Developpement des Plantes Alimentaires, Martinique

Dutch:
Prof. Robert Tjien Fooh, ADEKUS, Suriname

ADVISORY BOARD

Dr. Altagracia Rivera de Castillo, Dominican Republic, President
Dr. Claude Vuillaume, CIRAD, Guadeloupe
Dr. Harry Ozier Lafontaine, INRA, Guadeloupe
Dr. Arlington Chesney, CARDI, Caribbean Region
Dr. Rafael Perez Duverge, IDIAF, Dominican Republic
Prof. Vivian Carro, UPR, Puerto Rico
Dr. Chelston W. D. Brathwaite, IICA, Costa Rica
Dr. Errol Rhoden, HBCU, USA
Dr. Guy Anais, INRA (retired), St. Martin
Dr. Louis Petersen, DOA, U.S. Virgin Islands
Dr. Cassel Gardner, FAMU, Florida
Dr. Wendel Parham, CARDI, Trinidad and Tobago

Caribbean Food Crops Society
44th Annual Meeting
13-17 July 2008

Miami Beach Resort and Spa
Miami Beach, Florida, USA

"Repositioning Caribbean Agriculture: Challenges and Opportunities for Sustainability"

Reposicionando la Agricultura Caribeña: Retos y Oportunidades para la Sostenibilidad

Repositionner l'agriculture de la Caraïbe: Défis et opportunités pour la durabilité

United States Department of Agriculture, T-STAR Sponsored Invasive Species Symposium

The Role of the Caribbean Invasive Species Surveillance and Information Program (CISSIP) in the Regional Agriculture Repositioning Strategy

TABLE OF CONTENTS

WELCOME AND BACKGROUND……1
Dr. Douglas L. Archer, Dr. Hector Santiago Anadon, Dr. David Sammons, Dr. H. Arlington Chesney, and Dr. Larry Arrington

SESSION I: TOWARDS A CARIBBEAN BASIN INVASIVE SPECIES SAFEGUARDING STRATEGY FRAMEWORK: FROM GRENADA 2003 TO MIAMI 2008

REVIEW AND UPDATE: CARIBBEAN INVASIVE SPECIES WORKING GROUP (CISWG)……..8
Mr. Bruce Lauckner

OVERVIEW AND STATUS UPDATE: MULTI-DONOR FUNDING INITIATIVES FOR CISSIP……...16
Ms. Margaret Kalloo

USDA/APHIS INITIATIVES IN SUPPORT OF CISSIP ……..17
Mr. Wayne De Chi, Mr. Russell Duncan and Mr. Robert Balaam

THE GEF/CABI PROJECT ON MITIGATING THE THREAT OF INVASIVE ALIEN SPECIES IN THE INSULAR CARIBBEAN ……..27
Dr. Ulrike Krauss

THE FRENCH OVERSEAS DEPARTMENT INVASIVE SPECIES INITIATIVES IN THE CARIBBEAN BASIN ……..32
Mr. Jean Iotti, Mr. Emmanuel Sutter, and Mr. Philippe Terrieux

CIRAD INVASIVE SPECIES INITIATIVES IN THE CARIBBEAN BASIN ……..47
Dr. Emmanuel Wicker , Dr. Catherine Abadie , Dr. Jean Heinrich Daugrois , Dr. Luc Baudouin, Dr. Michel Dollet, Dr. Marie-Françoise Zapater, Mr. Claude Vuillaume and Dr. Pierre-Yves Teycheney

T-STAR INITIATIVES IN SUPPORT OF INVASIVE SPECIES EFFORTS IN THE GREATER CARIBBEAN REGION……57
Dr. Martha R. Roberts

SESSION II: PANEL DISCUSSION

CLOSING THE INSTITUTIONAL AND TECHNICAL FRAMEWORK GAPS FOR AN EFFECTIVE CISSIP……69
Dr. Carlton Davis, Dr. H. Arlington Chesney, Dr. Gene Pollard, Ms. Margaret Kalloo, Dr. Moses Kairo, Mr. Claude Vuillaume, Mr. Robert Balaam, Dr. Timur M. Momol

SESSION III: TECHNICAL ISSUES RELATING TO INVASIVE SPECIES THREATS IN THE CARIBBEAN BASIN

RED PALM MITE SITUATION IN THE CARIBBEAN ……..80
Dr. Amy L. Roda, Dr. Ashley Dowling, Dr. Cal Welbourn, Dr. Jorge E. Peña , Dr. Jose Carlos V. Rodrigues , Dr. Marjorie A. Hoy, Dr. Ronald Ochoa, Russell A. Duncan and Wayne De Chi.

CITRUS GREENING UPDATE ……..88
Dr. Harold W. Browning

2009 FLORIDA CITRUS PEST MANAGEMENT GUIDE: HUANLONGBING (CITRUS GREENING)……89
Dr. R. H. Brlansky, M. M. Dewdney, M. E. Rogers and K. R. Chung

BLACK SIGATOGA AND MOKO: IMPACT AND SPREAD OF TWO DESTRUCTIVE BANANA DISEASES IN THE CARIBBEAN BASIN ……...94
Dr. Randy C. Ploetz

THE CHILLI THRIPS, *SCIRTOTHRIPS DORSALIS*: CURRENT STATUS IN THE GREATER CARIBBEAN REGION.....103
Dr. Waldemar Klassen and Dr. Dakshina R. Seal

DEVELOPING STRATEGIC RESEARCH FOR BIOLOGICAL CONTROL OF NEW PEST THREATS: THE PASSION VINE MEALYBUG, *PLANOCOCCUS MINOR,* AS A CASE STUDY 118
Dr. Moses T. K. Kairo, Dr. A. Francis and Dr. A. L. Roda

HIGHLIGHTS OF PART ONE OF SESSION THREE.....124
Mr. Everton Ambrose

GIANT AFRICAN SNAIL IN THE CARIBBEAN SUB-REGION.....126
Dr. Gene V. Pollard, Mr. Bret Taylor and Ms. Angela Fields

CARAMBOLA FRUIT FLY SITUATION IN LATIN AMERICA AND THE CARIBBEAN.....135
Ms. Alies Van Sauers-Muller

ADDRESSING ANIMAL HEALTH ISSUES IN CARICOM MEMBER STATES.....145
Dr. Lloyd A. W. Webb

AVIAN INFLUENZA: PANDEMIC PREPAREDNESS FOR SMALL AGRIBUSINESSES.....151
Dr. Joanne M. Brown

MICROBIAL THREATS TO THE SAFETY OF FOOD PRODUCTS IN TRADE BETWEEN THE LATIN AMERICA - CARIBBEAN REGION, THE USA, AND OTHER COUNTRIES 162
Dr. Lloyd A. W. Webb

DISCUSSION OF TECHNICAL ISSUES.....170
Ms. Florita Kentish, Moderator

CLOSING REMARKS AND ADJOURNMENT 175
Dr. John Fernandez Van Cleve

2008 Proceedings of the Caribbean Food Crops Society. 44(1):1-6. 2008

WELCOME AND BACKGROUND

OPENING REMARKS by Dr. Douglas L. "Doug" Archer, *Associate Dean for Research and Professor of Food Safety, Florida Agricultural Experiment Station, University of Florida, 1022 McCarty Hall, P.O. Box 110200, Gainesville, FL 32611-0200; Phone: 353-392-1784; Email: dlarcher@ufl.edu* .

Good Morning! My name is Doug Archer. This morning I am serving as the moderator of the Welcome and Background Session. I am an Associate Dean for Research and the current Director of the T-STAR Program at the University of Florida/Institute for Agricultural Sciences. I have held this post for 3 months, so it's very new to me. So this welcome means more to me than a just a simple welcome; it's probably the Organization's welcome as well.

If you will be speaking later and using a Power Point presentation, please make certain that the IT person has that Power Point prior to you giving your talk; so just bring it over there and have it set up. Also there will be simultaneous translations in Spanish, French and English, and the translation devices can be picked up outside the door here.

I don't expect too much controversy; I don't think we will have a question and answer session since this is a welcome, and I not sure how controversial a welcome can be. However, possibly, we can find one.

The first person to give you a welcome is Dr. Hector Santiago Anadon, who serves as the Associate Dean and Deputy Director of the Agricultural Experiment Station at the University of Puerto Rico – Mayaguez Campus. He has held this post since 2005. He holds a doctoral degree in poultry genetics and physiology, and he serves as Chair of the Board of Directors and Chief Executive Officer of the Caribbean Food Crops Society.

OPENING REMARKS by *Dr. Hector Santiago Anadon*. Researcher, Department of Animal Industry and Associate Dean and Deputy Director, Agricultural Experiment Station, Mayaguez Campus of the University of Puerto Rico.

Thank you and good morning! I will be very brief in order to get the Symposium started. The CFCS is grateful to have, during the course of its annual meeting, an invasive species symposium.

Invasive species are a common problem to many of our countries, and pose a tremendous threat to the agricultural sector in our Region. In many cases, invasives can affect production by reducing yields and profitability of crops due to an increase in management practices and the use of agrochemicals to control pest infestation. In most scenarios an integrated pest management approach is the best way to control and to diminish the negative affects caused by invasives.

Problems with invasives are more prevalent today despite the control exerted by regulatory agencies in our countries to limit the means by which these exotic organisms spread. In Puerto Rico, for example, invasives are keeping the researchers at our Experiment Station very busy; since in the last five years we have had to deal with the introduction to our shores of the Black Sigatoka – a disease of plantains and bananas - and the coffee berry borer that is affecting our coffee. And more recently, the red palm mite has posed an enormous threat to the agricultural sector and to our tropical landscape.

I want to recognize the contribution of the Tropical and Subtropical Agricultural Research Program, T-STAR, for their continuous sponsorship of this Symposium over the last couple of years. This Symposium provides the forum to the T-STAR grantees and the researchers of other institutions to share the results of the research conducted on invasives in the Caribbean Region. Before concluding, I want to acknowledge the Caribbean Invasive Species Working Group, and in particular, Dr. Carlton Davis and Dr. Waldemar Klassen for their leadership and dedication for their planning, organization and execution of this Symposium. I thank you, all, for coming.

Dr. Archer. The next to welcome you is Dr. David Sammons. Currently Dr. Sammons is the Director of International Programs, Institute of Food and Agricultural Sciences, University of Florida. His Office provides administrative leadership and support for international activities in the teaching, outreach and research missions of the University of Florida/IFAS. For a 2-year period prior to his appointment at the University of Florida, Dr. Sammons was on a special assignment with the USAID in Washington, DC, serving as senior advisor for University Relations, Agricultural Research, Training and Outreach in the Office of Agriculture. He has a wide range of international experiences, and he is perfect to welcome us here this morning: Dr. Sammons.

OPENING REMARKS by Dr. David Sammons, Director of International Programs, Institute of Food and Agricultural Sciences, University of Florida.

Thank you, Dr. Archer. Two years ago in 2006, I made my move from my previous assignment with USAID to the University of Florida; and before I had arrived in Florida, I received a call from someone I had never met before, but who is known to all of you, Dr. Bill Brown. Bill said: "I would like you to be on a Symposium that T-STAR is organizing. I said: "What is T-STAR?" and he explained T-STAR to me. I said what do you want me to talk about? He said: "I want you to talk about invasive species and about this working group"; and he sent me documentation as background, and asked that I read it and be prepared to participate in a Panel Discussion at the CFCS meeting in San Juan. So I agreed. When I arrived in San Juan, I was not even an employee of the University of Florida at that time. My official start date was about 2 weeks later. Bill said that he wanted me to be involved with invasive species from day one and it was actually day 1 minus two weeks that I became involved. I have stayed involved with T-STAR and invasive species work ever since and have come to appreciate not only the good work that T-STAR is doing but the good work that all of you are leading throughout the Region in trying to integrate knowledge and to exchange information about the important pest problems that confront all of us, and to deal with them proactively to avoid more widespread damage to the agricultural infrastructure that all of us care so much about.

Early in my tenure at the University of Florida, Dr. Larry Arrington, who is sitting at this table, and from whom you will hear in a few minutes, called me into his office. He said I wish to illustrate for you why it is so important to have international leadership in IFAS. He noted that there was a threatening pest organism in the Region approaching Florida as a potential threat to Florida Agriculture. He said that he had proactively sent a team of Extension Specialists to this South American country to learn from the extension pest management specialists in that country, the knowledge and procedures they had for countering this pest; so that when it entered Florida, we would be prepared. Well, in fact as we had anticipated, this pest did arrive, and literally

within days we had a 4-page brochure ready to distribute to growers in the state who were threatened by this pest organism – thanks to our colleagues in this South American country. I cite this simply to illustrate the importance of staying connected, of staying networked, of interacting with each other - sharing knowledge, sharing experience, working together towards these threats that confront us all. So I welcome all of you to this session and look forward to learning from you and hearing from you about the work that you are doing.

Incidentally, I want you to know that the Caribbean Invasive Species Working Group will meet on Friday. This is a by-invitation-only meeting; and I hope that all of you who are invited will attend. This is going to be an important – a pivotal – meeting with respect to our invasive species work. Also tomorrow morning from 8 am until noon in this room, we are going to have a technical session on Crop Protection and Pest Management that I think will be of interest to many of you as well. Welcome!

Dr. Archer. The next to welcome you is Dr. H. Arlington Chesney, a native of Guyana, and Executive Director of the Caribbean Agricultural Research and Development Institute or CARDI, which is based in Trinidad and Tobago. Prior to joining CARDI, Dr. Chesney held a number of important positions in the Interamerican Institute for Cooperation in Agriculture, IICA. Dr. Chesney spent 14 years as Operations Manager and Managing Director of the Caribbean Food Corporation, and prior to that 16 years working in Guyana's Government rising from Agricultural Assistant to a number of research and management positions to Chief Agricultural Officer. Dr. Chesney!

OPENING REMARKS by Dr. H. Arlington Chesney, Executive Director, CARDI.

Dr. Archer, Dr. Santiago, Dr. Cheek, Dr. Sammons, Dr. Arrington, ladies and gentlemen, this is my first appearance before you as Executive Director of CARDI, and my first opportunity to participate with you in invasive species issues. But first, let me inform all of you that Mr. Bruce Lauckner, who cannot attend this meeting because of the sudden onset of illness, is out of the hospital and resting at his home.

CARDI has been in support of this invasive species initiative since the 2003 CFCS meeting in Grenada, and we will continue to be supportive of it. Bruce Lauckner, who has been chairing the Caribbean Invasive Species Working Group, and the whole of CARDI, are committed to the whole process of dealing with invasive species. We participated in developing CRISIS, the Caribbean Regional Invasive Species Intervention Strategy; CISSIP, the Caribbean Invasive Species Surveillance and Information Programme, a project to help us attack the problems; and we participated in the not yet successful efforts to find funding for CISSIP. We want to assure you that our support this process will continue.

We are currently in the process of restructuring and re-invigorating CARDI in order to be better able to support its clients and strategic partners, and of course, our stakeholders who provide us with our funding base – and in that context to play a much larger role not only in invasive species but in the whole aspect of plant health. If we work in invasive species, then we must work in a much wider context of plant health.

I want to suggest something about CISSIP. We have made a number of efforts to secure the totality of funding for CISSIP, and so far we have not been able to achieve it. I think this topic is important to all of our institutions, and maybe what we need to do is to pull out pieces of the project and assign each to an individual institution to be placed within their existing

programs – so at least we could make a start and show the donors that we are working. Somehow the donors are very reluctant; and they prefer to deal with an emergency rather than with its prevention. Perhaps this is something we could discuss on Friday at the meeting of the Caribbean Invasive Species Working Group.

Finally I would like to thank the University of Florida and the T-STAR Program for their continuing support, maybe for their resilience and, perhaps, for their patience in dealing with so many various persons in the Region, who not only speak English with a different accent, but some of us who speak Spanish and some French, and we sometimes have difficulty communicating even amongst ourselves. So thank you T-STAR for your support. Carlton, you have been very supportive, Waldy, also, and we look forward to working with you as we combat this ever-growing problem of invasive species. Thank you very much Mr. Chairman.

Dr. Archer. Next we have Dr. Larry Arrington. Dr. Arrington is Dean for Extension and Director of the Florida Cooperative Extension Service. Dr. Arrington manages the overall Program of the Florida Extension Service, which is supported by both UF/IFAS and Florida A&M University. Dr. Arrington reports to the Senior Vice President for Agriculture and Natural Resources, Dr. Jimmy Cheek, who is also here to welcome us this morning. The University of Florida extension programs are conducted through 18 academic departments, 13 Research and Education Centers and 67 County offices; so Larry is an incredibly busy individual. Dr. Arrington!

OPENING REMARKS by Dr. Larry R. Arrington, Dean for Extension, IFAS, University of Florida.

Good morning! Let me add my welcome to each and every one of you! We are so glad to have you in our State for this important meeting. As we listened to the presentations yesterday, we learned about a number of challenges and issues that threaten the stability of agriculture throughout the Caribbean Region; whether they are energy costs, marketing difficulties, food costs, food safety, trade – it went on and on as we listened to the presentations yesterday. But, probably none of those are as important as the pest and disease issues – the invasive species issues - that we face around this Region. And certainly those issues know no country boundaries in any way, shape, or form. Certainly, T-STAR has been and continues to be an important part of the solution of diseases that we are facing, and I just want to acknowledge the role that T-STAR has played.

Doug spoke to you about the cooperative extension system in Florida that I am responsible for. Our faculty are located throughout the State and they are dedicated to educating our citizens about these new pest and disease issues that we continually confront. In Florida, we are compelled to say that there is a new bug or disease issue every month. We are very proud that on a several occasions, even before the bug arrived, we had prepared educational materials that we could and did distribute to our clientele.

We are not merely committed to working with our farm clientele as we face disease pressures, invasive species pressures, we are also heavily engaged with our urban citizens, because we found that those folks, also, need to understand and cope with the devastating diseases that we face in this State.

I hope that you will stop by one of the booths and learn about the Caribbean Regional Diagnostic Network. This is one of the four major components proposed for CISSIP, which Dr.

Chesney referred to, and we believe that this program is critical. Several countries have signed on to participate in this network; and Dr. Chesney, we commend you for trying to find the money to pay for implementing and operating the Network, since money to pay for it certainly is a critical issue.

We believe that when the Caribbean Regional Network is fully in place, it will help to assure us of accurate and rapid diagnostics, it will help us with communications, it will help us with mapping pest distribution throughout the Region. So, on behalf of the University of Florida, we are very committed to that effort, and we will do what we can to make that happen throughout the Region. Again, welcome to Florida! If you have questions about the Extension system, I would love to sit down and talk with you.

Dr. Archer. Next to welcome you is Dr. Jimmy Cheek. He is the 2008 President of the Caribbean Food Crops Society and the Senior Vice President for Agriculture and Natural Resources of the University of Florida. Dr. Cheek was appointed Senior Vice President in January 2005; as such he is the administrative head of the Institute of Food and Agricultural Sciences – so he is in charge of all academic research, teaching, Extension and outreach programs. Prior to holding his current position, Dr. Cheek was Dean of the College of Agriculture and Life Sciences from 1999 – 2004; and we are very proud of that college. It is the 4th largest college of its type in the country. It has 1200 graduate and 3800 undergraduate students. So with that, Dr. Cheek!

OPENING REMARKS by Dr. Jimmy Cheek, Senior Vice President for Agriculture and Natural Resources of the University of Florida..

Thank you, Doug. This is a very precarious situation because Joan Dusky is in charge of this segment of the program scheduled to end at 8:30, and it is now 8:30. So, Joan, I guess you are going to kick me off before I have a chance to say anything – or are you going to let me go on for a few minutes?

Dr. Joan Dusky, Moderator and Associate Dean for Extension, IFAS, University of Florida. I will let you go on.

Dr. Jimmy Cheek. Well on behalf of the University of Florida and the State of Florida, we welcome you to this T-STAR Symposium. T-STAR is a very important part of the portfolio of research and extension that we do at the University of Florida and I know that you do in various parts of the Caribbean.

Invasive species have a history of coming to Florida from the Caribbean and the Pacific, and some move from Florida to the Caribbean and elsewhere.

I was in Hawaii about three weeks ago and met with the people there about T-STAR. This year we were very fortunate to get T-STAR placed in the Farm Bill, and that is very important to us because the appropriation for T-STAR does not have to be an "earmark" year after year. Also this is critically important because both the Democrats and Republicans are talking about having no earmarks. The difficulty, though, with it being in the Farm Bill is that the T-STAR Progran is authorized but the corresponding funds are not appropriated; and so we will have to work every year to get money for it. But it will be much easier to do that than to get an earmark. So that is a major accomplishment for the University of Puerto Rico, the University of the Virgin Islands, the University of Florida, the University of Hawaii, and the University of Guam – and in our case – all of the Caribbean worked very hard to get this accomplished.

Invasive species – I don't think I need to say to you - are a major issue in Florida. Larry said that we get either an insect or a disease every month, and that is true; and they devastate various things that we try to grow in Florida. I mentioned to you yesterday when I spoke about citrus greening disease – it's a major challenge to us.

About three years ago at the University of Florida, we developed an Emerging Pathogens Institute. Our T-STAR work was instrumental in thinking about the idea of an Emerging Pathogens Institute. We have a Director for this Institute, Dr. Glenn Morris. He is a medical doctor and epidemiologist by training. Doug Archer had him down recently to visit our Citrus Research and Education Center, and he came back with an enhanced understanding of greening. He understood how this disease was very important to the State of Florida, and therefore very important to the emerging pathogens initiative at the University of Florida; and all those have ties back to T-STAR.

I think that in the next session of this Symposium and during the rest of the day, you are going to learn from each other the things that are happening with invasive species. We have plenty of work to do. I think that our major challenge is that we do not have enough money to do much-needed work. But certainly you are working in a very important area – one that is critical to food and agriculture in the Caribbean Region. We thank you for being here, and also we welcome you to the University of Florida! Doug.

Dr. Archer. Thank you, Dr. Cheek. To conclude this welcoming session, I would like to add my welcome from the University of Florida. I took over the T-STAR Program from Bill Brown. We all owe Bill Brown a huge debt of gratitude. Bill worked to build these programs throughout his career, and we all wish him well in his new endeavors. One of the things that I am learning is that we are living in a state where – by any reckoning - nothing should grow at all. The bug of the month, the new insect, is real. It does amaze me that we can actually grow crops and sell them because there is something that is going to gobble them up. Thank Goodness we are building the network that Dave Sammons mentioned; so that we can act as an early warning for you and you can act as an early warning for us.

We will do everything possible to maintain our commitment to T-STAR, and we will try to grow the program over time, and certainly not allow it to shrink. So, thank you, and welcome again; and with that I will turn it over to Dr. Dusky.

2008 Proceedings of the Caribbean Food Crops Society. 44(1):7. 2008

SESSION I: TOWARDS A CARIBBEAN BASIN INVASIVE SPECIES SAFEGUARDING STRATEGY FRAMEWORK: FROM GRENADA 2003 TO MIAMI 2008

Dr. Joan Dusky. I am Joan Dusky Associate Dean for Extension at the University of Florida. At 3 minutes before the end of each speaker's talk I will give the signal to wrap up the talk so that we stay on time and provide for one or two questions from the audience. I wish to introduce Ms. Dionne Clark-Harris, who is our rapporteur. Our first speaker is Dr. Arlington Chesney, Executive Director of CARDI. He will give us an update of the activities of the Caribbean Invasive Working Group.

Dr. Arlington Chesney. Thank you Madam Chair. Let me say that I will not give you the opportunity to give me the 3 minute warning. As you know, this topic was to be addressed by Mr. Bruce Lauckner, who unfortunately suffered a sudden illness and could not be here. However Bruce's extensive abstract appears on page 29. In addition, Margaret Kalloo, who is the next speaker, advised me very pleasantly that in order for her to talk about CISSIP and the efforts to find funding for it, she has to go back into the history of CISWG, the Caribbean Invasive Working Group. So my task is very short: it is to ask you to read Bruce's abstract, which appears on page 29 and to listen to Margaret's talk. So after listening very attentively to Margaret speak, I will be very happy to answer your questions. Thank you very much.

EDITORS' NOTE: Mr. Bruce Lauckner provided the manuscript of his talk and it follows below.

Proceedings of the Caribbean Food Crops Society. 44(1): 8- 15. 2008

SESSION I: TOWARDS A CARIBBEAN BASIN INVASIVE SPECIES SAFEGUARDING STRATEGY FRAMEWORK: FROM GRENADA 2003 TO MIAMI 2008

REVIEW AND UPDATE: THE CARIBBEAN INVASIVE SPECIES WORKING GROUP (CISWG)

Bruce Lauckner, *Head Strategic Alliances /Biometrician, Caribbean Agricultural Research and Development Institute, St Augustine, Trinidad and Tobago. Phone: 1-868-645-1205/6/7; Fax: 1-868-645-1208; blauckner@cardi.org*

ABSTRACT: The Caribbean Invasive Species Working Group (CISWG) was formed following an initiative of the Caribbean Food Crops Society when it held a special 1 day symposium on invasive species at the 39th Annual Meeting in Grenada in 2003. At this session scientists, policy makers and trade specialists from throughout the Greater Caribbean Region discussed the issues caused by introduced pests and pathogens.

CISWG is a networking and information sharing facility chaired by CARDI, which has been officially recognised by the CARICOM Council for Trade and Economic Development (COTED). CISWG has also been officially recognised by the non CARICOM member governments of Costa Rica, Dominican Republic, France and the United States of America. The major purposes of CISWG are outlined. The geographical area of interest is all countries in the Caribbean Sea, all countries with borders on the Caribbean Sea, as well as countries in northern South America and the United States of America. Apart from CARDI the other formal members of CISWG are (in no particular order), CARICOM Secretariat, CABI, CIRAD (France), France - Service de la Protection des Végétaux, Direction de l'Agriculture et de la Forêt, Costa Rica Ministry of Agriculture, IDIAF (Dominican Republic), The Nature Conservancy (USA), FAO, IICA, PAHO, USDA/APHIS, University of the West Indies, Florida A&M University, University of Florida, and the University of Puerto Rico. In addition all governments in the Region belonging to the Organisation of American States have been invited to have an official representative for CISWG and many of these have nominated a representative.

The first major activity undertaken by CISWG was a workshop held in Trinidad in June 2004 entitled "Facilitating Safer US-Caribbean Trade: Invasive Species Issues." This meeting identified the key issues which were outlined in a document prepared by CISWG entitled "Caribbean Regional Invasive Species Intervention Strategy" - the "CRISIS Document".

The CISWG members have developed a project proposal entitled "Caribbean Invasive Species Surveillance and Information Programme" (CISSIP), which consists of four major components and a number of minor components. The major components are (i) Pest Survey and Inspection Programme (PSIP), (ii) Caribbean Regional Diagnostic Network (CRDN), (iii) Invasive Species Information System (ISIS), and (iv) Public Education Programme (PEP).

Other current activities underway by CISWG include the coordination of regional efforts to control the Red Palm Mite *(Raoiella indica);* a Caribbean Pathway Analysis which is examining the pathways taken by invasive species into and within the Region, support for the Caribbean Plant Health Directors Forum, and also support to an invasive species project pertaining mostly to marine environments, being executed by CABI, and funded by the Global

Environment Facility of the World Bank and the United Nations Environment Programme.

KEY WORDS: Regional Invasive Species Intervention Strategy, coordination, pest survey

INTRODUCTION

Invasive species have probably been a threat to natural ecosystems for millions of years, but the problem has become especially acute in recent decades as humans and their goods rapidly and continuously criss-cross the planet by means of intercontinental aircraft, and ocean-going vessels.

In the 19th century, many of the invasions were caused by careless or thoughtless actions. For example the introduction of the mongoose to the Caribbean to control rats and snakes. In more recent years accidental invasions have become more frequent and more damaging. In the 1990s, the Pink Hibiscus Mealy Bug (*Maconellicoccus hirsutus* – Green) arrived in Grenada and quickly spread to many other islands and to North and South America with devastating effects on the preferred host plants. In this decade the Red Palm Mite (*Raoiella indica* Hirst) seems to be destroying the region's coconut trees after having first arrived in the French Caribbean.

The above examples were almost certainly caused by human activity rather than any natural process such as wind, sea or bird transport. In attempting to control or reduce this undesirable traffic most countries have legislation in place which can regulate trade in commodities from countries which have pests not present in the importing countries. However, countries must abide by the Sanitary and Phytosanitary Agreement and the rules of the World Trade Organization.

Thus control of invasive species is necessary for a country or region to protect its trade in agricultural commodities. In 2003, the Caribbean Food Crops Society (CFCS) at its 39th Annual Meeting in Grenada took the initiative to develop a full one day plenary symposium entitled "Challenges and opportunities in protecting the Caribbean, Latin America and the United States from invasive species". Nineteen presentations were made and a special volume of the proceedings was published (Klassen *et al.,* 2003).

OUTCOME OF THE GRENADA CFCS MEETING

During the 39th CFCS meeting in Grenada, some of the scientists, policy makers and trade specialists who attended the one-day plenary session on invasive species held a number of breakout sessions. These sessions led to the formation of a group of scientists from different institutions who agreed to work together on the invasive species issues.

The first actions of this group were to develop a list of proposed invasive species projects and also to develop a number of invasive species policies and recommendations. These proposals and recommendations were developed, after the meeting, in electronic communications between the group of scientists and are detailed in the above mentioned special volume of proceedings (Klassen *et al.,* 2003).

Perhaps the most important outcome of the Grenada symposium was the initial drafting of the 'Caribbean Regional Invasive Species Strategy (CRISIS)'. This initial draft was done by Edward "Gilly" Evans of the University of Florida, Everton Ambrose of IICA and Moses Kairo of CABI and was based on the policy recommendations developed during and after the meeting.

WORKSHOP IN TRINIDAD, JUNE 2004

The working group of scientists formed after the CFCS meeting in Grenada was instrumental in an important workshop, which took place in Port of Spain, Trinidad in June 2004. This workshop was entitled 'Facilitating Safer US-Caribbean Trade: Invasive Species Issues'. The sponsoring organizations were (in alphabetical order) CAB International (CABI), Caribbean Agricultural Research and Development Institution (CARDI), Caribbean Development Bank (CDB), Food and Agriculture Organisation of the United Nations (FAO), Inter-American Institute for Cooperation on Agriculture (IICA), Ministry of Agriculture, Land and Marine Resources (MALMR) of Trinidad and Tobago, University of Florida (UF) and University of the West Indies (UWI). The proceedings of this meeting (Klassen *et al* 2004) are available from CARDI and the University of Florida.

FINALISATION OF CRISIS DOCUMENT

The symposium in Trinidad identified the need to complete and finalise the CRISIS document and following further work by Everton Ambrose, Martha Roberts and others, the draft document was presented to the 19th meeting of the CARICOM Council for Trade and Economic Development (COTED) held in Guyana in May 2005. COTED noted the strategy and mandated CARDI to circulate the document to CARICOM member states for review and comments. This was done and the Caribbean Regional Invasive Species Intervention Strategy was adopted at the 21st COTED meeting held in Trinidad in May 2006 as a regional strategy.

The goals of the CRISIS strategy are:

- Prevent the introduction of new invasive species
- Reduce the impact and further spread of invasive species already present
- Develop harmonised policies and regional cooperative frameworks
- Develop and maintain effective coordinated networks of information
- Build the management and research capacity
- Raise awareness of the dangers posed by invasive species with economic interests (operating in agriculture, fisheries, forestry, environment, public health, export/import, banking), military, local non-government organisations, policy makers and the general public
- Facilitate access to and retention of markets
- Promote interaction among all stakeholders including the private sector, local, national, regional and international entities.
- Develop technical capacities to identify, prevent, monitor and manage potential invasive species and major pathways of introduction

OFFICIAL RECOGNITION OF CISWG

Following the above events and the mandate from COTED for CARDI to circulate the CRISIS strategy document, meetings of the group of scientists were chaired by CARDI. The scientists proposed the name 'Caribbean Invasive Species Working Group' (CISWG) and the group was recognised by COTED. The COTED also 'endorsed CARDI as the lead agency in building the necessary strategic partnerships for the control and management of invasive species in the region'

The current members of CISWG (July 2008) are:

- CARDI (Chair)
- CAB International
- CARICOM Secretariat
- CIRAD (French Agricultural Research Centre for Agricultural Development)
- Costa Rica, Ministry of Agriculture
- FAO
- Florida A&M University
- France, Service de la Protection des Végétaux, Direction de l'Agriculture et de la Forêt, Ministère de l'Agriculture, de l'Alimentation et de la Pêche,
- IDIAF (Dominican Republic Institute for Agriculture and Forestry Research)
- IICA
- The Nature Conservancy
- PAHO (Pan American Health Organisation)
- University of Florida
- University of Puerto Rico
- University of the West Indies
- USDA/APHIS

As can be seen from the list of current members, CISWG is not restricted to CARICOM countries and agencies. By their very nature, invasive species do not recognise political and national divisions. Therefore, CISWG is a network covering the wider Caribbean (English, Spanish, Dutch and French speaking). From the outset of these activities (i.e., the Grenada CFCS meeting) the United States has also been very prominent; chiefly through institutions and agencies operating in the State of Florida, which is a major pathway for invasives entering from and traveling to the Caribbean.

It is important to realise that CISWG is not a Board or an Institute with formal terms of reference, but a mechanism for networking, policy development and programme development. Countries in the region of operation (the wider Caribbean) have been invited to name a person as an official liaison agent with CISWG. These countries are also invited to attend CISWG meetings. Many countries have named a representative to liaise with CISWG, but even those that have not are invited to attend meetings and attempts are made to keep them informed of developments and activities of CISWG.

Countries who have named a representative include Costa Rica, Dominican RepublicFrance and the USA who are not members of CARICOM. This emphasises the policy of CISWG to include all countries in or near the Caribbean whatever political grouping they may or may not belong to.

CISWG holds a formal meeting at least once per year and an electronic maiking list (listserv) is maintained.

The purposes of CISWG can be summarised as follows:

- To develop strategies which safeguard the Caribbean against attacks by invasive alien species.
- To prevent as far as possible, the introduction of invasive alien species.
- To develop management, containment or eradication strategies, as appropriate, for those invasive alien species which succeed to enter the region.
- To share information on invasive species, both alien and indigenous, and on attempts to control them.
- To focus primarily on invasive species which present a threat to agriculture and trade in agricultural commodities and products.

CARIBBEAN INVASIVE SPECIES SURVEILLANCE AND INFORMATION PROGRAMME (CISSIP)

After the completion of the CRISIS strategy it was obviously necessary to determine how CISWG could assist to operationalise the strategy. In an attempt to do this, CISWG has developed a proposed programme known as CISSIP (Caribbean Invasive Species Surveillance and Information Programme) which, if funded and established, will partly implement the CRISIS strategy.

CISSIP will facilitate rapid diagnosis and timely collection, analysis and dissemination of information on pests and disease threats throughout the Caribbean. There will be four major components supported by a number of auxiliary components. The major components are described below:

1. Pest survey and inspection programme (PSIP). This will establish a regional target pest list that will be the basis for regional pest surveys and provide focus to port of entry inspection activities on commodities moving into or within the region.
2. Caribbean Regional Diagnostic Network (CRDN). This will use web-based distance diagnostic technology to link strengthened diagnostic capabilities in the region. This will assure rapid and proper diagnosis, communication, decision-making and implementation of emergency measures. An effort is underway to construct the CRDN with available resources. Thus Florida, Puerto Rico, the Dominican Republic and Haiti have implemented the use of the Distance Diagnostic and Identification System (DDIS), which was pioneered by the University of Florida Cooperative Extension Service. A secure server dedicated to facilitate the work of this network is provisionally located on the campus of the University of Florida. The latter with funding from the USDA T-STAR Programme has been providing training to scientists and technicians in the Dominican Republic, while USAID has funded the diagnostic laboratory and training in Haiti. USDA/APHIS has procured microscopes and software for one web-connected diagnostic laboratory in each of five countries, and the CARICOM secretariat is in process of facilitating the allocation of these resources to appropriate CARICOM countries.
3. Invasive species information system (ISIS). This will link to existing information systems in the wider Caribbean and provide detailed current information on pest/pathogen threats both external and internal to the region. The system will contain

target priority lists of invasive alien species for each country and the region. Other information will be available subject to the authority of the participating country; this will include real-time pathway status updates, invasive alien species interception data from ports of entry and reports of new pests. The system will also include a global reference database on important pests to the region and invasive species alerts to facilitate timely initiation of protective and mitigation measures.

4. Public education programme (PEP). The education programme will disseminate accurate information for use by governments, media, agencies, industries and the public concerning invasive species and best practices for prevention, eradication, control and management.

The auxiliary components of CISSIP will provide project management, in-service training to conduct the major components and advanced graduate training to develop professionals to continue the programme in the future.

The proposed total budget for CISSIP is nearly US$16M over 5 years. CARICOM submitted the proposal to the Agricultural Donors Conference, which was held in Port of Spain in June 2007. This was followed up with a formal proposal to the Inter-American Development Bank for funding. However, to date, funding has not been secured. It remains a major task of CISWG to obtain funds. This may have to be done in several parts as few funders are likely to have resources to cover the whole budget. There is also the problem that, notwithstanding the environmental, economic and social damage being caused, the urgency of the need to mitigate against invasive species needs to be more widely appreciated.

SOME OTHER CISWG ACTIVITIES

CISWG's networking attempts to ensure awareness of and participation in all invasive species activities in the Caribbean which present a threat to agriculture and trade in agricultural commodities and products. There has been an emphasis on crops rather than livestock, because the chief veterinary officers and CARIBVET (Caribbean Animal Health Network) are very active in the mitigation and control of alien species which threaten livestock production.

Three activities in which CISWG is participating are briefly described below:

1. Control of Red Palm Mite (*Raoiella indica* Hirst). This mite entered the Caribbean in 2004 and was first reported in Martinique. It then spread to St. Lucia (2005), Dominica (2005) and Trinidad (2006). It continued to spread rapidly throughout the region and into south Florida where it is now well established along the Atlantic.

Yield losses at some major coconut estates in Trinidad are reported to be well over 50% (probably about 70%) which is having a very profound effect on the coconut industry including coconut beverages and coconut ice cream. In addition to this the impending loss of coconut palms from Caribbean beaches will be a severe environmental blow to the tourist industry.

A Red Palm Mite Working Group was set up, coordinated by CARDI as chair of CISWG. Moreover, at the April 2008 meeting of Caribbean Plant Health Directors, Red Palm Mite and Giant African Snail (*Achatina fluica* Ferussac) were identified as priority major threats and

CARDI (as chair of CISWG) was asked to facilitate networks of scientists working with both these pests. This new network for Red Palm Mite has been formed as an electronic group with a workspace on the internet and will continue the work of the previous red palm mite working group.

Control programmes for the red palm mite are underway by CABI (with funding from USDA/APHIS), University of Florida and the governments of St. Lucia, Dominica, Grenada, Jamaica and Trinidad and Tobago. CARDI is seeking help from countries where the red palm mite is native to identify a biological control agent(s) which can be utilised in the Caribbean. The coordination by CARDI/CISWG is aimed at information sharing between all these various efforts, avoiding duplication of resources and trying to ensure that findings by one party are quickly known by others as control of this very damaging pest is crucial.

2. CISWG Caribbean Pathway Analysis. This is being executed on behalf of CISWG by USDA/APHIS at the Plant Epidemiology and Risk Analysis Laboratory, Raleigh N.C., and is attempting to determine the paths taken by invasive species within the Caribbean and into and out of the Caribbean into other countries with emphasis on the USA. Some components are:

- Quantitative analysis of risk posed by airline passengers
- Quantitative analysis of mail and express courier pathways
- Natural spread of pests in the Caribbean
- Characterisation of tourism/movement of people in the Caribbean
- Characterisation of trade in the Caribbean

This analysis has been in progress for some months and is producing some interesting results. A drawback is the quality of information available to determine some of the components; unfortunately, the Caribbean is a region where information is not always available and, if it is, it can be difficult to obtain.

3. GEF Invasive Alien Species Project. The Global Environmental Fund (GEF) has a project entitled 'Mitigating the Threats of Invasive Alien Species in the Caribbean. The main executing agency is the United Nations Environment Programme with many other executing agencies including CABI. The components are:

a. Development of national invasive alien species strategies
b. Establishment of Caribbean-wide cooperation and strategy
c. Information and knowledge generation, management and dissemination
d. Prevention of new invasive alien species introductions in terrestrial, freshwater and marine systems
e. Early detection, rapid response and control of invasive alien species in terrestrial, freshwater and marine systems

These components are very similar to the objectives of CISWG, but do not have the emphasis on agriculture and trade in agricultural products. Component b is utilising CRISIS as a strategy to be built on to envelop the other areas of interest (apart from agriculture) in terrestrial, freshwater and marine systems. CISWG is participating in fora organized by this project and has been recognized as a co-financing partner.

CONCLUSIONS

CISWG has been successful in developing a strategy for invasive species and a proposal to execute much of strategy. It has also managed to bring together, diverse partners in a region where networking can be difficult to accomplish.

Another success has been the fact that different agencies and governments are no longer ignorant about the work of others.

There remains the challenge of obtaining funding for the governments and institutions to be able to control the threats of invasive species; there is also some way to go to convince everybody of the need to put considerable effort into the prevention of entry of invasive alien species into the Greater Caribbean Region and into the eradication or control of those harmful species that do become established in the Region.

REFERENCES

Klassen W., W. Colon and W.I. Lugo (2003). Caribbean Food Crops Society. Thirty Ninth Annual Meeting 2003. Grenada. Volume 39, Number 1. Published by Caribbean Food Crops Society.

Klassen W., C.G Davis, E.A. Evans, B. Lauckner, H. Adams and M.T.K Kairo (2004). Facilitating Safer US-Caribbean Trade: Invasive Species Issues Workshop. Port of Spain, Trinidad and Tobago, West Indies. 2-4 June 2004. Published by University of Florida, Gainesville, Florida.

Proceedings of the Caribbean Food Crops Society, 44 (1): 16. 2008

OVERVIEW AND STATUS UPDATE: MULTI-DONOR FUNDING INITIATIVES FOR CISSIP

***Margaret Kalloo**, Senior Project Officer, Agricultural Development Unit*
Caribbean Community Secretariat, Turkeyen, Greater Georgetown, Guyana; Telephone: 592 222 0001 -0075, Ext 2635; email: mkalloo@caricom.org .

Editors' Note: Circumstances did not permit Ms. Kalloo to provide either an abstract or a manuscript. However she reported that the proposed total budget for CISSIP was nearly US$16M over 5 years, and that CARICOM had presented this grant proposal to the Agricultural Donors Conference, which was convened in Port of Spain in June 2007 by CARICOM, FAO and IICA. Since it became apparent that the proposal if funded would absorb more than one half of the funds available for Regional projects, it did not receive strong support. Nevertheless the CISSIP proposal was formally submitted for consideration to the Inter-American Development Bank. However, this Bank declined to fund it. Ms. Kalloo indicated that progress in implementing CISSIP is being made by the various CARICOM countries that are upgrading their diagnostic laboratories.

Proceedings of the Caribbean Food Crops Society. 44(1):17- 26. 2008

USDA/APHIS INITIATIVES IN SUPPORT OF CISSIP

Mr. Wayne De Chi [1], Mr. Russell Duncan [2], and Mr. Robert Balaam [3]. [1] USDA APHIS, c/o CARDI, St Augustine, Trinidad and Tobago, Phone: 868-645-1205; Wayne.DeChi@aphis.usda.gov ; [2] USDA APHIS, Agricultural Science Officer, USDA APHIS IS, Brussels, Belgium; [3] USDA APHIS, Offshore Initiatives Coordinator, USDA APHIS PPQ, Homestead, FL, USA

ABSTRACT: In 2007-2008, APHIS assisted in conducting capacity building workshops in Puerto Rico, Nicaragua, Guatemala, Honduras, Costa Rica, Colombia, Ecuador, Jamaica, and Trinidad. These were conducted in partnership with several private and public cooperators from the Region. The workshops emphasized the need to eliminate pests at the source of imported agricultural products, so that clean product arrives at the ports of entry of the importing country.

In collaboration with the Inter-American Institute for Cooperation on Agriculture (IICA) two capacity building workshops on scale insects and mealybugs of economic importance were held; one in Barbados for Barbados and the Organization of Eastern Caribbean States(OECS), and the second in Jamaica for Jamaica, Trinidad and Tobago, the Dominican Republic, Bahamas, and Haiti.

Between 2005 and 2008 APHIS assisted the Caribbean Region with surveys for the Red Palm Mite and the Giant African Snail. A USDA APHIS malacologist from the Academy of Natural Sciences in Philadelphia, PA, an entomologist from the APHIS Center for Plant Health Science and Technology (CPHST), and an acarologist from the USDA-ARS Systematic Entomology Laboratory in Beltsville, Maryland were assigned to upgrade the surveillance and pest identification skills of technical officers in the Caribbean Region. Financial assistance was provided for pest detection programs in Caribbean countries, in particular those targeted to Tephritid fruit flies, red palm mite, giant African land snail, and mealybugs. APHIS supported the Tephritid fruit fly trapping programme by providing trapping supplies to most countries in the region.

APHIS cooperated with the Panama Ministry of Agriculture and the University of Panama to conduct plant pest surveys near the Panama Canal which is a major pathway for movement of commodities, and possibly plant pests, from Asia into the Greater Caribbean. The focus of these surveys has been on mealybugs, mites, wood borers and molluscs. APHIS provided support for regional meetings in the Caribbean concerned with the preparedness in the event the introduction of Highly Pathogenic Avian Influenza; these meetings resulted in the allocation of needed resources and strengthening safeguarding institutions in some countries.

APHIS collaborated with CABI, CARICOM, CIRAD FAO and IICA in assembling Plant Health Directors of many Greater Caribbean countries with the objective developing coordinated programs to accomplish, in part, the desired outputs of the CISSIP proposal. In 2009 APHIS will continue its assistance to the Plant Health Directors Forum and the latter's technical working groups.

APHIS helped implement the Caribbean Regional Diagnostic Network, a component of CISSIP, through the purchase of five state of the art internet connected distance digital diagnostic laboratory systems for deployment in five Caribbean countries.

KEY WORDS: coordinated regional safeguarding, introduced pests, Caribbean Plant Health Directors, pest surveillance, diagnostic network, information system, internet

INTRODUCTION

In 2003, scientists, policy makers and trade officials from throughout the Caribbean Region, including the United States, met in Grenada to discuss the issues caused by introduced pests, and as a result, the Caribbean Invasive Species Working Group (CISWG) was formed. Subsequently the Council for Trade and Economic Development (COTED), a ministerial body within The Caribbean Community (CARICOM) endorsed CISWG and directed it to prepare a project proposal, "The Caribbean Invasive Species Surveillance and Information Programme (CISSIP)". Three interdependent sub-systems of CISSIP were developed which targeted three broad functions: (a) pest survey and inspection (the Pest Survey and Inspection Program or PSIP), (b) rapid diagnosis of pest problems (the Caribbean Regional Diagnostic Network or CRDN), and (c) information and communication (the Invasive Species Information System or ISIS).

As a result of a high level of synergy between the APHIS program of work for 2007-2008 and the expected output of CISSIP, capacity building workshops and program evaluations were conducted during 2007and 2008 in several countries to promote high quality safeguarding systems. Workshops were held in Puerto Rico, Nicaragua, Guatemala, Honduras, Costa Rica, Colombia, Ecuador, Jamaica, and Trinidad. These were conducted in partnership with several private and public cooperators from the Region. The workshops emphasized the need to eliminate pests at the source of imported agricultural products, so that clean product arrives at the ports of entry of importing countries.

Financial assistance was provided for pest detection programs in the Caribbean countries, in particular those targeted to Fruit Flies, Red Palm Mite, Giant African Land Snail, and mealybugs.

The CARICOM Secretariat, CABI, CIRAD, FAO, IICA and USDA-APHIS assembled many of the the Plant Health Directors of the Greater Caribbean for the first time ever with the objective developing coordinated programs to accomplish, in part, the desired outputs of the CISSIP proposal. Also support for regional meetings in the Caribbean concerned with the preparation and readiness of the introduction of Highly Pathogenic Avian Influenza resulted in progress in allocating needed resources and strengthening safeguarding institutions in some countries in the region.

Safeguarding funds targeted for the Caribbean were used to help implement the Caribbean Regional Diagnostic Network, a component of the CISSIP proposal, through the purchase of five state of the art internet connected distance digital diagnostic laboratory systems for deployment in five Caribbean countries.

These activities are expected to significantly facilitate progress toward coordinated regional safeguarding as outlined in the CISSIP proposal.

The United States Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS) support for CISWG and ultimately the Caribbean Invasive Species Surveillance and Information program (CISSIP) had its roots in the development of a strategy for the Caribbean, called the Caribbean Regional Invasive Species Intervention Strategy (CRISIS).

CRISIS recognises that with increased market access and trade, there is a need to strengthen, improve and upgrade the resources, policies and programmes, laws, transparency and information sharing with the Greater Caribbean Region.

The overall purpose of CRISIS is to safeguard the Greater Caribbean from the threat of invasive alien species and to develop a framework for dealing with both indigenous and introduced pest species. This CRISIS document was presented to CARICOM's Council for Trade and Economic Development (COTED). COTED then directed the Caribbean Invasive Species Working group to fully develop two proposals.

1. Timely internet-based tracking of invasive pest introduction and interception
2. Development of a Caribbean pest and disease diagnostic system based on distance digital imaging internet–based communication

As a result of a high level of synergy between the APHIS program of work for 2007-2008 and the expected output of CISSIP, capacity building workshops and program evaluations were conducted in several countries to promote high quality safeguarding systems. Workshops were held in Puerto Rico, Nicaragua, Guatemala, Honduras, Costa Rica, Colombia, Ecuador, Jamaica, and Trinidad. These were conducted in partnership with several private and public cooperators from the Region.

CARICOM, APHIS, and IICA assembled the Plant Health Directors of the Greater Caribbean with the objective developing coordinated programs to accomplish, in part, the desired outputs of the CISSIP proposal.

The APHIS Mission Linkage to the Plant Health Directors was to strengthen safeguarding system domestically and in other countries by helping to build in them the capacity to address key animal, plant health and natural resource issues of concern to them, and to initiate efforts to protect the United States from dangerous exotic pests and diseases. Principally through these efforts, we were able to share many of the USDA's scientific and technical capabilities.

Safeguarding funds targeted for the Caribbean were also used to advance the implementation of the distance diagnostic and Information system module of the CISSIP proposal by procuring of five digital diagnostic laboratory systems (microscopes, digital cameras, etc.) and making them available for deployment in five Caribbean countries.

CAPACITY BUILDING PROGRAMS

In collaboration with the Inter-American Institute for Cooperation on Agriculture (IICA) two capacity building workshops on scale insects and mealybugs of economic importance were held; one in Barbados for Barbados and the Organization of Eastern Caribbean States(OECS), and the

second in Jamaica for Jamaica, Trinidad and Tobago, the Dominican Republic, Bahamas, and Haiti.

The main objectives of these capacity building workshops were to:

1. Train Caribbean Ministry of Agriculture officials to detect and identify mealybugs and scale insects of economic importance for submission to the Systematic Entomology Laboratory or other US identification service institutions in order to determine the known Caribbean distribution of these target pests.
2. Assist these countries to gain the capacity to identify pests which will facilitate the development of the pest list of each country.

These capacity building workshops had their justification rooted in several key areas that affect the viability of sustainable agriculture in the Caribbean.

The first is based on the Jagdeo Initiative on repositioning Caribbean agriculture and better meet the needs of domestic and export markets. The Jagdeo Initiative has identified key binding constraints affecting agriculture. One of the key binding constraints addressed by this workshop was a lack of skilled high quality human resources. A recommendation of this initiative was for a positive intervention to improve the supply, capacity and competitiveness of skilled personnel. Through this pest identification workshop, technical officers in the Caribbean would be able to identify mealybugs and scale insects of economic importance to the region and by extension those affecting the wider Caribbean. With these workshops, it is expected that some enhancement of the region's capacity to control these pest problems will be achieved, leading to increases supply of the indigenous commodities now being prohibited to the West Indian diaspora in the United States.

Secondly, within the various Caribbean countries, increased fruit production has been identified as an important aspect of any crop diversification thrust. Generally fruit production has remained a backyard enterprise, except for some small acreages of mango, papaya, avocado and pineapple on some islands. Nevertheless, entrepreneurs can and do market sufficient fruit from such smallholdings or from backyard collections to earn significant income. St Vincent exports significant quantities of mango and avocado intra regionally. Grenada, too, continues to export to Trinidad and Tobago large quantities of soursop, sugar apple, sapodilla, mango and tamarind. St Lucia had a fairly substantial mango trade with Barbados and other neighboring islands before this trade was disrupted because of the presence of the mango seed weevil.

While any system of backyard or other small scale production is one in which pest populations will naturally tend to be kept at low levels, it is well documented that a shift to large–scale monoculture systems allows some pest insect species to achieve major pest status. Hence it may be fairly safe to predict that significant increases in fruit production in the region will result in the increased pest status of some pest species already existing in the country. To prevent this one has to ensure that adequate preventive pest management programmes are developed and implemented as an integral component of any scheme for increased fruit production. One important aspect of such an action is the proper identification of the in-country pests as a

foundation for developing and implementing a proper crop protection program.

Thirdly, the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS agreement) entered into force with the establishment of the World Trade Organization (WTO) on 1 January 1995. This SPS agreement while permitting governments to maintain appropriate sanitary and phytosanitary protection reduces possible arbitrariness of decisions concerning imports and encourages consistent rational science-based decision making. In particular, the agreement clarifies which factors should be taken into account in the assessment of the level risk involved in allowing certain imports. Measures to protect the health of animals and plants should be based as far as possible on the analysis and assessment of objective scientific data. In order to comply with the risk assessment process each country must identify all in-country pathogens and pests and compile a pest list, which will inform the risk assessment process.

Central and South American

Since October 2005, APHIS has been cooperating with the Costa Rica Ministry of Agriculture and others in a program designed to reduce the number of pests encountered on Dracaena plant exports from Costa Rica. This program is called the "Dracaena Clean Stock Program" and currently encompasses ten Dracaena growers. The objective is to eliminate pests at the source of imported agricultural products, so that clean product arrives at ports of entry of the importing country.

APHIS is also cooperating with officials of the Panama Ministry of Agriculture and the University of Panama to conduct plant pest surveys near the Panama Canal which is a major pathway for movement of commodities, and possibly plant pests, from Asia to countries, states, and territories on the eastern side of the Canal. The focus of these surveys has been on mealybugs, mites, wood borers and molluscs. APHIS personnel are assisting with survey and diagnostics. The cooperating agencies have developed a target pest list and are exchanging information obtained from the surveys.

An APHIS-assisted activity planned for later in 2008 includes a "Citrus Certification (Plants) Program" in seven Central American countries. The program will concentrate on field inspection and identification of citrus pests and diseases.

APHIS conducted several seminars in Central and South American countries that were designed to educate regulatory officials, producers, and exporters concerning U.S regulations and inspection procedures for the importation of agricultural commodities. The seminars focused on pests commonly intercepted at U.S. ports of entry. The seminars focused on specific commodities of importance to the host country and on the pests commonly intercepted on those commodities. Trainers instructed participants on how to inspect for these pests, how to identify them, and techniques to mitigate them. In Colombia, the seminar focused on cut flowers. In Costa Rica and Guatemala, APHIS personnel conducted an export review on propagative plants, and on fruits and vegetables. A seminar was conducted in Ecuador with the focus on cut flowers, and fruits and vegetables. In Costa Rica, APHIS personnel provided training on pests of false coriander. Again, the objective of these activities is to eliminate pests at the source of imported agricultural products, so that clean product arrives at ports of entry of the importing

country.

CARIBBEAN PLANT HEALTH DIRECTORS FORUM

Unlike most other regions of the globe, the Greater Caribbean had not yet put in place the mechanisms required to assure that free and fair trade is also safe trade. Indeed the insular Caribbean is one of the Regions of the globe that does not have in place a functioning regional organization to protect against invasive plant pests. The organizers hope that the Caribbean Plant Health Directors Forum will discharge some of the responsibilities for coordinated regional safeguarded normally undertaken by a Regional Plant Protection Organization.

This Caribbean Plant Health Directors Forum was expected to be a government-to-government activity that adopts the elements of a model plant health safeguarding system and implements these elements. Examples of such effective implementation were drawn from the Caribbean and the USA safeguarding programs. Forum speakers provided an overview of various technical issues to representatives of the Ministries of Agriculture from the Caribbean countries as a continuation of other phytosanitary training sessions related to pest detection and safeguarding that were conducted during the 2007-2008 fiscal years. During this meeting the plant health directors discussed the authorities, policies, and resource requirements needed for an effective national phytosanitary system. The following topics were discussed:

- The basic elements of a model plant health safeguarding system.
- Offshore risk management
- Regulatory exclusion and border bio-security
- Permit systems
- Pest diagnostics
- Domestic pest detection and surveillance
- Rapid response to pest introductions
- Pest management (banana, fruit flies)
- Risk analysis
- Risk mitigation and systems approaches
- Export programs
- Data management and communication networks
- The formation of six technical working groups each focused on priority pest or pest complex
- Mitigation measures to control/eradicate significant plant pests
- Caribbean Invasive Species Surveillance and Information Program (CISSIP)
- Caribbean Pathway Analysis Project

Expected Results/Deliverables discussed included**:**

- Increased support for technical staff within the Ministries of Agriculture,
- Improved ability of the Caribbean countries to identify and address pest risks,
- Increased trade opportunities for Caribbean countries realized by reducing the number of pests present in products eligible for trade in the global market place
- Improved safeguarding for the Region.

- Caribbean Pathway Analysis Working Group Meetings
- Formation of a CARICOM Chief Plant Health Forum and recommendations for adoption as a Regional Strategy.

Anticipated follow-up activities include:

- Technical assistance workshops by subject matter experts to respond to country-specific pest interception problems,
- Development of specific Terms of Reference for the technical working groups,
- Pest Risk Assessment training for appropriate technical personnel, and the formation of a Pest Analysis Unit for the region

WORKING GROUPS OF THE CARIBBEAN PLANT HEALTH DIRECTORS FORUM

Plan of action

Following the Plant Health Directors meeting on April of 2008, technical working groups were formed to address the highest priority pest concerns of the region. These technical working groups are: Fruit Flies, Giant African Snail (see Pollard et al., 2008), Red Palm Mite (Roda, et al. 2008), Palm Pest Complex, Banana Streak Virus, and Emergency Response. These working groups will meet to discuss a generic draft Terms of Reference and then adapt them to the specific working groups.

How each activity or function will be accomplished

Each technical working group has been assigned a chairperson. The meeting of each working group will be held in the country of the assigned chairperson. Each working group function will be guided by a draft Terms of Reference, and it will schedule its plan of work. The technical working group will report on progress at the next Plant Health Directors meeting scheduled for February of 2009:

The specific **Terms of Reference** are:

1. To investigate (research) the nature and scope of the pest or pest complex
2. Determine the manner of spread
3. Determine the agents of transmission
4. Identify Countries – those infested and not infested, and those threatened via trade
5. Identify the commodities/plant species affected
6. Identify commodities/species serving as alternate hosts
7. Develop recommendations concerning pest to be placed on Regional and various National Priority Pest Lists
8. Identification of the reference materials for compilation of the Pest Lists
9. Assist in the conduct of pest risk analyses.
10. Determine and recommend system for prevention, control and or eradication of pests in the field and at the ports of entry where possible.

11. Determine the Best Management Practices for the pest for inclusion in a production manual and/or other technological packages.
12. Determine the level of diagnostics required for detection, control or eradication.
13. Advise on surveillance activities/projects/programs required
14. Develop recommendations for training and building capacity
15. Recommend emergency preparedness for outbreaks
16. Advise on Public awareness
17. Investigate new methods of prevention, spread, control, and eradication
18. Address emerging issues.
19. Prepare discussion papers if relevant
20. Assist with the development of notifications with respect to WTO obligations
21. Make recommendations for international, regional or national considerations (including ISPMs, etc.).
22. Report to the Meeting of Plant Health Directors
23. Verification and validation of information?
24. Advise on synergies with other initiatives, programs and projects
25. Advise on affiliations with other Groups and Associations

APHIS'S CONTRIBUTION TO THE CARIBBEAN REAGIONAL DIAGNOSTIC NETWORK (CRDN)

Timely and accurate information is the key to the detection, exclusion, eradication, control and management of invasive species. Clearly a regional internet-based invasive species surveillance and diagnostic network is needed to facilitate safeguarding the Region against harmful organisms that threaten food security, to protect biodiversity, for biosecurity and to meet obligations and enhance transparency under the various International Agreements and Conventions in order to facilitate global trade and prevent damage to national economies. The Caribbean Regional Diagnostic Network (CRDN) is a key component of CISSIP, and it would greatly enhance the Region's diagnostic capabilities. Currently the CRDN connects Florida, Puerto Rico, the Dominican Republic and Haiti.

A vital component of the USDA APHIS International Services mission continues to be infrastructure building through technical assistance that would strengthen safeguarding systems and build plant health awareness. To this end, USDA APHIS purchased five sets of microscopes equipped with digital cameras and appropriate software for expanding the CRDN regional network into five countries.

It was been suggested, that the distribution of these digital imaging systems be initiated in collaboration with the CISWG in advancing the CISSIP project. Thus the CARICOM secretariat is in process of facilitating the allocation of these resources to appropriate CARICOM countries. The countries selected to receive these diagnostic capabilities will include those CISSIP-Phase 1 countries that currently lack equivalent capabilities and as a second priority, a few of the CISSIP-Phase 2 countries. In order to facilitate early detection of invasive species arriving from outside the Region, the enhanced diagnostic facilities should be located in countries with international airports or seaports that handle substantial volumes of perishable agricultural commodities.

OTHER PROGRAMS

Between 2005 and 2008 APHIS assisted the Caribbean Region with the survey for the Red Palm Mite and the Giant African Snail. A USDA APHIS malacologist from the Academy of Natural Sciences in Philadelphia, PA, an entomologist from the Center for Plant Health Science and Technology (CPHST), and an acarologist from the USDA-ARS Systematic Entomology Laboratory in Beltsville, Maryland visited the Caribbean to train technical officers in the region.

Fruit flies continue to be a major problem in the region, APHIS supports the fruit fly trapping programme by providing trapping supplies to most countries in the region.

CONCLUSIONS

In 2007-2008, APHIS assisted in conducting capacity building workshops in Puerto Rico, Nicaragua, Guatemala, Honduras, Costa Rica, Colombia, Ecuador, Jamaica, and Trinidad. These were conducted in partnership with several private and public cooperators from the Region. The workshops emphasized the need to eliminate pests at the source of imported agricultural products, so that clean product arrives at the ports of entry of the importing country.

In collaboration with the Inter-American Institute for Cooperation on Agriculture (IICA) two capacity building workshops on scale insects and mealybugs of economic importance were held; one in Barbados for Barbados and the Organization of Eastern Caribbean States(OECS), and the second in Jamaica for Jamaica, Trinidad and Tobago, the Dominican Republic, Bahamas, and Haiti.

Between 2005 and 2008 APHIS assisted the Caribbean Region with the survey for the Red Palm Mite and the Giant African Snail. A USDA APHIS malacologist from the Academy of Natural Sciences in Philadelphia, PA, an entomologist from the APHIS Center for Plant Health Science and Technology (CPHST), and an acarologist from the USDA-ARS Systematic Entomology Laboratory in Beltsville, Maryland were assigned to upgrade the surveillance and pest identification skills of technical officers in the Caribbean Region.

APHIS has been cooperating with the Panama Ministry of Agriculture and the University of Panama to conduct plant pest surveys near the Panama Canal which is a major pathway for movement of commodities, and possibly plant pests, from Asia into the Greater Caribbean. The focus of these surveys has been on mealybugs, mites, wood borers and molluscs.

Fruit flies continue to be a major problem in the region, APHIS supports the fruit fly trapping programme by providing trapping supplies to most countries in the region.

CARICOM, APHIS, and IICA assembled the Plant Health Directors of the Greater Caribbean with the objective developing coordinated programs to accomplish, in part, the desired outputs of the CISSIP proposal. In 2009 APHIS will continue its assistance to the Plant Health Directors Forum and the latter's technical working groups. We anticipate challenges and rewards as we moved forward in our quest to reduce the threat of alien invasive species into the Region.

REFERENCES

Caribbean Invasive Species Working Group (CISWG). 2004. Caribbean Regional Invasive Species Intervention Strategy.

Caribbean Invasive Species Working Group (CISWG). 2007. Project proposal: Caribbean Invasive Species Surveillance and Information Program.

Maximay, S. 2005. Nature Scope and Status of Activities in Member States that Contribute to the Alleviation of Key Binding Constraints Documented in the Jagdeo Initiative (unpublished)

Pollard, G.V. 1985. Insect Pests as Constraints to the Production of Fruits in the Caribbean. Proceedings of a Seminar on Pests and Diseases Constraints in the Production and Marketing of Fruits in the Caribbean, Barbados, West Indies.

Pollard, G.V., A. Fields and B. Taylor. 2008. Giant African snail in the Caribbean Sub-Region. Proceedings of the 44th Annual Meeting of the Caribbean Food Crops Society. 44 (1): 126-134.

Roda, A., A. Dowling, C. Welbourn, J. E. Peña, J. C. V. Rodrigues, M. A. Hoy, R. Ochoa, R. A. Duncan and L.W. De Chi. 2008. Red palm mite situation in the Caribbean and Florida. Proceedings of the 44th Annual Meeting of the Caribbean Food Crops Society. 44 (1): 80-87.

Proceedings of the Caribbean Food Crops Society. 44(1):27- 31. 2008

The GEF/CABI project "mitigating the threat of invasive alien species in the insular Caribbean"

U. Krauss[1], M. Bilz[2], V. Lopez[1], K. McLaughlin[3], P. Polar[1], M. Seier[4], and S. Murphy[4]. [1] CABI Caribbean and Latin America, Gordon Street, Curepe, Trinidad & Tobago; Corresponding author: u.krauss@cabi.org; [2] CABI Head Office, Nosworthy Way, Wallingford, OX10 8DE, UK; [3] United Nations Environment Programme (UNEP), Washington Office, 900 17th Street, NW Suite 506, Washington, DC 20006, USA;[4] CABI Europe-UK, Bakeham Lane, Egham, Surrey, TW20 9TY, UK.

ABSTRACT. Invasive Alien Species (IAS) pose a major threat to the vulnerable aquatic and terrestrial biodiversity of Caribbean islands and to people depending on this biodiversity for their livelihoods. Caribbean states have recognized the need for a regional strategy and expressed strong interest in linking up their national efforts in implementing Article 8 (h) of the Convention on Biological Diversity (CBD) to mitigate the threats of IAS in the Caribbean. The project proposed through CABI and UNEP for GEF funding aims to widen this narrow scope of dealing with IAS by establishing an extensive framework addressing IAS that threaten aquatic and terrestrial ecosystems and their biodiversity in the Caribbean. This framework will build on existing national measures in the plant and animal health sector and feed biodiversity capacity into the project by linking with national and regional stakeholders. The proposed project will provide the participating countries and other partners in the Caribbean region with the necessary tools and capacity to address existing and future biological invasions. The five project components are:

[1] Development of National IAS strategies in the five participating countries: Bahamas, Dominican Republic, Jamaica, St. Lucia, and Trinidad & Tobago

[2] Establishment of Caribbean-Wide Cooperation and Strategy

[3] Knowledge generation, management and dissemination

[4] Prevention of New IAS Introductions in Terrestrial, Freshwater and Marine Systems

[5] Early Detection, Rapid Response and Control of IAS Impacts

The project and its preparation is funded by the Global Environment Facility (GEF) and co-financed by the countries themselves and numerous partners. The first phase of the GEF funding cycle, the Project Development Facility-A (PDF-A) was successfully implemented from July 2006 to February 2007. In April 2008, the second phase, the Project Preparation Grant (PPG) of nine months duration commenced. If successful, this will be followed by a four-year Full Size Project focusing on the above-mentioned countries while benefiting the whole of the Caribbean region as well as global biodiversity.

KEY WORDS: Biodiversity, Caribbean, invasive species

INTRODUCTION

Invasive Alien Species (IAS) pose a major threat to the marine, freshwater and terrestrial biodiversity of Caribbean islands and to people depending on this biodiversity for their livelihoods. The overall goal of the project is to conserve globally important ecosystems, the species and genetic diversity within the insular Caribbean. The objective is to mitigate the threat to local biodiversity and economy by IAS in the insular Caribbean, including terrestrial, freshwater and marine ecosystems.

The Caribbean, designated as one of the world's biodiversity hotspots by Conservation International, supports exceptionally diverse ecosystems (marine, freshwater and terrestrial) of global ecological and economic importance. Marine ecosystems comprise a major share of the region's globally important biodiversity, a fact recently recognized by the United Nations, which designated the Caribbean Sea as Special Area in 2006. The Caribbean small island developing states (SIDS) currently participating in the proposed project harbor centers of terrestrial and/or marine biodiversity of global significance.

Alien species introduced into the Caribbean usually constitute a regional problem, affecting not only each of the participating countries but potentially the Caribbean as a whole. The potential for such introductions, deliberate or accidental, is growing through the increase in international economic and cultural links in such diverse areas as agriculture, aquaculture, transport and trade (commodities and pets), tourism (e.g. ecotourism, hotel and golf-course landscaping, yacht traffic) and industrial development. The small scale of the Caribbean economies necessitates a regional approach, which is legally supported through the Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Cartagena Convention of 1983).

The project is being developed by CABI and UNEP for funding by the Gobal Environment Facility (GEF), in collaboration with a wide range of partners[1], in three stages: the Project Development Facility A (PDF-A), the Project Preparation Grant (PPG, fromerly PDF-B), and the Full Size Project (FSP). The project aims to reduce the overall risk posed by invasive alien species on a national and regional level, thereby safeguarding of biodiversity of global significance. In addition to preventive measures, pilot projects will also test other cost-effective and innovative approaches to combat invasives species in those areas with globally significant biodiversity which have already been impacted upon.

PROJECT DEVELOPMENT FACILITY-A (PDF-A) ACHIEVEMENTS

Following the approval of an 8-month-long PDF-A phase in July 2006, activities were initiated in six pilot countries – The Bahamas, Cuba, Dominican Republic, Jamaica, St. Lucia and Trinidad & Tobago. The main objective of the PDF-A was to confirm the countries to be

[1] Co-finance, in kind or in cash for PDF-A, PPG and/or FSP has been committed by: Bioversity International, CABI, CARICOM, CARINET, CERMES, CISWG, Florida A&M University, GISP, IABIN, IICA, InGrip, IUCN, RAC/REPMEITC, Smithsonian Institution, The Nature Conservancy, UNEP-CAR/RCU, University of Florida - IFAS, US Dept. of Agriculture-APHIS, US Dept. of Commerce-NOAA, US Dept. of State, and the University of the West Indies.

involved in the project and revisit the 'baseline situation' in order to refine the objectives of the two subsequent phases, PPG and FSP (Full-Sized.Project) Three activities were undertaken towards the fulfillment of the objectives: a national consultation, an International Workshop (IWS) and two baseline desk studies.
In each country, the national consultations were coordinated by one or more lead agencies, using existing structures to involve relevant stakeholders in the process. A standardized questionnaire was circulated to capture current information in various sectors. Key stakeholders then attended an in-country workshop, facilitated by CABI, to review existing capacities and gaps in order to identify needs to be addressed and pilot activities to be set up under the FSP (Full-Sized Project). Structures to guide the in-country activities under PPG and FSP phases were also discussed.

Delegates from the pilot countries then joined representatives from 15 global and regional organizations at the IWS held in Trinidad & Tobago from 22-26 January 2007. During the week, the participants exchanged information, refined objectives and outcomes of the FSP and drew up tentative co-finance plans taking into consideration GEF's new Resource Allocation Framework IV (RAF IV). They also reviewed pilot activities and deliberated on coordination mechanisms for the PPG and FSP. Subsequently, CABI coordinated the finalization and submission of the PPG proposal to GEF, through UNEP, and to other funding agencies.

Two desk studies were undertaken in order to address the need for (1) information on marine IAS and their management and (2) legislative frameworks for IAS. The first study was commissioned by UNEP-CAR/RCU's sub-program "Conservation and Sustainable Use of Major Ecosystems in the Wider Caribbean" of the Regional Programme on Specially Protected Areas and Wildlife (SPAW) to compile information on national and regional capacities and experiences on marine invasive species management programs in the Wider Caribbean, including ballast water (BW). The final report is available in the public domain[2]. The in-house review of current legislative framework in the six pilot countries revealed that there is currently no comprehensive legislation on invasive species per se. However all countries possess plant and animal health and quarantine legislation; other IAS are covered under legislation in specific areas such as apiculture, coastal and marine environments, forest, protected areas and wildlife.

PROJECT PREPARATION GRANT (PPG) DELIVERABLES

PPG implementation was initiated in May 2008 with the creation of a national IAS team, headed by a national IAS expert in each of the five pilot countries. A roundtable at the beginning of PPG (3-4 June 2008) brought the partners together to discuss the status quo of their selection and to agree on the final PPG work program as well as the project management structure, including collaborative linkage leads.

In preparation for the FSP, the PPG comprises three major activities:

[1] Collate gaps in existing plans and policies as baseline for strategic review under the FSP (Full Sized Project)

[2] Outline national and regional communication and capacity-building strategies for the FSP, also with a view towards the development of a Caribbean-wide cooperation and strategy under FSP

[2] http://www.cep.unep.org/newsandevents/news/2006/final-cabi-unep-car-rcu-report.pdf

[3] Develop criteria and initiate baseline surveys for species and sites selection for pilot projects, define pilot projects in five countries and provide incipient technical input for tentative project design and activity costing at national level, including coordination and monitoring & evaluation plan.

PPG Activity 1 will enable the countries to start developing or reviewing their national IAS strategies (FSP Component 1). Once each country knows the gaps and has an overview of existing as well as missing data and information they will be able to focus on closing these gaps in the FSP, e.g. by carrying out research and by drafting strategies and discussing them at governmental and stakeholder level.

PPG Activity 2 will support the countries' efforts in generating, managing and disseminating information and knowledge (FSP Component 3). Following on from the PDF-A, each country is in the process of completing the list of stakeholders concerned with IAS (including those not previously involved) and planning their involvement in FSP activities. This includes the identification of target groups for public awareness activities in the FSP. Simultaneously, more specialized training needs are being identified, which will then be addressed through capacity-building activities in the course of the FSP (Full-Sized Project).

In the pilot projects under the FSP, the countries will test different measures to prevent new IAS introductions (FSP Component 4) and to detect, respond to and control species invasions (FSP Component 5). The PPG Activity 3 will support the countries in deciding which sites and/or species are best suited for those pilot projects, a process initiated under PDF-A. Pilot projects can consist either of management of a certain species at different sites, or management of a particular site where there is one or more species invading. The countries will collect and review existing information regarding those sites and species to ensure feasibility and up-to-date priority activities before starting the FSP (Full-Sized Project).

Within PPG Activity 3, the executing agency and the project partner will develop a Project Monitoring and Evaluation (M&E) Plan and performance and result indicators in compliance with the GEF M&E Policy. At the end of PPG the project will have identified all relevant stakeholders and established baseline information as prerequisites for designing an M&E Plan and associated indicators. The indicators will follow the SMART principle and allow for setting specific and measurable expected results. It is intended to monitor and evaluate a diverse range of project impacts such as behavior change of stakeholders, financial sustainability of the project, institutionalization of IAS management including the implementation of strategies and policies, and ecosystem status including the reduction in IAS spread. The M&E Plan will link closely into the project's reporting cycle and dissemination activities. Furthermore, it will be designed in a way that allows GEF to carry out long-term evaluation after the FSP concludes.

OUTLOOK FOR THE FULL-SIZED PROJECT (FSP)

The proposed GEF project aims to establish an extensive framework addressing IAS that threaten aquatic and terrestrial ecosystems and their biodiversity. It will hereby build on existing national measures in the plant and animal health sector to strenghten capacity to address biodiversity concerns and to link national and regional stakeholders. A regional framework, led

by the regional executing agency CABI, will ensure that enabling policy and capacity is built in a coordinated manner amongst participating countries and further engender replication in the region. The coordinated regional approach suggested will strengthen the ability of Caribbean countries to respond in a coherent, consistent and effective manner to invasive species prevention and mitigation in the region.

Prevention is widely viewed as the most cost-effective IAS management approach, but a "plan B" is often needed. The proposed project will provide the participating countries and other partners in the Caribbean region with tools they can easily amend and adapt for existing and future biological invasions. The pilot countries selected for the proposed GEF project are representative for the ecosystem diversity and species richness, as well as for the geophysical, political, socio-economic and socio-cultural complexity of Caribbean states. It is therefore anticipated that each participating country will act as a model for the wider dissemination of the project findings, and replication in the Caribbean region.

Proceedings of the Caribbean Food Crops Society. 44(1): 32-46. 2008

LES INITIATIVES FRANÇAISES EN MATIÈRE DE PRÉVENTION CONTRE LES ESPÈCES INVASIVES DANS LA RÉGION CARAÏBE.

***Jean IOTTI**, Emmanuel Sutter, Philippe Terrieux et Frédéric de Fillippi. Service de la Protection des Végétaux, Direction de l'Agriculture et de la Forêt, Ministère de l'Agriculture, de l'Alimentation et de la Pêche,Rue des Pionniers, Marigot de Bellevue, BP 438, 972000 Fort de France, Martinique, France*

RESUME. *The plant protection strategy in Martinique and in the archipelago of Guadeloupe, i.e. eight small islands known as "French West Indies", is based on three main pillars. These pillars are implemented in the framework of a complex set of European and overseas-specific regulations, and according to the standard French administrative rules and organization, which are not always customized for tropical agriculture issues.*

The first pillar is Import-Export control (quarantine invasive species control).

The second pillar concerns control of invasive and other pest species in nurseries (control on quarantine invasive species and pests impacting on production).

The third pillar is surveillance and protection of crops grown in fields.

Import-Export regulations are a mix of the present European regulations, which prioritize free trade within the European Union (Martinique and Guadeloupe being part of the EU), while import regulations with third countries avoid import bans for vegetables, and prioritize specific requirements for quarantine pests.

In contrast, the Specific Overseas Regulation, is based mainly on import bans and an accumulation of old-fashioned requirements, which are based more on precautionary principles than on reasonable science-based arguments.

In order to integrate the European regulations, 200 invasive pests and plants risk analyses have been completed. These PRAs are the foundation of the new "European Overseas Regulations", which are being drafted.

To combat the most dangerous invasive species, Project PANDOeR [New Pathogens: Detection, Observation, Eradication] was initiated. It consists of putting in place a system for the early detection and eradication of threatening diseases. The targeted diseases and insects are those present in the Caribbean islands that may impact the environment and economy of Martinique (tourism, agriculture, and employment) and that are potentially invasive: coconut lethal yellowing and the red palm mite on palm trees, Black Sigatoka (and Yellow Sigatoka, which is already present), moko disease of banana, fruit flies, etc. PANDOeR involves several administrative or professional partners, and aims at (i) controlling possible invasions of dangerous invasive species, and (ii) limiting the geographical range extensions of already present pests, etc.

KEY WORDS: *European Plant Protection Regulations, French West Indies Plant Protection Regulations, pest risk analysis, territory surveillance, Black Sigatoka, red palm mite, Moko disease, fruit flies, lethal yellowing.*

INTRODUCTION

La protection de l'agriculture antillaise contre les nombreux ravageurs déjà présents sur le territoire de Martinique ou de Guadeloupe, ou menaçant de s'y introduire, est assurée par les Services de la Protection des végétaux (SPV), appartenant à la Direction de l'Agriculture et de la Forêt, représentation locale du Ministère chargé de l'Agriculture français.

Ces services travaillent en partenariat étroit avec les instituts de recherche et les laboratoires locaux ou nationaux : le Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), l'Institut National de la Recherche agronomique (INRA), le Laboratoire national de la Protection des Végétaux (LNPV), le laboratoire d'analyses du Conseil général de Martinique (LDA972) ; les actions sont menées en collaboration avec les organisations professionnelles en place : la Fédération de défense contre les organismes nuisibles (FREDON), la Chambre d'Agriculture, enfin les groupements de producteurs des filières végétales et bien sur les producteurs.

Bien qu'appliquant les méthodes et la réglementation nationales émanant de l'Office National de la Protection des Végétaux (ONPV) français qui se nomme la Sous Direction de la Santé, de la Qualité et de la Protection des végétaux, les SPV de Martinique et de Guadeloupe ont du adapter leurs actions au contexte particulier d'une agriculture tropicale insulaire, encore fortement structurée par des monocultures d'exportation (banane), ou industrielles (canne à sucre, ananas de conserve), et soumise à une forte pression parasitaire.

La problématique des espèces invasives y revêt une importance particulière, les menaces dans l'arc antillais devenant de plus en plus concrètes. Les récentes introductions de la cochenille de l'hibiscus et du cycas, du tigre de l'avocatier, de l'acarien rouge du cocotier, d'un thrips ravageant les poiriers, ont montré la rapidité et la gravité du danger.

Les SPV de Martinique et de Guadeloupe s'appuient sur une réglementation particulière adaptée aux organismes de quarantaine les plus menaçants, qui s'applique aussi bien pour les importations de pays tiers, dont les pays de la zone CARICOM, qu'aux pays de la CEE, dont la France.

A ce titre ils sont considérés, bien que faisant partie de la France, comme des ONPV indépendants. Leur fonctionnement s'appuie sur des zones douanières également protectrices vis à vis des importations. La collaboration avec les services des Douanes est exemplaire et efficace.

MISSIONS, ACTIONS ET METHODES

Les missions du SPV sont de deux ordres : la protection des cultures, et la qualité des denrées alimentaires d'origine végétale, notamment la surveillance des organismes génétiquement modifiés, des mycotoxines, et le contrôle de la bonne utilisation des produits phytopharmaceutiques (importation, distribution, application).

Ce dernier point, quoiqu'il revête de plus en plus d'importance et requière de moyens humains et financiers, ne sera pas développé dans cet exposé.

La protection des cultures locales s'appuie sur trois « piliers », qui sont :

(i) Le contrôle de l'importation des végétaux aux frontières contre l'introduction d'organismes nuisibles de quarantaine (ONQ),
(ii) Le contrôle des pépinières, notamment de vitroplants de banane, contre l'introduction d'organismes nuisibles de quarantaine.
(iii) La surveillance biologique du territoire. Les explications qui suivent s'appuient sur l'exemple de la Martinique.

(i) Le contrôle de l'importation des végétaux aux frontières s'exerce par les bureaux situés au ports et à l'aéroport, qui sont de PEC (Points d'Entrée communautaire, c'est à dire aux frontières de l'Europe). Les Antilles comptent à elles seules 5 des 37 PEC français. Les arrivées de bateaux de commerce caribéens non conteneurisés et des ferries sont aussi controlées à leur port de débarquement. Enfin les colis postaux sont filtrés directement à la messagerie princiaple. Toute importation de végétaux non contrôlée par le SPV ne peut être dédouanée.

Les importations commerciales de denrées végétales non transformées sont systématiquement contrôlées, au moins au niveau documentaire, les inspections physiques étant ciblées sur les filières les plus à risque.

En Martinique, en 2007,

- 4 010 lots de végétaux ont été contrôlés à l'import, soit 32 202 tonnes et 3 579 062 unités (fleurs, plantes, greffons)
- Exportations : 21 certificats export seulement pour 2,841 tonnes et 4450 unités, mais il faut noter que 310 000 tonnes/an sont exportées sans contrôle vers la CEE (bananes, melons)

Arrivée des vols passagers à l'aéroport Aimé Cézaire : contrôle du contenu des bagages personnels

Le danger d'introduction d'organismes nuisibles de quarantaine le plus important ne réside pas tant dans les flux commerciaux que dans les flux de passagers et touristiques. C'est pourquoi, un arrêté préfectoral (c'est à dire local) interdit toute importation de produit végétal frais dans les bagages particuliers. Un agent de la FREDON, à temps plein, financé par la filière banane, assure en collaboration constante avec la Douane le contrôle des différentes arrivées : port inter-îles, aéroport, marinas. En 2007, pour la Martinique, 202 interceptions ont été réalisées sur le circuit passager grâce à la parfaite collaboration de la douane, qui passe au scanner les bagages arrivés des vols les plus sensibles (Amérique du Sud, Guyane française, Guadeloupe).

L'une des difficultés majeures rencontrées par les inspecteurs aux frontières, mais aussi pour leurs usagers, réside dans l'application d'une double réglementation : la réglementation générale européenne : la directive 200/29/EC du 8 mai 2000, qui ne comporte pas d'annexes spécifiques consacrées aux agricultures ultra périphériques (DOM françaises, régions ultra- marines espagnoles et portugaises) et la réglementation DOM en vigueur depuis 1990, souvent trop rigoureuse ou obsolète.

Un projet d'intégration d'annexes spécifiques (ONQ, végétaux interdits, conditions particulières d'importation pour les végétaux, etc) pour les régions ultrapériphériques dans la réglementation européenne, sous la forme d'une nouvelle directive semblable dans ses principes à la directive 200/29/EC, est en cours de finalisation. L'étude des listes pertinentes devant figurer dans les annexes DOM se fonde sur 130 analyses de risque phytosanitaire (ARP) pour les ONQ et 70 ARP pour les plantes invasives, réalisées par le CIRAD de 2005 à 2006, sur financement européen (POSEIDOM Phytosanitaire)

(ii) Le contrôle des pépinières locales est la base des actions régaliennes sur le territoire dans le domaine de la Protection des Végétaux, soit pour la certification export, mais surtout pour les suivis sanitaires nécessaires lors d'importation (cas des anthuriums, de l'ananas), le suivi et la libération après mise en quarantaine des végétaux importés en dérogation. Il s'agit principalement, depuis une quinzaine d'années, du contrôle de la filière de productions de plants de banane sains issus de vitroplants.

Serre insect proof de grossissement de vitroplants,
Saint Joseph, Martinique

Chaque année, de 1.5 à 2 millions de tels plants participent au renouvellement de 800 à 1 000 ha de bananeraies. En effet la pratique recommandée et suivie par une majorité de planteurs en Martinique est de régénérer leurs parcelles, après destruction totale et jachère d'une année au minimum, par des vitroplants garantis indemnes de nématodes et de virus. Cette technique à permis de réduire de 80% l'utilisation de nématicides. Elle participe également au contrôle du charançon noir du bananier, dont les population sont désormais contrôlées par des piégeages de masse à base d'une phéromone d'agrégation, la sordidine.

Le SPV a investi massivement en hommes, matériel et technologie pour permettre l'indexage de chacun des centaines de lots de vitroplants importés pour trois virus, Banana Bunchy Top Virus, Cumcumber Mosaïc Virus, Banana Bract Mosaïc Virus, prélévés chaque semaine à un taux de 0.1 à 1%, selon les variétés. Ceci a représenté annuellement près de 10000 analyses réalisées localement par le laboratoire de Santé des végétaux, puis libérés pour la vente. Ralstonia Solanacearum est aussi régulièrement contrôlé

(iii) La surveillance biologique du territoire comprend deux volets :
Le premier volet est en grande partie confié par le SPV à la FREDON, organisme professionnel : il s'agit d'aider les agriculteurs à diagnostiquer les maladies et insectes qui attaquent leur cultures, et à identifier les meilleures stratégies de lutte, dont les méthodes alternatives au traitements chimiques. Une équipe de 20 techniciens, s'appuyant sur les groupements communaux de défense contre les organismes nuisibles, les GDON , balaye le territoire. Ils disposent d'un laboratoire mobile, d'un laboratoire de diagnostic (insectes, champignons), et ont recours au laboratoire départemental de Santé des Végétaux pour les maladies causées par des virus et des bactéries. Ces actions complémentent et alimentent la surveillance générale du territoire, menée aussi par le SPV en collaboration avec les groupements de producteurs des différentes filières.

Le deuxième volet constitue le projet **PANDOeR** « PAthologies Nouvelles : Détection, Observations, eRadication ».

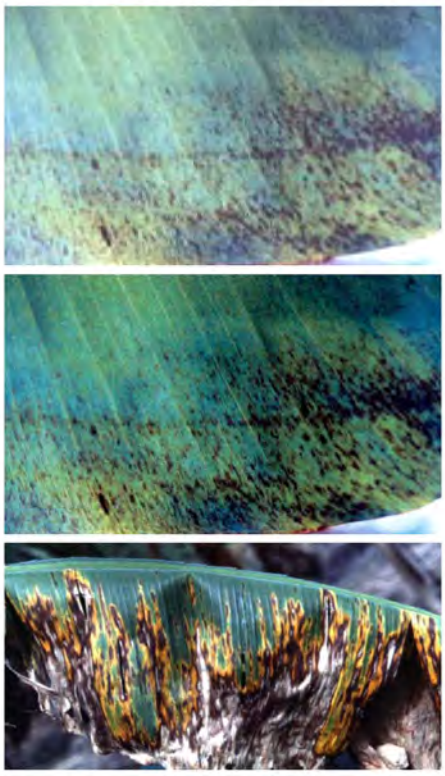
Il s'agit de mettre en place des systèmes permettant la détection précoce et l'éradication de maladies menaçantes: Les maladies et insectes ciblés sont ceux présents dans des îles de la zone caraïbe, pouvant avoir un impact environnemental et économique important pour la Martinique (tourisme, agriculture, emploi), et potentiellement invasives : la jaunisse létale du cocotier et le « Red palm Mite » des palmacées, la cercosporiose noire (et cercosporiose jaune déjà présente), la maladie de moko du bananier, les mouches des fruits…..

- Les objectifs de PANDOeR sont :
- être capable de détecter de manière efficace et précoce l'arrivée d'un nouveau pathogène (mise en place du réseau de surveillance et système d'alerte),
- être capable d'éradiquer le pathogène exogène (élaboration protocole et méthodes adaptées), ou au pire le contenir dans la zone d'introduction

- Et secondairement :
- renforcer la coopération entre les acteurs des filières concernées, notamment la recherche et la profession agricole

- formation aux méthodes de détection appropriées des correspondants du réseau de surveillance,
- acquisition de nouvelles technologies de laboratoire,
- meilleure sensibilisation et formation des agriculteurs aux maladies émergentes,
- renforcer la communication et la sensibilisation grand public aux risques encourus par l'environnement et l'agriculture ne Martinique.

Les réseaux d'observation suivants ont été montés depuis 2007 :



Symptômes de la cercosporiose

Les réseaux de surveillance fonctionnent de manière partenariale :

SPV, FREDON, Chambre d'Agriculture, groupements de producteurs, SICA TG (société en charge des traitements aériens), Office national des Forêts (ONF) collaborent et bénéficient de l'appui méthodologique du CIRAD.

Les analyses nécessaires sont confiées au laboratoire de santé des végétaux du Conseil général de la Martinique , avec l'appui du Laboratoire national de la Protection des Végétaux et du CIRAD.

Les actions déjà lancées ou envisagées comprennent des actions de réflexion et d'organisation avec les partenaires identifiés, la mise en oeuvre des dispositifs de surveillance, des séances de formation des différents acteurs, enfin une stratégie de communication vers les agriculteurs, les voyageurs, les agents des structures administratives impliquées.

CONCLUSION

La défense des cultures en milieu tropical insulaire, notamment pour les îles de la région caraïbe, de petite taille, perméables aux flux anthropiques nombreux et multi-modaux, repose pour beaucoup sur la capacité à prévenir l'introduction d'espèces invasives, ou à les éradiquer rapidement.

Si la lutte contre les ravageurs déjà présents constitue l'essentiel des efforts pour les agriculteurs, le contrôle aux frontières et la surveillance biologique du territoire représentent pour les ONPV locaux un challenge essentiel qu'ils ne peuvent réussir qu'en collaboration avec les partenaires institutionnels et professionnels présents sur le territoire : ports, aéroports, marinas, zones agricoles, espaces naturels et jardins particuliers.

Un autre aspect essentiel est le partage d'informations, la mise en place de réseaux d'alerte et de stratégies de lutte communes entre les pays de la région Caraïbe.

C'était l'objectif du T-STAR symposium du 15 juillet à Miami, organisé dans le cadre de la Conférence CFCS 2008, qui a été un succès incontestable dans ce domaine.

APPENDIX : ENGLISH TEXT

FRENCH INITIATIVES IN PREVENTING INVASIVE SPECIES IN THE CARIBBEAN REGION

Jean IOTTI, Emmanuel Sutter, Philippe Terrieux and Frédéric de Fillippi. Service de la Protection des végétaux, Direction de l'Agriculture et de la Forêt, Ministère de l'Agriculture, de l'Alimentation et de la Pêche, Rue des Pionniers, Marigot de Bellevue, BP 438, 972000 Fort de France, Martinique, France.

ABSTRACT. The plant protection strategy in Martinique and in the archipelago of Guadeloupe, i.e. eight small islands known as "French West Indies", is based on three main pillars. These pillars are implemented in the framework of a complex set of European and overseas specific regulations, and according to the standard French administrative rules and organization, which are not always customized for tropical agriculture issues.
The first pillar is Import-Export control (quarantine invasive species control), the second concerns nurseries' control (control on quarantine invasive species and pests impacting on production), and the third concerns crop surveillance and protection.
Import-Export regulations are a mix of the present European regulations, which prioritize free trade within the European Union, Martinique and Guadeloupe being part of the EU), while import regulations with third countries avoid import bans for vegetables, and prioritize specific requirements for quarantine pests.
In contrast, the Specific Overseas Regulation, is based, mainly on import bans, and an accumulation of old-fashioned requirements, which are based more on precautionary principles than on reasonable arguments. In order to integrate the European regulations, 200 invasive pest and plant risk analyses were completed. These PRAs are the foundations of the new "European Overseas Regulations", which are being drafted.
To combat the most dangerous invasive species, Project PANDOeR, was initiated. It involves several administrative or professional partners, and aims at (i) controlling possible invasions of invasive species, and (ii) geographical range extensions of already present pests, etc.

KEY WORDS: European Plant Protection Regulations, French West Indies Plant Protection Regulations, pest risk analysis, territory surveillance, Black Sigatoka, red palm mite, Moko disease, fruit flies, lethal yellowing.

INTRODUCTION

The protection of the French West Indies' agriculture against numerous pests already present in Martinique and Guadeloupe, or those at risk of being introduced, is managed by the Plant Protection Service (SPV) under the Direction of Agriculture and Forestry, which represents locally the French Department of Agriculture.

These services work in collaboration with research institutes and local and national laboratories: French Agricultural Research Center for International Development (CIRAD); French National Institute for Agricultural Research (INRA); National Crop Protection Laboratory (LNPV); and the analytical laboratory of the Martinique General Council

(LDA972). These actions are carried out in collaboration with local professional organizations: the federation for defense against invasive species (FREDON), the Chamber of Agriculture, and producers' groups.

Although the SPVs of Martinique and Guadeloupe apply methods and regulations originating from the National Plant Protection Office, they have had to adapt their actions to the particular context of tropical island agriculture strongly based on export (banana) or indutrial (sugar cane, canned pineapple) monocultures, and subjected to heavy pest pressure.

Invasive species need special attention; threats in the West Indies arc have become more and more apparent. Recent invasions of Maconellicoccus hirsutus, Aulacaspis yasumatsui, Pseudacysta persea (Heidemann), Eriophes guerreronis, and a thrips destroying pears have demonstrated the speed and seriousness of the danger.

The SPVs of Martinique and Guadeloupe rely on a special regulation adapted to the most threatening quarantine pests and that applies to importations from third world countries, including countries in the CARICOM zone, as well as European Union countries, including France.

For this reason, although belonging to France, the SPVs of Martinique and Guadeloupe are considered as independent ONPVs. Their roles rely on protection by customs at the borders in terms of imports. Their collaboration with customs services is exemplary and efficient.

MISSIONS, ACTIONS AND METHODS

SPV missions are two fold: (1) crop protection, and 2) assuring the quality of agricultural plant products, particularly monitoring genetically modifed organisms, mycotooxins, and phytopharmaceutical products (import, distribution, application).

Although of progressively more importance and requiring substantial human and financial resources, this last point will not be discussed in this report.

Local plant protection is based on three main pillars. (i) The first pillar is the monitoring of the importation of plant products at ports-of-entry to prevent the introduction of quarantine pests; (ii) the second pillar concerns the monitoring of nurseries, particularly banana in vitro plants, to prevent the introduction of quarantine pests; and (iii) the third concerns biological surveillance of the territory. The following is a relevant example from Martinique:

(i) Control of plant importation at the borders. This is carried out by the offices located at the ports and the airport, which are hubs for Europe. The French West Indies has 5 of the 37 French hubs. The arrival of boats with non-containerized commercial Caribbean cargo and of ferries are also inspected at the shipping ports. Mail is checked directly at the mail coach service. Any plant importation not inspected by the SPV will not clear customs.

Commercial importation of unprocessed agricultural plant products are systematically inspected and documented. Physical inspections target the highest risk commodities.

In 2007, in Martinique:

- 4,010 lots of plant products were inspected for import, representing 32,202 metric tons and 3,579,062 units (flowers, plants, and transplants).
- Export : Only 21 export certificates were rendered for 2,841 metric tons and 4,450 units; however, it is notable that 310,000 metric tons/year are exported without inspection to European Union countries (banana and melon).

The danger of introduction of invasive quarantine pests resides not so much in commercial trade as in the movement of passengers and tourism. This is why there is a local law prohibting importation of fresh plant products in passenger baggage. A full time FREDON officer, funded by the banana industry, works in collaboration with customs to monitor the different types of arrival: inter-island port, airport, marinas. In 2007, in Martinique, 202 interceptions were made during passenger inspection thanks to the perfect collaboration with custom officers, who scan baggage items from the highest risk arrival flights (from South America, French Guyana, and Guadeloupe).

Figure 1. Station at Martinique Aimé Césaire International Airport for inspection of arriving aircraft passengers and inspectionof their baggage

One of the major problems facing inspectors at the points-of-entry, as well as their users, relates to the double application of regulations: 1) the general European regulation, Directive 200/29/EC of 8 May, 2000, which does not contain a specific annex applicable to agriculture in the « most remote regions » (the French Overseas Departments, and the Spanish and Portuguese remote regions), and 2) the French Overseas Department (DOM) regulation, in place since 1990, and which is often too severe or obsolete.

A project to integrate specific annexes (quarantine pests, prohibited plant products, special conditions for the importation of plant products, etc.) for the most remote regions in the

European regulation, in the form of a new directive similar in principle to Directive 200/29/EC, is being finalized.

The monitoring programme also helps control the black banana weevil, Cosmopolites sordidus, whose populations are now controlled by use of traps made with an aggregation pheromone called sordidin. The SPV has invested in human resources, material, and technology to allow the indexing of each of hundreds of imported in vitro plant lots for three viruses, Banana Bunchy Top Virus, Cucumber Mosaïc Virus, and Banana Bract Mosaïc Virus by sampling at a weekly rate of 0.1 to 1%, depending on the varieties. This represented about 10,000 analyses done annually by the local plant health laboratory prior to release for sale. Ralstonia solanacearum is also monitored regularily.

Figure 2. Insect proof greenhouse for growing out vitroplants, Saint Joseph, Martinique

The study of relevant lists appearing in the DOM annexes is based on 130 pest risk analyses (PRA) for quarantine pests and 70 PRAs for invasive plant species, which were prepared by CIRAD from 2005-2006 with European financial support (« POSEIDOM Phytosanitaire »).

(ii) Monitoring of local nurseries. This is the basis for better actions in the territory in the area of Plant Protection, be it for export certification, but mainly for phytosanitary follow-up of imports (anthuriums, pineapple), and for follow-up and release by special dispensation after imported vegetables have been quarantined. For about fifteen years, this activity has consisted mainly of inspecting the production of in vitro banana plants.

(iii) Biological surveillance of the territory. This consists of two components:

A. **General systematic surveillance**. This first component is in large part entrusted by the SPV to the FREDON, the professional organization; and it consists of helping agricultural producers diagnose diseases and insects attacking their crops and to identify the best control strategies,

including methods alternative to chemical treatments. A team of 20 technicians, relying on the commercial community groups combating invasive species and pests, the GDON, sweeps the territory. They have a mobile laboratory, a diagnostic laboratory for fungi and insects, and they refer samples to the department of plant health for the identification of diseases caused by viruses and bacteria. These actions complement and increase the general surveillance of the territory, carried out also by the SPV in collaboration with all different producer groups.

B. The PANDOeR project (New Pathogens: Detection, Observation, Eradication) is the second component. It consists of putting in place a system for the early detection and eradication of threatening diseases. The targeted diseases and insects are those present in the Caribbean islands that may impact the environment and economy of Martinique (tourism, agriculture, and employment) and that are potentially invasive: coconut lethal yellowing and the red palm mite on palm trees, Black Sigatoka (and Yellow Sigatoka, which is already present), moko disease of banana, fruit flies, etc.

The objectives of the PANDOeR project are :
Primarily :

- To create the capacity for the early and efficient detection of the arrival of new pathogens (implementation of a surveillance network and a sytstem to issue alerts),
- To develop the ability to eradicate the exotic pathogens (prepartion of protocols and adaptation of methods) or, in the worst case, to contain them in the area of introduction.
- And secondarily:
- To reinforce the cooperation between all concerned parties, particularily the research and agricultural sectors,
- To train people working on surveillence in detection methods,
- To acquire new laboratory technologies,
- To raise the awareness of producers and to enlighten about emerging diseases,
- To reinforce communication and raise the awareness of the general public on environmental and agricultural risks in Martinique.

Each surveillance network work as a partnership of SPV, FREDON, Chamber of Agriculture, producer groups, SICA TG (society in charge of aerial treatments), ONF (national office of forestry). They work together and benefit from methods developed by CIRAD. Important identifications and analyses are conductecd at the plant health laboratory of the General Council of Martinique with help from the national plant protection laboratory and CIRAD. Actions that are planned or already undertaken consist of (a) review, planning and organization of teams with the identified partners, (b) implementation of surveillance, (c) training sessions for the different actors, and (d) development and implementation of a strategy for communication with producers, travelers, and officials of the implicated administrative structures.

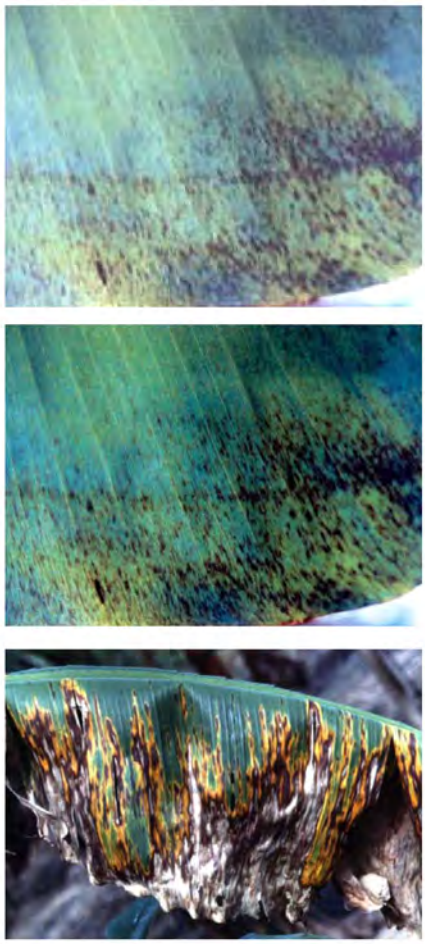
CONCLUSIONS

Crop protection in tropical island environments, in particular in islands of the Caribbean region, which are small in size and susceptible to numerous and varied man-made pathways, relies mostly on the capacity to prevent the introduction of invasive species or to quickly eradicate them. While control of existing pests constitutes an important effort for producers, border

control and biological surveillance of the territory is an important challenge for the local plant service (ONPV) that can only be met in collaboration with institutional and professional partners present in the territory: ports, airports, marinas, agricultural zones, natural spaces, and private gardens.

Another important aspect is information sharing, setting up an alert network system, and joint or combined control strategies between the Caribbean countries. This was the objective of the T-STAR symposium organized by CFCS in July 15, 2008 in Miami, Florida ; and which was an undeniable success in this field of work.

The following observation networks have been set up since 2007 :



Symptômes de la cercosporiose

EDITORIAL NOTE : The translation into English of the original French tex twas made by Dr. Kayimbi M.Tubajika, Plant Pathologist/Risk Analyst, USDA APHIS CPHST, Pest Epidemiology & Risk Analysis Laboratory, North Carolina State University, 1730 Varsity Drive Suite 300, Raleigh, NC 27606. The editors are very grateful to Dr. Tubajika for this valuable service.

Proceedings of the Caribbean Food Crops Society. 44(1):47-56. 2008

CIRAD INVASIVE SPECIES INITIATIVES IN THE CARIBBEAN BASIN

Dr. Emmanuel Wicker [1§], Dr. Catherine Abadie [2], Dr. Jean Heinrich Daugrois [3], Dr. Luc Baudouin [4], Dr. Michel Dollet [4], Dr. Marie-Françoise Zapater [5], Mr. Claude Vuillaume [2] and Dr. Pierre-Yves Teycheney [2]. [1] CIRAD-PRAM, 97285 Le Lamentin Cedex 2, Martinique, FWI;
[2] CIRAD-UPR75 and CIRAD-DG, Station de Neufchateau, 97130 Capesterre Belle-Eau, Guadeloupe, FWI; [3] CIRAD-UPR75, Station de Roujol, 97170 Petit-Bourg, Guadeloupe, FWI ;
[4] CIRAD-UPR29, Campus international de Baillarguet, TA A-29, F-34398 Montpellier Cedex 5, France ; [5] CIRAD-UMR BGPI, Campus International de Baillarguet, TA A-54, F-34398 Montpellier Cedex 5, France.
[§] : current address : UMR PVBMT, Station de Ligne-Paradis, 7 chemin de l'IRAT, 97410 Saint-Pierre, Réunion Island
*Author for correspondence: teycheney@cirad.fr

ABSTRACT. Several research programmes of CIRAD (Centre de Coopération en Recherche Agronomique pour le Développement) target invasive species in the Caribbean. These programmes deal primarily with pathogens (bacteria, bacteria-like, fungi and viruses) of major crops grown in the French West Indies (Guadeloupe and Martinique) and elsewhere in the Caribbean, such as banana, sugarcane and coconut. CIRAD has developed new tools for the detection of some of these pathogens: Ralstonia solanacearum (causal agent of Moko disease), Mycosphaerella fijiensis (causal agent of Black Sigatoka disease, BSD), Banana streak viruses (BSV), Banana mild mosaic virus (BanMMV) and banana virus X (BVX). Using these and existing detection tools, the presence, prevalence and diversity of pathogens established on or threatening banana, sugarcane and coconut in the Caribbean were investigated. These investigations resulted in recommendations for the control of the above-mentioned pathogens. Also, several of the detection techniques developed in these investigations were successfully transferred to Caribbean Plant Protection Services, paving the way for the development and implementation of a regional surveillance network of crop diseases.

KEY WORDS: crops; invasive species; Ralstonia solanacearum; Black Sigatoka; coconut lethal yellowing; Sugarcane yellow leaf curl virus; Banana streak viruses; diagnostic; surveillance networks.

INTRODUCTION

CIRAD has developed several initiatives on invasive plant pests and pathogens that are present in the Caribbean. These initiatives are primarily focused on Ralstonia solanacearum, Black Sigatoka, coconut lethal yellowing and viral diseases of sugarcane and banana. They include (i) research activities, (ii) transfer of diagnosis techniques to plant protection and quarantine services and (iii) participation in surveillance networks, either existing or under construction.

Epidemiological and molecular studies are the key component of many CIRAD research activities in the Caribbean. They are often carried out in the frame of international collaborative

projects, such as surveys undertaken in Grenada and St Vincent on banana Moko disease. Epidemiological studies were also carried out in Guadeloupe and Martinique on several pathogens affecting sugarcane, such as sugarcane yellow leaf virus and leaf scald disease. These studies have helped implement strategies for controlling established and emerging diseases and pests of sugarcane. Likewise, epidemiological and diversity studies carried out on coconut lethal yellowing, Black Sigatoka and Banana streak viruses helped in the establishment of control strategies.

Diagnosis and monitoring tools and techniques are one of the major outputs of CIRAD research activities. Transfers of these tools and techniques to plant protection and quarantine services of Caribbean countries are a key component of the CIRAD's strategy, which aims at increasing food security in the Region through better control of pathogens. These transfers are achieved through collaborative projects and regional workshops. Such workshops were successfully organised in Guadeloupe in order to transfer techniques for the detection and monitoring - for example - of Black Sigatoka and the detection of several viruses infecting Musa species.

CIRAD also plays an active role in global surveillance networks such as PANDOeR and the current USDA/CARICOM joint initiative for promoting plant health in the region through existing networks (CISWG, CISSIP). CIRAD's current projects involve the development of a Regional Black Sigatoka surveillance and control network, and a participatory database on major diseases of banana, coconut, horticultural crops, sugarane and yam.

Moko disease

Moko disease is an ancient disease in the Caribbean. Moko disease was first described in Guyana in 1840, then reported during devastating outbreaks in 1890 in Trinidad (Rorer, 1911), and it reached the industrial banana plantations of Central America in the 1950s (Sequeira, 1998). It is now emerging and spreading over the Caribbean, affecting Jamaica since 2003, and St Vincent since 2007.

Moko disease is caused by specific strains of the soilborne beta-proteobacterium, Ralstonia solanacearum (formerly called race 2). The most recent phylogenetic analyses demonstrated that this bacterial species should be considered a species complex composed of four phylotypes related to geographical origin : I = Asian, II= American, III=African, IV=Indonesian (Fegan & Prior, 2005, Prior & Fegan, 2005). The robustness and reliability of this 4 phylotypes scheme was clearly demonstrated by recent genomic studies using a DNA chip microarray approach (Guidot et al., 2007). Moko-inducing strains are distributed within phylotype II in four genetic groups named sequevars: sequevar 3 originating from Central America, sequevar 4 from Peru and Colombia, sequevar 6 from Venezuela and sequevar 24 being specific to Brazil (Fegan & Prior, 2006).

Thanks to the recent development of strain-specific identification tools, field surveys were carried out in Martinique and Grenada. They showed that Moko-related strains can also threaten vegetable and flower crops. In Martinique, phylotype II/sequevar4NPB strains, which are not pathogenic on banana but do belong to the Moko strain's genetic group, are pathogenic on

anthurium, Heliconia and cucurbits, and are spreading rapidly on tomato (Wicker et al., 2007, Wicker et al., 2009).

In Grenada, where Moko disease has been described since 1978 (Ambrose, 1987), Moko strains were found to induce insect-transmitted and soil-borne infestations; all were assigned to sequevar 6 following multiplex-PCR gene sequences analyses; whereas, R.solanacearum strains pathogenic on vegetables (particularly tomato) were all assigned to sequevar 5. Molecular diagnosis studies thus showed that Moko disease was re-emerging on the island, due to the loss of know-how on disease prevention among farmers. This loss of understanding and skills is the result of failure of older experienced growers to transmit to young growers the basic preventive measures they had learned during the early 1980's.

Mapping of the different Moko groups within the Caribbean subregion is essential to the implementation of effective control strategies, since it provides important data on the origin of strains, leading to the identification and quantification of pathogen flows. To this aim, such a mapping is currently being undertaken in the West Indies, in the frame of collaboration between the University of the West Indies (St Augustine) and CIRAD Réunion.

Black Sigatoka disease

Mycosphaerella leaf spot diseases are the most damaging and costly diseases of bananas and plantains (Jones, 2000) especially for banana export production. They are due to ascomycete fungi whose ascospores are naturally spread by wind. Mycosphaerella fijiensis, is responsible for the Black Sigatoka (BS), and Mycosphaerella musicola is responsible for Sigatoka Disease (SD). These foliar diseases affect yields and fruit quality. BS is more severe than SD because it affects plantains and its infectious cycle is shorter (Jones, 2000). Control against Mycosphaerella leaf spot diseases rely on frequent aerial fungicide sprays. On average, 10 annual fungicide sprays are necessary to control SD in the French West Indies, whereas 30 to 60 sprays are necessary to control BS, depending on environmental conditions and spraying strategy.

All major banana producing countries in Latin America, the Caribbean and Africa are affected by BS, except several Caribbean islands (French and English West Indies) which are affected by SD but remain free of BS so far. BS as first described in Fiji in 1963 and has been spreading worldwide rapidly since, probably by means of transportation of infected bananas plants. It was first detected in Latin-America (Honduras) in 1972 and in the Caribbean (Cuba) in 1990 (Jones, 2000). Then it spread to Jamaica (1995), the Dominican Republic (1996) and Haiti (1999). More recently, it was described in 2003 in Trinidad (Fortune et al., 2005), in 2004 in Grand Bahama island (Ploetz, 2004) and Puerto-Rico (Irish et al., 2006). The last emergence in the Caribbean was in 2005 in Grenada (Graham, 2007).

Because of the above-mentioned recent history, BS is considered to be an emerging disease. It currently threatens banana production in several Caribbean areas and its introduction in disease-free areas such as the French West Indies and Windward islands could have a devastating effect on their banana production. Therefore, CIRAD's initatives on BS aim at a better control of the disease through 3 kinds of activities as follows:

- **BS surveys.** Surveys consist in analysing banana areas, collecting infected leaf samples and performing visual and molecular diagnosis. Four surveys were realised in 2004 in Saint-Lucia, Saint Vincent, Dominica and Suriname, following the request of banana producers' organizations. Twelve to twenty samples were harvested in each country and analysed by morphotaxonomic observations and molecular diagnosis. No positive samples could be identified at that time.
- **Assistance and training in BS diagnosis.** Two kinds of diagnosis were developed by CIRAD. The first one is based on morphotaxonomic observations, i.e observation of conidia and conidiophores in order to differentiate M. fijiensis from M. musicola (Zapater et al., 2008). It requires the occurrence of sporulating lesions. A molecular diagnosis was also developed, based on a method developed in Australia (Johanson et Jeger, 1993). It allows an early detection of the disease and is therefore essential to surveillance. CIRAD has taken part in symptom recognition workshops organised by Wibdeco (banana organization from the Windwards) in 2004 in Saint-Lucia, Saint-Vincent and Dominica. About 100 persons from Ministries, producer organisations and quarantine services were trained. CIRAD organised in 2008 two BS diagnosis trainings for plant protection staff: one was organised at CIRAD Guadeloupe, with participants from Saint-Vincent, Dominica and Saint-Lucia; another took place at CIRAD's headquarters in Montpellier (France), with participants from the 4 French overseas departments (Guadeloupe, Martinique, French Guyana and Réunion Island). Thus, several key persons from the 5 currently BS-free banana countries have skills to detect BS at early stages.
- **Initiative to set up a BS surveillance network in the Caribbean**
  - FWI network: based on its experience on BS, CIRAD has taken part in the implementation of a BS surveillance network in the FWI (see the paper of J. Iotti et al.). This network aims at surveying all banana areas (commercial and backyards) in order to detect potential BS introduction as early as possible and eradicate it. It started operating in April 2008 in Martinique and will startoperating in Guadeloupe in 2009. It is coordinated by the French Plant Protection services and involves CIRAD, FREDON and banana producers' organisations.
  - Regional network: in October 2006, CIRAD organised a BS regional workshop in Guadeloupe, with 32 participants from agriculture services and banana producers from 13 Caribbean countries. The main output of this workshop was the implementation of a Caribbean BS network, which aims at increasing the exchange of information and at promoting collaboration between Caribbean countries. There is no official structure yet but CIRAD plays a key role in this regional network. Some specific needs were identified, such as disease surveillance, diagnosis and development of alternative control methods such as resistant varieties and use of biofungicides.

Finally, a research project coordinated by CIRAD, funded by the French National Research Agency (ANR) and called ANR Emerfundis was started in 2008. It aims at unraveling the dynamic of M. fijiensis populations in the Caribbean, based on the analysis of historical data and genetic structure of fungal populations. All Caribbean banana countries where BS has been reported are taking part in this project by collecting historical data and, in some cases,

collecting biological samples. Historical data are currently being processed whereas molecular analyses are planned for 2010.

LETHAL YELLOWING DISEASES

Lethal yellowing diseases are caused by phytoplasmas. They have destroyed coconuts by the thousands in the Caribbean region and CIRAD has put a priority on research on these diseases (Dollet 2002). CIRAD's interventions focus on three factors: (i) the pathogen and the etiology of the disease itself, (ii) the vector and finally, (iii) search for sources of genetic resistance in coconut.

In the family of Lethal yellowing diseases, several types can be distinguished depending on symptoms and epidemiology (Dollet et al. 2008). They are caused by various phytoplasma strains that can be identified using heteroduplex mobility assay (Marinho et al. 2008). CIRAD collaborated in research conducted to characterize the pathogen and the development of the disease in Cuba (Llauger et al. 2006), the Dominican Republic (Martinez et al. 2008) and Jamaica (Myrie et al. 2003; Myrie et al. 2007).

Although Myndus crudus has been identified as a vector of the disease, search for possible alternative vectors are still needed and CIRAD collaborates with CICY in Mexico in this domain (Julia et al. 2008). CIRAD also contributes to a better knowledge of the ecology and diversity of Myndus crudus and related species, in collaboration with CIB in Jamaica (Brown et al. 2002, Brown et al. 2008).

At the turn of the century, an outbreak of the disease occurred in Jamaica. It affected varieties that were, so far, considered resistant (at least partially) to the disease. One possible cause for this outbreak was that the planting material that was used was not true to the varieties that were evaluated for resistance in the 70's. Molecular characterization showed that, although some deviations existed, they were insufficient to explain the intensity of the recent attack (Baudouin et al. 2008; Lebrun et al. 2008). This indicates that changes occurred also in pathogens or vectors.

BACTERIAL AND VIRAL DISEASES OF SUGARCANE

CIRAD has developed epidemiological research programmes on several diseases that are affecting sugarcane in the Caribbean. Most of these studies are focused on the variability of pathogen populations and their dispersion patterns, including studies on climate conditions favouring this dispersion. These programmes are primarily focused on two pathogens;

- Xanthomonas albilineans, the causal agent of sugarcane leaf scald, is mainly transmitted by harvesting tools and stalk cuttings. However, this bacterial pathogen can also be transmitted by aerial means, and aerial spread is an important step in the disease cycle. Recent studies showed that the amount of rainfall during the wet season is a key factor in leaf scald epidemics and disease progress in Guadeloupe (Champoiseau 2009).
- Sugarcane yellow leaf virus (SCYLV), the causal agent of an emerging aphid vectored disease called yellow leaf, is present in numerous sugarcane countries

worldwide. In the Caribbean, the virus was first identified in the French West Indies in 1996. SCYLV was diagnosed later at CIRAD's sugarcane quarantine facility in Montpellier in seed cane originating from Barbados and Cuba (Daugrois, 2008). It was also detected in Belize and Jamaica lately during a survey realized by Cirad Guadeloupe. Recent studies showed that genetic variation occurs within SCYLV, and four genotypes of the virus differing in aggressivity and virulence have been reported so far (Abu Ahmad et al., 2007). Characterization of SCYLV genotypes and vector population dynamics are essential to analyse the risk of yellow leaf epidemics. To this aim, CIRAD has undertaken a study of yellow leaf incidence in 34 farmers' fields, and aphid vector populations and distribution of SCYLV genotypes in the two closely related islands of Guadeloupe and Martinique. Important differences in disease incidence and frequency of virus genotypes between both locations were unveiled, suggesting the occurrence of strong local effects on virus populations that need to be further characterized. Therefore, disease progress in one location cannot yet be predicted based on the situation in another relatively close location, and the status of yellow leaf disease must be studied locally in order to determine the risk of epidemics and to measure its impact on sugarcane production.

Results from research programmes fuel the development of sugarcane crop protection strategies. For example, the implementation of pathogen detection techniques help CIRAD to promote the safe movement of sugarcane germplasm through varietal exchange performed under the control of the International Sugarcane Quarantine, which is located at CIRAD's headquarters in Montpellier (France) and operated by the French plant protection services. CIRAD has also developed tools for distance diagnosis of ratoon stunting, yellow leaf and leaf scald diseases by means of tissue blot that can be sent by mail for diagnosis, avoiding the need to send plant samples. This technique was used succesfully for disease diagnosis in Jamaica (Falloon, 2006), Belize and the Dominican Republic.

CIRAD also focuses on the genetic characterization of resistances against sugarcane pathogens and on phenotyping its sugarcane germplasm collection for such resistance, in order to develop disease resistant hybrid varieties.

VIRAL DISEASES OF BANANA

Of the 8 characterized virus species affecting banana and plantain, 4 are present in the Caribbean: Banana mild mosaic virus (BanMMV), Banana streak viruses (BSV), Banana virus X (BVX) and Cucumber mosaic virus (CMV). CIRAD has research activities on the three former. These activities are primarily focused on the characterization of the diversity of viral populations, in order to develop and/or optimize detection techniques that are both sensitive and polyvalent, and that can be used to assess the levels of prevalence of virus species in banana and plantain plantations.

Diversity studies were carried out on BanMMV (Teycheney et al., 2005a) in Guadeloupe. They incidentally led to the discovery of a new virus species, Banana virus X (BVX) in Guadeloupe

(Teycheney et al., 2005b). This research resulted in the development of distinct detection techniques adapted to the diversity of both viruses (Teycheney et al., 2007). Likewise, optimized detection techniques were established for BSV (Le Provost et al., 2006), in order to minimize the risk of detecting false positives resulting from the presence of endogenous BSV sequences that are present in the genome of some banana and plantain cultivars (Hohn et al., 2008). Using such detection tools, prevalence studies were carried out for BSV and BVX in Guadeloupe (Perefarres et al., in press) and for BSV in Cuba (Javer et al., in press), leading to recommendations on the control of these viruses.

Transfer of detection techniques to plant protection services in the Caribbean are an essential part of CIRAD's strategy, which aims at increasing food security in the region through a better control of pathogens. It is also essential that these techniques are widely transferred to and used by private companies multiplying planting material, especially vitroplants, in order to avoid outbreaks resulting from the large scale distribution of virus-infected plants. To this aim, several workshops were organized, with staff from plant protection services and private companies attending.

CONCLUSIONS

Invasive species are threatening health, agriculture and food security worldwide, especially in tropical insular environments such as the Caribbean, where they can spread very rapidly and become endemic. Their control requires coordinated efforts from scientists, protection services and private operators.

CIRAD has developed research programmes focused on several diseases and pathogens of major crops in the Caribbean, with research teams based in the French West Indies and in mainland France. These research programmes aim primarily at increasing our knowledge on pathogens diversity and population dynamics. They are leading to better diagnosis tools and surveillance strategies that need to be implemented both at national and regional levels, in order to prevent the spread of existing pathogens and the introduction of new ones. To this aim, CIRAD has developed an extensive collaborative network with research institutions and plant protection services in the Caribbean. CIRAD is also taking part in initiatives aiming at the development of surveillance networks of pathogens in the Caribbean.

Increased movements of the human population and goods, global warming and environmental changes deeply affect the dynamics of diseases and the rate of emergence of new diseases. Public attention has been focused on the recent emergence or re-emergence of animal and human diseases such as AIDS, SARS or Bluetongue. However it is expected that similarly important diseases affecting crops will emerge at an accelerated rate in the future, although it should be kept in mind that they have never stopped emerging (Anderson et al., 2004). Global response is therefore needed in order to face this global threat. One of the keys to success is the implementation of regional coordinated strategies including the development of unique surveillance networks for crop diseases and pests, data exchange and joint response strategies.

REFERENCES

Abu Ahmad Y., Costet L., Daugrois J.H., Nibouche S., Letourmy P., Girard J.C., and Rott P., 2007. Variation in infection capacity and in virulence exists between genotypes of Sugarcane yellow leaf virus. Plant Dis. 91: 253-259.

Ambrose E., 1987. Moko disease control: the Grenada experience. Proceedings of the Improving Citrus and Banana production in the Caribbean through sanitation: Seminar proceedings. Wageningen: CTA, 108-14.

Anderson P.K, Cunningham A.A., Patel N.G., Morales F.J., Epstein P.R., Saszak P., 2004. Emerging infectious diseases of plants: pathogen pollution, climate change and agrotechnology drivers. Trends Ecol Evol **19**: 535- 544.

Baudouin L., Lebrun P., Berger A., Myrie W., Been B., Dollet M. 2008. The Panama Tall and the Maypan hybrid coconut in Jamaica : Did genetic contamination cause a loss of resistance to Lethal Yellowing?. Euphytica **161**: 353-360. http://dx.doi.org/10.1007/s10681-007-9568-2

Brown J.K., Dollet M. 2007. Evaluation of the mitochondrial COI gene as a useful genetic marker for Myndus crudus and other Myndus spp. : Phytopathology **97** : S174.

Brown J.K., Dollet M., Harrison N.A., Jones P. 2002. Investigtaions into the phylogeography and ecology of Myndus crudus (van Duzee) (Hemiptera, Fulgoromorpha, Cixiidae), the leafhopper vector of coconut lethal yellowing. In : 14th International Auchenorrhyncha Congress, Berlin, Germany, 8 August 2002. s.l.

Champoiseau, P., Rott, P., and Daugrois, J.-H., 2009. Epiphytic populations of Xanthomonas albilineans and subsequent sugarcane stalk infection are linked to rainfall in Guadeloupe. Plant Dis. **93**:339-346.

Daugrois, J.H., Edon-Jock, C., Fernandez, E., Girard, J.-C., P. Rott, 2008. Status of sugar cane yellow leaf disease in the French West Indies and in other islands of the Carribean. Proceeding of the West Indies Sugar Technologists, XXIX conference, April 21-25, Montego Bay, Jamaica. 8pp.

Dollet M., Quaicoe R.N., Pilet F. 2008. Review of coconut Lethal yellowing type diseases. Diversity, variability and diagnosis In : International Workshop on Lethal Yellowing Diseases on Coconut, Ghana, Accra, 3-6 June 2008. [S.l.] : s.n., p. 90-97. http://www.cirad.bf/fr/anx/conf_publi.php?idconf=601&idpubli=60120201

Dollet M. 2002. CIRAD Concept: Toward a global research programme on integrated control of lethal yellowing-like phytoplasma diseases of the coconut palm. In : CFC; FAO; Coconut Industry Board. Proceedings of the Experts consultation on sustainable coconut production through control of lethal yellowing disease, Kingston, Jamaica, 14-18 January 2002 .

Falloon T., Henry E., Davis M.J., Fernandez E., Girard J.-C., Rott P., Daugrois J.-H., 2006. First report of Leifsonia xyli subsp. xyli, causal agent of ratoon stunting of sugarcane, in Jamaica. Plant Dis. **90**: 245.

Fegan M, Prior P, 2005. How complex is the "Ralstonia solanacearum species complex". In: Allen C, Prior P, Hayward Ac, eds. Bacterial wilt disease and the Ralstonia solanacearum species complex. Madison: APS Press, 449-62.

Fegan M, Prior P, 2006. Diverse members of the Ralstonia solanacearum species complex cause bacterial wilts of banana. Australasian Plant Pathology **35**: 93-101.

Fortune M.P., Gosine S., Chow S., Dilbar A., St Hill A., Gibbs H., Rambaran N., 2005. Plant Pathology **54**: 246.

Graham P. 2007. Declaration of Black Sigatoka in Grenada. Report GD 1/4 in International Phytosanytary Portal.

Guidot A, Prior P, Schoenfeld J, Carrere S, Genin S, Boucher C, 2007. Genomic structure and phylogeny of the plant pathogen Ralstonia solancearum inferred from gene distribution analysis. Journal of Bacteriology **189**: 377-87.

Hohn T., Richert-Pöggeler K., Staginnus C., Harper G., Schwartzacher T., Teo C.-H., Teycheney P.-Y., Iskra-Caruana ML, Hull R., 2008. Evolution of integrated plant viruses. In M. Roossinck ed. Plant virus evolution. Heidelberg, Germany : Springer, 53-82.

Irish B. M. , Goenaga R., Ploetz R.C. 2006. Mycosphaerella fijiensis, causal agent of Black Sigatoka of Musa spp. found in Puerto Rico and identified by Polymerase Chain Reaction. Plant disease, **90**: 684.

Javer, E., Acina-Mambole, I., Font, C., Quiala, I., González, G., Echemendía, A.L., Teycheney., P.Y., 2009. First report of Banana streak virus species Goldfinger, Imové, Mysore and Obino l'Ewaï in Musa spp in Cuba. Plant pathology (in press).

Johanson A., Jeger MJ. 1993. Use of PCR for detection of Mycosphaerella fijiensis and M.musicola, the causal agents of Sigatoka leaf pots in banana and plantain. Mycological Research **97:** 670-674

Jones, D. 2000. Diseases of Banana, Abaca and Enset. CABI Publishing, CAB International, Oxon, UK.

Julia J.F., Sanchez-Soto S., Navarez M., Oropeza C., Oritz C.F., Castillo R., Dollet M. 2008. Search for the insect vectors of Lethal Yellowing (LY), a phytoplasma disease in Mexico : Phytopathology, 98 (8, su) (suppl.199). http://dx.doi.org/10.1094/PHYTO.2008.98.6.S199

Lebrun P., Baudouin L., Myrie W., Berger A., Dollet M. 2008. Recent lethal yellowing outbreak: Why is the Malayan Yellow Dwarf Coconut no longer resistant in Jamaica?. Tree genetics and genomes, 4: 125-131.http://dx.doi.org/10.1007/s11295-007-0093-1

Le Provost G., Iskra-Caruana M.-L., Acina I., Teycheney, P.-Y., 2006. Improved detection of episomal Banana streak viruses by multiplex immunocapture PCR. J. Virol. Meth. **137**: 7-13.

Llauger R., Alonso M., Fabre S., Gonzales C., Julia J.F., Luis M., Rodriguez M., Peralta E.L., Cueto J., Dollet M. 2006. Current status of coconut lethal yellowing research in Cuba : In : XLVI Annual Meeting American Phytopthological Society, Cartagena, Colombia, Septembre 12-16, 2006.

Marinho V.L.A., Fabre S., Dollet M. 2008. Genetic variability among isolates of Coconut lethal yellowing phytoplasmas determined by heteroduplex mobility assay (HMA). Tropical plant pathology 33: 377-380.http://dx.doi.org/10.1590/S1982-56762008000500006

Martinez R.T., Narvaez M., Fabre S., Harrison N., Oropeza C., Dollet M., Hichez E. 2008. Coconut lethal yellowing on the Southern Coast of the Dominican Republic is associated with a new 16Sr IV group phytoplasma. Plant pathology **57**: 366. http://dx.doi.org/10.1111/j.1365-3059.2007.01726.x

Myrie W., Harrison N., Dollet M., Been B. 2007. Molecular detection and characterization of phytoplasmas associated with lethal yellowing disease of coconut palms in Jamaica. Bulletin of Insectology, 60: 159-160. http://www.bulletinofinsectology.org/pdfarticles/vol60-2007-159-160myrie.pdf

Myrie W., Dollet M., Been B. 2003. Study on the diversity of phytoplasma associated with lethal yellowing. In : 42nd Annual meeting on the American Phytopapthological Society-Caribbean Division, South Padre Island, Texas, U.S.A, April 6-10, 2003.

Péréfarres F., Le Provost G., Acina I., Lockhart BEL, Iskra-Caruana ML, Candresse T., Teycheney P.-Y., 2008. Detection, prevalence and diversity of Banana streak viruses (BSV), Banana mild mosaic virus (BanMV) and Banana virus X (BVX) in Guadeloupe. Acta horticulturae (in press).

Ploetz R. 2004. First Report of Black Sigatoka of Banana Caused by Mycosphaerella fijiensis on Grand Bahama Island. Plant disease, 88: 772.

Prior P, Fegan M, 2005. Diversity and molecular detection of Ralstonia solanacearum race 2 strains by multiplex PCR. In: Allen C, Prior P, Hayward Ac, eds. Bacterial wilt disease and the Ralstonia solanacearum species complex. Madison: APS Press, 405-14.

Rorer JB, 1911. A bacterial disease of bananas and plantains. Phytopathology 1: 27-52.

Sequeira L, 1998. Bacterial wilt: the missing element in International banana improvement programs. In: Prior P, Allen C, Elphinstone J, eds. Bacterial wilt disease: Molecular and ecological aspects. Heidelberg, Paris: Springer - INRA Editions, 6-14.

Teycheney P.-Y., Laboureau N., Iskra-Caruana M.-L., Candresse, T., 2005a. High genetic variability and evidence for plant-to-plant transfer of Banana Mild Mosaic Virus. J. Gen. Virol. 86: 3179-3187.

Teycheney P.-Y., Marais A., Svanella-Dumas L., Candresse, T., 2005b. Molecular characterization of banana virus X (BVX), a novel member of the Flexiviridae. Arch. Virol. 150: 1715-1727.

Teycheney P.-Y., Acina I., Lockhart B. E. L., Candresse T., 2007. Detection of Banana mild mosaic virus and Banana virus X by polyvalent degenerate oligonucleotide RT-PCR (PDO-RT-PCR). J. Virol. Meth. 142: 41-49.

Rivas G., Zapater M.F., Abadie C., Carlier J. 2004. Founder effects and stochastic dispersal at the continental scale in the fungal pathogen of banana Mycosphaerella fijiensis. Molecular Ecology. 13 : 471-482.

Wicker E, Coranson-Beaudu R, Cadasse S, William M-A, 2009. Emerging strains of Ralstonia solanacearum in the French West Indies raise new challenges to tomato breeders. In: Saygili H, Sahin F, Aysan Y, eds. 2nd International Symposium on Tomato Diseases. Kusadasi: ISHS-ACTA HORTICULTURAE, 279-86. (808.)

Wicker E, Grassart L, Coranson-Beaudu R, Mian D, Guilbaud C, Fegan M, Prior P, 2007. Ralstonia solanacearum Strains from Martinique (French West Indies) Exhibiting a New Pathogenic Potential. Applied and Environmental Microbiology **73**: 6790-801.

Zapater MF, Abadie C., Pignolet L. Carlier J., Mourichon X. 2008. Diagnosis of Mycosphaerella spp. responsible to Mycosphaerella leaf spot diseases of bananas and plantains through morphotaxonomic observations. Fruits, 63: 389-393.

Proceedings of the Caribbean Food Crops Society. 44(1): 57-68. 2008

T-STAR INITIATIVES IN SUPPORT OF INVASIVE SPECIES EFFORTS IN THE GREATER CARIBBEAN REGION

Martha R. Roberts, Special Assistant to the Director, Florida Experiment Station, Institute of Food & Agricultural Sciences, University of Florida, North Florida Research and Education Center, 155 Research Road, Quincy, Florida 32351-5684. Phone: (850) 875-7100; email mroberts@ifas.ufl.edu .

ABSTRACT. The T-STAR program supports basic and applied research on invasive species with respect to (i) their biology, ecology, (ii) methods of diagnosis/identification, detection, surveillance, exclusion, eradication and control and (iii) development of comprehensive safeguarding strategies, including international policy development and coordination among all countries and territories, and the use of internet-based communications to facilitate all aspects of a coordinated Regional system to prevent and mitigate invasive species impacts. Currently significant emphasis is on building technical and institutional policy support platforms for an effective US/Caribbean Basin Invasive Species Safeguarding System.
A brief history of the T-STAR program is presented including the actions taken by various scientists and administrators to arrive at the invasive species program in the Greater Caribbean Region. A list of invasive species research projects currently funded by T-STAR is included.

INTRODUCTION

The T-STAR program (Tropical & Subtropical Agriculture Research) is part of the Special Grant Program of the USDA-CSREES and it has been funded for more than 25 years under Public Law 89-106. T-STAR is a collaboration and partnership currently with a priority focus on invasive species and at the University of Florida it is currently headed by Dr. Douglas L. Archer. The T-STAR program has extensive partnerships in the Caribbean through the Caribbean Invasive Species Working Group, which includes CARDI, CARICOM Secretariat, CABI, CIRAD, France - Service de la Protection des Végétaux, Direction de l'Agriculture et de la Forêt, Costa Rica Ministry of Agriculture, FAO, PAHO, IDIAF, IICA, UPR, FAMU, The Nature Conservancy, UWI, USDA/APHIS, and the Agricultural Ministries of the Greater Caribbean nations. The purpose of this presentation is to demonstrate the solid, long-term and on-going commitment of the Institute of Food and Agricultural Sciences at the University of Florida (UF/IFAS) to the invasive species efforts in the Greater Caribbean.

University of Florida and University of Puerto Rico faculty members have conducted research on pathogens and pests in the Caribbean for many years and some of these studies have been funded by the T-STAR Program since its inception. The invasion of Florida by alien invasive species was chronicled by Professor J. Howard Frank and he found that 270 species of exotic insects became established in Florida in the period of 1970 to 1989 for an average annual rate of 14.2 species (Frank, J. H. and E. D. McCoy. 1992, 1995). Since 1986 this task has fallen to Dr. Michael Thomas, Florida Department of Agriculture and Consumer Services, who found that from 1986 through 1999 the number of exotic insect species established each year varied

between 4 and 21 (Thomas 2000). Similar studies were conducted in Puerto Rico by Professor Rosa A. Franqui (1999), and in the Pacific Basin by Muniappan et al. (1991).

Alarmed by these findings, Mr. Dean F. Davis, the first T-STAR Director, urged that T-STAR conduct two workshops on invasive species, one with respect to the Caribbean Basin and the other with respect to the Pacific Basin. Mr. Davis asked Dr. Waldemar Klassen to take the lead in organizing and conducting the first of these international workshops, "Mitigating the effects of exotic pests on trade and agriculture, Part A, The Caribbean". This workshop was held at Homestead, Florida in June, 1999 (Klassen, 1999), and the second, Part B, The Pacific, was held at the University of Guam in 2001 (Klassen et al., 2002; Muniappan and Campbell, 2002). The proceedings of these two T-STAR workshops documented the vulnerability of the Caribbean and Pacific Basins to the influx of invasive species as a result of the globalization of trade, tourism and smuggling (Hara, 2002; Shannon, 1999). These findings were reinforced by a study of the National Plant Board (1999), "Safeguarding American plant resources. A stakeholder review of the APHIS-PPQ Safeguarding System" and by studies on the incursion of plant pathogenic viruses into the Western Hemisphere by Polston and Anderson (1997). Both the T-STAR workshops and the National Plant Board Study concluded that the century-old strategy of safeguarding against invasive alien species by inspecting cargo and travelers at ports of entry had become grossly inadequate, and that the focus of safeguarding mitigations have to be shifted to the sites of origin of imports and of baggage so that pest-free cargo and baggage would arrive at the ports of entry of importing countries (Zadig, 1999). Similar findings for animal invasive pests and diseases were dealt with in the Animal Health Safeguarding Review (2001) conducted by the USDA and the National Association of Departments of Agriculture (NASDA) Research Foundation; Roberts chaired the International Subcommittee for this review (NASDA, 2001).

Although the two T-STAR workshops resulted in an increased appropriation by the US Congress for research on invasive species, they had no discernible impact on safeguarding policies and aarrangements in the Greater Caribbean Region. Dr. William F. Brown, Assistant Dean for Research, University of Florida/IFAS and successor to Mr. Davis as T-STAR Director, was concerned that the myriad of research projects on invasive species conducted in the Greater Caribbean Region had not resulted in a slowing the rate of influx and spread of these harmful exotic creatures. Thus Dr. Brown perceived the need for a Caribbean invasive species strategy that would include international policy development and coordination among all countries and territories and include regulatory all relevant regulatory agencies. Moreover Dr. Brown felt that such international policy development should focus on enhancing detection, combating, forecasting and regulating invasive alien species.

In 2002 Dr. Brown was encouraged by the CFCS Board of Directors to hold a T-STAR Symposium on invasive species at the Society's 39th annual meeting in Grenada. Dr. Brown enlisted Drs. Klassen, Carlton Davis, Norm Leppla, J. Howard Frank, Gail C. Wisler, who were University of Florida faculty, as well as Connie Riherd of the Florida Department of Agriculture and Consumer Services, and Mr. Michael J. Shannon of USDA-APHIS to plan and organize the symposium: "Challenges and Opportunities in Protecting the Caribbean, Latin America, and the United States from Invasive Species" (Klassen et al., 2003). A most important outcome of this Symposium was the formation of the Caribbean Invasive Species Working Group, which immediately began to work on a strategy to slow the influx of invasive alien species into the

Region and to cope with those already present. Subsequent Symposia in this series have been held in Guadeloupe in 2005, in Puerto Rico in 2006 and now in Miami Beach (2008).

In 2004, Drs. Klassen and Davis and Mr. Bruce Luackner of CARDI took the lead in holding a followup workshop on "Facilitating Safer US-Caribbean Trade: Invasive Species Issues". To accomplish this expensive undertaking, the organizers used modest sums of funds from the University of Florida Center for Tropical Agriculture and the University of Florida International Agricultural Trade and Policy Center to leverage support from CAB International, CARDI, Caribbean Development Bank, FAO, IICA, Ministry of Agriculture, Lands and Marine Resources of Trinidad and Tobago, University of Florida T-STAR and the University of the West Indies. The Workshop was very well attended by representatives of Ministries of Agriculture, academic institutions, research and regulatory agencies, environmental groups, and private sector organizations. The Workshop reached consensus on the need to combat invasive alien species in coordinated Region-wide manner.

In order to support policy development and the development of institutional platforms for coordinated Regional safeguarding, T-STAR funded a grant: "Facilitation and Coordination of the Florida/Caribbean Basin Inter-Institutional Invasive Species Initiative" for the 3 years, October 2005 to September 2008, with Dr. Davis as Project Director and Dr. Klassen as co-director. Recently T-STAR funded a sequel titled: "Building Technical and Institutional Policy Support Platforms for An Effective US/Caribbean Basin Invasive Species Safeguarding System" for two years, October 2008 to September, 2010 with Dr. E. A. "Gilly" Evans as Project Director and Drs. Davis and Klassen as co-directors.

DESCRIPTION OF THE T-STAR PROGRAM

T-STAR leverages both state and federal funding for the advancement of agriculture, natural and human resources in tropical and subtropical regions. The T-STAR program was authorized by U.S. Congressional legislation and is an outgrowth of the World Food Conference in Rome in 1974. At that conference, representatives announced that the United States could not "feed the world" but would contribute to the assistance of developing countries in efforts to strengthen their own food production capabilities. The U.S. Congress has granted major funding through a T-STAR appropriation since the early 1990s with a funding level from $6 to 10 million per year usually provided.

T-STAR actually has two major components: 1) The Caribbean Basin Administration Group (CBAG) comprised of the University of Florida, the University of Puerto Rico and the University of the Virgin Islands, and 2) the Pacific Basic Administrative Group (PBAG) comprised of the University of Hawaii and the University of Guam.

Much of the research conducted in the temperate United States is not applicable to tropical areas. Florida is the only continental U.S. state that has tropical and sub-tropical agriculture. In tropical and sub-tropical climates there are large differences in climate, soils, crops, pests and diseases and in many developing nations there are socio-economic constraints. Plant pests and diseases have a year-round growing season in these climates and invasive species impact is severe with an escalating need for prevention and control. The challenges of tropical and subtropical agriculture

present significant requirement for additional efforts on post-harvest procedures, value-added processing and market development.

The overall T-STAR program goals are two-fold: to develop strategies and tactics to stem the influx of exotic diseases, insects and weeds and to control and/or eliminate existing non-indigenous species and diseases; and to provide research that maintains and enhances production of established tropical and subtropical agricultural products.

One of the main partnerships of the T-STAR program and the University of Florida has been the University's Caribbean Invasive Species Initiative. The spread of the invasive Tomato Yellow Leaf Curl Virus in the Caribbean Region is a dramatic example of the need for such partnerships on invasives. This devastating invasive was discovered on the southern tip of Cuba in 1987, next detected in Dominican Republic and Haiti in 1990, then in the Bahamas in 1996, in south Florida in 1997 (where it has rapidly spread throughout the entire state), in 2001 it was discovered in Puerto Rico and Guadeloupe, and in 2002 in Dominica. It is safe to say that this pest is prevalent throughout the Greater Caribbean today wreaking havoc on the food production and native species. Florida growers spend at least $800 per acre each year in attempts to control the disease.

The successful history of this tropical and subtropical research program may be found on the University of Florida website at http://research.ifas.ufl.edu/T-STAR.asp. This includes the T-STAR program description, the program's history, strategic plan, operational policies, as well as other program summaries. Of most interest to the Greater Caribbean Region are the research highlights and the new current projects sections where all the T-STAR projects are listed for each year beginning in 1996. For instance, the current projects in progress for 2008 are shown in A. Research highlights of each project affecting tropical and subtropical agriculture can be accessed.

The mission of T-STAR is to conduct high quality and useful agricultural research which is provides information and technologies relevant to industry needs, has demonstrated impact, protects the environment, enhances economic opportunities, and provides for the social well-being of the people in the tropical and subtropical regions of the United States of America through collaborative efforts.

Florida's agriculture as part of the Greater Caribbean Region is a very fragile ecosystem not only providing for food production but also for tourism, recreation and ecological diversity. This mission and this statement explain clearly why the cooperation and collaboration of the T-STAR program and the Caribbean Invasive Species Working Group is so important.

To expand further, the T-STAR program has multiple goals involving; current agricultural products, environment, value-added agriculture, new food and fiber products, expanding agricultural linkages, decision support systems, non-indigenous pests and diseases, and nutrition and health. Some examples of the T-STAR goals clearly show how the objectives of these goals mesh with the Caribbean invasive species effort. On the environment, T-STAR seeks to develop agricultural practices that are environmentally acceptable through an agro ecosystem's approach in fragile systems susceptible to invasive species degradation. On value-

added agriculture, this goal seeks to enhance the role of value-added agriculture in tropical island ecosystems. For new foods and fibers goal, T-STAR seeks to expand and diversify presently unexploited food and fiber products which have potential for commercial production in the U.S. tropical and subtropical regions all the while realizing this cannot be achieved without invasive species control. In the area of expanding agricultural linkages, T-STAR has a goal to expand tropical and subtropical agriculture's linkages to related industries and economic sectors. The decision support systems goal seeks to develop and deliver user friendly decision support packages to help client needs.

For this program, T-STAR's goal on non-indigenous pests and diseases (CORE) is most appropriately known by this acronym for it is at the core or heart of T-STAR to develop strategies to stem the influx of invasive pests and diseases and work to control or eliminate such species. And last, but not least, in nutrition and health, T-STAR seeks to enhance linkages of the agriculture and food system with nutrition, health, and socio-economic status of the people in the tropical and sub-tropical regions.

In the past, the UF/IFAS T-STAR has made diligent efforts to support

- Development of Regional Strategy to cope with invasive species (CRISIS)
- Development of Regional Network – Caribbean Invasive Species Working Group (CISWG)
- Development of an Implementation Plan - Caribbean Invasive Species Surveillance and Information Program (CISSIP)
- Efforts to move forward in partnership throughout the Caribbean

The state of Florida has experienced frequent and devastating losses from invasive species due to the costs of interdiction, control, eradication and loss of markets and trade. The eradication effort for citrus canker, most recently detected in Miami in 1995, cost over $2 billion in state and federal funds before defeat was declared due to widespread dissemination of the disease from hurricanes and tropical storms. Florida regrettably has the record of detecting one new arthropod per month entering the U.S. through Florida ports and airports. In addition, at least four new animal diseases, never before detected in the U.S., are identified in Florida each year coming through our ports and airports.

CARIBBEAN INVASIVE SPECIES WORKING GROUP (CISWG)

The record of losses from invasive species makes our regional collaborations and partnerships on invasive species a critical effort to the Greater Caribbean of which Florida is a part. UF/IFAS has been a long term partner with CABI, the Caribbean Research and Development Institute (CARDI), the CARICOM Secretariat, CIRAD, Service de la Protection des Végétaux, Direction de l'Agriculture et de la Forêt, France, Costa Rica Ministry of Agriculture FAO, PAHO, IDIAF, IICA, Ministries of Agriculture, The Nature Conservancy, University of West Indies, University of Puerto Rico, Florida Agricultural & Mechanical University (FAMU) and USDA-APHIS.

The partnership proposed a Region-wide strategy to strengthen national safeguarding capabilities and to develop a coordinated Regional safeguarding network. The Caribbean Regional Invasive Species Intervention Strategy, with the appropriate acronym of "CRISIS", was recognized as a

valuable strategic framework for the Region and was accepted by the Council on Trade and Economic Development (COTED) of CARICOM in May 2008, as well as by the French Government, Dominican Republic, Costa Rica, and USDA/APHIS.

As soon as this overall strategy was in place, we began to work diligently to prepare an implementation program to put the strategy into effect. This implementation plan, known as the Caribbean Invasive Species Surveillance and Information Program (CISSIP) has not yet taken effect comprehensively; however, parties are seeking full funding and various components have been put in place with resources currently available with various partners. CISSIP components include the Caribbean Regional Diagnostic Network (CRDN), developing and enhancing laboratory diagnostic capacities, Pest Survey and Inspection Program (PSIP), Invasive Species Information System (ISIS), training programs for field and laboratory identification and diagnosis, a Public Education Program (PEP), and capacity building programs for plant and animal protection personnel in Caribbean Ministries of government. It is envisioned that CISSIP will have close links with CaribVET, which treats animal and zoonotic pathogens.

This CISSIP implementation program does indeed provide an umbrella of efforts on invasive species, agricultural, animal and plant health threats, agricultural bioterrorism, sanitary and phytosanitary trade barrier issues, and zoonotic diseases. The program combines not only agricultural interests but also non-agricultural public issues such as natural resource protection, ecosystem diversity, human health and safety and food security and availability.

KEY INVASIVE SPECIES SUPPORTERS AT UF/IFAS

The key supporters and partners associated with the T-STAR program at the University of Florida are at the highest level. Dr. Jimmy Cheek, Senior Vice President for Agriculture and Natural Resources and head of the Institute of Food and Agricultural Sciences has been a long time supporter of T-STAR and invasive issues. (Editorial note: In February, 2009 Dr. Cheek left UF/IFAS to become Chancellor at the University of Tennessee. Dr. Larry Arrington, UF/IFAS Dean for Extension, is now the Interim Senior Vice President.) Dr. Mark McLellan is Dean for Research, IFAS, and Director of the Florida Experiment Station. The invasive species thrust in the Greater Caribbean has been strongly championed by three individuals: Drs. Bill Brown, Waldemar Klassen and Carlton Davis. Dr. Bill Brown, former Assistant Dean for Research and a CISWG leader was former head of T-STAR at UF/IFAS and is now Dean for Research at the University of Tennessee. Dr. Waldemar Klassen, Professor Emeritus and long term invasive species researcher, has been a leader on the CISWG since its inception. He retired in January, 2009, but continues to actively assist Dr. E. A. "Gilly" Evans with the T-STAR Project: "Building Technical and Institutional Policy Support Platforms for an Effective US/Caribbean Basin Invasive Species Safeguarding System". Dr. Carlton Davis, Distinguished Service Professor, Food and Resource Economics Department, retired in December, 2008, but he, too, continues to assist Dr. Evans with the above Project. Dr. Martha Roberts has served in a supportive role as Ex Officio Secretary for CISWG to which she brought experiences of long term state government service. Her service has been greatly reduced because of the current budget crisis in Florida's government.

The new T-STAR and invasive species team at UF/IFAS includes Dr. Doug Archer, Professor and Associate Dean for Research, IFAS, former Assistant U.S. Surgeon General and former head of the Department of Food Science and Human Nutrition who now heads the T-STAR program. Dr. David Sammons, Director of International Programs, UF/IFAS, will be the new face of IFAS for CISWG and is the former Special Advisor with US AID and Associate Dean of the College of Agriculture and Head of International Programs at Purdue University. Responsibility for the University of Florida role in developing and operation the Caribbean Regional Diagnostic Network has been vested in Dr. Tim Momol, District Extension Director and Professor of Plant Pathology.

Many faculty, in addition to those named above, have been long time supports of invasive species efforts in the Caribbean, including but not limited to: Stephen Brown, Harold Browning, James Cuda, Edward "Gilly" Evans, Joseph E. Funderburk, Robin Giblin-Davis, Michael J. Davis, J. Howard Frank, Amanda Hodges, Forrest "Bill" Howard, John VanSickle, Marjorie A. Hoy, Carrie Harmon, Lance Osborne, Aaron Palmateer, Randy Ploetz, Jane Polston, Robert J. McGovern, Tim Momol, Jiannong Xin, Kenneth A. Langeland, Norm Leppla, Yuncong Li, Jorge Pena, Pamela Roberts, Bielinski M. Santos, Dakshina Seal, Rudolf Schreffran, Tom Spreen, Philip Stansly, Chris Waddill, Van Waddill, Susan Webb, Sara Workman, etc.

UF/IFAS EFFORTS ON INVASIVES

The UF/IFAS T-STAR program helped organize and supported invasive species symposia and training efforts across the region beginning in 2003 in Grenada, followed by the next symposium in Trinidad in 2004, Guadeloupe in 2005, Puerto Rico in 2006 and Miami in 2007. This UF/IFAS program has been an active participant in CISWG, has worked with partners in CRISIS and CISSIP, and worked to establish Digital Diagnostic Centers in the Dominican Republic and Haiti and provided DDIS training efforts.

Internal Florida efforts on invasive species have included:
1. T-STAR Workshop: Winning the War on Invasive Species - Miami 2007
2. Showcased and discussed the application of software developed to assist in evaluating the economics of managing invasive species in agriculture and the environment
3, Formation of UF/IFAS Invasive Species Coordinating Council in 2007 to create university coordination with wide-spread faculty involved in invasive species efforts
4. Operation of the Center for Aquatic and Invasive Plants and participation in the Florida Exotic Pest Plant Council

UF/IFAS has many statewide research and education facilities and has extension offices in all 67 counties providing needed knowledge in agriculture, human and natural resources and the life sciences.

SUMMARY

The T-STAR program at UF/IFAS continues to strongly support the Caribbean Invasive Species issues with close partnerships throughout the region. The Program strongly supports the Caribbean Invasive Species Working Group (CISWG), the regional strategy, CRISIS, and efforts

to implement the components of CISSIP by means of available resources and by seeking grant support. We are honored to host this invasive species symposium in Florida and to continue our regional partnerships through active strong support and leadership.

REFERENCES

Frank, J. H. and E. D. McCoy. 1992. The immigration of insects to Florida, with a tabulation of records published since 1970. Fla. Entomol. 75(1): 1-28.

Frank, J. H. and E. D. McCoy. 1995. Invasive inventive insects and other organisms in Florida. Fla. Entomol. 78(1): 1-15.

Franqui, R. A. 1999. History of introduced pests in Puerto Rico and potential introductions. Pp. 49-56. In Klassen, W. (ed.) Mitigating the effects of exotic pests on trade and agriculture, Part A. The Caribbean. Proceedings of T-STAR Workshop-X, Homestead, Florida, June 16-18, 1999, sponsored by the Cooperative State Research, Education, and Extension Service, USDA. 292 pp.

Hara, A. H. 2002. Preventing alien species invasion by pre-shipment disinfestation treatments. p. 111-121. In Muniappan, R. and R. Campbell (eds.). 2002. Invasive species and their management. Proc. Pac. Science Intercongress Session on Invasive Speies, June 1-6, 2001. Micronesica, Supplement No. 6, July 2002. University of Guam Press. 135 pp.

Klassen, W. (chair). 1999. Mitigating the effects of exotic pests on trade and agriculture, Part A. The Caribbean. Proceedings of T-STAR Workshop-X, Homestead, Florida, June 16-18, 1999, sponsored by the Cooperative State Research, Education, and Extension Service, USDA. 292 pp.

Klassen, W., C. F. Brodel and D. A. Fieselmann. 2002. Exotic Pests of Plants: Current and Future Threats to Horticultural Production and Trade in Florida and the Caribbean Basin. Micronesica, Suppl. 6; Invasive Species and Their Management. pp. 5-27.

Klassen, W., W. Colon and W. I. Lugo (editors). 2003. Challenges and Opportunities in Protecting the Caribbean, Latin America, and the United States from Invasive Species. Proc. Caribbean Food Crops Society 39(1): 1-141.

Muniappan, R., M. Marutani and G. R. W. Denton. 1991. Exotic pests in the Pacific: Problems and Solutions. Micronesica Supplement 3, 133 pp.

Muniappan, R. and R. Campbell (eds.). 2002. Invasive species and their management. Proc. Pac. Science Intercongress Session on Invasive Speies, June 1-6, 2001. Micronesica, Supplement No. 6, July 2002. University of Guam Press. 135 pp.

NASDA. 2001. The Animal health Safeguarding Review. 2001. National Association of State Departments of Agriculture. http://www.nasdahq.org/ASGRwebsite/Index.pdf .

National Plant Board. 1999. Safeguarding American plant resources. A stakeholder review of the APHIS-PPQ Safeguarding System. APHIS, USDA, Wash. D.C. 133 pp., plus appendices.

Polston, J. E. & P. K. Anderson. 1997. The emergence of whitefly-transmitted geminiviruses in tomato in the Western hemisphere. Plant Disease 81(12):1358-1369.

Shannon, M. 1999. Challenges in safeguarding Florida and the U.S. against invasive pests. p. 11-13. In W. Klassen (chair), Mitigating the effects of exotic pests on trade and agriculture, Part A. The Caribbean. Proceedings of T-STAR Workshop-X, Homestead, Florida, June 16-18, 1999, sponsored by the Cooperative State Research, Education, and Extension Service, USDA. 292 pp.

Thomas, M. C. 2000. The exotic invasion of Florida: a report on arthropod immigration into the Sunshine State. http://doacs.state.fl.us/~pi/enpp/ento/exoticsinflorida.htm.

Zadig. D. 1999. Safeguarding American plant resources: Highlights of a review by the National Plant Board of relevant APHIS programs. P. 229-234. In W. Klassen (chair), Mitigating the effects of exotic pests on trade and agriculture, Part A. The Caribbean. Proceedings of T-STAR Workshop-X, Homestead, Florida, June 16-18, 1999, sponsored by the Cooperative State Research, Education, and Extension Service, USDA. 292 pp.

Table 1. Research Projects funded in Florida by the USDA-CSREES T-STAR Program in 2008

Title of Project	**Project Director**	**Period of Project**
Control of the Citrus Root Weevil with Trypsin Modulating Oostatic Factor and Cathepsin L specific inhibitor.	Borovsky, Dov (FL)	2 Years - Start: 10/08
An integrated approach for sustainable control of chilli thrips, Scirtothrips dorsalis Hood	Chen, Jianjun (FL)	2 Years - Start: 10/08
Building Technical and Institutional Policy Support Platforms for an Effective US/Caribbean Basin Invasive Species Safeguarding System	Evans, Edward (FL)	2 Years - Start: 10/08
Control of Mexican Bromeliad Weevil-An Invasive Species	Frank, J. Howard (FL)	2 Years - Start: 10/08
Resistance in the southern cattle tick, Boophilus microplus, to acaricides used on St. Croix and Puerto Rico	Kaufman, Phillip (FL)	2 Years - Start: 10/08
Investigating bio-ecological factors influencing infestation of the invasive passionvine mealybug, Planococcus minor (Maskell) (Hemiptera: Pseudococcidae). A potential threat to the US	Liburd, Oscar (FL)	2 Years - Start: 10/08
"Potential of indigenous and commercially produced predators for biological control of the newly introduced red palm mite, Raoiella indica "	Pena, Jorge (FL)	2 Years - Start: 10/08
GIS-Based Spatial Analysis of Movement of Silverleaf Whitefly and Begomovirus	Schuster, David (FL)	2 Years - Start: 10/08
Development of knowledge and technologies to manage chilli thrips, Scirtothrips dorsalis Hood (Thysanoptera: Thripidae)	Seal, Dakshina (FL)	2 Years - Start: 10/08

Title of Project	Project Director	Period of Project
Analysis of recessive resistance in pepper to the bacterial spot pathogen: durability and interaction with a worldwide collection of strains of Xanthomonas species.	Jones, Jeffrey (FL)	2 Years - Start: 10/08
Management, epidemiology and detection of laurel wilt on avocado and avocado relatives in Florida	Ploetz, Randy (FL)	2 Years - Start: 10/08
"Molecular Surveillance for Emerging Pathogenic Plant Viruses: A Proactive Approach to Protecting Agriculture"	Polston, Jane (FL)	2 Years - Start: 10/08
Orange Rust of Sugarcane: Assessing Its Impact in the U.S. and Caribbean and Development of Management Strategies for Its Economic Control	Raid, Richard (FL)	2 Years - Start: 10/08
Assessment of the threat represented by the new genotypes of *Phytophthora infestans* causing late blight on tomato in Florida for improved integrated management strategies	Roberts, Pamela (FL)	2 Years - Start: 10/08
Developing Non-invasive Genotypes of the Biofuel and Forage Crop Napiergrass	Altpeter, Fredy (FL)	2 Years - Start: 10/08
Genetic Sterilization for Preventive Control of Invasiveness in *Lantana camara*	Deng, Zhanao (FL)	2 Years - Start: 10/08
Implementation of the IFAS Assessment of Non-Native Plants in Florida's Natural Areas	Ferrell, Jason (FL)	2 Years - Start: 10/08
Melaleuca quinquenervia - a model system for elucidating belowground mechanisms of plant invasions.	Giblin-Davis, Robin (FL)	2 Years - Start: 10/08
Removal of Para Grass (*Urochloa mutica*) in Wetlands to Restore Wildlife Habitat	Mac Donald, Greg (FL)	2 Years - Start: 10/08
Smutgrass biology and management in tropical grazing systems	Sellers, Brent (FL)	2 Years - Start: 10/08

Title of Project	Project Director	Period of Project
Genetic, Morphological, and Reproductive Characterization of Invasive Elephantgrasses and Genotypes Selected as Bioenergy Crops	Sollenberger, Lynn (FL)	2 Years - Start: 10/08
Effects on Morbidity and Mortality in *Perkinsus marinus*-infected *Crassostrea virginica* exposed to Exotic Perkinsus from Imported Ornamental Clams, *Tridacna crocea*	Sheppard, Barbara (FL)	2 Years - Start: 10/08
Black Sigatoka Resistant Banana and Plantain Hybrids: Introduction, Value Adding, and Marketing Perspectives	Perez, Fernando (FL)	2 Years - Start: 10/08
Suppression of the coffee berry borer, *Hypothenemus hampei* (Ferrari), populations by means of biological control for a sustainable coffee production in Puerto Rico.	Gallardo, Fernando (FL)	2 Years - Start: 10/08
Characterization and control of new and emerging viruses affecting cucurbits in Puerto Rico	Rodrigues, Jose (FL)	2 Years - Start: 10/08
Integrated Management of Black Sigatoka of *Musa* sp.	Chavarria-Carvajal Jose (FL)	2 Years - Start: 10/08
Polymorphic Genes Evaluation in Senepol Cattle Germplasm	Pagan, Melvin (FL)	2 Years - Start: 10/08
The Effect of Hair Color and Type on Heat Tolerance, Tick Resistance and Growth Rate of Cattle Under Grazing Conditions	Godfrey, Robert (FL)	2 Years - Start: 10/08

Proceedings of the Caribbean Food Crops Society. 44(1): 69-79. 2008

SESSION II: INSITUTIONAL ISSUES

PANEL DISCUSSION ON CLOSING THE INSTITUTIONAL AND TECHNICAL FRAMEWORK GAPS FOR AN EFFECTIVE CARIBBEAN INVASIVE SPECIES SURVEILLANCE AND INFORMATION PROGRAM (CISSIP)

Panel members: Dr. Carlton Davis, Dr. H. Arlington Chesney, Dr. Gene Pollard, Ms. Margaret Kalloo, Dr. Moses Kairo, Mr. Claude Vuillaume, Mr. Robert Balaam, and Dr. Timur M. Momol.

Chair: Carlton G. Davis; Rapporteur: E. A. Edwards

Dr. Carlton G. Davis. Welcome to the panel discussion on "Closing the Institutional and Technical Framework Gaps for an Effective Caribbean Invasive Species Surveillance and Information Program". I will now introduce the panel.

First we have Dr. Moses Kairo. Moses was Regional Director of CABI stationed in Trinidad. Two years ago he took the position of Director of the Center for Biological Control, Florida A&M University, Tallahassee, Florida. We are delighted to have Moses here.

Next we have Mr. Claude Vuillaume of CIRAD, Guadeloupe, French West Indies. Claude has been with CISWG from the very beginning. Claude has been very helpful in moving toward Regional safeguarding.

Then we have Mr. Robert Balaam. Bob is the Offshore Coordinator of the APHIS Caribbean Safeguarding Initiative, and he has contributed substantially to formulating and strengthening the APHIS Initiative. He is stationed in Homestead, Florida.

Then we have our very good friend, Dr. Tim Momol. Tim is a professor of plant pathology at the University of Florida, and a Regional Director of Extension, stationed in Gainesville, Florida. Tim has a long history of doing diagnostic work, and he has been a key person in our quest for developing a Caribbean Regional Diagnostic Network, and he made a trip with us last year to the Dominican Republic to work out an agreement to start the construction of the Network.

Also we are pleased to have Dr. Gene Pollard, who served for 15 years as Senior Plant Protection Officer, FAO Sub-Regional Office for the Caribbean located in Bridgetown, Barbados. Recently Gene retired, so he is nere not as an FAO representative, but in a private capacity.

Dr. Arlington Chesney was – for a number of years – Director of the Caribbean Regional Office of IICA located in San Jose, Costa Rica. Last October Dr. Chesney took the position of Executive Director of CARDI. Dr. Chesney participated in the formation of CISWG in Grenada in 2003, and he has been a key member since that time.

Last but certainly not least we have Ms. Margaret Kalloo, Deputy Program Officer for Agricultural Development, CARICOM Secretariat, Georgetown, Guyana. Margaret became involved in June 2004 when CISWG conducted a workshop in Port of Spain, Trinidad on "Facilitating Safer US-Caribbean Trade: Invasive Species Issues", Margaret has been deeply engaged in CISWG ever since.

We have an excellent panel of experts, who will share their thoughts with us as to how we can close the institutional and technical gaps, so that we can move forward with the CISSIP project. Before we start, I thought it would be informative to have some carry-over from the last session.

Unfortunately, since we ran out of time in the last session, we did not have a discussion. However there are some very interesting "take away" points from the last session. I think it might be useful to bring those into this discussion. So, I have asked Ms. Dionne Clarke-Harris, the Rapporteur of the last session to give us a few of the take away points of the last session. But before I do that, let me recognize Dr. Gilly Evans, Rapporteur of this Panel Discussion Session.
And one housekeeping item: today there will be an additional option for lunch, since the Hibiscus Court in the Lower Lobby will be open.

Ms. Dionne Clarke-Harris. Thank you Dr. Davis. Good morning everyone! I have a small nutshell of takeaway points from the first half of this session. This session is titled "Towards a Caribbean Basin Invasive Species Safeguarding Strategy Framework: From Grenada 2003 to Miami 2008". We had a wide range of topics that set the stage for the remainder of the Symposium.

- We had presentations on the conceptualization of the collaborative mechanisms that we need for regional efforts in safeguarding.
- We had overviews and updates of some of the on-going activities that have been underway across the Region.
- Some presentations addressed capacity building and environmental protection from invasive species.
- What was clear from most of the presentations is that collaboration is indeed essential; and individual countries acting alone cannot protect themselves from invasive species; and our defense is only as strong as that of the weakest link in the whole effort.
- We talked about the Working Group, CISWG, and the Regional safeguarding strategy, CRISIS and the proposed surveillance and information sharing proposal, CISSIP.
- CRISIS has been widely endorsed, and CARICOM and various countries have agreed to participate in constructing and operating CISSIP.
- Funding is one of the main issues in launching CISSIP; so how do we move forward? Do we projectize CISSIP and ask individual organizations to each take responsibility for one component?
- Capacity building is critically important in the various countries and territories in the Region, since the chain is only as strong as it weakest link.
- Diagnostic capability is key, since you cannot prevent that which you do not recognize.
- And we also must have a mechanism for the collection and timely dissemination of information; so that when an invasive species is first encountered that all of the countries and territories are notified in a timely manner, and, thus, they can take defensive measures.

I hope this summary will suffice.

Dr. Carlton G. Davis. Thank you, Dionne. You did an excellent job. Since we have a very short period of time, we decided to ask the panelists to each take five minutes to give us their perspective on what we need to do to close the technical and institutional gaps needed to launch CISSIP. We will take the panelists in the order that they are listed in the program, and after all of them have spoken, we will open it up to the floor for discussion. So now I ask Dr. Arlington Chesney to give us his take on where we are, and where we need to go. Dr. Chesney.

Dr. Arlington Chesney. Thank you, Carlton. Since I am sitting next to Carlton, I have to behave myself. As you know, those of us who come from the Caribbean tend to lash out at

things. I will concentrate my remarks primarily on CISSIP, since that is the vehicle we identified to move forward with. When you look at it, at first you get the impression that we don't have any money for CISSIP. But when you look around you see that there is a substantial amount of work going on that relates to CISSIP. When you listen to the talks in this Symposium, you perceive that there is a substantial amount of work going on in relation to the three major areas that are defined as components of CISSIP; this includes work by USDA-APHIS, CIRAD, CABI, UF-CRDN-DDIS, etc. So it seems to me that if we could put together the crossword puzzle, we could then put in some pieces from the work that is on-going and from what is planned – because there is also some indication of planned work. Thus, we could then identify what is left to be done, and that would make CISSIP a more manageable prospect for potential donors as we move forward.

I noted, also, particularly from the CIRAD presentation –which, unfortunately, I could not hear in its entirety because of a phone call - there are networks already established in the Region. How can we use those networks and their information to further this work against invasives; how do we link that into CISSIP? This afternoon, we will have a discussion on PROCICARIBE; how can these networks and the vast amount of information be linked into PROCICARIBE for the benefit of the wider Caribbean?

Then, what came up here – Joan mentioned it – that we need to collaborate, but I did not get the impression that there is much sharing of information. I am a layman in this area. But some of the information I heard today was new to me, and none of my people in CARDI have mentioned it to me. So it seems to me that there needs to be some central hub through which information is passed and disseminated. There are two mechanisms: you could either send it to the hub, which in turn would disseminate it through the spokes, or you circulate it around the whole periphery of the wheel. The chairman of the Working Group, Bruce Lauckner of CARDI, is not here, but maybe this is a role that the Chairman of CISWG may wish to take on. And in that context we could also develop a better information system to assist us in moving forward. In summary, therefore, Mr. Chairman, I am more optimistic about the success of CISSIP after the previous session than I was before that Session. We have tried to find funding for the whole of CISSIP, but it was too big a bite for any one funding agency to swallow. So, I think we need to divide CISSIP into manageable pieces, and assign each piece to a certain lead organization. In that way we would be able to move forward. Thank you.

Dr. Carlton Davis. Thank you, Che, for those insightful comments. I now ask Dr. Gene Pollard to give us his thoughts.

Dr. Gene Pollard. Good morning to all! Thank you, Carlton. First I wish to thank the organizers for inviting me here in my own capacity. As mentioned before, I recently retired from the Food and Agriculture Organization of the United Nations after 15 years of service, and at the moment I am trying to enjoy my first weeks of retirement, but I do not think this is the best way to be doing it. Nonetheless, I am quite pleased to be here. And I should say that anything that I might say in the next few minutes will probably be influenced by the time I have spent with the Food and Agriculture Organization, since. I have not yet established an identity outside of that Organization in terms of what I might say. We do have some serious institutional and technical framework gaps that detract from constructing a system of Regional safeguarding or CISSIP.

Looking at the institutional framework gaps, FAO has in the past identified several constraints to international policy in regulatory frameworks for biosecurity in food and agriculture. And according to that organization, the international policy – I am just quoting from one of FAO's strategy papers: "the international policy and regulatory framework is disjointed and incomplete and further in international programs of biosecurity there is a need to develop common methodologies particularly for risk analysis, international standard setting including environmentally related standards and integrated management and monitoring". I think if we use this as a starting point for CISSIP and for other work we need to do….. The message here is that we need to have more collaboration. As Dr. Chesney just indicated much of the information he has learned here today is all quite new to him – what I think he meant that is that the information is still within the confines of the particular researcher or the research agency; and if CISSIP is to really function as a Regional Mechanism and Regional Program, then CISSIP needs to have a way of gathering all that we have been doing over the last few years and to make this information readily available to all of the stakeholders in this room. And there is a need to extend international policies, arrangements, and assessments to corresponding national policies and arrangements. I believe that yesterday someone in one of the presentations mentioned that there are too many different agencies within a given country dealing with various aspects of the problem of invasive species management, so that it is not possible even within each individual country to bring together common coherent programs or one integrated program to manage invasive species.

In terms of technical gaps, again, these have been identified over and over. We have inadequate resources as it relates to human, technical, financial or physical. Earlier today Margaret Kalloo talked about the financial shortfalls, and the need to continue to pursue support with the donors for the programs identified under CISSIP. As Dr. Chesney said, we need to, perhaps, break CISSIP into smaller units. So we really need to think of different project types within the CISSIP program, so that various donor agencies can feel more comfortable in funding an aspect of CISSIP.

With respect to needed physical resources, these are largely national activities; for example, the lack of diagnostic capabilities within countries, and the need for countries to get their laboratories up to scratch. And I believe that the CARICOM Secretariat has been pursuing a project to assist in laboratory strengthening in the Region. In fact, just before I retired from FAO, I had developed two project proposals where countries in the eastern Caribbean were eligible for EU funding within the SFA – the Strategic Framework Agreement, which is the mechanism that has replaced Lome funding. And countries have agreed to allow FAO to develop and implement these projects with EU funding. These two countries, St. Vincent and St. Lucia, have had projects approved, which - in part - are for the strengthening of plant protection and plant quarantine laboratories. So there are some initiatives in the Region to assist with laboratory strengthening.

The other resource constraint, inadequate human resources – that we have heard about over and over. There is a real shortage of trained personnel within Caribbean countries. Such personnel are needed to carry out Phytosanitary responsibilities within Central America and the Caribbean, and CISSIP calls for some training. And we heard of USDA-APHIS training programs not just in the Caribbean but, also, in Central America. Also we are aware of CIRAD training programs. In

addition, the University of Florida and the University of Puerto Rico have initiated some distance diagnostic training in relation to construction of the Caribbean Regional Diagnostic Network.

Now, let me emphasize that from a Regional safeguarding perspective, there has to me much greater collaboration.

It is also vitally important that at the national level countries must take much greater responsibility to develop their human resources, and to develop their physical and laboratory infrastructure to provide for better diagnostic capabilities. The fact is that in dealing with invasive species, you have to be able to identify and recognize what is coming in and prior to that what you already have; so that you know something is an invasive. If you don't know what organisms you already have in your country, you cannot really say what is new; so the diagnostic capabilities are critical, as has been identified in the CISSIP program. And I certainly hope that at the country level – the national level – decisive efforts will be made to develop this capability even without the funding coming from something like CISSIP. Thank you!

Dr. Carlton Davis. Thank you, Gene. We really appreciate your thoughts and your willingness to come out of retirement so soon, after having served FAO so diligently for 15 years. We really appreciate the fact that you have come to participate. Thank you very much for coming! Now I will call on Ms. Margaret Kalloo to express her thoughts.

Ms. Margaret Kalloo. Thank you Professor Davis. Good morning, again! With respect to closing the institutional and technical framework gaps for making CISSIP effective, where are we? We started off this process with several partners working with a degree of coherence in how to deal with invasive species. We still have those same several partners, but now many other people and instutions outside that initial group are willing to come in and assist. And therefore, in thinking of institutions, the original CISWG members need to sit together and to think very coherently to identify who are those other strategic partners that we need to enlist, so as to widen – if not deepen the institutions working together in safeguarding against invasive species or the threat of invasives. Whether these are international agencies that we did not consider sufficiently initially and whether these are national agencies that we did not consider before, we need now to sit and to consider with the perspective of gaining strength as to how to narrow the gaps, and of how to move forward with CISWG, the CISSIP Project and the Pathway Analysis that has started concurrently in this process. It has evolved, and it has not really been directed because things were moving at a really fast pace, and we were under pressure from the Ministers of Agriculture within CARICOM, and within the universities, also. We had a lot of pressure to get things going, but now is the time for reflection, and we need to step back and really think coherently as to how we move forward. So in terms of institutions we may want to consider that.

With respect to the technical gaps, that is another aspect that we need to look at. Within CISSIP the participating countries, and I speak now for the CARICOM countries in terms of their infrastructure, we need – as a Community - to pull together and start working, not independently, but working as a group and to improve those systems that we can for ourselves without the assistance of the CISSIP Project, but rather to provide that platform from which CISSIP can take off.

So in that context CARICOM and CARICOM countries have moved forward this year and last year in terms of trying to strengthen ourselves. We convened the Plant Health Directors within the CARICOM countries and within the wider Caribbean, as we heard from the APHIS presentation this morning. It is a wide body and a wide group of technical people as well as policy people. Never mind that we deal both with policy and technical issues because we come from countries whose resources are constrained. As policy people in CARICOM, we multitask and try to get things going, and we deal with technical issues and budgets and so forth, but those are the realities that those of us in resource challenged countries have to deal with. So the Plant Health Directors Group is really a group that has been formed to help advise on policy issues and on the technical issues that are related to all invasive species, so that is a plus for us. And we did this with the assistance of the participating Regional and International organizations initially with the leadership of APHIS.

We need to continue that and we need to strengthen that because it is a policy group and it has technical groups, too on all these invasive species that have importance to CARICOM and to the wider Caribbean starting with Cuba and running to Suriname. I have no authority to speak on the Latin American countries in the wider Caribbean such as Venezuela, Paraguay, and so as you move up the coast. So we need to recognize that group as the group that can define policies to a large extent within CARICOM. For us in CARICOM that is important because we need that structure so that we can have coherence in policies that we want our Ministers to adopt and to construct a Regional framework for us to work within. So we are looking at that.

But when we look at the institutions that we have in the CISSIP Project, and we recognize that CARDI has chaired this as we set up this whole thing. And I know that most of you here are plant people, but we need to ensure that we need to keep them on board – not only on the animal health side but also on the plant health side. We need to keep CIRAD involved within the framework of the CISSIP Project; recognizing the work we have been doing. This CISSIP Project is the product of all of us. We need to strengthen these ties. The organization - even that of CISSP - needs strengthening.

And there is one more thing that I wanted to say: the institutions and the organizations working within CARICOM and within the wider Caribbean, we need to sit together and strategize as to how we can really work the CISSIP Project to the benefit of all of us. At these workshops and symposia dealing with invasive species, we have never sat down and figured out how we can factor these programs into a regional safeguarding - and that needs strengthening.

With respect to labs, the CARICOM Community has been working together to strengthen the laboratory infrastructure in the Region; and this, also, is in support of moving CISSIP forward. That Project is coming on board this year, as we strategize as to how we can use laboratories across the Region, given that we do not have all that we need to have and that some countries have more than others. So we need to find a way to make use of those laboratories to the benefit of the whole Community.

And the last point that I need to make is where we are closing some technical gaps, and that is important. The CARICOM member states at this point in time - at least 13 of them - have what they can afford. Agricultural health and food safety can be a committee, it can be a group that

has been sanctioned by the governments and focuses on plant health, animal health and food safety. So we are making progress, and we have benefited from the framework of the CISSIP Project. Chair, with that I conclude my comments.

Dr. Carlton Davis. Thank you Margaret for giving us your thoughts. Since our time is very short, I will now call on Dr. Moses Kairo to give us his perspective. Moses.

Dr. Moses Kairo. I think a lot of the key issues have been covered by preceding speakers. But I want to step back a bit. With regard to CISSIP we are really talking about surveillance and information as two key components as opposed to actions for actually dealing with invasive species. And in looking at institutional gaps, it is a fact that Ministries of Agriculture generally have been the key Ministries with the capacity to do things and take the leading role in dealing with invasive species. However as issues of invasive species have come to the fore, and as countries have had to begin meeting obligations under various relevant international instruments, the fact that invasive species are a greater issue has also come to the fore.

And I think countries now are being challenged on the one hand of pulling together all the different entities within each country that deal with invasive species, but also of pulling together the resources needed for the greater good. So I see that an important issue is the need for greater coordination starting from within each country – bringing all the different entities, private sector entities, non-governmental organization entities, creating mechanisms wider than the grass roots level that actually ensure that resources are really being maximized. Because the goal is so different, players who have a role are very busy and they are spending a lot of resources, but really not producing much in terms of outputs that we can actually measure. So I think that [production of outputs] may be just starting there.

This group, for example, has formed a kind of linkage with regards to plant protection. But we also need to involve also players from environmental studies - at least more of the people whose devotion is largely to the environment. They have a lot of interest in invasive species, and they actually depend on agricultural people where the capacity for safeguarding resides. So I see areas of synergy there.

Also I want to talk about the issue of taxonomy and diagnostics. It is a fundamental and critical component of safeguarding and, hence, of CISSIP. And ultimately I see a big persistent challenge that goes beyond the immediate needs of CISSIP. Given the declining capacities of small economies to support fundamental science and especially their declining capacities in taxonomy, diagnostics is going to remain a big challenge in the Caribbean. And this is something that needs to be overcome.

The last point that I wish to talk about is training – not just at the diagnostic level, but at a broader level, such as graduate training in biology that appeals not just to people in agriculture or other applied fields, but, also, to people generally who are interested in conservation. We really do need to encourage more people to come into the field of conservation. Thank you.

Dr. Carlton Davis. Thank you very much, Moses. We very much appreciate the points you have made. Now I ask Mr. Claude Vuillaume of CIRAD to relate his thoughts. Claude has been with us from the very beginning, and he has been very helpful to our effort in many ways.

Mr. Claude Vuillaume. Thank you, I would like to briefly present some thoughts and perspectives on CRISIS, CISWG and CISSIP – how can we move forward. Thus the Ministry of Agriculture, IRD (Institut de recherche pour le développement), INRA and CIRAD are all engaged together in fighting against invasive species. So we have an interest in CISSIP and to collaborate with you, and mainly, I think, along a line similar to CaribVET and considering the successful first meeting of the Region's plant health directors it may be important to develop CISSIP and CaribVET in parallel.

And this afternoon we will have a meeting of PROCICARIBE and, also, with a representative of CACHE. We will discuss how it is possible to organize a meeting of a special working group to discuss research priorities, and I am sure that one of these priorities will be invasive species. With respect to funds, we have to make do with what we have. In CIRAD we have resources from the Government of France – the Regional Cooperation Fund - to create some networks with Caribbean countries. But we also have some new funds, Inter-Island Cooperation Fund. Thus my colleagues and I are now considering ways to put forward a cooperative project involving the Eastern Caribbean States on Black Sigatoka.

Now with the EU and with the World Bank – if you want to present a project - it is necessary to create a consortium to obtain support to develop a surveillance system on invasive species. A consortium is a very powerful mechanism for obtaining grants from such bodies. I think that would be very important to do this. So once again, this afternoon we will meet with PROCICARIBE and CACHE to see if it is possible to organize a special working group. One of the first tasks would be to organize a surveillance and information system at the general level and especially for invasive species. Thank you!

Dr. Carlton Davis. Thank you, Claude, we really appreciate your comments. I now call on Bob Balaam to give us his thoughts.

Mr. Robert J. Balaam. In preparing for this panel discussion, I contacted Carlton and I asked specifically what I should talk about? So we discussed various ideas. Finally Carlton offered: "Bob, it's not just what you say but how you say it." So with that guidance, Carlton, I prepared some brief specific remarks that I will read, so that I don't get myself in trouble.

There is a multiplicity of institutional and philosophical differences between and among countries in the Greater Caribbean Region. The Region is composed of Dutch-, English-, French- and Spanish- speaking nations. The Region is represented by numerous research, regulatory and trade institutions or agencies. Each has its own constituency, philosophy and strategy on how to reposition agriculture in the Region. However, there is one common theme or thread that binds us all together, and that is invasive species.

If left unaddressed, invasive species will significantly impact the Region's economic strength, the safety of the food supply, the ability to sustain food production and the ability of each of our nation to effectively trade agricultural products across its borders in a safe and efficient manner.

The institutions and the agencies within the Region need to work together effectively to safeguard agriculture, natural resources and human health from the impacts of invasive species.

The Caribbean Regional Invasive Species Intervention Strategy, or CRISIS, has defined the overall framework by which this can be accomplished. The Caribbean Invasive Species Surveillance and Information Program, or CISSIP, has defined the first steps in addressing such specific actions of CRISIS.

APHIS is currently assisting the Caribbean Invasive Species Working Group, CISWG, with the Caribbean Pathway Analysis, which will evaluate pathways for exotic plant pest movement into, within and out of the Region. I think that most of us already recognize that due to the volume of commodities and passengers involved, fruits and vegetables and propagative materials from Central America pose a potential pathway, the tourism industries of the islands of the West Indies are a potential source of pest movement by air and sea passengers, and cut flowers from several South American countries, such as Colombia and Ecuador also present potentials for pest movement across international borders.

Movement of commodities and the pests and diseases that they may harbor can affect our Region's food supply, our food and other agricultural production, our natural resources sustainability, and our ability to trade effectively within the world marketplace.

CISSIP as you know contains three main components: (1) an on the ground pest detection and surveillance program, (2) a web-based digital diagnostic system and (3) a web-based information sharing system. There are other components, but to me, these are the 3 primary technical ingredients. Without the dedication of resources by each individual country to some pest and disease detection and surveillance efforts, the other two main components - the diagnostic system and information sharing - will not be fully effective. We must first look for and find new pests, so that we can respond quickly and effectively to contain, eradicate, control, or manage these organisms before they have the ability to spread throughout our country or throughout the Region.

We must develop pest surveillance activities against pests of limited distribution within the Region, so that we can report the status of quarantinable pests to our trading partners, and thereby lessen the negative impacts of trade where possible.

The budget for implementation of CISSIP is huge, and is not likely to be fully fundable from outside sources in the near future. Therefore, each country in the region needs to make a commitment to begin funding some of these activities on its own. As CRISIS states, no individual country by itself can negate the impacts of invasive species on our Region. We must, each, bear some responsibility for this effort.

We can no longer say that funding for tourism is more important, that economic development is more important, or that health and human safety are more important than controlling invasive species. Invasive species can impact all of these social and economic issues. If we fail to quickly detect new introductions of harmful new invasive species and if we fail to quickly and effectively respond by mitigating those introductions, then we are opening the door to negatively

impacting tourism, agricultural production, maintenance of a safe and abundant food supply and maintenance of an effective and prosperous trade policy with our trading partners.

The impacts of invasive species can be felt throughout all of our way of life that we currently recognize as important. We cannot continue to wait for someone else to fund our needs. The near term economic future is not bright, and the failure to use our existing resources will only put us further behind in preventing negative impacts of encroaching invasive species.

One step the each one of us should consider as part of our cooperative effort is to re-evaluate our funding priorities, and dedicate at least one person to early pest detection and surveillance within our sphere of influence.

Whether we are a regulatory agency, or a research institution, or an entity involved in the production of food or other agricultural commodities, each of us can bring some small component to the overall goals of CISSIP without waiting for external funding - which may not soon come. The networking and information sharing will soon follow, but first we need to establish a surveillance program for detecting invasive species. As someone else has already said, we should look to the Caribbean Plant Health Directors as a reliable group to make pest surveillance happen because they already have the infrastructure. Thank you.

Dr. Carlton Davis. Thank you, Bob. I just want to let you know that we folks in the Caribbean do not run away from the truth; so it does not offend us. No last but not least, I call on an old friend, Dr. Tim Momol for his comments, Tim.

Dr. Tim Momol. Thank you. I wish to thank Carlton, Waldy and Bill Brown for inviting me. Carlton, told me that I have 15 minutes, so I have prepared a Power Point presentation. I am just kidding you; I will take just five minutes. I will cover mainly the technical part of the CRDN component of CISSIP. This figure is just a reminder, $120 billion dollars, the annual cost to the US of losses caused by harmful invasive species; and this estimate according to colleagues at Cornell University.

Invasive species are not only invasive plants, but also insects, plant pathogens and other organisms. They are a real threat to agriculture and natural resources, and they impact food safety, crop biosecurity and international trade. We emphasize prevention, but it is unlikely that we will ever be able to prevent all introductions of invasive species. Nevertheless, with effective detection and diagnostic networks, we can contain or eradicate invasive species, once they have been introduced.

Detection and diagnostic networks are essential for rapid and effective response. This slide shows the different components of an effective diagnostic network. The brain of the network in terms of data management is the clinic information management system for the diagnostic network. But the main activity is – as you see – in the diagnostic clinic labs in meeting the pest identification needs to cope with problems in in the fields of farmers. This portion is an expansion of the system and, of course, in some special cases, unknowns - new diseases and new insects – are encountered. In these instances the expert lab plays a very important role.

The clinic information management system allows the expert to be located anywhere in the world with access to the internet – provided that the expert is supplied with high quality images of the pathogen or pest. Of course, when regulatory issues are involved, then such highly sensitive and important information will immediately be shared with the country's pest regulatory agency for guidance on how to proceed. Basically the rest of the system is a decision-support tool for pest regulatory organizations.

It is very important to enhance laboratory capacities and capabilities. It is important that networks are coordinated through standard operating procedures, communication protocols, and certification of labs. It is desirable to have all of the labs use the same basic set of protocols.

Regular training of personnel is very important, since we cannot achieve high quality performance without regular training. Expert laboratories play a vital role in such training and in the identification of new invasive species.

The DDIS has been proposed for use as the clinic information management system. It is a cohesive and distributed diagnostic system. It serves a database, and provides secure web-based communication, and maps pest distributions.

I emphasize the importance of secure internet communication. In the Caribbean several valuable databases have been constructed, but some of them are open, and in times of crisis, network security is very important. DDIS is a collaborative basic diagnostic tool, and it has many valuable features which you can see at the UF/IFAS DDIS website: http://ddis.ifas.ufl.edu .

We will have a poster display on distance diagnostics this afternoon at 5 PM, so please visit the UF/IFAS booth.

If you already have a well-equipped and well-provisioned diagnostics laboratory, then you will not need anything more to connect to the network. However, it is very important for each country to develop a strong extension system. Unfortunately, as we learned yesterday, the extension systems in a number of countries in the Caribbean have been dismantled. Without an effective extension system, it is not easy to develop networks to find, to detect, and to diagnose.

Policies and protocols on data confidentiality are very important. Building trust with partners and the public requires consistent behavior over a long period of time, but it is extremely important.

CISSIP cannot be widely implemented without major funding. Of course, there are different ways and different methods to accomplish this. CISSIP needs to be strongly supported and championed within the heart of the Caribbean Region, so that its implementation can be advanced. CISSIP offers many opportunities for partnerships in research, extension and in teaching. Tomorrow, Carrie Harmon will make a presentation about diagnostic networks, some of them international in the Crop Protection and IPM Section. Thank you for your attention.

Proceedings of the Caribbean Food Crops Society. 44(1): 80-87. 2008

SESSION III: TECHNICAL ISSUES RELATING TO INVASIVE SPECIES THREATS IN THE CARIBBEAN BASIN

A PEER REVIEWED PAPER

RED PALM MITE SITUATION IN THE CARIBBEAN AND FLORIDA

Amy Roda[1], Ashley Dowling[2], Cal Welbourn[3], Jorge Peña[4], Jose Carlos V. Rodrigues[5], Marjorie A. Hoy[6], Ronald Ochoa[7], Russell A. Duncan[8] and Wayne De Chi[9]. [1] USDA APHIS PPQ CPHST, c/o ARS Subtropical Horticulture Research Station, 13601 Old Cutler Rd., Miami, FL 33158. Amy.L.Roda@APHIS.USDA.GOV ; [2] Dept. of Entomology, University of Arkansas, Fayetteville, AR 72701; [3] Division of Plant Industry, Florida Dept. Agriculture & Consumer Services, Gainesville, FL 32614-7100; [4] Dept. of Entomology and Nematology, University of Florida, TREC – IFAS, Homestead, FL ; [5] University of Puerto Rico, Crop Protection Department Jardín Botánico Sur, 1193 Calle Guayacan, San Juan PR, 00926; [6] Dept. of Entomology & Nematology, University of Florida, Gainesville, FL 32611-0620; [7] SEL, USDA, ARS, PSI, BARC-West, 10300 Baltimore Ave., Beltsville, MD 20705; [8] USDA-APHIS-IS-Caribbean Area, Santo Domingo, Dominican Republic; [9] USDA-APHIS-IS, Port of Spain, Trinidad

ABSTRACT: The red palm mite (Raoiella indica Hirst Tenuipalpidae), a pest of coconuts and ornamental palms in Asia and Africa, was reported in the Caribbean in 2004. By 2008, it spread to at least twelve islands, to two counties in Florida and to Venezuela. Red palm mite causes yellowing and leaf necrosis with severe reduction of leaf stomatal conductance. Growers are reporting > 70% reduction in coconut yield. Genetic studies of red palm mite collected from multiple regions in Asia, Africa and the Caribbean revealed several distinct haplotypes. All Caribbean samples have the same haplotype, which matches samples from coconut in Réunion and areca palms in India. The populations from coconut in India exhibited a different haplotype. Biological control and pesticide options are being studied to manage the pest. The efficacy of acaricides against red palm mite was tested to provide palm, banana and ornamental nursery growers with an updated list of acaricides with good control potential. Natural enemy studies in the Caribbean have shown that thrips, phytoseiid, lacewing, and coccinelid predators attack red palm mites. Fungal infections have been reported in Puerto Rico, Dominica and Trinidad. Predatory mite numbers, especially in the Phytoseiidae, increase in response to higher numbers of red palm mites. However, these local predators are apparently not controlling red palm mite outbreaks. Foreign exploration for natural enemies is being conducted in Mauritius and India. A phytoseiid predator is currently being evaluated in quarantine in Gainesville, Florida.

KEYWORDS: acaricides, biological control, predatory mite, foreign exploration

INTRODUCTION

The red palm mite (Raoiella indica Hirst Tenuipalpidae), an invasive pest of coconuts and ornamental palms in the Old World, has rapidly spread through the Caribbean. A pest risk analysis conducted by USDA APHIS PPQ Plant Epidemiology and Risk Analysis Laboratory

concluded that the red palm mite is a serious economic threat to the nursery palm industry and to both indoor and outdoor environments based on cumulative risk, host range, dispersal potential, economic impact, environmental impact and habitat suitability (Borchert, 2007). Due to the likelihood of the pest spreading throughout the Caribbean, South America, Central America and the continental US, programs were developed in the Caribbean and Florida to identify potential pathways for the pest, optimize survey protocols, and determine mitigation strategies that would minimize the impact of red palm mite in the region.

RESULTS AND DISCUSSION

The red palm mite was first reported in the Western Caribbean in Martinique in 2004 (Flechtmann and Etienne, 2004). By 2008, it spread to at least 12 islands, two counties in Florida and to Venezuela. Red palm mite populations are extremely high and the mite is attacking multiple plant species within multiple monocot plant families (Table 1). Many of R. indica's hosts are new reports such as bananas, gingers and heliconias. However not all reported hosts are well suited for mite development and population growth. Higher populations were found on coconut (Cocos nucifera), Christmas palm (Adonidia merrilli), Washingtonia spp., Chinese fan palms (Livistona chinensis) and others (Farzan Husin, unpublished data). Coconut production decreased over 75% on plantations in Trinidad one year after the detection of the mite in 2006 and has remained at this lower level for 2 years (Philippe Agostini, President Trinidad and Tobago Coconut Growers Assoc., personal communication). Susceptible palms show severe damage with bronzing and chlorosis of leaves, however, no mass die-off of adult palms due to the mite has been documented in the Caribbean. Reports from Puerto Rico indicate that heavily infested small coconuts have died (Jose Carlos Rodrigues, personal observation). Jepson et al. (1975) and Sathiamma (1996) reported red palm mite as a serious pest to coconut seedlings in nurseries and young palms in the field. Although listed as a pest of date palms in Israel, the mite was not considered economically important (Gerson et al., 1983; Zaid et al., 2002).

Red palm mite feeding causes a rapid yellowing of the leaf that has been confused with disease and nutrition problems (Kane and Ochoa, 2006). On coconut these symptoms take 2-3 months to manifest after initial infestation (Rodrigues et al., 2007a). Red palm mites are dispersed through trade of infested material and naturally by wind. They can live for prolonged periods on cut palm fronds and can remain on dry fronds for over 3 weeks, continuing to feed and reproduce as long as the palm frond remains green (Ron Ochoa, personal observation). The red palm mites may survive on craft items made of infested fronds or floral arrangements for an extended period of time.

Studies were conducted to determine the potential origin of the red palm mites found in the Caribbean (Ashley Dowling, unpublished data). Red palm mites were collected by researchers worldwide and a Bayesian analysis was used to determine how closely related were the various red palm mite populations. Raoiella indica was not found in Australia. The Raoiella collected from Australia were different species and were used as an outgroup. These mites were very different from all R. indica collected (22-25% sequence divergence). The populations of red palm mite from the Middle East (UAE and Iran) each exhibited different haplotypes representing the earliest divergence R. indica populations and based upon current sampling, possibly the origins of the species. Red palm mites collected from coconuts in India possessed a different

haplotype than those collected from other palms as did populations from the Philippines. All Caribbean populations of the red palm mite shared the same haplotype that was identical to populations from Reunion and those found on Betel nut in India. Based on these results a diagram of the potential movement of red palm mite populations through out the world was developed (Fig. 1).

A red palm mite technical working group composed of technical experts, risk analysts and stakeholders was formed in 2006 to identify methods and strategies to survey, detect, identify, and manage red palm mite. Due to the difficulty of detecting the pest at low numbers, its wide host range and its capacity for wind dispersal, the group concluded that eradication was not a feasible option. Additionally, the economic impact of the pest remained unclear and did not warrant the expense for eradication given the limited understanding of the pest. The group recommended that survey efforts focus on early detection in order to institute programs to slow the spread of the pest and that high risk areas needed to be targeted (e.g. nurseries receiving imported material, and ports of entry). Information on the red palm mite needed to be provided to inspectors (both State and Federal), extension agents, pest surveyors and citizens using multiple media venues (websites, brochures, and training sessions). The only plausible wide scale mitigation option was biological control and the selection of resistant varieties of palms and Musa spp. Local generalist predators and pathogens would likely provide a level of control with exotic natural enemies adding further suppression. Pesticide options were needed for growers and for limited use in the landscape (homeowners, botanical gardens). Chemical control needed to consider the end use of the material treated (e.g. coconuts used as ornamentals or for coconut water). Pesticides are currently registered for mite control on these commodities and preliminary studies have been conducted on their efficacy against red palm mites (Rodrigues et al., 2007b).

The red palm mite is a difficult pest to detect due to its small size (<100 microns), the height of palm trees, and the large number of highly dispersed host plants where the mite could first establish. The most common survey methodology was a visual inspection of fronds, looking for damage and the presence of red palm mite colonies with a hand lens. Additional techniques used include washing leaf samples in alcohol and inspecting the rinse under a dissecting microscope or wiping a white tissue on the underside of the frond looking for red stains. Suspect mites are placed in alcohol for later slide mounting and confirmation of identification. Photographs and samples are taken to verify unknown host plants. The Florida Cooperative Agriculture Pest Survey developed a survey methodology based on experiences in the Caribbean that was effective in detecting the presence of the pest in the U.S (Smith and Dixon, 2008). Initially an extensive educational outreach program was initiated to inform the nursery industry, local government, and homeowners about the likely incursion of the pest. These efforts included information brochures, websites, and extension/nursery association presentations. Field surveys were conducted in high risk or "hot zone" areas that had the highest potential for exotic pest introduction in Florida. The areas selected had the largest numbers of host plants as well as a large number of people traveling to and from the Caribbean islands. Nurseries with high numbers of palms were chosen with preference given to those bringing in coconut seeds for propagation from Jamaica. Using the information learned about red palm mite populations on different palms, coconut, Christmas palm and bananas were specifically selected because of the increased likelihood of finding the pest on these species. Permanent inspection sites or "sentinel sites" were established in hot zone areas that were easily accessible (parks with open admission, public

waterways), had several host plants for inspection, contained palm trees with fronds that can be reached by the surveyor, and were located in or around a point of entry. The sentinel sites were checked at least once a month and surveyed extensively after major weather events such as hurricanes and tropical storms. Often these sites were linked to other regular survey efforts such as fruit fly monitoring.

On November 29, 2007 the first U.S. continental red palm mites were collected in Palm Beach County from a site that was part of the CAPS/Fruit Fly Detection Sentinel Survey Program (Smith and Dixon, 2008). At the time of the first find, 579 sentinel sites had been established in 12 counties in southern Florida. After the detection, delimiting surveys were conducted in the environs and nearby nurseries. Additional sentinel sites were set up in 3 more counties. Working with the Florida Nursery Association, the Florida Division of Plant Industry developed a nursery compliance agreement that outlined survey and chemical practices needed to allow intra/inter State movement of host plant material. As of July 2008, the red palm mite spread was confined to two counties (Palm Beach and Broward). By January 2009, the mite had spread to two additional counties (Miami-Dade and Monroe).

Due to their large population sizes, host range, and dispersal patterns, the only feasible wide-scale mitigation of red palm is biological control. Throughout the Caribbean, efforts have been made to monitor for local natural enemies and to determine their impact on red palm mite populations. In one study, changes in red palm mite and predatory mite populations were monitored at a coconut estate in Trinidad and along the coast in Puerto Rico (Amy Roda, unpublished data). Samples that represented the upper, mid and lower canopy were taken and all mobile mite stages were counted. Red palm mite populations have increased dramatically since 2006, doubling each sample period. Initially more mites were found in the lower canopy but as the quality of these fronds decreased, red palm mite populations shifted to upper portions of the canopy. Interestingly, a predatory mite, Amblyseius largoensis (Muma) (Acari: Phytoseiidae), increased in numbers as the red palm population grew, and it followed the red palm mite to new locations in the coconut canopy. The other predators seen feeding on red palm mites, Aleurodothrips fasciapennis (Franklin, 1908) (Thysanoptera: Phlaeothripidae), Bdella sp. (Acari: Bdellidae), Cheletomimus sp. (Acari: Cheyletidae), Ceciodmyiidae and Chrysopidae, did not increase in numbers nor did they follow R. indica movement to other locations in the canopy. The predators not identified to species are likely new species. Other natural enemies found in the Caribbean included predacious mites (Amblyseius spp. Amblyseius longispinus (=Neoseiulus longispinus Evans 1952) (Acari: Phytoseiidae), and Armascirus taurus (Kramer, 1881) (Acari: Cunaxidae)), predacious beetles, Telsimia ephippiger Chapin (Coleoptera: Coccinellidae) and a possible pathogenic fungus (Hirsutella)

Red palm mite is not considered a serious pest in India where natural enemies are reported to control mite populations (as cited in Peña et al., 2006). These natural enemies include ladybird beetles and predatory mites (phytoseiids). Phytoseiid mites are considered more amendable to a classical biological control program due to their relative prey specificity. In October 2007, scientists from the University of Florida and Mauritius collected candidate exotic predatory mites in Mauritius. They found that red palm mite populations were low and confined to coconut trees. The predatory mites they found in association with the red palm mite were brought to Florida for testing in quarantine. Laboratory studies will determine if the exotic predators can feed and reproduce on a diet composed solely of red palm mite. The predatory mites were identified

morphologically as Amblyseius largoensis (Muma), a species found throughout the Caribbean and USA. Current genetic studies are indicating that the predators collected in Mauritius are in fact a different, cryptic species distinct from those found in the USA. Further exploration for natural enemies in other countries where red palm mite is not economic pest may produce additional candidates for eventual release in the Caribbean and USA.

RED PALM MITE WEBSITES OF INTEREST

Chemical recommendations (Accessed January 2009):
http://mrec.ifas.ufl.edu/lso/RPM/RPM.htm

Florida Department of Agriculture and Consumer Services (Accessed January 2009):
http://www.doacs.state.fl.us/pi/enpp/ento/red_palm_mite.html

USDA APHIS RPM Site (Accessed January 2009):
http://www.aphis.usda.gov/plant_health/
plant_pest_info/red_palm_mite/index.shtml

REFERENCES

Borchert, D. 2007. Risk Analysis of Potential Consequences Associated with the Introduction of the Red Palm Mite, Raoiella indica, into the United States. USDA APHIS Plant Protection and Quarantine Pest Risk Assessment.

Flechtmann, C. H. W., and J. Etienne. 2004. The red palm mite, Raoiella indica Hirst, a threat to palms in the Americas (Acari: Prostigmata: Tenuipalpidae). Systematic and Applied Acarology 9:109-110.

Gerson, U., A. Venezian and D. Blumberg. 1983. Phytophagous mites on date palms in Israel. Fruits 38:133-135.

Jepson, L. R., H. Keifer, and E. W. Baker. 1975. Mites injurious to economic plants. University of California Press, Berkeley. 614 p.

Kane, E., and R. Ochoa. 2006. Detection and identification of the red palm mite Raoiella indica Hirst (Acari:Tenuipalpidae). USDA, ARS, Beltsville, MD.

Peña, J. E., C. M. Mannion, F. W. Howard and M. A. Hoy. 2006-2008. Raoiella indica (Prostigmata: Tenuipalpidae): The red palm mite: a potential invasive pest of palms and bananas and other tropical crops of Florida. University of Florida. Publication Number: EENY-397. http://edis.ifas.ufl.edu/IN681. Accessed January 2009.

Rodrigues, J. C. V., R. Ochoa, and E. Kane. 2007a. First Report of Raoiella indica Hirst (Acari: Tenuipalpidae) and its damage to coconut palms in Puerto Rico and Culebra Island. International Journal of Acarology 33:3-5.

Rodrigues, J. C. V, J. E. Peña and A. L. Roda. 2007b. Impact of the Invasion of the Red Palm Mite, Raoiella indica, in Puerto Rico. Proceedings of the Caribbean Food Crops Society. 43:134.

Sathiamma, B. 1996. Observations of the mite fauna associated with the coconut palm in Kerala, India. J. Plantation Crops 24:92-96.

Smith, T. R. and W. N. Dixon. 2008. 2007 Florida CAPS Red Palm Mite Survey 2nd Interim Report. October 2006 to January 2008. Florida Cooperative Agriculture Pest Survey. Program Report No. 2007-02-RPM-02.

Welbourn, C. 2007. Pest Alert: Red Palm Mite Raoiella indica Hirst (Acari: Tenuipalpidae). Florida Department of Agriculture and Consumer Services. Division of Plant Industry. http://www.doacs.state.fl.us/pi/enpp/ento/r.indica.html. Accessed January 2009.

Zaid, A. and E. J. Arias-Jimenez. 2002. Date Palm Cultivation. FAO Plant Production and Protection Paper. 156 Rev. 1. Rome Italy. http://www.fao.org/docrep/006/Y4360E/y4360e00.htm#Contents. Accessed Jan. 2009.

Table 1: A list of reported host plants for the red palm mite in the Caribbean Region (Welbourn 2007)

Family	**Scientific Name**	Common Name(s)
Arecaceae	Acoelorraphe wrightii (Grises. & H. Wendl.)	Everglades palm
Arecaceae	Adonidia merrilli (Becc.) Becc. (=Veitchia)	Manila palm, Christmas palm
Arecaceae	Aiphanes spp.	Multiple crown palm, ruffle palm
Arecaceae	Areca catechu L.	betel nut palm
Arecaceae	Areca spp.	
Arecaceae	Bactris plumeriana Mart.	Coco macaco, prickly pole
Arecaceae	Caryota mitis Lour.	fishtail palm
Arecaceae	Chamaedorea spp.	chamaedorea palm
Arecaceae	Cocos nucifera L.	Coconut palm
Arecaceae	Dictyosperma album (Bory) H. Wendl. & Drude ex Scheff.	princess palm, hurricane palm
Arecaceae	Dypsis decaryi (Jum.) Beentje & J. Dransf.	triangle palm
Arecaceae	Dypsis lutescens (H.Wendl.) Beentje & J.Dransf. (=Chrysalidocarpus)	areca palm, golden cane palm, butterfly palm
Arecaceae	Licuala grandis H. Wendl.	Licuala palm, ruffled fan palm
Arecaceae	Livistona chinensis (Jacq.) R. Br.	Chinese fan palm
Arecaceae	Phoenix canariensis hort. ex Chabaud	Canary Island date palm
Arecaceae	Phoenix dactylifera L.	date palm
Arecaceae	Phoenix reclinata Jacq.	Senegal date palm
Arecaceae	Pritchardia pacifica B.C. Seem. & H. Wendl.	Fiji fan palm
Arecaceae	Pseudophoenix sargentii H.Wendl. ex Sarg.	buccaneer palm
Arecaceae	Pseudophoenix vinifera (Mart.) Becc.	Cacheo, katié
Arecaceae	Ptychosperma elegans (R.Br.)Blume	solitaire palm, Alexander palm
Arecaceae	Ptychosperma macarthurii (H.Wendl. ex H.J.Veitch) H.Wendl. ex Hook.f.	Macarthur palm
Arecaceae	Rhapis excelsa (Thunb.) A. Henry ex Rehder	lady palm, bamboo palm
Arecaceae	Roystonea borinquena O.F. Cook.	royal palm

Table 1 continued

Family	**Scientific Name**	Common Name(s)
Arecaceae	Syagrus romanzoffiana (Cham.) Glassman	queen palm
Arecaceae	Syagrus schizophylla (Mart) Glassman	arikury palm
Arecaceae	Washingtonia robusta H. Wendl	Mexican fan palm
Heliconiaceae	Heliconia psittacorum L. f.	parrot flower
Heliconiaceae	Heliconia caribaea Lam.	wild plantain, Balisier
Heliconiaceae	Heliconia rostrata Ruiz & Pavon	lobster claw heliconia
Heliconiaceae	Heliconia bihai (L.) L.	Macaw flower
Musaceae	Musa acuminata Colla	edible banana, plantain
Musaceae	Musa balbisiana Colla	wild banana
Musaceae	Musa uranoscopus Lour	red-flowering banana
Musaceae	Musa x paradisiaca L.	edible banana, plantain
Musaceae	Musa sapientum L. (synonym of the above)	edible banana, plantain
Musaceae	Musa corniculata Rumph.	red banana
Musaceae	Musa spp.	banana, plantain
Pandanaceae	Pandanus utilis Bory	screw pine
Strelitziaceae	Strelitzia reginae Banks ex Dryard	bird of paradise, crane flower
Strelitziaceae	Ravenala madagascariensis	traveler's tree
Zingiberaceae	Etlingera elatior (Jack.) M. Sm. (=Nicolaia)	red torch ginger
Zingiberaceae	Alpinia purpurata (Vieill.) K. Schum	red ginger, jungle king/queen

Fig. 1: Hypothetical routes of introduction for the red palm mite, Raoiella indica. These routes are based on sequence analysis of the cytochrome oxidase gene. Haplotypes found in Australia belong to numerous undescribed species of Raoiella and data suggests Australasian origins for the genus. Raoiella indica appears to have originated from an Australian ancestor, possibly after introduction to the Middle East where multiple haplotypes of R. indica persist.

Proceedings of the Caribbean Food Crops Society. 44(1): 88. 2008

CITRUS GREENING UPDATE

Harold W. Browning, Professor and Center Director, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850-2299. Phone: 863-956-1151 ext. 1215; email: hwbr@ufl.edu

EDITORIAL NOTE: Circumstances have prevented Dr. Harold Browning from developing a manuscript of his excellent talk. However with the approval of Dr. R. H. Brlansky, the senior author, the following recent publication is included unchanged in these Proceedings: Brlanksy, R.H., M.M. Dewney, M.E. Rogers amd K.R. Chung. 2009 Florida Citrus Pest Management Guide: Huanglongbing (Citrus Greening), PP-225, http://edis.ifas.ufl.edu/CG086.

UF UNIVERSITY of FLORIDA
IFAS Extension

2009 Florida Citrus Pest Management Guide: Huanglongbing (Citrus Greening)[1]

R.H. Brlansky, M.M. Dewdney, M.E. Rogers and K.R. Chung[2]

Huanglongbing (HLB), commonly called citrus greening, is caused by the bacterium, *Candidatus* Liberibacter asiaticus. The name huanglongbing means "yellow shoot disease" which describes the symptom of a bright yellow shoot that commonly occurs on a sector of an infected tree. HLB is a serious disease of citrus because it affects all citrus cultivars and causes tree decline. HLB has seriously affected citrus production in a number of countries in Asia, Africa, the Indian subcontinent and the Arabian Peninsula, and was discovered in July 2004 in Brazil. Wherever the disease has appeared, citrus production has been compromised with the loss of millions of trees. HLB has not been reported in Australia or in the Mediterranean Basin. In August 2005, the disease was found in the south Florida region of Homestead and Florida City. Since that time, HLB has been found in commercial and residential sites in nearly all counties with citrus. The HLB species found in Florida is the Asian species which occurs in warm low altitude areas and is transmitted by the Asian citrus psyllid (*Diaphorina citri* Kuwayama). The Asian citrus psyllid was discovered in Florida in 1998 and now occurs throughout the state wherever citrus is grown.

The early symptoms of HLB on leaves are vein yellowing and asymmetrical chlorosis referred to as 'blotchy mottle.' The blotchy mottle symptom is the most diagnostic symptom of the disease especially on sweet orange. Leaves might be small and upright with a variety of chlorotic patterns that often resemble mineral deficiencies such as those of zinc, iron, and manganese. Some leaves may be totally devoid of green or with only islands of green spots. The blotchy mottle symptom also may be confused with other diseases or damage such as stubborn, severe forms of citrus tristeza virus (CTV), Phytophthora root rot, water logging, citrus blight, or leafminer tunnels. Root systems of infected trees are often poorly developed and new root growth may be suppressed. As mentioned above, early symptoms of yellowing may appear on a single shoot or branch. The yellowing usually spreads throughout the tree over a year and affected trees may show twig dieback causing the productivity to decline in a few years. Fruit are often few in number, small, may be lopsided

1. This document is PP-225, one of a series of the Plant Pathology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Date printed: November 2005. Date revised: November 2008. This publication is included in SP-43, 2009 Florida Citrus Pest Management Guide. A copy of this publication may be found at **http://edis.ifas.ufl.edu/CG086**. Please visit the EDIS Web site at **http://edis.ifas.ufl.edu**. For a copy of this handbook, request information on its purchase at your county extension office.

2. R.H. Brlansky, professor, and M.M. Dewdney, assistant professor, Plant Pathology Department; M.E. Rogers, assistant professor, Entomology and Nematology Department; and K.R. Chung, associate professor, Plant Pathology Department; Citrus REC, Lake Alfred, Florida; Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

with a curved central core and fail to color properly remaining green at the stylar end. Many fruit drop prematurely from afflicted trees. A yellow stain may be present just beneath the peduncle on a cut fruit. The affected fruit often contain aborted seeds and have a salty bitter taste. Symptoms may be enhanced by the presence of other pathogens such as CTV.

The causal bacterium, *Ca.* Liberibacter asiaticus has not been cultured and diagnosis is by PCR. Detection of the bacterium is usually only possible from symptomatic tissues. Four different species of *Ca.* Liberibacter exist. There are three species that cause HLB in citrus; *Ca.* L. asiaticus, *Ca.* L. africanus found in Africa and *Ca.* L. americanus discovered in Brazil in 2004. There is also *Ca.* L. africanus sp. capensis that causes a disease in cape chestnut and the most recently discovered, *Ca.* L. psyllauros, that is responsible for Zebra chip of potato. The host range of the *Ca.* Liberibacter spp. that cause HLB includes all citrus species regardless of rootstock. Normally symptoms are severe on sweet orange, mandarins and mandarin hybrids; moderate on grapefruit, lemon and sour orange; lime, pummelo and trifoliate orange are listed as more tolerant. However in south Florida, the symptoms were severe on pummelo, lime and grapefruit.

When psyllids are abundant and conditions are favorable, HLB can spread, destroying existing groves and preventing the commercial production of oranges and other citrus cultivars. Infected mature trees may decline and become non-productive and young trees that become infected never come into full production. In China, the disease was reported to kill young trees in 1-2 years. HLB also can be transmitted with infected budwood. Therefore, use of certified disease-free planting materials is essential to minimize further spread.

Recommended Practices

1. HLB is difficult to manage and continued production of citrus has proven difficult and expensive in areas where it is widespread. Since HLB is transmitted by the Asian citrus psyllid, which is well established in Florida, there is clearly a potential for the continued spread of HLB throughout Florida citrus. The use of clean budwood and certified healthy trees is essential. It is now mandatory in Florida that budwood sources and nursery production is carried out under psyllid-proof enclosures and are certified HLB free. Systemic insecticides such as imidacloprid are an important part of psyllid control (see ENY-734 Asian Citrus Psyllid and Citrus Leafminer). Some biological control of the psyllid is available but the amount of psyllid control provided by introduced parasitoids has not been sufficient to limit disease spread.

2. The Asian citrus psyllid feeds on many rutaceous plant species. The psyllid has a preference for the landscape ornamental, orange jessamine (*Murraya paniculata*). It has been found to be a host of *Ca.* Liberibacter spp. and can serve as a potential source of inoculum. Another rutaceous ornamental, *Severinia buxifolia* or orange boxwood, is also a host for the bacterium as well as the psyllid. Movement of these ornamentals is restricted under state compliance agreements and should not be moved from areas where the disease occurs.

3. Scouting for greening infected trees should be done routinely so that infected trees can be removed. It has been suggested that scouting be conducted four or more times per year. The frequency of scouting may be higher in areas previously determined to have HLB positive trees. Symptoms are the easiest to find from October to March. However, symptoms may be present at other times of the year. The current methods used to scout are walking, using all-terrain vehicles and on platforms mounted on vehicles. Symptomatic tree numbers and the rows in which they are found should be marked with colored flagging tape and GPS coordinates taken or the sites marked on a map to facilitate relocation and removal of these trees. In some cases, an HLB PCR diagnostic test may be necessary to confirm the disease (see diagnosis below).

4. Diagnosis of HLB may be difficult since some nutrient deficiency symptoms and other problems are often confused with some of the symptoms associated with HLB. HLB affected leaves accumulate starch. An iodine based starch test can be used to assist in determining what

leaves should be sent for PCR diagnosis. The iodine test alone is not used for HLB diagnosis; however, it is a useful indication that the tree likely has HLB. The procedure for the test can be found on the Citrus Research and Education Center HLB Web site at the address listed below. Samples of suspected HLB infected trees may be sent for PCR diagnosis to the Southern Gardens Diagnostic Laboratory or to the Southwest Florida REC in Immokalee. The procedures for submission of suspect samples for PCR testing is available at the following Web sites:
http://www.flcitrusmutual.com/content/docs/issues/canker/sg_samplingform.pdf or
http://www.imok.ufl.edu/hlb/index.htm

5. Removal of infected trees is the only way to ensure that they will not serve as a source of the bacteria for psyllid acquisition and subsequent transmission. Prior to removal, the infected tree should be treated with a foliar insecticide (such as Danitol, fenpropathrin) to kill all adult psyllids feeding on that tree. Failure to control these psyllids will result in the infected psyllids dispersing to new plants once the diseased tree is removed. Pruning of symptomatic limbs has been attempted in many countries to reduce the inoculum available to the psyllids. However, because the disease is systemic, pruning has not been successful since other parts of the tree may already be infected but not yet symptomatic. Additionally, if a tree is still infected after pruning, the new flush produced will serve as a feeding site for adult psyllids to acquire *Ca.* Liberibacter spp. The infected psyllids may then disperse to uninfected trees once the new flush hardens off.

6. Integrated pest management strategies should focus on the following: use of disease-free nursery trees, reduction of the inoculum by frequent disease surveys, removal of symptomatic trees, and suppression of Asian citrus psyllid populations. Refer to ENY-734, Asian Citrus Psyllid and Citrus Leafminer, in the Florida Citrus Pest Management Guide for more information on management of Asian citrus psyllid.

Additional Information:

Links to websites on citrus greening disease can be accessed through the Citrus Research and Education Center Web site at the following addresses:

http://greening.ifas.ufl.edu

http://edis.ifas.ufl.edu/CH200

http://edis.ifas.ufl.edu/HS375

Figure1. Yellow shoot symptom (indicated by arrowhead) on sweet orange tree affected by greening.

Figure 2. Leaf mottle symptom (left) caused by greening and healthy leaves (right).

Source: K.-R. Chung and R. H. Brlansky PP-210: Citrus Diseases Exotic to Florida: Huanglongbing (Citrus Greening). Citrus REC, Lake Alfred, Florida; Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

Figure 3. Small fruit with poor juice quality and leaves showing mineral deficiency symptoms (left) caused by greening.


Figure 4. The Asian citrus psyllid, Diaphorina citri that transmits citrus greening. Note: wings held rooflike.

Source: K.-R. Chung and R. H. Brlansky PP-210: Citrus Diseases Exotic to Florida: Huanglongbing (Citrus Greening). Citrus REC, Lake Alfred, Florida; Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

Proceedings of the Caribbean Food Crops Society. 44(1): 94-102. 2008

BLACK SIGATOKA AND MOKO: IMPACT AND SPREAD OF TWO DESTRUCTIVE BANANA DISEASES IN THE CARIBBEAN BASIN

Randy C. Ploetz, University of Florida, IFAS, Tropical Research & Education Center, 18905 SW 280th Street, Homestead, FL 33031-3314 USA. 305 246-7000; email: kelly12@ufl.edu

ABSTRACT. Black Sigatoka (aka black leaf streak), caused by the fungus Mycosphaerella fijiensis, and Moko disease, caused by the bacterium Ralstonia solancearum phylotype II, are among the most destructive diseases of banana. Black Sigatoka first appeared in the Western Hemisphere in Honduras in 1972, and then spread rapidly to other producing areas on the mainland. However, its movement in the Caribbean Islands has been slower and less extensive. The history of Moko disease is similar, in that it is widely spread in mainland tropical America but is still absent on most of the Caribbean Islands. Inter-island dispersal of M. fijiensis and R. solancearum is constrained by several factors. The pathogens are disseminated most effectively by man, but are thought to spread naturally up to, respectively, 200 and 90 km. Given the later possibilities and the distances that are involved, natural spread in most outbreaks of these diseases in the Caribbean cannot be ruled out. Only the arrival of black Sigatoka in Cuba, Florida and Jamaica, and that of Moko disease in Grenada and Jamaica are clearly the result of anthropogenic dissemination. The future spread and impact of these diseases in the region is discussed.

KEY WORDS: black Sigatoka, black leaf streak, Mycosphaerella fijiensis, Moko disease, Ralstonia solancearum phylotype II, Pseudocercospora fijiensis, quarantine, detection, sanitation, eradication

INTRODUCTION

Banana and plantain (a type of banana) are among the most important agricultural products in the tropics. Over 100 million metric tons of fruit are produced annually and that that enters international commerce is worth \$5 billion yr^{-1} (FAO, 2008). Locally consumed fruit are major staple foods in sub-Saharan Africa and Latin America; in Rwanda and Uganda, per capita consumption approaches 1 kg day^{-1}.

Diseases are major constraints in the production of this important crop. They affect every organ of the plant, and are caused by fungi, bacteria, viruses and nematodes. They reduce yield; affect the appearance, shelf life and marketability of harvested fruit; debilitate the host plant; and, in the case of systemic vascular wilts, kill plants.

There are ca 100 significant diseases of banana, a handful of which cause major damage (Jones, 2000; Stover, 1972; Wardlaw, 1961). Among the most notorious are black Sigatoka (aka black leaf streak) and Moko disease. Neither of these diseases is native to the Caribbean basin. This paper details their spread in the region, discusses the causal agents and the symptoms they cause on banana, outlines their epidemiology and management, and examines their current and potential impact. This review concludes with a warning of other diseases that threaten banana production in the Caribbean Basin.

OVERVIEW OF DISEASES

Black Sigatoka. In the Caribbean, black Sigatoka has been detected in Cuba (1990), Jamaica (1995), the Dominican Republic (1996), Haiti (1997), Trinidad (2003), Grand Bahama (2004) and Puerto Rico (2004) (Carlier et al., 2000; EPPO, 1998; Fortune et al., 2003; Irish et al., 2006; Ploetz, 2004).

Black Sigatoka affects diverse banana cultivars, including those that normally resist yellow Sigatoka, a related, globally distributed disease of this crop (Carlier et al., 2000). Black Sigatoka is a great threat due to its wide host range, great virulence and damage potential, and the ease with which it moves naturally and anthropogenically.

Symptoms of black Sigatoka begin as minute reddish brown flecks on the lower leaf surface (Ploetz et al., 2003). They become visible on the upper surface, elongate, darken and often develop a wet, oily appearance. Dark borders and yellow haloes surround spots longer than 1–2 cm, and they become grey and sunken as they mature. In susceptible cultivars, the entire leaf surface may be killed and no healthy leaf tissue remains by the time fruit mature. In severe cases, the bunch either does not develop fully or falls from the plant. The disease also causes fruit to ripen prematurely, which can be a serious problem when fruit are shipped long distances.

Black Sigatoka is caused by an ascomycete fungus, Mycosphaerella fijiensis (anamorph: Pseudocercospora fijiensis). Mycosphaerella fijiensis is closely related to M. eumusae, cause of eumusae leaf spot, and M. musicola, cause of yellow Sigatoka. DNA sequence analyses suggest that these major leaf pathogens of banana may have evolved from a common ancestor (Carlier et al., 2000; Crous and Mourichon, 2002).

Mycosphaerella fijiensis produces two primary spores, ascospores and conidia. The pseudothecia in which ascospores are produced are mainly globose, 47-85 m in dia, and immersed in the leaf tissue (Carlier et al., 2000). They occur on both leaf surfaces although they are most common on the upper side. Their ostioles protrude above the leaf surface and are dark brown and conspicuous. Asci are bitunicate, obclavate and lack paraphyses, and ascospores are colorless, 12.5-16.5 m x 2.5-3.8 m, two-celled, and constricted at the septum. The teleomorph is virtually indistinguishable from that of M. eumusae and M. musicola.

Conidia are produced in streaks early in their development, mainly on the lower leaf surface (Carlier et al., 2000). Conidiophores are pale brown, single- to six-celled, straight to geniculate, occasionally branched, subcylindric, 16.5–62.5 x 4–7 μm and in predominantly hypophyllous fascicles (Crous and Mourichon, 2002). Conidiogenous cells are up to 25 μm long, 2–4 μm wide at the apex, and have 1–3 thickened scars. Conidia are subhyaline, obclavate to cylindric-obclavate, have an obclavate basal cell, usually six- to eight-celled, 10–120 x 2.5–5 μm, with hila that are slightly thickened and darkened at the rim. Although the presence of this basal scar was shown recently to be phylogenetically unimportant in cercosporoid fungi (the former anamorphic genus for this pathogen, Paracercospora, was based on this feature) (Crous and Mourichon, 2002; Stewart et al., 1997), it is a valuable diagnostic character that enables M. fijiensis to be distinguished from M. eumusae and M. musicola.

M. fijiensis spreads naturally primarily via ascospores, both within the plant canopy, and within and between plantations (Carlier et al., 2000). Since ascospores are sensitive to UV light, they do not survive long after they are exposed to sunlight. Their ephemeral nature limits the spread of this disease to probably no more than 200 km (Parnell et al., 1998). However, anthropogenic spread via infected plants, leaves and plantation residues can move M. fijiensis great distances.

Black Sigatoka can be difficult and expensive to manage (Ploetz, 2000). In export plantations where monocultures of susceptible Cavendish cultivars are grown, fungicides in oil emulsions are applied frequently via aircraft. Although these practices can be very effective, their expense restricts their use to the export trades. When susceptible cultivars are grown for local consumption, management is restricted to backpack application of fungicides or cultural practices, such as the removal of affected leaves and improved in-plantation drainage and ventilation. However, these measures are not available or economical for many local producers who, thus, experience consistent losses due to the disease. Fortunately, disease pressure is reduced in multicropped situations that are common among small-holders.

Moko disease. Moko disease has been confirmed on Trinidad (1890s), Grenada (1978), Jamaica (2004) and St Vincent and the Grenadines (2005) (IPP, 2007; Pro-MED, 2004; Thwaites et al., 2000).

Moko disease, caused by Ralstonia solanacearum, affects diverse dessert bananas, plantains and cooking bananas (Thwaites et al., 2000). 'Bluggoe' is especially susceptible, and the disease is named after a synonym of this cultivar, 'Moko'. The pathogen that causes this disease is thought to be endemic to the Central and South American mainland, occurring on native relatives of banana, Heliconia spp. (see below). In the Western Hemisphere, Moko disease is now recognized on banana in an area extending from the Amazon Basin to Guatemala and southern Mexico.

Moko disease was first recorded on banana in the Caribbean on Trinidad in the 1890s, where it eliminated 'Bluggoe' (Thwaites et al., 2000). Another outbreak in Trinidad in the 1960s devastated the island's export trade, and the disease has since spread to Grenada, Jamaica, and St Vincent and the Grenadines. The only verified establishment of Moko disease in the Eastern Hemisphere is in the Philippines, where infested planting material from Honduras is thought to be responsible (Fagan and Prior, 2006). A similar outbreak on ornamental heliconia in Australia was eradicated (Hyde et al., 1992). Reports of Moko disease in India and several countries in Africa are erroneous.

Moko is a classic "new encounter" disease (Buddenhagen, 1960; French and Sequeria, 1970). Heliconia spp. are common understory plants in tropical America that are in the same taxonomic order as banana, the Zingiberales. The Moko pathogen coevolved on these banana relatives in the New World, and made the host jump from heliconia to banana when that crop was introduced from the Eastern Hemisphere.

Externally, the oldest leaves in the canopy become chlorotic, wilt, buckle and ultimately die (Ploetz et al., 2003). Younger leaves are then affected until the entire canopy is involved.

Leaves remain attached to the pseudostem which eventually collapses. Suckers can also be affected, and if suckers are cut with infested machetes they become blackened and stunted in 2-4 wk. When insect-transmitted strains of the pathogen infect cushions on the peduncle, the male bud whithers and darkens, and the causal bacterium often oozes from the bud.

Fruit may turn yellow and their peel split. Internally, pulp of affected fruit is firm, brown and later turning gray. On 'Bluggoe', the color is more reddish-brown and a red-brown liquid may occur at the fruit center. The vascular system in the rhizome, pseudostem and peduncle is also discolored light to dark brown. Severed vascular strands exude a milky discharge of the pathogen when placed in water.

Internal and external symptoms of Moko and Panama disease, caused by the fungus Fusarium oxysporum f. sp. cubense, are quite similar. However, only Moko affects fruit and plants younger than 4 months old.

Ralstonia solanacearum is an aerobic, Gram-negative, non-fluorescent, rod-shaped bacterium (Schaad et al., 2001). It is a widespread and diverse pathogen that has been divided into five biovars based on carbohydrate utilization, and five races that are determined by host range. Race 1 causes a vascular wilt on some Musa taxa, but not on the edible cultivars or heliconia (Thwaites et al., 2000). In contrast, strains that cause Moko disease are in biovar 1 and race 2, and are quite variable. They have restricted geographical distributions, occurring in a single country or region, and display varying levels of virulence on different banana cultivars and heliconia. They also display distinct colony phenotypes on Kelman's medium, and have disparate abilities to persist in soil and be vectored by insects, an important epidemiological trait. Virulent isolates of the bacterium produce extracellular polysaccharides and are not motile. More recently, R. solanacearum was subdivided into four phylotypes corresponding to groups identified via sequence analysis of the 16S-23S rRNA gene intergenic spacer region and the endoglucanase gene. Phylotype II contains strains primarily from the Americas and those that cause Moko disease (Fagan and Prior, 2006).

Root to root infection is possible, and moving water also disseminates the bacterium. However, spread by insects and man is most dangerous (Thwaites et al., 2000). Trigona bees, wasps and other flying insects have been reported to vector certain strains of this pathogen (especially the SFR, and to a lesser extent B, strains) 90 km. Insect-driven epidemics can move rapidly due to the strength and range of the insects that are involved and the rate at which plants become infectious. Within 15 days of flower infection, SFR strains begin to ooze from bracts and peduncles to initiate another cycle of infection. Contaminated farm machinery, machetes that are used for pruning, and infected fruit and rhizomes are all effective vehicles of dissemination.

Regular inspection and eradication programs are essential for the management of Moko disease. These include:

1) early recognition of the disease;
2) removal of the male bud;
3) rigorous disinfestation of farm implements, especially machetes that are used for bud removal and mat maintenance; and

4) destruction of affected and neighboring plants with herbicides. These sites can be replanted 6-12 months after host residues have decayed.

'Bluggoe' and other ABB cooking bananas with dehiscent bracts are most susceptible, and are also sources of inoculum for commercial bananas (Ploetz et al., 2003). In these situations, 'Pelipita' ABB, which has persistent bracts, or clones with aborting male buds can be used to replace susceptible cultivars. Although alternative weed hosts have been reported, their importance in the Moko disease cycle is debated (Thwaites et al., 2000).

FUTURE SPREAD AND IMPACT

Given the destructive nature of black Sigatoka and Moko disease, every effort needs to be made to reduce their movement and impact. Excluding the pathogens from the remaining pathogen-free islands would be most desirable, as disease management is always more expensive and difficult after a pathogen has arrived (Ploetz, 2007). Enhanced awareness of these diseases, how they are spread, and enforcement of quarantine measures that would inhibit their importation to new areas should receive high priorities.

Parnell et al. (1998) determined that ascospores of M. fijiensis survive only 6 hours of exposure to UV light and, on this basis, suggested that the maximum distance that black Sigatoka could move naturally was ca 200km. Given this distance, at least four outbreaks of black Sigatoka in the Caribbean could have resulted from natural movement: 1) over the Straights of Florida from Florida to Grand Bahama (100km), 2) over the Windward Passage from Cuba to Haiti (85km), 3) over the Mona Passage from the Dominican Republic to Puerto Rico (110km), and 4) over the Serpent's Mouth from Venezuela to Trinidad (35km) (Fig. 1). In contrast, distances that would have been involved in the outbreaks in Cuba, Florida and Jamaica exceed the 200km limit; they apparently resulted from man's intervention. The later conclusion agrees with activities that are thought to have occurred in Cuba (movement of infected banana suckers from Nicaragua), Florida (importation of infected banana suckers by a hobbyist) and Jamaica (infected banana trash in a disabled banana boat that was waylaid in Kingston).

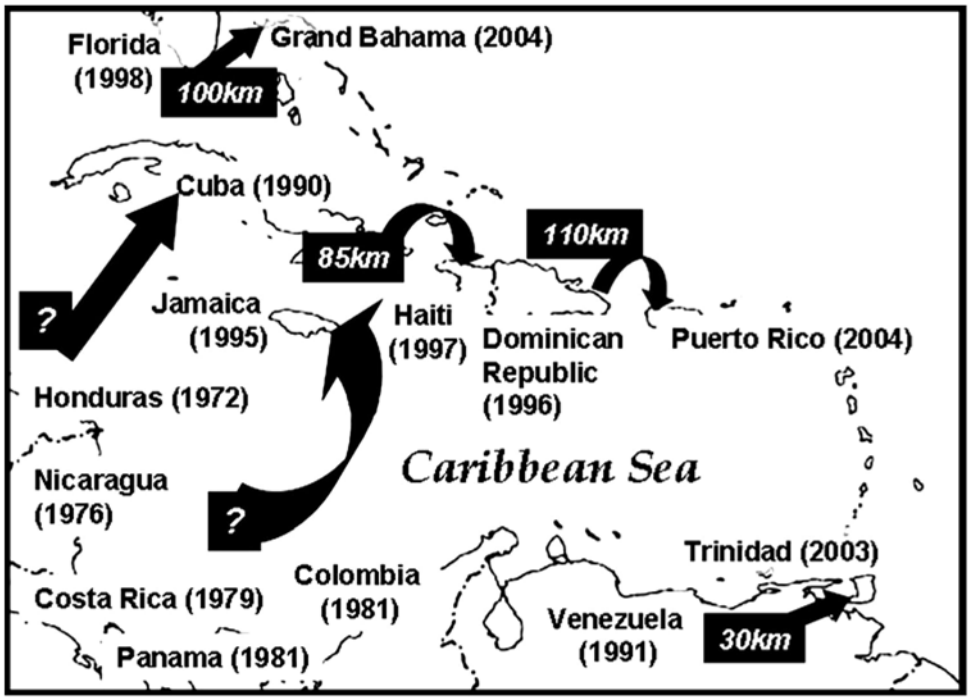


Figure 1. Countries in the Caribbean Basin in which black Sigatoka has been reported and the (year) in which detection first occurred. Natural movement was possible from Florida to Grand Bahama (100km), Cuba to Haiti (85km), the Dominican Republic to Puerto Rico (110km), and Venezuela to Trinidad (35km). In contrast, the outbreaks in Florida, Cuba and Jamaica were greater than 200km from the nearest infested landmass and were probably not natural (resulted from the unsafe importation of germplasm or movement of infested plantation trash).

Insect-vectored strains of the Moko pathogen are capable of moving up to 90km, and the SFR strains are moved most efficiently. Since SFR strains are present in Venezuela, Trinidad and Grenada (Thwaites et al., 2000), natural dissemination was possible over the 30 km distance from Venezuela (presumed to be infested prior to the 1890s) to Trinidad, and from Grenada to Carriacou, the southernmost island in the Grenadines (Fig. 2). Outbreaks of Moko disease in Jamaica and Grenada exceed the indicated 90km range and, thus, probably did not occur naturally.

Unfortunately, these pathogens will continue to move in the Caribbean, and cyclonic winds would enable natural movement even against the prevailing east-to-west tradewinds. Note is made of the generally eastern movement of black Sigatoka in the four outbreaks that are discussed above (Fig. 1), and the movement of Moko disease from Grenada to Carriacou (Fig. 2), which occurred soon after Hurricane Ivan passed through the area in 2004, the first serious hurricane in the area since 1955. The uncommon occurrence of hurricanes at that latitude may have helped isolate Moko disease on Granada for the 27 years that elapsed before it was found on Carriacou in 2005.

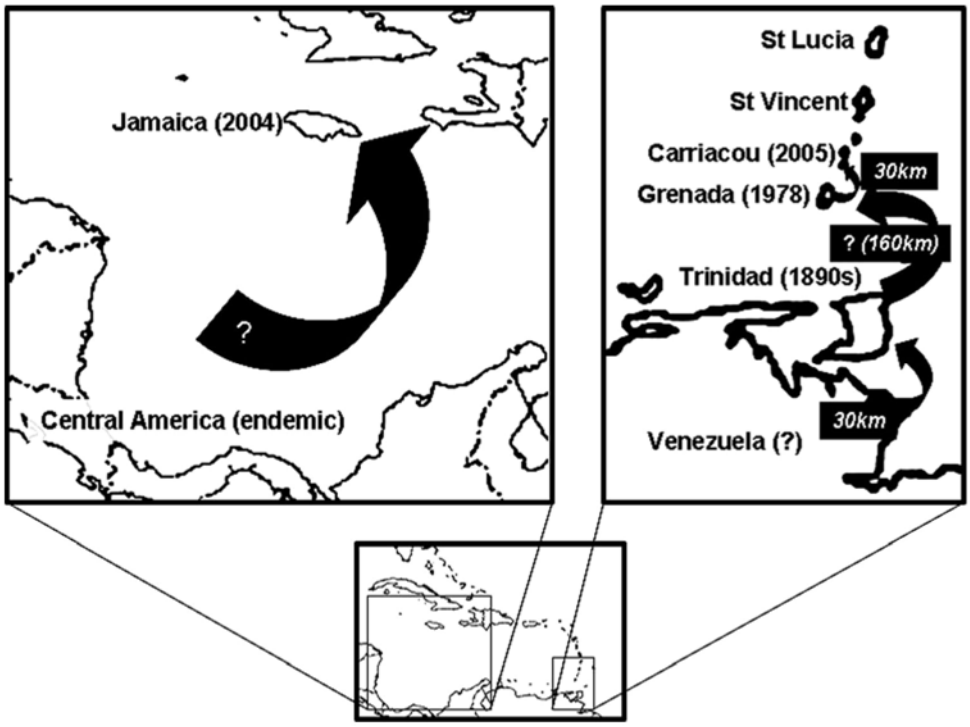


Figure 2. Caribbean islands in which Moko disease has been detected are listed with (year) of detection. The movement from Venezuela to Trinidad (30km) and Grenada to Carriacou (30km) may have resulted from the natural spread of insect-vectored SFR strains of the Moko pathogen, whereas the outbreaks in Jamaica and Grenada were more than 90 km from the nearest infested landmass (=supposed maximum range for the pathogen) and probably resulted from anthropogenic activities.

SUMMARY

In summary, natural spread cannot be ruled out in at least four outbreaks of black Sigatoka and two outbreaks of Moko disease in the Caribbean. However, it is probable that outbreaks that preceded these occurrences relied on human assistance. Had black Sigatoka not been moved by man to Cuba and Florida, subsequent outbreaks of the disease in Haiti, the Dominican Republic, Puerto Rico, and Grand Bahama, may not have occurred. Likewise, if Moko disease had not been moved to Grenada, it is possible that it would not have moved to Carriacou.

Thus, it appears that man has been a significant factor in the establishment and subsequent movement of black Sigatoka and Moko disease in the Caribbean. Their histories should serve as precautionary warnings. Under no circumstances should traditional seedpieces of banana (suckers) be moved among islands in the region. Such activity risks further movement of black Sigatoka and Moko disease, as well as equally serious diseases from outside the region (Ploetz, 2008). Only virus-indexed, tissue culture plantlets should be used when moving new banana germplasm across international borders (Diekmann and Putter, 1996).

Once these diseases are established in an area, their management will take different approaches. Black Sigatoka-tolerant cultivars are widely used in Cuba, and may assume greater importance on other Caribbean islands as the disease spreads, yields are reduced, and other control measures

are shown to be noneconomic. Markets, consumer preferences, environmental conditions (which ultimately determine disease pressure), and the types of producers who grow these fruit will determine the extent to which cultural and chemical control measures are used. Effective sanitary measures exist for Moko disease (see above), and production can be maintained when they are used in infested areas. Cultivars with dehiscent bracts or small, nondeveloping male buds, could also be used to replace susceptible clones where insect-vectored strains of the pathogen exist.

LITERATURE CITED

Buddenhagen, I.W. 1960. Strains of Pseudomonas solanacearum in indigenous hosts in banana plantations in Costa Rica, and their relationship to bacterial wilt of banana. Phytopathology 50:660-664.

Carlier, J., Four , E., Gauhl, F. Jones, D.R., Lepoivre, P., Mourichon, X., Pasberg-Gauhl, C., and Romero, R.A. 2000. Black leaf streak. Pp. 37-79 in: D.R. Jones (ed.) Diseases of Banana, Abac and Enset. CABI Publishing Wallingfrd, Oxon UK.

Crous, P.W., and Mourichon, X. 2002. Mycosphaerella eumusae and its anamorph Pseudocercospora eumusae spp. nov.: causal agent of eumusae leaf spot disease of banana. Sydowia 54:35-43.

Diekmann, M. and Putter, C.A.J. (eds). 1996. FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm. No. 15, Musa 2nd edn. Food and Agriculture Organization of the United Nations / International Plant Genetic Resources Institute, Rome, 28 pp.

EPPO. 1998. 128. Black Sigatoka disease of banana and plantain is spreading in the Americas. EPPO Reporting Service 1998, No. 798.

Fagan, M., and Prior, P. 2006. Diverse members of the Ralstonia solanacearum species complex cause bacterial wilts of banana. Australasian Plant Pathology 35: 93–101.

FAO. 2008. FAOSTAT online database at: <http://www.fao.org/default.htm>

Fortune, M.P., Gosine, S., Chow, S., Dilbar, A., St, Hill, A., Gibbs, H., and Rambaran, N. 2005. First report of black sigatoka disease (causal agent Mycosphaerella fijiensis) from Trinidad. Plant Pathology 54:246.

French, E. R. and Sequeira, L. 1970. Strains of Pseudomonas solanacearum from Central and South America: A comparative study. Phytopathology 60:506-512.

Hyde, K.D., McCulloch, B., Akiew, E., Peterson, R.A., and Diatloff, A. 1992. Strategies used to eradicate bacterial wilt of Heliconia (race 2) in Cairns, Australia, following introduction of the disease from Hawaii. Australasian Plant Pathology 21:29-31.

IPP. 2007. Moko disease declaration. International Phytosanitary Portal Report number VC-1/1. 13 Jun 07.

Irish, B. M., Goenaga, R., and Ploetz, R. C. 2006. Confirmation via the Polymerase Chain Reaction of Mycosphaerella fijiensis, causal agent of black Sigatoka of Musa spp., in Puerto Rico. Plant Disease 90:684.

Parnell, M., Burt, P.J.A., and Wilson, K. 1998. The influence of exposure to ultraviolet radiation in simulated sunlight on ascospores causing black Sigatoka disease of banana and plantain. International Journal of Biometerology 42:22-27.

Ploetz, R.C., Thomas, J.E., and Slabaugh, W. 2003. Diseases of Banana and Plantain. pp. 73-134. In: R.C. Ploetz (ed.) Diseases of Tropical Fruit Crops. CABI Publishing. Wallingford, UK. 544 pp.

Ploetz, R.C. 2000. Management of the most important disease of banana and plantain, black Sigatoka. Pesticide Outlook 11:19-23.

Ploetz, R.C. 2004. First report of black Sigatoka of banana caused by Mycosphaerella fijiensis on Grand Bahama Island. Plant Disease 88:772.

Ploetz, R.C. 2007. Diseases of tropical perennial crops: Challenging problems in diverse environments. Plant Disease 91:644-663.

Ploetz, R.C. 2008. Tropical race 4 of Panama disease: A dangerous threat to sustainable production of banana and plantain. Poster. Caribbean Food Crops Society. Miami.

ProMED. Moko Disease, Banana – Jamaica (St. James). Jamaica Observer [edited]. St James banana farmers bracing for impact of Moko disease. 16 Mar 2004.

Schaad, N.W., Jones, J.B., and Chun, W. (eds.) 2001. Laboratory Guide for the Identification of Plant Pathogenic Bacteria. APS Press, St. Paul.

Stewart, E.L., Liu, Z., Crous, P.W., and Szabo, L.J. 1999. Phylogenetic relationships among some cercosporoid anamorphs of Mycosphaerella based on rDNA sequence analysis. Mycological Research 103:1491-1499.

Stover, R.H. 1972. Banana, Plantain and Abaca Diseases. Commonwealth Mycological Institute, Kew, Surrey, UK, 316 pp.

Thwaites, R., Eden-Green, S.J., and Black, R. 2000. Diseases caused by bacteria. pp. 213-239 in: Jones, D.R. (ed.) 2000. Diseases of Banana, Abac and Enset. CABI Publishing. Wallingford, UK. 544 pp.

Wardlaw, C.W. 1961. Banana Diseases including Plantains and Abaca. Longmans, Green and Co Ltd., London, UK. 648 pp.

Proceedings of the Caribbean Food Crops Society. 44(1): 103-117. 2008

THE CHILLI THRIPS, SCIRTOTHRIPS DORSALIS: CURRENT STATUS IN THE GREATER CARIBBEAN REGION

Waldemar Klassen[1], Dakshina R. Seal[1], Matt A. Ciomperlik[2], and Daniel A. Fieslemann[3], [1]Tropical Research and Education Center, University of Florida, IFAS, 18905 SW 280 Street, Homestead, FL 33031. [2]USDA APHIS PPQ, Pest Detection Diagnostics and Management Laboratory, Edinburg, TX 78541-9398, and [3] USDA/APHIS/PPQ/CPHST, Raleigh, NC 27606. Klassen@ufl.edu

ABSTRACT. In 2003 the chilli thrips, Scirtothrips dorsalis, which originated in southern Asia, was found to be established in St. Vincent and the Grenadines. Now its current known distribution in the Greater Caribbean Region is Barbados, Florida, Jamaica, Puerto Rico, Texas, Trinidad & Tobago, St. Lucia, St. Vincent, Venezuela and Suriname. It appears to be absent from the French West Indies, Guyana, Hispaniola and Costa Rica. In 1995 S. dorsalis was found on flowers in the baggage of a passenger from El Salvador to the USA, but there is no recent evidence to suggest that the pest is established in El Salvador or in any Central American country or in Cuba. In 2004, the pest was found attacking eggplant (Solanum melongena), pepper (Capsicum spp.), okra (Abelmoschus esculentus) and cucurbits in Trinidad. In the recent past the pest reached damaging levels on hot peppers in St. Lucia and St. Vincent, on carrot, sea island cotton, and sweet potato in Barbados, on mango in Puerto Rico and on roses in Texas and on numerous ornamental landscape plantings in Florida. It is still not an economic problem on vegetable and tropical fruit crops in Florida, although it was damaging in strawberry fields in 2006. In Texas, S. dorsalis is still being found on plants in retail garden centers and it has been detected on one residential property in the Houston area. Interceptions of S. dorsalis at US ports of entry have become infrequent. From January 2007 to June 2008, only three interceptions of S. dorsalis were made at US ports of entry, which indicates that the industry and regulatory officials in infested countries which export into the US market are taking effective actions. Recent advances on the biology and control of this pest are mentioned briefly.

KEY WORDS: distribution in Greater Caribbean, ornamental, tropical fruit and vegetable crops, carrot, cotton, mango, pepper, sweetpotato

RESUMEN

LOS THRIPS DE LOS CHILES, SCIRTOTHRIPS DORSALIS: ESTADO ACTUAL EN LA MAYOR REGIÓN DEL CARIBE

EXTRACTO. En el 2003 el thrip de los chiles, Scirtothrips dorsalis se originaron en Asia Meridional, fueron encontrados para ser establecidos en San Vincente y las Granadinas. Ahora su distribución se conoce actualmente en la mayor región del Caribe como Barbados, la Florida, Jamaica, Puerto Rico, Tejas, Trinidad; Trinidad Tobago, Sta. Lucía, San Vincente, Venezuela y Suriname. Aparece ser ausente en Las Antillas francesas, Guyana, La Espanola y Costa Rica. En 1995 S. dorsalis fue encontrado en unas flores dentro de las maletas de un pasajero que viajaba de El Salvador a los Estados Unidos de America, pero no hay evidencia reciente para asegurar que el parasito fue establecido en El Salvador o en otro País de Centroamerica o en Cuba. En el 2004 el parásito fue econtrado atacando a la berenjena (Solanum melongena), pimiento

(Capsicum spp.), Okra (Abelmoschus esculentus) y cucúrbitas en Trinidad. En el pasado el parásito alcanzó niveles perjudiciales en los pimientos calientes en Sta. Lucía y San Vincente, la zanahoria, algodón de Isla del Mar, en el boniato dulce(sweet potato) en Barbados, en el mango en Puerto Rico y en las rosas en Tejas y tambien en plantaciones ornamentales numerosas en los Jardines de la Florida. Todavía no es un problema económico en la cosechas de Frutas Tropicales y Vegetales en La Florida, aunque fue perjudicial en campos de la fresa en el 2006. En Tejas, los S. dorsalis. todavía se están encontrando en las plantas en centros de jardínes al por menor y se ha detectado una característica residencial en el área de Houston. Las interceptaciones de los S. dorsalis en los puertos de los U.S.A. la entrada han llegado a ser no frecuentes. En Enero del 2007 a Junio del 2008, solamente tres interceptaciones de los S. dorsalis fueron hechas en la entrada en los puertos de los U.S.A., esto indica que la industria y los funcionarios reguladores en los países infestados que exportan en el Mercado Norteamericano están tomando medidas eficaces. Los avances recientes en la biología y el control de este parásito se mencionan poco.

PALABRAS CLAVES: Distribución Mayor en verdura del Caribe, ornamental, fruta tropical, zanahorias, algodón, mango, pimientos, boniato dulce.

INTRODUCTION

Exactly five years have passed since Dr. T. L. Skarlinsky discovered that Scirtothrips dorsalis, the chilli thrips, had become established and was causing damage in the Caribbean, namely in St. Vincent (Skarlinsky 2003). In May 2003, two months prior to this discovery the Florida Nursery, Growers & Landscape Association (FNGLA) had asked the Major Nursery Pest & Disease Identification Task Force to assemble a short list of pests and pathogens which did not yet occur in Florida, but which once present in the state, would likely cause the greatest economic damage to the nursery and landscape industries. This team compiled a list of 13 exotic organisms dubbed the "Unlucky Thirteen", which includes the chilli thrips, Scirtothrips dorsalis Hood (FNGLA 2003).

Beginning in October 2004 we initiated studies in collaboration with the Ministry of Agriculture and Fisheries, St. Vincent and the Grenadines on the biology, ecology and control of the chilli thrips. In addition we have attempted to determine the geographical distribution of this invasive species within the Greater Caribbean Region.

BASIC BIOLOGY AND DETECTION

S. dorsalis is capable of reproducing both sexually and parthenogenically (Hodges et al. 2005). Adults typically mate 2-3 days after their pupal molt and the females begin to lay eggs 3-5 days after emergence. Females tend to lay eggs continuously with the total number of eggs ranging from 40-68 (Venette and Davis 2004; GPDD 2006). Populations of S. dorsalis under favorable conditions have the capacity to double every 8 or 9 days (Seal et al. 2008).

Eggs are inserted into tender plant tissues. The egg stage lasts one week, which is long enough for an infested flower or fruit to be sent from a producer in Asia and delivered to a consumer in the Greater Caribbean Region–without being detected by an inspector at the port of entry. The immature stages are cryptic and about 1 mm long and the adults are less than 2 mm long. The

odds of detecting the chilli thrips on infested pepper fruits can be increased by 3-fold or more by dislodging them with the Miller-Skarlinsky shaker box.

Larvae and adults feed on meristems and other new plant tissues including new shoots, new leaves, young fruits, and flowers of the host plant, causing damage and spreading disease. Types of damage include browning or blackening of infested plant parts, that may also create stains and scars (Venette and Davis 2004; CABI 2005; Hodges et al. 2005). Severe infestations may lead to deformation and defoliation. The axillary leaf branches tend to sustain the most damage (CABI 2005). S. dorsalis has been known to transmit several plant diseases including Tomato Spotted Wilt Virus, which causes Bud Necrosis Disease in peanuts, Yellow Spot Virus on groundnut, nonviral Chilli Leaf Curl disease (Schall 1995), Peanut Chlorotic Fan Virus, and Peanut Yellow Spot Virus (Amin et al. 1981; Mound and Palmer 1981; Ananthakrishnan 1993).

Although S. dorsalis larvae and adults are almost invisible to the naked eye, their damage is readily recognized because the pest's feeding activity on meristems and other tender tissues causes discoloration, and ugly distortion, upward curling of leaves and defoliation. The adults' dark antennae and transverse dark bands across the abdominal segments are a useful clue in making a preliminary identification.

S. dorsalis is highly polyphagous, feeding on plants in more than 40 plant families, and it has numerous common names including Assam thrips, castor thrips, chilli thrips, chile thrips strawberry thrips, and yellow tea thrips.

PATHWAYS AND SPREAD

S. dorsalis may be spread over large distances through infested commodity shipments. For example in 2003, live larvae and pupae under the calyces of treated peppers arrived at Miami International Airport from St. Vincent and the Grenadines (Skarlinsky 2003). S. dorsalis has been intercepted at U.S. ports of entry on the leaves, fruit, and flowers of 30 different plant species shipped from Asia (USDA-APHIS 2006). The pest was spread throughout Florida on infested potted ornamental plants (Rosa sp.) and Capsicum spp. (pepper) seedlings merchandized by chains of retail garden centers; and this has been the pathway in Texas (Ludwig 2008).

According to an analysis preformed by USDA-APHIS (Meissner et al. 2005), the most important pathways whereby transboundary spread over long distances of S. dorsalis is most likely to occur are as follows:

1. air passengers and crew and their baggage, and cargo,
2. mail, including mail from express mail carriers,
3. infested smuggled material (which cannot be quantified), and
4. windborne dispersal.

The volume of air travel involving the Greater Caribbean Region was very high during the past two decades. For example in 2004, 13 major and 22 minor airlines conducted flights between the Caribbean and the USA. Also the volume of perishable agricultural commodities traded internationally has been doubling every 5 or 6 years (Klassen et al. 2002; Zadig 1999) and 3 million tons of fresh flowers, fruits and vegetables enter Miami each year (Klassen et al. 2002).

In the 3.5 years between Oct. 1, 2001 and Feb. 14, 2005, the number of shipments of agricultural commodities from the Caribbean to the continental USA were as follows: Dominican Republic – 133,921; Haiti - 46,142; Jamaica 5,932, Dominica, 3,083 and Trinidad and Tobago, 2,086, Puerto Rico, 60; St. Vincent and the Grenadines, 26; St. Lucia, 16; Bahamas, St. Kitts and Nevis, and US Virgin Island, each 7; Antigua and Barbuda, 5; Barbados, 3; Curacao, 3; Anguilla, 2; Cayman Islands, 2; Aruba, Cuba, Grenada, Guadeloupe, Martinique, Montserrat, and Turks and Caicos, each 1 (Meissner et al. 2005).

Numerous records of S. dorsalis interceptions at US international airports demonstrate that S. dorsalis life stages in the baggage of passengers readily survive on flights from Asian countries to the USA. Inspectors are not likely to detect S. dorsalis eggs, which are inserted into plant tissues and invisible to the unaided eye, while larvae and pupae are hidden under calyces and in crevices and adults may take flight (Meissner et al. 2005).

Interceptions of various species of thrips in the international mail from various parts of the world occurred 241 times between 1985 and 2004. In one instance live specimens of S. dorsalis survived on live plant material sent by mail from Vietnam to New York. (Meissner et al. 2005).

Infested plants sold to consumers by chains of retail stores were the main pathway whereby S. dorsalis was dispersed throughout Florida in the fall of 2005 and early 2006.

The likelihood that some Scirtothrips dorsalis adults are borne on air currents is very high, because (1) the pest is found primarily on terminal leaves, buds and flowers of host plants (Seal et al. 2006), (2) daily flight activity is greatest between 10 am and 4 pm when the air is the most buoyant and wind gusts are the strongest (Seal et al., 2008), and (3) the pest flies above the canopy of tea and other host plants (Takagi, 1978). Thrips are known to be passively borne long distances in wind currents (Laughlin, 1977; Lewis 1973; 1997).

Meissner et al. (2004) used historical weather data and the modeling methods of Draxler and Rolph (2003) and Magarey et al. (2004) to calculate the trajectories of air currents which moved from St. Lucia to South America, Central America, the eastern Caribbean, Mexico, Cuba, the Bahamas and the continental USA. Of the 122 trajectories studied, the percentage passing over these destinations were South America (40), Central America (31), eastern Caribbean (12), Mexico (6) Cuba (4), the Bahamas (2.6) and the continental USA (4). The average numbers of days that were required for a parcel of air to travel from St. Lucia to these destinations were as follows: South America (1.6), Central America (3.8), eastern Caribbean (4.3), Mexico (6.1), Cuba (3.4), the Bahamas (3.2) and the continental USA (6.2). Desiccation during flight probably would kill most thrips. A study in southern Australia (Laughlin 1977) showed that during the winter with an average temperature range of approximately 10-14°C, thrips could most likely survive in the air without food or water, for over 24 hours, while at summer temperatures of approximately 19-23°C, survival times of airborne thrips were predicted to average 6 hours, and on very hot days only 3 hours. Thus dispersal of viable S. dorsalis on wind currents is unlikely except between closely adjacent land masses; but this may be a very significant pathway within a given land mass.

In the western hemisphere, S. dorsalis was first discovered on St. Lucia and St. Vincent in 2003 (Skarlinsky, 2003; Seal et al., 2006) and in Trinidad in 2004 (MALMR, 2005). S. dorsalis was already very widely dispersed on these islands at the time of first detection, which suggests that dispersion of the pest had been wind-assisted, since the rapid transport of infested plants throughout these mountainous islands by people seems unlikely.

ECONOMIC IMPORTANCE

The native host plants of S. dorsalis are believed to be various Fabaceae including Acacia, Brownea, Mimosa and Saraca (CABI/EPPO, 1997). In Asia S. dorsalis is of considerable economic importance as a pest of the sixteen crops listed in Table 1.

Due to polyphagous behavior and very large host range, S. dorsalis has the potential to cause significant economic damage to a diverse variety of commodities if it were to establish widely in the U.S. S. dorsalis has been reported as a serious pest on cotton in Ivory Coast, India, and Pakistan, on citrus in Japan and Taiwan, on peanuts in India, on peppers and chilies in India, mangos in Taiwan, litchi (lychee) in China, on roses in India and Taiwan, Hevea brasiliensis in Malaysia, and lotus in Taiwan, (Meissner et al. 2005), strawberries in Queensland and Australia, tea in Taiwan, soybeans in Indonesia, (Hodges et al. 2005), pepper and groundnuts in India, grapevine (although S. dorsalis may not breed on grapevine) and tea in Japan, (GPDD 2006), and chilli peppers in Sri Lanka (Schall 1995). S. dorsalis has also been reported to cause damage in onions, tomatoes, tamarind, cashews, and castor beans (Hodges et al. 2005). The majority of the above listed commodities occur in the U.S. and in fact 34 major commodity hosts exist in areas climatically suitable for establishment (Meissner et al. 2005). According to a preliminary analysis by Garrett (2004), if S. dorsalis caused only 5% loss to these crops it would result in $3 billion dollars in losses in the USA, but if crop loss were to reach 10%, then the total economic loss could reach close to $6 billion dollars.

STATUS OF Scirtothrips dorsalis IN THE GREATER CARIBBEAN REGION

Barbados. A team from the Barbados Ministry of Agriculture and Rural Development and USDA-APHIS surveyed Barbados for S. dorsalis in 2005 and 2006 (Taylor et al. 2007). They found S. dorsalis distributed in most of the Parishes, but that in general the population densities of S. dorsalis in Barbados were lower than those observed previously on other Caribbean islands, perhaps indicating that it may have been introduced more recently. Hot peppers (Capsicum chinensis) were widely affected throughout the island, although severe damage was not observed. Adults and larvae were found on sweet pepper (Capsicum annuum), beans (Phaseolus vulgaris), carrots (Daucus carota sativus L.), eggplant (Solanum melongena L.), and on sea island cotton (Gossypium barbadense L.). On the latter, population densities of the pest reached very high levels (100 – 200 larvae and adults per terminal) and caused bronzing of the upper leaf surface, stunting, slight curling, and leaf drop.

Florida. In Florida the chilli thrips, S. dorsalis, was first detected in 1991 in a retail center in Okeechobee County, and in 1994 in another retail center in Highlands County. Both of these infestations apparently failed to persist (Silagyi and Dixon, 2006). No additional detections were reported between 1994 and 2005. In 2004, the Florida Cooperative Agricultural Pest Survey

(CAPS) program conducted a survey for S. dorsalis in Broward and Miami-Dade Counties in South Florida. The survey targeted primarily ethnic markets and their environs with some commercial pepper and cucurbit fields included. Specific commodity surveys of tomato (Lycopersicum esculentum) and pepper (Capsicum spp.) were also conducted in 2004 and early 2005, but no S. dorsalis was found (Silagyi and Dixon, 2006).

However, during the summer of 2005, a number of home owners observed damage symptoms on roses (Rosa sp.) and especially on the cultivar 'Knockout'. Geoff Coolidge, a fancier of roses, published an article in the September 2005 issue of 'The Rose Petal', the newsletter of the Greater Palm Beach Rose Society, in which he stated: "It seems a new species of thrips has entered our Florida gardens and its damage has become very apparent over the summer months. Severe damage from these "new thrips" has been recently detected on roses from Miami to Orlando" (Coolidge, 2005). The thrips, collected on October 1 and 2, 2005 in retail garden centers in Highlands and Okeechobee Counties were identified as S. dorsalis (Hodges et al. 2005).

The Cooperative Agricultural Pest Survey (CAPS), APHIS, the Florida Department of Agriculture and Consumer Services and the University of Florida immediately undertook surveys. By the end of 2005, S. dorsalis had been detected 77 times in 60 retail garden centers in 16 counties (Map 1) (NPAG, 2006: Silagyi and Dixon, 2006). Most of the infested plants in retail centers were 'knockout' rose, and the remainder were pepper seedlings. Next, the CAPS team designed an environs survey based on 5-mile radii around positive nursery detections in Lake, Orange and Seminole Counties all in central Florida with the highest number of positive samples. The objectives of the survey were to establish the extent of S. dorsalis populations had become established near infested garden centers and to identify additional host plants in Florida. The survey was conducted June 5 - 9, 2006. Within each 5-mile radius, residential and commercial areas with ornamental rose plantings and/or gardens containing peppers were inspected visually. Additional ornamental plants in close proximity to roses or peppers were also inspected.

Of the 37 samples submitted for identification, 27 samples taken from 25 properties were identified positive for S. dorsalis, which indicated that the pest was established on 45% of the surveyed properties on the following taxa: Capsicum sp., Duranta erecta, Pittosporum tobira, Rhaphiolepsis umbellate, Rhododendron sp., Ricinus communis, Rosa sp. and Viburnum suspensum. By September 2006, S. dorsalis had been positively identified 186 times in 24 of Florida's 67 counties in a multitude of settings such as retail garden centers, residences, businesses, parks and along roadside. By November, 2007, S. dorsalis had been found in 30 counties (Bostic, 2007). S. dorsalis was a significant problem in strawberry production in 2006, but not subsequently (Andrew Derksen, personal communication). Many strawberry growers release predatory mites on strawberry against phytophagous mites, but it is not known if these mites prey on S. dorsalis.

Reproductive host plants of S. dorsalis in Florida. Plants in Florida on which S. dorsalis has been found to reproduce (Osborne, 2008) are as follows: Antirrhinum majus L. (Liberty Classic White Snapdragon), Arachis hypogaea L. (peanut or groundnut, grown in greenhouse), Begonia sp. (Begonia), Breynia nivosa (W. Bull) Small (snow bush, snow-on-the-mountain), Capsicum

annum L. (pepper), Celosia argentea L. (celosia – red fox), Coreopsis sp. (tickseed), Cucumis sativus L.(cucumber), Cuphea sp.(waxweed, tarweed), Duranta erecta L. (golden dewdrop, pigeonberry, skyflower), Euphorbia pulcherrima Willd. (poinsettia), Eustoma grandiflorum (Raf.)Shinn. (Florida Blue Lisianthus), Ficus elastica 'Burgundy' Roxb. ex Hornem (Burgundy Rubber Tree), Fragaria x ananassa (strawberry), Gaura lindheimeri Engelm. & Gray (Lindheimer's beeblossom), Gerbera jamesonii H. Bolus ex Hook. f. (Gerber daisy), Glandularia x hybrida (Grönland & Rümpler) Neson & Pruski (Verbena), Gossypium hirsutum L. (cotton grown in greenhouse), Hedera helix L. (English ivy), Impatiens walleriana Hook. f. (Super Elfin White), Lagerstroemia indica L. (Crape myrtle), Ligustrum sp. (Ligustrum), Ocimum basilicum L. (Sweet Basil), Pelargonium x hortorum Bailey (Geranium), Pentas lanceolata (Forssk.) Deflers (Graffiti White), Petunia x hybrida (Petunia Easy Wave Red), Pittosporum tobira (Thunb.) W. T. Aiton (Variegated Pittosporum), Plectranthus scutellarioides (L.) R. (Coleus), Plumbago auriculata Lam. (Cape leadwort, plumbago, jamin azul), Ricinus communis L. (Castor Bean), Rhaphiolepis umbellate (Thunb.) Makino (Yeddo Hawthorn), Richardia brasiliensis Gomes (Brazil Pusley, tropical Mexican clover, in a greenhouse), Rhododendron sp., Rosa sp. (rose), Salvia farinacea Benth. (Victoria blue), Shefflera arbicola (Hayata) Merr. (umbrella tree), Tagetes patula L. (marigold), L. Tradescatia zebrina hort. ex Bosse (wandering jew), Vaccinium corymbosum L. (highbush blueberry), Viburnum odoratissimum var. awabuki (K. Koch) Zabel (sweet viburnum), Viburnum suspensum Lindl. (Viburnum), Viola x wittrockiana Gams (Wittrock's violet), Vitis vinifera L. (grapevine), and Zinnia elegans Jacq. (Zinnia Profusion White).

Regulatory response in Florida. The regulatory response of the Florida Department of Agriculture and Consumer Services is that (1) S. dorsalis is a serious plant pest of quarantine significance, and (2) when detected in retail garden centers or commercial nurseries, all infested nursery stock is quarantined until the pest has been eliminated (Clark, 2006).

S. dorsalis continues to significantly damage landscape ornamental plants, most commonly roses, ligustrum, lisianthus, pittosporum, various herbs including sweet basil, begonia, and Indian hawthorn. The pest is easily killed with certain insecticides, which provide temporary control (Seal et al. 2005; Seal et al. 2006a). In many instances, landscape care companies apply insecticidal sprays every two or three weeks, or whenever the plants have new flushes of growth. Thus far in Florida the pest has not posed a problem in commercial vegetable and tropical fruit production. As a result of our collaboration with the Ministry of Agriculture, Forestry and Fisheries of Saint Vincent and the Grenadines, which had begun in January 2004, we had developed high quality information on within-plant, within-field distribution, sampling, and chemical control of S. dorsalis (Seal et al., 2006a and 2006b). Thus within less than two months after the initial detection of S. dorsalis in Florida, we had published provisional management guidelines for S. dorsalis outbreaks in Florida (Seal et al., 2005). Also a continuing series of training workshops for County extension personnel and horticultural industry representatives were organized and implemented under the leadership of Dr. Amanda C. Hodges, University of Florida Extension Scientist, and Professor Lance S. Osborne, Mid-Florida Research and Education Center.

Threat of further spread within the USA. The potential distribution of S. dorsalis in the continental USA was assessed by Nietschke et al. (2008) using the NAPPFAST weather-based

mapping tool. They projected that S. dorsalis has the potential to establish and become a serious economic problem on the southern and western coastal plains of the USA.

US Chilli Thrips Interagency Working Group. In 2006 the "Chilli Thrips (S. dorsalis) Interagency Working Group" was formed. It includes National Plant Board representatives and USDA-APHIS PPQ staff from the southern states, Arizona and California and is chaired by Mr. Bill Grefenstette of APHIS PPQ. This Working Group has been charged with "designing and implementing necessary operational plans to prevent or minimize Chilli Thrips effects on the various industries. The working Group will be taking into consideration the following issues: 1) Industry concerns and needs; 2) Economic implications of the pest; 3) Technical recommendations; 4) practical options to limit the spread and impact of Chilli Thrips; and 5) Assist in the registration of needed insecticides" (National Plant Board, 2008).

Jamaica. In 1995 S. dorsalis was found on bitter melon, Momordica charantia, taken from a traveler from Jamaica upon arrival at the international airport in Atlanta, Georgia. Dr Lisa Myers, Chief Plant Protection Officer, Plant Protection Unit, Ministry of Agriculture and Lands (email to Ms. Dionne Clark-Harris, 22 May 2008) suggested this was the basis for the assertion in a pest alert by Florida Department of Agriculture and Consumer Service (Hodges et al., 2005) that S. dorsalis was established in Jamaica. However in 2007 S. dorsalis was found on hot pepper in one commercial field at Ebony Park by Ms. Juliet Goldsmith, Plant Protection Officer, Ministry of Agriculture, Jamaica, but it could not be found in a subsequent survey (Myers, ibid). Nevertheless On March 2, 2008 infested sugar apple (Annona squamosa L.) fruit, which had been produced in Jamaica, was taken from a traveler crossing on land from British Columbia, Canada to Blaine, Washington (PestID Database, March 2, 2008). Taken together, this very limited information suggests that S. dorsalis may be present in Jamaica but in very sparse populations.

Puerto Rico. In early 2006, S. dorsalis was confirmed from samples collected in Jardin La Ceiba, Puerto Rico (NPAG, 2006). The initial detection was made on roses, which may have originated from an infestation in a nearby retail garden center. Now, as determined by the Cooperative Agricultural Pest Survey, the pest is widespread throughout the island, and it is most troublesome on mango and somewhat damaging on pepper, cucurbits and watermelon (J. Moreno and A Ramirez, personal communication, 2008).

St. Lucia. A team from the St. Lucia Ministry of Agriculture, Forestry and Fisheries, University of Florida and USDA-APHIS (Ciomperlik and Seal, 2004) surveyed 4 of the 8 Districts of St. Lucia in January 2004. These were Districts 3, 4, 5 and 7. S. dorsalis was found in all of them. The highest total number of S. dorsalis adults (58) was collected in District 5 followed by District 4. The crops and corresponding percentages of leaf samples positive for S. dorsalis were as follows: pepper, >50%; cucumber, 46%; and eggplant, 40%. In addition, S. dorsalis was found on Amaranthus sp., zucchini and on an ornamental crop. During this single visit, S. dorsalis was not found on canteloupe, summer squash, tomato, or watermelon.

St. Vincent and the Grenadines. In 2003, Skarlinsky (2003) discovered S. dorsalis in pepper fields on St. Vincent. Therefore, a team from the St. Vincent and the Grenadines Ministry of Agriculture and Fisheries, University of Florida and USDA-APHIS (Ciomperlik and Seal, 2004)

surveyed the 8 Districts of St. Vincent in January 2004, and found S. dorsalis in 7 Districts with the largest numbers collected in Districts 1 and 4E. The numbers of S. dorsalis collected in the Districts in descending order in other districts were 4E, 1, 7, 5, 8, 6, 3 and 4W. The percentages of infested samples from various crops were as follows: pepper, >60%; okra, 60%; pumpkin, 28.5%; watermelon, 28.5%; eggplant, 20% and tomato,17%. However S. dorsalis was not found on Amaranthus sp., cantaloupe or cucumber. In an experimental planting of pepper cultivars, the percentages of infested samples were as follows: bell pepper, 47%; 'Habanero', 37%; Scotch Bonnet', 27%; 'West Indian Red', 18%; and 'Santa Fe', 11%.

Additional thrips species identified from Saint Vincent included Thrips palmi Karny, Chaetanaphothrips sp. Frankliniella spp. and others. The numbers of other thrips greatly exceeded S. dorsalis in all crops samples. S. dorsalis accounted for only 23% of the total thrips collected on pepper.

Suriname. The pest was detected in 2004 on bitter melon/gourd (Momordica charantia) (EPPO, 2004). In December 2005 field surveys conducted by Maitrie Jagroep, Suriname Ministry of Agriculture, Animal Husbandry and Fisheries and M. A. Ciomperlik, USDA-APHIS showed that S. dorsalis was established on hot pepper and 'Cleopatra" citrus rootstock in the three surveyed coastal regions of Kwatta, Commewijne and Saramacca (GPDD, 2007). The pest caused leaf curl on 'Cleopatra' citrus root stock seedlings, but not on grafted lemon or orange varieties. Lab lab (Dolichos lablab) and bitter melon/gourd were both infested with the pest but much less severely than hot pepper.

Texas. In November 2005, M. A. Ciomperlik found S. dorsalis on pepper (Capsicum sp.) seedlings in retail outlets in 3 counties of the Rio Grande Valley of south Texas (NPAG, 2006), but no established populations could be found in the field. Then in November 2007, S. dorsalis was found established on roses in the landscape in Houston, Harris County, Texas (Ludwig, 2008). In addition, S. dorsalis specimens have been found on various ornamental and vegetable plants in retail outlets in northeastern Texas (Ludwig, 2008). The pest is viewed as a serious threat to the production of cotton, peanuts, grapes, tomatoes and hot peppers in Texas.

Trinidad and Tobago. Shripat and Parkinson (2005) reported that "a detection survey was conducted in May 2004 in Trinidad. S. dorsalis was found in 21 (9%) of the 240 farms surveyed in 6 of the 8 counties in Trinidad. S. dorsalis was found in Solanum melongena, Capsicum spp., Abelmoschus esculentus and cucurbits. St. George West County had the highest incidence of S. dorsalis. In this county the pest was observed at 8 (27%) of 30 farms sampled in 6 of 15 areas surveyed. In Caroni it was observed at 4 (13%) of 30 farms; in St. Patrick East 3 (10%) of 30 farms; in Nariva/Mayaro at 3 (10%) of 30 farms; St. Andrew/St. David at 2 (7%) of 30 farms and in St. George East and only 1 (3%) of 30 farms surveyed. The pest was not found in samples collected from St. Patrick West and Victoria.

S. dorsalis was found mainly on the leaves of crops and to a lesser extent in flowers. The predominant thrips species on these vegetable crops was Thrips palmi. Followed by Frankliniella insularis and then S. dorsalis.

According Fortune (Dr. Mario Fortune, personal communication), S. dorsalis is not considered to be a significant pest in Trinidad.

Venezuela. Since 2000, S. dorsalis has been causing damage to grapevine (Vitis vinifera L.) in western Venezuela (CABI, 2005; Collins et al., 2006).

Countries in which S. dorsalis is believed to be absent. S. dorsalis has not been found in the French West Indies (J. Iotti personal communication, 2008), Dominican Republic (Serra, 2008), nor in Costa Rica (Seal and Klassen, unpublished). In 1995 S. dorsalis was found on flowers in the baggage of a passenger from El Salvador to the USA, but the authors are not aware of evidence to suggest that the pest is established in El Salvador or in any Central American country, or in Cuba.

ACTIONS NEEDED TO CONTAIN AND MANAGE THE PROBLEM

[1] Appropriate regulatory policies and programs throughout the Greater Caribbean Region need to be maintained and in some instances developed.

[2] Systematic surveys are needed to determine: (1) if new host species exist (2) the limits of geographic spread, and (3) whether natural controls are being assembled, e.g., what is preventing S. dorsalis from reaching outbreak levels in Jamaica and Trinidad?

[3] The most urgent need in Florida is to develop a durable pest management system for use on ornamental plantings that does not require frequent interventions with insecticides. Readily available predatory mites and thrips should be evaluated for use in inundative releases. Additional natural enemies should be brought from south Asia. Also, evaluations of entomopathogenic fungi and other entomopathogens, as well as innovations in formations of these agents should be accelerated.

[4] Presumably for the short term, the insecticides used in rotational schemes against insect pests of tropical fruit and vegetable crops will protect these crops from S. dorsalis. Nevertheless, both vegetable crops and tropical fruits should be scouted for indications that S. dorsalis is becoming adapted to measures used in the commercial production of these crops.

ACKNOWLEDGEMENTS

The initial studies in St. Lucia and St. Vincent and the Grenadines were funded in part through a Cooperative Agreement between USDA-APHIS and the University of Florida. Some of the subsequent studies were funded by USDA-CSREES through a T-STAR grant to the first two listed authors. We are very grateful to the following individuals for providing important information: Ms. Dionne Clark-Harris, CARDI, Jamaica; Ms. Cynthra Persad and Dr. Mario Fortune, MALMR, Trinidad and Tobago; Ms. Alies van Sauers-Muller, Ministry of Agriculture, Suriname; Ms. Aixa Ramirez, and Mr. Javier Moreno, CAPS, Department of Agriculture, Puerto Rico and Mr. Robert Balaam, CSI, APHIS and Dr. Lance S. Osborne, Mid-Florida Research and Education Center, University of Florida/IFAS, Apopka, Florida. We are indebted to Ms. Miriam Cadree Martinez is for translating the English abstract in to Spanish.

REFERENCES

Amin, P. W., Reddy, D. V. R., Ghanekar, A. M. 1981. Transmission of tomato spotted wilt virus, the causal agent of bud necrosis of peanut, by Scirtothrips dorsalis and Frankliniella schultzei. Plant Disease 65: 663-665.

Ananthakrishnan, T.N. 1984. Bioecology of Thrips. Indira Publishing House, Oak Park, Michigan. 223 p.

Ananthakrishnan, T. N. 1993. Bionomics of thrips. Annual Review of Entomology 38: 71-92.

Bostic, P. 2007. By any name, a rose is a tempting target. Saturday, November 10, 2007. http://www.heraldtribune.com/article/20071110/NEWS/711100744/1270/NEWS0101.

Bournier, J.P. 1999. Two Thysanoptera, new cotton pests in Cote d'Ivoire. Annales de la Societe Entomologique de France 34: 275-281.

CABI/EPPO. 1997. Quarantine Pests for Europe, 2nd Ed. CABI Publishing, Wallingford, UK.

Chang, N. T. 1991. Important thrips species in Taiwan. AVRDC Publication No. 91-342: 40-56.

Chiu, H.T., S.M. Shen and M.Y. Wu. 1991. Occurrence and damage of thrips in Citrus orchards in Southern Taiwan. Chinese Journal of Entomology 11: 310-316.

Chu, C. C., M. A. Ciomperlik, N. T. Chang, M. Richards and T. J. Henneberry. (2006) Developing and evaluating traps for monitoring Scirtothrips dorsalis (Thysanoptera: Thripidae). Florida Entomologist 89 (1): 47-55.

Ciomperlik, M. A. and D. R. Seal. 2004. Surveys of St. Lucia and St. Vincent for Scirtothrips dorsalis Hood, January 14-23, 2004. Animal and Plant Health Inspection Service, USDA, Raleigh, NC. 8 pages.

Ciomperlik, M.A., M. Jagroep and A. Van-Sauers Mueller. 2005. A survey report for chilli thrips (Scirtothrips dorsalis Hood) in Suriname. 8 pages. https//secure.opis.info/newsDetails.cfm?reporID=10508

Clark, R. A. 2006. Scirtothrips dorsalis, chilli thrips: regulatory update. Plant and Apiary Inspection, Division of Plant Industry, FDACS. www.sepdn.org/DesktopModules/ViewDocument.aspx?DocumentID=2322

Collins, D. R. Cannon and A. MacLeod. 2006. Chilli thrips, Scirtothrips dorsalis. Plant Pest Notice 40. Central Science Laboratory, Department for Environment, Food Rural Affairs (DEFRA), U. K.

Coolidge, G. 2005. "New thrips" cause significant damage to rose foliage and blooms. September issue, The Rose Petal, Newsletter of the Greater Palm Beach Rose Society. 3 pages.

Draxler, R. R. and G. D. Rolph. 2003. HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) Model access via NOAA ARL READY Website. Silver Springs, MD, NOAA Air Resources Laboratory.

EPPO. 2004. European and Mediterranean Plant Protection Organization Reporting Service. May 2004 Issue. http://www.invasive.org/library/eppo/Rse-0406.pdf .

EPPO. No date. Data sheets on quarantine pests: Scirtothrips dorsalis. European and Mediterranean Plant Protection Organization. 4 pages. Retrieved July 1, 2008.

FNGLA. (Florida Nursery, Growers and Landscape Association). 2003. The unlucky 13. Report of the Major Nursery Pest & Disease Identification Task Force. Florida Nursery Growers, and Landscape Association, Orlando, Florida, USA. 1 p.

GPDD (Global Pest and Disease Database). Scirtothrips dorsalis Hood. Retrieved July 1, 2008.

Hodges, G., G. B. Edwards, W. Dixon. 2005. Chilli thrips Scirtothrips dorsalis Hood (Thysanoptera: Thripidae): A new pest thrips for Florida. Florida Department of

Agriculture & Consumer Services, Division of Plant Industry. http://www.doacs.state.fl.us/pi/enpp/ento/chillithrips.html .

Klassen, W., C. F. Brodel and D. A. Fieselmann. 2002. Exotic Pests of Plants: Current and Future Threats to Horticultural Production and Trade in Florida and the Caribbean Basin. Micronesica, Suppl. 6; Invasive Species and Their Management. pp. 5-27.

Laughlin, R. 1977. The gum tree thrips Isoneurothrips australis. Survival at different temperatures and humidities and its relation to capacity for dispersal. Australian Journal of Ecology 2: 391-398.

Lee, H. S. and H. C. Wen. 1982. Seasonal occurrence of and injury caused by thrips and their control on mangoes. Plant Protection Bulletin, Taiwan 24: 179-187.

Lewis, T. 1973. Thrips, their biology, ecology and economic importance. London, New York, Academic Press.

Lewis, T. 1997. Thrips as Crop Pests. Wallingford, Oxon, UK, CAB International.

Ludwig, S. 2008. Chilli thrips: A new pest in Texas. Texas AgriLife Extension Service. http://chillithrips.tamu.edu/

Magarey, R. D., S. A. Isard, T. Keever and C. E. Main. 2004. Evaluation of potential for atmospheric transport of soybean rust spores from Roraima, Brazil, and Cali, Columbia to the continental United States. http://www.ceal.psu.edu/Rep29Aug04.pdf

MALMR (Ministry of Agriculture, Land and Marine Resources of Trinidad and Tobago). 2005. Notification of the Discovery of Asian thrips, Scirtothrips dorsalis. www.agriculture.gov.tt/documentlibrary/downloads/ .

Meissner, H., A. Lemay, D. Borchert, B. Nietschke, A. Neeley, R. Magarey, M. Ciomperlik, C. Brodel and T. Dobbs, 2005. Evaluation of Possible Pathways of Introduction for Scirtothrips dorsalis Hood (Thysanoptera: Thripidae) from the Caribbean into the Continental United States. Plant Epidemiology and Risk Analysis Laboratory, Center for Plant Health Science & Technology, Animal and Plant Health Inspection Service, USDA, Raleigh, NC. 125 p.

Miyazaki, J.R., I. Kudo and A. Iqbal. 1984. Notes on the thrips (Thysanoptera) occurring on the soybean in Java. Kontyu 52 (4): 482-486.

Mound, L. A., and J. M. Palmer. 1981. Identification, distribution and host plants of the pest species of Scirtothrips (Thysanoptera: Thripidae). Bull. of Entomol. Res. 71: 467-479.

National Plant Board. 2008. National Plant Board Representatives on Non-NPB Committees. http://www.nationalplantboard.org/committee/nonnpb.html .

Nietschke, B. S., D. M. Borchert, R. D. McGarey, and M. A. Ciomperlik. 2008. Climatological potential of Scirtothrips dorsalis (Thysanoptera: Thripidae) establishment in the United States. Florida Entomologist 91(1): 79-86.

NPAG (New Pest Advisory Group). 2006. NPAG Report on Scirtothrips dorsalis Hood: Chilli Thrips, Thysanoptera/Thripidae. March 3, 2006. Plant Epidemiology and Risk Analysis Laboratory, Center for Plant Health Science & Technology, Animal and Plant Health Inspection Service, USDA, Raleigh, NC.

Okada, T., and I. Kudo. 1982. Relative abundance and phenology of Thysanoptera in a tea field. Japanese Journal of Applied Entomology and Zoology 26: 96-102.

Osborne, L. S. 2008. Scirtothrips dorsalis Hood. http://mrec.ifas.ufl.edu/lso/thripslinks.htm. Updated May 22, 2008.

Panickar, B. K. and J. R. Patel. 2001. Population dynamics of different species of thrips on chilli, cotton and pigeonpea. Indian Journal of Entomology 63: 170-175.

Schall, R.1995. NPAG data: Scirtothrips dorsalis Chilli (Assam) thrips. Center for Plant Health Science and Technology, USDA, APHIS.

Seal, D. and M. A. Ciomperlik. 2004. Surveys of St. Lucia and St. Vincent for Scirtothrips dorsalis (Hood), Jan. 14-23, 2004. USDA APHIS PPQ, Technical Report. 19 pp.

Seal, D. R., M. Ciomperlik and W. Klassen. 2005. Chilli Thrips (castor thrips, Assam thrips, yellow tea thrips, strawberry thrips), Scirtothrips dorsalis Hood, Provisional Management Guidelines. http://edis.ifas.ufl.edu/IN638.

Seal, D. R., M. Ciomperlik, M. L. Richards and W. Klassen. 2006a. Comparative effectiveness of chemical insecticides against the chilli thrips, Scirtothrips dorsalis Hood (Thysanoptera: Thripidae) on pepper and their compatibility with natural enemies. Crop Protection 25: 949 – 955.

Seal, D. R., M. Ciomperlik, M. L. Richards and W. Klassen. 2006b. **Distribution** of the Chilli thrips, Scirtothrips dorsalis Hood (Thysanoptera: Thripidae), within pepper plants and within pepper fields on St. Vincent. Florida Entomologist, 89(3): 311 – 320.

Seal, D. R., W. Klassen and C. Sabines. 2008. Biological parameters of chilli thrips, Scirtothrips dorsalis Hood (Thysanoptera: Thripidae) on selected hosts. Florida Entomologist (submitted).

Shripat, C. and K. Parkinson. 2005. Report on the survey for the presence and distribution of Asian thrips (Scirtothrips dorsalis Hood) in Trinidad. Ministry of Agriculture, Land and Marine Resources of Trinidad and Tobago, May, 2005. 14 pages

Silagyi, A. J. and W. N. Dixon. 2006. Assessment of Chili Thrips, Scirtothrips dorsalis Hood, in Florida. Florida Agricultural Pest Survey Program Report No. 2006-08-SDS-01. 8 p.

Skarlinsky, T. L. 2003. Survey of St. Vincent pepper fields for Scirtothrips dorsalis Hood USDA APHIS PPQ, 5 pp.

Tatara, A. and Furuhashi, K. (1992) [Analytical study on damage to satsuma mandarin fruit by Scirtothrips dorsalis, with particular reference to pest density]. Japanese Journal of Applied Entomology and Zoology **36**, 217-223.

Taylor, B. M., I. H. Gibbs, and M. A. Ciomperlik. 2007. Chilli thrips (Scirtothrips dorsalis) (Thysanoptera: Thripidae) in Barbados, a new pest of sea island cotton. 43rd Annual Meeting of the Caribbean Food Crops Society, Sept. 16-21, 2007, San Jose, Costa Rica. Abstract

Thirumurthi, S., K. A. Ali, and T. R. Subramanian. 1972. A note on the varietal incidence of grapevine (Vitis vinifera) berry thrips (Scirtothrips dorsalis Hood). South Indian Horticulture 20: 92-93.

Tsuchiya, M., S. Masui, and N. Kuboyama. 1995. Color attraction of yellow tea thrips (Scirtothrips dorsalis Hood). Japanese Journal of Applied Entomology and Zoology 39: 299-303.

USDA-APHIS. 2003. Port Information Network (PIN-309): quarantine status database. U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Riverdale, MD, USA. (Restricted access database.).

USDA-APHIS. 2006. Port Information Network (PIN-309): quarantine status database. U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Riverdale, MD, USA. Retrieved 2/24/06, 2006, from http://mdrds54.aphis.usda.gov/pin309/. (Restricted access database.).

Zadig. D. 1999. Safeguarding American plant resources: Highlights of a review by the National Plant Board of relevant APHIS programs. P. 229-234. In W. Klassen (chair), Mitigating

the effects of exotic pests on trade and agriculture, Part A. The Caribbean. Proceedings of T-STAR Workshop-X, Homestead, Florida, June 16-18, 1999, sponsored by the Cooperative State Research, Education, and Extension Service, USDA. 292 pp.

Table 1. Crops in Asia on which Scirtothrips dorsalis is a pest of considerable economic importance

Crop	Country; Reference
Cashew, Anacardium occidentale L.	India; Ananthakrishnan (1984)
Castor bean , Ricinus communis L.	India; Ananthakrishnan (1984)
Chilli pepper, Capsicum annum var. annum L.	India; Ananthakrishnan (1984)
Citrus, especially C. unshiu Marcov (satsuma mandarin)	Japan, Taiwan; Chiu et al. (1991), Chu et al. (2006); Tatara and Furuhushi (1992), Tschuchiya et al. (1995)
Cotton, Gossypium spp.),	India, Cote d'Ivoire; Bournier (1999)
Grapevine, Vitis vinifera L.	India, Japan; Thirumurthi et al. (1972)
Hydrangea spp.	CABI/EPPO (1997)
Kiwi, Actinidia chinensis Planchon	CABI/EPPO (1997)
Mango, Mangifera indica L.	India; Ananthakrishnan (1984)
Onion, Allium cepa L.	India; Ananthakrishnan (1984)
Peanut, Arachis hypogaea L.	India; Mound and Palmer 1981).
Pepper, sweet (Capsicum annum var. annum L.) and hot (C. chinense Jacq.)	India, Taiwan, Thailand; CABI/EPPO (1997), Ananthakrishnan (1984)
Persimmon, Diospyros kaki Thunb.	Japan; CABI/EPPO (1997)
Rose, Rosa spp.	India; Ananthakrishnan (1984)
Rubber tree, Hevea brasiliensis (Willd. ex A. Juss.) Müll. Arg.	Taiwan; (CABI/EPPO, 1997)
Sacred lotus, Nelumbo nucifera Gaertn.	India; CABI/EPPO (1997)
Soybean, Glycine max (L.) Merr.	Indonesia; Miyazaki et al. (1984)
Strawberry, Fragaria ananassa X F. virginiana Duchesne	Queensland, Australia; Mound and Palmer (1981)
Tamarind, Tamarindus indica L.	India; Ananthakrishnan (1984)
Tea, Camellia sinensis (L.) Kuntze	Taiwan, Japan; Okada and Kudo (1982)
Tobacco, Nicotiana tabacum	India; Ananthakrishnan (1984)
Tomato, Lycopersicon esculentum Mill.	India; Ananthakrishnan (1984)
Various ornamentals	India; Ananthakrishnan (1984) , Japan

Proceedings of the Caribbean Food Crops Society. 44(1): 118-123. 2008

DEVELOPING STRATEGIC RESEARCH FOR BIOLOGICAL CONTROL OF NEW PEST THREATS: THE PASSION VINE MEALYBUG, PLANOCOCCUS MINOR AS A CASE STUDY

M.T.K. Kairo[1], A. Francis[1] and A. Roda[2], [1]Center for Biological Control, College of Engineering Sciences, Technology and Agriculture, Florida A&M University, Tallahassee, Florida, [2]USDA APHIS PPQ, Center for Plant Health Science and Technology.

ABSTRACT. Classical biological control is one of the key approaches to the management of invasive alien pests. This typically involves the importation and release of natural enemies from the pest's area of origin. Due to increased concerns about the ecological safety of imported biocontrol agents, regulatory requirements for information during the importation process have increased considerably in recent years. Thus, a considerable amount of knowledge has to be generated before a natural enemy can be introduced. This also means that a considerable amount of time can be lost before implementation of biological control program. In principle, the process can be speeded up if research on potential threats is done in advance. However, the challenge to such a pre-emptive approach is that there are many potential threats and only limited resources. This paper discusses ongoing pre-emptive research on Planococcus minor, a high risk pest threat to the United States and other countries in the Caribbean Basin. It also discusses the value and application of such strategic research, and identifies key considerations for institutionalizing this approach.

KEY WORDS: Pre-emptive biological control, invasive species, Planococcus minor

INTRODUCTION

The management of invasive alien species (IAS) continues to be a major challenge to plant protection authorities, and despite increased efforts, new problematic invasive species have continued to emerge at an alarming rate. In part, this is not surprising because, many countries are still a long way from establishing all the required safeguarding mechanisms. However, it is important to emphasize that even with the best safeguarding systems in place, it is impossible to have a totally impermeable system, that is, unless all trade and movement of people and goods ceases. Countries are, therefore, taking a pragmatic approach based on risk analysis as espoused in the WTO-SPS agreement. However, once an IAS becomes established in a new environment, efforts switch to risk management and classical biological control is one of the central approaches for managing an established IAS.

The decision to implement classical biological control is, however, frequently delayed for various reasons including: 1) initial emphasis may be placed on eradication efforts which could go on for several years, 2) there may be a desire to carry out research to assess the role of indigenous natural enemies, which may adapt to attack the new IAS, and 3) non-availability of essential financial or human resources. Typically, pre-introductory research on agents for weed control may easily take 5-10 years, before the first releases are made. Whereas for arthropod pests, it was not uncommon for releases to be made within 1-3 years of initiating the effort. The

increasingly stringent regulatory requirements now may require considerable research to support requests for introduction and release of biological control agents. This means that such efforts to introduce natural enemies of an IAS are increasingly requiring considerably greater investment in resources and time to undertake the necessary work. Greater availability of knowledge on potential pests and their natural enemies can enhance the process and thus reduce delays in the introduction and release of biological control agents. This paper discusses the potential for and value of pre-emptive/strategic research of this nature.

SCOPE FOR STRATEGIC RESEARCH

'Strategic research', from our perspective means research aimed at imminent or eventual major pest threats, i.e., to generate knowledge which will bolster mitigation efforts across the continuum from prevention to management activities. Therefore our interest is on those species for which there is sufficient reason for concern. Pests are deemed to be of concern if they are listed on the Cooperative Agricultural Pest Survey (CAPS) list (USDA, 2005) or other prioritized lists. The CAPS list includes pests which have become established but have a limited distribution and pests which have not yet been found in the United States, but which are frequently intercepted. The list is ranked on basis of potential environmental and economic impact. Our primary focus is on pests which are not yet established in the United States. The knowledge available on such species varies considerably, from those where there is a wealth of information available, to those where little, if anything is known.

The broad goal of our strategic research is to generate knowledge which will bolster mitigation efforts across the continuum from prevention to management activities. For instance some of our work is focused on development of digital identification tools on some high priority taxa. However, this paper is concerned with research that is focused on aspects of management of invasive alien species and especially biological control.

For logistic and other reasons, we have also narrowed our taxonomic and geographic focus to mealybugs and to the Caribbean respectively. Recent history has shown that the Caribbean is an important source area as well as conduit for the introduction of pests into the United States as demonstrated in the case of the pink hibiscus mealybug, Maconellicoccus hirsutus (Green)

On the other hand, mealybugs are among the most important pest invaders in the United States. For instance, at least two mealybug species became established in the United States during every decade of the last century and in the 1990s, this number rose to seven (Miller et al., 2002). We are primarily interested in two species, the passion vine mealybug, Planococcus minor and, the coffee mealybug, Planococcus lilacinus. The former is one of the high priority pests on the CAPS list. Both species are among the top 10 listed by Miller et al. (2002) with highest risk of entry into the United States. In this paper we use P. minor to illustrate the scope of the strategic research being conducted.

Planococcus minor IN THE WESTERN HEMISPHERE

The passionvine mealybug is a polyphagous pest with a host range exceeding 200 plant species. The pest is native to Asia, but has been recorded in several countries in the Caribbean and

Central, and South America (Table 1). These records suggest that the mealybug has been in the region for quite a few years yet despite records increasingly frequent interceptions, this pest has not become established in the United States. Taxonomic experts have, however, pointed to the fact that the species is very similar morphologically to the citrus mealybug, Planococcus citri, and there is a possibility that the validity of the records from the Region may be questionable. Assuming that the records of the pest in the region are accurate, then, this begs the question why no major outbreaks have been reported in the respective countries. Against this background, our research was initiated with the following objectives:

1. To confirm the presence of the mealybug in the region and to assess its pest status and identify its main host plants.
2. To generate information on various aspects of the pest's biology and ecology including: development and reproduction at different temperatures, phenology, surveys to identify natural enemies.
3. Conduct studies to understand the biology and impact of key natural enemies.
4. Develop techniques for surveillance based on pheromones; also develop rearing techniques for the mealybug and any potential natural enemies.

The overarching purpose of this research was to develop technology for surveillance and control of the pest.

Table 1. Distribution of passionvine mealybug in the Western Hemisphere (Watson and Chandler, 2002; Williams and Granara de Willink, 1992)

Insular Caribbean	Central and South America
Antigua and Barbuda	Brazil
Cuba	Colombia
Dominica	Costa Rica
Guadeloupe	Guatemala
Grenada	Guyana
Haiti	Honduras
Jamaica	Mexico
St Lucia	Uruguay
US Virgin Islands	
Trinidad	

PRELIMINARY FINDINGS

The research on P. minor in Trinidad is ongoing and will be fully reported later. Here we highlight some of the significant findings. The passionvine mealybug has been found at various locations in Trinidad and this insect has been positively confirmed as P. minor. To date, the closely related species, P. citri, which is most often confused with P. minor, has not been found in Trinidad.

The weight of evidence collected thus far suggests that in Trinidad P. minor is restricted to only a few host plants. Cocoa is the most important host plant in Trinidad and the pest prefers feeding on cocoa pods.

Populations of the mealybug are very low at all locations and it is attacked by a complex of natural enemies including both predators and parasitoids (Table 2). Research continues to quantify the impact of the key natural enemies and to understand their ecology. However, it seems that the existence of this broad natural enemy complex may explain the low prevalence of the mealybug.

Two of the most important parasitoids recovered, are already present in the United States.

Table 2. Some of the common natural enemies of Plannococcus minor from Trinidad (Francis et al., in prep.).

Species	Location
Leptomastix dactylopii, parasitic wasp, Encyrtidae	Maracas-St. Joseph ,La Reunion Station, Santa Cruz, Lopinot , Fishing Pond
Coccidoxenoides perminutus, parasitic wasp, Encyrtidae	Biche, Fishing Pond
Gahaniella tertia, parasitic wasp, Encyrtidae	Maracas-St. Joseph
Signiphora n. sp. #11 mexicanus group*, parasitic wasp, Signiphoridae	La Reunion Station
Coccidoctonus trinidadensis, parasitic wasp, Encyrtidae	Lopinot
Diadiplosis coccidarum, predaceous larvae, Cecidomyidae	All sites
Several Coccinelid spp. , predaceous larvae and adults	

DISCUSSION AND CONCLUSIONS

Benefits of strategic research: Strategic research allows for better preparedness, and has the potential to minimize delays in implementation of biological control. Strategic research will also save considerable time should the pest become introduced. The invasion of Florida by the pink hibiscus mealybug is a good example of the benefits of strategic research. Because USDA-APHIS and Caribbean partners had developed and tested the methods for management of the pest, this meant that natural enemies were introduced within a very short time (weeks) of the first reports of the pest in Florida. Furthermore, key stakeholders were already well informed and this helped to avoid panic, inappropriate regulatory measures and huge economic losses.

Strategic research is also critical in guiding complimentary research in other countries. In the case of P. minor a priority for other affected countries in the Caribbean would be to conduct

surveys to establish whether or not some of the specialist natural enemies are already present. If not, countries may wish to make a decision to introduce specific natural enemies.

Assuming that all of us are convinced that it is important to develop action plans for priority high risk invasive alien species, it would be useful to consider how this can best be done, given the regional interest as demonstrated in this symposium to increase collaboration and synergy between Caribbean Basin partners interested in strengthening regional safeguarding. An important starting point might be the development of a list of regional pest priorities. This could begin by listing species that are already in the region but have a limited distribution. It will also be important to identify the institutions and people working on particular species. Such an effort can be effectively implemented through established networks such as the Caribbean Invasive Species Working Group (CISWG). Information exchange would be critical.

A typical strategic plan for biological control of new pest threats should contain (1) a summary of available knowledge, (2) identification of key gaps which require research and (3) an assessment of the requirements and complexity of implementing classical biological control for specific targets. Other useful information will include a listing of potential collaborators across the globe.

In conclusion, it is clear that any knowledge generated in advance of a pest becoming established in a new country is likely to be of immense value in guiding the development of responsive action. Strategic research is therefore inherently beneficial. Given the common nature of many pest problems affecting the Caribbean Basin, the development of partnerships and networking will be immensely beneficial. It is anticipated that with more examples of successful research, increased awareness and interest for other scientists to conduct related research will develop.

ACKNOWLEDGEMENTS

This work is a collaborative effort between Florida A&M University and the USDA-APHIS-PPQ, Center for Plant Health Science and Technology and is funded through a Cooperative Agreement between FAMU and USDA. We acknowledge the support and input of our collaborators in Trinidad: The Ministry of Agriculture, Land and Marine Resources, Trinidad and Tobago and CABI, Caribbean and Latin America Regional Centre.

REFERENCES

Francis et al _____

Miller, D.R.; Miller, G.L. and Watson, G.W 2002. Invasive species of mealyugs (Hemiptera: Pseudococcidae) and their threat to US agriculture. Proceedings of the Entomological Society of Washington. 104: 825-836.

USDA 2005. Cooperative Agricultural Pest Survey Program Aid No. 1830. Detecting Plant Pests and Weeds Nationwide United States Department of Agriculture, Animal and Plant Health Inspection Service. http://www.aphis.usda.gov/lpa/pubs/pub_phcapsdetecting.pdf (Accessed March 14, 2009)

Watson, G.W. and Chandler, L.R. 2000. Identification of mealybugs important in the Caribbean region. Commonwealth Science Council and CAB International. Egham, UK: CAB International.

Williams, D.J. and Granara de Willink, M.C. 1992. Mealybugs of Central and South America. Wallingford, UK: CAB International.

Proceedings of the Caribbean Food Crops Society. 44(1): 124-125. 2008

SESSION III: TECHNICAL ISSUES RELATING TO INVASIVE SPECIES THREATS IN THE CARIBBEAN BASIN

Highlights of Part I of Session III

Mr. Everton Ambrose, Regional Specialist, Agricultural Health and Food Safety (AHFS), IICA Office in Saint Lucia, P. O. Box 1223, Castries, Saint Lucia. Phone: 758 451 6760/61 ; Fax: 758 451 6774 ; Email: Ambroseiica@candw.lc; iica@candw.lc

The following papers were presented:

a) Red Palm Mite situation in the Caribbean and Florida
b) Citrus Greening Update
c) Black Sigatoka and Moko: Impact and Spread of two Destructive Banana Diseases in the Caribbean Basin
d) The Chilli Thrips: (Scirtothrips dorsalis): Current status in the greater Caribbean Region
e) Developing Strategic Research for Biological Control of New Pest Threats: The Passion Vine – Mealybug (Planococcus minor), as a case study

Some major points raised in the presentations were as follows:

A. General

- Invasive species are spread very long distances primarily due to human activity in transporting infected or infested host plant materials. However spread over shorter distances (e.g. in the order of up to 100 km), probably is mediated by wind for the red palm mite, and for the chilli thrips. Even though wind is known to transport spores long distances, they tend to be readily destroyed by ultraviolet rays in sun light. Thus the probability of spore survival during long distance transport is greatly reduced under a clear sky.
- Invasive species are generally difficult to eradicate mainly because, in many cases, detection is made only after establishment of the invasive species has occurred over a wide area.
- Establishment is generally rapid because of the absence of effective natural enemies and detection occurs too late to arouse the public and/or because anticipatory public education or even contingency plans for public education usually do not exist.
- Little is known of alien pests in distant continents, therefore, investigative research is necessary. However in instances in which the biology and control invasive species was studied shortly after the pest arrived in the Region, great benefits accrued to countries that were invaded after methods of detection, monitoring and control had been developed. For example, studies of the pink bibiscus mealy bug and the chilli thrips conducted on the Caribbean islands first invaded were highly beneficial to growers of later invaded sites.
- For some invasive species no early detection methodology has been developed, and the range of symptoms exhibited makes initial detection and recognition difficult.

B. Management – Approach

- Prevention strategy
    - Predetection – (i) create awareness by producers, public, travelers, surveillance,

- (ii) conduct of research on the biology and control of the most dangerous invasvive species prior to their arrival, and
- (iii) develop contingency plans for the the Region and for each country.
- (iv) Strengthen legislation – quarantines and authorization of off-shore detection.

- Monitoring and Surveillance
  - Field surveys
  - Survey of host and non hosts

- Control Methods
  - Chemical
  - Sanitation
  - Biological
    - Natural enemies – local or exotic
    - Resistant crops
    - Physical use of water and other methods of dislodging
    - Changes inimical to the invasive pest
      - Growth cycle
      - Production methods
  - Understanding the biology and ecology of the invasive species
  - Need for a coordinated approach at the national and regional levels
  - Need for development of contingency plans

Proceedings of the Caribbean Food Crops Society. 44(1): 126-134. 2008

GIANT AFRICAN SNAIL IN THE CARIBBEAN SUB-REGION

Gene V. Pollard[1], Angela Fields[2] and Bret Taylor[3]; [1]Trinidad and Tobago; [2]Department of Biological and Chemical Sciences, The University of the West Indies, Cave Hill, Barbados; [3] Ministry of Agriculture and Rural Development, Graeme Hall, Christ Church, Barbados. Email: Phone: (+) 868 662 2002 Ext 4055 (Office); E-mail: gene.pollard@sta.uwi.edu .

ABSTRACT. The giant African snail (GAS), Achatina fulica, is native to East Africa, and is now very widely distributed and established across the Indo-Pacific region. In 1984, this pest was first reported in the Caribbean sub-region in Guadeloupe and has spread since to several other countries. The only other report for the wider Caribbean Basin is for Florida, United States of America, where the pest was introduced in the late-1960s. GAS has been described as the most damaging land snail world-wide, reportedly attacking over 500 plant species inclusive of tree crops, ornamentals, vegetables and root crops; it has also been reported to vector several plant pathogens. Achatina fulica is therefore considered a major agricultural and horticultural pest species. Additionally, GAS is of public health concern being an intermediate host and vector of the parasitic rat lungworm, Angiostrongylus cantonensis, the agent of the human disease, eosinophilic meningitis (or cerebral angiostrongyliasis). However, in most of the affected countries in the Caribbean, the snail has not proved to be a major pest, mainly affecting household gardens and uncultivated or semi-wild areas; the few reports of agricultural losses involve mainly vegetables. Management of this pest in several of the affected countries consists mainly of the use of chemical baits and physical collection of snails combined with limited public awareness programmes. While its spread to date has been slow, the establishment of the giant African snail in the Caribbean is a cause for concern for the agricultural sector and, lesser so, as a potential public health problem. However, it should be noted that the spread of GAS has not been anywhere near the rapid spread of other recently introduced invasive alien species in the Caribbean sub-region, e.g. hibiscus mealybug or red palm mite and neither has the impact been as devastating.

KEYWORDS: Giant African snail, Caribbean sub-region, distribution, management

INTRODUCTION

Achatina fulica or giant African snail (GAS), native to East Africa, is now very widely distributed across the Indo-Pacific region where it has become well established in most of those countries to which it has been introduced (Mead, 1961; Raut and Barker, 2002). In 1984, this pest was first reported in the Caribbean sub-region in Guadeloupe (Frankiel, 1989 cited in Raut and Barker, 2002) and, in 1988, from neighbouring Martinique. In 1995, GAS was reported from two other French West Indian islands, Marie Galante and Saint Martin (F.D.G.D.E.C., Guadeloupe, 2004). Since that time, there had been no further reports of this pest into any country in the Caribbean sub-region until Saint Lucia reported its introduction in July 2000. Subsequently, GAS was positively identified in 2000 in Barbados (Fields et al., 2006) and Anguilla (Connor, 2006), in Dominica in 2007 (Ministry of Agriculture, pers. comm.); Antigua in 2008 (Ministry of Agriculture, pers. comm.).

The only other report for the wider Caribbean Basin was the introduction and establishment in Miami, Florida, United States of America, in 1966 (Mead, 1979).

ECONOMIC IMPORTANCE IN AGRICULTURE AND HORTICULTURE

According to Mead (1961), as quoted by Mead and Palcy (1992), GAS is considered the world's most economically important snail pest in agriculture and horticulture, reportedly attacking over 500 different plant species inclusive of tree crops, ornamentals, vegetables and root crops (Plant Protection Service Secretariat of the Pacific Community, 1999). Additionally, it can scavenge on decaying organic matter and can frequently be seen at waste rubbish tips and on animal dung. Because of its wide host range, Achatina fulica is considered of serious economic importance, being deemed a major agricultural and horticultural pest species. Data from Samoa, for example, indicate agricultural losses of between 45 to 85 percent in root crops [Alocasia spp., yam leaves and stems (Discorea spp.), taro petioles and above ground tubers (Colocasia)], vegetables (brassicas, sweet and green peppers, pumpkins) as well as young banana leaves, especially Cavendish varieties (Matalavea, 1997, unpubl.). These are also major crop groups in the Caribbean sub-region. Other major crops of economic importance in this sub-region which may be attacked by GAS include cacao (particularly seedlings), coffee, banana, citrus fruit and seedlings, breadfruit and papaya. Mead (1979), quoting several authorities, also reported that GAS has been shown to vector plant pathogens such as Phytophthora palmivora of black pepper, coconut, betel nut, papaya and vanda orchid, P. colociae of taro and P. nicotianae parasitica of eggplant and tangerine. One must note that P. palmivora is an important pathogen in the Caribbean sub-region. Several other instances of serious economic damage to agriculture and horticulture due to GAS activity have been reported. For example, one report from the state of Bihar in India indicated GAS causing ... severe damage to vegetables, paddy, banana, papaya and a host of other economic and ornamental plants: between 30-80 percent in kitchen gardens and 15-25 percent in field crops (Birat, 1971). Srivastava (1973) also reported on the economic importance of GAS in India.

However, there are contrasting views on the pest status of GAS. One authority was of the view that this pest probably has got a worse reputation than it might deserve although recognising that damage may be total in small plots, e.g. vegetable and flower gardens including a variety of seedlings and cuttings; such damage was believed to be greatest when the pest has been newly established and is in a phase of increasing population growth. Mead (1979) further suggested that "damage is fairly localized and not catastrophic or devastating on a broad scale as so often portrayed"; further, he indicated that "The negative factor creating the greatest and most lasting impression ... is that of the sheer numbers and concentration of individuals". One report, for example, (as quoted in a GAS leaflet of the Australian Plant Inspection Service, AQIS, 2000), indicated that two years after GAS was introduced into America Samoa in 1975, one million snails were hand-collected; during June/July 1980, 135 tonnes (about 5.4 million snails) were collected and in September of that same year, 21 million individuals (http://www.aqis.gov.au/docs/plpolicy/gas/htm). According to Mead (1979) it is such numbers that ... intensifies the nuisance factor, often to the point where it is the principal, if not indeed the only tangible reason for objecting to the presence of the snails. The presence of slime trails and excreta in gardens or even on walls of houses and the stench from large numbers of dead and

decaying snails, especially when a chemical baiting programme is being implemented, are major factors contributing to the "nuisance factor" identified by Mead (1979).

PUBLIC HEALTH IMPORTANCE OF GIANT AFRICAN SNAIL

Apart from its agricultural pest status, GAS is of public health concern. It is an intermediate host and vector of the parasitic rat lungworm, Angiostrongylus cantonensis, the agent of the human disease, eosinophilic meningitis (or cerebral angiostrongyliasis) (Beaver and Rosen, 1964). This is a major disease in Southeast Asia and the Pacific Islands (Aguiar et al., 1981; Andersen et al., 1986; Lindo et al., 2004). Molluscs other than GAS can vector this parasite, and the nematode has been reported from a number of countries in the Caribbean sub-region including the Bahamas, Cuba, Dominican Republic, Haiti, Jamaica and Martinique and Puerto Rico (Aguiar et al.,1981; Andersen et al., 1986; Lindo et al., 2002; Raccurt et al., 2003; De Meuron, 2005; Vargas, et al., 1992). Cases of the disease have been reported from Cuba (Pascual, et al., 1981), Puerto Rico and Jamaica (Lindo et al., 2002; 2004), Martinique (De Meuron, 2005) and Dominican Republic (Leone et al., 2007). The death of a child from eosinophilic meningitis associated with Angiostrongylus cantonensis infection has been reported from Jamaica (Lindo et al., 2004). In Jamaica, both Rattus norvegicus and R. rattus serve as primary hosts (Lindo et al., 2002).

Consumption of raw or improperly cooked snail meat is thought to be the most common cause of the disease, but cases have occurred after ingestion of raw vegetables (Slom et al., 2002) or raw vegetable juice (Tsai et al., 2004) contaminated with third-stage larvae or the consumption of infected paratenic hosts such as frogs (Lai et al., 2007). However, there are reports that infection occurred in Taiwanese children through contact with GAS. Apart from man, other mammalian species like rodents, dogs and horses can be infected (Robinson, 2000).

GIANT AFRICAN SNAIL IN THE CARIBBEAN – DISTRIBUTION AND MANAGEMENT

GAS in Guadeloupe and Martinique. According to Philippe Tormin (personal communication), GAS was first reported in 1984 in Guadeloupe in the National Park in the centre of the island and since that time has spread to practically all of the country. The pest was reported for Martinique in 1988. In Guadeloupe, GAS attacked a number of agricultural crops including cucumber, banana, yam, dasheen, citrus, papaya, hibiscus; indirect damage also resulted. Management of the pest was mainly through the use of metaldehyde bait, physical collection of snails and implementation of a public awareness campaign. Nearly 20 years after its first reporting, GAS is still a problem in Guadeloupe but somewhat less so. For example, the amount of metaldehyde bait applied has been reduced drastically from 24 tonnes in 1995 to 8.4 tonnes in 1999. However, there has not been sufficient research on the pest to allow for an improved management strategy.

GAS in Saint Lucia. Though first identified in June 2000, the pest may have been introduced for at least one year prior to this, if not longer, judging by the size (6-7 cm) of some of the existing specimens collected at that time. Initially, distribution was limited to the north-western region of the country; however, the pest has continued to spread island-wide. A large number of plant

species were initially attacked and included various fruit trees (papaya, mango, breadfruit, coconut, citrus), pineapple, tannia and ornamentals (viz. hibiscus, glyricidia, variegated immortelle, croton, aloe, ficus, ornamental palms).

On first reports of the pest, the Ministry of Agriculture unsuccessfully attempted to eradicate the pest through the implementation of several actions. These included:

[1] A pest surveillance programme to determine the extent of infestation
[2] Sourcing of as much information as possible (e.g. through the internet and from CABI Bioscience)
[3] Proclaiming GAS a notifiable pest under the plant protection regulations of the country so as to allow for necessary legal authority for any actions as declared by the government
[4] Initiating a community-based programme to physically collect and destroy snails, at least from residential areas
[5] A chemical baiting programme using methaldehyde
[6] limited public awareness activity

These actions proved to be unsuccessful. The pest is still mainly a problem for home gardens though a few farmers have complained about pest damage. In those cases, mainly vegetable crops were attacked and this has been mitigated through hand collections of snails and application of molluscicides.

According to a Ministry of Agriculture spokesperson, certain studies still have to be done, e.g. a new survey to determine the current extent of spread; a search to determine whether any natural enemies have emerged; determination of the presence/absence of the rat lung worm; the impact of the GAS on local molluscs.

GAS in Barbados. In Barbados, GAS was first identified in the south-west of the island at one locality in the parish of St Michael at Spring Garden, in September 2000 and subsequently spread to other parishes. This was believed to be aided in part by illegal dumping and inadvertent transport by vehicles (Fields et al., 2006). At present, the pest can be found in all parishes, widely distributed throughout the country, in gullies, other wooded habitats and in residential areas. While the snails feed mainly on detritus, fallen fruit and faecal matter (Fields, 2007) there have been unconfirmed reports of GAS damage to cabbages, cucumbers and breadfruit. However, as in Saint Lucia, GAS is still mainly considered a pest of residential areas.

Following introduction of GAS, a management programme was developed consisting mainly of the use of metaldehyde-based baits. However, according to Fields (2007), preliminary studies suggested that the baiting programme implemented in several gullies was not very effective.

GAS in Anguilla. GAS is found in all habitat types sampled, in grasslands, scrublands and woodlands. The snail is well established on the island and is considered a pest. An eradication programme initiated by the government was aborted due to resident's concerns about molluscicide use (Connor, 2006).

GAS in Dominica. Dominica was particularly at risk of the introduction of GAS given the fact that they maintain active trade links and passenger contacts with Guadeloupe and Martinique

(there is regular ferry service with these French islands) and Saint Lucia, as well as Barbados on a more limited scale; and all these countries are infested with GAS. The snail was first reported in Dominica in March 2007 in Dos D'Ane in the north of the island in an area of about 10,000 m^2. This was a sparsely inhabited area with only two dwellings close by. One farmer had found one snail and then another the following day, after which he called the Ministry of Agriculture. The public awareness campaign run by the Ministry was most likely the cause of concern by the farmer.

Immediately on the identification of GAS, an area of 0.6 ha was cleared and burnt. A drain was built along the edge of this area which abutted a forested region, in an effort to provide a physical barrier. Additionally, a chemical control programme was initiated using metaldehyde bait as well as hand picking of snails. The last sighting of GAS individuals was in June 2007 and continual monitoring has not revealed any snails since[3]. The Ministry of Agriculture in Dominica is convinced that GAS has been eradicated from the country. However, wider surveys still need to be conducted.

GAS in Antigua. GAS was identified in Antigua in April 2008 in two areas in the south-west of the island, Jolly Hill and Bolans New Extension. The pest had not been reported in Barbuda. At the time of reporting in April 2008, the Government had implemented internal quarantines, a public education programme and surveillance in the infested areas as part of its GAS management efforts.

ASSISTANCE TO THE CARIBBEAN SUB-REGION.

Following the introduction of GAS into Saint Lucia and Barbados in 2000 and, given the real threat posed to the wider Caribbean by this invasive species, several countries approached the Food and Agriculture Organization of the United Nations (FAO) in 2000 for technical assistance under FAO's technical cooperation programme. Under this programme, a two-year project for the management of GAS was approved in 2002 for USD 193,000. The overall objective of the project was to strengthen the capacity within the beneficiary countries of the Eastern Caribbean region to implement a sustainable integrated and environmentally sound management strategy for GAS.

The expected outputs of the project were different for infested and un-infested countries. For Saint Lucia and Barbados, the specific outputs of the assistance were to develop and implement an IPM programme inclusive of a monitoring and surveillance system; to train plant protection and quarantine and extension officers and farmers in management of the pest; and to develop and initiate a public awareness programme. For the non-infested countries at the time (Antigua and Barbuda, Dominica, Grenada, St Kitts and Nevis, St Vincent and the Grenadines, Trinidad and Tobago), the specific outputs were to develop and implement detection surveys; to train plant protection and quarantine and extension officers in all aspects of GAS management; and to develop and initiate a public awareness programme. This project was implemented with collaboration of other agencies, particularly with the Caribbean Area Office of USDA-APHIS

[3] (Personal Communication – As of March 2008, according to the senior plant protection officer, Ministry of Agriculture).

and the Inter-American Institute for Cooperation on Agriculture (IICA). The objectives of this project were mainly achieved (FAO, 2004, unpubl.).

Additionally, USDA APHIS, in collaboration with several regional partners, convened a meeting of a GAS Working Group in Barbados in July 2008, to further the work on the management of GAS in the Region.

DISCUSSION AND CONCLUSIONS

Mead (1979), in commenting on the June 1966 introduction of GAS into Miami, Florida, suggested that the turn of events could be regarded as .. almost standard format: surreptitious introduction, unsuspected establishment, uninhibited reproduction, insidious spread, explosive appearance, alarmed discovery, frantic quarantines, protracted controls, secondary infestations, near-eradication, cautious optimism, uncertain prognosis and indefinite anticipation; this author further commented that ... In every known, investigated, major, established infestation in the past, this series of events predictably and relentlessly evolved into: multiple foci, peripheral spread, unfeasible quarantines, impractical control, abandoned control, maximum population, disease syndrome, population decline, population decimation, population stability and simulated endemism.

One might venture to suggest that the current situation in the Caribbean lies squarely in the first half of Mead's thesis on establishment, i.e. ... explosive appearance, alarmed discovery, frantic quarantines, protracted controls, and with the existing reaction being ... unfeasible quarantines, impractical control, abandoned control. Time would determine whether the scenarios in Saint Lucia and Barbados would fully follow the hypothesis of Mead. In fact, the impact of GAS in Guadeloupe has diminished since its introduction in 1984 and so appears to be following Mead's thesis.

The Caribbean sub-region has had recent and previous experience with the spread of several invasive alien species, e.g. hibiscus mealybug (HMB), Maconellicoccus indica and red palm mite, Raoiella indica. HMB, for example, was first reported in Grenada in 1994 and within 4 to 5 years it was distributed from South America (Guyana and Venezuela) into Central America (Belize) and North America (southern California) and in the majority of Caribbean islands (Kairo et al, 2000). Within a decade, HMB was in practically every Caribbean country and continued to spread in the Americas. While the spread of GAS to date has been slow, the establishment of this invasive pest in the Caribbean is a cause for concern not only for the agricultural sector, but is also, very importantly, a public health problem. However, it should be noted that the spread of GAS has not been anywhere near the rapid spread of other recently introduced invasive alien species in the Caribbean sub-region.

While eradication of GAS is possible, as has been shown for Miami in the 1970s, this requires a great concerted effort. As was outlined for the Miami experience, eradication involved immediate quarantine of infested areas; demarcation of adjacent buffer zones; a continuing publicity programme and cooperation of the public; frequent surveys including hand collection and destruction; elimination of shelters; regulation of refuse disposal; and chemical control even months after the last live specimen was found (Mead, 1979). It is doubtful whether there are

resources available in Saint Lucia or Barbados for such a sustained eradication programme. Nonetheless, Dominica seems to believe that they have eradicated the pest after determining its establishment at a very early phase and then taking immediate eradicative measures. Implementation of an effective management programme might be more feasible in the other instances in Barbados and Saint Lucia. For the other countries in the Caribbean where this invasive species has not yet been known to occur, it is imperative that increased quarantine procedures for this pest be immediately implemented; this should include increased port vigilance especially for goods and vessels from infested countries as well as a monitoring and surveillance programme developed and implemented, if this has not as yet been done.

REFERENCES

Aguiar, P. H., Morera, P., and Pascual, J. 1981. First record of Angiostrongylus cantonensis in Cuba. The American Journal of Tropical Medicine and Hygiene 30(5): 963-965.

Andersen, E., Gubler, D. J., Sorensen, K., Beddard, J., and Ash, L. R. 1986. First report of Angiostrongylus cantonensis in Puerto Rico. The American Journal of Tropical Medicine and Hygiene 35(2): 319-322.

Australian Plant Inspection Service (AQIS) 2000. Giant African snail, No.3. (http://www.aqis.gov.au/docs/plpolicy/gas/htm).

Beaver, P. C. and Rosen, L. 1964. Memorandum on the first report of Angiostrongylus in man by Nomura & Lin. 1945. American Journal of Tropical Medicine and Hygiene 13(4): 589-590.

Birat, R.B.S. 1971. Field observations on the control of the giant African land snail Achatina fulica Bowdich in Bihar. Pesticides Annual, December 1971: 76.

Connor, R. 2006. Distribution, habitat association, species abundance and perceptions of residents towards Achatina fulica in Anguilla. MSc thesis, University of Exeter, 41pp.

De Meuron, K. 2005. Angiostrongylose en Martinique. II Congrès de la Société Antillo-Guyanaise de Pédiatrie: 10-12.

FAO 2004. Report: Evaluation Workshop on the Management of the Giant African Snail, 29-30 June 2004, Grenada, 10pp, unpublished.

F.D.G.D.E.C. (Fédération Départmentale des Groupments de Défense Contre les Ennemis de Cultures) Guadeloupe 2004, Achatine or giant African snail, 20 years later in the French West Indies. Paper presented at the Regional Evaluation Workshop on Assistance for the Management of Giant African Snail, 29-30 June 2004, Grenada. 4pp; unpubl. Food and Agriculture Organization of the United Nations, Sub-Regional Office for the Caribbean.

Fields, H. A., Gibbs, I. & Taylor, B. 2006. Colonisation of Barbados by the giant African snail, Achatina fulica Bowdich 1822. Journal of the Barbados Museum and Historical Society 52: 233-241.

Fields, Angela. 2007. Giant African Snails (GAS) and Barbadian Gullies. A Report to the Ministry of Energy and the Environment, pp 23.

Kairo, Moses T.K., Pollard, G.V., Peterkin Dorothy D. and Lopez, Vyjayanthi F. 2000. Biological control of the hibiscus mealybug, Maconellicoccus hirsutus Green (Hemiptera: Pseudococcidae) in the Caribbean. Integrated Pest Management Reviews 5: 241-254.

Leone, S., De Marco, M., Ghirga, P., Nicastri, E., Esposito, M., & Narciso, P. 2007. Eosinophilic meningitis in a returned traveler from Santo Domingo: case report and review. Journal of Travel Medicine: 14(6):407-410.

Lai, C., Yen, C., Chin, C., Chung, H., Kuo, H., and Lin, H. 2007. Eosinophilic meningitis caused by Angiostrongylus cantonensis after ingestion of raw frogs. The American Journal of Tropical Medicine and Hygiene 76(2): 399-402.

Lindo, J. F., Waugh, C., Hall, J., Cunningham-Myrie, C., Ashley, D., Eberhard, M. L., Sullivan, J. J., Bishop, H. S., Robinson, D. G., Holtz, T., and Robinson, R. D. 2002. Enzootic Angiostrongylus cantonensis in rats and snails after an outbreak of human Eosinophilic Meningitis, Jamaica. Emerging Infectious Diseases 8(3): 324-326.

Lindo, J. F., Escoffery, C. T., Reid, B., Codrington, G., Cunningham-Myrie, C., and Eberhard, M. L. 2004. Fatal autochthonous eosinophilic meningitis in a Jamaican child caused by Angiostrongylus cantonensis. The American Journal of Tropical Medicine and Hygiene 70(4): 424-428.

Matalavea, S. 1997. Progress Report on Giant African Snail Project (TCP/SAM/6612), pp 13, unpublished.

Mead, A.R. 1961. The Giant African Snail: A Problem in Economic Malacology. University of Chicago Press: Chicago, Illinois. 257 pp.

Mead, A.R. 1979, Economic Malacology with particular reference to Achatina fulica. Pulmonates, Volume 2B, Edited by Vera Fretter and J. Peake, 150 pp. Academic Press.

Mead, A.R. and Palcy, L. 1992. Two giant African land snail species spread to Martinique, French West Indies. The Veliger 35 (1): 74-77.

Pascual, J., Planas Bouli, R., and Aguiar, 1981. H. Eosinophilic meningoencephalitis in Cuba, caused by Angiostrongylus cnatonensis. The American Journal of Tropical Medicine and Hygiene, 30(5): 960-962.

Plant Protection Service Secretariat of the Pacific Community. 1999. Giant African Snail, Pest Advisory Leaflet/ Secretariat of the Pacific Community, no.6 (revised), 3rd edition.

Raccurt, C. P., Blaise, J. & Durette-Desset, M. C. 2003. Présence d'Angiostrongylus cantonensis en Haiti. Tropical Medicine and International Health 8(5): 423425.

Raut, S. K. and Barker, G. M. 2002. Achatina fulica Bowdich and other Achatinidae as pests in tropical Agriculture pp. 55-114. In Molluscs as Crop Pests, ed. G. M. Barker. CAB International, Wallingford.

Robinson, David G. 2000. Public health concerns: Mollusk-vectored Angiostrongyliasis, Unpublished report, USDA-APHIS-PPQ P7RA National Identification Services; Updated 05/16/2000.

Robinson, David G., Zimmerman F. J. and Fields A. 2004. The terrestrial malacofauna of Saint Lucia, 16 pp, unpublished.

Slom, T. J., Cortese, M. M., Gerber, S. I., Jones, R. C., Holtz, T. H., Lopez, A. S., Zambrano, C. H., Sufit, R. L., Sakolvaree, Y., Chaicumpa, W., Herwaldt, B. L., and Johnson, S. 2002. An outbreak of eosinophilic meningitis caused by Angiostrongylus cantonensis in travellers returning from the Caribbean. New England Journal of Medicine, 346(9): 668-675.

Srivastava, P.D. 1973. The giant African snail and its control. Indian Farming, December 1973: 33-36.

Tsai, H., Lee, S., Huang, C., Yen, C., Chen, E. & Liu, Y. 2004. Outbreak of eosinophilic meningitis associated with drinking raw vegetable juice in southern Taiwan. American Journal of Tropical Medicine and Hygeine, 71(2): 222-226.

Vargas, M., Gomez-Perez, J.D. & Malek, E.A. 1992. First record of Angiostrongylus cantonensis (Chen, 1935) (Nematoda: Metastrongylidae) in the Dominican Republic. Tropical Medicine and Parasitology 43(4): 253-255.

Proceedings of the Caribbean Food Crops Society. 44(1): 135-144. 2008

CARAMBOLA FRUIT FLY SITUATION IN LATIN AMERICA AND THE CARIBBEAN

Alies van Sauers-Muller, Carambola Fruit Fly Program Coordinator, Agricultural Experiment Station, Ministry of Agriculture, Animal Husbandry and Fisheries
Letitia Vriesde laan 8, Paramaribo, Suriname. Email cffsur@sr.net

ABSTRACT: The carambola fruit fly, Bactrocera carambolae Drew and Hancock (CFF) is a member of the oriental fruit fly species complex. CFF was recognized to be present in Suriname in 1986, but it appears to have been present since at least 1975. CFF originated in Asia, where it occurs in Indonesia, Malaysia and southern Thailand. Fifteen percent of Suriname's human population originated in Indonesia. Probably the CFF was introduced into the Western Hemisphere by persons traveling from Indonesia to Suriname. The spread of the CFF infestation and infested host plants were delimited soon after 1986. By 1990, the fly had spread throughout the northern (inhabited) part of Suriname and eastward into French Guiana. Subsequently the CFF spread westward to infest two border villages in Guyana, and, east of French Guiana, into the Brazilian State of Amapa. CFF's major hosts are carambola (Oxalidaceae: Averrhoa carambola L.) and curaçao apple (Myrtaceae: Syzygium samarangense (Blume) Merr. and Perry), which originated in Asia. Most tropical fruits are good hosts of CFF. In 1990 the first control actions were undertaken to prevent the fly from spreading westwards, and in 1997 a regional eradication program was initiated. The male annihilation technique (MAT) served as the main method for eliminating CFF populations. This technique involved the area-wide placement of 5 cm x 5 cm x 1 cm wood fiber blocks impregnated with methyl-eugenol mixed with malathion to lure and annihilate CFF males. Additional methods used were bait sprays, soil treatments, host fruit destruction, and pruning of host fruits. In urban areas the MAT technique was applied by spraying min-u-gel containing methyl eugenol and malathion onto tree trunks, electric-line poles etc. After good progress in freeing areas of CFF, the project closed in 2003 due to lack of funding, and by 2007 the CFF had reclaimed all cleared areas that had been infested at the initiation of the control project. In addition, the CFF has spread to new areas in Guyana. In the Brazilian State of Amapa, containment activities will continue relentlessly, due to the threat the pest represents to the Brazilian fruit industry. For Suriname, control of fruit flies in the future will have to include suppression of the CFF as one of the major economically important tropical fruit fly species. Alternative methods will be evaluated including biological control and localized application of bait sprays in fruit production areas. The establishment and expanding distribution of the CFF in the Guyana's represents a continuous threat to the fruit production in the Caribbean and the Latin American region.

KEY WORDS: Bactrocera carambolae, carambola fruit fly, hosts, geographical distribution, male annihilation technique, bait sprays, biological control

RESUMEN: La mosca de la carambola, Bactrocera carambolae Drew and Hancock (CFF) es una especie en el complejo de la mosca de la fruta Oriental. Su presencia en Suriname fue reconocida en 1986, pero parece haber estado presente al menos desde 1975. La CFF es originaria de Asia, donde se encuentra en Indonesia, Malasia y el sur de Tailandia. El 15 % de la

población de Suriname es originaria de Indonesia. Probablemente la mosca fue introducida en el Hemisferio Occidental por personas que viajaron de Indonesia a Suriname. La delimitación de la infestación de la CFF y sus hospedantes fueron determinados poco tiempo después de 1986. Para 1990 la mosca se había expandido a través del Norte (la parte habitada) de Suriname y en el Este hacia adentro de la Guayana Francesa. Subsecuentemente la CFF se dispersó hacia dos aldeas en la frontera con Guayana y, en el este de Guayana Francesa, hacia adentro del estado de Amapá en Brasil. Los principales hospedantes de la CFF son carambola (Oxalidaceae: Averrhoa carambola L.) y perita de agua (Myrtaceae: Syzygium samarangense (Blume) Merr. and Perry), ambos de origen asiático. Muchas frutas tropicales son buenos hospedantes de la CFF. En 1990 se iniciaron las primeras acciones de control para prevenir la diseminación de la mosca hacia el Oeste y en 1997 se inició un programa regional de erradicación. La técnica de aniquilación de machos (TAM) fue usada como principal método para eliminar poblaciones de la CFF. Esta técnica consiste en la colocación en forma extensiva de bloques fibrosos de 5 cm x 5 cm x 1 cm que fueron impregnados con metilo-eugenol y malatión para atraer y aniquilar los machos de la CFF. Métodos adicionales usados fueron la aspersión de cebos tóxicos y aplicaciones al suelo, destrucción de frutas de hospedantes, y la poda de hospedantes. En zonas urbanas la TAM fue aplicada en forma de aspersiones de min-u-gel con metilo-eugenol y malatión sobre troncos de árboles, postes de electricidad, etc. Después de buen progreso en liberar áreas de la CFF, el proyecto cerró en 2003 a falta de recursos y para 2007 la CFF se había dispersado nuevamente a todas las áreas que estaban infestadas al inicio del proyecto de control. Asimismo, la mosca se dispersó hacia nuevas áreas en Guayana. En el Estado de Amapá en Brasil, las actividades de control en la barrera de contención continuaran inexorable, en vista de la amenaza que esta plaga representa para la fruticultura brasileña. Para Suriname, el control de moscas de la fruta tendrá que incluir la supresión de la CFF como una de las especies tropicales de mosca de la fruta de mayor importancia económica. Métodos alternativos serán evaluados, incluyendo el control biológico y la aplicación localizada de cebos tóxicos en áreas de producción de frutas. El establecimiento de la CFF en las Guayanas representa una continua amenaza para la producción frutícola en el Caribe y la región de América Latina.

PALABRAS CLAVES: Bactrocera carambolae, mosca de la carambola, hospederos, distribución geográfica, técnica de aniquilación de machos, aspersión de cebos tóxicos, control biológico.

INTRODUCTION

The carambola fruit fly, Bactrocera carambolae Drew and Hancock, also known as CFF, is a member of the oriental fruit fly species complex. This fly appears to have been present in Suriname since at least 1975, because preserved specimens of that date are present in the insect collection of the Suriname Agricultural Experiment Station (van Sauers-Muller, 1991). It was collected again in 1981 from curaçao apple, and finally in 1986 identified as Dacus dorsalis, the oriental fruit fly. However, it became clear soon that what was thought to be the oriental fruit fly was a complex of over forty (Drew and Hancock, 1994) to seventy-five species (Clarke et al., 2005). Hereafter this complex is know as the Bactrocera dorsalis complex. The carambola fruit fly is one of these species.

CFF originated in Asia, where it occurs in Indonesia, Malaysia and southern Thailand (White et al., 1992) and several surrounding countries (Clarke et al., 2005). The introduction of CFF into the Western Hemisphere is thought to have been mediated by persons traveling from Indonesia to Suriname, since Suriname has a diverse human population, 15 % of which originated in Indonesia.

MATERIALS AND METHODS

After the discovery of CFF in Suriname, surveys were conducted by collecting fruits to delimit the spread of the infestation and to identify the infested host plants. By 1990, the fly had spread mainly into the northern (inhabited) part of Suriname and eastward into French Guyana. Subsequently, CFF spread westward to infest two border villages in Guyana, and southeastward into the Brazilian State of Amapá (Fig. 1). By that time, surveys were conducted using McPhail traps baited with Torula yeast tablets and with Jackson traps baited with methyl-eugenol, and after several years (1990 in Suriname) also with malathion as the killing agent in these Jackson traps.

From 1986 to the present, fruits have been collected to determine the host plants of the carambola fruit fly. This collection also provided information on native Anastrepha fruit flies and the parasitoids present in the country. In all four countries detection systems were harmonized using standardized methods with Jackson traps (baited with methyl-eugenol and the killing agent malathion); in areas where the MAT technique was applied trapping with plastic McPhail traps with Torula yeast served as the detection system.

The male annihilation technique (MAT) served as one of the main methods for eliminating CFF populations. This involved the area-wide placement 5 cm x 5 cm x 1 cm pressed wood fiber blocks (P.T. O'Malley Lumber in Baltimore, Maryland) impregnated with methyl-eugenol mixed with malathion to lure and kill CFF males. In urban areas this method was replaced by the use of min-u-gel, a powder mixed with methyl-eugenol and malathion sprayed on tree trunks, electricity poles, etc. Only in certain parts in the city, with larger backyards with fruit trees and streets wider apart, blocks were applied additionally. In manuals for the oriental fruit fly control a distribution rate of 4 fiber blocks per hectare is advised. In 2001, calculations based on field experience showed that over 18 blocks per hectare were needed to eradicate the carambola fruit fly from an area.

Additional methods were applied in areas with more persistent fly populations. These were bait sprays (Nulure with malathion (57%) 4:1), applied using manual backpack or motorized backpack sprayers and in several areas aided with aerial applications with an agricultural plane. Also host fruit destruction, pruning of host fruits, and occasionally soil treatments to control pupae (using the insecticide diazinon) were used (van Sauers-Muller and Fleurkens, in preparation).

RESULTS AND DISCUSSION

CFF infests a number of hosts. Its major hosts are carambola (Oxidalidaceae: Averrhoa carambola L.) and Curaçao apple, also referred to in the literature as Java apple (Myrtaceae:

Syzygium samarangense (Blume) Merr. and Perry). These two fruit species originated, as did several others, in Asia. Other good hosts are mango (Anacardiaceae: Mangifera indica L.), sapodilla (Sapotaceae: Manilkara achras (Mill.) Fosberg), West-Indian cherry (Malpighiaceae: Malpighia punicifolia L.) - also known as Barbados cherry and acerola, guava (Myrtaceae: Psidium guajava L.), star apple (Sapotaceae: Chrysophyllum cainito L.), jujube (Rhamnaceae: Ziziphus jujuba Mill.). Minor hosts are golden apple (Anacardiaceae: Spondias cytherea), Surinam cherry (Myrtaceae: Eugenia uniflora L.),

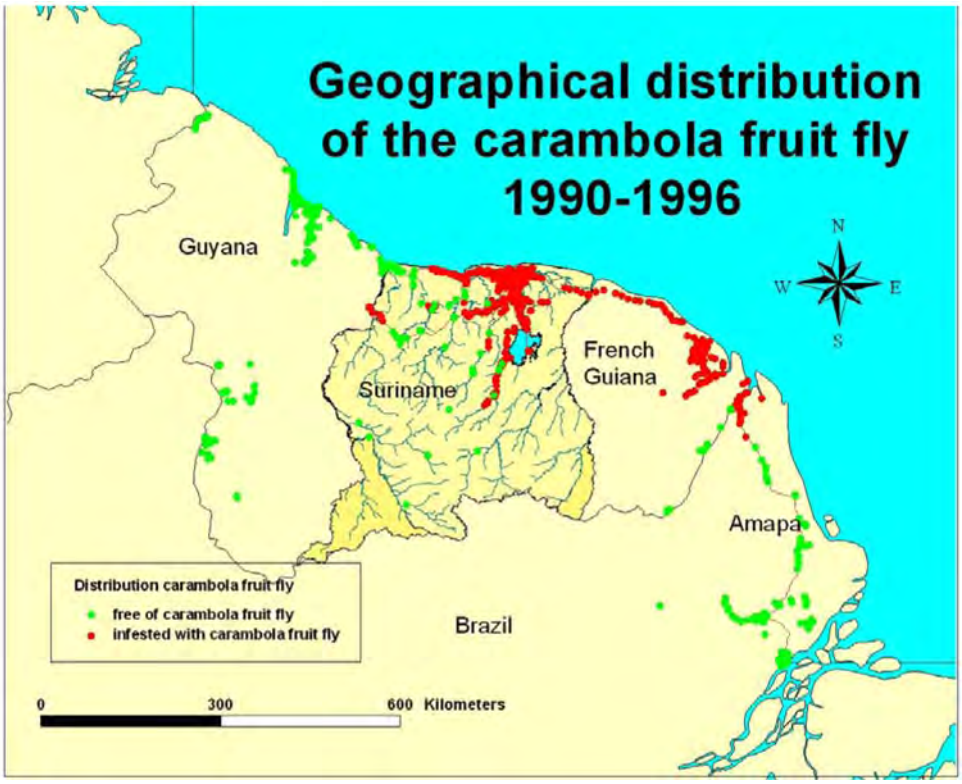


Fig. 1. Known distribution of the carambola fruit fly in Guyana, Suriname, French Guiana and Brazil just before activities of the regional eradication program were initiated.

sweet orange (Rutaceae: Citrus sinensis Osbeck), grapefruit (Rutacea: Citrus × paradisi Macfad.), mandarin (Rutaceae: Citrus reticulata Blanco), tropical almond (Combretaceae: Terminalia catappa L.), cashew (Anacardiaceae: Anacardium occidentale L.), hog plum (Anacardiaceae: Spondias mombin L.) and Malay apple (Myrtaceae: Syzygium malaccense (L.) Merr. and Perry). Infestations were also found in some forest fruits; although mainly in areas with high CFF populations. Apart from hog plum, infestations were found in Eugenia cf patrisii Vahl, a forest cherry (Myrtaceae) (van Sauers-Muller, 2005) and in Inga sp., a Mimosaceae; all these samples came from locations in villages. None of these forest fruits were found infested when they were collected from locations further away from CFF populations.

This fruit collection also provided information on the local fruit fly species and their parasitoids (van Sauers-Muller, 2004). Although more than six local parasitoids were found, none of these

seemed of any importance as parasitoid for the Carambola fruit fly. One important fruit fly species, which is present in many parts of South America, the Mediterranean fruit fly (medfly), Ceratitis capitata Wied., has not been found in Suriname during all trapping and fruit collection activities.

In 1990 the first control actions were undertaken in Suriname to prevent the fly from spreading further westwards. Actions were undertaken in Wageningen (district Nickerie) and Coronie (Fig. 2 and 3) (van Sauers-Muller, 1993). In the village of Wageningen (approx. 3 km²), min-u-gel was applied as the MAT method; in Coronie (50 km²) first several major host trees were pruned

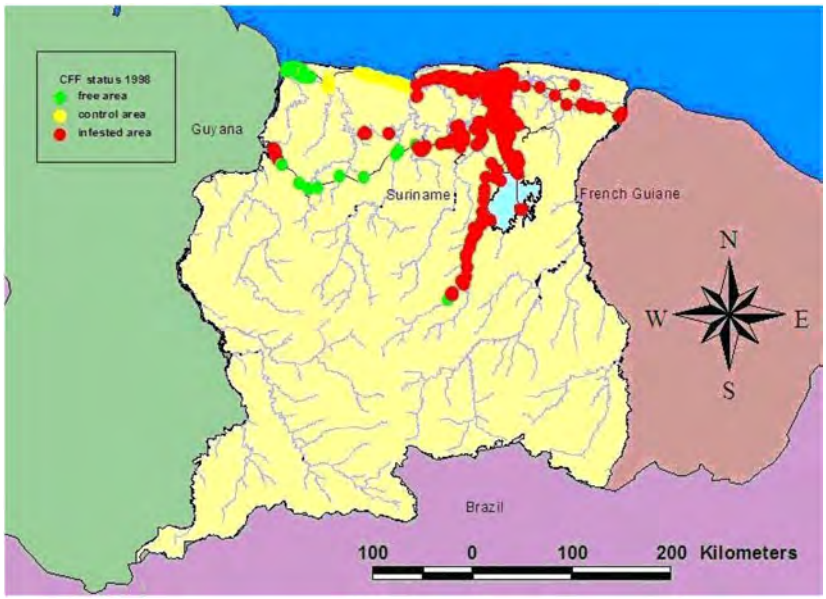


Fig. 2. Carambola fruit fly control action area, 1990-1997.

to decrease the population of the fly, followed by min-u-gel applications and later with the use of the impregnated pressed wood fiber blocks. The relatively isolated conditions of these infested areas (bordered in the north by the Atlantic Ocean, to the south by extensive swamps) made the successful application of MAT possible.

These control actions were extended to larger areas at the start of the regional program in 1997. The countries involved in this program were Guyana, Suriname, French Guiana and Brazil (especially with the state of Amapá, which borders French Guiana) (Fig. 3). In 1997, large scale control of CFF was initiated in a number of areas where CFF was found, working in Suriname from west to east and in French Guiana from east (St. Georges) to west. The main control method was the ground application of pressed wood fiber blocks impregnated with a 4:1 mixture of methyl-eugenol and malathion 96 % u.l.v. This resulted in a reduction of the infested areas in the following years (Fig. 4).

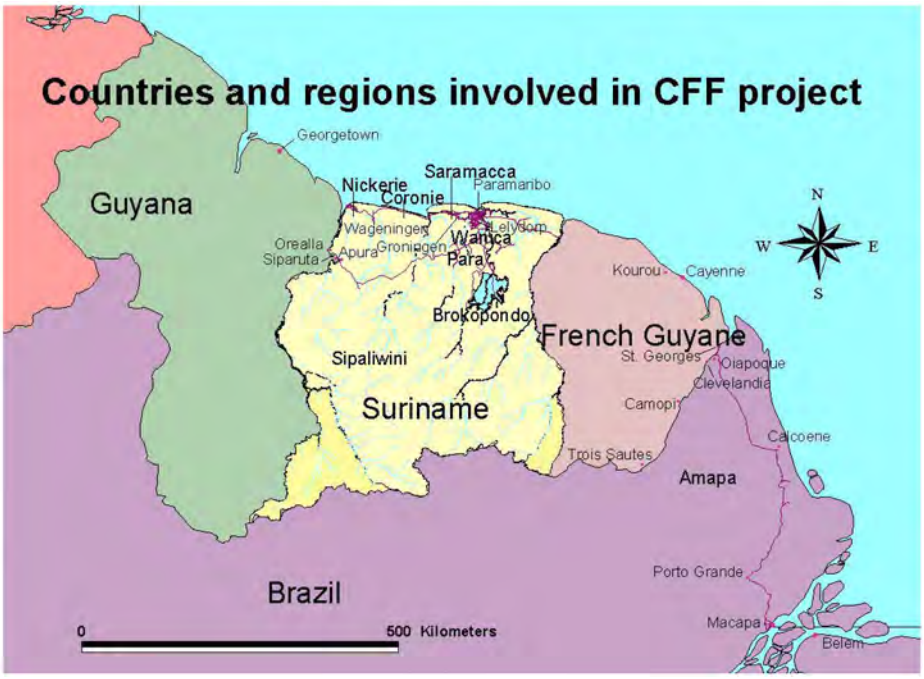


Fig. 3. Countries (Guyana, Suriname, French Guiana and Brazil) involved in the Regional Carambola Fruit Fly Control Program.

In Guyana, trapping for carambola fruit fly started in 1987; CFF was first found in 1993 in two villages (Orealla and Siparuta) on the border with Suriname. The infestation was eradicated by 1998 when the last fly was found in April, 1998. Two years later the whole country was declared free of CFF (Malavasi, A. and D. Midgarden, 2000), and eradication gradually progressed eastward, freeing most of Suriname from CFF (Fig. 4).

To the east, in French Guiana, the first carambola fruit fly was found in 1989 and in Brazil in 1996 in the Oiapoque area, adjacent to the heavily infested St. Georges village (Fig. 3) in French Guiana (Malavasi et al. 2000). CFF was eradicated from these areas bordering Brazil and in the eastern half of French Guiana (Fig. 4).

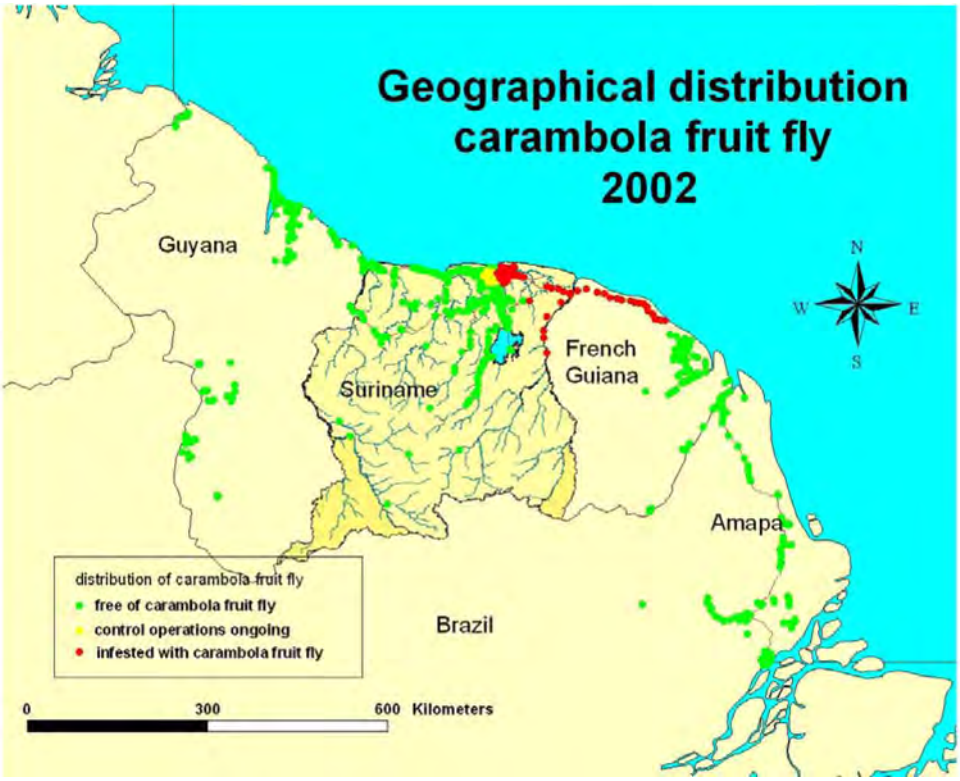


Fig. 4. Reduction in distribution of the CFF in the four countries before the regional program had to be closed.

Since the closing down of the regional program in 2003, due to lack of funding, CFF has gradually spread and re-infested areas that had previously been freed from infestation. By 2007, all areas that had been infested at the initiation of the control project had again become infested (van Sauers-Muller, A., 2006). In addition, the CFF has spread to new areas in Guyana (Fig. 5). In the Coronie district of Suriname this happened gradually, suggesting a natural spread of the fly. However the village of Apura on the border with Guyana is over 90 km from infested areas, so it is likely that re-infestation was caused by movement of infested fruits. The same is valid for the new areas in Guyana, as the distance between these and the infested areas either in Suriname or on the Corantijn River is over 180 km. Apart from the official border controls and ports of entry (Macapa and Belem) controls in all involved countries and the road controls in the State of Amapá, Brazil, no quarantine measures are in place to control the human spread of CFF. A public relation campaign is in place in the State of Amapá in order to decrease the transit of host material in the State.

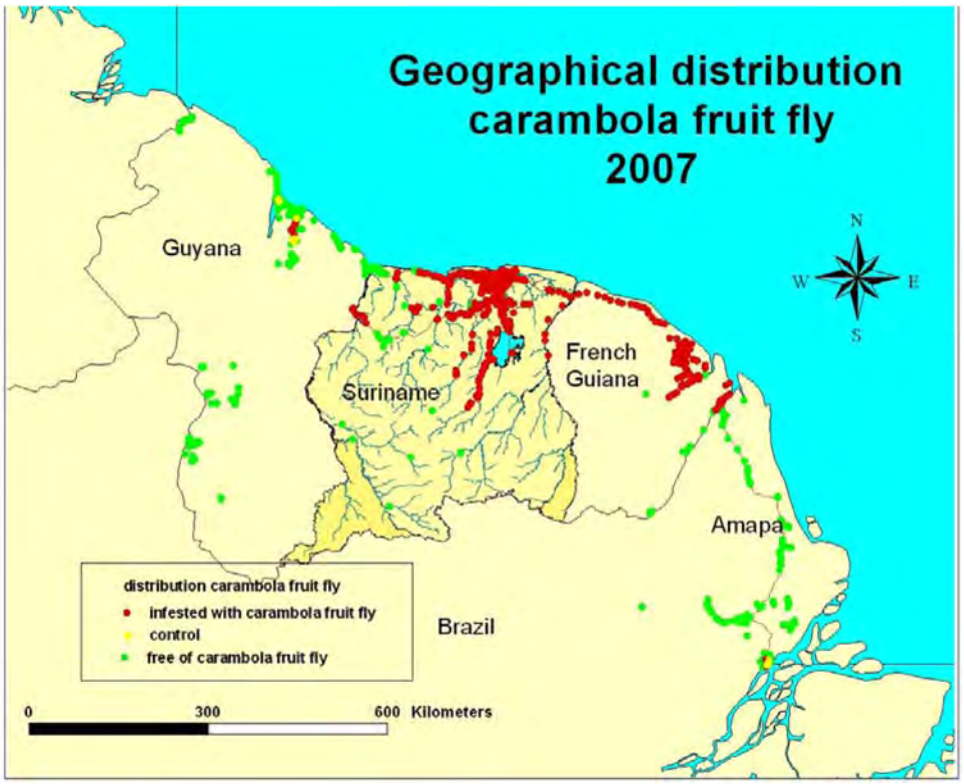


Fig. 5. Re-infestation of areas in the four countries.

In Brazil, an extensive detection system is in place and CFF is usually eradicated every time an outbreak occurs (Godoy, M.J.S. 2006). Surveillance and eradication efforts are continuing on a permanent basis, due to the importance of the pest for the fruit industry. Due to the cessation of all eradication activities in French Guiana, a continuous containment and control program will be necessary along the Oiapoque River, since CFF is not under control in the village of Saint Georges (French Guiana). For Suriname, control of fruit flies in the future will have to take into account the control of the CFF as one of the major tropical fruit fly species. Alternative methods will be evaluated including biological control and localized application of bait sprays for suppression of tropical fruit flies in orchards.

In some islands in the Caribbean, trapping surveys include trapping for Bactrocera species; but up to the present no CFF has been caught.

CONCLUSIONS

In conclusion, the closure of the successful Regional Carambola Fruit fly Program resulted not only in the discontinuation of eradication activities, but also in the loss of all progress made and the reinvasion of the freed areas. The permanent establishment and expanding distribution of the CFF in Guyana, Suriname, French Guiana and Brazil represents a continuous threat to the fruit production in the Caribbean and the Latin American region. Areas in the region most exposed to the potential spread of CFF are shown in Figure 6.

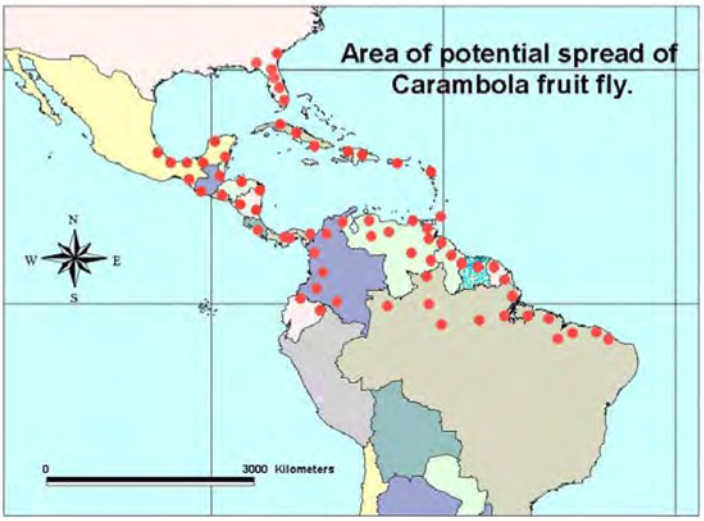


Fig. 6. Potential spread of the carambola fruit fly in northern South America and in the Greater Caribbean Region.

ACKNOWLEDGEMENTS

I am very grateful to several anonymous reviewers in helping improve the clarity and accuracy of this report.

REFERENCES

Clarke, A.R., K.F. Armstrong, A.E. Carmichael, J.R. Milne, S.Raghu, G.K. Roderick and D.K. Yeates. 2005. Invasive phytophagous pests arising through a recent tropical evolutionary radiation: The Bactrocera dorsalis complex of fruit flies. Annu. Rev. Entomol. 50: 293-319.

Drew, R.A.I. and D.L. Hancock. 1994. The Bactrocera dorsalis complex of fruit flies (Diptera: Tephritidae: Dacinae) in Asia. Bulletin of Entomological Research, Suppl. 2, p. 1-68.

Godoy, M.J.S. 2006. The Carambola fruit fly program in state of Amapá, Brazil. Abstracts 7th International Symposium on fruit flies of economic importance. Bahia, Brazil. Area wide action programs, ID 372-1.

Malavasi, A. and D. Midgarden. 2000. Annual report, Carambola fruit fly programme. 15 p.

Malavasi, A., A. van Sauers-Muller, D. Midgarden, V. Kellman, D. Didelot, Ph. Caplong and O. Ribeiro. 2000. Regional programme for the Eradication of the Carambola Fruit Fly in South America. In: Proceedings of 5th Int. Symp. of Fruit Flies of Economic Importance, Penang, Malaysia, June 1-5, 1998, p. 395-399.

Van Sauers-Muller, A. 1991. An overview of the Carambola fruit fly Bactrocera species (Diptera: Tephritidae) found recently in Suriname. Florida Entomologist, 74 (3): 432-440.

Van Sauers-Muller, A. 1993. Pilot eradication project for the Carambola fruit fly in Coronie, Suriname. In: M. Aluja and P. Liedo, Fruit Flies: Biology and Management, pp 439-442.

Van Sauers-Muller, A. 2004. Records of native parasitoids of fruit flies in Suriname, South America. 5th Meeting of the Working Group on Fruit flies of the Western Hemisphere. Ft. Lauderdale, Florida. p.68.

Van Sauers-Muller, A. 2005. Host plants of the Carambola Fruit Fly, Bactrocera carambolae Drew & Hancock (Diptera: Tephritidae), in Suriname, South America. Neotropical Entomology 34 (2), 203-214.

Van Sauers-Muller, A. 2006. Carambola fruit fly programme Suriname. Abstracts 7th International Symposium on fruit flies of economic importance. Bahia, Brazil. Area wide action programs, ID 310-1.

Van Sauers-Muller, A. and M. Fleurkens. 2009. Control methods applied for suppression and eradication of the Carambola fruit fly in Suriname, South America. In preparation.

Proceedings of the Caribbean Food Crops Society. 44(1): 145-150. 2008

ADDRESSING ANIMAL HEALTH ISSUES IN CARICOM MEMBER STATES

Lloyd .A. W. Webb, Sub-regional Advisor on Veterinary Public Health, Caribbean Food and Nutrition Institute, Pan American Health Organization, Kingston, Jamaica. Email: Email: webblloy@cpc.paho.org; webblloy@cfni.paho.org

ABSTRACT. More than 75% of human diseases are contracted from animals. Contaminated or infected meats and other foods can affect trade. Foods may contain hazards at the point of production, or acquire hazards along the food chain from farm to table. These hazards may be chemical (drug, pesticide or other chemical residues) or biological (foood borne diseases). Caribbean countries with their striving tourist industry are very vulnerable to transboundary and endemic animal diseases that require the full intervention of veterinary resources. Inter-ministerial and inter-sectoral collaboration and coordination are paramount in addressing the concerns. Thus public and private partmerships are needed, which involve national authorities, industry, academia and research institutions. Import and export products must comply with the guidelines and regulations of WTO/SPS, OIE, Codex Alimentarius and IPPC. Thus foods of animal origin require disease diagnostics, risk assessment and overall food safety and quality controls. Skilled and experienced personnel are needed with expertise in clinical veterinary services, animal production and herd health medicine. Of special concern are methicillin-resistant Staphylococcus aureus (MRSA), a bacterium responsible for difficult-to-treat infections. Pathogens may survive food harvesting, storage, manufacturing and preparation. This veterinary diagnostics are essential. A legal framework with standards and regulatory procedures may be beneficial with endorsement by regional forums, such as the already established CVO/CEDHO/DVPH Forum. Caribbean countries should collaborate more to promote and support the development of entities and instruments within the countries and within the Region to assist in the coordination of the different multi-sectoral actors, particularly the health and agricultural sectors.

KEY WORDS: Zoonoses, transboundary, endemic, animal diseases, diagnostics, MRSA, regional forums, CVO/CEDHO/DVPH Forum, inter-ministerial, inter-sectoral collaboration

INTRODUCTION

It is accepted globally, that animals serve as a major source of human illnesses. Much has changed in the manner in which man co-habited with his animals and became ill because of direct encounter between man and his pet or livestock in the early days. But even today, companion animals continue to be a threat to man for diseases transmission. It is well known that many animals receive state-of-the–art treatment by veterinary practitioners and at grooming clinics. Even the way in which meats and other foods are processed in food establishments, some using the most modern methodology and technology, has changed considerably. At the same time, it is known that animals continue to serve as the origin of several communicable diseases contracted by humans (Figure 1). Emerging and re-emerging diseases have crossed, or have threatened to cross country borders, and the experiences have often revealed that the state of preparedness of the countries that face potential risks is still unsatisfactory. For example, the

epizootic of Avian Influenza since 2003, demonstrated the weaknesses in the existing infrastructure within countries, and the apparent lack of mechanisms and systems to address disease prevention and control. Within the Caribbean Community, there were numerous concerns regarding disease detection and response, disease containment and eradication, laboratory diagnostics and laboratory infrastructure, surveillance systems, among others. It was obvious that these all required resources, and that governments and private sector groups would need to revisit and examine the current veterinary infrastructure in CARICOM countries in order to deal effectively with the veterinary problems that may emerge.

Veterinary professionals alone cannot address the numerous intersectoral issues and therefore, inter-ministerial and inter-sectoral collaboration and coordination are paramount. Public and private sector personnel must partner together, and academia and research institutions must become equal partners in any strategy adopted. Additionally, serious consideration should be given to agricultural technologies and management practices of agriculture from farm to fork, gate to plate, and boat to throat. This means that from the farm production level through the intermediary stages of harvesting, manufacturing and processing, marketing and distribution, up to the consumption level, there must be data and research aimed at identifying the presence of hazards linked to animals and the potential spread to humans. It is known that in some countries, memoranda of understanding and agreements have been entered into to meet the multi-sectoral needs. This consideration is important in the Caribbean.

Veterinary Public Health issues require the support of veterinarians to respond to this changing world, in which public health issues ranging from animal diseases to environmental impact assessment, and overall food safety and quality must be viewed in the context of risk analysis and science-based research. Experiences and knowledge of clinical veterinary field services, animal production and health, and herd health medicine, are needed to contribute to finding solutions for global challenges related to requirements for compliance to the World Trade Organizations/Sanitary. In the early 1970s, there was an attempt by Caribbean governments to establish Veterinary Public Health (VPH) Units. Only four countries (Barbados, Guyana, Jamaica and Trinidad and Tobago) institutionalized the VPH program. Those Units were specifically focused on using professional veterinary knowledge and experiences to address disease prevention, control and eradication and a comprehensive program for health care through a Primary Health Care framework. Today, only Guyana, Jamaica and Trinidad and Tobago retain such units. However, the twenty-first century challenges are signaling to us, that there are emerging and re-emerging diseases (whether bacteria, viruses or parasites) that would require the joint action of colleagues in Ministries of Agriculture, Ministries of Health, and in other ministries (Tourism, Trade, Consumer Affairs, among others).

It is frequently said that the small island states of the Caribbean comprise a community in which the several countries share a single domestic space. But each country is sovereign and therefore must decide on its own course of action, even if such action means entering into partnership with others to use a collective approach in which veterinary colleagues from neighbouring countries join forces to attack common problems. To many, this latter approach seems favourable, particularly since it is perceived that once a trans-boundary disease enters any one of these countries, it may have been perceived as having entered the entire region. Through networking among the various stakeholders in country, a strategic approach is possible to address the

numerous challenges. This joint action can assist in disease detection, response, containment and eradication depending in the degree of commitment.

The potential economic and social impact of animal diseases on Caribbean states is significant enough to merit finding solutions speedily to the problems. It is essential to develop prevention strategies at the pre-harvest and post-harvest levels and to monitor product flow from the farm to the table or from the farm to the port in the case of exports. Improved surveillance is required at the country level and then at the regional level. These actions will facilitate early detection and early warning. Response actions could be done by utilizing expertise from amongst the countries in the event of a crisis. Additionally, a closer look at the Animal Health Infrastructure in these small island states in which the required national expertise is not available, may well provide some thoughts for the establishment of a mechanism to address animal health issues in CARICOM countries.

CHALLENGES:

Food safety and food security factors are inherently linked to foods due to the nature of the foods themselves. But they are also linked to the biological agents associated with food animals and their by-products. For example, we must carefully consider the variety of exotic foods in our hemisphere. These include the BBQ chicken, sold on the streets of several of our countries, the numerous patties and pies (Jamaican pattie, beef pies, chicken pies, cheese puffs); other forms of meats (jerk pork, fried chicken, stewed beef) and other Caribbean dishes (Figure 2). While we must consider the foods, we are also challenged by the food handling practices of the vendors and cooks that prepare and sell the foods sold for human consumption. It is well known that diseases such as E.coli and Staphylococcus aureus (Staph) can be passed on to consumers via food handlers who do not practice good food hygiene.

FINDING SOLUTIONS

There are constraints in finding ways to deal with the challenging issues, among which constraints are the limitations associated with scarce finances and inadequate human resources. Alternatives have been explored. For example, alliances have been fostered amongst national bodies for enhanced integrated Food Safety Programs, and more recently, the concept of the establishment of National Agricultural Health and Food Safety Agencies, has been pursued.

There is scope for veterinarians and other agricultural and health personnel to make significant contributions to the knowledge base of animal data; particularly as they impact the safety of the foods we consume, and the trade that is of importance to countries. The reality is that many human diseases come from animal sources. This may be due to direct or indirect animal contact resulting in the spread of zoonoses (Brucellosis, rabies, leptospirosis, and tuberculosis), or through products that may be consumed after contamination by disease agents from animal sources (Salmonella, E. coli 0157:H7, and Campylobacter).

In short, we continue to live in a world in which people need animals for food, social and economic development, and companionship. And it is a fact that animals often serve as vectors for the transmission of fatal diseases, such as, rabies, leptospirosis, and BSE. Where diseases are

not fatal, they may sometimes cause chronic problems. For example, tuberculosis and brucellosis are diseases that are chronic. We are fortunate in that some diseases (such as Foot and Mouth Disease) are not known to exist in our Caribbean states. We need to act to ensure that we remain free of them.

A well designed Agricultural Health and Food Safety program is believed to be indispensable to ensuring that all our peoples are protected from diseases and unwholesomeness associated with foods. And this applies whether foods are sold at hotels, in restaurants, in supermarkets, or on the street; or whether they are produced, manufactured and packaged for export.

In another context, our CARICOM partners struggle to monitor and control indiscriminate use of antimicrobials that may contribute to allergic reactions. We struggle also with common diseases shared by man and animals. Among these diseases are West Nile Fever caused by the West Nile Virus, tuberculosis, and more recently there is the threat of Hantavirus Syndrome and the Norwalk Virus among cruise ships to our CARICOM states. Global travel means, therefore, that although the Caribbean sub-region does not experience the impact of diseases such as Foot-and-Mouth Disease (FMD) and human rabies caused by dogs, the threat of these diseases still lie at our doorsteps. Therefore, our contribution is needed for the advancement of human health in all aspects, whether in zoonoses, food protection, education in veterinary public health, biomedical models for the development of human drugs and vaccines, and the prevention, control and eradication of diseases exotic to our shores (e.g. foot-and-mouth disease).

An enhanced surveillance system, for example on food-borne diseases, would help us obtain current data on microbial contamination of food, and to determine whether such contamination may be due to poor handling of the food itself or to other factors. Such data can inform the need for training and retraining of our food handlers from farm to table, including giving training in good agricultural and good manufacturing practices.

In this regard, I believe that the Pan American Commission for Food Safety (COPAIA) that has been formed at the Pan American Institute for Food Protection and Zoonoses (INPPAZ) can support countries in the establishment of food safety policies and strategic approaches aimed at reducing or preventing diarrhoeal and other diseases associated with the foods we eat, whether at home, at work, at school or at play. We believe that there can be great benefits as COPAIA works with the Office of Caribbean Program Coordination, and with the Caribbean Epidemiologic Centre (CAREC), and the Caribbean Food and Nutrition Institute (CFNI). Together much can be accomplished. In a similar way, we believe that through the Inter-American Network of Food Analyst Laboratories (INFAL) and the support of CAREC, there can be an enhanced laboratory networking amongst our countries.

Figure 1. New, Emerging & Re-emerging Diseases, 2004.
Source: Dr. Judy Gerberding, Director of Centers for Disease Control and Prevention, USA.

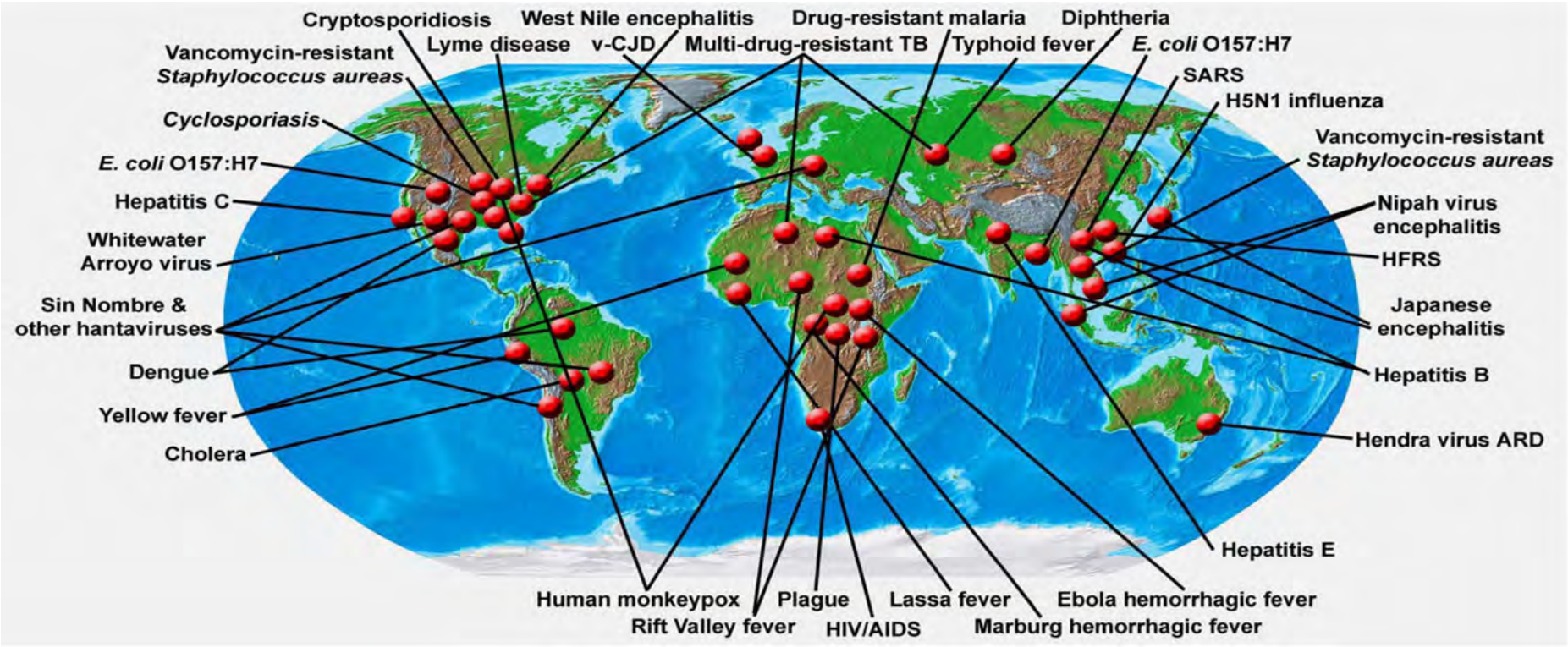


Figure 2. Street food preparation and vending in the Caribbean Region.

Product preparation is an extremely important step in street food vending

Proceedings of the Caribbean Food Crops Society. 44(1): 151-161. 2008

AVIAN INFLUENZA: PANDEMIC PREPAREDNESS FOR SMALL AGRIBUSINESSES

Joanne M. Brown DVM,MS, DACVPM, Deputy Commissioner, Florida Department of Agriculture and Consumer Services, Tallahassee, Florida, PL 10, 400 S. Monroe St, Tallahassee, FL 32399 USA Email brownjo@doacs.state.fl.us

ABSTRACT. Some influenza viruses, such as the highly pathogenic H5N1 avian influenza that appeared in south-east Asia in mid-2003, can be devastating to domestic poultry and some of these may cause severe illness in humans and even death. The Florida Department of Agriculture and Consumer Services (FDACS), Division of Animal Industry, regularly monitors our domestic fowl for evidence of influenza. Poultry from other countries with serious strains of avian influenza virus are not permitted to enter the United States. Commercial poultry must originate from avian influenza free flocks. Veterinarians, veterinary laboratories, and those working with birds are required to report diseases suspected as being influenza. Diseased poultry are tested and fully investigated and any reports of influenza-like disease are handled on an urgent basis until the disease can be fully identified and assessed.

In the event of finding a serious strain, emergency measures will be taken immediately to contain the virus among exposed poultry. Quarantine and other emergency plans are in place to eradicate such a disease as quickly as possible, should it be found. Samples are regularly collected from live bird markets, fairs and exhibits, botanicas, backyard flocks and commercial poultry breeding flocks in the state, and they participate in a voluntary surveillance and testing program.

Florida has had Emergency Plans in place since 2005 for rapid containment and eradication of disease in Florida and also to protect flocks not in the affected areas. FDACS works closely with the Florida Department of Health (DOH) and the Fish and Wildlife Commission (FWC)-Wildlife Services. FWC-Wildlife Services also conduct surveillance testing of wild and domestic birds in Florida. Additional preparedness steps are the establishment of a Poultry Emergency Disease Committee, GIS mapping of all poultry premises, establishment of a work group with USDA, DOH and FWC and outreach education programs using presentations and brochures.

A future influenza pandemic in humans is considered a certainty by the scientific community, but when it will happen is entirely uncertain. In January 2007, the FDACS, the Florida Division of Emergency Management met with food and water distributors and leaders of the Florida agriculture industry to address the supply and distribution of food in the event of an influenza pandemic. Since most small agribusinesses lack the financial or personnel resources to develop Pandemic Influenza preparedness plans, FDACS and DOH prepared a small business pandemic influenza preparedness "Tool Kit". Every level of agricultural production - from the materials supplied to farms to the commodities sold at retail - should be taken into account in a comprehensive plan to maintain delivery of food to consumers during an influenza pandemic.

A copy of the preparedness brochure may be down loaded at the following web site: http://www.doacs.state.fl.us/pdf/Pandemic_Influenza_Agriculture_Planning_Toolkit.pdf .

INTRODUCTION

Avian influenza is a serious disease concern for poultry producers and animal health officials. While influenza strains in birds, just as in people, vary considerably in severity, some influenza

viruses can be devastating to domestic poultry. Recent information on Asian strains that may infect people as well as birds has only heightened those concerns. The Florida Department of Agriculture and Consumer Services (FDACS), Division of Animal Industry, regularly monitors our domestic fowl for evidence of influenza (Fig. 1, 2a, 2b and 2c).

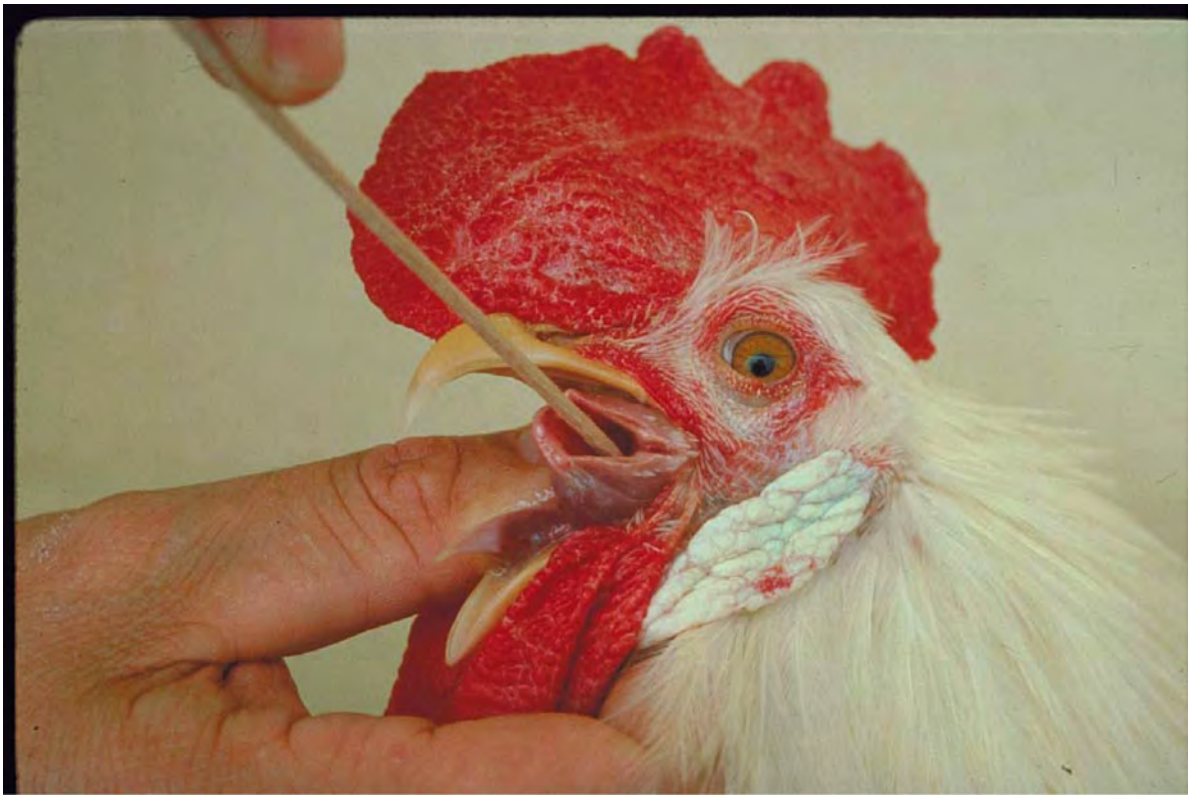


Figure 1. Collecting sample to test for avian influenza

Poultry from other countries with serious strains of avian influenza virus are not permitted to enter the United States. Additionally, poultry entering Florida from other states cannot be imported from quarantined areas and all other poultry must have a permit for entry. Commercial poultry must originate from avian influenza free flocks in addition to meeting other import requirements.

Infected birds shed influenza virus in their saliva, nasal secretions, and feces. Susceptible birds become infected when they have contact with contaminated secretions or excretions or with surfaces that are contaminated with secretions or excretions from infected birds. Domesticated birds may become infected with avian influenza virus through direct contact with infected waterfowl or other infected poultry, or through contact with surfaces (such as dirt or cages) or materials (such as water or feed) that have been contaminated with the virus.

Veterinarians, veterinary laboratories, and those working with birds are required to report diseases suspected as being influenza. Diseased poultry are tested and fully investigated and any reports of influenza-like disease are handled on an urgent basis until the disease can be fully

identified and assessed. In the event of finding a serious strain, emergency measures will be taken immediately to contain the virus among exposed poultry. Quarantine and other emergency plans are in place to eradicate such a disease as quickly as possible, should it be found.

The department's Division of Animal Industry has authorized agents trained to collect samples. Testing to determine the presence of the disease is being conducted at both the department's animal health diagnostic laboratories. Samples are regularly collected from live bird markets, fairs and exhibits, botanicas, backyard flocks and commercial poultry breeding flocks in the state, and they participate in a voluntary surveillance and testing program.

SURVEILLANCE

Figure 2a. Surveillance for avian influenza in a botanica, live bird market, animal sale market and backyard flocks.. Note: A botanica is a shop that sells herbs, charms, and other religious or spiritual items, especially those associated with Santeria

SURVEILLANCE (continued)

Figure 2b. Surveillance for avian influenza in a fair or exhibition, in making a call to examine sick birds at a poultry farm, in a commercial meat-type operation and in a commercial egg-type operation.

Florida has had Emergency Plans in place since 2005. These quarantine plans are in place for rapid containment and eradication of disease in Florida and also to protect flocks not in the affected areas. The Florida Department of Agriculture and Consumer Services (FDACS) works closely with the Florida Department of Health (DOH) and the Fish and Wildlife Commission (FWC)-Wildlife Services. FWC-Wildlife Services also conduct surveillance testing of wild and domestic birds in Florida.

Additional preparedness steps being taken are the establishment of a Poultry Emergency Disease Committee, GIS mapping of all poultry premises and establishment of a work group with USDA,

DOH and FWC. There are also outreach education programs using presentations and brochures (Fig. 3).

PANDEMIC PREPAREDNESS FOR SMALL AGRIBUSINESSES

A relatively small number of human of avian influenza cases have been associated with the ongoing H5N1 outbreaks in poultry and wild birds in Asia and parts of Europe, the Near East and Africa (Fig. 4). More than half of those people reported infected with the virus have died. Most of these cases have occurred in previously healthy children and young adults who had close contact with H5N1-infected poultry or H5N1-contaminated objects and surfaces. H5N1 avian influenza is still a very rare disease in people. This virus does not readily infect humans, and it does not spread very readily from an infected person to a non-infected person. Even so, since all influenza viruses have the ability to change, scientists are concerned that H5N1 virus may mutate to be able to infect humans and to spread readily from person to person. Since these viruses rarely infect people, human populations have little or no immune protection against them. However if the H5N1 virus were to mutate so as to have the ability to spread readily from person to person, a worldwide outbreak of influenza (pandemic) could begin.

A future influenza pandemic in humans is considered a certainty by the scientific community, but when it will happen is entirely uncertain. In January 2007, the FDACS along with the Florida Division of Emergency Management met to address the issue of the supply and distribution of food in the event of a widespread outbreak of influenza. Included in the meeting were our food and water distribution partners and leaders from the Florida agriculture industry.

As a result of the meeting, it was determined that most small agribusinesses lack the financial or personnel resources to develop Pandemic Influenza Preparedness Plans of their own despite the critical role such businesses play in the production and delivery of our food supply (Fig. 5).

As a result, we have prepared a small business pandemic influenza preparedness "Tool Kit," to help businesses develop plans of their own (Fig. 6). Every level of agricultural production - from the materials supplied to farms to the commodities sold at retail - should be considered and taken into account if we are to develop a comprehensive plan to maintain delivery of food to the tables of consumers during an influenza pandemic event.

This document is meant to be a template for small businesses to incorporate their own business practices so they can participate and assist in a comprehensive preparedness plan.

A copy of the preparedness brochure may be down loaded at the following web site:
http://www.doacs.state.fl.us/pdf/Pandemic_Influenza_Agriculture_Planning_Toolkit.pdf

With respect to an eventual avian human influenza pandemic, an abbreviated summary of planning assumptions of the Florida Department of Health are shown in Figure 7. Figure 8 shows a planning checklist for avian influenza pandemic developed by U.S. Dept. of Health & Human Services and the Centers for Disease Control and Prevention for use by large businesses. For use by individuals and families, the U.S. Dept. of Health & Human Services and the Centers for Disease Control and Prevention have developed the planning checklist shown in Figure 9.

Figure 3. Poster to arouse interest and encourage learning about highly contagious poultry diseases

OUTREACH EDUCATION

- Distribute information about FDACS NPIP program and USDA Biosecurity campaign

BIOSECURITY

- Poultry Owners Must Practice Good Biosecurity

Figure 4. Transmission of avian influenza from bird to bird to mammals (primarily swine) and primarily from swine to humans.

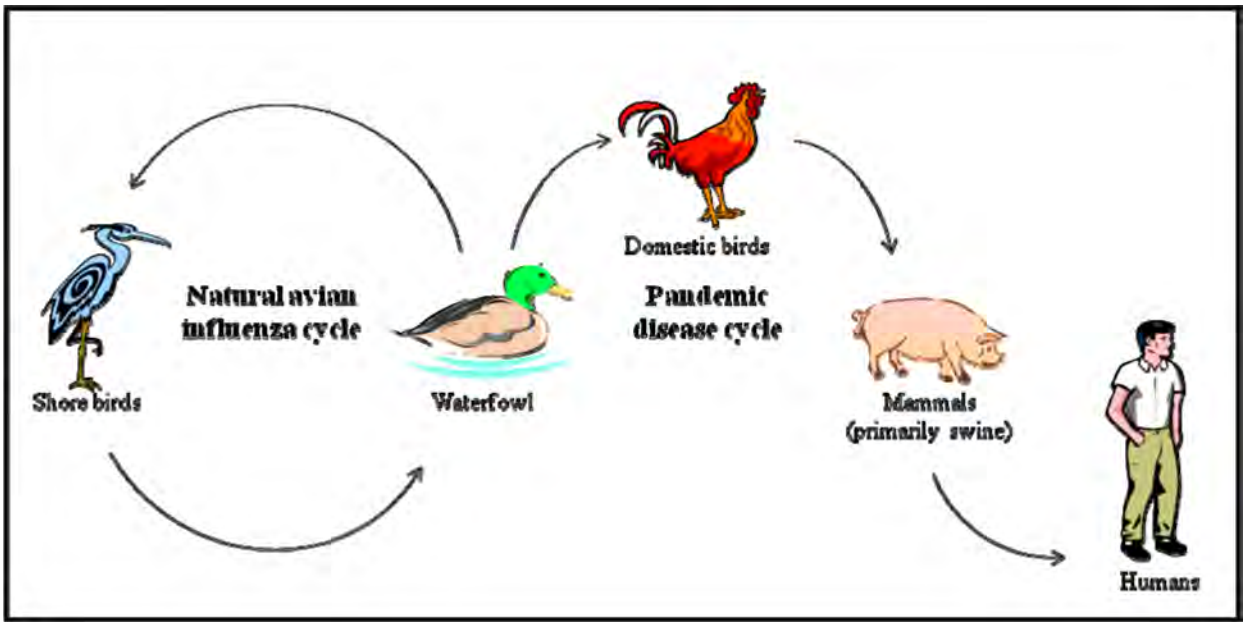


Figure 5. Business preparedness plans for avian influenza pandemic

- All industries were aware of a possible influenza pandemic, **yet**
- Most agricultural industries did not have preparedness plans for their businesses.
- No organized effort was ongoing to develop preparedness plans for individual firms.
- Pandemic preparedness was not underway for most of the agricultural enetrprises or small agribusinesses

Figure 6. Pandemic influenza: Agricultural Planning Toolkit brochure.
This brochure may be down loaded at the following website:
http://www.doacs.state.fl.us/pdf/Pandemic_Influenza_Agriculture_Planning_Toolkit.pdf

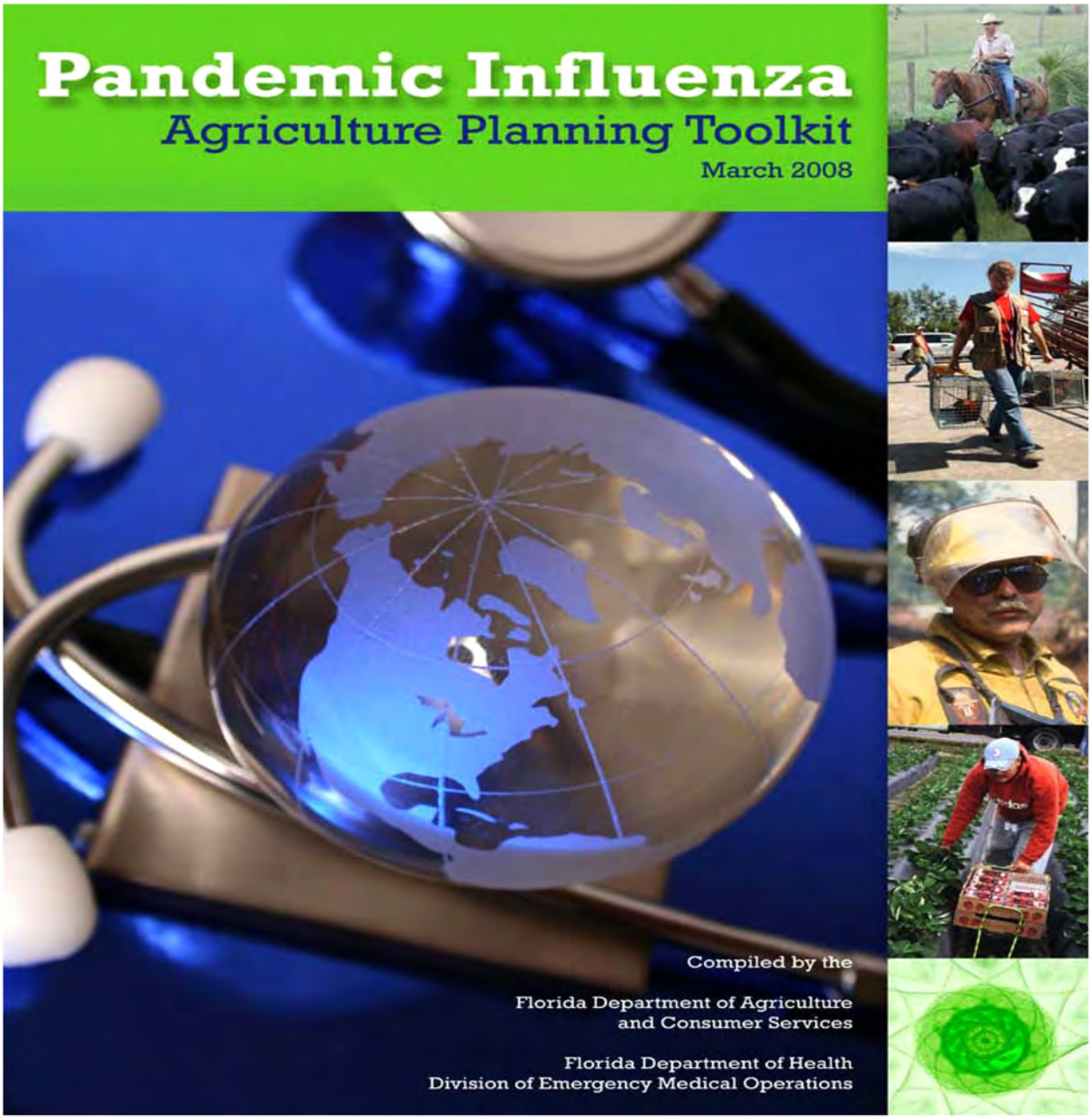


Figure 7. Florida Department of Health planning assumptions for eventual avian influenza pandemic

PLANNING ASSUMPTIONS

Abbreviated Summary of Florida Department of Health Current Pandemic Influenza Planning Assumptions

The pandemic characteristics presented in this document are planning assumptions that are subject to change over time.

A future influenza pandemic in humans is considered a certainty by the scientific community. When it will happen is entirely uncertain.

Pandemic Influenza

Susceptibility to the pandemic influenza virus will be universal.

Efficient and sustained person-to-person transmission signals an imminent pandemic.

Illness rates will be highest among school aged children (about 40%) and decline with age.

Among working adults, an average of 20% will become ill during a community outbreak.

Seventy-five percent of those who become ill with influenza (an estimated 35% of the general population) will seek outpatient medical care (an estimated 25% of the general population).

The number of hospitalizations and deaths will depend on the virulence of the pandemic virus. Estimates differ about ten-fold between more and less severe scenarios. Per HHS planning guidance, Florida is planning for a severe influenza pandemic similar to 1918, as compared to a moderate pandemic similar to 1957, 1968. Either one could happen.

Risk groups for severe and fatal infection cannot be predicted with certainty but are likely to include infants, elderly, pregnant woman, and persons with chronic medical conditions.

Persons who become ill may shed the virus and can transmit infection for up to one day before the onset of illness. Viral shedding and the risk of transmission will be greatest during the first 2 days of illness.

Multiple waves (periods during which community outbreaks occur across the country) of illness could occur with each wave lasting two to three months. Historically the largest waves have occurred in the fall and winter, but the seasonality of a pandemic cannot be predicted with certainty.

A future influenza pandemic in humans is considered a certainty by the scientific community. When it will happen is entirely uncertain.

3

Figure 8. Planning checklist for avian influenza pandemic developed by U.S. Dept. of Health & Human Services and the Centers for Disease Control and Prevention for use by large businesses

BUSINESS PANDEMIC INFLUENZA PLANNING CHECKLIST

In the event of pandemic influenza, businesses will play a key role in protecting employees health and safety as well as limiting the negative impact to the economy and society. Planning for pandemic influenza is critical. To asist you in your efforts, the Department of Health and Human Services (HHS) and the Centers for Disease Control and Prevention (CDC) have developed the following checklist for large businesses. It identities important, specific activities large businesses can do now to prepare, many of which will also help you in other emergencies. Further information can be found at www.pandemicflu.gov and www.cdc.gov/business.

1.1 Plan for the impact of a pandemic on your business:

Completed	In Progress	Not Started	
☐	☐	☐	Identify a pandemic coordinator and/or team with defined roles and responsibilities for preparedness and response planning. The planning process should include input from labor representatives. • Owner, manager, team input from all other relevant stake holders in your business plus local emergency management contacts
☐	☐	☐	Identify essential employees and other critical inputs (e.g., raw materials, suppliers, sub-contractor services/ products, and logistics) required to maintain business operations by location and function during a pandemic. • Personnel, supplies (feed, packaging materials, fuel, agrichemical inputs, storage, local networking) and transportation • Talk to your suppliers about their panflu plan (domestic and international). Identify alternate suppliers.
☐	☐	☐	Train and prepare ancillary workforce (e.g., contractors, employees in other job titles/descriptions, retirees). • Cross-train your employees. Figure out what jobs need to be trained ahead of time and jobs that can be trained at the time, time critical jobs, i.e. specialty crop harvesting, coordination with other agribusinesse at harvest time.

Items in red have been added by the Florida Department of Agriculture and Consumer Services and specifically tailored for agriculture businesses

8

PANDEMIC FLU PLANNING CHECKLIST FOR INDIVIDUALS AND FAMILIES

You can prepare for an influenza pandemic now. You should know both the magnitude of what can happen during a pandemic outbreak and what actions you can take to help lessen the impact of an influenza pandemic on you and your family. This checklist will help you gather the information and resources you may need in case of a flu pandemic.

1. To plan for a pandemic:

- ☐ Store a supply of water and food. During a pandemic, if you cannot get to a store, or if stores are out of supplies, it will be important for you to have extra supplies on hand. This can be useful in other types of emergencies, such as power outages and disasters (2-3 weeks is recommended).
- ☐ Periodically check your regular prescription drugs to ensure a continuous supply in your home.
- ☐ Have any nonprescription drugs and other health supplies on hand, including pain relievers, stomach remedies, cough and cold medicines, fluids with electrolytes, and vitamins (30-day supply is recommended).
- ☐ Talk with family members and loved ones about how they would be cared for if they got sick, or what will be needed to care for them in your home.
- ☐ Volunteer with local groups to prepare and assist with emergency response.
- ☐ Get involved in your community as it works to prepare for an influenza pandemic.

2. To limit the spread of germs and prevent infection:

- ☐ Teach your children to wash hands frequently with soap and water, and model the correct behavior.
- ☐ Teach your children to cover coughs and sneezes with tissues, and be sure to model that behavior.
- ☐ Teach your children to stay away from others as much as possible if they are sick. Stay home from work and school if sick.

3. Items to have on hand for an extended stay at home:

Examples of food and non-perishables

- ☐ Ready-to-eat canned meats, fruits, vegetables, beans, and soups
- ☐ Protein or fruit bars
- ☐ Dry cereal or granola
- ☐ Peanut butter or nuts
- ☐ Dried fruit
- ☐ Crackers
- ☐ Canned juices
- ☐ Bottled water – 1 gallon/person/day
- ☐ Canned or jarred baby food and formula
- ☐ Pet food
- ☐ Other nonperishable foods

Be sure to check expiration dates and rotate stock. Replace any items past their expiration date

Items in red have been added by the Florida Department of Agriculture and Consumer Services

Proceedings of the Caribbean Food Crops Society. 44(1): 162-169. 2008

MICROBIAL THREATS TO THE SAFETY OF FOOD PRODUCTS IN TRADE BETWEEN THE LATIN AMERICA-CARIBBEAN REGION, THE USA AND OTHER COUNTRIES

Lloyd .A. W. Webb, Sub-regional Advisor on Veterinary Public Health, Caribbean Food and Nutrition Institute, Pan American Health Organization, Kingston, Jamaica. Email: Email: webblloy@cpc.paho.org; webblloy@cfni.paho.org

ABSTRACT. A large amount of data on the microbial threats to the safety of food products in trade originating from the English-speaking Caribbean countries come from public health sources. Many of the countries depend on diagnostics information from Public Health Laboratories or Analytical Laboratories, and the Chemistry Food and Drug Laboratories (in at least two CARICOM states). While the Ministry of Agriculture is the principal Ministry that directs the affairs of the export of food and agricultural products, the technical input regarding inspection and certification of such products for export often lies with inspectors from the Ministry of Health. Should this really matter? How efficient is the inspection process? How effective is the national laboratory in the support of regional and international trade. There is paucity in the information regarding food products to be exported from several CARICOM countries, but there is an equal scarcity of information on imported products from third countries and international trading partners. Some projections are made on addressing the lack of data in CARICOM countries.

Caribbean countries are challenged to deal with microbial threats. But a genuine effort to address the deficiencies could prove valuable to the member countries, working collectively as a single domestic space with many common linkages. Through networks and partnerships, much could be achieved. Networks and partnerships could result in enhanced surveillance and diseases detection, and lead to great achievements in food safety and trade.

KEYWORDS: Imports, Exports, Inspection, farm-to-fork concept, HACCP

INTRODUCTION

Microbial threats to food safety are linked to numerous microorganisms whether bacteria (Prokaryotes), parasites and fungi (Eukaryotes) or viruses (Fig. 1). Amidst the multitude of microbes there are only a few that are harmful as food-borne pathogens (Fig. 2). Most of these pathogens exert their effect through food consumption, particularly when such foods are not properly cooked or handled before eating. Interestingly, all raw foods contain microorganisms through the ubiquitous nature of such organisms. Therefore, it is essential to evaluate the environment in which such foods are grown, harvested, transported, cleaned or washed, processed, stored, further processed, cooked, sold and consumed. This is the farm-to-fork concept often referred to in food safety circles.

The subject of this presentation is more related to food safety and trade issues. This means that there should be control measures in place at all stages of the food chain to ensure that the food is kept safe. In most cases however, scarce human and financial resources constrain the relevant

authorities, whether public or private, to have the appropriate controls at each stage. One measure of compromise is to apply the concept of the hazard analysis critical control point

Figure 1. Microbial threats to food safety are linked to numerous microorganisms:

- Bacteria (prokaryotes)
- Parasites and fungi (eukaryotes)
- Viruses

Figure 2. Only a few microorganisms are harmful as food-borne pathogens

- Linked to improperly cooked food
- Improperly handled foods before eating
- Raw foods

- Essential to evaluate the environment where foods are grown, harvested, transported, cleaned or washed, processed, stored, cooked, sold and consumed
- Control measures should be in place at all stages of the food chain to ensure that the food is kept safe

(HACCP) methodology and identify the critical points in the food chain where control measures should be mandatory. But even this approach, in countries such as developing states, becomes challenging. For example, when a small island state has a single inspector who is involved in a multiplicity of tasks, it is virtually impossible to have the time to focus on the critical control point, especially when the single individual has to perform the same functions at many different establishments, and all establishments, more or less, operate during the same hours of work.

Furthermore, it is necessary to keep in mind that in dealing with food safety issues, even for trade products, there are numerous stakeholders (farmers, processors, manufacturers, food handlers, consumers) that must be actively involved along the food chain. If all these players are well informed about food borne diseases and seek to apply the control measures, or even become involved in a structured surveillance programme, it will be beneficial to the control of microorganisms in foods. But there still remains an important question: How can these persons identify the many microorganisms that are microscopic? They really cannot, but if they are informed of, and understand the epidemiological factors that embrace disease occurrence, it may prove helpful.

SOURCES OF FOOD-BORNE PATHOGENS

It is well known that meats, milk, vegetables, rice, potatoes, and fish are common sources of food-borne Bacillus cereus. Brucella spp are found in raw or improperly processed foods of milk origin (including cheese) (Figs. 3, 4, 5 and 6). Salmonella spp are found in raw meats, milk, poultry and poultry products, eggs, fish, shrimp, and even in coconut, sauces and salad dressings. Shigella spp are found in salads generally and sandwich fillings, milk, dairy products and poultry products. In still other cases, microorganisms such as Staphylococcus spp and Escherichia coli

0157:H7 are prevalent in meat and meat products, poultry products and salads, while Campylobacter jejuni is found in raw chicken, beef, raw milk and shellfish, to name a few (Fig. 7). This could mean that when these products are traded, the microorganisms unless destroyed prior to shipping, also may accompany the products, whether raw or cooked. An informed farmer, processor, food handler that undertakes agricultural practices, good handling practices or good manufacturing practices, can greatly assist other persons along the food chain.

Figure 3. Animals serve as a major cause of microbial diseases

- Co-habitation
- Animal handling practices
- Trade
- Companion animals (pets)
- Transboundary introduction

- There are a number of very dangerous emerging and re-emerging diseases
  - Animals and humans

Figure 4. Incidence of food borne illnesses

- Only small numbers of food borne disease cases (FBDs) are known and reported
- Actual Incidence: 300-350 times greater than reported
- About 3.3 million to 12.3 million infections occur annually in the USA alone
- WHO estimated that 70% of 1.5 billion episodes of diarrhea that occur globally each year are directly caused by chemical/biological contamination of foods

---

CHALLENGES IN INTERNATIONAL TRADE IN FOODS

Caribbean countries are net importers of food and food products (both raw and processed). In many cases, countries seek to outsource foods from all over the world. But not all countries have the same standards for preparing or processing and shipping foods, and this puts the recipient country at risk for receiving foods that may well be contaminated and serve as a source of disease transmission. This risk applies to any country that is involved in trade on the international market. But the major concern is that when the recipient country lacks the capacity and capability to detect contaminants or hazards (biological, physical or chemical), the risk is even greater. Such is the case of Caribbean countries in which diagnostic laboratories are either inadequate or absent; where surveillance at the port is inadequate and sometimes even ineffective; where a recognized sampling plan is not in place; and where due to financial constraints, countries are often not able to visit exporters to observe the operation and food handling practices in the country of export.

Consequently, in some countries, food imports are often examined at the points of entry by Public Health officials from Ministries of Health, Such is the case in several Caribbean island states. Fortunately, most of the imported foods are usually processed foods which may pose a lower food safety risk. The greater challenge though, is with the inspection of raw foods which may not always have the expert attention of veterinary inspectors at points of entry (Fig. 8). This

is further complicated when at such points of entry a proper refrigeration system is not in place. It is not unusual to have two agencies inspecting different types of foods at entry points. For example, in the USA, foods are inspected at points of entry by the US Department of Agriculture (USDA) as well as by the US Food and Drugs Administration (USFDA). The distinction is that in the USA scenario, there is usually a continuous presence of staff from both departments and the definition of the food (e.g. meat) is clear.

In the Caribbean, a veterinary presence is often lacking at ports, and response by the officers themselves to inspect in-coming food products of animal origin may be compromised if the responsible officer is engaged in another emergency at the time the product is to be inspected. It means therefore, that a large amount of data on the microbial threats to the safety of food products in trade originating from the English-speaking Caribbean countries come from public health sources. Such foods are usually the exotic foods (patties, pies, shark and bake, doubles, etc) and are usually internal trade among nationals, with products sold on the streets, or in parks, or at work sites. They are often prepared at home and brought to the site for sale. This practice is in itself risky, but the details will not be mentioned in this presentation.

NEED FOR DIAGNOSTIC LABORATORIES

Many of the countries lack functional Veterinary Diagnostic Laboratories at which representative samples could be tested. Thus, not much sampling, if any, is done on food imports and exports, and to a large extent, where inspection is done at the port, it may be subjected to organoleptic evaluation. The Ministry of Agriculture remains however, the principal Ministry that directs the affairs of the export of food and agricultural products, but the technical input regarding inspection and certification of such products for export sometimes rests with inspectors from the Ministry of Health. Several countries therefore, depend on Public Health Laboratories or Analytical Laboratories, and the Chemistry Food and Drug Laboratories (in at least two CARICOM states) to get diagnostic information. From personal knowledge, although laboratory technicians may often have similar training and diagnostic skills, there is generally reluctance for persons in food laboratories to conduct tests on animal products, except in unusual circumstances. The reciprocating action also takes place among technicians in Veterinary Diagnostic Laboratories. This is a signal for concern when raw food products of animal origin are to be tested in Analytical Laboratories.

Laboratory services are key factors in food monitoring for microbial agents (Fig. 9). Therefore, any program that is unable to sustain a proper diagnostic laboratory in support of routine sampling of foods, will be compromised. It is well known that laboratory planning should be done taking into account the type of sampling to be done and the volume of samples to be processed. It is not critically important to have all foods tested using a single laboratory, but it is most important to ensure that food standards and protocols are closely followed, ad that the laboratories are equipped with capable workers and appropriate facilities, supplies and equipment and effective methods of analysis. The laboratory then can be the critical factor in obtaining information on food-borne disease trends, the identification of food hazards and observing the association with identified agents and contact with affected persons.

At a time when globally, emerging and re-emerging infectious diseases are threatening the health of the peoples of the world and affecting trade internationally, it is imperative to put measures in place to reduce the incidence of such infectious diseases. Strong inspection and surveillance programs, driven by modern diagnostics would greatly minimize the risks from exposure to such diseases. In a community such as the CARICOM Community that is devoid of organized integrated surveillance programs and inadequate laboratory support, it will definitely compromise an already unacceptable situation in which human resources are scarce. At the same time, the emerging diseases demand that countries prepare to prevent the introduction of such diseases through early disease detection, and prompt response and containment. The introduction of infectious agents, automatically compromises trade in imports into, as well as exports from, the affected country/countries.

As just stated, a proper inspection program and good surveillance protocols can greatly reduce the serious impact of trans-boundary infectious agents/diseases. National laboratories must however, be strengthened to support both programs and in the long term, facilitate regional and international trade.

CONCLUSIONS

Caribbean countries are challenged to deal with microbial threats (Fig. 10). But a genuine effort to address the deficiencies could prove valuable to the member countries, working collectively as a single domestic space with many common linkages. Through networks and partnerships, much could be achieved.

Figure 5. Reported cases of food born illnesses in the Caribbean countries, 1981 – 2000 . Actual Incidence appears to be 300-350 times greater than reported

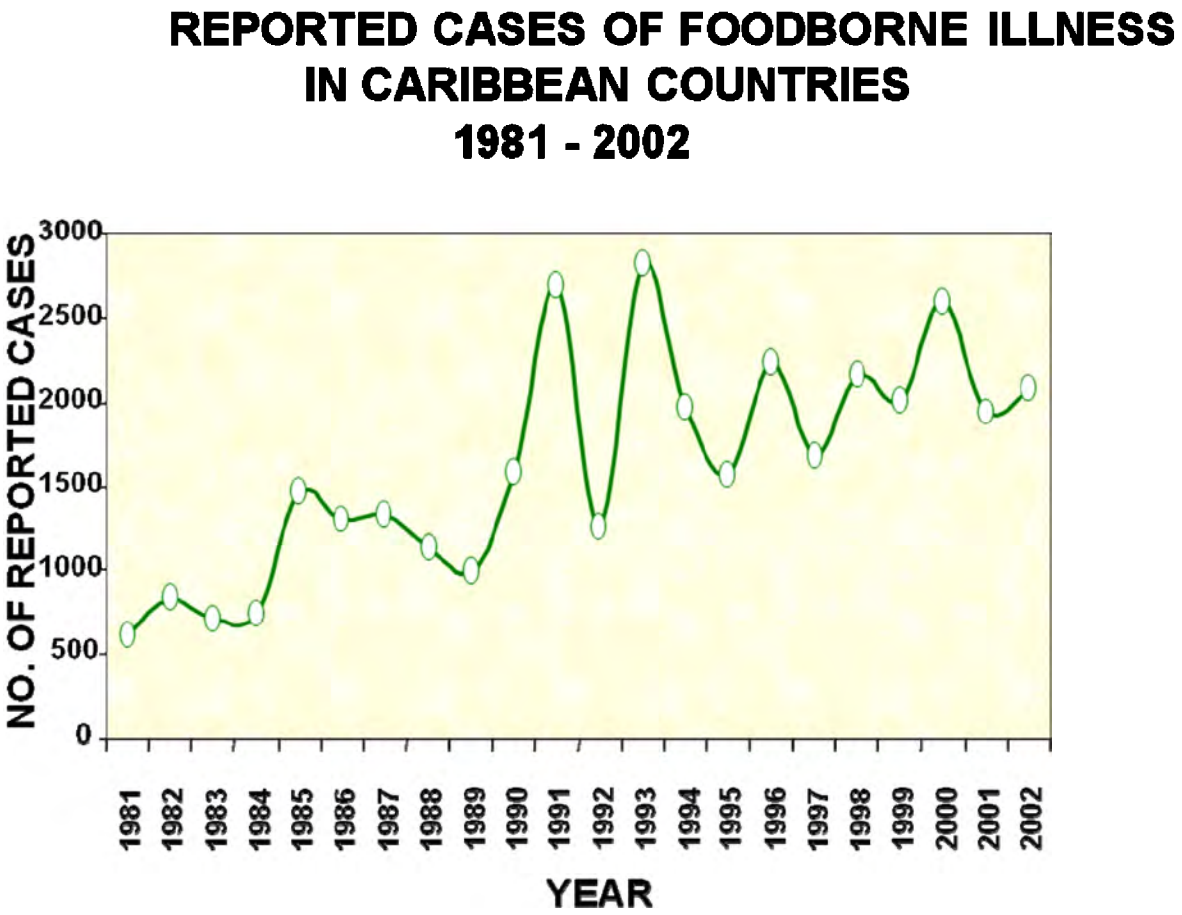


Figure 6. Food-borne pathogens

■ Bacterial: ▪ Bacillus cereus ▪ Brucella ▪ Campylobacter* ▪ Clostridium botulinum ▪ Clostridium perfringens ▪ E. coli O157:H7* ▪ Listeria monocytogenes* ▪ Salmonella non-typhoidal ▪ Shigella ▪ Staphylococcus ▪ Streptococcus ▪ Yersinia enterocolitica	■ Parasitic: ▪ Cryptosporidium* ▪ Cyclospora* ▪ Giardia* ▪ Toxoplasma* ▪ Trichinella ■ Viral: ▪ Norwalk-like viruses* ▪ Rotavirus* ▪ Astrovirus* ▪ Hepatitis A

Figure 7. Principal sources of pathogens

Pathogens	Sources
Brucella spp	Raw milk and cheese
Campylobacter	Raw chicken, beef, raw milk and shellfish
E. coli O157:H7	Meat and meat products, poultry products and salads
Salmonella	Poultry, cattle, pig, produce, raw meats, milk, poultry, eggs, fish, shrimp, coconut, sauces and salad dressings
Shigella spp	Salads generally and sandwich fillings, milk, dairy products and poultry products
Staphylococcus Spp	Meat and meat products, poultry products and salads

Note: Caribbean countries are net importers of food and food products (both raw and processed)

Figure 8. Challenges in safeguarding the Caribbean Region against food-borne pathogens

- Fragmentation of programmes
- Inspection of raw foods which may not always have the expert attention of veterinary and plant inspectors at points of entry
- Veterinary presence often lacking at ports of entry
- Lack of functional Veterinary Diagnostic Laboratories
    - Mainly organoleptic evaluations

Figure 9. Infrastuctre needs to assure microbial safety of foods

- Laboratory Facilities
    - Key factors in food monitoring for microbial agents
- Diagnostic Methods
- Disease detection and response
- Disease containment and eradication
- Surveillance Systems
- Competent, trained human resources

Figure 10. Conclusions

- Caribbean countries are challenged to deal with microbial threats
- A genuine effort to address the deficiencies could prove valuable to the member countries, working collectively as a single domestic space with many common linkages
- Networks and partnerships could result in enhanced surveillance and diseases detection, and lead to great achievements in food safety and trade

---

2008 Proceedings of the Caribbean Food Crops Society. 44(1):170-174. 2008

DISCUSSION OF TECHNICAL ISSUES

Moderator: Ms. Florita Kentish, FAO Representative to Trinidad and Tobago, Guyana and Suriname. Email: Florita.kentish@field.fao.org

Ms. Florita Kentish. Now we have a period of discussion. Are there any questions and interventions of any sort?

Ms. Carol Thomas. Thank you very much Madame Chair. I want to make a general comment, and I have a question for Dr. Webb. Dr. Webb, you mentioned various kinds of pathogens - microbial contaminations causing food-borne illnesses. Now we have been noticing that many of these pathogens causing food-borne illnesses that previously were considered to be related to animal products are now being seen increasingly associated with plant products, including E. coli, Salmonella, etc. When we think in terms of the kinds of collaboration that you referred to where, you know, we should no longer strictly consider plant health issues in isolation but considered together with animal health issues for greater collaboration. And I know there have been attempts to get this done. Your presence here, for example, and Dr. Joan Brown's presence and her talk on planning for avian influenza pandemic issues, indicates the move toward more collaboration between the disciplines. But I just wondered what is the prospect of all of this? Is it something that we see within the Caribbean as necessary and important? And are there further indications that this is happening? I just wondered.

And another quick thing that I also want to mention: you also made the point about – in dealing with the challenges of disease response mechanisms that need to be put in place, and, again, with the preparedness that Dr. Brown mentioned; and I just want to applaud the IICA, USDA, CIRAD initiative that is called the Veterinary Epidemiology Program, which actually is in the process of being launched now as we speak. There is now a meeting being held in the Dominican Republic on this particular subject, and it is an attempt, Dr. Webb, as you know, to bring veterinary epidemiologists together in the Region to form a quick response team – to train them and to form a quick response team - for addressing animal health issues and for surveillance. And I wondered if there would be any reason for having a similar activity – a similar program – related to plant health? Thank you.

Dr. Lloyd Webb. With regard to the first point, I think we are on track in creating that nexus of strength where it assist us to deal with the issues that we share, whether plant or animal. I think what is important is that as we continue to strengthen our network, perhaps, we need to have a program in which we can have a greater exchange of information. For instance, one of the things that would be very important for the Region would be to look at tracking the diseases that occur in our animals, the diseases that occur in man and the diseases that occur in plants. Because you may find, for instance, Salmonella – but is it the same strain of Salmonella that is in plants, that is in animals and that is in man? Those are issues that can certainly help the decision-makers to put certain things in place; and can even help in educating the farming community, the manufacturing or processing community and also the inspectorate - as the public authority. So I think, yes, there is a lot of scope that we can work on.

Now with regard to the second point in terms of epidemiology or epidemiological training, I think it is significant. In fact, I would not necessarily look at it as a plant component. I think we need to consider that in epidemiology we are looking at the gathering of facts, you know, and information. And as we continue this collaboration, we should try not to have a clear distinction between one and the other. Because it is very important that we recognize that – especially when we are dealing with scarce resources in a Region like the Caribbean, - if you have a good epidemiologist - that person should be able to basically show the links, you know, between the various partners, whether you are dealing with a plant issue, an animal issue or human issue. Okay? That would be my take on it. I do not know whether Dr. Brown would want to express her views.

Dr. Joanne Brown. Well, you know, having rapid response teams to meet plant or animal dieseas issues is an excellent idea. Here in Florida we have what we call Agricultural Rapid Response Teams for both plant and animal diseases. And we have an expert panel, whose members are based at the county level. They are volunteers who serve on each team and they are ready to go at any time in response to emergencies.

Dr. Colmar Serra. I would like to ask Ms. Alies van Sauers-Muller about her conclusion that the eradication of the carambola fruit fly was not possible. Do you think that it was not possible because of the conditions prevailing in the area? I would like to know how much work was done, and how much money was spent in your country and in neighboring countries. Also I would like to know what your perspective is. I view this as an important case because we want to learn about this case for possible future programs in the Dominican Republic.

Ms. Alies van Sauers-Muller. I did not say that we could not eradicate the carambola fruit fly. We showed clearly that we had eradicated the fruit fly from a large part of the then infested area, but then we ran out of money; and so we could not continue the eradication program. Eradication costs a lot of money, and it costed more than we had estimated initially, because we required more inputs than we had anticipated. As I told you, based on programs against the oriental fruit fly, we planned to apply four insecticidal attractant blocks per hectare, but we had to apply as many as 18 blocks per hectare for a long period of time because this was required to get rid of this fly.

At this moment, the fly still seems to be confined to areas where people live, and where it is infesting cultivated host plants. However we are now finding that the fly is beginning to infest the fruit of non-cultivated wild forest plants. Yet I think eradication is still possible, but it will cost a lot of money, which does not seem to be available at the moment.

There are quite some management options available particularly for infestations in backyards, but we need a much greater public education program to support this activity. With respect to biological control, we have a number of parasitoids, but most of these are associated with Anastrepha species, although last year we did find one on the carambola fruit fly in a limited area. However this parasitoid does not do any good in suppressing the fly; and therefore, we are thinking of introducing a species of egg parasitoid, which is present in Malaysia, and which is already widely used to suppress Bactrocera spp. populations.

Dr. Colmar Serra. What was the cost of the eradication program?

Ms. Alies van Sauers-Muller. I know that the program spent several million US dollars. I would like to refer to refer to the final IICA report on the Regional Project, which has data on how much we spent to get as far as we did in eradicating populations of the fly. I hope that document will soon appear.

Dr. Waldemar Klassen. I believe it was less than five million dollars, which is not much in relation to the losses that may occur as the pest expands its geographical range.

Unknown Speaker. Just to follow up a bit on the situation of the Giant African Snail on Dominica, where it is defoliating plants and is of public health concern. It was first found in 2004, and public awareness of the snail began only in 2005 or 2006 - thereabouts, and the Ministry of Agriculture took it upon itself to launch a program not to eradicate but to more or less control the Giant African Snail, and they went around to different villages putting out a bait containing a molluscicide along the sides of houses and in other areas. A few people complained about the impact that the bait might have on the animals and on the children, and as a result of the Ministry's consultation with its legal advisors, the Program has been suspended. Now, people actually buy the bait and use it for themselves, so to speak. But my question to Dr. Pollard is this: in terms of the snail carrying a nematode, which can cause disease; so my question is this: is there a plan to test some of the snails on the Caribbean islands to determine if they carry that particular disease? And taking into consideration that on several islands, including the French territories, people are experimenting with using the snail as a sort of culinary delicacy; so is there any program to see if they carry human pathogens?

Dr. Gene Pollard. There is no Regional program to do it; this would have to be a national activity. In terms of the snail being used as food, once the snail has been properly cooked, there is no risk to human health. But eating snails that have been improperly cooked – and there have been reports that in just handling the snails, there is a slight risk of being contaminated with the nematode. But once the snails have been properly cooked, and in fact some of the snails used as escargot in some countries would be some species of the Achatina genus to which the giant African snail belongs. They are widely eaten in many places; in Barbados, I know at least one person who eats these snails and who has been encouraging other locals to use it as food. But food is cultural, and while the Caribbean people eat saltwater snails and marine gastropod mollusks or conch, there seems to be an aversion to eating land snails in much of the English-speaking Caribbean. But land snails can be eaten if they are properly prepared and cooked. There is no risk.

Ms. Florita Kentish. Any other questions?

Dr. Richard Pluke, Virgin Islands. Dr. Pollard, you have a great deal of experience with new pests coming into the Caribbean Region. Are we getting any detailed biogeographical understanding of where new pests are coming from and how likely they are to move about the Caribbean after they have been introduced. One example I was thinking of was the entry of an insect into Antigua this year. Based on how people are moving around the Caribbean as well as the geographical relationships of land masses, do you have any comments in this regard?

Dr. Gene Pollard. There are many anecdotal accounts as to where exotic species have come from. In fact, I was quite surprised to see – many years ago – when I discussed the pink hibiscus mealybug, there was a publication by a well-known international agency, which I see represented here today, which stated that the mealybug came in the baggage or luggage of diplomats from Asia. I cannot remember from which country, and maybe someone here could remind me, but I was extremely surprised to see that an international organization would assert that the pest came into the Region in the diplomatic baggage of a specific country. So there are several angles to be considered. I mentioned that in the case of the giant African snail some say it was brought over from Guadeloupe by a French national who was living in St. Lucia at the time. A number of the new pests that have gotten into the Caribbean Region are of Asian or southeast Asian origin. How they got in, I cannot say, but a number of the pests that came into the Region originated in Asia, and some of the latter probably originated in southeast Asia. Maybe this is something that CISWG can do: try to determine the origin and track the movement of some of these invasive species that arrived in the past decade and one-half. In Barbados, alone during the past ten years, there have been at least 8 or 9 or 10 new introductions.

Once a new pest – a new alien invasive species - gets in to the Region, then you can bet your life that with time that pest will continue to spread because many Caribbean people move from one island to the next, and because many people move with food. I remember standing in the airport in Miami a few years ago, and this suitcase got stuck in the conveyer belt, and this suitcase ripped open, and there were pumpkins and so on tumbling out of the suitcase. I was shocked. I just looked at the person next to me and he looked at me, and we both started to laugh. So people tend to travel with their food. I remember a study done in the Pacific Region some years ago, trying to track the introduction of pests by tracking the movements of islanders from one island to the next. It was not as difficult as trying to do such a study in Miami or some large country because there were only a few flights moving among these islands. So it was quite easy to track the movement of the people and to analyze interceptions, and so on. Here in the USA there are many data on pest interceptions coming out of each country involved with trade and tourism. So maybe this could be an item that we can put on the agenda of the CISWG Group. Thank you.

Ms. Florita Kentish. Margaret Kalloo, please?

Ms. Margaret Kalloo. I was not going to bring this up, but now I think it might be useful. With respect the giant African snail, and the interest in food consumption, is there a food safety regulation with respect to cooking temperatures for these snails so that one can ensure its safety for consumption? If cooked giant African snail were to be offered as a food delicacy by enterprises in the Region, would they have access to information on the proper method of preparation including the required cooking temperature? Secondly, if the snail does not have a significant impact on agriculture, perhaps a feasibility study including an economic assessment should be conducted for the benefit of enterprises that may wish to offer the giant African snail as a culinary item. Could that be considered by the Giant African Snail Technical Working Group that we have in Region? Gene, I need expert information on these points.

Dr. Gene Pollard. Well, I have been called a number of things, but I have never been classified as one of the island chefs. So I am not prepared to recommend a particular cooking temperature or cooking regime, but the thing is that these snails are widely used in many countries, and in fact, I have a publication with me on giant African snail farming in Ghana. You have detailed information on how to produce this snail.

Ms. Margaret Kalloo. Well, I was really hoping that other members of the panel, those with public health expertise might respond.

Dr. Lloyd Webb. I can respond. I am not aware that there are standards for the cooking of snails, but the Codex Alimentarius has a wide range of standards, and maybe there is one there – I don't know, since I have never looked at it. From a Caribbean or Greater Caribbean point of view, I think that if we find – but I am not hearing that the giant African snail is widespread; what I am hearing is that it is being used. But if it becomes an issue where it really is used as a food, you know as a major food, or is being promoted as a food and is being accepted, I think it would be wise for us to look at some standards. I do not think this would be too difficult, I mean, this is what the Codex Alimentarius Committees do – they do look at standards. And of course we can look at things from the Caribbean perspective. So I think there are possibilities, but first we need to determine to what extent it is a major concern, because the development of a standard is not an easy thing. It requires a lot of work, and, indeed, you would not expend that amount of energy if, indeed, it is not a major concern. That would be my take on it.

Ms. Margaret Kalloo. Well, I was looking at giant African snail production not as a part of the Caribbean's cultural cuisine, but as an export product for the region's small farmers. So it might be wise for us to look a little further into what its commercial potential may be. Now I am not advocating the propagation of a highly damaging invasive species – especially not with this group – so forgive me CISWG, but from the perspective of moving agriculture forward, I think we should we look at its potential as an export product for small enterprises.

Dr. Joanne Brown. If I might make a comment, in the United States for poultry it is recommended that you cook it to a minimum of 165 degrees Fahrenheit to kill pathogenic bacteria. I don't know if you can extrapolate poultry to snails, but 165 degrees Fahrenheit will kill the pathogenic bacteria, but this may not give you a well done snail, but at least you won't have a harmful snail.

Dr. Gene Pollard. Just a quick comment. You know the snail is so widely used that, although there may not be standards, there certainly are methods of ideally cooking this organism.

Ms. Florita Kentish. Well, I want to thank the presenters for their excellent presentations and the audience for the stimulating questions. Let me ask the Rapporteur if she wants to make some summary comments. No she does not. So that is the end of this part of the session. Thank you very much!

Proceedings of the Caribbean Food Crops Society. 44(1): 175-177. 2008

CLOSING REMARKS AND ADJOURNMENT

Dr. John Fernandez Van Cleve, Dean, College of Agricultural Sciences, University of Puerto Rico-Mayaguez Campus, P. O. Box 9030, Mayaguez, PR 00681. Phone: (787) 833-3486; FAX: (787) 832-4220; email:
john@uprm.edu

My name is John Fernandez. I am the Dean of the College of Agriculture of the University of Puerto Rico. I am here to offer some closing remarks to this Invasive Species Symposium. When Carlton and Kwame first called me to invite me, my first reaction was: "Kwame, I am only a researcher and professor by training and profession and an administrator by accident, I don't have the faintest idea about the differences between Black Sigatoka and red palm mite." However, I confess that I have learned some basics by just attending the Symposia sponsored by T-STAR during past CFCS meetings. We have had a long day, but we have gathered useful information that we can, each, relate to our ongoing invasive species initiatives in our own countries and in our own Region.

In the morning we had the opportunity to learn about the status of the Caribbean Invasive Species Surveillance and Information Program (CISSIP), and also about other on-going initiatives that support CISSIP safeguarding strategies, which are (1) creating a Regional diagnostic network, (2) developing laboratory diagnostic capacity, (3) establishing a pest surveillance and inspection program, (4) developing an invasive species information system, (5) training programs, (6) public awareness programs, and (6) establishing capacity building programs in the Caribbean.

The CARICOM Secretariat, CIRAD, FAO, IICA and USDA-APHIS assembled many of the the Plant Health Directors of the Greater Caribbean for the first time ever with the objective developing coordinated programs to accomplish, in part, the desired outputs of the CISSIP proposal. This Caribbean Plant Health Directors' Forum has appointed six technical working groups to tackle important invasive species issues. The USDA, Animal and Plant Health Inspection Service has made significant progress to establish pest survey and inspection programs in the Caribbean Region, and it has been instrumental in domestic pest detection, commodity inspections for facilitating export of products of several CARICOM nations and Central American nations. It has provided technical workshops on several phytosanitary issues, and on inspection and identification of some invasive several invasive species.

We also learned about some of the on-going efforts of CABI in the conservation of globally important ecosystems and species and genetic diversity in the Caribbean, as presented by Dr. Krauss. The proposal of a Global Environmental Facility in the Caribbean is of great interest. However I particularly liked the slide with the comment: "Invasive species – relax if you can".

The French through the Plant Health Directorate of the French Ministry of Agriculture are very active in monitoring the border inspection points and through biological surveillance. CIRAD has done a lot of research on alternative methods of combating invasive pests. They already

provide several key elements of the CISSIP initiative as part of their daily mission by maintaining invasive species information databanks, Regional invasive species monitoring programs, and by creating expertise in laboratory and expert services. CIRAD is actively building a Regional network for sugarcane diseases, and another regional network impacting on bananas.

The USDA, through the T-STAR Program, has actively supported invasive species work in the Caribbean, especially since 2003 by the sponsorship of these Symposia at CFCS meetings. One of the things that Dr. Cheek did not mention in his welcoming address this morning is that most of the budget of T-STAR for this year was allocated exclusively to funding invasive species research proposals. As eloquently expressed by Dr. Martha Roberts, the big problem of agricultural production in tropical areas is the year-round growing season and the year-round plant diseases that affect them. In addition the temperature and humidity prevailing in our Region create an ecological heaven for these pests.

The Caribbean Invasive Species Surveillance and Information Program was the main focus of this discussion during the morning session. It seems that the main obstacles at present are (i) funding and (ii) various institutional, political and technical issues between the countries of the proposed alliance. I think the best message to deliver to our funding agencies, ministers and policy makers is that these invasive plants, insects, bacteria and fungi are not aware of any of these differences, and they respect neither borders nor political differences.

My impression as an unbiased onlooker this morning was that much is being done on invasive species: monitoring, capacity building, diagnostics and prevention. However, these efforts are fragmented by political differences, region, and languages. We ought to make a concerted effort to strengthen strategic alliances between working groups such as APHIS, IICA, CARDI, CABI, CIRAD, FAO, PAHO, IDIAF, CONIAF, and educational institutions such as University of Florida, FAMU, UPR, University of the Virgin Islands, and UWI.

The first real attempt to link every effort against invasive species in the Caribbean is today a reality with the Caribbean Invasive Species Working Group. The first real attempt to develop a Regional strategy to contend with invasive species in the Caribbean is CRISIS, the Caribbean Regional Invasive Species Intervention Strategy. The logical approach to implement such a strategy is CISSIP, the Caribbean Invasive Species Surveillance and Information Program. And into that we have to put a lot of efforts.

I was particularly impressed with the quality of the late morning panel and in the late afternoon panel. The discussion attempted to resolve some of the technical and institutional gaps for funding of CISSIP. Several of the points that I could gather were of particular interest. Firstly, the recognition that substantial work has been accomplished by individual institutions in the areas defined by CISSIP. The problem is information sharing, and CISSIP was suggested as the best repository for information. Secondly, that each nation should pursue funding with donors to strengthen their physical resources for invasive species.

The best example that I can provide to you is the initiative by the IDIAF in the Dominican Republic, where they presented an idea to the Secretary of Agriculture about a distance

diagnostic network, and they secured the funding for establishing six diagnostic centers throughout the Dominican Republic territory; and at this moment they are all connected to the Distance Diagnostic Network involving the University of Florida and the University of Puerto Rico. There was a statement that we cannot continue to look to someone else to finance our project, and that each member should evaluate their funding priorities. Those are very important words!

Also it was said that for CISSIP to be successful, the member countries need a strong extension system with strong producer - extension agent efficient interactions. A relevant example was given from my home country, Puerto Rico, where Black Sigatoka was first detected by extension agents, who had been prepared for the identification of the disease. Also the coffee berry borer in Puerto Rico was first detected and reported by my extension agents. So I think that the Extension Service, staffed with well prepared scientists, needs to be a very important part of the CISSIP Project.

During the afternoon session, we learned more about the incidence, management and prevention practices pertaining to invasive species such as red palm mite, citrus greening, Black Sigatoka and Moko disease, chilli thrips, passion vine mealybug, giant African snail, carambola fruit fly, some food-borne pathogens and Asian avian influenza – certainly a scary situation for Caribbean agriculture. The good news is that it is reassuring that substantial resources are being spent for concerted research efforts to give us solutions to deal with those invasive species. The bad news is that for every one that we find ways to deal with, ten more invasive species appear.

We would like to express our appreciation to all the presenters today for such excellence in presentation. Also we express gratitude to T-STAR for its generous support. And finally, a special message of appreciation to the Organizing Committee of this Symposium. Now, before I officially adjourn this Symposium, I invite participants to join the authors of posters in the Mediterranean Room East for refreshments and for the Poster Session. Also the Red Palm Mite Emergency Group meets in the Regency Conference Room, and interested participants are welcome. Good day to you.

NOTES:

Caribbean Food Crops Society
Sociedad Caribeña De Cultivos Alimenticos
Societé Caraibe Des Plantes Alimentaures

44TH ANNUAL MEETING
REUNION ANUAL
CONGRÈS ANNUEL

HOSTING ORGANIZATION

University of Florida
Institute of Food and Agricultural Sciences

CO-SPONSORS

Florida A&M University
Florida Cattlemen's Association
IICA
UF/IFAS International Programs
UF/IFAS T-STAR
(Tropical-Subtropical Agricultural Research)
USDA
USDA/APHIS
USDA/CSREES

Miami, Florida
July 13-17, 2008