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# **CARIBBEAN FOOD CROPS SOCIETY**

# **40**

**Fortieth**

**Annual Meeting 2004**



PROCEEDINGS  
OF THE  
40<sup>th</sup> ANNUAL MEETING

Caribbean Food Crops Society  
40<sup>th</sup> Annual Meeting  
19 - 23 July, 2004

Westin Resort and Villas  
St. John, United States Virgin Islands

***“Strengthening Partnerships for Sustaining Caribbean Agriculture”***

Edited

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**SUPPORT OF FLORIDA EXTENSION DIAGNOSTIC CLINICS BY A WEB-BASED PLANT DIAGNOSTIC CLINIC MANAGEMENT AND REPORTING SYSTEM**

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**ABSTRACT:** The University of Florida-Institute of Food and Agricultural Science has four official plant disease diagnostic clinics statewide. The Florida Extension Plant Disease Clinic located at the Southwest Florida Research and Education Center (SWFREC) in Southwest Florida provides disease diagnostic service primarily to the commercial agriculture industry. The majority of samples (70%) that are processed are submitted from the diverse vegetable and transplant industries. The timely return of diagnostic results is critical to clients making disease management decisions. A database application, eClinic, was developed to improve the capabilities of the diagnostic clinic to provide the results to the client. The program is easy-to-use, web-based, and provides management of a clinic records by both clinic personnel and the client. The program increases the efficiency of the internal management by automatic tracking of diagnostic samples and notification of action required to the clinic personnel. The program allows for reduction in the physical handling of paper documents and access from any computer with web access to a person with a valid account. When the diagnostic report is completed, the client may choose to receive e-mail notification with a secure link to the final report or the report is sent via a traditional reporting method (FAX and postal mail). The privacy and security of the client is maintained with a secure encrypted password. The client has improved access to past reports within the system. This archived data can be used by them to keep track of past pest problems, time of occurrence, and control recommendations. Another feature is the automatically generated list which contains the date, host, and disease diagnosis by county for the clinic and is automatically posted to the SWFREC website. Extension agents and specialist can access this list for information regarding disease outbreaks. The eClinic system supports multiple diagnostic clinics within the Florida Extension Clinic network and provides reporting to state, regional, and national databases. The secure, confidential information can be used to alert state and national agencies to new disease outbreaks, increased incidence of a particular disease, and geographic distribution to a county within a state. The program is amendable to specific applications and is being modified to include support for images and videos, billing and invoicing, links to electronic extension publications, and improved database analysis of accountability, reporting, and disease trends.

**USDA APHIS OFFSHORE PEST INFORMATION SYSTEM**

*Robert J. Balaam. USDA APHIS PPQ, Pest Detection and Management Programs, 61 Britton Road, Stockton, NJ 08559*

**ABSTRACT:** The Offshore Pest Information System (OPIS) is designed to collect, analyze, communicate and use relevant international information concerning pests not known to occur in the U.S. Safeguarding requires scientifically sound, rapidly accessible, and completely communicated international information. Homeland Security Presidential Directive 9 calls for development of coordinated surveillance and monitoring systems. OPIS is designed to identify for regulatory officials of the U.S. and its trading partners, a maximum number of targeted plant pests and animal diseases, which represent significant threats to agriculture and natural resources. Approximately 100 pests have been identified as “priority” targets. Current information on the density and distribution of priority target pests is collected regularly, abroad, and a web-based reporting and reference system has been developed for timely communication. APHIS will conduct a pilot program of OPIS in the Caribbean Region, Brazil, and South Africa. Mutual benefits include increased communication about specific pests with potential for disrupting trade, as well as the facilitation of pest mitigation programs, such as biological control of the pink hibiscus mealybug.

**GROUND-BASED VALIDATION OF SURFACE ENERGY FLUX ESTIMATES BASED ON REMOTE SENSING TECHNIQUES**

*Eric Harmsen. Department of Agricultural and Biosystems Engineering, University of Puerto Rico, Mayaguez, PR 00683*

**ABSTRACT:** The ability to estimate short-term fluxes of water vapor from a growing crop are necessary for validating estimates from high resolution remote sensing techniques, such as NASA's Advanced Thermal and Land Applications Sensor (ATLAS). On February 11th, 2004, the ATLAS was used to evaluate the Urban Heat Island Effect within the San Juan Metropolitan area. To validate energy flux estimates from ATLAS, a ground study was conducted at the University of Puerto Rico Agricultural Experiment Station in Rio Piedras (located within the metropolitan area). Short-term (10 second) micro-meteorological parameters including soil heat flux, soil temperature, soil moisture and net radiation were measured. Wind speed, relative humidity, and air temperature were measured at two vertical positions above the ground. Vertical differences in soil water tension (negative pressure) were also measured continuously. This paper only presents results from the ground-based study, since the ATLAS results are not expected to be available until September 2004. Large differences in relative humidity were observed between 20 and 200 cm heights above the turf grass, whereas temperature differences were negligible. Estimates of evapotranspiration are presented based on the Penman-Monteith and the gradient flux methods. Typical differences in soil tension between 20 cm and 40 cm below the ground surface were around 20 cbars. An error analysis is also presented which shows why it is necessary to use a single sensor for measuring vertical differences in relative humidity and air temperature.

**AN INTERNET-BASED SYSTEM FOR ASSESSING CROP WATER USE IN THE CARIBBEAN REGION**

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**ABSTRACT:** This paper describes the progress made thus far in developing an internet-based system for assessing crop water use in the Caribbean Region. Initial efforts have resulted in a prototype computer program (PR-ET) that is capable of estimating evapotranspiration within Puerto Rico, requiring only the site elevation, latitude and climate division. Current efforts involve the design of a web-based system, in which data from other islands can easily be incorporated into its climate parameter database. A module is being added whereby a soil water balance can be performed which will allow optimal planning of irrigation systems given the local climate, crops, and soil. The final product will be similar to the popular computer program CropWat, but additionally will incorporate the climate parameter estimation algorithm for islands of the Caribbean Region. The prototype computer program estimates climate data necessary as input to the Penman Monteith reference evapotranspiration method. The Penman-Monteith method has been recommended by the United Nations Food and Agricultural Organization (FAO) as the single best method for estimating reference evapotranspiration ( $ET_0$ ) throughout the world. The FAO recommends using the Penman-Monteith method over all other methods even when local data is missing. Studies have shown that using estimation procedures for missing data with the Penman-Monteith equation will generally provide more accurate estimates of  $ET_0$  than will other available methods requiring less input data. The FAO's recommendation to estimate missing climate data was the motivation for the present study.

**COMPARISON OF AQUAPONIC AND FIELD CROP PRODUCTION OF BASIL AND OKRA IN THE TROPICS**

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**ABSTRACT:** Basil (*Ocimum basilicum*, ‘Genovese’) and okra (*Abelmoschus esculentus*, ‘Clemson Spineless’) were cultured in an aquaponic system, using raft culture, and in soil, using drip irrigation, in two separate experiments to compare production. The 110-m<sup>3</sup>, aquaponic system, which produces 4 to 5 mt of tilapia annually, consisted of four fish-rearing tanks, a solids removal component, and six hydroponic tanks with 214-m<sup>2</sup> of total plant growing area. The aquaculture effluent was supplemented with Ca, K, and Fe. In experiment 1, dried composted cow manure was applied to the field plot at 5.87 mt/ha. Basil was planted at 8 plants/m<sup>2</sup> in both treatments, harvested after 28 days at a height of 15 cm, and harvested a second time after 28 days. Based on four crops, projected annual basil production is 23.4 kg/m<sup>2</sup> in the aquaponic system and 7.8 kg/m<sup>2</sup> in soil. In experiment 2, a field plot was prepared by adding gypsum (4 t/ha) and N-P-K (21-7-7) at 100 kg/ha. Field okra received four foliar applications of micronutrients (iron, manganese, and molybdenum). Okra seedlings were transplanted at 2.7 plants/m<sup>2</sup> in both treatments and cultured for 11.7 weeks. Harvests began in week 5 in the aquaponic system and week 10 in the soil. Production was 2.67 kg/m<sup>2</sup> in the aquaponic system and 0.15 kg/m<sup>2</sup> in the soil.

## SUSTAINABLE ROOT AND TUBER CROPS PRODUCTION IN TRINIDAD AND TOBAGO - CASSAVA GERMPLASM CHARACTERIZATION AND UTILIZATION

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**ABSTRACT:** The root crops cultivated and consumed in Trinidad and Tobago that are of significant, economic and nutritional importance are cassava (*Manihot esculenta* Crantz), sweet potato (*Ipomoea batatas* L.), dasheen (*Colocasia esculenta* Schott var. *esculenta*), and eddoe (*Colocasia esculenta* Schott var. *antiquorum*). Approximately 1,250 ha of land are under root crop cultivation annually at an estimated value of TT \$7.5 million. Root crop consumption is assuming greater importance of the 40% of households identified as falling below the poverty line. Research on root crops by the MALMR addresses agronomic, pest and post-harvest problems as well as germplasm conservation, morphological description and the availability of quality planting material. There is the potential for moving the cassava and sweet potato industry forward through agro-processing. Processed products in Trinidad and Tobago include frozen cassava, farina, chips and pastries. These can be utilized in the School Nutrition Programme. This paper presents characterization data of 19 cassava cultivars, farmer's problems related to thrips and mite infestation and planting material production and conservation for sustainable development.

**Key words:** Root crops, Sustainable development, Planting material production.

### INTRODUCTION

Tropical root crops are important food staples targeting food security, poverty alleviation and sustainable production issues in the 21<sup>st</sup> century in the global food market (Chandra, 1998; CGIAR, 1999). Root crops are adapted to a wide range of edapho-climatic conditions, produce a large amount of food per unit of labour and land, the tubers can be harvested and consumed during crop growth and their strong historic link with mankind indicates their potential for ecologically sustainable development. The Consultative Group on International Agricultural Research (CGIAR, 1999) in their vision statement to the year 2020 made the following statement:

*"By 2020, roots and tubers will be integrated into emerging markets through the efficient and environmentally sound production of a diversified range of high quality, competitive products for food, feed and industry. These crops' adaptation to marginal environments, their contribution to household food security and their great flexibility in mixed farming systems make them an important component of a targeted strategy that seeks to improve the welfare of the rural poor and to link smallholder farmers with these emerging growth markets."*

Of these food staples, the annual growth rate of world cassava production was 2% during the last decade (1987-97) (Ceballos, 2001). Regionally, root and tuber crops are important



staples in the West Indian diet, are produced in traditional mixed farming systems and provide significant incomes for rural farmers as well as hucksters and traders (Collymore, 2002). In Trinidad, an estimated average annual 1,101 ha of land was under root crop cultivation between 1991 to 2000 of which the estimated annual average hectareage for cassava production was 453 ha producing 2,265,000 kg of cassava valued at TT \$4,620,000. The production of this crop is gaining importance as the Government has revamped the entire sugar cane industry allocating Caroni lands for food crop farmers in its diversification programme (Persad, 2004).

The crop is marketed in one of two ways: the "middle man" who harvests the tubers directly in the field under the farmer's supervision or by the farmer who sells his produce to the processing plants or the fresh market including the supermarkets. Root crop consumption is assuming greater importance in the diets of 40% of households identified as falling below the poverty line (GORTT, 1996). Most of the harvested cassava is consumed in the fresh state by boiling and frying. Locally processed products include frozen cassava, cassava chips, farine, and cassava flour (Seesahai and Henry, 1998). Additionally, the School Nutrition Programme utilizes 15,000 kg of cassava monthly in the school feeding programme. Domestic exports to Barbados and the USA increased during 1991 to 2002 reaching a peak of 37,285 kg in 2002 valued at \$305,959 (Collymore, 2002).

One of the significant aspects of Government's policy impacting on sustainable food production and food security in the Republic of Trinidad and Tobago is the ongoing maintenance and use of its plant genetic resources (MALMR, 1995). This policy will be briefly described for cassava.

## CASSAVA GERMPLASM CHARACTERIZATION AND UTILIZATION

The morphological description of landraces and introduced cassava cultivars as well as their continuous maintenance in field gene banks is one of the primary disciplines of the Root and Tuber Crop Programme of the MALMR.

*"Caribbean people know about sustainable development.....we know how to sustain ourselves....we have done it for generations....through our families.....through our communities....and when we can't find a way to sustain ourselves here we have migrated." Antrobus, 1991.*

*"Caribbean economies face the vagaries of a rapidly changing global economic environment, in which their agro-economies might suffer adverse economic shocks associated with regional marketing realignment of traditional partners... sustainable agricultural development must be based on agricultural diversification." Davis, 1995.*

*"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." FAO, 1997.*

This mandate is in keeping with current research within the CGIAR programme on roots and tubers where the collection, characterization and conservation of 5,500 *Manihot* germplasm is currently being accomplished (CGIAR, 1999). The programme of the MALMR is not to get into the arena of molecular linkage maps or DNA –based markers for characterizing cassava

diversity, but rather to employ a computerized database programme for the morphological description of cassava using the International Plant Genetic Resources Institute (IPGRI) cassava descriptor list.

In 1994, the Caribbean Seed and Germplasm Resources Information Network (CSEGRIN) under the auspices of the Food and Agriculture Organization of the United Nations (FAO) launched a computerized database programme for the morphological description of cassava and other crops.

The morphological descriptors collected for cassava were sent to IPGRI for use in their international database to facilitate the exchange of genetic material globally. PROCICARIBE- the Caribbean Agricultural Science and Technology Network System subsequently launched the Caribbean Roots and Tubers Network (CAROT) in 2001 to continue the impetus on Caribbean National Programmes of research and development in roots and tubers aimed specifically at enhancing domestic food security.

The MALMR employed the use of these descriptors to its germplasm collection using the standard format for crop descriptor lists. The format used was to collect both germplasm passport data as well as characterization and evaluation data.

*"Food security means access by all people at all times to the food needed for a healthy life. Sustainable food security aims to achieve this goal without compromising the productive capacity of natural resources, the integrity of biological systems or environmental quality". (FAO and UNDP, 1994)*

Nineteen cassava cultivars maintained *ex situ* at the research division fields were selected from an initial collection of 65 cultivars for characterization. Cultivars were selected with specific character traits viz. tolerance to cassava bacterial blight, low cyanide levels, high consumer acceptability and ability to produce high yields under moderate to low soil nutrient status. After this characterization exercise, there was a perceived need to prepare a document on these cultivars that was visually effective, employed the use of critical characterization data and operational to meet the needs of the farmers and processors. Therefore, a standard descriptor sheet for each cultivar was developed and minimum, relevant information entered on each data sheet. Photographs of both the aerial and subterranean plant parts were then included on another sheet. Table 1 gives a summary of the characterization and evaluation data of the 19 cassava cultivars held in the gene bank at the Research Station, Centeno, Trinidad (Seesahai et al., 2000).

#### FARMER'S FIELD PROBLEMS AND THE USE OF THE CASSAVA GENE BANK TO SOLVE THESE PROBLEMS.

There were two major problems facing the cassava plantations:

1. The presence of Cassava bacterial blight (CBB) from 1960 to 1990.
2. The ability of the cassava tuber to boil to a soft consistency. The first question that all cassava retailers are asked –"Is the cassava cooking?" Hence, market demand was always subject to the cooking quality of the cassava tuber.

The popular, indigenous cultivated cassava variety in the 1960's was Maracas Black Stick (MBS) and this variety was susceptible to CBB. Research conducted during 1960 to 1990 by the

pathologist and agronomist at the Research Division of the MALMR in collaboration with scientists from CIAT identified the following solutions to this problem:

- *The identification of the causal agent of CBB and the varieties susceptible to this disease through varietal screening, field surveys, symptomatology and aetiology studies (Phelps, 1977; Pegus and Rajnauth, 1977,1978; Rajnauth and Pegus, 1987; Rampersad, 1987).*
- *The identification of the cultivar CMC 40 from the gene bank with similar tuber characteristics as MBS but which was highly tolerant to CBB and the control measures required to sustain the cultivation of susceptible cultivars (Rajnauth and Pegus, 1987; Lozano, 1986).*
- *The production of disease free planting material and a rapid method for cassava planting material production by farmers (Persad and Seesahai, 1987).*
- *Farmer education of disease control strategies.*

The continuous introduction, multiplication and distribution of new cultivars to farmers and state organizations, such as Orange Grove Estate and Caroni (1975) Limited, from CIAT as early 1962 led to the cultivation of many of these cultivars on state lands and farmers' holdings. From these accessions, farmers discovered that one of the introduced cultivars M MEX 59 boiled to a soft consistency at any stage of maturity (6-12 months) wherever it was cultivated. This cultivar had a wide spatial stability, was adapted to a wide range of soil and agro-ecological zones and produced yields of from 4,000 to 35,000 kg/ha fresh tuberous roots. However, it was susceptible to CBB, thrips, and mites and required continuous fertilization to produce consistently high yields. M MEX 59 is the wonder variety of the Trinidad root crop farmer and is in high demand by consumers.

## RECENT DEVELOPMENTS IN PROBLEMS RELATED TO CASSAVA PRODUCTION IN TRINIDAD

Two major problems have recently surfaced in cassava cultivation in Trinidad and Tobago (Seesahai et al., 2003). There were high populations of thrips (*Frankinella williamsi* and *Corynothrips stenopterus*) and mites (*Mononchylus* and *Tetranychus* species) on cassava cultivars, especially on M Mex 59. Symptoms of thrips damage include damage to the growing point of the plant, abnormal leaf development, distorted, and deformed young leaves with irregular yellow spots. Symptoms of mite damage include systemic chlorosis of young leaves subsequently developing a mosaic like appearance, defoliation and stem necrosis from the top to the bottom of the stem. Populations were so high in some fields that carbohydrate production was negatively affected resulting in spongy pith of the stems and poor starch filling of the tubers that subsequently became spongy. In some fields, yields were reduced by 80%. Rotting of the planting material beginning from the cut ends of the cassava stick and advancing upwards in the stems. Preliminary investigations conducted in the pathology laboratory at Centeno showed that bacteria and fungi were absent from the rotted tissue. A field survey showed that all varieties cultivated in the different counties of Trinidad were susceptible to this problem. The possibility exists that there may be a relationship between the incidence of thrips and mites and the deterioration of the cassava planting material. A project is currently being conducted under greenhouse conditions to investigate the correlation between the incidence of thrips

(*Corynothrips stenopterus*) and the breakdown of the stem pith tissue in cassava planting material.

## DISCUSSION

Cassava is the fourth largest food crop in the world and its social history goes back 9,000 years ago when Amerindian peoples learned how to process the tuberous roots to remove its toxins. Trinidad and Tobago has an extremely high food import bill - TT \$1.7b in food imports 2003 (Express, 2004). The national population must think about its ability to feed itself beyond the next millennium. Development of strategies to accomplish this goal is strongly rooted in the words food security and sustainability. The thrust to push the cassava and sweet potato industry forward through agro-processing was recently identified as a major component of the Agricultural Sector Reform Programme. Processed products can be used for both human and animal consumption-the technological information is available but the political will must be present to link increased productivity by actual increases in ha as well as increased yields per unit land area with agro-processing.

Sustainable cassava production is closely linked with the available germplasm resources that lend themselves to specific ecosystems and processing. The present collection contains varieties that demonstrate the capacity to yield over 20,000 kg/ha, are tolerant to a range of pests and diseases, and can be produced year round. Boiled and fried cassava is well accepted by the school children and the general population in their diets as a basic carbohydrate staple. Indeed, cassava flour added to cakes and pastries can be a novel way of increasing demand for cassava. There already exists a niche market substituting cassava flour for wheat flour for people who are sensitive to gluten. Supermarkets sell cassava chips and frozen cassava and the cassava export market to Caricom countries such as Barbados is on the increase. Studies incorporating cassava ensiled in molasses or salt to replace the corn ration used to feed pigs in Trinidad has been successfully demonstrated to increase live weight gains (Ramlal et al., 1987).

Development of the crop, especially its income-generating capacity offers the opportunity to specifically target poverty alleviation for the most vulnerable as well as the displaced workers of Caroni (1975) Ltd. (Persad, 2004). Net returns per hectare after deducting total operating costs for producing one hectare of cassava was TT\$ 31,514.00 (Collymore, 2002) and this can be substantially increased through the use of timely application of fertilizers and the use of higher yielding varieties. Research continues to offer solutions to field problems such as the reduction of pest and disease problems through field surveys, identification of these pests and diseases, and implementation of control measures by training both farmers and extension officers.

## SUGGESTED RESEARCH AGENDA

### Germplasm improvement

- Hybrids combining MBS M Mex 59 to incorporate the genes for resistance to thrips and mites.
- Accessing cultivars from CIAT that consistently boils to a soft texture, tolerant to pests and diseases; low cyanogenic glucoside levels; adaptable to lowland, tropical conditions with a high, spatial stability.
- Accessing cultivars with high starch content.

Integrated pest and disease management.

- To develop economically and environmentally sustainable management practices by employing biological and cultural control practices. These activities to include integrated pest management through farmer participatory research techniques.

Development of sustainable, cassava based production systems.

- To develop technologies for production of "clean" planting setts by farmers.
- Maintaining and enhancing soil fertility and curbing soil erosion on hilly lands.

Agro-processing.

- Increasing value-added production by improving agro-processing and the development of nuclear type cottage industries for both local and export markets.
- Ensiling waste cassava for use as animal feed for non-ruminants, rabbits, and shrimp farming.

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Table 1. Characterization and Evaluation of 19 Cassava Varieties at CES.

CLONE	YIELD QUALITY		AND MORPHOLOGICAL				TRAITS			ROOT FORM		
	YIELD kg/ha	CONSUMER ACCEPTABILITY	LEAF COLOUR	PETIOLE COLOUR	STEM COLOUR	PLANT FORM	HEIGHT cm	NO. OF STORAGE ROOTS	COMMERCIAL ROOTS %		ROOT LENGTH cm	ROOT DIAMETER cm
M Trin 1	11500	high	green	red	gray	erect	245	10	78	medium	narrow	con. Cyl.
M Trin 2	11400	high	gr-prgr	gr. Red	silver	parasol	220	11	40	medium	narrow	con. Cyl.
M Trin 4	8600	high	gr. Prp.	red	silver	erect	212	9	56	medium	narrow	con. Cyl.
T 10/72	13800	high	gr. Prp.	red prp.	gray	open	173	9	58	long	narrow	con. Cyl.
T 12/72	22900	intermediate	prp. Gr.	gr.yw.	silver	erect	159	18	56	medium	narrow	con. Cyl.
TO 3/72	8900	low	prp.gr.	gr.red	orange	open	264	8	50	medium	narrow	irregular con.
Blue Stick Maracas Black	20300	very high	lt. gr.	gr.yw.	silver	cylind.	180	11	67	medium	narrow	Cyl.
Butter Stick	19500	very high	gr. Prp.	gr. red	lt. brown	open	240	9	70	medium	narrow	cylind.
M Guy 2	18500	very high	prp.	gr. Yw.	lt. brown	open	192	8	75	medium	narrow	cylind.
M Guy 3	10800	intermediate	lt.gr.	gr. Yw.	golden	open	210	10	50	medium	narrow	cylind. con.
M Guy 6	12200	intermediate	gr.prp.	red prp.	gray	erect	140	6	67	medium	nar.-medium	Cyl. con.
V 05/72	15000	intermediate	prp	gr. Yw.	silver	parasol	173	11	82	medium	nar.-medium	Cyl.
V 06/72	19500	intermediate	gr.prp.	gr. red	golden	open	205	11	45.5	med.-long short-	nar.-medium	cylind.
CIAT Hybrid	20500	high	lt.gr.	gr. Yw.	silver	open	126	10	60	medium	narrow	conical con.
M Col 22	13200	very high	lt.gr.	red	lt. brown	erect	147	9	78	medium	narrow	Cyl.
CMC 40	11900	very high	prp	gr. Yw.	lt. brown	cy.ind. erect-	120	7	85	medium	narrow	conical
M Mex 59 Yuca varNegra	21100 18500 22400	very high very high very high	gr.prp. lt.gr. gr.prp.	red red red prp.	golden lt. brown silver	open erect parasol	195 220 226	12 8 13	83 75 76	medium medium medium	narrow medium narrow	cylind. con. Cyl. con. Cyl.

Medium 15-30 cm; Narrow < 5 cm; Gr. – Green; Prp. – Purple; Yw. – Yellow; Lt. – Light; D. Dark; Cyl. – Cylindrical; Diff. – Difficult; Irreg. – Irregular.

Continuation of Table 1. Characterization and Evaluation of 19 Cassava Varieties at CES.

MORPHOLOGICAL TRAITS AND LEVELS OF PESTS AND DISEASES													
CLONE	ROOT FORM	ROOT POSITION	ROOT SURFACE COLOUR	ROOT SURFACE TEXTURE	CORTEX REMOVAL	PULP COLOUR	CASSAVA BACTERIAL BLIGHT	LEAF SPOTS	MITES	THRIPS	SHOOT FLY	CYDNIIDAE BUG	
M Tin 1	Con. Cyl.	Horizon.	D. Brown	Rough	Difficult	White	Intermed.	Low	Intermed.	Low	Low	Low	Intermed.
M Tin 2	Con. Cyl.	Irregular	D. Brown	Rough	Difficult	White	Intermed.	Low	Intermed.	Low	Low	Low	Intermed.
M Tin 4	Con. Cyl.	Irregular	D. Brown	Rough	Sl. Diff.	W. Cream	Intermed.	Intermed.	Low	Low	Low	Low	Intermed.
T 10/72	Con. Cyl.	Irregular	D. Brown	Rough	Difficult	W. Cream	Intermed.	Low	Intermed.	Low	Intermed.	Intermed.	Intermed.
T 12/72	Con. Cyl.	Horizon.	L. Brown	Rough	Difficult	W. Cream	Intermed.	Low	Intermed.	Low	Intermed.	Intermed.	Intermed.
TO 3/72	Irregular	Irregular	D. Brown	Rough	Easy	W. Cream	Intermed.	Low	Low	Low	Intermed.	Intermed.	Intermed.
Blue Stick Maracas	Con. Cyl.	Irregular	D. Brown	Rough	Difficult	W. Cream	Intermed.	Intermed.	Low	Low	Low	Low	Intermed.
Black	Cylind.	Vertical	D. Brown	Rough	Difficult	W. Cream	Intermed.	Intermed.	Intermed.	Low	Intermed.	Intermed.	Intermed.
Butter Stick	Cylind.	Horizon.	D. Brown	Rough	Easy	Yellow	Intermed.	High	Low	Low	Intermed.	Intermed.	Intermed.
M Guy 2	Cylind.	Horizon.	D. Brown	Rough	Difficult	W. Cream	Intermed.	Intermed.	Intermed.	Low	Low	Low	Intermed.
M Guy 3	Con. Cyl.	Horizon.	L. Brown	Rough	Difficult	White	Intermed.	Intermed.	Intermed.	Low	Low	Low	Intermed.
M Guy 6	Con. Cyl.	Horizon.	D. Brown	Rough	Difficult	White	Intermed.	Low	Intermed.	Low	Intermed.	Intermed.	Intermed.
V 05/72	Cylind.	Horizon.	D. Brown	Rough	Easy	W. Cream	Intermed.	Low	Low	Low	Intermed.	Intermed.	Intermed.
V 06/72	Conical	Horizon.	D. Brown	Medium	Difficult	W. Cream	Intermed.	Intermed.	Intermed.	Low	Intermed.	Intermed.	Intermed.
CIAT Hybrid	Con. Cyl.	Horizon.	D. Brown	Rough	Difficult	W. Cream	Intermed.	Intermed.	Intermed.	Low	Intermed.	Intermed.	Intermed.
M Col 22	Conical	Horizon.	Yellow	Smooth	Easy	W. Cream	Intermed.	Low	High	Low	High	Intermed.	Intermed.
CMC 40	Cylind.	Horizon.	D. Brown	Rough	Difficult	Cream	Resist.	Low	Intermed.	Low	Intermed.	Intermed.	Intermed.
M Mex 59	Con. Cyl.	Vertical	D. Brown	Rough	Easy	W. Cream	Intermed.	Low	High	Intermed.	Intermed.	Intermed.	High
Yuca variegata	Con. Cyl.	Horizon.	Yellow	Medium	Easy	W. Cream	Intermed.	Intermed.	Intermed.	Low	High	High	High

Medium 15-30 cm; Narrow < 5 cm; Gr. – Green; Prp. – Purple; Yw. – Yellow; Lt. – Light; D. Dark; Cyl. – Cylindrical; Diff. – Difficult; Irreg. – Irregular.



**CROP YIELD OF VEGETABLES UNDER ORGANIC AND INORGANIC FERTILIZATION REGIMES**

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**ABSTRACT:** The use of organic waste as a soil ameliorant is gaining popularity in sustainable systems of crop production. Long-term applications of both organic and inorganic fertilizers are being investigated at the UWI Field Station in Trinidad to determine their effect on crop yield and maintaining soil productivity. Established in 2002 on the St. Augustine series (a loamy clay Orthoxic Tropudults), crop residue, manure and inorganic fertilizer were integrated into soil management strategies on rotated corn (*Zea mays* L.) and pigeon peas (*Cajanus cajan* L.). The results of multiple seasons of cropping showed that productivity of crops could be improved with the use of either/both organic and inorganic fertilizers. Comparisons of the two with controls are provided in the paper.

**ON-FARM EVALUATION OF CUCUMBER CULTIVARS FOR SUMMER PRODUCTION IN THE U.S. VIRGIN ISLANDS**

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**ABSTRACT:** An on-farm cultivar evaluation trial for cucumber (*Cucumis sativus* L.) was conducted to compare differences in plant growth parameters related to fruit characteristics and marketable yield during the summer season. Eight cultivars (Calypso, Cobra, Eureka, Dasher II, SMR 58, Marketmore 76, Olympian F<sub>1</sub> and Poinsett 76) were transplanted on June 12, 2003 into rows 1.52 m apart and spaced 0.41 m within rows. The trial was established using a randomized complete block design with three replications. Cultivars were harvested on five dates from July 23 to August 10, 2003. Data collected at each harvest included total number of fruits, fresh weight, number of marketable fruits, fruit length, vine length to first flower and fruit. Except for fruit length, differences among cultivars in all measured parameters were significant. New cultivars Cobra and Olympian F<sub>1</sub> produced yields that were not significantly ( $P>0.05$ ) different with common cultivars Calypso and Dasher 2. Cultivar Eureka produced the smallest (202 g) fruit while largest fruits (414 g) were produced by cultivar Olympian F<sub>1</sub>. Vine length to formation of first fruit was shortest (8.7 cm) with cultivar Olympian F<sub>1</sub> and longest (20.9 cm) with cultivar Calypso. In all cultivars, formation of first flower in the vine did not develop into fruit. The study indicates that new and improved cultivars are available to farmers who want to replace old and common cultivars. Best cultivars are Cobra and Olympian F<sub>1</sub>.

**INTRODUCTION**

Cucumber (*Cucumis sativus* L.) is a very popular fresh market vegetable crop in the Virgin Islands. It ranks second after lettuce in terms of total volume produced in 1998 (U.S. Department of Commerce, 2000). The 1998 Census of Agriculture reported a total production of 45,450 lbs (20.7 metric tons) from 16 acres (6.48 ha) the highest among other vegetables (U.S. Department of Commerce, 2000). This production level is however, not sufficient enough to meet demands such that the Virgin Islands have to import most of the cucumbers from other islands or from the U.S. mainland (Pearrow, 1992). There is potential for increasing cucumber production in the Virgin Islands since its tropical climate is suitable for year-round cultivation. Furthermore, excellent local markets exist and growers have been taking advantage of this market.

Variety selection, often made several months before planting, is one of the most important management decisions made by the vegetable farmer (Maynard et al., 2002). Proper choice of varieties is important for successful cucumber production and marketing. Failure to select the most suitable variety or varieties may lead to loss of yield or market acceptability. Important characteristics that are considered in choosing cucumber varieties include market acceptance, yield, fruit quality, diseases, and pest resistance. Most common cucumber varieties grown in the Virgin Islands are the slicing and semi-pickling types. Cultivar evaluation trials for cucumber were conducted at the UVI Agricultural Experiment Station more than ten years ago in 1991 (Palada et al., 1993). Five variety trials were conducted from 1988 to 1991 evaluating yield

performance of eight varieties. Results of these trials indicated that cultivars Victory, Dasher II, and Tropicuke maintained high yields ranging from 23 to 41 t ha<sup>-1</sup> (Palada et al., 1993). Marketable yields varied with growing season and high yields were obtained during the winter-spring season. Virgin Islands vegetable farmers are constantly looking for cultivars superior to common cultivars that have been cultivated and grown for decades. This study was conducted to: 1) identify and select alternative/suitable cucumber cultivars for local market in the Virgin Islands and 2) compare differences in plant growth parameters related to fruit characteristics and marketable yield of cucumber cultivars during the summer production season.

## MATERIALS AND METHODS

The trial was located on a farmer's field in Estate Glynn, St. Croix, Virgin Islands (Lat. 17°42'N, Long. 64°48'W). The soil is a Glynn gravelly loam (clayey, skeletal, mixed, superactive, isohyperthermic, typic argiustoll) as described by Lugo-Lopez et al., (1998). Average rainfall is 1015 mm per year. The trial was planted on June 12, 2003 and harvested from July 23 to August 10, 2003. Eight cultivars were evaluated including three commonly grown varieties as local or standard checks. The new cultivars were Cobra, Eureka, Olympian F<sub>1</sub>, Poinsett 76, and SMR 58. The commonly grown cultivars were Calypso, Dasher II, and Marketmore 76. Cobra, Eureka and Calypso are semi-pickling types while Olympian F<sub>1</sub>, Poinsett 76, and SMR 58 are slicing types comparable to Dasher II and Marketmore 76.

The cultivars were planted in plots consisting of three rows 5 m long and spaced 1.5 m apart. Each plot measured 4.5 m x 5 m or 22.5 m<sup>2</sup>. Plants were spaced 0.41 m within rows with plant population density equivalent to 16,260 ha<sup>-1</sup>. All plots were drip irrigated to maintain soil moisture tension at -30 kPa. The experiment was established using a randomized complete block design with three replications. Dehydrated and composted cow manure (2-1-2) was incorporated in the soil prior to planting at the rate of 4.0 t ha<sup>-1</sup> as basal fertilizer application. This was followed by weekly fertigation of 20-20-20 kg ha<sup>-1</sup> N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O. The total fertilizer applied was 200-80-200 kg ha<sup>-1</sup> N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O. Insect pests and diseases were controlled with regular spraying of Dipel, M-Pede, Admire, and Trigard.

The crop was harvested five times on July 23, 25, 29, August 6 and 10, 2003. Five plants in the middle row were sampled for measurement of total number of fruits, fresh weight of fruits, number of marketable fruits, fruit length, and vine length to first blossom (flower) and fruit. Data were analyzed for statistical significance using the SAS program.

## RESULTS AND DISCUSSION

### Vine length to first flower and fruit

The first flowers in cucurbits are normally male flowers and therefore will not develop into fruit. Cultivars vary in vine length to formation of first flower or fruits. Data on Table 1 show that cultivars differ significantly ( $P < 0.05$ ) in vine length to the formation of first flower and fruit. Vine length to first flower was shortest (5.5 cm) in Marketmore 76, and longest (17.9 cm) in Calypso (Table 1). Marketmore 76, Olympian F<sub>1</sub>, Poinsett 76 and SMR 58 have vine length to first flower shorter than 10 cm whereas cultivars Eureka, Dasher II, Cobra, and Calypso had vine length to first flower above 10 cm. Cultivars also differed significantly ( $P < 0.05$ ) in vine length to formation of fruit (Table 1). It was shortest (9.7 cm) for Olympian F<sub>1</sub> and longest

(20.9 cm) for Calypso. Cultivars with shorter vine length to first fruit may indicate earliness compared to those with longer vine length. These cultivars can be harvested early in the season and may benefit farmers in terms of high market price. Cultivar Olympian F<sub>1</sub> seems to fit this characteristic and may be ideal for early harvest.

#### Number of fruits, fruit size, and fruit length

The number of marketable fruits varied significantly ( $P < 0.05$ ) among cultivars (Table 2). Cultivars Cobra and Dasher II produced the greatest number of marketable fruits that were significantly higher than cultivars Marketmore 76 and SMR 58. Cobra, which is a new slicing type cucumber, produced almost similar number of marketable fruits with Dasher II, a commonly grown cultivar in the Virgin Islands. This indicates that Cobra is a good alternative cultivar to local varieties grown by farmers. The number of marketable fruits produced by cultivar Eureka, a new semi-pickling type cucumber was lower but not significantly ( $P > 0.05$ ) different from marketable fruits produced by cultivar Calypso, a common variety grown in the Virgin Islands (Table 2). Eureka therefore is an alternative cultivar for semi-pickling cucumbers. Most consumers in the Virgin Islands prefer the pickling type of cucumber since the fruit size is relatively smaller than the slicing types.

Fruit size and weight also differed significantly ( $P < 0.05$ ) among cultivars (Table 2). The largest average fruit size (414 g) was produced by Olympian F<sub>1</sub>, while the smallest fruit size (202 g) was obtained from cultivar Eureka. Dasher II and Marketmore 76 produced fruit size which was greater than 300 g, while the rest of the cultivars except Olympian F<sub>1</sub> had fruit size in the range of 202-278 g (Table 2).

There were no significant differences in fruit length among cultivars (Table 2). Fruit length ranged from 11.9 cm for Eureka and 17.0 cm for Marketmore 76. Generally, the slicing type cucumbers such as cultivars Marketmore 76, Olympian F<sub>1</sub>, Dasher II and Poinsett 76 have fruits longer than the semi-pickling type of cucumbers such Calypso, Cobra and Eureka.

#### Marketable yield

Early in the growing season the crop was severely infested by thrips and mites causing stunted growth. Most of the affected leaves turned whitish in color and eventually changed to brown. Visual observations indicated that some cultivars were more susceptible than others. For example, cultivar SMR 58, Marketmore 76, and Eureka were seriously infested compared to other varieties and resulted in lower yields (Figure 1). Because of insect infestation, the crop was only harvested five times. Except for Calypso, all other cultivars were harvested four times. Most cultivars produced the highest yield during the fourth and fifth harvests, however; in general yields were below 15 t ha<sup>-1</sup>.

As shown in Figure 1, total cumulative marketable yield was highest for Dasher II and Olympian F<sub>1</sub> followed by cultivars Cobra, Poinsett 76, and Calypso in descending order. Cultivars Eureka, Marketmore 76 and SMR 58 produced the lowest yields that were below 6 t ha<sup>-1</sup> (Figure 1).

Differences in total marketable yield were significant ( $P < 0.05$ ) among cultivars (Figure 1). In terms of marketable yield, Dasher II and Olympian F<sub>1</sub> were highly superior to Eureka, Marketmore 76, and SMR 58. The yield difference between Dasher II and Olympian F<sub>1</sub> was not significant, thus, Olympian F<sub>1</sub> is an alternative cultivar to Dasher II, an old variety. Marketable

yield of semi-pickling cucumber Cobra was higher but not statistically different from Calypso. Therefore, Cobra is a better alternative to Calypso compared to Eureka in this category.

In general, yield levels obtained from this summer trial were lower than those obtained in previous trials at the experiment station. For example, marketable yield of 18 t ha<sup>-1</sup> was recorded for Dasher II during the spring-summer season trial (Palada et al., 1993). High yields were obtained during the winter-spring and summer-fall growing seasons.

## SUMMARY AND CONCLUSIONS

This study has shown that there are new alternative cultivars for cucumber production in the Virgin Islands. Cultivars differed in vine length to formation of first flower and fruit, number of marketable fruits, fruit size, fruit length, pest tolerance, and marketable yield. For slicing cucumber, cultivar Olympian F<sub>1</sub> is a good alternative to commonly grown cultivar Dasher II. For semi-pickling cucumber, cultivar Cobra is a better alternative to commonly grown cultivar Calypso. These new cultivars are available to farmers in the Virgin Islands who may want to replace old and common cultivars.

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Table 1. Vine length to first flower and fruit of cucumber cultivars, St. Croix, USVI, Summer2003.

Cultivar	Vine length first flower (cm)	Vine length to first fruit (cm)
Calypso	17.9 a	20.8 a
Cobra	10.2 bc	13.5 ab
Dasher II	12.1 bc	13.1 ab
Eureka	11.4 bc	12.0 bc
Marketmore 76	5.5 d	11.7 c
Olympian F <sub>1</sub>	9.2 c	9.7 c
Poinsett 76	7.9 b	13.4 ab
SMR 58	7.9 b	15.6 ab

Mean separation in columns by Duncan's Multiple Range Test,  $P=0.05$ .

Table 2. Number of marketable fruits, fruit size and length of cucumber cultivars, St. Croix, USVI, Summer 2003.

Cultivar	Marketable fruits (number/ha)	Fruit size (g)	Fruit length (cm)
Calypso	30106 abc	262 bc	12.2
Cobra	38710 a	278 bc	14.1
Dasher II	41935 a	323 ab	16.9
Eureka	25806 abc	202 c	11.9
Marketmore 76	13977 c	354 ab	17.0
Olympian F <sub>1</sub>	30106 abc	414 a	15.7
Poinsett 76	35484 ab	276 bc	15.6
SMR 58	19355 bc	248 bc	12.3

Mean separation in columns by Duncan's Multiple Range Test,  $P=0.05$ .

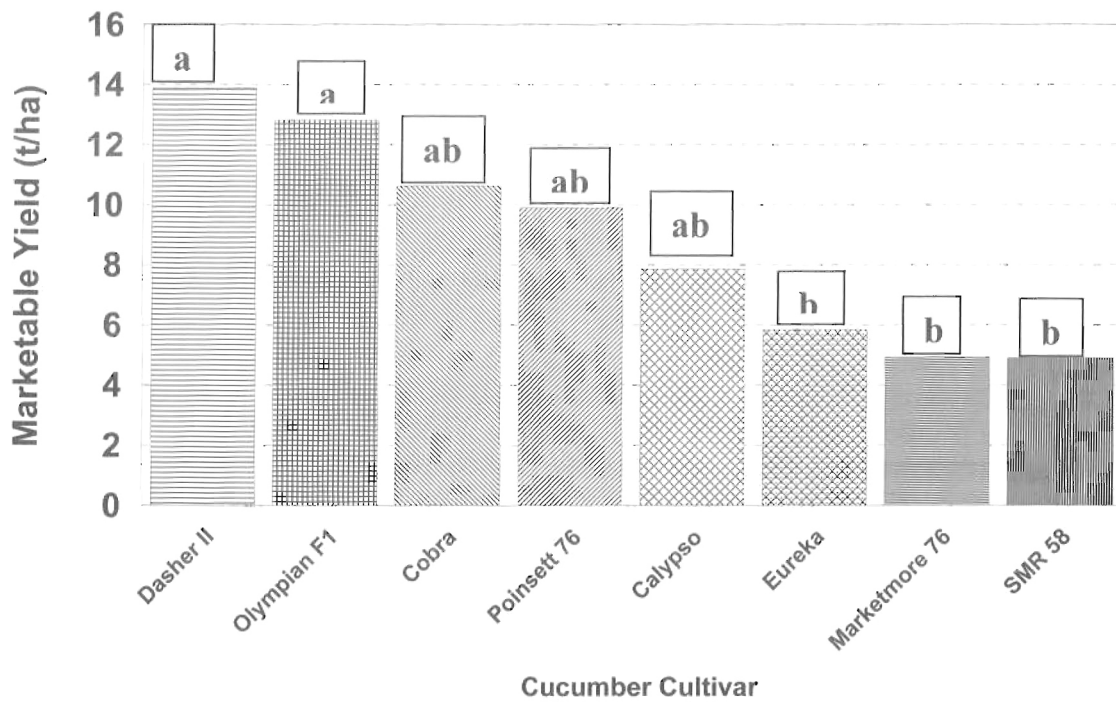


Figure 1. Marketable yield of cucumber cultivars, Estate Glynn, St. Croix, Summer 2003.  
 (Bars with common letters are not significantly different by Duncan's Multiple Range Test,  $P=0.05$ )

**GROWTH AND YIELD OF HOT PEPPER IN HEDGEROW INTERCROPPING WITH MORINDA CITRIFOLIA L. DURING EARLY ESTABLISHMENT**

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**ABSTRACT:** Intercropping high-value horticultural crops with tree crops is an economically attractive, but little studied, agroforestry option in the U.S. Virgin Islands. A study was conducted to evaluate growth and yield performance of hot pepper (*Capsicum chinense* L.) under hedgerow intercropping with Morinda (*Morinda citrifolia* L.), a popular medicinal tree in the Virgin Islands. Morinda hedgerows were established at 5-m spacing forming 5-m wide alleys between hedgerows. One year after hedgerow establishment, seedlings of hot pepper cultivar 'West Indies Red' were transplanted in alleys at 1 m row spacing and 0.60 m plant spacing within rows. Similar spacing was used for plots planted with monoculture hot pepper (no hedgerows). The experiment was designed using a randomized block with four replications. The Morinda hedgerows were not pruned during the cropping year. Data were collected on hot pepper height, number and weight of marketable fruits. Hedgerow plant height and canopy width were also determined at 3-month interval. Treatment effect of hedgerow on growth and yield of hot pepper was compared with monoculture crop. Analysis of data indicated that during the early establishment of hedgerows, plant height and marketable yield were not significantly ( $P>0.05$ ) reduced in hedgerow intercropping. Differences in height and yield by rows relative to distance from hedgerows were not significant ( $P>0.05$ ). However, average yield under hedgerow intercropping was slightly lower than monoculture (no hedgerow) crop. This study would indicate that during the early stage of hedgerow establishment, tree-crop competition is not critical in reducing growth and yield of hot pepper. Long term effects of hedgerows on productivity of intercrops will be further investigated.

INTRODUCTION

The Virgin Islands is endowed with tropical climate and natural resources that provide opportunities for year-round cultivation of high value crops. However, in spite of the ideal conditions, agricultural productivity and overall economy of the islands are declining. The decline in agricultural output can be attributed to several factors including the after effects of hurricanes, decrease in the number of farms and disappearance of important plant species such as medicinal plants, indigenous herbs and medicinal trees with economic potentials. Despite the general decline in farming activity, there has been a slow but increasing trend in the number of farms (McElroy and Albuquerque 1985; Moore 1991). For example, in 1998 a combined total of 134 farms were growing vegetables and herbs in the island of St. Croix alone. Part-time farmers manage most farms with farm size averaging less than two hectares (U.S. Dept. of Commerce 2000; D'Souza 2002).



The high cost of inputs (fertilizers, pesticides, irrigation and labor) for vegetable production tends to discourage small-scale farmers to invest and expand their farming operation. Vegetable crops are no longer profitable to grow in the Virgin Islands since aside from high cost of production, imported produce from the U.S. mainland and neighboring islands are cheaper than locally grown vegetables. This gives local farmers a competitive disadvantage. It is estimated that local production constitutes only 5 to 10% of the total produce sold in the local market (Dominique 1990; D'Souza 2002).

Alternative high value horticultural crops such as medicinal plants, culinary herbs and spices may have economic advantage over common and traditional vegetable crops. Medicinal plants, for example, are important horticultural crops in the Virgin Islands. About half of the farmers are involved in growing and producing herbs, spices and medicinal plants (Palada et al., 2003). The economic importance of these plants indicates that more research and development efforts must be pursued to maintain and conserve germplasm materials. The growing interest in medicinal plants and trees among farmers in the Virgin Islands signifies that these crops may offer better alternative to traditional vegetable crops. In addition, intercropping medicinal plants or trees with high value horticultural crops such as hot peppers may increase economic returns and improve income of small-scale farmers. Medicinal trees like Neem (*Azadirachta indica*), Moringa (*Moringa oleifera*), and Noni (*Morinda citrifolia*) are becoming popular in home gardens on St. Croix and St. Thomas (Thomas and Palada 1994; Thomas 1997; Palada and Davis 2000; Palada et al., 2002). Some of these trees have been grown with vegetable crops in agroforestry systems (Palada et al., 1994; O'Donnell et al., 1995; Rao et al., 2004).

Hot peppers are specialty crops with high market value both for local and export markets. Studies indicate that hot pepper is an ideal crop for Virgin Islands and that production is increasing (Crossman et al., 1999; Palada and O'Keefe 2001). It is one of the most popular cash crops with excellent market opportunity. Morinda or popularly known as Noni is becoming an important medicinal tree in the Virgin Islands. Almost all plants parts (leaves, fruits, flowers, seeds and roots) of Morinda have wide medicinal uses. Intercropping Morinda with hot pepper may provide high combined economic returns for the disadvantaged small-scale farmers of the Virgin Islands.

Cultivation of medicinal plants and high value crops may offer a potential alternative to conventional fruit and vegetable production in the Virgin Islands. Although it can be a viable option for small-scale farmers, little research information is available on the limitations and benefits of this system. This study was conducted with the following objectives: 1) study the interaction between Morinda hedgerows and hot peppers at early establishment; and 2) determine the effect of Morinda hedgerows on growth and yield parameters of hot peppers.

## MATERIALS AND METHODS

This study was conducted at the Agricultural Experiment Station, University of the Virgin Islands, St. Croix, U.S. Virgin Islands, Eastern Caribbean (17°42'N, Long. 64°48'W). Annual rainfall ranges from 1000 to 1100 mm. Morinda tree hedgerows were established on August 2001 using two-month old seedlings. Hedgerows were spaced 5 m with in-row spacing of 1 m. Each plot was planted to three hedgerows forming two 5 m alleys. Hot pepper cultivar Habanero was planted in alleys between Morinda hedgerows on September 13, 2002. Each alley was planted to four rows giving a total of eight rows per plot (Figure 1). Because of unusual

heavy rainfall and incidence of virus disease, this crop failed and complete harvesting was not possible.

A second hot pepper crop using cultivar West Indies Red was planted on February 10, 2003. Hot pepper was planted at row spacing of 1 m and plant spacing (in-row) at 0.61 m. Based on the spacing used plant population density of hot pepper was 16,393 plants/ha. The trial was established using a randomized block design with 4 replications. Treatments consisted of hedgerow and no hedgerow (control) plots.

Composted cow manure (2-1-2) at the rate of 5.0 t ha<sup>-1</sup> was applied as basal fertilizer for hot peppers. This was followed by 15 weekly fertigation of soluble fertilizer 20-20-20 NPK at a total rate of 100 kg NPK/ha. Hot peppers were drip irrigated based on soil moisture tension maintained at -30 kPa. Insect pests were managed with regular spraying of organic and chemical pesticides including Dipel, Mpede, Pyrelin, Azatin, Malathion and Botanicguard using recommended levels.

For Morinda hedgerows, data were collected on canopy and plant height at three months interval. At harvest of hot pepper, data were collected on plant height, number and weight of fruits that were classified into marketable and non-marketable. To determine the effect of Morinda hedgerows on plant growth and yield parameters of hot pepper, two rows of hot pepper adjacent to center hedgerow were sampled for these measurements. Thus, rows 2 and 3 were rows directly adjacent to hedgerow while rows 1 and 4 were considered outer rows (Figure 2).

## RESULTS AND DISCUSSION

The effect of Morinda hedgerows on hot pepper plant height was not significant ( $P > 0.05$ ) as shown in Table 1. In fact, the average plant height of hot pepper was slightly taller in hedgerow intercropping compared to control (no hedgerow). Differences in plant height between plants adjacent to hedgerows and outer rows or in control plots were small (Table 1) indicating that during the early establishment of Morinda hedgerows, tree-crop competition is not significant to influence plant growth of intercrops. This result is consistent to those reported by Palada et al., (2003) under Moringa hedgerow intercropping system with medicinal plants. They reported no significant effect of Moringa hedgerows on plant height of basil (*Ocimum basilicum*) and lemongrass (*Cymbopogon citratus*). At early establishment stage, growth rate of hedgerow species is slow and interaction between trees and crops are minimal in terms of competition for light (shading effect) and soil moisture.

The number and weight of fruits per plot also were not significantly ( $P > 0.05$ ) influenced by hedgerow intercropping (Table 1). However, both the average number and weight of fruits in hedgerow intercropping were slightly lower than the control (no hedgerow). Hedgerow intercropping reduced fruit number and weight by 10 and 30%, respectively. A 10% reduction in fruit number may not be significant to small-scale farmers since during off-season when there is low supply of hot peppers in the market; farmers sell their produce by the number regardless of size and weight. For example, hot pepper can sell at three fruits for a dollar in St. Thomas (Crossman et al., 1999; Palada and O'Keefe 2002).

On a per hectare basis, the number of fruits and marketable yield of hot pepper were also not significantly influenced (reduced) by hedgerow intercropping with Morinda (Table 2). The number of fruits was reduced by 5% whereas marketable yield was reduced by almost 10%. This again indicates that during early establishment of hedgerows, there is no significant effect on

yield of intercrops. This result is similar to those obtained in hedgerow intercropping medicinal plants with *Moringa* as reported by Palada et al., (2003).

The real evidence of tree-crop competition is expected to appear when the hedgerows are fully established and start to develop much wider canopy and extensive root system. This is expected to be in the third year after establishment. Therefore, there is a need to continue and extend this experiment beyond three years to generate data for solid conclusion and recommendation. Furthermore, several seasons of yield data are needed to evaluate the economic benefits of this system.

## SUMMARY AND CONCLUSIONS

This study demonstrates the initial effect of *Morinda* tree hedgerows on growth and yield of hot pepper in an alley cropping system. Preliminary results indicate that during the early stage of hedgerow establishment, tree-crop competition was not critical in reducing growth and yield of hot peppers. Farmers will have the option to grow high value crops such as hot peppers with medicinal trees with no immediate or direct effect on crops. However, it is expected that in succeeding years the competitive effect of hedgerows will be manifested and may result in significant yield reduction of intercrops. The yield reduction might be offset by economic returns from hedgerow products that are marketable in the form of fruits and other plant parts used for medicinal purposes. Additional studies are needed to determine the long-term effect of tree-crop competition on total productivity of this system in the tropics.

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Table 1. Row effect of Morinda hedgerow on plant height, fruit number and fruit weight of hot pepper under hedgerow intercropping, St. Croix, U.S. Virgin Islands, 2003.

Treatment	Hot pepper row number	Plant height (cm)	Fruits (no. m <sup>-2</sup> )	Fruit weight (g m <sup>-2</sup> )
Hedgerow	1	56	66	837
	2*	50	106	565
	3*	62	47	534
	4	<u>51</u>	<u>31</u>	<u>351</u>
	Mean	55	63	572
No Hedgerow	1	57	101	1128
	2*	52	63	723
	3*	55	60	683
	4	<u>47</u>	<u>55</u>	<u>694</u>
	Mean	53	70	824

\* Rows adjacent to Morinda hedgerows.

Table 2. Plant height, number of fruits and marketable yield of hot pepper in hedgerow intercropping with Morinda, St. Croix, U.S. Virgin Islands, 2003.

Treatment	Plant height (cm)	No. of fruits per ha	Marketable fruit yield (kg ha <sup>-1</sup> )
Hedgerow	58 a	162,106 a	1750 a
No Hedgerow	53 a	171,946 a	1984 a

Mean separation in columns by Duncan's Multiple Range Test (P=0.05).

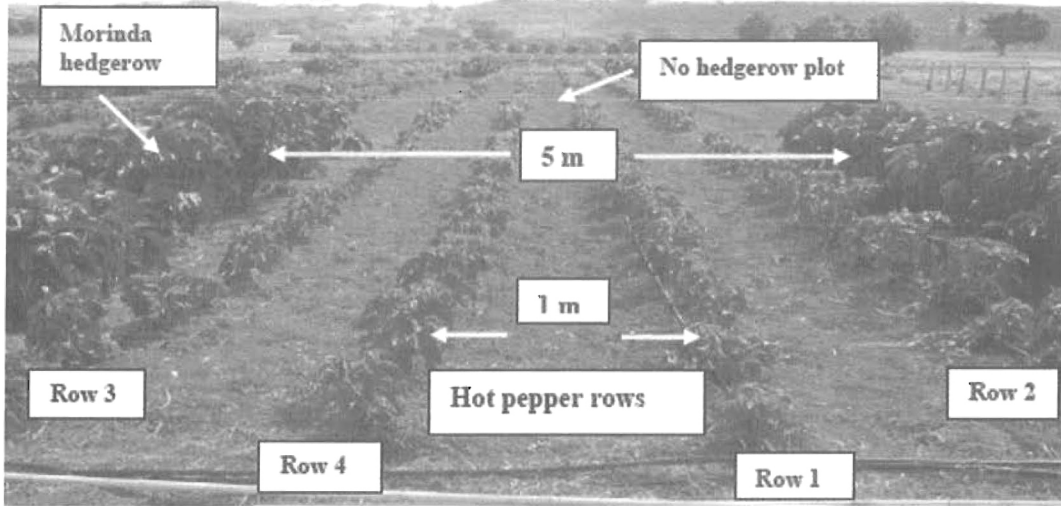


Figure 1. Plot layout of Morinda-hot pepper hedgerow intercropping experiment, UVI Agricultural Experiment Station, St. Croix, U.S. Virgin Islands.



Figure 2. Morinda center hedgerow showing adjacent hot pepper rows R2\* (left) and R3\* (right) together with outer rows R1 (far left) and R4 (far right) used in sampling for yield estimate.

**DESCRIPTION AND PERFORMANCE OF JAMAICAN SCOTCH BONNET PEPPER  
[*CAPSICUM CHINENSE* (JACQ.)]**

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**ABSTRACT:** Jamaican Scotch Bonnet pepper (*Capsicum chinense* Jacq.) is an important non-traditional crop with exports of fresh fruits accruing US\$1M/ annum. It is also an essential ingredient in the world's famous Jamaican Jerk Seasoning, sauces and other dishes. Internationally, there is a major demand for Scotch Bonnet peppers, attracting premium prices in the North American and European markets. A review of the literature showed that there is marked confusion as to what constitutes Jamaican Scotch Bonnet pepper. As a result of this, various peppers are presented and sold in the overseas market as Jamaican Scotch Bonnet pepper. Recognizing this, the Ministry of Agriculture initiated a series of trials between 1990 and 2000 to characterize and evaluate the pepper. Resulting from this work, a descriptor standard has been developed for Scotch Bonnet. It is erect in growth habit, with bonnet-shaped fruits with 3-4 locules. A typical fruit is 2.5cm long and 3.5cm wide, very pungent with an unmistakable aroma, and matures from green to orange/yellow at ripening. At spacing of 0.9m x 0.9m, yields of 23,400 kg per ha may be realized. The plant is highly tolerant to the root knot nematode (*Meloidogyne incognita*), but highly susceptible to Tobacco Etch Virus and Potato Virus Y infections.

**EVALUACION DE BANANOS LOCALES E INTRODUCIDOS BAJO CONDICIONES DE PRODUCCION ORGANICA**

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Se realizó una investigación en la Estación Experimental Ysura del Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF) durante el período septiembre 2001 y mayo 2003. El objetivo fue evaluar clones e híbridos elites de Banano, locales e introducidos con alto potencial productivo. El suelo es un aluvión con textura franca. Se utilizó un diseño de bloques completos al azar con 9 tratamientos y 4 repeticiones. La densidad de población fue de 2,500 plantas ha<sup>-1</sup>. Los clones introducidos evaluados fueron: FHIA 01, FHIA 02, FHIA 18, FHIA 23, IRFA 909 el IRFA 910; los clones locales: Sedita, Manchoso y Gran Enano. El suelo se preparó con tractor mediante tres pases de rastra y surqueo. Se utilizaron plantas producidas en vivero. Se irrigó cada 15 días y las malezas se controlaron manualmente. Se aplicaron 2 libras planta<sup>-1</sup> gallinaza descompuesta y 1 libra planta<sup>-1</sup> de sulfato de potasio y sulfato de magnesio a todos los clones. Las variables analizadas fueron: altura de la planta (m), peso del racimo con raquis (kg), número de manos y número de frutos por racimo. Se analizó la varianza de los datos al 5 y 1%. Para la comparación de medias se realizó Duncan al 5%. El clon Sedita y el híbrido FHIA 23 tuvieron la mayor altura que los demás. Los racimos de FHIA 01, Gran enano y FHIA 23 alcanzaron el mayor peso del racimo con 21.4, 19.4 y 17.7 Kg., respectivamente. El FHIA 23 obtuvo el mayor número de manos (9) por racimo. Este híbrido, también tuvo el mayor número de frutos con 136 frutos. Los híbridos introducidos FHIA 01, FHIA 23 y el clon local Gran Enano tuvieron mayor peso por racimo.



**WHOLE FARM RESEARCH ON AN INTEGRATED AQUACULTURE/HORTICULTURE ENTERPRISE FOR SMALL ISLANDS**

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**ABSTRACT:** Caribbean agriculture faces growing challenges from limited land and water resources, low soil fertility, cheap imports, and high shipping costs. Output in the US Virgin Islands continues to recede. To stem this decline, the University established a small experimental farm that combines the strengths of integrated systems with multiple products and value-added marketing to demonstrate a profitable enterprise. The 2 ha farm harvests rainfall to produce fish and horticultural products. It consists of: (1) a 4200 m<sup>2</sup> catchment for collecting rainfall; (2) a 500 m<sup>3</sup> storage pond; (3) seven 80 m<sup>3</sup> fiberglass fish tanks; (4) a 150 m<sup>3</sup> effluent pond; (5) 1.2 ha of crops; and (6) a distribution system for water and effluent. Rainwater is used for fish culture and the effluent is sent to crops via drip irrigation. We rotate annual and semi-perennial crops with soil-improving legumes. During two years of construction, preliminary plantings produced 22,000 kg of produce that was sold to wholesale markets for \$33,500. We are now refining the crop mix, establishing high value marketing channels, increasing productivity, and improving the rotational sequence. Water budgeting and financial analysis will allow us to establish design criteria for more efficient and profitable integrated farms in the future.

**DIFFERENCES IN VEGETABLE CROPS YIELD RESPONSE TO COMPOSTED WASTE AS THE SOIL AMENDMENT IN URBAN GARDENING**

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**ABSTRACT:** To determine the feasibility of using composted wastes as soil amendments for growing vegetables vs. the conventional use of commercial fertilizer in urban gardens, both cool and warm season vegetable crops were grown in plots amended with composted yard waste, cow manure or commercial fertilizer (10-10-10). Both composted materials were applied at a rate of 44,800 kg/ha and the fertilizer (control plots) at 336 kg/ha. Crops grown were the cool season varieties broccoli, cabbage, lettuce, and onions while warm season varieties were bell peppers, collard greens, snap beans, and tomatoes. Seedlings were grown in a greenhouse and then transplanted in field plots when they were six weeks old. Cool season crops were planted on April 25 and warm season on May 10. Throughout the growing season, low-input sustainable techniques were used for crop maintenance so that no chemical pesticides were applied. Results showed that most of the varieties grown produced yields equal to or greater in the compost amended than in the fertilizer treated plots. Yield of vegetable crops showed significant varietal differences in yield responses to the composted wastes as soil amendments. For example, in Experiment II it can be seen that the yield of onions was about 24% higher in the Leagfro amended plots while in Experiment II the yield of tomatoes was 44% more in the composted amended plots. Generally, the vegetable crop varieties grown in soil amended with composted yard waste and cow manure produced yield that were equal to and sometimes exceeded that produced by plots amended with the commercial fertilizer (10-10-10).

**INTRODUCTION**

For the past decade, modern agriculture has been confronting a system in which “urban sprawl” is increasing and the gap between sparsely populated rural cropping systems and metropolitan areas has vastly decreased. More importantly, increase in agricultural activity within urban areas has been fueled by the demand for fresh vegetables by emigrees from rural areas (Garnett, 1996; Liebhardt et al., 1989; Weir and Allen, 1997). These emigrees from rural areas bring their crop producing desires with them and thus try to grow vegetable crops wherever they can (Liebhardt et al., 1989; Steele, 1996). A major deterrent to the production of vegetables in these garden areas is the lack of available land. In some metropolitan areas, this lack of garden space is partially alleviated by the use of abandoned and/or vacant lots (Garnett, 1996).

Since urban gardening is usually done in highly populated and small land areas, sustainable low-input techniques which rely on lower rates of fertilizer and pesticides application would be the more sensible cultural practice to use in growing vegetables in these gardens. Low input techniques are highly desirable in urban areas because of poor environmental quality brought on by high population density. These techniques improve the environment by improving land use and recycling waste (Smit and Nasr, 1992). Besides helping to clean up our environment, solid wastes (plant and animal) when composted have the potential to become viable sources of soil amendments in crop production (Dixon et al., 1995; Neuger, 1996). A

study near the city of Cleveland showed that composted waste from nearby businesses was successfully used for commercial fertilizer in the growing of crops in the metropolitan area (Neuger, 1996). In another study, fertilizer use was reduced by the addition of animal waste as a nitrogen source in crop production (Smit and Nasr, 1992). At The University of the District of Columbia, Washington, DC, Weir and Allen, 1997 and Dixon et al., 1995 successfully grew several cool and warm season vegetables using composted yard waste and biosolids composts as soil amendments.

While it has been shown that composted waste can successfully grow vegetables, there is a need to determine the yield response of different vegetables when grown in plots where composted waste was the soil amendment. Therefore, the purpose of this study was to evaluate the effect of two sources of composted waste as soil amendments in the production of several vegetable crops grown in a metropolitan area such as the District of Columbia.

## MATERIALS AND METHODS

The study was conducted over a period of two years (FY 2001-2002) at the University's Muirkirk Experiment Station in Beltsville, MD. Soil type at the station is an acid silt loam, classified locally as Christiana silt loam. The experimental design used was a randomized complete block (RCBD) consisting of three treatments and three replications per treatment. Treatments were composted cow manure from the Beltsville Agricultural Research Center in Beltsville, Maryland and composted yard waste (Leafgro) produced by the Maryland Environmental Center in Upper Marlboro, MD. Both the composted cow manure and yard waste were applied at a rate of 44,800 kg/ha. Plots in which commercial fertilizer (10-10-10) was applied at a rate of 336 kg/ha were used as the control. Main plots were composted waste and fertilizer treatments and vegetable crop varieties were subplots. Each sub-plot was 3m x 3m consisting of three rows each 91 cm wide. Crops used in the study were the warm season varieties such as bell peppers (*Capsicum annuum* var California wonder), collard greens (*Brassica oleracea* var Georgia) and snap beans (*Phaseolus vulgaris* var Kentucky wonder). Cool season varieties were broccoli (*Brassica oleracea* var premium crop), cabbage (*Brassica oleracea*), lettuce (*Lactuca sativa* var Iceberg), and onions (*Allium cepa* var Sweet spanish) (Table 1).

Both composted waste and fertilizer were broadcasted on seed beds and disked into the soil at a depth of three inches. After soil amendments were applied to seed beds and thoroughly mixed into the soil, samples were taken from each block and analyzed at the University of Maryland Soil Laboratory for pH level, percent of organic matter (% OM), and nitrogen concentration (Table 2). No herbicides were applied; therefore, only mechanical weed control (small manually operated garden cultivator and hoeing) were used throughout the field study. Seeds were germinated in a greenhouse and immediately after germination transferred to 7.6 cm diameter plastic pots (medium used was Pro-Mix, a potting mixture produced by Premier Horticulture, Inc., Quakertown, PA 18951, USA).

Seedlings were transplanted into field plots when they were six weeks old. Planting times for both years were April 25 for cool season crops and May 10 for the warm season crops. Within row spacing for cool season crops was 38 cm between each plant but varied slightly for warm season crops. Bell peppers and collards were planted 46 cm apart while snap beans were spaced 30 cm and tomatoes spaced 76 cm apart. During the growing season, field plots were maintained with limited cultural inputs. Data collected for analysis were the fresh weights of

heads from broccoli, cabbage and lettuce, mature bulbs of onions, leaves of collard greens, pods of snap beans and ripe tomatoes.

## RESULTS AND DISCUSSION

For both cool and warm season crops, yield response to the composted amendments depended on crop variety and environmental conditions existing in the field. Highest yield produced by onions in Experiment I was in the fertilizer amended plots. In Experiment II, the onion crop yield was highest in plots amended by leafgro (Table 3). In this experiment yield of onions was approximately 24% higher in the leafgro amended plots (Table 3). Lettuce produced its highest yield in the leafgro amended plots and lowest in the fertilizer treated ones in Experiment I (Table 3). In Experiment II, there were no significant differences in vegetative yield between the composted cow manure and the fertilizer (10-10-10) amended plots (Table 3).

Unlike lettuce, broccoli showed a significantly greater vegetative growth in the fertilizer amended plots than either in the composted cow manure or the leafgro treated plots. No data was obtained for this crop in Experiment II because plants were completely defoliated by wildlife (possibly ground hogs and rabbits). In Experiment I vegetative growth for cabbage was best in the fertilizer amended plots. Heads were larger in these plots than those in either the cow manure or the leafgro treated plots. In Experiment II, yield of cabbage in terms of head weight showed no significant differences between cow manure, leafgro and fertilizer amended plots (Table 3).

As indicated before, yield response of warm season crops in the compost amended plots depended on the variety. In Experiment I, yield of bell pepper showed no significant difference between that produced in the leafgro and fertilizer (control) and the leafgro amended plots (Table 4). Yield response by this crop in Experiment II was strikingly different because the lowest was produced in the fertilizer amended plots and highest in the leafgro treated plots (Table 4).

Vegetative yield of collard greens was significantly higher in the fertilizer amended plots in Experiment I but there were no significant differences in yield in either the composted amended plots or the fertilizer treated plots (Table 4). The favorable yield response of collard greens to all three soil amendments in Experiment II is attributable to the fact that this crop was very tolerable to the high temperatures and rainfall during the period May through August of the year 2002. Yield of snap beans was considerably higher in Experiment I (FY 2001) with the highest being produced in the fertilizer amended plots (Table 4).

The low yield in Experiment II was attributable to a severe attack of fungus disease (data not shown). Tomato plants produced significantly higher yield in the composted amended plots than in the control plots (fertilizer amended). For example, in Experiment II tomato plants produced approximately 44% more in the composted cow manure plots than in the fertilizer amended ones (Table 4). In both experiments, the soil organic matter concentration in plots amended with composted cow manure was higher than plots treated with commercial fertilizer (Table 2). In Experiment II, it should also be noted that both soil OM and nitrogen concentrations were higher than in Experiment I for plots given all three amendments (Table 2).

The higher levels of OM and nitrogen observed in Experiment II are attributable to the fact that these plots had more vegetative cover, which was turned under in the fall of FY 2001 and early spring of 2002. Yield response of the cool season vegetable crop varieties studied also followed this same OM and soil nitrogen concentration relationship except that cabbage total yield in Experiment II was higher than that obtained in Experiment I (Table 3, Figures 1 and 2). It should also be pointed out that the lower yield produced by the cool season crops lettuce,

broccoli and cabbage in the leafgro amended plots in Experiment I could be attributable to the relatively low OM and nitrate concentration (Table 2, Figure 1) in the soil.

This study has demonstrated that composted waste materials such as yard waste and cow manure can be successfully used in growing vegetable crops. Preliminary studies of others such as Weir and Allen 1997, Neuger 1996, and Smit and Nasr 1992 have supported these findings. However, it should be pointed out that the degree to which this composted waste can produce yields comparable to commercial fertilizer as the soil amendment depend on the crop variety and existing climatic conditions. For example, during experimental period (FY 2001-2002) the growing seasons were dominated by short spring seasons where temperatures were constantly in the range of 85-90° F followed by the usual hot summer months. Under this type of weather conditions, cool season crops such as broccoli and lettuce do not thrive very well. In this study, broccoli and lettuce grew well in early April. However, by the end of April to the first week in May when plants were just forming heads, most of them “bolted” and thus produced no marketable yield.

Unlike the cool season crops, warm season varieties such as bell peppers, collards and tomatoes were not adversely affected by the warm summer temperature and continued to grow well into the warmer climate of August to September. The yields of bell peppers and snap beans in the cow manure and fertilizer amended plots were much lower than that generally produced in the leafgro treated plots. This was particularly shown in Experiment II where the low yields of 12.9 and 9.8 kg/m<sup>2</sup> in the fertilizer amended plots were found for bell peppers and snap beans, respectively (Table 4, Figure 2). The low yields of these two warm season crops may be due to disease infestation during a rainy period in late June. Bell peppers were severely infected by anthracnose and the snap beans by what appeared to be the tobacco mosaic virus and fusarium wilt (data not shown).

## CONCLUSION

Based on this study, it can be seen that composted waste materials can be used as viable soil amendments in growing garden vegetables. Varieties grown in soil amended by composted yard waste and cow manure produced yields that were either equal to or sometimes significantly more than when commercial fertilizer was used as the soil amendment. However, to maximize productivity by using these composted materials as soil amendments, care should be taken to ascertain that adaptable varieties are chosen since they differ in their growth response to the composted soil amendments. Additionally, composted animal waste such as cow manure is often a host for various diseases, therefore, care should be taken to select varieties that are resistant to various bacterial, fungal and viral diseases. This is a critical issue since with urban gardening crops are grown under intensive conditions. Under these conditions, cultural practices such as rotation are not feasible and thus disease organisms tend to build up in seed beds. Although these problems can arise, with careful management, vegetable crops can be successfully grown with composted waste as the soil amendment. However, even if yields are not as good as when commercial fertilizer is used, it should be noted that benefits can be gained by the gardener since a cleaner environment can be derived when recycled materials are disposed of as soil amendments.

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Table 1. Composted waste and crops studied.

Composted Waste	Crops	
	Cool Season	Warm Season
Composted Yard Waste	Onion	Bell pepper
	Lettuce	Collard greens
	Broccoli	Snap beans
	Cabbage	Tomato
Composted Cow Manure	Onion	Bell pepper
	Lettuce	Collard greens
	Broccoli	Snap beans
	Cabbage	Tomato
Fertilizer (10-10-10)	Onion	Bell pepper
	Lettuce	Collard greens
	Broccoli	Snap beans
	Cabbage	Tomato

Table 2. Soil pH, organic matter and nitrate nitrogen levels after the addition of lime and compost as soil amendments.

Experiment No.	Soil Amendment	Soil Nutritional Components		
		pH	% OM	NO <sub>3</sub> (PPM)
I, FY 2001	Composted Cow Manure	7.5	3.7	16.6
	Leafgro	7.5	2.8	6.8
	Fertilizer	7.5	2.8	13.4
II, FY 2002	Composted Cow Manure	7.0	4.8	42.0
	Leafgro	6.6	5.4	35.1
	Fertilizer (10-10-10)	6.4	3.6	35.6

Table 3. Differences in the yield of cool season crops when composted waste is used as soil amendment.

Crop	Soil Amendment	Total Yield (kg/10m <sup>2</sup> )	
		Exp #1	Exp #2
Onion	Cow Manure	7.5	13.9
	Leafgro	14.3	16.4
	Fertilizer	20.2	12.5
Lettuce	Cow Manure	14.0	36.6
	Leafgro	17.2	31.8
	Fertilizer	11.4	37.0
Broccoli	Cow Manure	19.1	_*
	Leafgro	14.7	-
	Fertilizer	35.6	-
Cabbage	Cow Manure	37.9	60.5
	Leafgro	31.5	57.5
	Fertilizer	81.5	53.0
LSD .05		5.4	2.1

\* Plants defoliated by wild life.

Table 4. Differences in the yield of warm season vegetable crops when composted waste used as the soil amended.

Crop	Soil Amendment	Yield (kg/10m <sup>2</sup> )	
		Exp #1	Exp #2
Bell pepper	Cow Manure	13.3	16.9
	Leafgro	22.5	33.3
	Fertilizer	27.2	12.9
Collard greens	Cow Manure	60.5	53.9
	Leafgro	57.6	55.2
	Fertilizer	69.6	59.3
Snap beans	Cow Manure	36.7	15.8
	Leafgro	41.7	13.6
	Fertilizer	56.8	9.8
Tomato	Cow Manure	36.6	145.2
	Leafgro	59.3	69.0
	Fertilizer	26.4	82.0
LSD .05		11.4	8.0



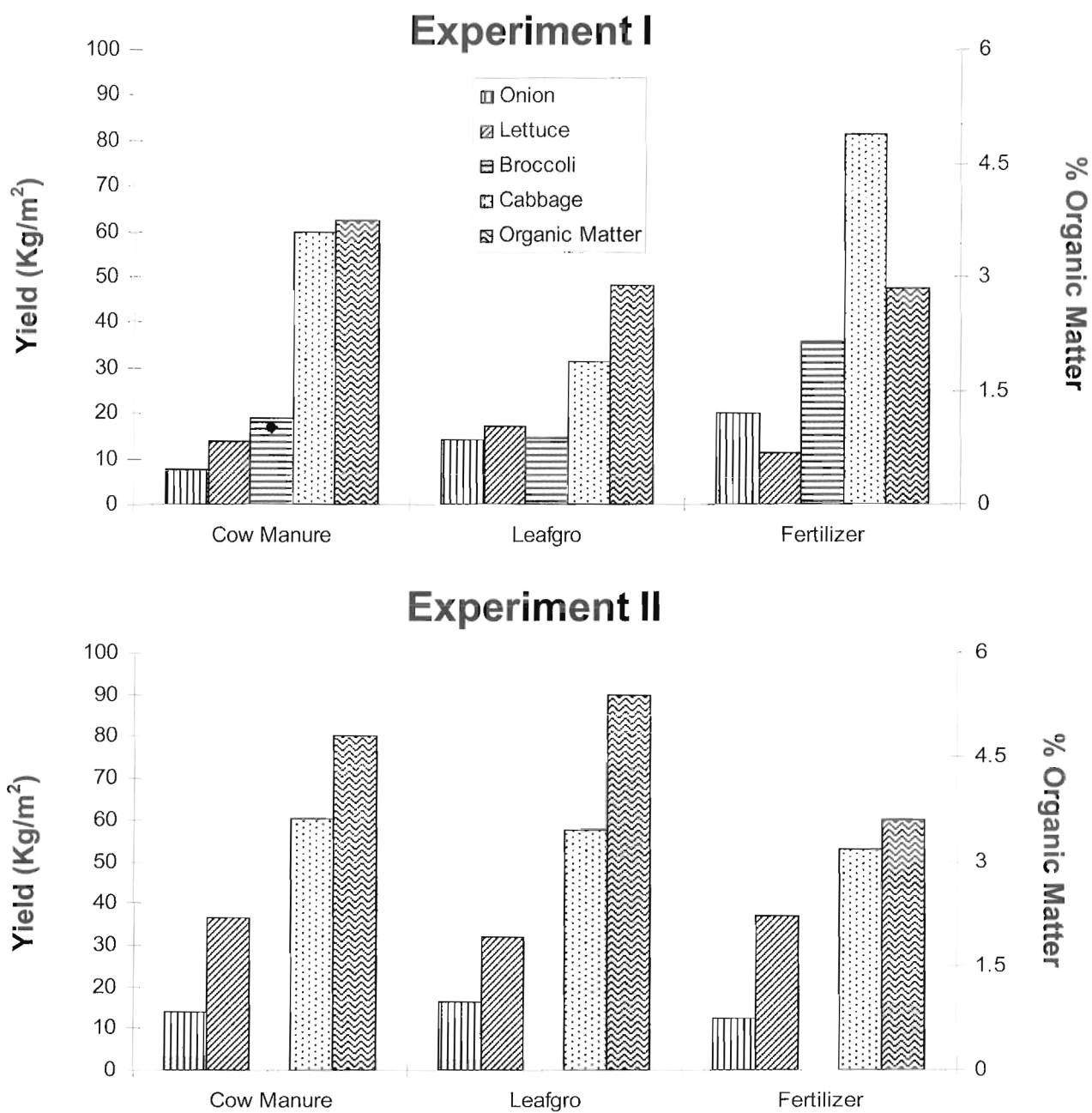
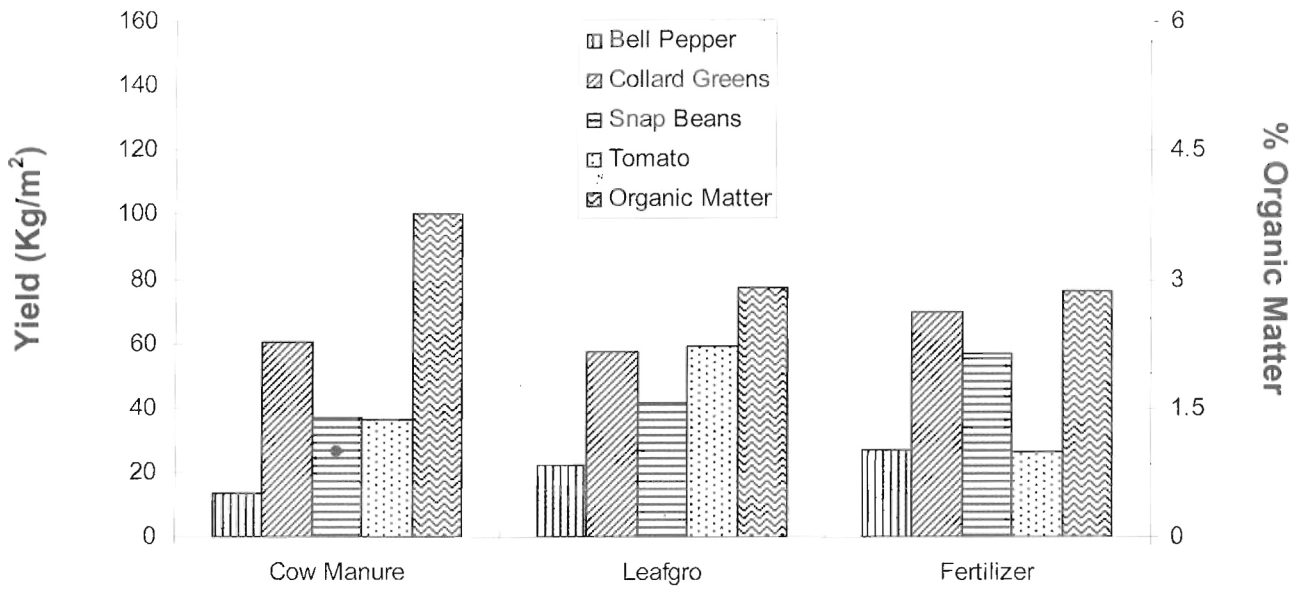


Figure 1. Relation of soil organic matter content to yield of warm season vegetable crops.

## Experiment I



## Experiment II

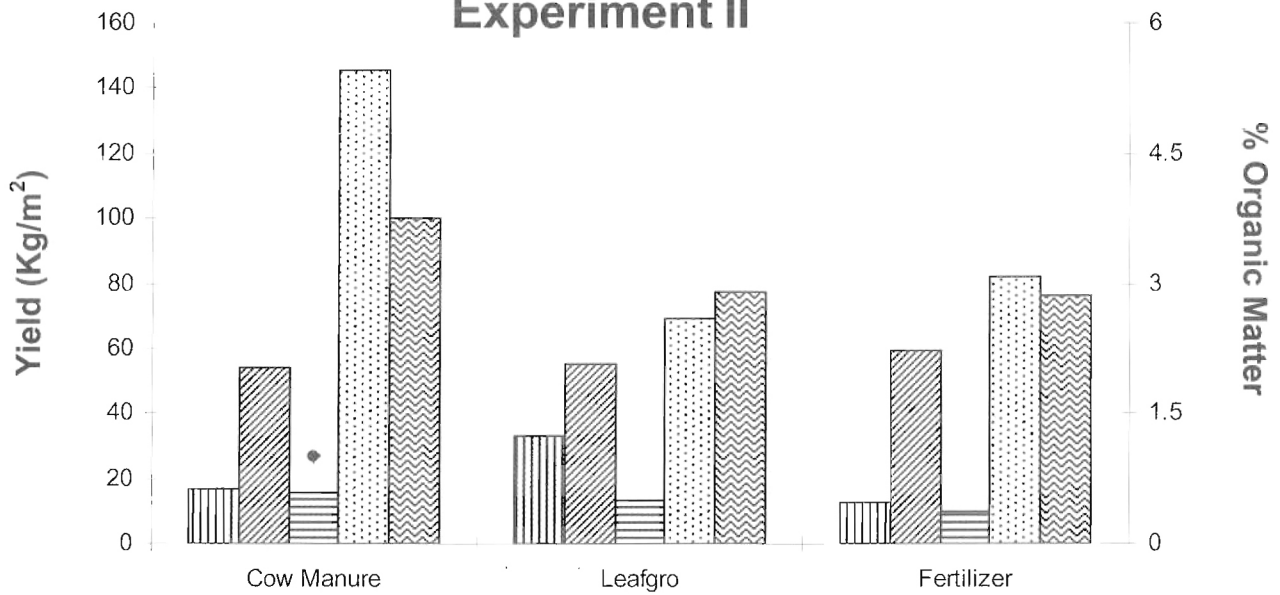


Figure 2. Relation of soil organic matter content to yield of cool season vegetable crops.

## ALCOHOL INSOLUBLE SOLIDS AND RELATIVE SWEETNESS FOR SWEETPOTATO VARIETIES RECOMMENDED FOR PUERTO RICO

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**ABSTRACT:** In sweetpotato, alcohol insoluble solids is an indirect measurement for starch. Recent efforts toward improvement of the tropical-type adapted to the Caribbean Basin relate to the assessment of starch and sugar concentration. The objective was to assess the starch content of two types of varieties recommended for use in Puerto Rico and to compare results to that of the standard variety. The results confirm the higher sweetness of the tropical-type variety as compared to that of the substaple-type. The increase in sweetness was accompanied by a decrease in alcohol insoluble solids. Percentage of alcohol insoluble solids for the substaple variety was significantly higher than that of the tropical-type indicating more starch concentration in the former. Dominicana, the standard variety used in Puerto Rico was statistically similar in alcohol insoluble solids to the substaple-type. It is reasonable to suggest that the Puerto Rican market has accepted a variety with a relatively high starch content.

### INTRODUCTION

Research documenting carbohydrate changes in sweetpotato (*Ipomoea batatas*) roots dates back to the 1910s (Hasselbring and Hawkins, 1915). In 1920, there was a report on Diastase (now Beta-amylase), the enzyme involved in the conversion of starch into sugars (Gore, 1920). Carbohydrates constitute about 80 to 90% of the dry matter in sweetpotato root and are mainly composed of starch and sugars (Martin, 1986; Kays et al., 1989; Picha, 1985). Starch may vary from 50 to 73%, whereas sugars varied 5.8 to 14.9% (Babu, 1994). Increase in total sugars after heating comes from the thermal and enzymatic hydrolysis of starch (Kays et al., 1989; Babu, 1994).

Tropical-type varieties, of preference in the Antilles of the Caribbean Basin, have greater dry weight than the dessert-type varieties, commonly grown throughout the Southern US (La Bonte et al., 2000). As the dry matter in sweetpotato storage roots is directly correlated to starch content, tropical-type varieties tend to be starchier than the dessert-types. In sweetpotato, the alcohol insoluble solids (insoluble fraction after the ethanolic extraction of sugars) is an indirect measurement for starch (Wu et al., 1991; Walter Jr., 1992; Walter Jr. et al., 1997).

Recent efforts toward improvement of the tropical-type adapted to the Caribbean Basin relate to the assessment of starch and sugar concentration. Base line information on the relative starchiness of sweetpotato varieties used in Puerto Rico was obtained by Hernandez-Carrion (2001); parts of the results are presented herein. The specific objective of this study was to assess the starch content of two types of varieties recommended for use in Puerto Rico and to compare results to that of the standard variety. This work was conducted as part of a more ample effort for the establishment of quantitative criteria for the selection of new tropical-type varieties.

## MATERIALS AND METHODS

Storage roots were obtained from a field planted at the Juana Diaz Experiment Station farm of the University of Puerto Rico. Data obtained for varieties 'Miguela' and 'Viola' were used. 'Miguela' is a tropical-type variety selected during the 1960-70s (Badillo-Feliciano, 1976), whereas 'Viola' is a substaple-type variety (Martin, 1987). Results on alcohol insoluble solids for 'Dominicana' were included to be compared to those of the two former varieties. Dominicana is cream-fleshed and the standard variety used in Puerto Rico.

Plantings were in May and December 1999. After planting, standard management practices were followed (University of Puerto Rico - Estacion Experimental Agricola, 1997). Data presented was for storage roots harvested 162 days after planting. Roots weighing from 150 to 450 g were selected at random, and after curing were processed either raw, boiled or microwaved. Roots were processed as: i) boiling water for 30 minutes, ii) microwaved at maximum energy in a 2450 MHz microwave oven for 12 to 15 minutes or iii) neither boiled nor microwaved (plain raw). Once treatments were applied, flesh was removed from the center of the root, dried at 55°C and ground to pass a # 20 mesh for preparing a flour. The flour was placed in glass jars and frozen at -20°C until the extraction of sugars, the concentration of which was determined.

Sugars extraction was made by using boiling the flour in 80% ethanol for 5 minutes. Sugars; glucose, fructose, sucrose, and maltose, were determined by using a chromatograph system equipped with an autosampler and a refractive index detector. Procedures for sugar determinations followed those described by Picha (1985) as modified by Hernandez-Carrion (Hernandez-Carrion, 2001; Hernandez-Carrion et al., 2003). Concentration of sugars was used to calculate sucrose equivalents as a measurement of sweetness (Koehler and Kays, 1991). Once sugars were extracted, the insoluble solid fraction (the alcohol insoluble solids) were placed in a tarred weighing dish, dried in a convection oven at 55°C for 24 h then weighed for the alcohol insoluble solids determination. Alcohol insoluble solids were expressed as a percentage of the flour used for sugar extraction.

## RESULTS AND DISCUSSION

### Sucrose equivalents:

As expected, across the flesh-processing treatments, sucrose equivalents for the tropical-type 'Miguela' were higher than those for the substaple-type 'Viola' in both the May and the December plantings (Table 1). These results confirm the higher sweetness of the tropical-type as compared to that of the substaple-type. Except for 'Miguela' in the May planting, sucrose equivalents increased after boiling and microwaving (Table 1). Increase in whole sweetness after boiling and microwaving has been associated primarily with the increase in the concentration of maltose. This general pattern has previously been reported by Picha (1985), Koehler and Kays (1991) and Hernandez-Carrion et al., (2003) among other researchers. In this study the increase in sweetness after boiling and microwaving was accompanied by a decrease in alcohol insoluble solids ( $r = -0.26$ ) (Table 1). The decrease in alcohol insoluble solids after heating in a proportion similar to the increase in total sugars has previously been reported by Szyperski et al., (1986), Wu et al., (1991) and Walter Jr. et al., (1997) among others.

## Alcohol insoluble solids:

Starch is the main component of the dry matter in sweetpotato storage roots. As previously stated, in sweetpotato the alcohol insoluble solids is an accepted indirect measurement of starch (Wu et al., 1991; Walter Jr., 1992, Walter Jr. et al., 1997). Percentage of alcohol insoluble solids for the substaple variety 'Viola' was significantly higher than that of the tropical-type 'Miguela' indicating more starch concentration in the former (Table 1). 'Dominicana', the standard variety used in Puerto Rico, however, was statistically similar in alcohol insoluble solids to the substaple-type 'Viola' (Table 2). Because 'Dominicana' has been the dominant variety for more than a decade in Puerto Rico; and because it is similar in starch content to a substaple-type, it appears reasonable to suggest that the Puerto Rican market has accepted a variety with a relatively high starch content. However, it must be taken into account that classification of sweetpotato varieties into types is strictly arbitrary and that there is variation in characteristics of varieties within a particular type. Notwithstanding, if there is a change in market from a relatively low starch content such as that in 'Miguela' to an increased starch content such as that in 'Dominicana', our breeding program must take into account such changes.

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Table 1. Sucrose equivalents and alcohol insoluble solids (AIS) for sweetpotato varieties planted in two seasons <sup>1</sup>.

Season of Planting	Variety	Variety Type	Flesh Processing Treatments					
			Raw		Boiled		Microwaved	
			Sucrose Equivalents	AIS %	Sucrose Equivalents	AIS %	Sucrose Equivalents	AIS %
May	Viola	Substaple	2.5	90	4.2	78	5.4	77
	Miguela	Tropical	10.0	84	5.8	76	6.0	74
November	Viola	Substaple	2.8	93	4.0	75	5.1	77
	Miguela	Tropical	5.5	89	4.9	73	6.2	73

<sup>1</sup> Results in this table are a summary of those which were excerpted from Hernandez-Carrion (2001). Results for other varieties were omitted for the effects of these proceedings.

Table 2. Alcohol insoluble solids for three sweetpotato varieties planted at two seasons <sup>1</sup>.

Month of Planting	Variety	Flesh Processing Treatments		
		Raw	Boiled	Microwaved
		%		
May	Viola	90a <sup>2</sup>	78a	77a
	Dominicana	91a	76b	75ab
	Miguela	84b	76b	74b
November	Viola	93a	75a	77a
	Dominicana	92a	76a	76a
	Miguela	89b	73b	73b

<sup>1</sup> Results in this table are a summary of those which were excerpted from Hernandez-Carrion (2001). Results for other varieties were omitted for the effects of these proceedings.

<sup>2</sup> Means followed by the same letter are not significantly different.

**LAND TENURE MANAGEMENT: A KEY DETERMINANT IN SUSTAINABLE FARMING THE - EXAMPLE OF MARTINIQUE**

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**ABSTRACT:** For the past fifteen years the notion of sustainable farming has become a constant reference in defining rural development policies. For many years, this concept was assimilated to that of the reproducibility of eco-systems and social and economic factors were not taken into consideration. Yet, in Martinique, as in many other insular states in the Caribbean, control over the way farmland is managed is a prerequisite in defining any so-called sustainable farming policy. The analysis of changes in the use of farmland shows that the intergenerational transfer of land is not ensured: the usable agricultural area has decreased by 38% in less than thirty years, with nevertheless substantial spatial variations. In the same way, it seems that more than 50% of farms are not economically viable because of their size. In addition, different studies on farming practises show that the land tenure structures of the farms may constitute an obstacle to the application of environmentally friendly practises. To address this problem, many regulations, tools and operators have been implemented in recent decades and at different territorial levels. In spite of everything, because of insufficient political will due to the paradoxical position of farmers and of their representatives (who speak out “in the name of the farming profession” for the preservation of farmland, but whose interests at the individual level are that their land should be declassified as building land), most of these measures have not had the desired effects. For 3 or 4 years, new initiatives have seen the light of day (implementation of the control of land tenure structures and definition of local sustainable development plans). The future of agriculture in Martinique – and therefore its sustainability – will probably depend on the rigour with which these measures are applied.

**RÉSUMÉ:** Depuis une quinzaine d’années la notion d’agriculture durable est devenue une référence constante dans la définition des politiques de développement rural. Pendant de nombreuses années, ce concept a été assimilé à celui de reproductibilité des éco-systèmes et les facteurs sociaux et économiques ont été déconsidérés. Pourtant, en Martinique, comme dans de nombreux autres états insulaires de la Caraïbe, la maîtrise de la gestion du foncier agricole constitue un préalable incontournable à la définition de toute politique agricole dite durable. En effet, l’analyse de l’évolution du foncier agricole montre que la transmission inter-générationnelle du foncier n’est pas assurée : la surface agricole utilisée a diminué de 38% en moins de trente ans, avec toutefois de fortes variations spatiales. De même, il apparaît que plus de 50% des exploitations agricoles ne seraient pas viables d’un point de vue économique du fait de leur structure. En sus, différentes études sur les pratiques des agriculteurs mettent en évidence que les structures foncières des exploitations constitueraient un frein à l’application de pratiques plus respectueuses de l’environnement. Face à ce problème, de nombreux règlements, outils et opérateurs ont été mis en œuvre au cours des dernières décennies et cela, à différentes échelles du territoire. Malgré tout, du fait d’une volonté politique peu marquée et accentuée par la position paradoxale des agriculteurs et de leurs représentants (qui militent « au nom de la



profession agricole » pour une préservation du foncier agricole mais qui, individuellement, ont souvent intérêt à ce que leurs terres agricoles soient déclassées et déclarées constructibles), la plupart de ces mesures n'ont pas eu les effets escomptés. Depuis 3 ou 4 ans, de nouvelles initiatives ont vu le jour (application du contrôle des structures et définition de plans communaux de développement durable). L'avenir de l'agriculture martiniquaise - et donc sa durabilité - risque de dépendre fortement de la rigueur avec laquelle ces mesures seront appliquées.

## SUSTAINABLE FARMING AND THE LAND TENURE MANAGEMENT

During the last fifteen years, the notion of sustainable development, defined by Brundtland (1987) as being the capacity to satisfy “the needs of the present without compromising the ability of future generations to meet their own needs” has become a constant reference in defining public policies. At the international level, following the Rio Earth Summit in 1992, many discussions were held during the World Summit on Sustainable Development in Johannesburg (26<sup>th</sup> August – 4<sup>th</sup> September 2002). At the level of France, this concept which led to the launching, on 3<sup>rd</sup> June 2003, of a national strategy for sustainable development within the framework of the inter-ministerial committee for sustainable development, was gradually taken into account in the elaboration of many general and sector-related policies. In the case of the farming sector, and in reaction to certain negative effects of productivity-based policies implemented since the end of the Second World War (degradation of soils, water pollution, etc.), this concept has gradually been adopted (hence the notion of sustainable agriculture) and resulted in adoption of new laws (the agricultural planning act of 1999 which recognises the multifunctional nature of agriculture), the defining of measures intended to reduce the negative effects of agriculture on the environment (official recognition of integrated farming, law of 25<sup>th</sup> April 2002, for example) and a gradual change of outlook on the part of public research organisations, etc.

Many methods were suggested for evaluating the “sustainability” of farming systems. Initially, most of them were principally focused on the evaluation of the environmental impact of farming activities. The comparative analysis of twelve of these methods (based on indicators) conducted by Hayo M.G. van der Werf and Petit J. (2002) reveals that only five methods took into consideration economic aspects and only two studied social aspects. In the same way, within the OECD, whereas work was started in 1994 on agricultural-environmental indicators, it was only very recently that economic and social components were integrated. Thus, a first working document, “A Framework for Indicators for the Economic and Social Dimensions of Sustainable Agriculture and Rural Development” (*« Cadre pour des indicateurs relatifs aux dimensions économiques et sociales d'une agriculture et d'un développement durables »* -[SEC (2001) 266]) was presented in February 2001 to the Council of Ministers. Gradually taken into consideration was the fact that farming is an open system that maintains with its environment, in the wider sense of the term, four types of relations: ecological, economic, social and intergenerational. These relations prefigure the four “pillars” of sustainability, which are respectively: reproducibility, viability, livability, and transferability (in French *reproductibilité, viabilité, vivabilité et transmissibilité*, Landais, 1999) (Figure 1).

Land tenure management is one of the key elements of the fourth of these pillars, in other words, transferability. Land tenure is an indispensable form of capital for farming and is often extremely sought after. The problems of land tenure security have been the object of many seminars and discussions around the world such as, for example, within the Permanent

Interstates Committee for Drought Control in the Sahel (*Programme Majeur* on Natural Resource Management / UDL / praia+9 / Land Tenure and Sustainable Farming). Moreover, it seems evident that the structures and the modalities of land tenure management can have a very strong impact on the three other components. For example, the size of farms can constitute a key determinant in terms of their economic viability. In the same way, system of land ownership often have significant consequences on farming practises and, indirectly, on the reproducibility of the system.

Land tenure management is therefore one of the key determinants of sustainability in farming. This is especially the case in countries where land resources are limited as in most of the Caribbean island States. Martinique is definitely concerned by the issue of defining land tenure management modalities consistent with sustainable farming. This issue can be broken down into the following questions: How to ensure the quantitative preservation of farmland and therefore permit the transferability of land tenure as well as the economic viability of farms? How to enable the qualitative preservation of farmland and therefore enable the reproducibility of eco-systems?

## RELATION BETWEEN LAND TENURE MANAGEMENT AND TRANSFERABILITY

The evolution in the agricultural surface area in a given territory is an indicator of the degree of transferability between generations of farmland and therefore of the sustainability of agriculture. A quantitative regression of farmland areas indicates, among other things, that not all of the conditions for transferability are filled and that, as a result, that farmland has not been managed in a sustainable manner.

In Martinique, between 1973 and 2000, the Usable Agricultural Area (UAA) decreased by more than 19000 ha, a regression of 38% (AGRESTE 2000) (Figure 2).

In other words:

- 2 ha of UAA have disappeared per day,
- which, on average, is equivalent to the disappearance of a farm every 2 days.

Evolution in UAA is extremely variable from a spatial point of view. Two practically homogenous areas present cases of greater decline:

- the Central-Caribbean sector (5 *communes*<sup>1</sup>) characterised by the presence of the agglomeration of Fort-de-France
- the southern coastal region (6 *communes*) characterised by its appeal for tourism and housing mainly because of the climate.

An analysis of the factors behind this evolution in UAA (Scherer, 2003) has made it possible to identify the importance of the following factors:

Endogenous factors:

- regression of grasslands, sugar cane, and vegetable crops
- decrease in the number of farms of under 2 ha and over 20 ha (Figure 5)
- proportion of the number of farmers aged over 65
- surface area in ownership and co-ownership

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<sup>1</sup> *Commune*: smallest administrative district in France.

Exogenous factors:

- contribution of the 40-59 age group within the population,
- the number of building permits delivered (mainly for individual homes)
- the number of revisions or changes made to the land-use plans (in French, *Plans d'Occupation des Sols - POS*).

This decline in UAA during at least thirty years clearly proves that there is no “transfer of farmland as such” from one generation to the next, even though the intensity of this phenomenon remains variable from a spatial point of view. This change is mainly due to a strong demand for land in other sectors than farming (especially housing) associated with supply, by farmers for whom real estate represents one of the main sources of revenue for retirement.

Differences in changes in UAA according to the *communes* is due to major spatial variations in the intensity of supply and demand, due respectively to:

- population change, to the regional development policies developed by the *communes*, etc.
- Also to the pedo-climatic conditions, to the degree of competitiveness of the different production sectors distributed in a non-homogenous manner over the whole of the territory, etc.

The combination of this supply and demand results in strong land speculation which in turn leads to high land prices; prices which make it difficult for young farmers to acquire farmland. This lack of transfer of farmland may, in the absence of any measures to counter this evolution, be the first factor in the disappearance (and therefore in the un-sustainability) of farming in Martinique. According to André Saurin, if the current trend continues, “Martinique will be an island without agricultural lands in 2030!”

## THE RELATION BETWEEN LAND TENURE MANAGEMENT AND VIABILITY

The economic viability of farms depends greatly, even if it obviously is not the only factor, on the surface area of the farm. A simple linear model of farming income for a given type of farm (family farm, company farm, etc.) and a category of surfaces (between 5 and 10 ha, for example, for irrigated banana farming) has made it possible to determine, for each type of farm production considered, the minimum surface required for a farmer to be able to make a decent living, in other words that the farm should provide an annual income of 15,000 euros (Figure 4).

This model, based on advice from experts, repeated many times has made it possible to determine surface area thresholds beneath which the economic viability of a farm remains uncertain. Examples of the main thresholds are:

- Banana: 7.5 ha with irrigation (from 8.5 to 20 ha, without irrigation, according to where the farm is situated)
- Sugar cane: 8 ha
- Pineapple: 4 ha
- Arboriculture: 7 ha
- Vegetable farming: 2 ha

By comparing these results with the distribution of farms according to their surface area (DAF, 2001) it appears that at least half the farms in Martinique are not viable economically because they are too small. Analysis of the evolution in the number of farms according to their

surface area tends to confirm the non-viability of a large number of small farms : 76% of farms under 2 ha in area disappeared between 1973 and 2000. At this level, it should be noted that the disappearance of farms of less than 2 ha was one of the major determining factors in the reduction in UAA in Martinique (cf. “endogenous factors”).

This structuring of farms is one of the main factors behind the un-sustainability of agriculture in Martinique. These small farms, which are generally not viable from an economic point of view, cannot be transferred to young farmers who would like to set themselves up. Because of that, when this type of farmer stops farming, the land is sometimes, but rarely, integrated within other existing farms. In most cases the land is left uncultivated until it is transferred to another activity sector in need of land, mainly housing.

## THE RELATION BETWEEN LAND TENURE MANAGEMENT AND REPRODUCIBILITY

To address new societal demands in terms of quality of products and the environment the French government and the European Union have initiated policies encouraging farmers to implement practises that are more respectful of the environment. Generally, the measures which have been proposed within the framework of these contractual policies (Agri-Environmental Measures, in French, *MAE : Mesures Agri-Environnementales*, Contract for Territorial Exploitation or *CTE : Contrat Territorial d'Exploitation*, and Contract for Sustainable Farming or *CAD : Contrat Agriculture Durable*) use up land. For example, if one considers the main produce of the island from an economic point of view, the banana, the only measure proposed in the framework of agri-environmental measures is the “fallowing + vitro-plant” system. Even if in the medium term it would seem that this practise does not lead to a reduction in farming revenue, when applied it nevertheless leads to a decline in income. But small farms cannot afford the slightest reduction in cash flow. Therefore it is virtually only the large farms that have been able to implement these types of measures.

This limiting factor of a small surface area also has significant consequences in terms of the management of soil fertility. For example, in a study (Etienne, 2001) conducted among vegetable farmers in Martinique, it appeared that practises in the management of soil fertility were greatly dependent on two characteristics concerning the land, size of the farm and the system of land ownership. Indeed, the usable agricultural area determines to a great extent the degree of intensification of production. Generally, the “small farmers” only produce vegetable and food crops whereas very often on the big farms, livestock farming is associated with such crops, enabling substantial organic input. In the same way, the type of tenure (and the degree of land tenure precariousness associated with it) is a strong determining factor of the time-frames within which farmers fix their objectives. Thus, sharecroppers or farmers without a leasehold manage their production system in the very short term: their objective is to produce a great deal in the shortest period of time without any real consideration for the consequences in terms of soil fertility. For example, for vegetable farming this generally results in an absence of soil improvement, that is the land is left fallow for very short periods between 2 crops: on average 2 months, sometimes more if climatic conditions impose it (whereas this period can be as long as 2 years on big farms associating livestock farming with vegetable farming); frequent working of the soil: on average, 5 passages of machines per year (compared with an average of 2 on big farms).

A similar situation has been observed concerning pineapple producers (Testut, 2001). Planters having cultivated pineapples during several years on the same plots all noted a decline

in yields, a sign of the exhaustion of the soil. This leads to them seeking to diversify with livestock farming (with fallow land used for pasture) and/or food and vegetable crops (with the input of manure) to let the soil “rest” and allow it to “recompose.” However, to implement such a strategy, most planters insist on the need to increase the size of their farms, since in terms of income, they cannot afford to decrease the surface areas for the production of pineapples and they do not have other land available.

Thus, it seems that land tenure management, because of the implications of the size of farms and of the type of tenure, can have a significant impact on the management of soil fertility. It is also obvious that these characteristics of land tenure structure have, in the same way as for the management of soil fertility, consequences on the use of pesticides. The fallowing of land (or certain crop rotations), conditioned by the usable area has impacts on parasite pressure and therefore on the use of pesticides. The land tenure structure of farms therefore is one of the determining factors concerning the amount of pollutants in an area. This has been largely demonstrated within the framework of the research programme on pollution caused by farming, conducted in the La Capot catchment basin (Houdart, 2003).

To conclude, it seems through these few examples that land tenure management does have consequences on the reproducibility of ecological systems and therefore, in the long term, on the sustainability of agriculture.

## WHAT MEASURES HAVE BEEN PROPOSED IN MARTINIQUE TO ADDRESS THIS PROBLEM?

As a response to competition between the farming sector and other land-consuming sectors:

According to the scale of the intervention there are two main tools for regulating land use applicable in Martinique: the Regional Development Plan (in French *SAR*, *Schéma d'Aménagement Régional*) which is applicable to the territory as a whole and the local urban plans/land-use plans (in French *PLU*, *Plan Local d'Urbanisme* which recently replaced the *POS*, *Plan d'Occupation des sols* ) defined at the level of each *commune*.

### The Regional Development Plan

Legislation (law of 2 August 1984) elaborated on the initiative and under the authority of the Regional Council. It fixes the basic orientations concerning the development, enhancement and protection of the environment. Even though the regional development plan developed in Martinique fixes, as an objective, the protection of a 40000 ha area of UAA, its impact has actually been rather limited, principally for the following reasons:

- Land-use plans have not always complied with regional development plans whereas, normally, this is mandatory.
- The 40.000 ha of UAA to be protected have not been identified, nor have they even been distributed quantitatively between the *communes*. Because of this, this “constraint”, applicable to all of the territory of Martinique, cannot easily be applied at the level of a *commune*, except if there is a strong political will to do so locally.

## The Land-Use Plans

The land-use plan is an urban planning document, created at the instigation of the *communes*, which establishes the general rules and rights concerning the use of land. In Martinique, 33 *communes* out of 34 have a land-use plan. However, the impact of such plans is particularly limited when it comes to the protection of farmland. Different reasons may explain this:

- The constant revision of the land-use plans (in 20 years, 24 *communes* have conducted at least one revision, 13 have conducted two revisions and 3 have conducted three revisions). This clearly illustrates the fact that the land-use plan in Martinique is not tool used for development planning but rather a tool for regularising actual situations.
- The fact that 30 to 40% of constructions have been made without building permits and that no sanctions have been applied.
- The non-compliance with regulations which forbid connecting illegal constructions to public utilities.

The lack of precision and instability of these land management tools that are the regional development plans and the land-use plans (or local urban plans) is illustrated by a lack of global land management planning. Because of this the real-estate market in Martinique today could literally be assimilated to a “free trade” market which, given the average income per hectare, benefits the housing market more than the farming sector.

At this level, it seems therefore that only a great deal of rigour in the definition and application of these tools will effectively protect farming land. Without seeking to implement an authoritarian solution, there is an urgent need to define precise rules for the use of land and to avoid constantly “changing” these rules. Such an approach could take inspiration from the “Commission for the Protection of Farmland in Quebec” which must give its authorisation before any piece of farmland may be declassified and whose authority seems to be strict and well respected.

In response to problems of transferability and economic viability of farms:

The Departmental master plan of land tenure structures (in French, *Shéma Directeur Départemental des Structures*, SDDS). After more than 20 years of operating illegally, the authorities in Martinique decided to implement a verification of land tenure structures. This master plan, developed by decentralised government and validated by farming representatives and the General Council, is aimed at defining the rules for the distribution of the rights to farm lands (and not property rights) between the different potential candidates. The principal rules which were selected in Martinique are the following:

- To favour the settling of young farmers (transferability)
- To favour the development of small farms into larger units in order to consolidate their economic viability (and indirectly to favour their reproducibility).

This verification of land tenure structures will enter into application in 2004.

## Rural Land Development Board

The main objective of the Rural Land Development Board (in French, *SAFER, Société d'Aménagement Foncier et Rural*) is to acquire and retrocede land in order to contribute to the constitution of viable farms. To do so it has the right of pre-emption. Between 1977 and 1992, SAFER Martinique acquired 1600 ha and retroceded 1800, which enabled the settling of a hundred farmers. Later, its activity declined considerably since its operations concerned only 23 ha in 1999 and 27 ha in 2000. With 1.5% of the real-estate market notified, the intervention of SAFER therefore remains modest and it seems difficult to imagine it increasing due to the following reasons:

- The organisation of sales to escape from the right of pre-emption (division, for example);
- The strategy among the “big landowners” of seeking land appreciation;
- Of “arrangements” between speculators and town halls;
- Of management problems encountered by SAFER (limited land and funding).

Many other tools or rules relating to land tenure management have been implemented in Martinique. For example the founding of a land bank by the Regional Council of Martinique, the law on fallow land, all of the laws concerning coastal land (in French *la zone des 50 pas*), the implementation of Agricultural Land Groupings (AGL), etc.

Currently, the latest political orientations seem to privilege the creation of public land administrations and the definition of farmland areas to be protected.

It seems, however, that the resolution of land management problems is to be found more in seeking to increase compliance with the laws and the implementation of policies announced than in developing new tools or operators. This requires the emergence of a true political will on the part of State administrations to ensure laws are complied with (building permits, connection to public utilities of housing without building permits, laws protecting coastal land, etc.), and also on the part of territorial authorities (*communes*, Regional Council and General Council) to define and implement regulations governing land use.

In order for these policies to be properly implemented, firstly, farmers and their representatives should truly promote and demand a real policy for the preservation of farmland. However, farmers often find themselves in a paradoxical situation since at the time of settling on their farms they demand access to land, and later many of them encourage land speculation: “the farm activity which is most profitable is the declassification of land within the context of land speculation!” This ambiguity is quite evident at the level of certain farmers’ unions which seek to preserve farmland whilst trying to limit as much as possible control over its management.

## CONCLUSION

The majority of the Caribbean States is or will soon be faced with a similar problem. High population growth, a large proportion of the working population in the farming sector, the development of infrastructures and housing, low competitiveness of the farming sector compared with other tropical countries, etc. are the characteristics encountered at varying degrees in all of the Caribbean islands. At first sight this phenomenon of the disappearance of farmland seems hard to reverse. It would therefore seem useful to learn from the experiences of neighbouring countries in order to avoid repeating the same mistakes.

On the other hand, one must not forget that the management of farmland does not only have an impact on the development and sustainability of farming. Because of the charm associated with farming activity (impact on the landscape, “local” production, agri-tourist activities, etc.), changes in farmland areas will have an impact on the development of tourism. In this respect, it should be noted that certain tourists who recently visited Martinique (especially people who had come 10 or 20 years earlier) expressed the opinion that there was “too much concrete”, that certain “landscapes were too spoiled”... in other words there is a risk that the sustainability of farming will correlate with the sustainability of tourism.

Of course, the sustainability of farming does not depend exclusively on land tenure management. Many other factors will also have to be taken into account, whether it is at the level of reproducibility (defining the best farming practises, for instance) or livability (better recognition of the farming profession). In a nutshell, controlling the management of farmland is a prerequisite for sustainable management.

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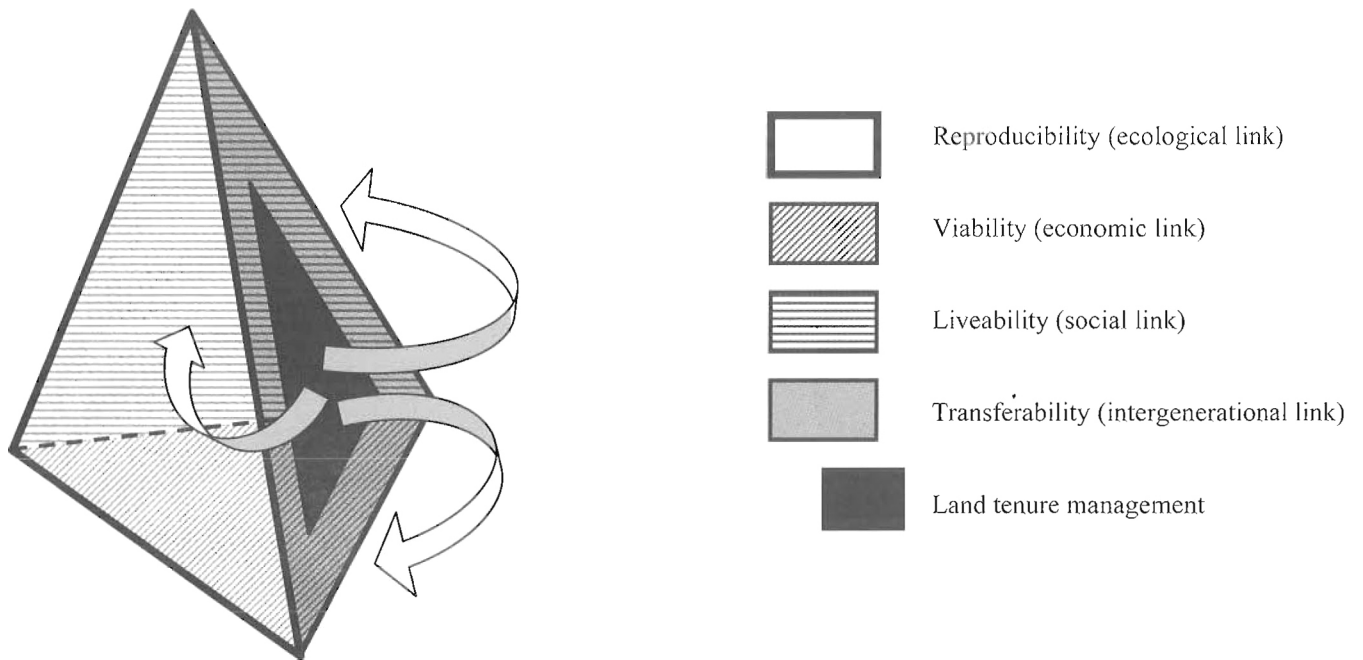


Figure 1. Importance of land tenure management within the main components of sustainable farming

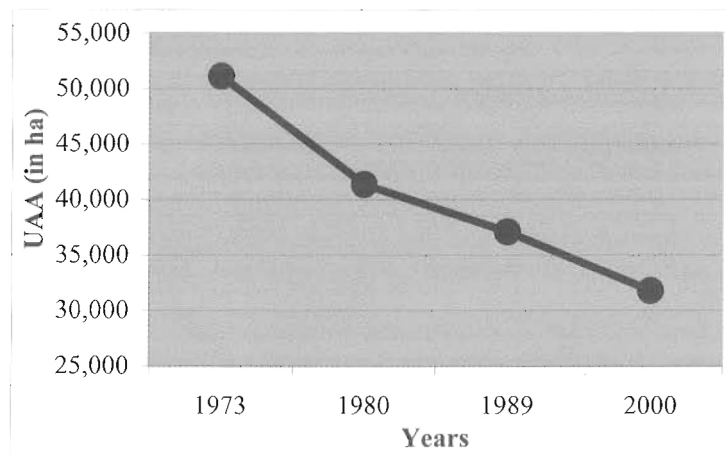


Figure 2. Evolution of UAA →

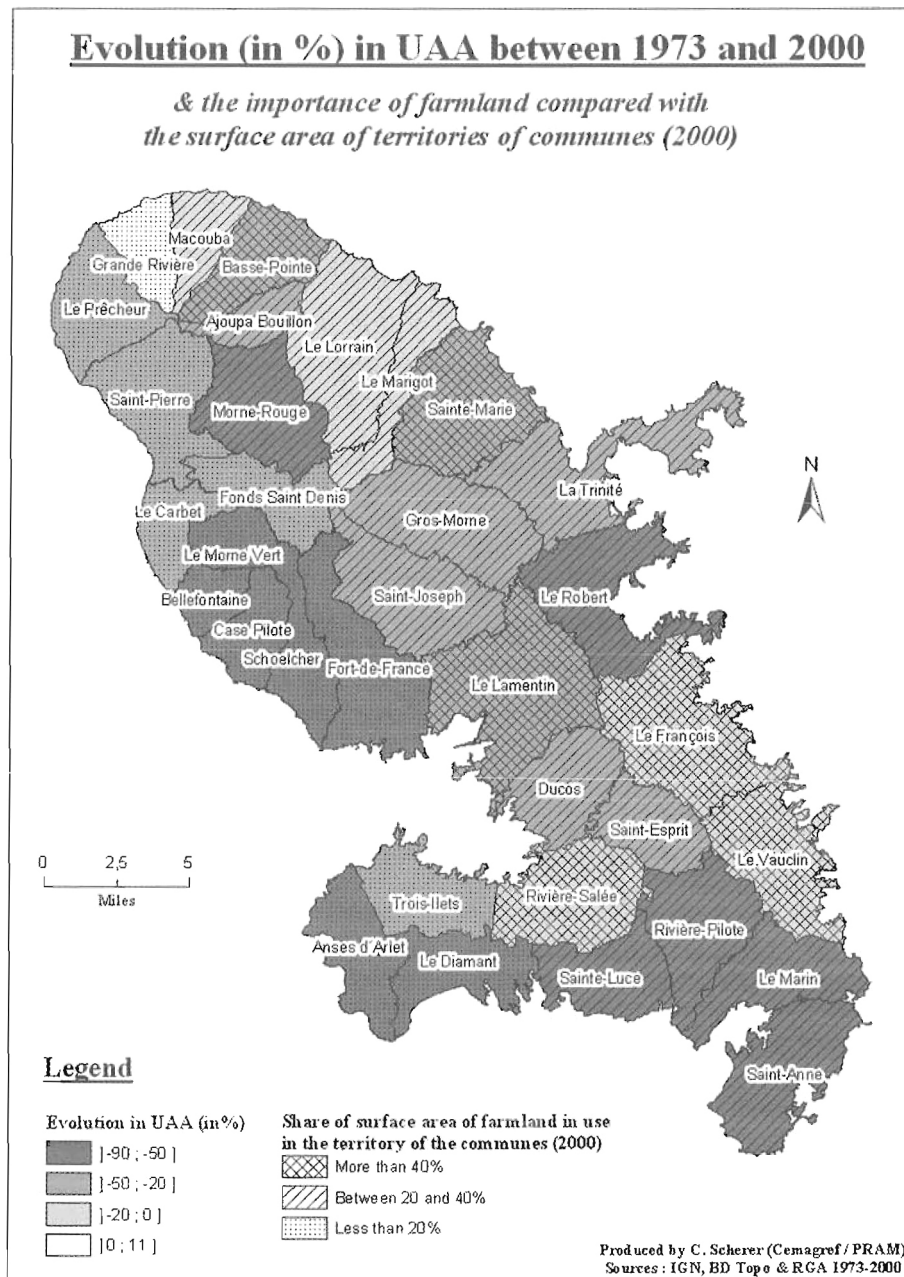


Figure 3. Evolution of UAA (in % and by *commune*)

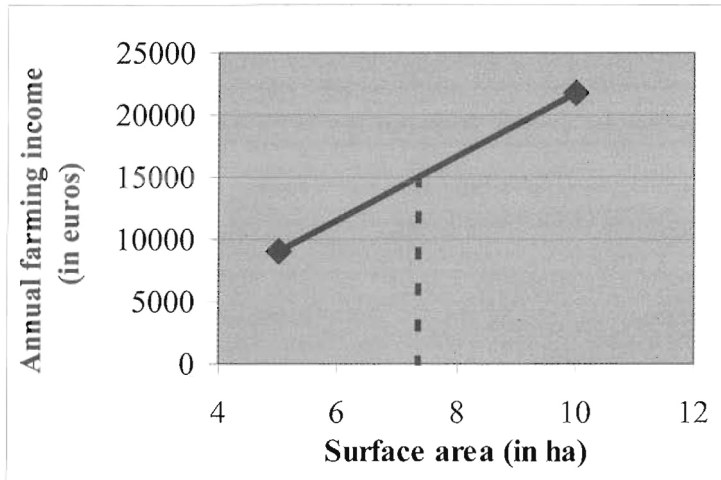


Figure 4. Annual farming income according to surface area.

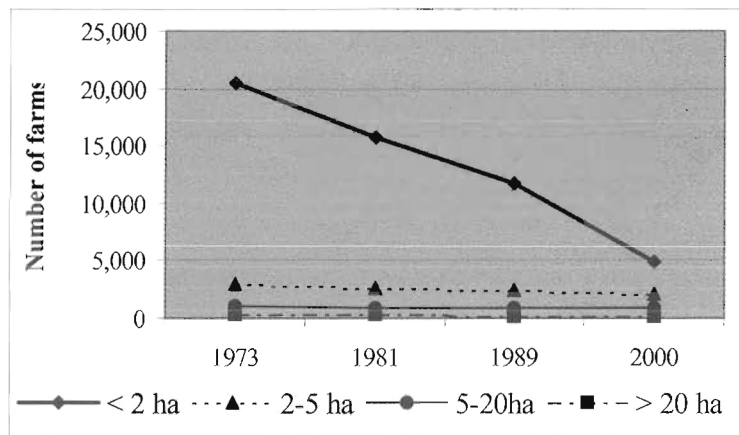


Figure 5. Evolution of the number of farms according to their surface area.

**WEIGHT OF GINGER (*ZINGIBER OFFICINALE*) PLANTING SETTS ON SPROUTING AND YIELD)**

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**ABSTRACT:** An experiment to determine the effect of seed sett weight of ginger (*Zingiber officinale*) rhizomes on its sprouting and yield was conducted at the Gurabo Agricultural Experiment Substation of the UPR from September 2003 to February 2004. Counts of ginger sprouts were made at 3, 4.5, 6, 9, 12.5, and 20 weeks after planting. At 4.5 weeks after planting, no differences were found in sprouting among the three heaviest seed sett treatments (112 to 126g, 84 to 98g, and 56 to 70g) which significantly produced more sprouts than the 28 to 42g and 14 to 27g seed setts. Sprout counts at 6, 9, 12.5, and 20 weeks after planting showed the same trends. At harvest (6 months after planting), yields were 5.56 kg/m<sup>2</sup> for the 84 to 98g setts, 4.93 kg/m<sup>2</sup> for the 112 to 126g setts, 3.21 kg/m<sup>2</sup> for the 28 to 42g setts, 2.62 kg/m<sup>2</sup> for the 14 to 27g setts without GA<sub>3</sub>. Results indicate that ginger seed setts of 52 to 70g weight should be used for planting.

**EVALUACION DE CLONES DE PLATANO (*MUSA SPP.*) COMERCIALES E INTRODUCIDOS EN EL SUROESTE DE LA REPUBLICA DOMINICANA**

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**RESUMEN:** Desde Octubre del 2001 a Marzo del 2003 se realizó un experimento en el campo experimental Palo Alto, Barahona con el objetivo de evaluar el comportamiento de clones locales de plátano (AAB) e híbridos (AAAB) introducidos. La región es clasificada como de clima tropical seco. Se utilizó un diseño de bloques completos al azar con 6 tratamientos y 3 repeticiones. La densidad de población utilizada fue de 2,500 plantas ha<sup>-1</sup>. Los clones locales evaluados fueron: Macho x Hembra Verde, Macho x Hembra Morado, Barahonero y Liborio. Los clones introducidos evaluados fueron FHIA 20 y FHIA 21. La preparación del suelo se hizo con tractor mediante tres pases de rastra y surqueo. El control de malezas se hizo de forma manual y químico. El riego se aplicó de acuerdo a los requerimientos del cultivo utilizando el sistema de melgas. La fertilización se realizó con la fórmula 15-6-25+1 Zn, en dos aplicaciones a 8 onzas planta<sup>-1</sup>. Las variables analizadas fueron: altura de planta, diámetro del pseudo tallo, peso de racimo, número de frutos por racimo y número de frutos comerciales. Se realizaron comparaciones de medias con la prueba de Duncan al 5%. Los clones más altos fueron Macho x Hembra Morado y Macho x Hembra Verde con 327.3 y 311.8 cm, respectivamente. El FHIA 21 y el Macho x Hembra Morado fueron los más vigorosos, con mayor diámetro del pseudo tallo (17.7 y 17.2 cm.). Los racimos de FHIA 21 y FHIA 20 con 17.4 y 16.6 kg, respectivamente, pesaron más que los clones locales y tuvieron más frutos por racimo (86 y 78 frutos, respectivamente). De los clones locales, el Macho x Hembra Morado fue el que obtuvo el mayor peso con 13 kg. Los clones Macho x Hembra Verde y Barahonero produjeron frutos más largo y con mayor diámetro que los híbridos FHIA 20 y FHIA 21.

**STRATEGIES TO PROMOTE THE SUSTAINABLE PRODUCTION OF PINEAPPLE (*ANANAS COMOSUS (L.) MERR*) CULTIVATION IN TRINIDAD AND TOBAGO**

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**ABSTRACT:** Pineapple is second only to citrus in the quantum of fresh fruit produced in Trinidad and Tobago. In 1994, the total land area in Trinidad under pineapple production was approximately 60 hectares. In Tableland, south Trinidad, approximately 250 hectares were cultivated in the year 2000. The rapid expansion in land clearing for increased pineapple cultivation continued and in 2004, approximately 470 hectares in Tableland are cultivated with pineapple. This lucrative crop, if sold at the present retail price of TT\$2.25 per kilogram, can contribute about TT\$19 million to the economy per annum. (TT\$6.25 = US\$1.00). The main production areas are established on heavy clays on sloping lands that are not ideally suited for pineapple growing. There is indiscriminate land clearing with no reference to slopes, soil or soil movement. Proper land preparation on the slopes is difficult, with accompanying problems of heavy run-off, water logging problems, land slippage, and erosion. The slow growing nature of the plant, the wide spacing used and reliance on persistent herbicides, applied at high rates, exposes the soil to the elements with disastrous consequences. As it exists, the resources are being degraded through non-sustainable practices. Fruit quality is less than optimum due to improper fertilizer usage and poor harvest and post harvest practices. Annual gluts are experienced and market possibilities through processed products have not been explored. This paper outlines strategies being undertaken by various institutions to promote pineapple production in a sustainable manner, such that all stakeholders in the commodity chain can continue to earn a livelihood in the medium and long term.

**Key words:** Pineapple cultivation, Conservation agriculture, Sustainable production, Land degradation

## INTRODUCTION

Commercial production of pineapple is not new to Trinidad, since the first pineapple canning plant in the world was situated in La Brea, southwest Trinidad (Barath, 1969). Production at the plant ceased due to the shortage of raw material caused by severe pest attack on the fruit.

Pineapple is the second most important fruit in production after citrus in Trinidad. In 1994, the total land area in Trinidad under pineapple production was approximately 60 ha (Baksh, 1994). In Tableland, south Trinidad, approximately 250 ha were cultivated in the year 2000 (Persad et al., 2001). The rapid expansion in land clearing for increased pineapple cultivation continued and in 2004, approximately 470 ha in Tableland are cultivated with pineapple (Florencia Gangaram - Extension Officer, Tableland, personal communication, 2004).

In Tableland, there are 60 pineapple farmers of which 35 are registered with the Tableland Pineapple Farmers Association (TPFA). Thirty-five percent of the lands are privately

owned, 30 per cent are rented, 10 per cent are ancestral lands, i.e. lands farmed by relatives of owners, and squatters farm 25 per cent.

Tableland farmers have opted to bulldoze cocoa estates and cultivate pineapple instead. Pineapple is the preferred crop because a higher profit margin can be obtained per hectare. A farmer earns \$TT 14000 ha<sup>-1</sup> per year, before expenses, from cocoa (*Theobroma cacao L.*) planted 1.8m x 1.8m. It is estimated that a pineapple farmer earns \$TT 36000 ha<sup>-1</sup> per year after expenses. The 470 hectares of pineapple can contribute \$TT 19 million to the economy per annum.

Cocoa trees were ideally suited for the sloping terrain of Tableland. The seedling trees effectively protected the slopes from the agents of erosion; with their vigorous taproots holding the soil together and the dense canopy shielding the soil surface from raindrop impact.

## FEATURES AND EFFECTS OF THE CURRENT PINEAPPLE PRODUCTION SYSTEM

### (a) Variety

The variety grown is a hybrid (Smooth Cayenne x Black Antigua) and is known locally as Tableland hybrid. The variety is quite popular with a high °Brix of 16.5-17.8 and a sweet, juicy internal fruit texture. It has a small crown to fruit size ratio. The fruit characteristics are shown in Table 1. The disadvantage of this variety is that with its conical shape, one cannot obtain a large number of premium slices compared to cylindrical shaped fruits like Smooth Cayenne, which is the most important variety in world trade.

### (b) Marketing

Approximately 85 percent of the pineapple produced are sold on the open market and consumed in the fresh state. Table 2 (CSO, 2003) shows that for the period 2000-2002, 11,317 kg of fresh and processed pineapple were imported (valued \$TT 138,356) compared to 150,126 kg exported (valued \$TT 976,937). Table 3 shows that for the same period, 1,310,126 kg of pineapple juice was imported (valued \$TT 7,831,315) compared to 378,895 kg exported (valued \$TT 3,315,710).

### (c) Agronomic practices

At Tableland, pineapple is grown on rolling, hilly topography on slopes ranging from 5° – 25°. The forest is bulldozed, then the land is ploughed and rotavated. This indiscriminate land clearing is done with no reference to slopes, soil or soil movement. The land is left bare and planting is done in June, which marks the onset of the rainy season. The removal of the cocoa and forest are very destructive operations on slopes and the newly loosened soil is very easily eroded by heavy rainfall.

The crop is fertilized with urea two months after planting. The ratoon crop is fertilized once with urea. For newly cleared lands, approximately two to three ratoons are obtained. Following this, the field is brush cut, ploughed, rotavated and replanted. One or a maximum of two ratoons are produced. The third cycle of production may result in one or no ratoons produced. With each successive cycle, the fruit weight from the crop and ratoon plants is



diminished. The use of the land at Tableland for short-term expedience has led to exploitation and degradation of the soil resources.

The Extension Services are of the view that the farmers are not keen to take on arduous, expensive conservation measures. They lack expertise, manpower and equipment to tackle the soil degradation problems in the large areas affected. Additionally, 60 per cent of the farmers do not own the land they cultivate. Where tenancy is insecure, farmers have little motivation to sustainably manage crop and land resources. Their main concern is the maximum extraction of resources from the land, with minimal inputs.

The farmer will then abandon this plot and clear a new site. With the rapid rate of expansion of hectarage, farmers are finding it increasingly difficult to find lands to expand cultivation. Farmers at Tableland prefer to farm on virgin land because of the good physical and chemical properties of the soil. There is a low seed bank and the pest and disease population is low. Consequently, fewer inputs are required to produce a successful crop. Land for purchasing or for rent is becoming increasingly scarce. Therefore, productivity per hectare has to be increased rather than opting to increase yield by expansion of hectarage under cultivation.

Some farmers are returning to the abandoned lands without the soil having a chance to regain its fertility. Others have opted to clear state lands.

#### (d) Soil characteristics

The principal soil type in pineapple-growing areas in the Tableland district is 177CD Talparo clay that belongs to the order Vertisol. The Talparo series belong to soils of the intermediate uplands (impeded internal drainage) and are generally found on hills and steep lands (Ali et al., 1973). On this soil, water percolation is slow due to the high percentage of clay (50-60% in the topsoil).

The Talparo series is not ideally suited for pineapple growing. In fact, the recommended land use is forest on the high slopes, with housing, industrial sites, food crops and sugarcane on the very low slopes. Conservation practices are recommended to prevent land slippage especially at the higher slopes (Ali et al., 1973). Talparo clay has poor drainage capabilities and low fertility. Proper land preparation on the slopes is difficult with accompanying problems of poor drainage, water logging, land slippage and erosion.

#### (e) Soil loss

The critical time for erosion is when the soil surface is bare and smoothest after ploughing and rotavating, and when rainfall intensity or duration is such that infiltration is exceeded (Evans, 1980). Large amounts of soil can be removed during the wet season.

A rapid reconnaissance survey was conducted during the period 13<sup>th</sup> – 15<sup>th</sup> June 2004 to study the effects of soil erosion on lands prepared for pineapple growing. This was done following 12 days of rainfall (1<sup>st</sup> – 12<sup>th</sup> June 2004) in which the average daily rainfall was 10.5 mm and the range was 0 mm – 37.5 mm.

Ten holdings were selected and the holdings ranged from two to four hectares. The total land area represented approximately 16 ha. This survey was done by the Fruits Department of the Central Experiment Station, Centeno. Slopes ranged from 10°-20°. Lands were cropped before and were ploughed and rotavated. Four of the holdings were bare and six had pineapple plants that were less than four months old. Sheet, rill erosion and soil detachment were seen on all

holdings. Gully erosion was observed on 30% of the holdings. There was deposition of silt sediments at the base of slopes. Evidence of water logging was seen at the bottom of all slopes. Erosion was caused by uncontrolled runoff water down the slopes.

Quantitative methods of measuring soil loss in the pineapple-growing areas have not been done. However, Georges (1976) compared soil loss on bare ploughed soil under plant and ratoon sugarcane on undulating land in south Trinidad (Table 4). The soil types compared were Talparo clay, Princes Town and Tarouba. The soil losses ( $\text{t ha}^{-1}$ ) on bare soil plots for the entire wet season (June- December) were measured.

The study also examined the effect of slope and length on soil loss by comparing two slopes ( $10\text{-}15^\circ$  and  $15\text{-}20^\circ$ ), and three lengths (4, 6 and 8m). Average soil loss on the Talparo series was  $65.45 \text{ t ha}^{-1}$ . This was more than three times that on the Tarouba series ( $24.31 \text{ t ha}^{-1}$ ) and about six times that on the Princes Town series ( $11.18 \text{ t ha}^{-1}$ ). Slope had no statistical significant effect on erosion. At  $10\text{-}15^\circ$ , soil loss ( $\text{t ha}^{-1}$ ) was  $78.29 \text{ t ha}^{-1}$  in Talparo clay compared to  $9.70$  and  $35.96 \text{ t ha}^{-1}$  with Princes Town and Tarouba respectively. The main effect of plot length on erosion was significant and negative on the three slopes. Soil loss on the 4m plots was greater than on the 6m and 8m plots.

Lindsay and Gumbs (1987) noted that accelerated soil erosion is a major limitation to sustained agricultural production on sloping lands. Various authors (Breckner, 1971 and Lindsay, 1979) have shown that soil losses due to erosion are high in Trinidad and soil conservation farming practices are imperative for slopes greater than  $6^\circ$ . These heavy annual losses on the sloping lands result in rapidly depleting productivity, which leads to irreversible soil degradation and a reduction in the overall natural resource base in the country.

#### (f) Loss of soil fertility

The chemical constituents of Talparo clay can undergo significant decline over time. Persad et al., (2001) compared the chemical constituents of Talparo clay in the year 2000 of the Poole-Tableland district in which pineapple was grown, with 1968 data on Talparo clay located in the adjoining La Gloria district (Table 5). Soil samples were taken at depths 0 – 30 cm. The results indicated significant reductions ( $P < 0.01$ ) in levels of pH, organic carbon, Nitrogen, Phosphorus, Calcium, Magnesium and Potassium.

Studies done by Persad et al., (2001) showed that nitrogen levels were generally adequate. As a rule, urea was the only fertilizer applied by farmers to the pineapple crop. The rate of application was 25g per plant, two months after planting. This is sometimes supplemented with foliar sprays.

Phosphate levels were high and were apparently associated with organic phosphates from previous estate crops such as cocoa. Calcium and magnesium levels were moderate and within acceptable levels for a new pineapple crop. However, potash levels were low for both the plant and ratoon crop. This suggests that there were depletion of soil reserves over time and lack of fertilization of present or previous crops (Persad et al., 2001).

## STRATEGIES TO PROMOTE SUSTAINABLE PRODUCTION

### (a) Conservation farming

The pineapple farmers of Tableland need to practice the basic tenets of conservation farming (FAO, 1989) in their hillside cultivation system. Conservation farming promotes sustainable production. It is a system of farming that protects the land from deterioration, yet increases or maintains farm production at the highest level to the benefit of the farmers.

According to FAO (1989), any farming system practiced on hillsides should take into account problems of rapid erosion caused by heavy and intense rainfall, quick runoff and steep topography. Problems arising from inappropriate land use and tillage that accelerate the rate of land degradation should be contemplated beforehand.

For hillside farming systems to be considered as conservation farming systems, they should be based (FAO, 1989) upon a land capability plan and land only used according to its capability. Correct use of land is the best means of erosion control. A farm plan should be produced which will serve as the basis for proper land use. The system should include conservation measures for each piece of land according to its erosion control needs. This might include conservation structures, agronomic measures, land capability and crop needs.

The system should include major farming and crop production activities with emphasis on soil cover, drainage and improvement of soil fertility and soil structure. Any farming practice that is destructive of land and environment should be discouraged. The farming system should incorporate better farm management practices and infrastructure such as farm roads, storage, marketing and maintenance practices for both conservation and infrastructure.

#### (b) Soil Conservation

Several studies in Trinidad have shown that soil conservation practices are farming imperatives for slopes greater than 6° (Georges, 1976; Lindsay, 1979 and Breckner, 1971). The lands with steep slopes require expensive storm channels, contour banks and drains, bench terraces and other conservation structures to sustain the soil resource. The heavy rainfall and low infiltration rates of the soil would require drainage channels to be constructed at intervals (Hudson, 1995). These would accommodate surface runoff and allow this runoff to move off the field with minimum soil loss. Proper drainage is critical to the successful growing of pineapple, as the root system is intolerant of poorly aerated soils (Malézieux and Bartholomew, 2003).

Farmer participation is the key to the success of any sustainable production programme. There is need to set up small conservation plots on farmers' holdings to demonstrate the effectiveness of recommended conservation measures in controlling erosion while cultivating pineapple. These plots can serve as training grounds for both farmers and Extension Officers. Technical assistance can be sourced from the Forestry Division and Soil Department of the Ministry of Agriculture and The University of the West Indies. Personnel should be well trained, qualified and experienced.

Soil conservation measures such as bench terracing, contouring and control of runoff water, involve heavy investment of labour and capital. The incentives (Table 6) offered by the state may not be sufficiently attractive for farmers to adopt recommended practices.

#### (c) Recommended Agronomic Measures

As growers aim for increased yield, much of the initial increase can come from improved practices, and not just application of nutrients to the soil. Many of these practices cost nothing.

For example, timeliness is important in land preparation, planting, weed and pest control, fertilizer application, floral induction and harvesting.

Other important considerations include the selection and pretreatment of healthy planting material to prevent introduction of pest and disease to the field. Grading of planting material according to size facilitates uniform flowering, fruiting and harvesting.

Significant quantities of vegetative residue remains at the end of the pineapple cycle and the amount and quantity of nutrients it contains is determined, at least in part, by the quantity of fertilizer applied during the crop cycle (Malézieux and Bartholomew, 2003). This residue can vary from 40-60 t ha<sup>-1</sup> on a dry-mass basis (Py et al., 1987). The incorporation of the residue by disking and ploughing could return substantial amounts of organic matter to the soil, as well as contribute significant amounts of nutrients to a subsequent crop of pineapple.

Planting at the appropriate spacing for Tableland hybrid is important since a planting density that is too low will expose the bare soil to the elements of erosion. Pineapple is an erosion- promoting plant. By virtue of its slow growth, the foliage does not provide a protective covering for the bare soil. The crop does not have a dense root system or produce leaf litter, which are beneficial to erosion control. Consequently, farmers need to plant at a spacing not more than 30cm x 45 cm.

Cover crops such as tropical Kudzu (*Pueraria phaseoloides*) can be planted when the land is fallow. This legume can provide ground cover and add nitrogen to the soil. Vegetative barriers such as the quick growing *Leucaena leucocephala* can be planted across slopes at appropriate intervals in order to retard soil from being washed down slope. Below these barriers, drainage channels can be constructed to remove excess runoff (Benge, 1980).

Agro forestry can be practiced on steep slopes (>20°). Timber and fruit trees such Teak (*Tectona grandis* Linn), Cedar (*Cedrela odorata* Roem) and Balata (*Mimusops balata* Cruegeri Pierre) that produce high valued products can be planted. These trees can bring environmental benefits through soil protection and efficiency of utilization of water and soil nutrients. They also create a wider diversity for fauna.

The major fruit pest at Tableland is the bud moth *Thecla basilides* (Geyer). The moth deposits its eggs on the inflorescence prior to anthesis. The larva feeds inside the developing inflorescence and eventually penetrates and digs out holes of varying depths in the fruit. This results in malformed fruit that is unmarketable (Py et al., 1987). In response to the actions of the larvae, the fruit exudes gum that hardens on contact with the air.

Farmers reported that between five to ten per cent of the fruits in the 2004 crop were malformed and unmarketable. Py et al., (1987) reported that control with insecticide is relatively easy if flowering is uniformly induced with forcing agents. It was also noted that predators exist in Trinidad, including the vespid wasp *Polistes rubiginosus* Lepeletier and a predator of larvae, *Heptamicra* sp. However, biological control of the bud moth in Trinidad has not been organized.

The nutritional status of the pineapple plant has a large influence on plant growth and, consequently on yield and fruit quality. At Tableland, the fertilizer input is restricted to urea. It is not surprising that fruit production and quality are reduced with each successful crop cycle.

Persad et al. (2001) have reported that soil tests conducted in the pineapple growing areas have low levels of potassium. Nitrogen and potassium are required in large amounts to sustain pineapple growth (Malézieux and Bartholomew, 2003). Potassium deficiency was associated with a decrease in photosynthesis and thus plant growth, fruit mass and slip production (Swete Kelly, 1993). Where potassium is deficient, fruits have reduced sugar and acid levels and have a pale colour ((Py et al., 1987), the fruit peduncle diameter is reduced (Py et al., 1987), the

peduncle is weak (Swete Kelly, 1993) and fruits are more prone to lodging and sunburn and have lower acidity and aroma development.

Since potash influences fruit quality, potash fertilizers should be utilized in the cropping programme, especially for ratoon crops.

The Ministry of Agriculture has implemented fertilizer on-farm trials at Tableland on farmers' holdings in Tableland. In these studies, the effect of urea application will be compared with other fertilizer treatments determined from soil tests and nutrient uptake for a pineapple crop.

The information expected to be generated from these trials include grade(s) of fertilizer recommended for crop plant and ratoon; rate, frequency and method of application; yield per hectare; number of successful ratoons produced; fruit quality; nutrient status of soil before planting and after harvest and cost of production. Proper soil fertility management is required to keep the soil productive and will contribute to sustainable pineapple production in Tableland.

#### (d) Farmers' cooperative

Farmers' cooperative can engage in bulk purchasing to reduce cost of inputs. Through the cooperative, they may be able to obtain better prices for their produce and lobby for improved infrastructure. As it exists, there is no common strategy by the producers for timing of production and marketing. Seasonal gluts of pineapple occur during the period May to July of each year due to natural flowering during the short days and prices at the farm gate can plunge from \$TT 3.00 to \$TT 0.80 kg<sup>-1</sup>. Farmers' cooperative can consider the feasibility of investing in processing plant and equipment to produce value added products such as pineapple chunks, slices, candied pineapple and juice. The high import bill for juices alone (Table 3) illustrates the potential for growth of this enterprise.

#### (e) Governments' role in promoting sustainable pineapple production

In Trinidad and Tobago, legislation governing land tenure and soil conservation should be reviewed. The duties and responsibilities of land owners, tenants and land users regarding erosion control, agronomic measures, soil management practices and good land use should be clearly enunciated, explained and enforced. Leases of those in possession of state land should not be renewed if they are encouraging soil erosion practices. Encroachment onto State lands should cease.

Most traditional soil conservation practices are highly labour intensive. FAO (1989) estimated that one would need to employ 400-500 man-days to construct one hectare of bench terraces on a moderate slope. Soil conservation activities funded by Government could create much needed employment opportunities in Tableland.

With the restructuring of the sugar industry of Trinidad and Tobago in 2003, arrangements are being made by the State to redistribute approximately 13,100 ha of sugar cane lands for farming and other enterprises. Further expansion in pineapple hectareage can occur on these lands. Ideally, minimally sloping lands should be selected for pineapple culture to protect the soil from erosion. Mechanization of operations, such as transport of the fruits and harvesting, can be considered to remove drudgery and decrease production cost.

Government facilitates the promoting of sustainable production of pineapple as follows:

- Provision of training and workshops at various training centers.

- Provision of diagnostic facilities for the management of pest and diseases.
- Provide soil tests and foliar analyses to improve soil fertility and crop nutrition.
- Identification of market opportunities by the National Agricultural Marketing and Development Company.
- Provision of a Packing House to facilitate pineapple export.
- Provision of infrastructure such as access roads.
- Implementation of an agricultural incentive programme which includes *inter alia*:
  - Soil conservation operations (Table 6).
  - Purchase of agricultural machinery and equipment.
  - Land preparation.
  - Pond construction for irrigation.
  - Purchase of spraying equipment and agrochemicals.

## CONCLUSION

The land resources at Tableland are being severely exploited. The achievement of sustainable development is a challenge to the Government, the pineapple farmers and all stakeholders. There is no quick fix to remedy the situation. Organizations such as farmers' groups, Extension, Forestry, State Land and Rural planning and development agencies need to coordinate their activities so that there is harmonization of conservation work with agricultural development. Government has to provide the essential infrastructure, design the necessary policies and programmes and enact and enforce appropriate legislation. Government has to lead the way. Without technical and financial support, there is very little in the field of soil conservation that can be accomplished. All stakeholders have to ensure that they perform their respective roles in promoting sustainable pineapple production in Tableland.

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Table 1 Fruit characteristics of Tableland Hybrid

Fruit Parameters	Observations
Seedy	No
Shape	Conical
Weight (Kg)	1.6 – 2.3
Length (cm)	16.0 – 16.5
Diameter (cm)	11.4 – 12.0
Eyes	Flat
Unripe external Fruit colour	Green
Ripe external Fruit colour	Yellow
Number of Fruitlets	85 – 110
Internal fruit colour	Light yellow
Internal fruit texture	soft juicy
Core diameter (mm)	12 – 14
<sup>o</sup> Brix	16.5 – 17.8
pH	3.4 – 4.0

Table 2. Fresh and processed pineapple imported and exported (2000 – 2002)

2000 - 2002			
Imports		Exports	
kg	\$TT	kg	\$TT
11,317	138,356	150,126	976,937

Source: C.S.O. 2003

Table 3. Pineapple juice imported and exported (2000 – 2002)

2000 - 2002			
Imports		Exports	
kg	\$TT	kg	\$TT
1,310,126	7,831,315	378,895	3,315,710

Source: C.S.O. 2003



Table 4. Bare soil erosion in tonnes per hectare for slopes, lengths and soil series.Slope °

Plot Length (m)		Princes Town	Talparo	Tarouba
10 – 15	4	12.71	101.65	53.11
	6	8.96	73.50	28.66
	8	7.44	59.71	26.10
MEANS		9.70	78.29	35.96
15 – 20	4	14.94	51.13	16.42
	6	10.35	46.81	16.24
	8	12.65	59.88	5.30
MEANS		12.65	52.61	12.65
Means for Soil Series		11.18	65.45	24.31
Mean height of soil eroded (cm)		0.09	0.48	0.19
Rainfall (mm)		696	1,008	922

Source: Georges (1976)

Table 5. Comparison of the chemical properties of Talparo clay sampled in 1968 and 2000.

Parameters	1968 *	2000 **
pH	5.75	4.70
Organic Carbon (g kg <sup>-1</sup> )	44.00	32.90
Nitrogen (g kg <sup>-1</sup> )	4.52	2.70
Phosphorus (mg kg <sup>-1</sup> )	41.00	33.00
Calcium (cmol kg <sup>-1</sup> )	13.75	6.75
Magnesium (cmol kg <sup>-1</sup> )	14.80	1.12
Potassium (cmol kg <sup>-1</sup> )	1.93	0.52
ECEC (cmol kg <sup>-1</sup> )	32.10	15.2
Base Saturation %	90.50	55.2

\*Brown and Bally 1970

\*\* Persad et al., 2001

Table 6. Agricultural Incentive Programme: Ministry of Agriculture, Land and Marine Resources 2004.

Soil Conservation Operations	% Cost	Maximum Payment (\$TT)
Contour drains per 30m	100	70
Storm drains per 30m	100	80
Contour banking, ridging or terracing per ha	100	370
Contour barriers per 30m	100	40
Terrace outlets per 30m	100	120
Check dams	50	200

## **TRIALS OF PASSIONFRUIT IN THE US VIRGIN ISLANDS**

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**ABSTRACT:** Passionfruit (*Passiflora edulis*) is a local tropical fruit used in juice, jelly and ice cream in St. Croix. However, almost all of the juice used for making passion fruit drinks comes from imported concentrate. A field trial was developed to evaluate fifteen passion fruit varieties of red, yellow and red/yellow hybrids in the US Virgin Islands. The passion fruit vines were grown on either a single wire or three wire trellis system. All varieties tended to produce within nine months, with production peaking in October-November. Production was greater for some varieties on the three-wire trellis system than a single wire system. During the first two years, multiple varieties were lost due to lack of tolerance to high pH, calcareous soils and St. Croix's climatic conditions. 'Noel's Special', a yellow selection from Hawaii, had a deep orange pulp and was a consistent producer. The fresh juice of all varieties was in a range between pH 2-3. Four varieties: 'Noel's Special', 'Panama Gold', 'Rainforest', and 'TWZ hybrid' are recommended for passion fruit growers. A single-wire trellis system can be as productive as a three-wire system and provide the added advantage of lower installation cost and wind tolerance.

### **INTRODUCTION**

The genus *Passiflora* is indigenous to the American tropics and over 400 species are known to exist (Martin and Nakasone, 1970). The most commonly used species for commercial production is *Passiflora edulis*. Passionfruit is a vine that requires support and comes in two forms: *P. edulis f. edulis* (purple or red fleshed) and *P. edulis f. flavicarpa* (yellow fleshed) (Vanderplank, 1991). Passionfruit is used in the Caribbean in juice, jellies, ice cream and liqueurs.

In the USVI, passion fruit is grown by farmers and backyard gardeners for local consumption. However, local production does not meet the local demand. Two of the constraints to production of passion fruit are the high pH, calcareous soils and semi-arid conditions. A germplasm evaluation trial was conducted at UVI in 1997 using seven different varieties (Zimmerman, 1998). The plants were trained onto T-trellis recommended by Colon-Velez (1997) and Robin (1992). This production plot was destroyed by Hurricane Georges in September 1998.

To resist tropical storm forced winds, new trellis was designed utilizing a one-wire system. The objectives of this study were (a) to evaluate fifteen varieties of passion fruit for fruit quality, production level and pest and disease susceptibility and (b) compare production between a 1-wire trellis and 3-wire T-trellis system.

### **MATERIALS AND METHODS**

Seeds were obtained for fifteen varieties of passion fruit (Table 1) and germinated in the greenhouse, with the exception of 'Noel's Special'. 'Noel's Special' is a hybrid and is propagated by nodal cuttings. The plants were transplanted in the field at two months of age.

Plants were planted in 2-m tall one-wire trellises. There were three meters between rows and two meters between plants within the rows. Eight varieties were also planted into a 2-m tall 3-wire T-shaped trellis system (Table 2). The plants were trained up to the wire using bamboo stakes. The plants were watered as needed using drip irrigation. Water-soluble fertilizer (12-12-12) was used during establishment, with the addition of chelated iron. Wood chip mulch was applied between the rows for weed suppression and water conservation. Harvest began in June of 2000 and continued three times per week as necessary. Total weight and number of fruit per variety were taken at each harvest. From each variety five fruit were randomly selected and weighed. The pulp volume, husk weight, brix and pH were also recorded.

## RESULTS AND DISCUSSION

### Yellow Varieties

Most varieties began production in June 2000 (the rest of the varieties began in July). Different varieties peaked at times but mostly in the month of October, November and December. Production dropped off dramatically in December, with zero production for any variety from January-April of 2001 (Figure 1).

There was a range of husk mass and pulp volume (Table 4). The trend of percent pulp tended to be 40-65% total pulp. 'Noel's Special' contained a deep orange colored pulp, which was very different from the other yellow varieties. The pH of all varieties fell between the pH of vinegar and lemon juice. All of the varieties had a brix of at least 12.

### Red Varieties

The red varieties followed a similar trend as the yellow varieties for monthly production with flowering beginning in April of 2000 and production beginning in June 2000 (Figure 3). The varieties had different peaks in monthly production, but fruiting for all varieties came to an abrupt halt in December with no production from January 2001-April 2001. Production was resumed in May 2001.

'Panama Red' produced significantly more fruit (164) than any other varieties. 'Lacy' produced the least number of fruit (Table 5). There was also a wide range of average fruit weights with 'HI x Brazil' producing the heaviest fruit at 107 g and 'Lacy' producing the lightest (19 g). The red varieties also entered decline after the first year, with only 'TWZ' having any significant production in 2002. The red varieties all had a relatively high pulp percentage. They all had brix of at least 12.5 (Table 6).

### 1 vs. 3 Wire System

The number of fruit produced varied widely (Table 3) on the 3 or 1-wire system. 'Rainforest' produced the greatest number of fruits with (199) and also one of the larger sized fruit (81g). 'UVI' produced the least number of fruits (72) but had one of the larger-sized fruit (80g). After year one, some of the yellow varieties began to decline and die (Figure 2). However, 'Panama Gold' was consistent each year.

Of the varieties that survived on the 1 wire vs. 3-wire system 'Noel's Special' and 'Panama Gold' showed no significant differences in production (Table 7). However, 'UVI

'Yellow' did have a significantly lower production level on the 1 wire system than the 3 wire system. The amount of vine mass was much lower on the one wire system than on the three, making it easier for wind to flow through the plants without damaging them.

#### Disease and Pests

Some pests and disease were noted, however there wasn't any difference in pest infestation of the one-wire system vs. the three-wire system. Spider mites caused limited damage during the dry season. Barnacle scale was also occasionally present. It was treated with Malathion. The red passionfruit varieties seem more susceptible to the scale. Bortytis mold was present during the wet season. No treatment was used and the mold subsided once conditions became drier. Passion fruit were also very susceptible to any type of mechanical damage such as weed whacker or lawn mower damage.

#### CONCLUSIONS

Many of the varieties died out within the first two years, particularly the red varieties. These varieties included: 'Columbian Market', 'Gold Giant', 'Fredrick', 'HI x Brazil', 'Jamaica', 'Lacy' and 'Yellow Sweet'. These varieties were unable to tolerate the high pH calcareous soils found on St. Croix. Based on the fact survival rate and production levels the following varieties are being recommended to farmers and homeowners: 'Noel's Special', 'Panama Gold', 'Rainforest' and 'TWZ Hybrid'. A single wire trellis system can be as productive as a three-wire system. It also cheaper to install and has a higher wind tolerance.

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Table 1. The varieties of passionfruit evaluated and their characteristic fruit color

Yellow		Red	Pink
Columbian Market	Panama Gold	Fredrick	TWZ Hybrid
Espino	Rainforest	HI x Brazil	
Gold Giant	UVI Yellow	Lacy	
Jamaica	Yellow Sweet	Panama Red	
Noel's Special		VI Red	

Table 2. Passionfruit varieties used in comparing production between 1-wire and 3-wire systems

Variety	Color
Fredrick	Red
HI X Brazil	Red
Noel's Special	Yellow
Panama Gold	Yellow
Panama Red	Red
UVI Yellow	Yellow
VI Red	Red

Table 3. Fruit production and size for yellow passionfruit varieties (ave. of one year cycle) on a one-wire system

Variety	# Fruit/Plant*	Fruit Weight(g)*
Columbian Market	77 e	66 ab
Espino	111 d	75 a
Gold Giant	178 b	80 a
Jamaica	138 d	62 b
Noel's Special	164 bc	81 a
Panama Gold	182 ab	56 b
Rainforest	199a	81 a
UVI Yellow	72 e	80 a
Yellow Sweet	162 bc	82 a

Table 4. Fruit Quality-Yellow

Variety	Husk (g)	Pulp (mL)	Pulp (%)	pH	% Brix
Columbian Market	36.5	39.3	46	3.12	16
Espino	31.3	39	59	3.26	14.7
Gold Giant	41.9	37.7	48	3.07	14.7
Jamaica	23.4	36.3	63	3.21	15.3
Noel's Special	40.6	47.3	51	3.27	14.3
Panama Gold	27.8	33.1	52	3.41	15.7
Rainforest	37.6	39.7	53	3.06	14.7
UVI Yellow	34.5	50.7	63	3.13	12.7
Yellow Sweet	31.0	43	63	2.69	13.7

Table 5. Fruit production and size for red passionfruit variety (ave. one year cycle) on a one wire trellis system

Variety	# Fruit/Plant	Fruit Weight (g)
Fredrick	123 b	26 c
HI x Brazil	147 b	107 a
Lacy	42 d	19 c
Panama Red	164 a	71 b
TWZ Hybrid	136 b	91 ab
VI Red	86 c	88 ab

Table 6. Fruit Quality-Red

Variety	Husk (g)	Pulp (mL)	Pulp (%)	pH	% Brix
Fredrick	11.2	14	57	3.11	15
HI x Brazil	55.5	43.5	48	2.96	12.7
Lacy	7.2	11	62	3.3	15.3
Panama Red	32.8	34	53	2.94	13.7
TWZ Hybrid	45.5	44.7	50	3.12	15.7
VI Red	22.7	33.3	73	3.27	14.3

Table 7. Production /Plant: 1 wire vs 3 wire (kg/plant)

Variety	1 wire	P=0.05	3 wire
Fredrick	6.7	*	2.5
HI x Brazil	14.2	ns	16.3
Lacy	1.7	*	.01
Panama Red	10.3	ns	13.2
VI Red	6.9	*	21.9
Noel's Special	11.8	ns	13.2
Panama Gold	13.6	ns	11.0
UVI Yellow	5.6	*	12.5

Figure 1. Monthly production of yellow passionfruit varieties over a yearly cycle on a one-wire system.

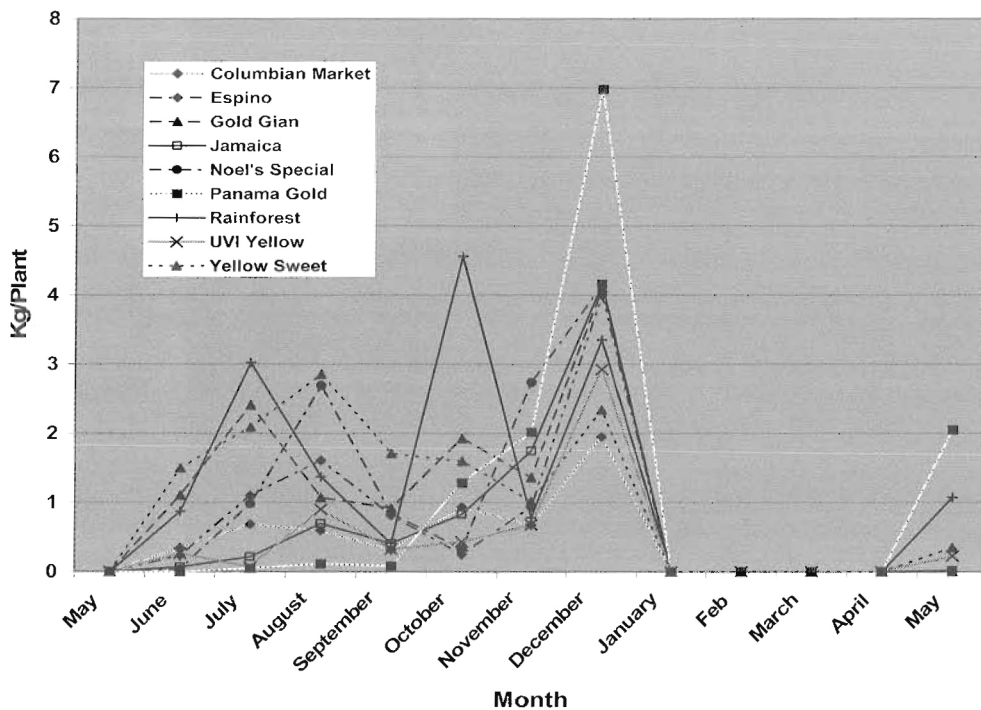


Figure 2. Average total production per plant over a three period for the yellow passionfruit varieties one a one-wire system.

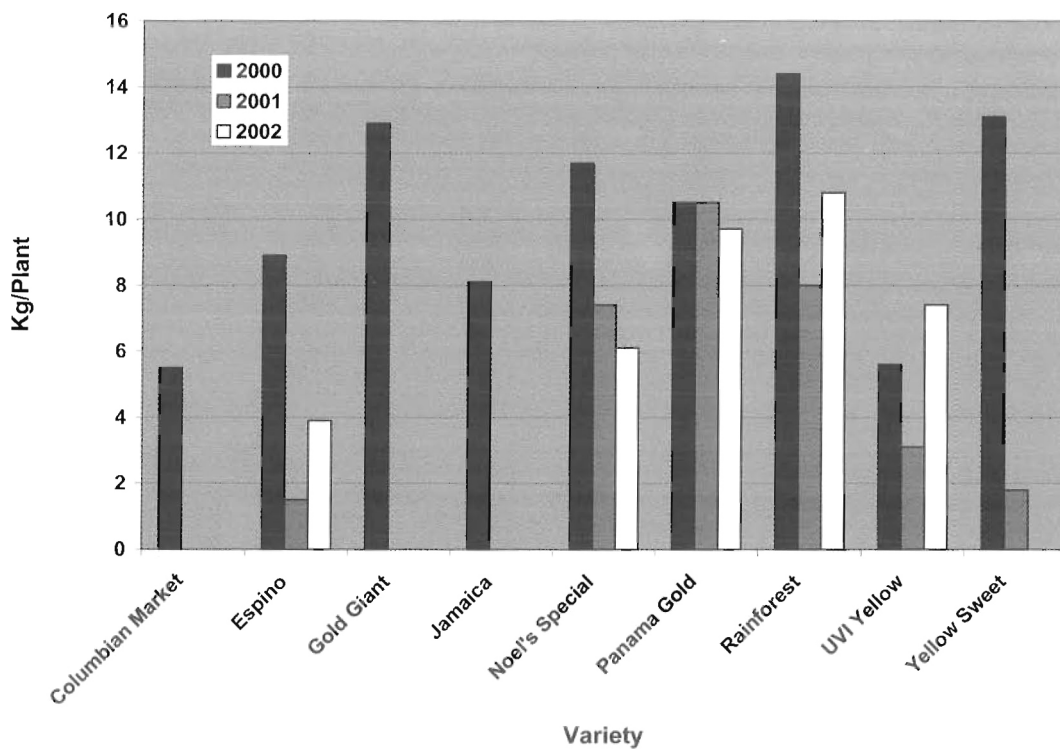


Figure 3. Monthly production of red passionfruit varieties over a yearly cycle on a one-wire system

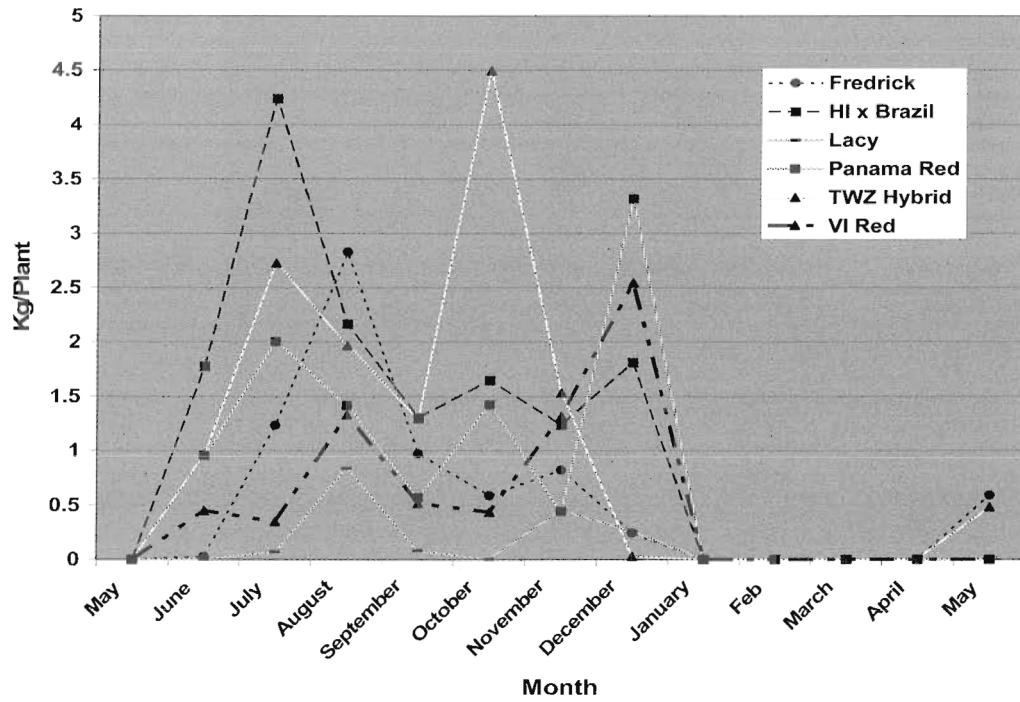
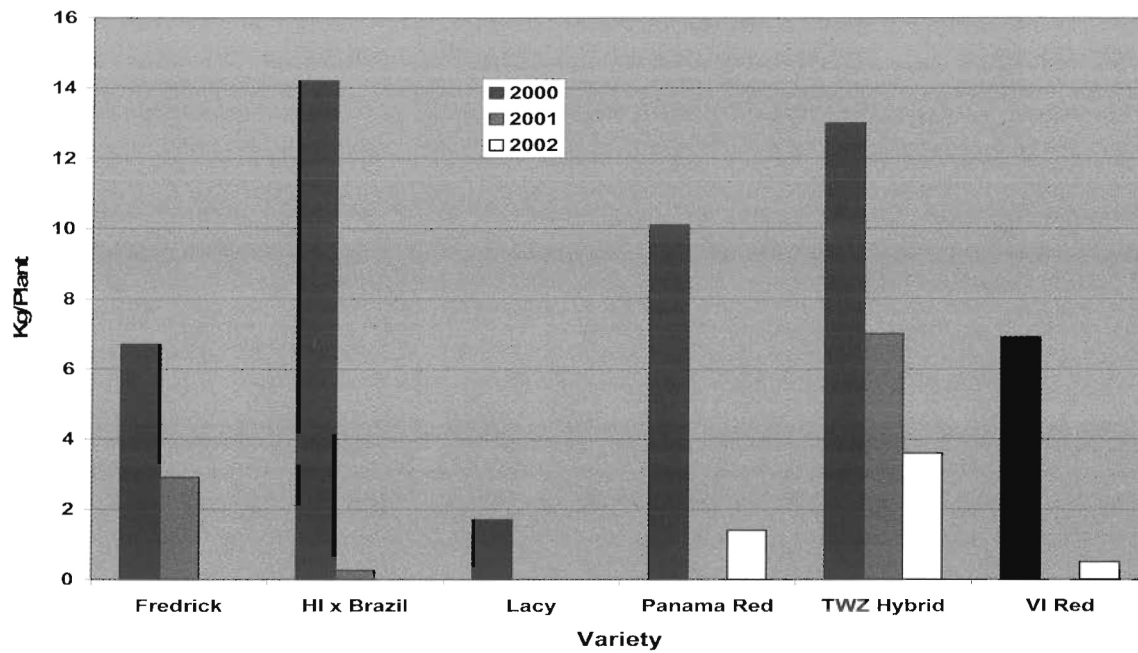


Figure 4. Average of total production per plant over a three-year period for the red passionfruit varieties on a one-wire system





**THE RIPENING OF *CARICA PAPAYA* L. AS AFFECTED BY 1-METHYLCYCLOPROPENE (1-MCP)**

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**ABSTRACT:** 1-MCP is a novel postharvest tool which has been proven to delay ripening and senescence in plant tissues; however its effects on tropical fruits are now being researched. In an attempt to extend shelf life, papaya fruits (cv. 'Tainung #2') were subjected to varying regimens of 1-MCP treatments to determine the best combination of concentration and duration of exposure to 1-MCP. Trials using hot water and thiabendazole were also performed in an attempt to decrease the occurrence of postharvest decay. Fruit were fumigated in airtight plastic containers with 1-MCP, and the effects of the gas were judged using a variety of parameters including ethylene and carbon dioxide evolution, skin colour, and firmness. The most successful treatment ( $0.05 \mu\text{l}^{-1}$  1-MCP for 15 mins. at  $20^{\circ}\text{C}$ ) increased the time to ripening by as many as 8-10 days. However, this time could be increased if postharvest disease infection could be controlled more effectively.

INTRODUCTION

Papaya (*C. papaya*), which belongs to the Caricaceae family, is cultivated throughout the tropics and is fast becoming one of the most important tropical fruits because of expanding export markets. Locally, 'Tainung #2' is one of the more popular cultivars, mainly because of its size (1 to 1.5 kg) and its sweet taste. 'Red Lady' fruits are also sold, but they are less common because of their size (3 to 5 kg).

Physiologically, papaya is a climacteric fruit with typical respiratory and ethylene production patterns. Morphologically, it is a berry normally composed of five longitudinal carpels with the flesh surrounding a central cavity (Paull, 1993). The fruit is extremely susceptible to common postharvest disorders, chiefly because of the stage of development at which it is harvested (with 6-10% yellow on its skin). Its fruit then becomes prone to mechanical damage during the latter processes of postharvest handling. The postharvest loss of fresh papaya due to mechanical and physiological damage, diseases, and pests has been estimated to vary between 40 to 100% in different countries (FAO, 1983).

It has been reported that fumigation with 1-methylcyclopropene (1-MCP) a volatile cyclic alkene inhibits ethylene action in various plant tissues (Sisler and Serek, 1997, 1999). 1-MCP is easily prepared, stable, and has neither a detectable odour nor toxic residual effects. Like ethylene, 1-MCP is a strained molecule, and therefore, their binding mechanisms are similar. However, 1-MCP remains bound to the receptor preventing an active ethylene-complex from being formed (Sisler and Serek, 1997). The 1-MCP treated tissues eventually regain ethylene sensitivity and it has been suggested that new receptor sites are generated (Sisler et al., 1996; Sisler and Serek, 1999).

The use of 1-MCP in interrupting ethylene's hormonal function has been well explored in ornamental horticulture. However, little is known about its effects, and therefore potential for

practical use in controlling ripening and senescence in fruits and vegetables, especially those of tropical origin.

Unfortunately, extended shelf life after 1-MCP treatment is associated with increased severity of external rots and blemishes, such as: anthracnose (*Colletotrichum* sp.); fruit rot (*Phytophthora* sp.) and stem end rot (*Botryodiplodia* sp.). Several studies have shown that hot water treatments coupled with fungicide application have significantly reduced the appearance of rots and blemishes. Today thiabendazole is one of the few available fungicides cleared for postharvest use in papaya. However, increased consumer awareness and concern about possible harmful effects of these fungicides have led to the resurgence of heat treatments - a non-chemical alternative which will not expose consumers to any significant health risks (Couey 1989). The most popular heat regimen applied to papaya is total immersion in water at 49°C for 20 minutes.

Thus, the main objective of this study is to establish a suitable postharvest regimen, which can extend the shelf life of *Carica papaya* L. using 1-MCP, while controlling the increasing postharvest infection, which occurs with extended storage.

## MATERIALS AND METHODS

For each trial mature papaya fruit ('Tainung #2') at the stage of colour break were hand harvested at a private farm in the Caura Valley in North Trinidad and packed in cardboard boxes lined with shredded paper. Fruit were transported to the Food Biology Laboratory, Department of Food Production, at The University of the West Indies, St Augustine within 1 hour of harvest. At the laboratory, all fruit were hand washed in tap water to remove field heat and surface debris. 1-MCP stocks were synthesized using a commercial preparation of 1-MCP (Agrofresh, Rohmhaas, USA) with a predetermined amount of water. Fruit were placed on a 2-inch tall stainless steel rack in a plastic bucket with the 1-MCP stock and immediately sealed for the required time. They were then stored at 20°C and 85-90% relative humidity on a trolley lined with foam of 1-inch thickness. Any fruit with noticeable postharvest disease were discarded throughout the experiment.

The effects of 1-MCP's on the fruits were judged using a variety of parameters including ethylene and carbon dioxide evolution, skin colour, firmness. Ethylene (C<sub>2</sub>H<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>) evolution were determined by gas chromatography (Finnigan, Model #9001; Austin Texas). Up until Day 5 (in Trial #2), the fruit were incubated in an airtight container and after 3 hours a 0.3 ml sample of gas was extracted from the headspace with a syringe via a rubber septum. On day 6 (in Trial #2 and throughout Trial #3) 0.3 ml samples were also withdrawn from the fruits' cavity. The actual amounts of C<sub>2</sub>H<sub>4</sub> and CO<sub>2</sub> produced were calculated against standard gas mixtures and expressed in ml/kg.

Skin colour was measured using a Minolta colorimeter (Model CR-200, Minolta Corp, Ramsey, N.J.) calibrated with a white calibration plate (CR-A43). Colour was expressed as L\*a\*b\*, where increasing 'L' values represent increasing lightness, 'a' values were positive for red and negative for green, and 'b' values were positive for yellow and negative for blue (Singha et al., 1991). Flesh firmness was determined on the cut surface 1-inch thick slice of papaya using a Koehler digital penetrometer (Model #K 19550, Koehler Instrument Company, N.Y.). Values were expressed in mm 2sec<sup>-1</sup>, where larger values represented softer fruit.

Each experiment design used was of completely randomized design with a factorial arrangement of variables. Data were subjected to Analysis of Variance using MINITAB (minitab

12) and the level of significance determined by the F-test. Comparison of the means was done using the least significant difference (LSD) method at the 5% level.

#### Trial #1

##### Hot water treatment

Fruit were subsequently treated with either hot water (49°C for 20 mins) and/or thiobendazole, air dried, fumigated with 5  $\mu\text{l}^{-1}$  1-MCP for 14 hours and stored at 20°C on a trolley lined with foam of 1 inch thickness. Hot Water Treatment: Fruit were completely immersed in a hot water bath constructed from a 150 L drum equipped with two VWR Scientific thermo-regulators (VWR Scientific, model # 1122, Niles, Illinois) on opposite ends. To keep fruit submerged, a padded stainless steel grill was placed at water level.

##### Thiobendazole (TBZ) Treatment

Fruit were totally immersed in a solution of 1000 ppm thiobendazole for 2 minutes and left to air dry.

##### Hot Water and TBZ Treatment

Fruit were first subjected to the hot water treatment, which was immediately followed by complete immersion in 1000 ppm TBZ.

Fruit that were not treated with hot water or TBZ were observed as the control. Five papayas, which were fumigated with air, were also stored under identical conditions, to be compared with the controls (1-MCP only).

## RESULTS AND DISCUSSION

At the end of this trial it was observed that hot water (49°C / 20 mins) treatment was the most successful in delaying the development of post harvest diseases in Tainung #2 papaya. Control fruit (5  $\mu\text{l}^{-1}$  1-MCP only) remained unaffected for a maximum of 8 days before rapidly succumbing to stem end rots and external lesions infected with *Colletotrichum* sp, *Phytophthora* sp. and some other secondary organisms that were not identified. By day 16 all fruit had succumbed to at least one postharvest infection and was discarded (Figure 1).

When fruit fumigated with 1-MCP were compared to fruit that were fumigated with air and stored for the same period, it was apparent that the 1-MCP did in fact arrest the ripening process in the treated fruit (Figure 1). 1-MCP treated fruit did not lose their initial green skin colour and the flesh became spongy as the observation period lengthened. Carbon dioxide was detected in the headspace of the incubation container throughout the trial; however, no ethylene was recorded. None of the 1-MCP treated fruit attained any of the characteristics associated with ripened papaya fruit.

1-MCP has been found to delay the respiratory climacteric in fruits (Golding et al., 1998; Feng et al., 2000) and decrease the rate of carbon dioxide production in treated tissue (Fan and Mattheis, 2000), who reported that climacteric respiration requires continuous ethylene action. 1-MCP can also delay the onset of the ethylene climacteric because it strongly inhibits the usual increase in activity of the ethylene biosynthetic enzymes ACC synthase and ASS oxidase (Natasuka et al., 1997). Natasuka et al., (1998) and Mullins et al., (2000) further hypothesized

that 1-MCP could inhibit the positive feedback regulation of both ACC synthase and ASS oxidase genes during fruit ripening. Sisler et al., 1999; Golding et al., 1998; Harris et al., 2000, also reported on the ability of 1-MCP to prevent total degreening since completion of the process involves enzymes whose biosynthesis may be irreversibly disrupted by 1-MCP.

Rupasinghe et al., (2000), and Feng et al., (2000) reported success in delaying softening in apples and avocados respectively with 1-MCP. Enzyme activity was low throughout the storage period (up to 18 days). Despite the lower activity however, they noted that fruit treated with 1-MCP ripened and softened normally. In Trial #1 none of the 1-MCP treated fruit softened normally leading to the conclusion that the 1-MCP treatment was too severe.

The extensive amount of decay development observed in the 1-MCP treated papayas was similar to the findings of Ku et al., 1999 (strawberries). This may be explained by the fact that ethylene activates pathogen defense mechanisms in plants, including phytoalexin and lignin biosynthesis, and the activation of antifungal hydrolases such as chitinases and glucanases, so small amounts of endogenous ethylene aid to maintain a basic level of resistance towards environmental and pathological stresses (Ecker and Davis, 1987; Boller, 1988).

#### Trial #2

The fruit were treated with 0.0, 0.5, 1.0 or 1.5  $\mu\text{l}^{-1}$  1-MCP (as described earlier) for either 1 or 3 hours in a factorial arrangement. Those fumigated with air were recognized as the control. The fruit were subsequently stored at 20-25°C and 85-90% RH.

## RESULTS AND DISCUSSION

By day 6, the control fruit had attained optimal ripeness which lasted as long as 15 days and quickly succumbed to postharvest disease or became over ripe as evidenced by their total loss of chlorophyll ( $L^* \geq 60$ ,  $a^* \geq 4.41$ ,  $b^* \geq 41.1$ ) and reduction in firmness (87.11mm/2sec). Figure 2 (a), and (b) clearly show that by as early as day 3 the control fruit were at a much more advanced state of chlorophyll degradation and respired at a greater rate than any of the treated fruit, even those subjected to the lowest concentration of 1-MCP (0.5  $\mu\text{l}^{-1}$ ) for the shortest period of time (1 h).

Both the concentration of 1-MCP applied and the duration of the fumigation significantly affected the amount of ethylene ( $p \leq 0.001$ ) and carbon dioxide ( $p \leq 0.05$ ) detected in the fruits' cavities. Concentration and duration of exposure also had a highly significant effect on loss of firmness ( $p=0$ ). All the remaining fruit lost their green colour by Day 15, but did not develop the usual orange-red skin colour. The highest  $L^*$  and  $a^*$  values recorded were 56.73 and 8.13 respectively, which were recorded on the control fruit since Day 6.

These observations suggested that the perception and/or production of ethylene was inhibited by 1-MCP thus delaying the onset of ripening. However, the poor development of quality after 15 days of storage, and the lack of significant differences between treatments suggest that even the lowest concentrations used were too severe. As such, both variables (concentration and duration of exposure) were manipulated in a subsequent trial in an attempt to discern their effects on the efficacy of 1-MCP action and to find a suitable fumigation regimen for papaya fruit.

### Trial #3

The fruit were treated with 0.0, 0.05 and 0.25  $\mu\text{l}^{-1}$  1-MCP for 2, 15 or 90 minutes in a factorial arrangement. Those fumigated with air were recognized as the control. The fruit were subsequently stored at 20-25°C. Observation continued until the supply of fruit was exhausted and analyses were performed at 4-day intervals.

### RESULTS AND DISCUSSION

Controls achieved optimal ripeness by Day 8 as evidenced by skin colour ( $L^*=63.1$  and  $a^*=11.2$ ), loss of firmness (96.7 mm/2 sec) and ethylene ( $7.37 \text{ ml kg}^{-1}$ ) and carbon dioxide ( $24.62 \text{ ml kg}^{-1}$ ) evolution (Figure 3). However at this time, no significant difference was detected between the control and any of the treated fruit.

When the results obtained treated fruit were analysed in isolation, significant differences could be detected. Time, duration of exposure and concentration of 1-MCP all influenced skin colour  $L^*$ , however no interactions between any of these factors were observed. On the other hand skin colour  $a^*$  was influenced by the interaction between time and duration of exposure.

Another physical attribute of the papaya affected by the interaction between time and duration of exposure was loss of firmness. Even up to day 12, the fruit treated for 90 minutes had in no way begun to achieve the desired texture and those treated for 2 minutes had surpassed it. The most desirable texture was that of the fruit treated for 15 minutes.

### CONCLUSION

The most suitable postharvest regimen for prolonging the shelf life of papaya is immersion in hot water (49°C for 20 minutes) followed by 0.05  $\mu\text{l}^{-1}$  1-MCP for 15 minutes. While the fruits subjected to the other treatments did last as long, they were unsuitable either because they had passed the stage of optimal ripeness (2-minute treatments) or they had not yet attained the desired physical and biochemical standards achieved by the untreated papaya fruits but had developed extensive disease infection.

Another conclusion that can be drawn from the above observations is that manipulating the length of time that the fruit is exposed to 1-MCP may be a more effective and economical approach since it allows extremely minute concentrations to be applied successfully.

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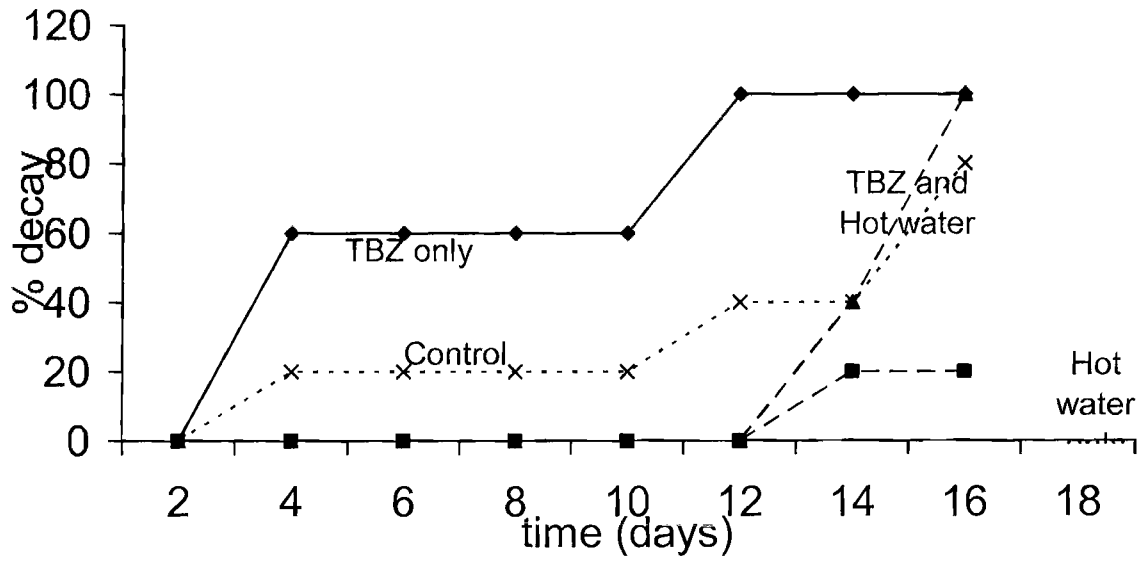


Figure 1. Percentage decay of Tainung #2 papaya fruit during storage at 20°C

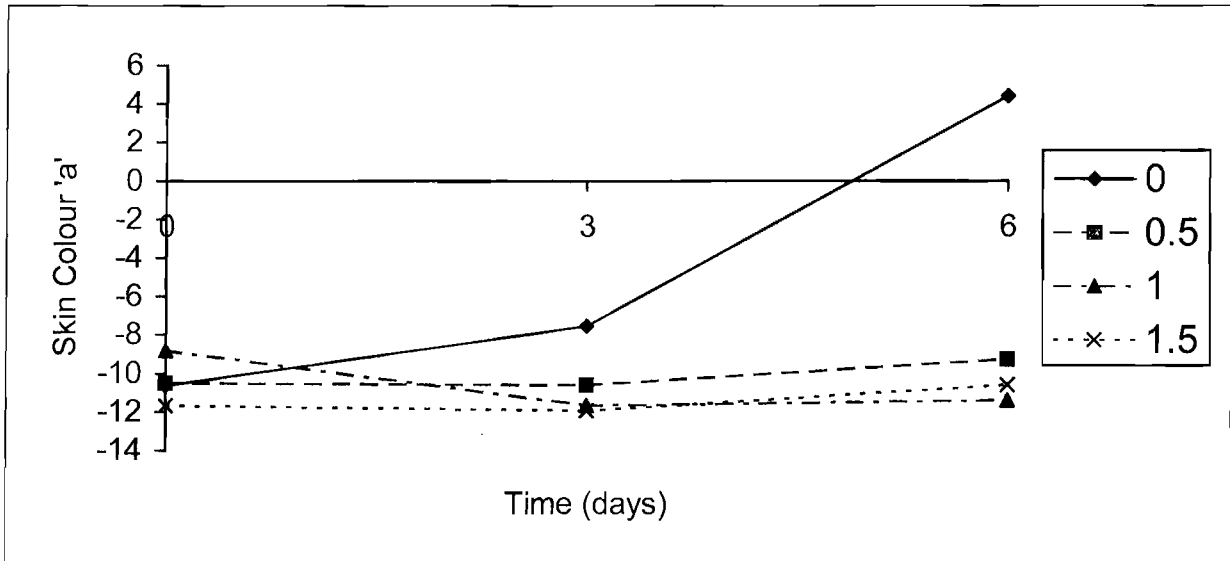


Figure 2a. Skin Colour 'a' of 1-MCP treated papayas

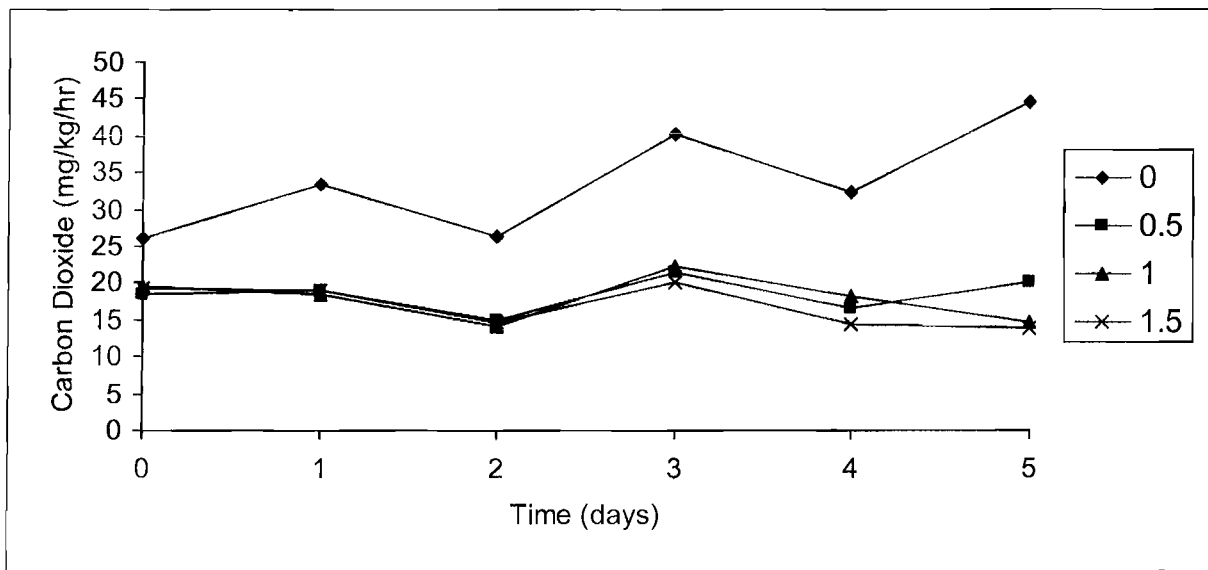


Figure 2b. Carbon dioxide evolution of 1-MCP treated papayas



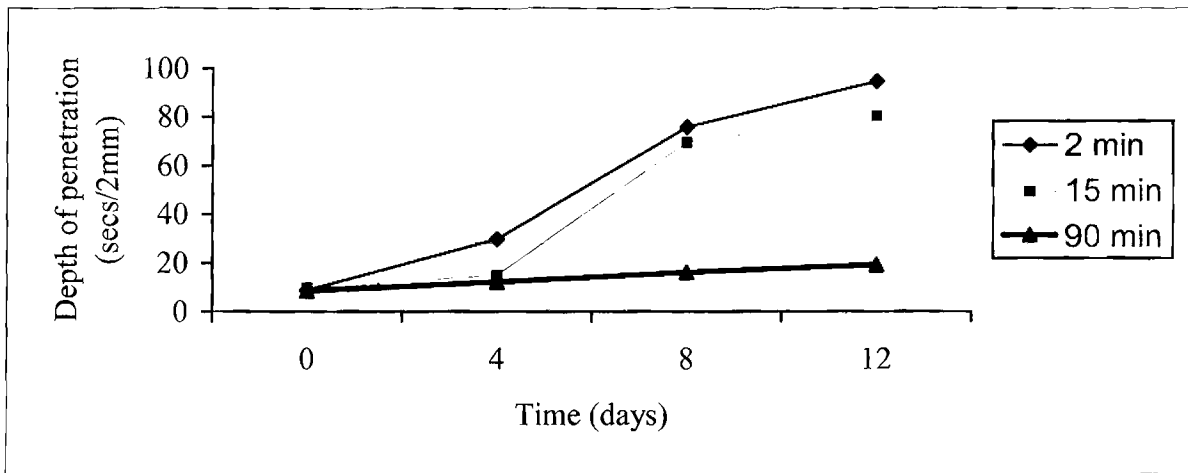


Figure 3. Loss of firmness in 1-MCP treated papaya

**DEVELOPMENT AND SELECTION OF TRANSGENIC PAPAYA FOR VIRUS RESISTANCE**

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**ABSTRACT:** Papayas were developed for resistance to papaya ringspot virus (PRSV). Immature zygotic embryos were excised and placed into tissue culture on embryo inducing medium. Embryogenic callus was developed and cocultivated with *Agrobacterium tumefaciens* containing the coat protein gene from the local strain of PRSV. Regenerated transgenic plants were screened in the greenhouse and the field with hand inoculation of PRSV. A system was developed to screen large numbers of papaya seedlings for transgenic plants using Kanamycin and DMSO. Breeding and selection for virus resistance has been ongoing for multiple generations to develop inbred homozygous papaya lines with PRSV resistance. Homozygous PRSV resistant transgenic papaya lines have been developed for the varieties 'Yuen Nong 1' and 'Washington'.

**EPIDEMIOLOGY OF BACTERIAL CANKER OF PAPAYA IN ST.VINCENT AND THE GRENADINES: A PRELIMINARY INVESTIGATION**

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**ABSTRACT:** Papaya, also known as paw paw, (*Carica papaya*) production has great economic potential in St. Vincent and the Grenadines. However, a limiting factor of production is diseases. A survey was conducted in 2002-2003 to assess the incidence and serenity of bacterial canker. Incidence ranged from 36% to 76.6% and severity was 18.61. An apparent weak relationship exist (regression analysis) between disease severity and seasons;  $r=.338$  and  $.134$  for the dry and wet season, respectively. Bacterial canker is distributed throughout the state; and the bacteria causing the disease has been characterized as the non-soft rot *Erwinia* spp. of the mature papaya plants monitored, 71.29% were severely affected by papaya bunchy top disease, which should be the focus of a papaya disease management strategy.

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**BIOLOGY AND MANAGEMENT OF MELON THRIPS [*THRIPS PALMI*, KARNY (THYSANOPTERA: THIRIPIDAE)]**

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**ABSTRACT:** *Thrips palmi* Karny, the melon thrips, is a serious pest of all vegetable crops in the South Florida. It occurs in all seasons with the peak abundance during January to April. *T. palmi* infests all plant parts- leaf, flower and fruit, causing significant damage to marketable fruit. Growers commonly use 'spinosad' to manage this pest. In absence of any insecticidal control, the minute pirate bug, *Orius insidiosus*, provides significant suppression of *T. palmi* during the period when vegetable season is over.

**THE CASE OF FARMERS, NATIONAL, REGIONAL AND INTERNATIONAL AGENCIES PARTNERING FOR THE MANAGEMENT OF THE COFFEE BERRY IN JAMAICA**

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**ABSTARCT:** The Jamaican coffee industry suffers estimated annual losses of \$US 2-3M because of damage to coffee beans by the coffee berry borer, *Hypothenemus hampei* Ferrari. Due to pressure from the international community, the Coffee Industry Board (CIB) is being forced to find alternatives to widely-used chemical control (involving application of an organochlorine insecticide, endosulfan) of the pest. In its effort to find alternatives, CIB initiated discussions with the Caribbean Agricultural Research and Development Institute (CARDI) Jamaica to implement the “Biological control of the coffee berry borer, *Hypothenemus hampei* Ferr. in Jamaica” project. Inputs in areas of finance, technical expertise, starting material, research and training were deemed necessary the successful implementation of this project. This was facilitated by strengthening already-existing partnerships. CIB provided financial support for the work to be carried out by CARDI Jamaica. The technical expertise was provided locally through the University of the West Indies (UWI), and internationally through PROMECAFE, a Latin American organization to which Jamaica belongs. PROMECAFE also provided stock cultures to begin rearing of the parasitoids in Jamaica. Field research was facilitated on coffee farms through cooperation of coffee farmers and CIB. Aspects of the laboratory research were conducted by UWI students for their final year research project course. The success of this project and its transformation to a national programme is dependent on stakeholders and interest groups being sensitized to the programme and trained in biological control and parasitoid rearing procedures. This was achieved through a partnership with the Rural Agricultural Development Authority, UWI, CIB and other members of the coffee industry. The partnerships that were strengthened during this project resulted in the successful development and implementation of the biological control of the CBB project. Three parasitoids were introduced and successfully reared in Jamaica, released in the field and their establishment confirmed. Rural rearing facilities have been established and over 110 Jamaicans trained/ sensitized about CBB biological control. It is expected that these fortified partnerships will help to ensure the sustainability of biological control as an integral component of an integrated approach to the management of CBB in Jamaica.

**Key words:** Coffee berry borer, *Hypothenemus hampei*, Management

## INTRODUCTION

*Coffea arabica* was first introduced in Jamaica in 1728 and Jamaica has become renowned for its Blue Mountain coffee, which is the most expensive brand in the world, generating approximately US \$ 0.8-1M annually from export alone. However, coffee production in Jamaica has been suffering economic losses estimated at US\$2-3 M annually due to damage to

coffee beans from attack by the coffee berry borer, *Hypothenemus hampei* Ferrari (Coleoptera: Scolytidae).

Since the first reports of its presence in Jamaica in 1978, the major form of control of the CBB has been chemical (endosulfan, an organochlorine insecticide), with cultural practices, such as the complete removal of berries from trees at the end of the harvest period (stripping) and field sanitation, playing a minor role in most cases. While endosulfan has been effective in controlling the CBB, there have been negative ecological backlashes (resurgence, resistance, replacement) and environmental repercussions associated with its use. Data collected from different parts of the island suggest the development of resistance to endosulfan by CBB populations (Witter and Mansingh, 1997).

Residues of endosulfan (0.157 – 2,330 ppb) were detected in samples taken from river and coastal sediment, and in fauna in watersheds near major coffee and citrus growing areas (Witter et al., 1999) and Robinson (1997) found that, while the chemical was rapidly accumulated by *Tilapia* from contaminated water, it was eliminated at a much slower rate. Additionally, the Jamaica Pesticides Control Authority is gradually reducing the quantity of endosulfan allowed to be imported to the island. This growing evidence of ecological backlashes and environmental pollution resulting from endosulfan application to coffee, coupled with the high economic costs (an estimated US\$75,000 is spent yearly to control the CBB) associated with the reliance on this insecticide, and the increased demand by consumers for safer coffee in the market place, prompted the Coffee Industry Board (CIB) to find alternatives to this insecticide.

Hence, the challenge facing the coffee industry is to find more sustainable approaches in the management of the CBB, such as biological control, physical control and use of biorationals. The CIB initiated discussions with the Caribbean Agricultural Research and Development Institute (CARDI) Jamaica Unit and in June 1999, CARDI Jamaica was contracted to implement the “Biological control of the coffee berry borer, *Hypothenemus hampei* Ferr. in Jamaica” project. The objectives of this three-year project were to (i) develop and refine protocol for mass rearing of biocontrol agents, (ii) release lab-reared parasitoids and monitor their establishment in the field, (iii) determine the potential of parasitoids to reduce coffee berry borer infestations in selected areas in Jamaica and (iv) train members of the coffee industry in the rearing and release of the parasitoids.

## PROJECT APPROACH

It was determined that the successful implementation of the project required inputs in the areas of finance, technical expertise, starting material, research and training. This was facilitated by strengthening already-existing partnerships. The CIB contributed the majority (82%) of the total cost of the project, while contributions from CARDI and PROMECAFE (a Latin American organization to which Jamaica belongs) amounted to 12 and 6%, respectively.

Technical expertise for the project was provided locally through the University of the West Indies (UWI), and internationally through PROMECAFE. A Technical Advisory Committee was also formed, comprising of the relevant representatives from UWI (Technical Advisor to the project), PROMECAFE (experts in the rearing of the parasitoids), CARDI (Project Manager) and the CIB (Project Coordinator). The primary role of this committee was to give technical guidance by ensuring that all technical aspects of the project were acceptably

sound. Stock cultures of parasitoids were obtained from Honduras and Guatemala through PROMECAFE to begin rearing of the parasitoids in Jamaica.

Field research was carried out by CARDI on the establishment of the parasitoids and their efficacy in reducing CBB populations was facilitated on coffee farms through the cooperation of coffee farmers, CIB and UWI. Laboratory research on parasitoid biology was conducted at CARDI by a UWI student for his final year research project course.

There was both international and local training under the project, which would not have been possible without the collaboration of CIB, PROMECAFE, Rural Agricultural Development Authority (RADA), UWI and other members of the coffee industry.

## PROJECT OUTPUTS

### Rearing of *Cephalonomia stephanoderis*

Parasitoids were imported to Jamaica from Honduras in 1999. After two and a half years, the initial 3,100 *Cephalonomia stephanoderis* Betrem (Family: Bethyridae) had been successfully multiplied to 591,227 *C. stephanoderis* (Figure 1). This was an almost 200-fold increase during that period.

### Field Establishment of *Cephalonomia stephanoderis*

The sites selected to carry out the studies were located at Rose Hill in the parish of St Andrew, Greenock in St Ann and Mountain Hill in St Catherine (Figure 2). The plots at Rose Hill were situated at 914 m ASL (above sea level) and received mean annual rainfall of 120.6 mm, while the plots at Greenock and Mountain Hill were situated at 551 m and 435 m ASL, respectively, and received mean annual rainfall of 103.2 and 127.5 mm, respectively.

One release of *C. stephanoderis* was made at each of the three experimental release plots. Monthly samples taken at each of the sites indicated that this parasitoid had become established at each sites as different stages of the parasitoid were recovered from coffee berries collected from the sites (Table 1).

### Field Efficacy of *Cephalonomia stephanoderis*

The CBB populations declined in plots in which *C. stephanoderis* had been released (release plots) one to three months after the release of the parasitoids. At the end of the coffee harvest, it was determined that the coffee yield from trees in release plots was higher than in the control plots, in which no parasitoids had been released (Figure 3).

### Laboratory studies

Biological studies on *C. stephanoderis* indicated that there was a significant ( $P = 0.05$ ) difference in the number of parasitoid offspring produced when rearing cultures were established at ratios of one parasitoid: one CBB-infested berry and one parasitoid: four CBB-infested berries. Longevity studies carried out to determine how long the adults could be stored showed that the mortality of adults stored at 11.6°C increased with time.

## Training

It was recognized that the success of this project and its eventual widening to a national programme was dependent on stakeholders and interest groups being sensitized to the programme and being trained in biological control and parasitoid rearing procedures. As was mentioned earlier, the cooperation of several organizations was critical in this aspect of the project. Two technicians (from CIB and CARDI) and one scientist (from CARDI) visited Honduras, Guatemala and Colombia where they received training in the rearing of three parasitoids of the CBB and were also able to visit coffee farms in these countries to view local production practices. Locally, three levels of training/sensitization were conducted by UWI, CARDI and CIB personnel for more than 110 persons drawn from RADA, CIB and the coffee industry. The training ranged from creating very basic awareness of biological control to intensive 3-4 week training in techniques used in rearing parasitoids, field data collection to monitor CBB population, and parasitoid establishment and field release of parasitoids. A rearing manual was produced as part of training tool, with information on CBB and parasitoids biology, how to rear CBB and parasitoids, methodology for field release of parasitoids and impact assessment. The audience targeted ranged from farm supervisors and workers to extension officers and specially selected farmers.

## FUTURE DIRECTION

The partnerships that were strengthened during this project resulted in its successful development and implementation. It is expected that these fortified partnerships will help to ensure the sustainability of biological control as an integral component of an integrated approach to the management of the CBB in Jamaica. Such an approach should incorporate:

- biological control, through rearing and releasing of parasitoids, with the continued involvement of coffee farmers, CIB, CARDI, UWI and PROMECAFE,
- physical control, through use of CBB attractant traps, with the cooperation of coffee farmers, CIB and PROMECAFE,
- cultural control, by reemphasizing the need for stripping of trees and ground sanitation at the end of the harvest period, which would require the CIB continuing to work with the coffee farmers and
- chemical control, through judicious use of insecticides, including biorationals and botanical insecticides, which would include CIB, UWI, input suppliers and coffee farmers.

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Table 1. Numbers of *Cephalonomia stephanoderis* released and recovered after one year at three experimental sites in coffee farms in Jamaica

Experimental Site	Number of Parasitoids	
	Released	Recovered
Rose Hill	37,800	>117
Greenock	10,000	> 565
Mountain Hill	5,000	> 4,700

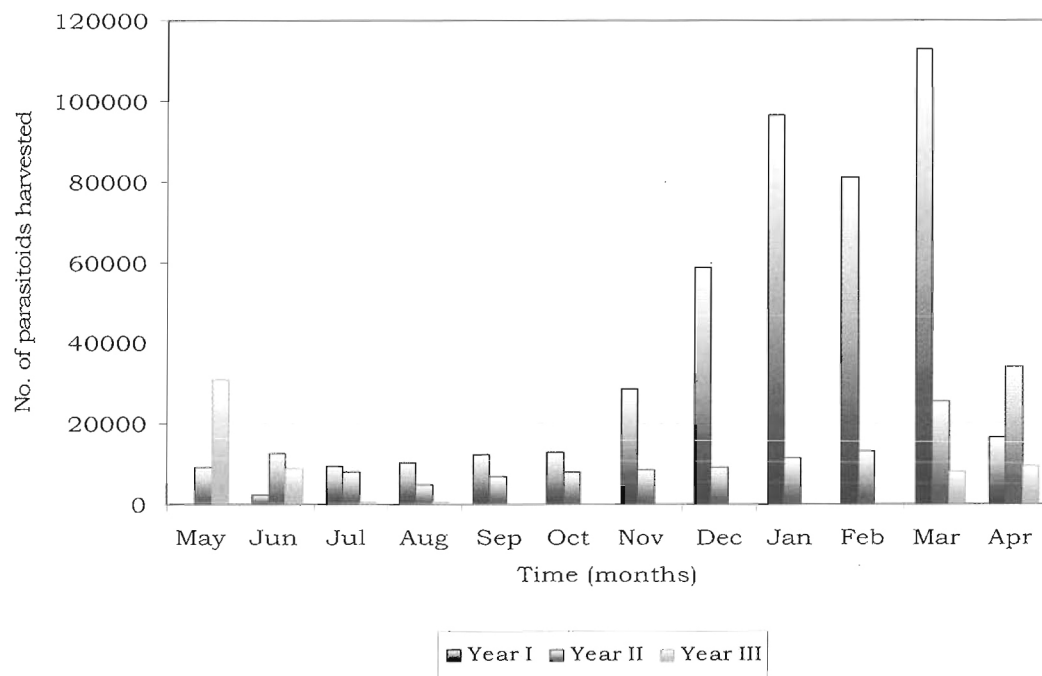


Figure 1. Production of *Cephalonomia stephanoderis* during the first three years of the project

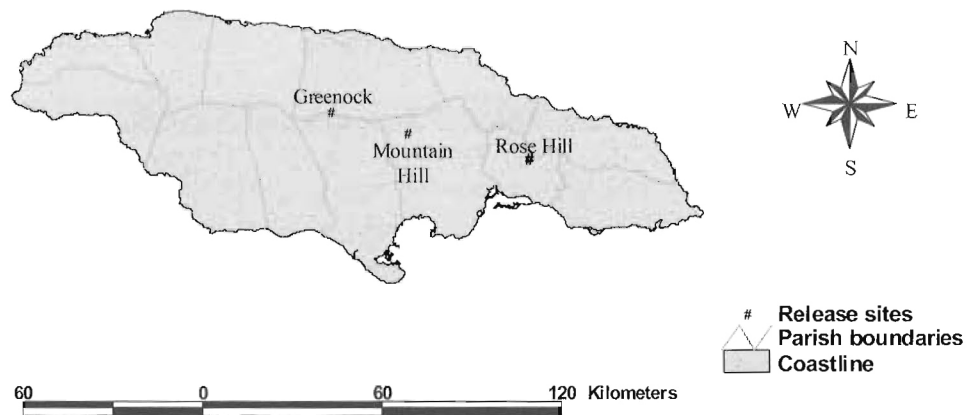


Figure 2. Map of Jamaica showing the study sites at Rose Hill in the parish of St Andrew, Mountain Hill in the parish of St Catherine and Greenock in the parish of St Ann

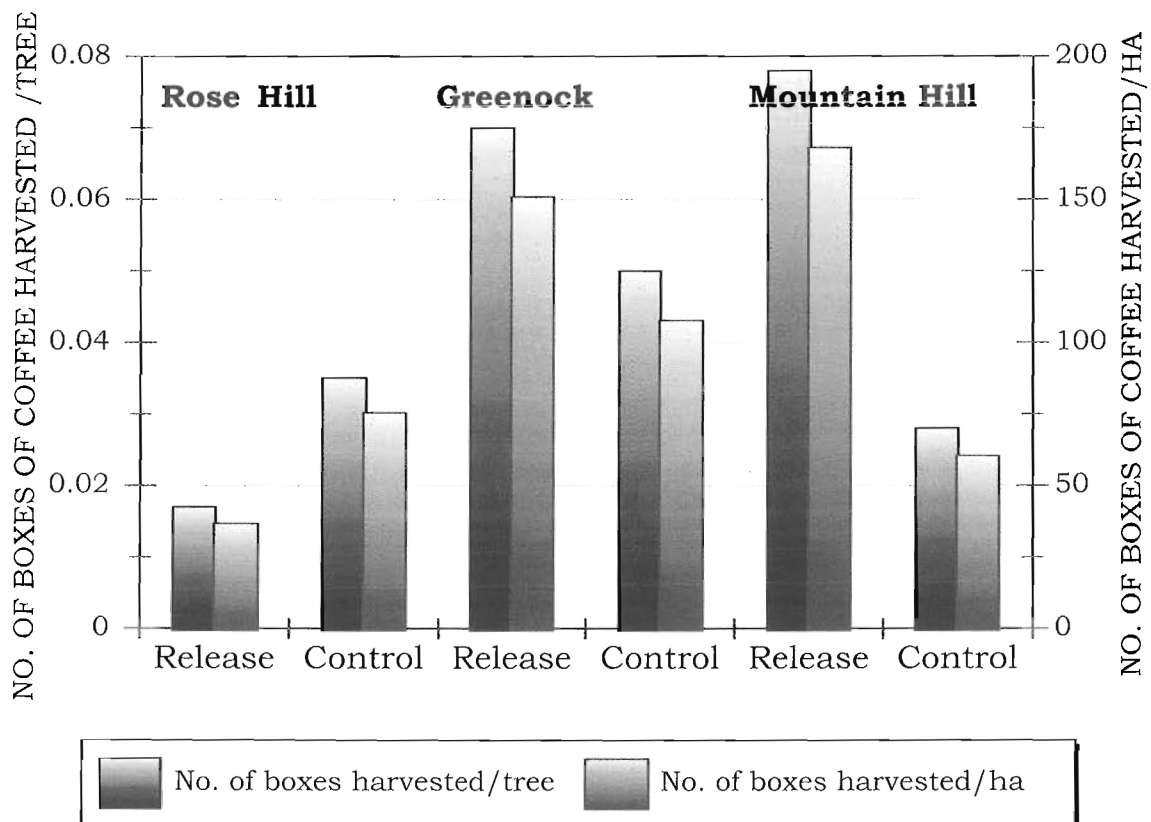


Figure 3. Mean coffee yields obtained from plots in Jamaica in which *C. stephanoderis* had been released (Release plots) and plots in which no releases (Control plots) were made

**MEETING THE CHALLENGES OF INVASIVE SPECIES USING A SYSTEMS APPROACH FOR PLANT DISEASE DIAGNOSTICS**

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**ABSTRACT:** Crop biosecurity with respect to new and emerging economically threatening diseases and pests has received much Nation-wide attention from scientists and government officials. Invasive pathogens and pests are extremely grave threats to Florida. The State's location, subtropical climate, and tourism, promote no less than 4-5 new significant plant disease introductions per year. It is critical that we have the capacity to detect, diagnose, and respond to intentional and accidental introductions of plant diseases and other pests. UF/IFAS is establishing the Florida Plant Disease Network, a web-based plant diagnostic and reporting system, which will complement the National Plant Diagnostic Network (NPDN) and the Southern Plant Diagnostic Network (SPDN). The Florida Plant Disease Network will focus to increase the State's effectiveness in meeting new invasive plant diseases and pests by training industry personnel, county faculty, extension specialists, researchers, and growers to be "First Responders" using modern and widely available tools, such as the Distance Digital Information System (DDIS) and Electronic Data Information Source (EDIS). A systems approach involving widely dispersed observers and diagnostic specialists should lead to faster detection, isolation and identification of plant disease causing agents. This will enable regulatory officials and growers to mitigate the potential devastation of exotic plant pathogens and pests.

**ENHANCEMENT OF BARN OWL POPULATIONS IN THE EVERGLADES AGRICULTURAL AREA OF SOUTH FLORIDA FOR SUSTAINABLE RODENT CONTROL**

*R. N. Raid. University of Florida, Everglades Research and Education Center, Belle Glade, FL 33430*

**ABSTRACT:** Small rodents, primarily in the form of rats and mice, cause an estimated \$30 million in damage annually to sugarcane and vegetable crops in south Florida. Traditionally, growers relied on chemical rodenticides in an attempt to manage rodent populations. However, rodenticides are costly, short-lived, and may be of concern environmentally. The common barn owl, *Tyto alba*, is endemic to Florida but populations remain far below optimum due to a perceived shortage of natural nesting sites. With a single pair of nesting barn owls capable of eliminating in excess of 1000 rodents per year, sugarcane and vegetable growers are interested in enhancing their populations to serve as a means of biological rodent control. Research has demonstrated that barn owls take readily to man-made nesting boxes placed along ditch banks and canals throughout the Everglades Agricultural Area. Prey diversity, box colonization, clutch sizes, and fledging success rates are being monitored to measure the success of the program.

**SCIRTOTHRIPS DORSALIS: A NEW THREAT TO THE GREATER CARIBBEAN REGION**

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**ABSTRACT:** Recently *Scirtothrips dorsalis* was found widely distributed on St. Lucia and St. Vincent, West Indies. Various life stages of the pest were found on pepper, tomato, pumpkin, squash, cucumber, cantaloupe, okra, amaranth, bean and ornamentals plants. The pest caused severe scarring of pepper fruits, and was found on the leaves, flowers and fruits of this crop. In eastern Asia, Africa and Oceania this thrips is a major pest of many vegetable crops, cotton, citrus and other fruit crops and ornamental crops. The potential geographic distribution of *S. dorsalis* in North America would extend the entire Caribbean region, and from southern Florida to north of the Canadian boundary. Options for meeting this threat will be discussed.

**THE EVALUATION OF FUNGICIDAL TREATMENTS AND IRRIGATION METHODS ON THE DEVELOPMENT OF DOWNY MILDEW AND OTHER DISEASES ON *CUCUMIS MELO* VARIETIES IN JAMAICA**

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**ABSTRACT:** There is a growing demand for cantaloupe and honeydew melon in Jamaica. Production of these crops has been plagued by high incidence of pest and diseases. Two experiments were conducted at the Bodles Research Station, St. Catherine, Jamaica, to evaluate fungicides against the diseases of significance to production, investigate the influence of sprinkler and furrow irrigation methods on disease severity, and to identify suitable varieties for local conditions. Significant differences were found among fungicide treatments in reducing the severity of downy mildew. Bravo was the most effective treatment, followed by combinations of Ridomil and Top Cop, and Bravo and Topsin. Downy mildew was more severe on sprinkler-irrigated plants compared to those using furrow irrigation. The results from both the fungicide and irrigation method trials showed that despite being most prone to develop downy mildew Tesoro Dulce and Dorado produced significantly higher yields. Hymark and Tam Uvalde were the most tolerant varieties to downy mildew. Further investigations using other recommended fungicides, could help determine the best strategy for disease control in *Cucumis melo* production in Jamaica.

**INTEGRATED CONTROL OF DODDER (*CUSCUTA PENTAGONA*) USING GLYPHOSATE, AMMONIUM SULFATE, AND THE BIOLOGICAL CONTROL AGENT *ALTERNARIA DESTRUENS***

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**ABSTRACT:** Studies were conducted to develop an integrated control strategy for dodder (*Cuscuta pentagona*) using glyphosate, ammonium sulfate, and *Alternaria destruens*. In greenhouse studies, dodder parasitizing citrus was sprayed with glyphosate using 0%, 0.25%, 0.50%, 1%, 2%, and 4% concentrations of Roundup Pro<sup>®</sup> or ammonium sulfate at 0%, 1%, 2%, 3%, 4%, 5%, and 10% w/v. Five weeks after treatment (WAT) dodder plants treated with glyphosate were dead and the control plants were 95% dead. Highest levels of damage on citrus from glyphosate at 1%, 2%, and 4% ranged from 28% to 50%; the lowest levels, 10% to 20%, were from 0.25% and 0.5%. Five WAT, dodder in ammonium sulfate and control treatments necrosed; damage to citrus was <10%. In a field study, sunn hemp (*Crotalaria juncea*) naturally parasitized by dodder was hand-sprayed with  $1.7 \times 10^5$  spores per ml of *A. destruens* at 100 ml per m<sup>2</sup>. The fungus was applied with and without a corn-oil-based carrier, PCC588. The fungal treatments produced 97% necrosis at 5 WAT; by 6 WAT, the control was 95% dead. Studies are underway to develop an integrated strategy using lowest effective levels of glyphosate, ammonium sulfate, and *A. destruens*. The reason for the damage and death of dodder in control treatments is also under investigation.

## INTRODUCTION

*Cuscuta* spp. are obligate parasites that predominate disturbed habitats, which preadapts them to becoming a serious weed problem. Dodder is found worldwide and has a wide host range including alfalfa, cranberry, tomato, citrus, various ornamental species, and many weed species. Some dodders are very host-restricted, while others will grow on numerous hosts. Reproduction is by vegetative fragmentation and seeds. Each plant is capable of producing several thousands of seeds that can remain viable in the soil for up to 20 years (Dawson et al., 1994).

Economic losses can be quite costly due to dodder parasitization with heavy dodder infestations leading to the death of the host plant. Herbicides are the primary means of dodder control. In the past, chlorpropham (1-methylethyl 3-chlorophenylcarbamate) was used to kill seedlings, but this herbicide is no longer available for use in the United States (Dawson et al., 1994). Other soil-applied herbicides used are DCPA (dimethyl tetrachloroterephthalate) (Dawson, 1967), dichlobenil (2,6-dichlorobenzonitrile) (Dawson, 1970), pronamide [3,5-dichloro-*N*-(1,1-dimethyl-2-propynyl)benzamide] (Liu et al, 1987), and pendimethalin [*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine] (Dawson, 1990). Glyphosate (*N*-(phosphonomethyl)glycine) applied to established plants has also been found to control dodder



without severely injuring the host plant (Dawson, 1989). Other control methods include mechanical removal by seed machines, tillage, and physically removing the dodder by hand.

The three objectives of this research were to (1) determine rates of glyphosate that are lethal to dodder but not to its host using 0%, 0.25%, 0.5%, 1%, 2%, and 4% concentrations of Roundup Pro<sup>®</sup>; (2) determine if dodder can be suppressed by desiccation without affecting the host plant by using ammonium sulfate (0%, 1%, 2%, 3%, 4%, 5%, and 10% w/v in water); and (3) determine if dodder can be suppressed by *A. destruens* under field conditions.

## METHODS AND MATERIALS

All studies had a randomized complete block (RCB) design and host plants were parasitized with *C. pentagona*. All treatments were applied with a hand-held sprayer at 100 ml per m<sup>2</sup> and ratings were taken weekly using a 0 – 5 scale (0 = 0%; 1 = 1-10%; 2 = 11-35%; 3 = 36 – 65%; 4 = 66 – 90%; and 5 = 91 – 100% necrosis of dodder biomass). In all studies, data were subjected to ANOVA and Fisher's protected LSD test at the 0.05% level.

### Greenhouse Studies

All studies conducted in the greenhouse took place at the University of Florida in Gainesville. Dodder was vegetatively propagated on *Citrus* sp. and rated over a 5-week period. In the glyphosate studies there were six treatments (glyphosate at 0% (control), 0.25%, 0.50%, 1.0%, 2.0%, and 4.0%) and in the ammonium sulfate studies there were seven treatments (ammonium sulfate at 0% (control), 1%, 2%, 3%, 4%, 5%, and 10%). Both studies had 4 replications per treatment with each experiment repeated once.

### Field Studies

The study conducted in the field took place at the Header Canal Farm, USDA-ARS-USHRL in Fort Pierce, Florida on sunn hemp (*Crotalaria juncea*) naturally parasitized by dodder (*C. pentagona*). *A. destruens* was applied at  $1.7 \times 10^5$  spores per ml with and without oil. Ratings were taken over an 8-week period. There were four treatments (control, oil (corn-oil-based carrier, PCC588), *A. destruens* + oil, and *A. destruens*), 8 replications, and the experiment was repeated once.

## RESULTS AND DISCUSSION

At 2 WAT, dodder treated with 2% and 4% glyphosate exhibited 100% injury, while untreated dodder was slightly injured (ca. 26% injury). By 5 WAT, all dodder plants treated with glyphosate were dead and untreated control dodder was 95% dead. The highest levels of damage on citrus from glyphosate at 1%, 2%, and 4% ranged from 28% to 50% while the lowest levels, 10% to 20%, were from 0.25% and 0.5%. Statistically, there were no differences between treatments of glyphosate at 4% and 2%; 1% and 2%; and 0.5% and 0.25%. In the ammonium sulfate studies, there were no differences between any treatments over time. Dodder was 98% injured by 4 WAT and the damage to citrus was <10%.

The effects of *A. destruens* applied with or without oil were observable by 2 to 3 WAT in the field studies. At 6 WAT, there were no differences among treatments, and by 8 WAT, dodder started to regrow in plots.

In all studies, untreated dodder (control) exhibited delayed but increasing levels of damage and eventually died. Further studies will be conducted to examine this phenomenon. In addition, other studies are being conducted to determine if an integrated management strategy can be developed using combinations of glyphosate, ammonium sulfate, and/or *A. destruens* to suppress dodder.

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**NATURAL ENEMIES OF PALM LEAF SKELETONIZERS IN FLORIDA, PUERTO RICO, AND THE U.S. VIRGIN ISLANDS**

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**ABSTRACT:** Studies are being conducted to elucidate the bionomics of palm leaf skeletonizers, *Homaledra sabalella* (Lepidoptera: Coleophoridae), and a closely related *Homaledra sp. n.* This paper reports the results of studies to identify natural enemies of these species in Florida, Puerto Rico, and the U.S. Virgin Islands. A collecting-rearing method for identifying the parasitoids is described. Similarities and differences found in the natural enemy complex attacking *Homaledra spp.* in Puerto Rico, Virgin Islands, and Florida are discussed. *Phytomyptera sp. n.* (Diptera: Tachinidae) was the most widespread parasitoid reared from both species of *Homaledra* in Florida. This species has not been reared from *Homaledra spp.* in Puerto Rico or the Virgin Islands. Damage to palms by *Homaledra spp.* is currently more extensive in Puerto Rico than in Florida. Possibly this may be related to the absence of *Phytomyptera*, which is so prominent in Florida. This tachinid should be studied as a potential biological control agent of *Homaledra spp.* for introduction into Puerto Rico.

## DEVELOPMENT OF LIGHT-EMITTING DIODE (LED) EQUIPPED INSECT TRAPS FOR MONITORING PEST INSECTS IN GREENHOUSES AND FIELDS, 2001 – 2004

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**ABSTRACT:** We equipped yellow sticky card (YC) and CC traps with 530 nm lime green light-emitting diodes (LED-YC and LED-CC) and blue sticky card (BC) traps with 470 nm blue LEDs (LED-BC) to increase trap catches of several pest insects. The LED-YC traps caught 1.3, 1.4, 1.8, and 4.8 times more adult *Trialeurodes vaporariorum* (Westwood), sweetpotato whitefly *Bemisia tabaci* (Gennadius) biotype B, *Aphis gossypii* (Glover), and *Bradysia coprophila* (Lintner), respectively, compared with YC traps in greenhouse studies. The LED-YC traps did not catch more *Eretmocerus* spp. than the standard YC traps. The LED-CC traps caught 6.1 times more *B. tabaci* compared with unlit CC traps. The LED-CC traps caught few *Encarsia erimicus* (Rose and Zolnerowich) and *Encarsia formosa* (Gahan) compared with YC traps. The LED-BC traps caught 8.1 times more adult *Franklinella occidentalis* (Pergande) compared with the unlit BC traps in field studies.

### INTRODUCTION

A LED consists of a semi-conductor chip housed in an epoxy case. When connected in a circuit, the LED emits light specific to the semi-conductor material (usually a combination of gallium, arsenic, and phosphorus). The recent development of the “cold” generation of LED light leads to high efficiency (15-20%) to convert electrical energy into light making the possible of using LEDs in plant production (Fang and Jao 2004).

Insect traps are vital component for detection and monitoring of insect populations. We equipped yellow sticky card (YC) and blue sticky card (BC) traps with 530 nm lime green and 470 nm blue LEDs (LED-YC and LED-BC) to increase trap catches of several pest insects. We also equipped a CC trap (= plastic cup trap) with a 530 nm LED for monitoring sweetpotato whitefly populations in the greenhouses and fields. We reported here our recent studies using LED technique to increase the trap catches of YC, BC, and CC traps in greenhouses with the LED lights. Details of the studies were reported elsewhere (Chen et al., 2004a, 2004b, Chu et al., 2003, 2004, Simmons et al., 2004).

### MATERIALS AND METHODS

The design of a LED clamp is shown in Figure 1. Figure 2 shows the arrangement of LED-YC and unlit YC to test their efficacies in a commercial poinsettia greenhouse in 2002. Figure 3 shows a close-up of the YC trap equipped with a LED clamp. Figure 4 shows the standard CC developed in 1996 for monitoring whiteflies in the field and greenhouses. Figures 5 and 6 show the design of a LED-CC trap and a LED-CC trap in use for in a greenhouse study. Figure 7 shows a BC traps equipped with a 470 nm blue LED clamp.

Experiments below were conducted using a randomized complete block design with 4-10 replicates:

Darkroom study. Treatments were lime green LED and white LED CC traps. The unlit CC traps were controls.

Research greenhouse studies. (1) Treatments were sticky clear plastic card traps equipped lime green LED. The unlit clear plastic card traps were controls. (2) Treatments were lime green LED-YC traps. The unlit YC traps were controls. (3) Treatments were lime green LED equipped and Tanglefoot coated CC traps. The unlit Tanglefoot coated CC traps were controls. (4) Treatments were lime green LED equipped CC traps. The unlit YC traps were controls. (5) Treatments were blue LED-BC traps. The unlit BC traps were controls.

Commercial greenhouse studies. Treatments were lime green LED-YC traps. The unlit YC traps were controls.

Field studies. Treatments were LED-BC traps. The unlit BC traps were controls.

## RESULTS AND DISCUSSION

Lime green LED-CC traps caught more *T. vaporariorum* and *B. tabaci* compared with white LED-CC and unlit CC traps (Table 1), indicating the two whitefly species were more attracted to the lime green colors.

The study on Tanglefoot coated clear plastic traps verified the color attraction of the whitefly species. In addition, more *Bradysia coprophila* were attracted to clear plastic traps equipped with lime green color compared with unlit clear plastic card traps (Table 2). YC traps equipped with lime green LED also caught more *B. tabaci*, *T. vaporariorum*, *B. coprophila*, and *A. gossypii*.

The LED-CC traps caught six times *B. tabaci* compared with Tanglefoot-coated CC traps in a greenhouse study (Table 3). The LED-CC traps did not catch significantly fewer *Bemisia tabaci* compared with unlit YC traps. Both studies showed that the traps equipped with LED caught fewer parasitoids except that LED-CC caught more *E. eremicus* and *E. formosa* compared with tanglefoot coated traps.

The study in a commercial poinsettia greenhouse showed that LED-YC traps caught more *B. tabaci* compared with unlit YC traps. This study and the study in a commercial gerber greenhouse showed that there were no differences in the catch of *F. occidentalis* and, but more catches in *B. coprophila* (Table 4).

More *B. tabaci* were caught on LED-YC traps in a research greenhouse planted with collard and melon but the differences in the catches of *F. occidentalis*, *E. eremicus*, and *D. catalinae* were not significant, except LED-YC caught more *D. catalinae* compared with unlit YC traps (Table 5).

LED-BC caught more *F. occidentalis* compared with unlit BC in greenhouse planted with potted bloomingdale ranunculus.

The LED-YC traps caught 1.3, 1.4, 1.8, and 4.8 times more adult *T. vaporariorum*, *Bemisia tabaci*, *Aphis gossypii* and *Bradysia coprophila*, respectively, compared with unlit YC traps in greenhouse studies. The LED-YC traps did not catch more *Eretmocerus* spp. than the unlit YC traps. The LED-CC traps caught 6.1 times more *B. tabaci* compared with unlit CC traps. The LED-CC traps caught few *E. eremicus* and *Encarsia formosa* compared with YC traps. The LED-BC traps caught 8.1 times more *Franklinella occidentalis*. The lime green LED-YC traps caught more adult greenhouse whiteflies, sweetpotato whiteflies, cotton aphids, and *B. coprophilas* but not more *Ertmocerus remicus* compared with unlit YC traps in greenhouses. The lime green LED-CC traps caught more *T. vaporariorum* and *B. tabaci* but

fewer parasitoids *Eretmocerus eremicus* and *Encarsia formosa* compared with unlit clear plastic traps in greenhouses.

Results indicate that LED-YC trap has potential for insect detection, monitoring, and control outside of greenhouses. LED-CC trap is compatible for use in combination with releases of *Eretmocerus* or *Encarsia* sp. for whitefly nymph in biological control greenhouses. Both LED-YC and LED-BC traps have potential for insect and monitoring in greenhouses and fields.

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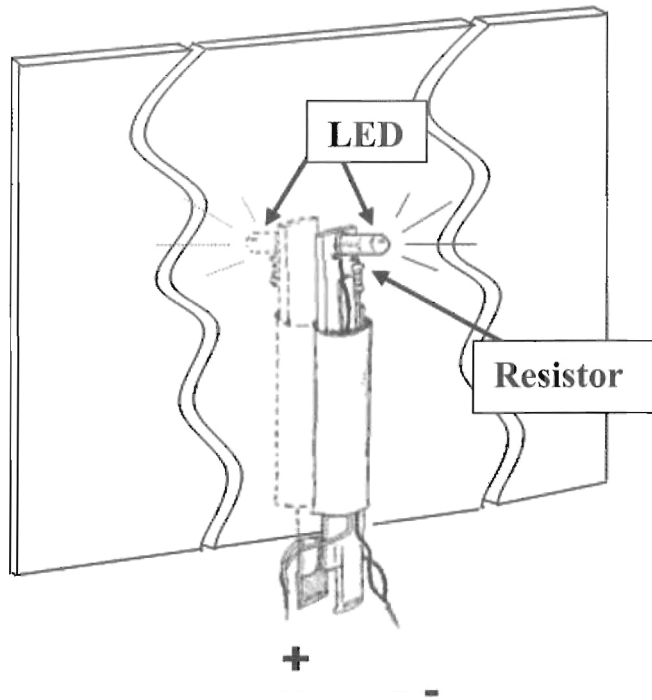


Figure 1. The design of a yellow sticky card trap equipped with a light-emitting diode clamp.



Figure 2. Arrangement of LED-YC and unlit YC to test their efficacies in a commercial poinsettia greenhouse in 2002.

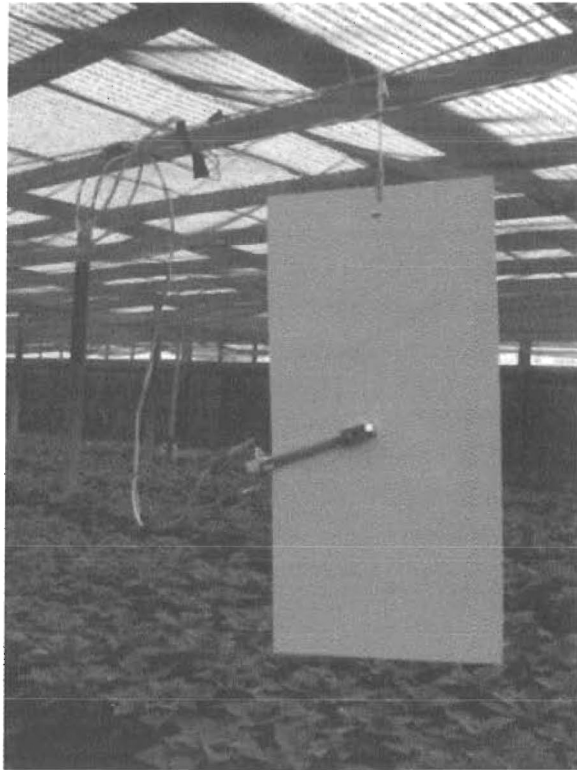


Figure 3. A close-up view of a yellow sticky trap equipped with a lime green light-emitting diode shown on one side of the trap in a commercial poinsettia greenhouse in 2002.



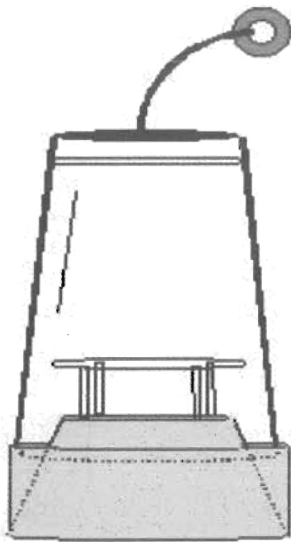


Figure 4. A standard CC trap for monitoring *Bemisia tabaci* populations in the field and greenhouses.

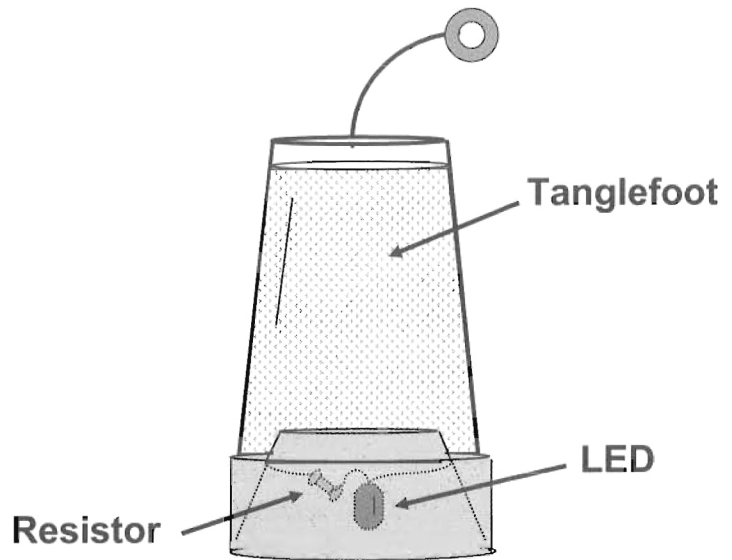


Figure. 5. The design of a CC trap equipped with a 530 nm green light-emitting diode.



Figure 6. A CC trap equipped with a 530 nm lime green light-emitting diode for trapping insects in greenhouses.

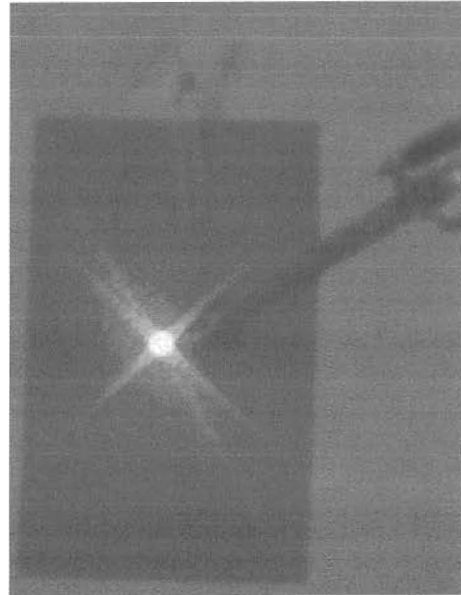


Figure 7. A blue sticky card trap equipped with a 470 nm blue clamp.

Table 1. Mean numbers of *Trialeurodes vaporariorum* and *Bemisia tabaci* caught in CC traps equipped with light emitting diodes (LED).

LED type	Lumens	No. adults/trap/day	
		<i>T. vaporariorum</i>	<i>B. tabaci</i>
No	2.2	10.0b <sup>a</sup>	91.3b
White	2.6	24.3b	52.6b
Lime green	2.6	138.1a	270.1a

<sup>a</sup> Means in a row not followed by the same letters significantly different, Tukey's test,  $P = 0.05$ .

Table 2. Mean numbers of *Trialeurodes vaporariorum*, *Bradysia coprophila*, *Bemisia tabaci*, and *Aphis gossypii* caught in traps equipped with light emitting diodes (LED).

Trap type	Insect species	No. adults/100 cm <sup>2</sup> /day	
		LED	Unlit
Clear plastic	<i>B. tabaci</i>	74.3a <sup>a</sup>	13.3b
	<i>T. vaporariorum</i>	7.4a	3.9b
	<i>B. coprophila</i>	4.0a	0.8b
Yellow card	<i>B. tabaci</i>	388.3a	274.5b
	<i>T. vaporariorum</i>	85.4a	65.3b
	<i>B. coprophila</i>	6.2a	1.3b
	<i>A. gossypii</i>	23.0a	12.7b

<sup>a</sup> Means in a row not followed by the same letter were significantly different,  $t$ -test,  $P = 0.05$ .

Table 3. Mean numbers of *Bemisia tabaci*, *Eretmocerus*, and *Encarsia formosa* caught in traps equipped with light emitting diodes (LED).

Trap type	No. adults/100 cm <sup>2</sup> or trap/day <sup>a</sup>		
	<i>B. tabaci</i>	<i>E. eremicus</i>	<i>E. formosa</i>
<i>Test 1</i>			
Coated-CC	497.7b <sup>a</sup>	1.8b	0.0a
LED-CC	3,055.3a	33.4a	0.2a
<i>Test 2</i>			
YC	232.4a	39.2a	81.6a
LED-CC	189.2a	2.8b	5.3b

<sup>a</sup> Means in a column of a test not followed by the same letter were significantly different,  $t$ -test,  $P = 0.05$ .

Table 4. Mean numbers of *Bemisia tabaci*, *Franklinella occidentalis* and *Bradysia coprophila* caught in traps equipped with light emitting diodes (LED).

Trap type	No. adults/100 cm <sup>2</sup> / week		
	<i>B. tabaci</i>	<i>F. occidentalis</i>	<i>B. coprophila</i>
<i>Poinsettia</i>			
YC	246.3b <sup>a</sup>	2.2a	8.0b
LED-YC	347.5a	2.5a	44.1a
<i>Gerbera</i>			
YC	-	7.3a	1.0b
LED-YC	-	8.4a	2.4a

<sup>a</sup> Means in column in a crops species not followed by the same letter are significantly different, *t*-test, *P* = 0.05.

Table 5. Mean numbers of *Bemisia tabaci*, *Franklinella occidentalis*, *Eretmocerus eremicus*, and *Delphastus catalinae* caught in traps equipped with light emitting diodes (LED).

Trap type	Mean no. adults/100 cm <sup>2</sup> /6 d			
	<i>B. tabaci</i>	<i>F. occidentalis</i>	<i>E. eremicus</i>	<i>D. catalinae</i>
<i>Collard</i>				
YC	19.4b <sup>a</sup>	33.5a	5.4a	1.1b
LED-YC	23.6a	35.1a	5.6a	1.5a
<i>Melon</i>				
YC	6.3b	5.6a	1.1a	0.2a
LED-YC9.	5a	6.1a	1.0a	0.4a

<sup>a</sup> Means in column in a crops species not followed by the same letter are significantly different, *t*-test, *P* = 0.05.

Table 6. Mean numbers of *Frankliniella occidentalis* caught in traps equipped with light emitting diodes (LED).

LED on blue card	No. <i>F. occidentalis</i> adults/4 wk
Yes	38.3a <sup>a</sup>
No	4.6b

<sup>a</sup>*t*-test, *P* = 0.05.

**COMPOSTED POULTRY LITTER EFFECT ON TILLER DYNAMICS, HERBAGE MASS AND CRUDE PROTEIN CONCENTRATION OF *BRACHIARIA BRIZANTHA* CV. MULATO**

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**ABSTRACT:** Composted poultry litter (CPL) applied to field crops can be an important source of nutrients and organic matter to improve soil quality. However, little is known on the effects of CPL on tiller dynamics and forage yield of the tropical grass *Brachiaria brizantha* cv. mulatto. A study was conducted in the fall of 2003 and spring of 2004 to evaluate four CPL rates and their influence on number of tillers, herbage mass (g/plant), and crude protein (CP) concentration of cv. Mulato at three harvests at 30-d intervals. Treatments included 0 (Control; C), 16 (low; L), 31 (Medium; M), and 62 kg/ha of N (High; H) CPL rates. Grass seedlings (6-wk old) were established in pots (1-gl) filled with soil of the Consumo type (Fine, mixed, semi-active, isohyperthermic Typic Haplohumults). Composted poultry litter was broadcast-applied and incorporated into the first 2-cm of the soil in the pots. Plants were irrigated as needed. From first to the third harvest, there was a minimal increase in tiller count (8.4 to 11) for the control. Corresponding increases observed for the L and M CPL rates were 14 to 28 and 21 to 28 tillers/plant. However, the magnitude of change in tiller counts at the H CPL rate was much greater (21, 23, and 44) at first, second and third harvest, respectively. There was also a linear effect ( $P < 0.05$ ) of CPL rates on herbage mass (g/plant on dry matter basis). For C, there were no changes in herbage mass from first to last harvest (mean of 16 g per plant). For the L and M rates of CPL minimal changes in herbage mass were noted from the first to third harvest. Herbage mass increases from 31 to 56, and 81 g/plant at first, second, and third harvest, respectively at the H CPL rate. There were differences in CP of cv. Mulato with increasing rates of CPL. Crude protein averaged 7.2, 6.6, 7.2, and 9.1% for the C, L, M, and H rates, respectively (a 2 percentage unit increase over C with H CPL). An important aspect of this study is that cv. Mulato can serve as a sink for this nutrient-rich compost and can also provide a profitable and environmentally acceptable use of CPL.

## INTRODUCTION

Livestock production in Puerto Rico is dependent on tropical pastures to meet their nutritional demand. Nitrogen is the most limiting nutrient for pasture production in Puerto Rico. Most of the soils used for pastures are mainly acidic (Oxisols and Ultisols). These soils have low organic matter content, and are prone to soil erosion. For increase yields, grasses rely on inorganic fertilizers, thus increasing cost of production. Nitrate leaching and subsurface lateral flow toward streams and rivers is a major environmental contamination of groundwater and other water resources in Puerto Rico. Phosphorus is also a major concern (Havlin et al., 1990). According to Hornik (1992), the quality of soil has been mainly associated with its productivity. This definition has now been expanded to include the capacity of a soil to function within

ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health. An alternative for improving soil quality is the use of compost.

Poultry litter (PL) is generated in large quantities in Puerto Rico. The Department of Agriculture of Puerto Rico reports an average yearly population of 8.2 million broilers, which yield approximately 71,500 metric tons of manure (Muñoz et al., 1990). This manure if composted represents an alternative source of organic matter for the maintenance of low fertility soils. According to Martínez and Guzman (1999), composting is a cost effective and environmentally sound alternative for PL recycling. On clay soils, good quality compost can improve soil structure, reduce surface crusting and compaction, promote drainage, and provide much needed nutrients. In sandy soils, compost increases water and nutrient retention, supplies nutrients, and increases microbial activity.

In an evaluation of time and mode of application of chicken manure for plantain production, an adverse effect was observed during germination with the application of 7.26 kg manure per plant at planting (Muñoz and Martínez, 1991). But other studies with PL was shown to promote faster turf establishment, improved turf density and color, increase root growth, and require less inorganic fertilizer and irrigation (Landschoot, 1996). Composts can supply all or most of the turf's nutrient requirement (i.e. N, P, S, K, Fe, Zn, Cu, and Mg). Studies with biosolids show that only about 10 percent of the N is available to plants during the first growing season. Certain types of compost have a high concentration of soluble salts, such as those made with spent animal manures. Those salts increase the electrical conductivity of the soil with compost additions, sometimes approaching limits considered detrimental to support crop growth (Martínez and Guzmán, 1999; Landschoot, 1996). Another problem is its variation in pH with very high (>8.5) or very low (<5.5) values can be detrimental to turf. The extremes in pH affect the availability of nutrients for plant use. Also, compost made from biosolids was shown to have higher heavy metal concentrations than those made from other sources. Applications of biosolids have showed significant increases in the levels of EDTA extractable metals (e.g., Cu, Zn, Cd, Cr, and Fe) (Martínez and Guzman, 1999).

Information on the use of PL on pasture crops in Puerto Rico is limited. Studies are needed to assess the effects of varying levels of composted poultry litter (CPL) on the chemical and biological properties of soils and their effects on grass growth. The present research investigated CPL litter effects on tiller dynamics, biomass and CP percentage of *Brachiaria brizantha* cv. mulato at 30-d intervals.

## MATERIALS AND METHODS

This experiment was conducted at the University of Puerto Rico, Mayaguez Campus. Soil type was an Ultisol, Consumo clay, (Fine, mixed, semiactive, isohyperthermic Typic Haplohumults). At the initiation of the experiment in 2003, field soil samples (taken at 0-30 cm depth) and CPL (produced at Vivero Finca Bayamón) were analyzed for major and micro-nutrients (Tables 1 and 2). Treatments included 0 N (control; C), 16 (L), 31 (M), and 62 kg/ha N (H).

Grass seedlings of cv. Mulato (6-wk old) were transplanted in pots (1-gl size) and CPL broadcast applied and incorporated into the first 2-cm of the soil. Plants were maintained in an open greenhouse and irrigated as needed. Plants in each pot were harvested by clipping to a 15-cm height every 30-d. At harvesting, the number of tillers were counted and recorded. The fresh weight of the clipped plants (g/plant) were recorded and full samples were dried in an open-draft

oven at 60°C for 48 hrs and dry matter percentage calculated. Dried samples were then ground in a Wiley mill to pass a 1-mm screen. Ground samples were analyzed for N following the procedures described by AOAC (1990) and CP calculated ( $N \times 6.25$ ).

Treatments (CPL) were arranged in a randomized complete block design and replicated five times. Data were analyzed using the GLM procedure of SAS (1990). Because of changes over time, data were sorted and analyzed by harvest date. Treatment comparisons were made using single degree of freedom contrasts for linear, quadratic, and cubic effects of CPL rates.

## RESULTS

There were significant ( $P < 0.05$ ) PL rate, harvest date and PL rates by harvest date interaction effects on tiller dynamics of cv. Mulato. In the data analyzed by harvest date, there was a linear response ( $P < 0.05$ ) to increasing rates of CPL. From the first harvest to the third, there was minimal increase in number of tillers (8.4 to 11). Similar increases were observed for the L and M rates. Major changes, however, were noted for the H rate (21, 23, and 44 tillers per plant) at first, second and third harvest, respectively (Figure 1).

There was also a linear effect of CPL rates on dry matter (DM) yield (g/plant). For the control, there were no changes in DM yield from first to last harvest (average of 16 g per plant). For the L and M rates of CPL minimal changes in dry weight of plants were observed from the first to third harvest. However, at the H rate of CPL, there were major changes in dry matter yield. Yields per plant of 31, 56, 81 g at first, second, and third harvest, respectively were recorded (Figure 2). The increase in DM at third harvest is highly correlated to number of tillers (44 tillers/plant).

There were differences in CP concentration of cv. Mulato with increasing application of CPL. Crude protein averaged 7.2, 6.6, 7.2, and 9.1% for the C, L, M, and H rates, respectively. There was a 2 percentage unit increase in CP with the H rate of CPL.

## CONCLUSIONS

Our results show positive linear responses for both number of tiller and DM yield of cv. Mulato to the high rate of CPL (62 kg/ha N). The increased DM yield due to the H CPL rate compared to that of the control at the third harvest may indicate mineralization of N and more N available for plant use. This gives CPL the quality of a slow release fertilizer. The two percentage unit increase in CP with addition of the H rate of CPL can serve to increase the nutritive value of cv. Mulato. Soil analysis is needed to determine changes in soil pH, and P and other minerals accumulating in the soil. Because of the slow release of N from CPL, there would be less leachate of N in the system. An important aspect of this study is that cv. Mulato or other tropical grasses can serve as a sink for this nutrient-rich compost and also provide a profitable and environmentally acceptable use of poultry litter compost.

## ACKNOWLEDGEMENTS

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Table 1. Soil analysis at two depths (Fine, mixed, semiactive, isohyperthermic Typic Haplohumults) and Composted poultry litter (CPL).

Sample Soil	Organic Matter*	K*	Mg*	Ca*	N*	P**	CEC***	pH
0-4" depth	2.1	3.1	21.1	49.6	.2	3	21.4	5.5
4-6" depth	2.6	6.7	25.2	57.7	.2	21	22.2	6.3
Poultry Litter	9.9	65.1	14.8	20.1	2	238	46.3	9.1

\* Values are in percent, \*\* P values are in ppm, \*\*\* Values are in meq/100g

Table 2. Micro-nutrients and sulfur composition of soil at two depths and of composted poultry litter (CPL).

ppm	Soil		CPL
	0-4"†	4-6"†	
Sulfur	139	322	964
Zinc	2.4	5.4	58.9
Manganese	55	84	126
Iron	31	39	60
Copper	3.9	4.5	4.9
Boron	0.3	0.8	3.8

† Soil depth

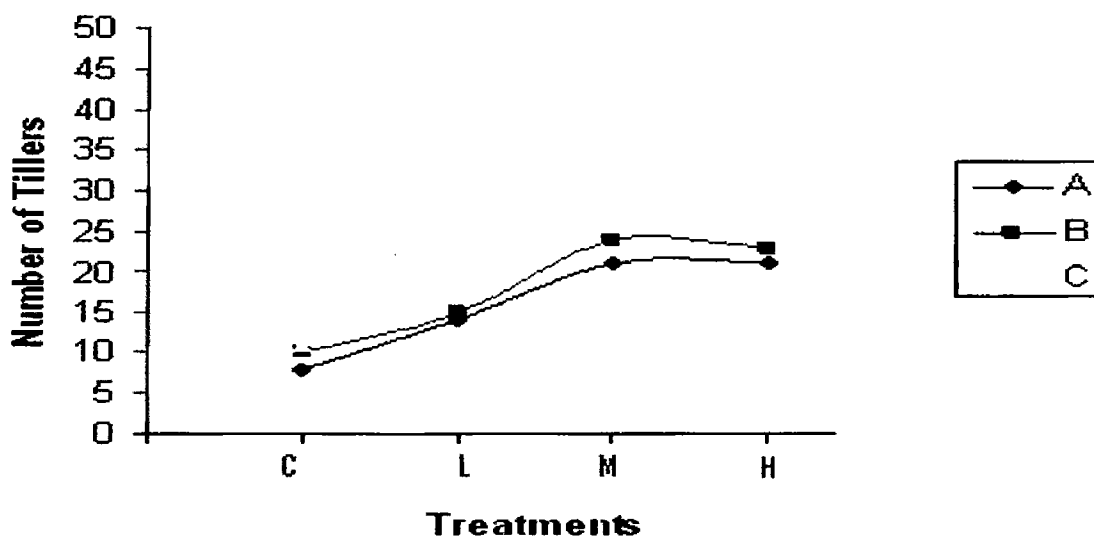


Figure 1. Number of tillers per plant for four CPL treatments at 30 (A), 60 (B) and 90-d (C).



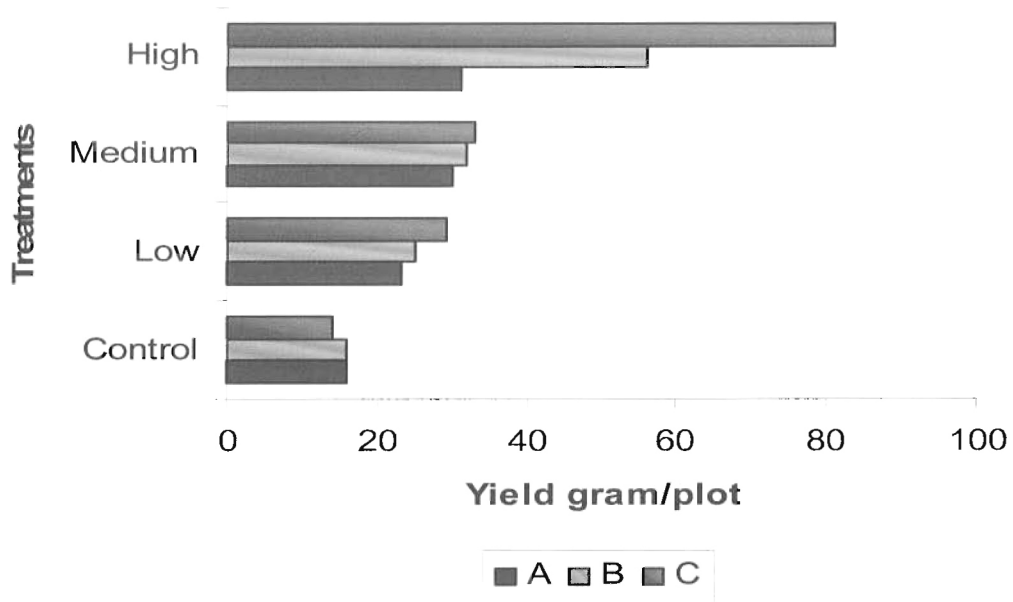


Figure 2. Dry matter yield (g/plot) for four CPL treatments at 30 (A), 60 (B) and 90-d.

**EVALUATION OF VARIOUS NITROGEN SOURCES ON BAHIAGRASS PRODUCTION**

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**ABSTRACT:** Two field studies were conducted on different soil types to evaluate the effects of different nitrogen sources on bahiagrass production. Treatments consisted of four sources of nitrogen applied at 67 kg N/ha (ammonium sulfate, ammonium nitrate, ammonium nitrate + sulfur, calcium nitrate, and a no nitrogen control). The study was a randomized complete block design with four replications. Results of this study show that bahiagrass yields and quality were highest on plots receiving ammonium sulfate as compared to other nitrogen sources. Yields and quality were also increased on plots receiving ammonium nitrate and sulfur as compared to plots only receiving ammonium nitrate. Tissue sulfur levels also increased with the addition of sulfur fertilizer. This study as well as results from previous studies conducted by the authors clearly shows the importance of sulfur fertilization for pasture grasses grown on coarse textured soils deficient in sulfur.

**USE OF FOOD INDUSTRY WASTES IN PASTURE PRODUCTION**

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**ABSTRACT:** A tremendous amount of waste is generated in consumer societies worldwide. Those resulting from industrial processing of food are potentially able to be recycled back into the primary food production stream as soil amendments. In the Caribbean, Trinidad represents one of those with a huge capability to complete this loop and recycle nutrients back into the food chain while protecting the environment. This paper provides a detailed analysis of one such waste material generated from a milk processing company and results of a greenhouse and field investigation using pasture grass.

**FORAGE AVAILABILITY AND QUALITY, AND CATTLE PERFORMANCE ON TROPICAL GRASS-LEGUME PASTURES**

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**ABSTRACT:** Cattle were grazed continuously for up to 168 d on three pasture types: *Aeschynomene evenia*-bahiagrass (*Paspalum notatum*), creeping vigna (*Vigna parkeri*)-bahiagrass, or pure bahiagrass in 2002 and 2003 to compare forage availability, nutritive value and animal performance. *Evenia* and *Vigna* contribution to total available forage averaged 4% and 6%, respectively, in 2002. Mean bahiagrass available forage (2620 kg ha<sup>-1</sup>), CP (77 g kg<sup>-1</sup>), and IVOMD (404 g kg<sup>-1</sup>) were the same for pasture types in 2002, but changed over time, ranging from 1710 to 3310 kg ha<sup>-1</sup> for forage availability, 91 to 69 g kg<sup>-1</sup> for CP and 409 to 307 g kg<sup>-1</sup> for IVOMD. Seasonal CP of vigna, and CP and IVOMD of *evenia* averaged 193, 162, and 537 g kg<sup>-1</sup>, respectively, but the IVOMD of vigna ranged from 631 to 721 g kg<sup>-1</sup>. In 2002, young steers of 230 kg initial LW barely maintained weight on any pasture type over 168 d. In 2003, 168-d seasonal average daily gain and gain ha<sup>-1</sup> of mature steers (370 kg initial LW) on vigna-bahiagrass (0.43 kg d<sup>-1</sup>, and 183 kg ha<sup>-1</sup>) were greater than on *evenia*-bahiagrass or pure bahiagrass (0.36 kg d<sup>-1</sup>, and 130 kg ha<sup>-1</sup>). The results suggest that the inclusion of perennial legumes in tropical perennial pastures may not improve forage nutritive value sufficiently for young steers, but performance of mature steers could be improved.

**PARTNERING FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT - THE CASE OF CARDI AND PARTNERS IN THE DEVELOPMENT OF THE GOAT INDUSTRY IN JAMAICA**

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**ABSTRACT.** Partnering with relevant institutions and agencies is intrinsic in the design and execution of CARDI's R&D programmes. In Jamaica, CARDI has partnered with the Ministry of Agriculture and its agencies - R&D Division of MoA (MoA-R&D), Rural Agricultural Development Authority (MoA-RADA) and the Veterinary Services Division (MoA-Vet) - the European Union (EU), the Canadian International Development Agency (CIDA), ALPART Mining Venture (ALPARTMINES) and the Goat Breeders Society of Jamaica (GBSJ) to develop the goat industry. In the early 1990s, with funding from EDF of the EU and CIDA, and within an enabling environment of Government policy support for the industry, CARDI partnered with MoA-R&D, MoA-RADA and MoA-Vet to develop and transfer housing, breeding, feeding and production technologies. The alliance, in collaboration with farmers, established the GBSJ, which subsequently spearheaded breed improvements and quality control, innovation and farmer education. Further financial input from ALPARTMINES in the late 1990s, and collaboration and synergy with their farmers' groups resulted in the establishment of the Sam Motta Goat Demonstration and Training Centre. This partnership of enabling environment, resource provision and investment, technical know-how, technology development and capacity building, and technology dissemination, and uptake and assimilation resulted in: (1) increased investments in goat farming, including 650 pedigree stock imported by farmers at a cost of US\$1.1M, (2) increased productivity in liveweight at birth (66.2%), weaning (47.9%), and 8-10 months of age (85.9%), and increased doe productivity index (72.4%), (3) more than 100 per cent increase each in the number of farm families earning part of their living from small ruminant production (from 27,000 to 59,600), the population of small ruminants (from 206,000 to 416,500) and local small ruminant meat production (from 618 to 1,375 MT), (4) stimulation of interest and involvement of corporate Jamaica in the small ruminant industry through the provision of dedicated small ruminant feeds and small ruminant veterinary products and tools.

## INTRODUCTION

The Caribbean Agricultural Research and Development Institute (CARDI) is the premier agricultural research and development organisation in the English-speaking Caribbean established in 1975 with the mission to enhance the socioeconomic well-being of Caribbean people through research that improves the competitiveness and sustainability of regional agriculture. The Institute places great emphasis on partnership and linkages in the conceptualisation, planning and execution of its programmes and the subsequent dissemination and application of the results. This paper highlights the application of the partnering philosophy by the CARDI in the development of the small ruminant industry in Jamaica.

Goats and sheep are believed to have been introduced to Jamaica in the 15<sup>th</sup> and 16<sup>th</sup> centuries by the Spaniards and the Portuguese (Oliveira and Thompson, 1988) possibly through Africa and India (Muschette and Miller, 1988). Since then, small ruminants, especially goats have become a way of life and important socio-economic activity in Jamaica. Research and development efforts began in the 1950s and 1960s with sheep, but it was not until the 1980s that greater attention started to be paid to goats. During 1987-1990 the Ministry of Agriculture executed a Government of Jamaica/European Union (then EEC) bilateral project funded by the European Union. The project trained producers to make cheese and leather craft, established revolving schemes for foundation stock and prophylactic medication, and initiated the formation of goat farmers' groups.

The involvement of CARDI in the development of the small ruminant industry began in the 1980s with a series of nutritional studies (Johnson 1983) but from the early 1990s it began partnering with the Ministry of Agriculture and its agencies, as well as donor agencies for a more focused development effort for the industry.

## METHODOLOGY

### Partners

The partners whose contributions form the basis of this paper and their respective roles are as follows:

- ALPART Mining Venture (ALPARTMINES): Donor agency and participant in technology validation and uptake.
- Caribbean Agricultural Research and Development Institute (CARDI): Technical know-how, technology development and dissemination and capacity building.
- Canadian International Development Agency (CIDA): Donor agency.
- European Union (EU): Donor agency.
- Goat Breeders Society of Jamaica: Investors, participants in technology generation, validation, dissemination, uptake and assimilation.
- Ministry of Agriculture (MoA): Policy and enabling environment.
- MoA – Research & Development (MoA-R&D): Technical know-how, technology development and dissemination and capacity building.
- MoA – Rural Agricultural Development Authority (MoA-RADA): Technology dissemination.
- MoA – Veterinary Services Division (MoA-Vet): Technical know-how and support services.

### Partnership at work

#### CARDI-MoA-EU

CARDI formally started research for the development of the small ruminant industry in Jamaica in 1991 following the launching in 1990 of the Jamaica component of the CARDI/Technology Transfer & Applied Research Project (TTARP) which was funded by the European Development Fund of the EU (the then EEC) under the EU/EDF-Lome III Agreement. The objective of the project was to facilitate “mutton” import substitution and enhanced farmer

income from improved goat productivity through the provision of improved breeding stock, and the application of improved feeding and management practices. The executing agencies were CARDI, MoA-R&D and MoA-RADA. The project was supervised and monitored by a Project Advisory Committee that comprised 14 members, 9 from the MoA, 3 from CARDI and 2 goat producers. Thus, although CARDI negotiated the TTARP the Sheep and Goat Development component was executed in Jamaica as national project for the benefit of Jamaican goat producers.

The project lasted up to 1997 and during that period we conducted ex-ante analysis to identify the constraints of the small ruminant industry and then developed and/or adapted appropriate technologies to address them. The major constraints identified were:

- Housing (lack of it; use of expensive materials)
- Breeding stock (mainly native goats with low productivity; insufficient numbers of breeding females)
- Feeds and feeding (limited use of forages; high dependence on commercial concentrate feed)
- Husbandry and production practices (lack of identification; absence of record keeping; long breeding intervals; emphasis on costly curative health management)

The technologies developed and/or adapted were as follows:

- **Housing:** We designed and constructed prototypes of improved housing solutions. The principal characteristics of the housing solutions were that they were constructed of local materials, raised off the ground and with slatted floor to promote sanitation and good health.
- **Breeding stock:** Forty-four (36 does and eight bucks) Anglo-Nubian goats were imported and put in breeding schemes to produce purebreds and crossbreds (with native goats) for small farmer breeders and other producers.
- **Feeds and feeding and production systems:** We developed improved forage systems based on multi-purpose trees, fodder and forage grasses and trailing legumes. We also developed rations from agro and industrial byproducts, which were comparable in animal productivity with the commercial concentrate feeds but at a lower cost. The forages and by-products feeds were used to develop three production systems – forage only, forage and by-product feed supplementation and by-product feeds feedlot.
- **Husbandry practices:** Animal identification systems and record keeping were introduced. Prophylactic health management was emphasized and management system was introduced to facilitate at most ten months breeding intervals.

### Transfer of technologies

The developed and/or adapted technologies were packaged as modules and transferred to our clientele. The transfer mechanisms used included direct on-farm participatory research and demonstration, field days and training sessions using developed information products, involvement of schools, farmers' groups and the outreach efforts of these groups.

## CARDI-MoA-CIDA

In 1993/94 while CARDI/EU TTARP was in progress CIDA funded a project for an islandwide survey and serological tests to determine the prevalence of caprine arthritis encephalitis (CAE) in Jamaica. In 1983 a consignment of dairy goats was imported into Jamaica from Canada. Some of the animals were subsequently diagnosed with CAE, at which time some animals had been sold as breeding stock to producers. Thus, there was concern that CAE had become endemic in the local goat population and, hence, the execution of the project. The results of the study, however, showed that there were only isolated cases of the disease in Jamaica. The project was executed by CARDI and MoA-Vet.

## CARDI-MoA-Farmers

The alliance of CARDI, MoA-R&D and MoA-RADA, in collaboration with farmers and other stakeholders in the industry, established in 1997 the Goat Breeders Society of Jamaica and the accompanying Herd Book for the registration of pedigree stock and the maintenance of quality and integrity of the breeds. The Society subsequently spearheaded breed improvements and quality control, innovation and farmer education.

## CARDI-ALPARTMINES

In 1998 we established the Sam Motta Goat Demonstration and Training Centre with the financial input from ALPARTMINES, and collaboration and synergy with their farmers' groups. The main focus of the Centre is the production of improved breeding stock. It also serves to develop and demonstrate sheep and goats, and crops production technologies on reclaimed bauxite lands, as well as train producers in the use of the technologies.

## RESULTS

The convergence of enabling environment, resource provision, technical know-how, technology development and capacity building, and technology dissemination, and uptake and assimilation by producers has enabled CARDI and its partners to contribute substantially to the development of the small ruminant industry in Jamaica. The key accomplishments during the decade of partnership for the development of the small ruminant industry are highlighted below.

**Increased investments in goat farming:** During the decade, producers invested, from their own resources, US\$1.1M to import some 650 pedigree stocks of goats (Nubian, Alpine and Boer) and sheep (Dorset, Katahdin, and Dorper) for breeding and foundation herds/flocks. More than 20,000 pedigree and upgraded native breeding goats were produced and distributed islandwide. Ten sheep and goat farmers' associations were formed and five schools got involved in small ruminant projects.

**Increased farm-level productivity:** At the farm level there was increased productivity in liveweight at birth (66.2%), weaning (47.9%), and 8-10 months of age (85.9%), and increased doe productivity index (72.4%, Table 1). The increased productivity translated to tangible benefits as exemplified by the uses of the income from small ruminant production (Table 2).

**Increased national-level productivity:** Statistics from national institutions and agencies show impressive growth during the decade of partnership. There was more than 100 per cent



increase each in the number of farm families earning part of their living from small ruminant production (from 27,000 to 59,600), the population of small ruminants (from 206,000 to 416,500) and national small ruminant meat production (from 618 to 1,375 MT, Table 3).

**Corporate involvement in the small ruminant industry:** The expansion in the small ruminant industry stimulated the interest and involvement of corporate Jamaica in the industry. Prior to 1990 there was no commercial livestock feed manufacture producing feed for small ruminants, but in 1998 there were four feed manufacturers producing dedicated goat feed. Also, during the decade merchants began selling dedicated veterinary products and tools for small ruminants.

## CONCLUSION

The paper has demonstrated the successful partnering for sustainable agricultural development through the convergence of donor resources, technical know-how, technology development and capacity building, and technology dissemination, and uptake and assimilation within an enabling environment of policy support. Partnership can, therefore, be used effectively in the development of other areas of agriculture in the region.

## ACKNOWLEDGEMENT

The information for this paper was derived from the activities for the development of the small ruminant industry in Jamaica and we acknowledge the financial support of the European Union (EU), The Canadian International Development Agency (CIDA), ALPART Mining Venture and the Government of Jamaica in the development of the projects and the contribution of various resources by producers in the overall development of the industry. The Technical Centre for Agricultural and Rural Cooperation (CTA)-ACP-EU and the Caribbean Agricultural Research and Development Industry (CARDI) sponsored my attendance at the 40th meeting of the CFCS to share our experiences with our colleagues.

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Table 1. Small ruminant productivity parameters at the farm level

Parameter	1991	2000	% Increase
Weight at birth, kg	2.01	3.34	66.2
Weight at weaning, kg	11.7	17.3	47.9
Weight at 8-10 months, kg	18.4	34.2	85.9
Doe productivity index*	13.4	23.1	72.4

\* Productivity index = Litter size x Prewearing survivability x Weaning weight

Table 2. Example of uses of income from small ruminant production

Uses	Number of farmers
Farm expansion	5
Home construction	4
Land acquisition	3
Motor vehicle acquisition	3
Ward higher education	2
Subsidise other business	1

Table 3. Small ruminant productivity parameters at the national level

Parameter	1990	1996 up	% Increase
Number of producers	27,000	59,600	120.7
Number of sheep and goats	206,000	416,500	102.2
National meat production, MT*	618	1,375	122.5

Data source: Ministry of Agriculture (1991), AGROCON Ltd. (1998), STATIN (1998)

\* Calculated from population data using extraction rate of 30% and carcass weight of 10 kg (1990) or 11 kg (1996 up)

**PRODUCTION OF HAIR SHEEP USING ACCELERATED LAMBING AND AN EXTENSIVE MANAGEMENT SYSTEM IN THE TROPICS**

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**ABSTRACT:** St. Croix White and Barbados Blackbelly hair sheep ewes were managed using accelerated lambing in an extensive management system. Ewes grazed guinea grass (*Panicum maximum*) in a rotational grazing system throughout the year. Single sire breeding took place during 35-d periods in February, June or October with each flock producing three lamb crops every 2 years. Lambs were weaned at 63 d of age. Overall ewe fertility was 89.8% and prolificacy was 1.77 lambs per ewe lambing. Ewes that were bred in October had higher prolificacy ( $P < 0.0001$ ) than ewes that were bred in February or June (1.87 vs 1.64 vs 1.73 lambs per ewe lambing, respectively). Ewes bred during October produced more triplets and fewer singles ( $P < 0.0001$ ) than ewes bred at other times of the year. Ewe productivity, expressed as the ratio of litter weaning weight to ewe body weight, increased ( $P < 0.0001$ ) from 41.6 to 50.3% during a 10-yr period. These results show that hair sheep productivity can be sustained and enhanced using accelerated lambing and extensive management in the tropics.

**Key words:** Sheep, Production, Lambs, Tropics, Management

## INTRODUCTION

Sheep production in the Caribbean is limited to the production of animals for meat. Since resources are limited in many areas of the tropics, the use of sheep for meat production is partly based on economics. Sheep can be raised on smaller plots of land, require less feed than cattle, produce multiple offspring and have a shorter inter-birth interval. The breeds of sheep found throughout the region consist of hair breeds. The predominant breed is the St. Croix White with smaller numbers of Barbados Blackbelly and various crosses of these two breeds. These breeds of sheep are well adapted to the tropical environment. Traits that make them well suited to the tropics include a lack of wool, the ability to breed at all times of the year, tolerance of intestinal parasites and the ability to produce and raise multiple lambs.

Many sheep producers in the Caribbean do not manage their flocks with defined breeding and lambing seasons. This is due to the fact that sheep in this region do not exhibit a true seasonal pattern of reproductive cycles due to the minimal change in photoperiod (Evans et al., 1991, Swartz and Hunte 1991). Hair sheep also have a postpartum interval to estrus of approximately 40 d (Godfrey et al., 1998). The short postpartum interval and year round breeding allows these breeds to produce multiple lamb crops in the same amount of time that temperate breeds only produce a single lamb crop.

The cost of importing concentrate feed is prohibitive for most livestock farmers in the US Virgin Islands and other islands of the Caribbean, so the vast majority of small ruminant production is based on a system that relies on forages as the major source of nutrients for the animals. The animals either graze in pastures or the forage is brought to the animals in a cut and carry system. The extensive management system of grazing animals relies heavily on the

seasonal availability of native forages, which is one of the limiting factors of livestock production in the tropics. The environment on St. Croix is considered to be semi-arid with seasonal precipitation. The dry period lasts from January through April, and September through December is the wettest time of the year (Godfrey and Hansen 1996). This seasonal pattern of rainfall leads to a seasonal pattern of forage production with the forage quantity being maximal during the rainy season.

This project was conducted to evaluate long term production traits of hair sheep using accelerated lambing and an extensive management system in the tropics. To accomplish this, production records from the research flock at the University of the Virgin Islands Agricultural Experiment Station were analyzed retrospectively.

## MATERIALS AND METHODS

Records from the research flock at the Sheep Research Facility on the St. Croix Campus from 1993 to 2003 were utilized. The breeds of sheep consisted of St. Croix White (STX) and Barbados Blackbelly (BB). The sheep were kept in two flocks, designated A and B. The A flock consisted of both STX (n= 25- 40) and BB (n= 20- 35) ewes. The B flock was composed of only STX ewes (n=30-35). Both flocks were maintained on guinea grass (*Panicum maximum*) pastures in a rotational grazing system. The A flock grazed a set of 8 pastures (0.8 ha each) and the B flock grazed another set of 8 pastures (0.4 ha each). Ewes were stocked in each set of pastures at a rate of approximately 10-12 ewes/ha of pasture. Pastures were managed using rotational grazing and ewes were moved every 7-21 d depending on forage availability.

All breeding was done using single sire matings (ram:ewe  $\leq$  1:20) with the ewes exposed to the rams for 35 d. During the breeding period the ewes and rams were split into breeding groups, placed in dry lots and fed a maintenance ration of a 16 % crude protein pelleted feed (PMI, Mulberry, FL) and guinea grass hay. The accelerated lambing system was based on an 8 mo cycle with each flock (A and B) bred 4 mo apart. This resulted in bleedings taking place during February, June or October, which led to lambing in March, July or November (Figure 1). Over time, each flock produced 3 lamb crops every 2 yr in a staggered progression (i.e., the A flock bred in February and the B flock bred in June). After the breeding period, the ewes were put back in their pastures for the duration of gestation and lactation. Ewes in both flocks were weighed each week throughout the year.

Ewes gave birth on pasture and the lambs were processed within 24 hr of birth. Lamb processing consisted of weighing, tattooing and ear tagging. At 7 and 11 wk of age lambs were given a clostridium/tetanus toxoid vaccine and dewormed. Lambs were weaned at  $63 \pm 4$  d of age. Weaning weight was collected at this time as well. Selection of replacement animals from the lamb crop was conducted around 3-4 wk after weaning. Initial selection of ewe and ram replacement lambs was based on type of birth, breed characteristics, weaning weight using a selection index and body conformation (Figure 2).

Ewe fertility was defined as the number of ewes lambing per the number of ewes exposed to rams. Ewe prolificacy was defined as the number of lambs born per the number of ewe lambing. Ewe productivity was defined as the litter weaning weight per ewe body weight at weaning. Data were analyzed using GLM procedures of SAS (1999) with year and breed as the main effects. Breed was not significant for any trait measured so data were pooled for final analysis.

## RESULTS AND DISCUSSION

Ewe fertility remained constant ( $P > 0.10$ ) during the 10-yr period (Figure 3). It ranged from 0.84 to 0.93% over time but there was no significant increase or decrease over the years. Ewe prolificacy increased ( $P < 0.0001$ ) over time (Figure 4). This was primarily due to an increase to 23.01 during 2002. During this year there was an unusually high number of triplet lambs born which caused the high prolificacy.

Even though these sheep do not exhibit a strong seasonal pattern to their cycles, there was an effect of time of year on the number of lambs born. Ewes that were bred in October had higher prolificacy ( $P < 0.02$ ) than ewes bred during either February or June (Figure 5). Previous work in our lab has shown that hair sheep on St. Croix do exhibit some seasonal patterns in their ovarian function (Godfrey et al., 1998). Progesterone concentrations during the postpartum period in ewes exposed to rams were higher during July (typical anestrous period in temperate regions) than in November (typical estrous period in temperate regions) indicating that hair sheep are barely responsive to the slight changes in photoperiod in the tropics. In another study it was shown that there was a small increase in ovulation rate between ewes bred during July and those bred during October (Godfrey et al., 2003). This is also evidenced in the present study where there were more lambs born to ewes bred during October than to ewes bred at other times of the year.

Ewe productivity increased ( $P < 0.0001$ ) over the years as well (Figure 6). The ratio of litter weaning weight to ewe body weight increased from 0.4 to a high of 0.6. These values are in agreement with those reported in an earlier study (Godfrey et al., 1997). The proportion of lambs alive at weaning increased ( $P < 0.0001$ ) over time (Figure 7). Individual lamb weaning weight increased ( $P < 0.0001$ ) over time (Figure 8). Weaning weight increased 43 % from 8 kg to 11.5 kg during the 10-yr period. The increases in lamb survival to weaning and lamb weaning weight are probably related. The heavier lambs are an indirect indicator of enhanced lamb vigor, which would lead to a higher survival rate as well. The higher weaning weight may also be an indicator of increased milk production of the ewes or it may be a response to the selection pressure put on weaning weight during the replacement animal selection process.

## CONCLUSION

Hair sheep can be successfully managed using an accelerated lambing system and extensive management under conditions found in the tropics. Because the sheep can breed all year round, they are more suitable to an accelerated lambing system that results in 3 lambs crops in a 2-yr period. By using defined breeding periods, lambs will be born during specified periods that further add to the management of the flock. By using selection pressure for growth traits of lambs such as weaning weight, advances can be made in producing larger lambs at weaning and will result in those lambs achieving market or breeding weight sooner.

## ACKNOWLEDGEMENTS

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Figure 1. The accelerated lambing system that was used to manage the breeding of the hair sheep flocks. Ewes were bred during February, June or October and lambed in July, November or March, respectively

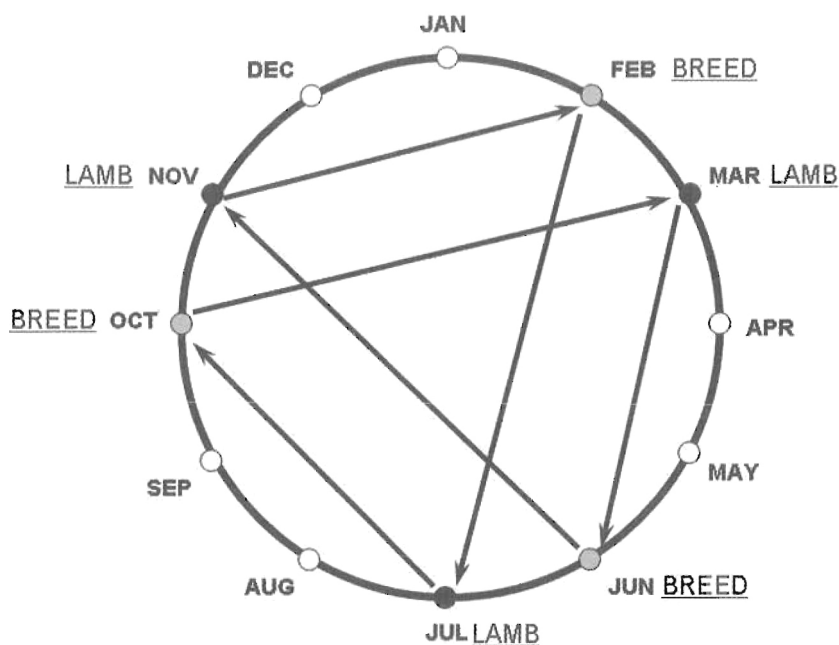
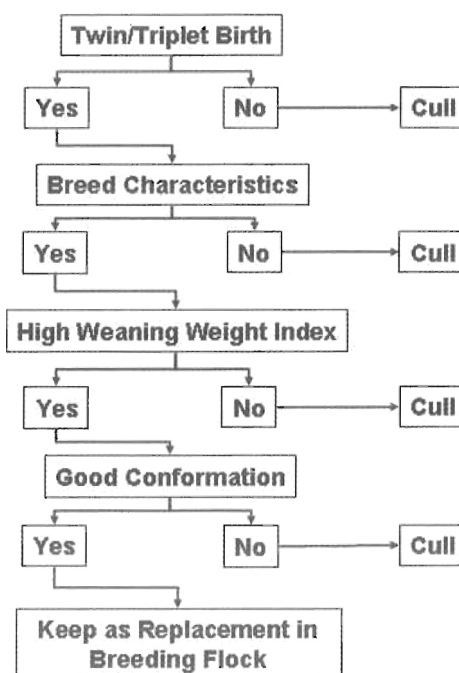


Figure 2. Selection flow chart used when selecting replacement ewe and ram lambs



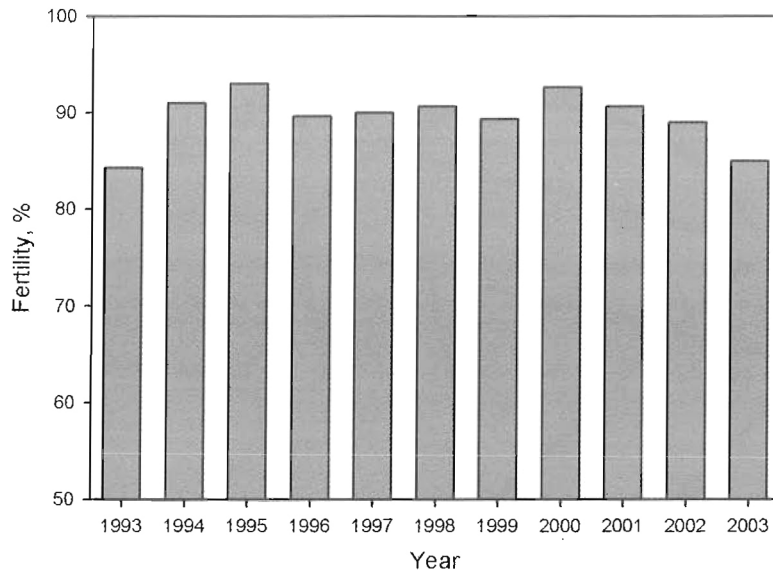


Figure 3. Ewe fertility, defined as the number of ewes lambing per the number of ewes exposed to rams, did not change over the 10-yr period ( $P > 0.10$ )

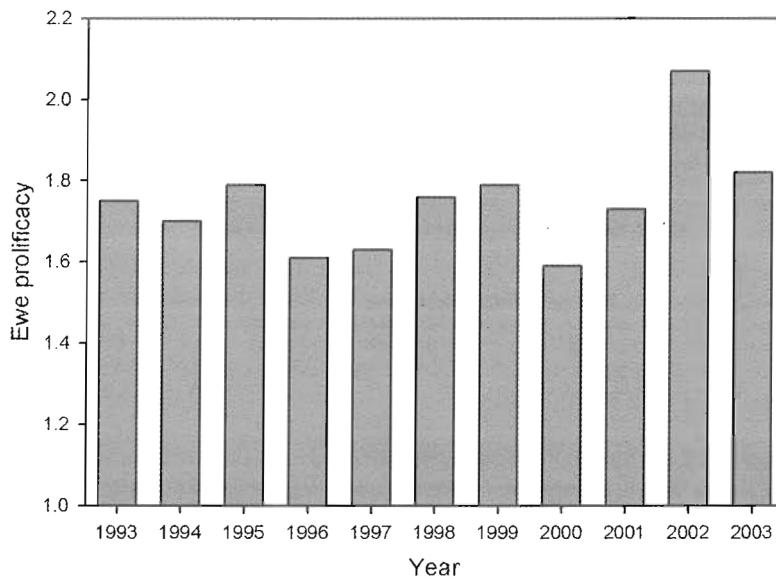


Figure 4. Ewe prolificacy, defined as the number lambs born per the number of ewes lambing, increased over the 10-yr period ( $P < 0.0001$ )



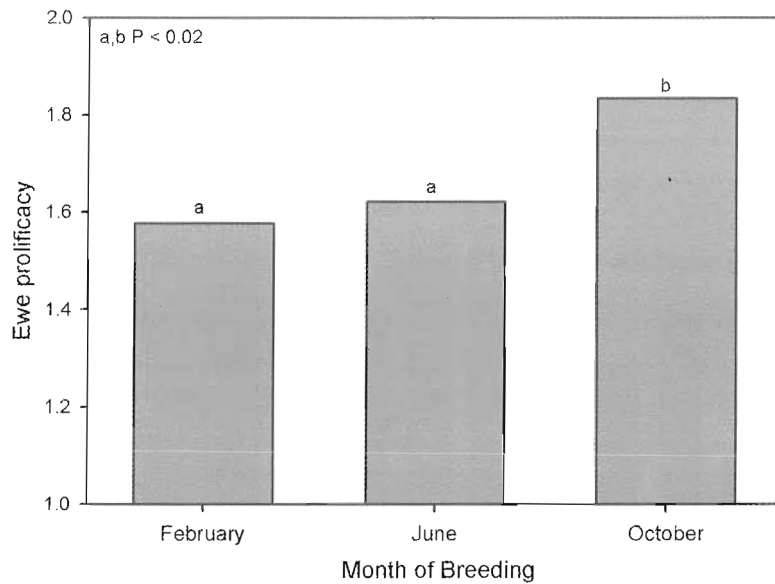


Figure 5. Ewe prolificacy during the different breeding seasons throughout the year, over the 10-yr period. Ewes that were bred in October had higher ( $P < 0.02$ ) prolificacy

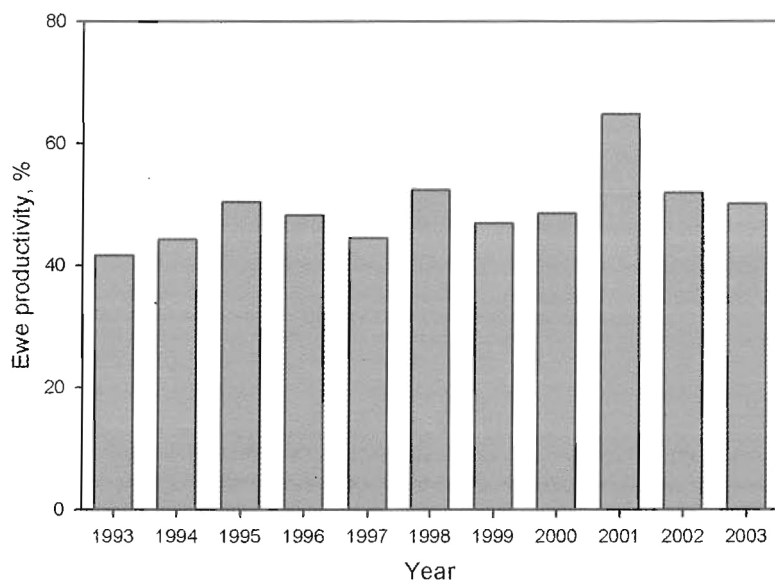


Figure 6. Ewe productivity, defined as litter weaning weight per ewe body weight at weaning, increased over the 10-yr period ( $P < 0.0001$ )

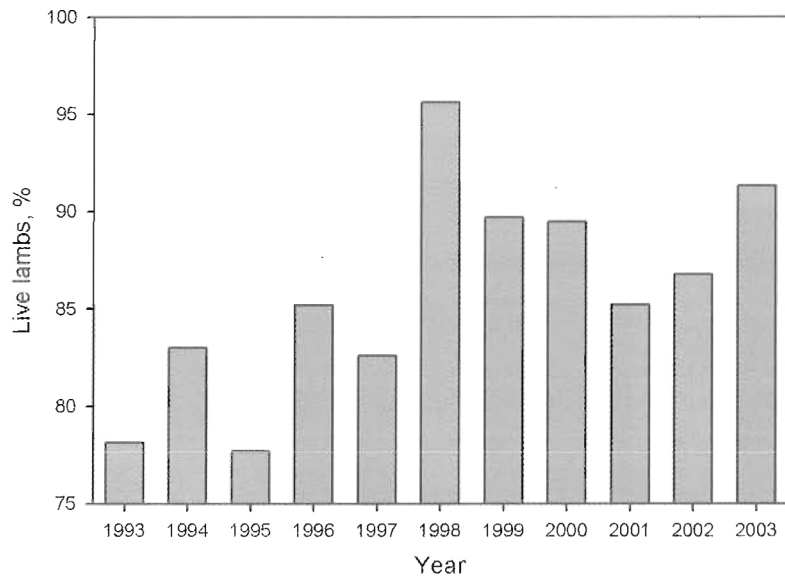


Figure 7. The proportion of lambs that survived to weaning during the 10-yr period. The survival rate of lambs increased over time ( $P < 0.0001$ )

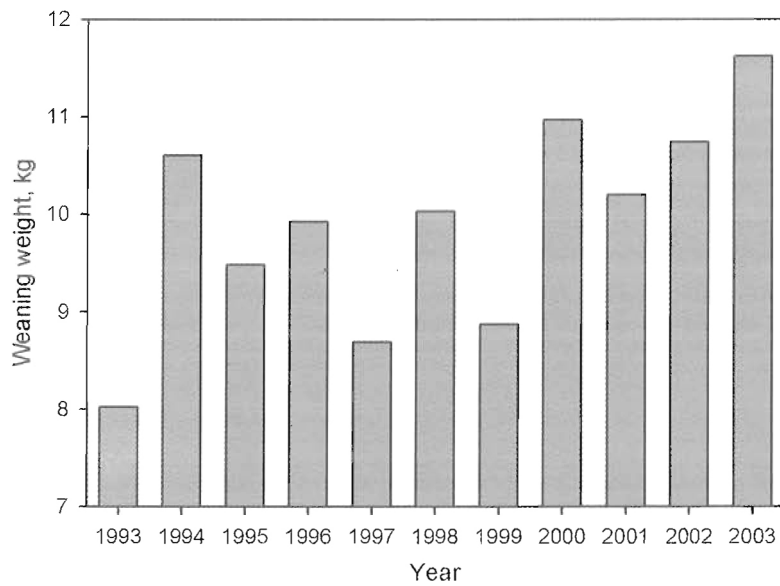


Figure 8. Lamb weaning weight during the 10-yr period. Lamb weaning weight increased over time ( $P < 0.0001$ )

**LA PRODUCTION DE REPRODUCTEURS SÉLECTIONNÉS DANS LA RACE OVINE MARTINIK: OBJECTIFS – MISE EN OEUVRE – RÉSULTATS – PERSPECTIVES**

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**RÉSUMÉ:** La race ovine Martinik est de création récente (1993). Ses origines, les objectifs et le schéma d'amélioration génétique (sélection) ont été décrits par ailleurs (Leimbacher, 1991; Leimbacher, 1996; Leimbacher et al., 2000). De même, l'on a discuté de l'intérêt que représente la gestion des ressources génétiques animales locales pour la conservation de la biodiversité dans la Région Caraïbe (Naves et al., 1998; Naves et al., 2001). Sont présentés ici, dix années d'efforts de sélection engagés par un groupe d'éleveurs réunis au sein d'une Unité de sélection (USOM). Ces résultats nous permettent de penser que cette nouvelle race de mouton sans laine (Hair Sheep) constitue une ressource génétique très intéressante pour l'espèce et qu'elle pourra contribuer très utilement, avec les autres races de la Région au maintien, voir au développement de la production de viande ovine dans les Tropiques .

**ABSTRACT:** The Martinik Hair Sheep breed has been created recently (1993). Its origin, purpose and genetics program have been described previously (Leimbacher, 1991; Leimbacher, 1996; Leimbacher et al., 2000). The interest for the conservation of genetic resources of local breeds to sustain the biodiversity in the Caribbean Region has also been discussed (Naves et al., 1998; Naves et al., 2001). The efforts employed since ten years by a group of farmers within a selection Unit (USOM) to produce selected pedigree stock, are explained. Their results make us think that this new Hair Sheep breed is a very interesting genetic resource for the specie. This breed may very usefully, contribute with the other Hair Sheep breeds within the Region (Wildeus, 1991), in the development of Mutton production in the Tropics

**INTRODUCTION:**

A la Martinique, les ovins sont exclusivement élevés pour la viande. Une coopérative spécialisée petits ruminants, la SCACOM créée en 1978, est responsable du développement du secteur. Afin de mener à bien sa mission, la SCACOM met en œuvre ou coordonne plusieurs types d'actions pour atteindre ses objectifs. Ce sont : l'organisation de la production , l'organisation des approvisionnements, la mise en marché d'une viande de mouton locale produite conformément à des recommandations précises, basées sur l'utilisation d'aliments produits localement et suivant des techniques de conduite respectueuses de la réglementation européenne et de l'environnement. Parmi ces éléments, la définition et le respect d'une politique génétique basée sur l'utilisation de la race de mouton locale, apparaissent essentiels (F. Leimbacher et al.2000)

A cet effet, une Unité de sélection de la Race Ovine MARTINIK, constituée dès 1993 (USOM), assure la production de reproducteurs sélectionnés. Reposant sur des méthodes validées par le Ministère de l'Agriculture français, le programme d'amélioration génétique adopté permet la conservation et l'amélioration du potentiel zootechnique par la diffusion d'animaux reconnus de la Race Ovine MARTINIK et de qualifications certifiées.

## Le Mouton MARTINIK – Description :

Se caractérisant par l'absence de laine, cette race fait partie du groupe des ovins à poil (Ovinos de Pelo ou Hair Sheep) Elle s'apparente aux races Barbados Black Belly et Pelibuey présentes dans toute l'Amérique centrale et le Bassin caraïbe dont elle partage des aspects morphologiques communs bien que d'aspect généralement plus « compact »(S. Wildeus, 1991) La couleur de la robe est variable suivant les familles : brun clair et brun acajou avec ventre et pattes noires sont les cas les plus fréquents. *La couleur de la robe n'est pas un critère de sélection, par contre, la présence de laine ou celle de cornes sont à proscrire.*

D'un poids compris entre 40 et 45 kgs pour les femelles et de 50 à 65 kgs pour les béliers, le Mouton MARTINIK est assez haut sur pattes et bon marcheur.

### Conduite d'élevage :

Dans les élevages sélectionneurs de l'USOM, la conduite est assez intensive, avec un chargement de l'ordre de 15 à 20 brebis /ha.

- 3 élevages sont en pâturage libre
- 3 au pâturage avec stabulation le soir
- 1 élevage pratique le pâturage pour les mères et l'élevage en bergerie des agneaux
- 1 élevage est en bergerie permanente
- 

### L'Alimentation :

Les animaux sont élevés à l'herbe sur savane naturelle ou prairies plantées principalement en *Digitaria decumbens* et *Bracharia humidicola*. La pratique de la complémentation est courante (surtout en période de sécheresse ou dans les zones et périodes de fortes pluies) Les quantités distribuées ne sont pas toujours régulières. Les compléments alimentaires les plus fréquents sont : maïs + soja ; pulpe d'ananas; déchets de banane et concentré.

### La Reproduction :

Le mode de reproduction pratiqué est la monte naturelle, il n'y a pas d'insémination artificielle. Les périodes de lutte sont programmées. Elles ont lieu tous les quatre mois et durent 1 mois (avril – août – décembre) Le bélier retenu est introduit dans le lot de femelles à saillir. Lorsque plusieurs mâles sont utilisés sur une même période, l'on constitue des lots de lutte. Les agnelles sont mises en lutte pour la première fois vers l'âge de 8-9 mois. Les jeunes mâles sont utilisés dès l'âge de 14 à 16 mois.

### Le Schéma de sélection:

Le programme d'amélioration génétique de la race ovine « MARTINIK » repose sur l'application d'un programme de sélection rigoureux basé sur l'amélioration de caractères de production (valeur laitière et reproduction) et d'adaptation au milieu (schéma classique français avec sélection en ferme pour les femelles et passage des jeunes béliers en centre d'élevage) (F.Leimbacher, 1996)

Les outils de sélection mis en œuvre par l'USOM:

L'identification pérenne et le livre génétique (Flockbook) sont les éléments logistiques et de gestion préalable à tout travail de sélection. Les méthodes et supports utilisés sont ceux agréés par le Ministère de l'Agriculture français.

Le standard de la race. Il est défini par l'USOM sous forme d'une grille de notation utilisée par les membres d'une commission de marquage pour l'inscription au livre généalogique (Flockbook, livre ouvert) des animaux conformes. Les caractères éliminatoires sont : la présence de laine, de cornes, les défauts physiques apparents, un développement insuffisant. La commission de marquage est constituée d'experts, de techniciens et d'éleveurs.

Le contrôle de performances. Il repose sur l'enregistrement des mises bas et du nombre d'agneaux produits par brebis (prolificité-fertilité) et de la croissance des agneaux constatée par des pesées. Des déclarations de lutte et de mises bas permettent de valider les informations enregistrées lors de la saisie des données (naissances et pesées)

Le calcul du gain de poids quotidien (Gmq) entre 10 et 30 jours est utilisé comme un indicateur de la valeur laitière des mères, le Gmq 30-70 jours, comme un indicateur de la précocité des agneaux (Système CPOV) Les pesées sont effectuées par un technicien qui transcrit et transmet les informations à un centre de calcul qui, après validation, les transfère sur la base de données nationale (CTIG-INRA)

Les calculs d'indexation. Les résultats de reproduction sont utilisés pour calculer, pour chaque femelle, un index prolificité. Les Gmq 10-30 sont pris en compte pour calculer un index valeur laitière. Cette indexation permet de classer les valeurs génétiques de chaque brebis au sein de la population pour ces deux caractères. Les indexations sont recalculées 3 fois par an

La qualification. Elle repose sur la prise en compte de la qualification des ascendants, de la notation du « Standard » et des notes propres (indexation pour les femelles ayant produit et indices pour les mâles)

Ceci a conduit à établir une grille de qualification jeunes et adultes qui tient compte de la distribution des valeurs et des qualifications dans la population. Cette grille de qualification peut et doit donc être révisée de temps en temps afin de tenir compte de l'évolution de la valeur génétique de la population.

## LA SELECTION

Sélection des femelles. Les brebis ayant la meilleure valeur génétique sont classées : Mère à bélier (MB) celles qui sont un peu moins bonnes, sont classées : Mères à agnelles (MA) Les agnelles issues de ces brebis et elles mêmes les mieux qualifiées sont retenues pour le remplacement dans les troupeaux de sélection. Le surplus est vendu aux éleveurs « commerciaux »

Sélection des béliers. Parmi les jeunes béliers issus de mères à béliers, les plus intéressants sont orientés vers un centre d'élevage où ils sont regroupés vers l'âge de 5 mois. Dans ce centre ils sont élevés pendant trois mois de façon identique sur prairie avec complémentation quotidienne de concentré de 150 à 300 g./jour. A l'issue de ces trois mois ils sont notés (note Standard et conformation) Ces informations sont utilisées pour le calcul d'un « indice » qui permet de les classer.

Les meilleurs béliers sont dirigés vers les élevages de sélection en fonction des besoins

des éleveurs. Les moins bons sont éliminés et dirigés vers la boucherie. La part restante est vendue aux éleveurs « commerciaux » pour produire de la viande de mouton local.

Le Statut sanitaire : Les troupeaux de sélection de l'USOM appliquent un programme de dépistage et de contrôle régulier pour les principales pathologies ovines. En effet il est indispensable que le statut sanitaire des troupeaux permette de s'assurer qu'il n'y a pas de risque de propagation des maladies suivantes : brucellose, parasitoses internes ou externes, dermatophilose.

## **RÉSULTATS DE L'APPLICATION DE CE PROGRAMME :**

Les résultats présentés ici permettent de situer le fonctionnement du schéma génétique de la Race Ovine Martinik entre 1996 et 2002 période où l'évolution est bien engagée. A noter que durant la période de 1993 à 1996, les travaux avaient porté sur la mise en place du Centre d'élevage ainsi que la validation des données pour la détermination des seuils de qualification

### Evolution des performances zootechniques

Ces résultats sont présentés par campagne de production et non par année civile. Chaque campagne compte 3 périodes de mises bas , exceptée la campagne 2000 qui n'en a compté que 2.

### La production des troupeaux

Si le nombre d'élevages a augmenté de 30 %, l'évolution du nombre de femelles présentes dans la base de sélection est plutôt modérée. A une augmentation de 9 % des femelles présentes dans la base (Table 1) s'associe une diminution de 35 % de la taille moyenne des troupeaux (Table 2). Ceci résulte de l'arrivée de 3 nouveaux élevages, lesquels se sont constitués à partir des troupeaux mères existants.

Le nombre de mises bas, suit la même évolution que le nombre de femelles, soit + 9 %, montrant ainsi une productivité homogène des troupeaux. On observe une baisse de la prolificité moyenne des troupeaux jusqu'à -30 % (Table 2). Cette baisse de prolificité s'explique partiellement par l'introduction importante d'agnelles de renouvellement dans les troupeaux de sélection à laquelle s'ajoute, la vente de brebis adultes aux nouveaux adhérents. Ce résultat montre bien la nécessité de renforcer la gestion du renouvellement des cheptels. Une analyse du mode de sélection des reproducteurs permettra de préciser si des raisons « génétiques » ont pu influencer ces résultats.

Pour ce qui est de la mortalité, elle est inférieure à 15 % excepté dans les années difficiles:1999, année pluvieuse et 2001 année de sécheresse, où ce critère reflète significativement l'hétérogénéité des conditions d'élevage.

### Evolution pondérale des jeunes :

Le poids à 70 jours (sevrage) gagne 3 kg de 1997 à 1999 (Graph 1) Les écarts types sont 0, 5kg environ.

Ce critère, qui reflète le potentiel de croissance, est un élément de sélection des jeunes mâles destinés au centre d'élevage où ne sont admis que ceux dont le poids au sevrage est supérieur ou égal à 12 kg. Ainsi, sur cette base, le choix des futurs reproducteurs mâles est plus large depuis 1998 (Graph 1). A noter aussi que la campagne 2000 compte une période de mises bas en moins, d'où un nombre moindre d'animaux pris en compte.

L'évolution des GMQ (Graph 2) fait ressortir que les GMQ 10-30 (indicateur de la valeur laitière des mères) et les GMQ 30-70 (indicateur de la croissance des agneaux) évoluent en parallèle. Les résultats de la campagne 2000 et 2001 trouvent une grande part d'explication dans les conditions climatiques de 1999 et de 2001 dont nous avons indiqué l'incidence sur les résultats de mortalités des agneaux. Ces deux années mises à part, nous pouvons constater qu'aussi bien la valeur laitière des mères (+ 25 g. en 2002) que la croissance des agneaux (+ 30 g. en 2002) ont progressés. *Une analyse plus fine des résultats est en cours.*

## Inscriptions et qualifications

### Inscription des agnelles

Il s'agit ici des agnelles inscrites au livre généalogique (conformité au Standard, note  $\geq 20$ ) à l'issue des tournées de marquage (Graphique 3). En 2002, les brebis avaient fourni 37 % des agnelles inscrites soit 19 % de plus qu'en 1996. Ce critère fait l'objet d'une croissance régulière. En 2001 il n'y a eut qu'une tournée de marquage d'où la chute de 20 % entre 2000 et 2001.

Pour ce qui est des notes de Standard (sur 32 points) elles gagnent, en 4 ans, 3 points sur la moyenne, allant de 22 à 25 entre 1996 et 1999. Pour la même période, la note maximale gagne 5 points, allant de 25 à 30, pour atteindre 31 en 2000 et 2002.

### Qualification des brebis

En matière de qualification des femelles adultes, le pic a été atteint en 1998, avec plus de 40 % des brebis qualifiées MA et MB. Ce résultat est d'autant plus intéressant que les seuils venaient d'être resserrés. A ce jour, le potentiel de qualification se maintient entre 20 et 25 % de brebis qualifiées MA et 10 à 15 % MB sur la base des index. Une nouvelle révision des seuils nous permettra d'accroître la pression de sélection et de fait le niveau de qualification des reproductrices.

### Le Centre d'élevage de jeunes béliers

Depuis sa création jusqu'en 2002, le Centre d'élevage de Jeunes béliers a contrôlé 264 jeunes mâles dont 212 ont été qualifiés et inscrits au Livre généalogique de l'USOM. Parmi Ceux-ci, de 1 à 2 béliers par éleveur et par an retournent dans les élevages USOM (Base de sélection)

Les jeunes béliers restants sont vendus aux éleveurs producteurs de viande de mouton local par l'intermédiaire de leur Coopérative (SCACOM) soit de 15 et 20 béliers sélectionnés chaque année.

#### Diffusion de reproducteurs

##### Sur la Martinique

Sur une moyenne de 200 à 220 jeunes femelles inscrites par an, les éleveurs de l'USOM en vendent environ 80. Ces agnelles sont principalement destinées à l'installation de jeunes éleveurs. Les béliers qualifiés en Centre sont, soit répartis au sein des élevages de l'USOM (base de sélection) soit vendus à des éleveurs par la Coopérative spécialisée « Petits ruminants » (SCACOM) pour en améliorer le potentiel de production de leurs troupeaux.

Les résultats sont visibles sur le poids moyen (+ 3 kg en 4 ans) et le rendement (+ 5 % en 3 ans) des carcasses commercialisées par cette coopérative

##### A l'exportation

A ce jour, des reproducteurs USOM ont été vendus en Guyane française (150 brebis et 10 béliers.) et à Sainte-Lucie (15 animaux). D'autres ventes sont sur le point d'être conclues.

### **TRAVAUX EN COURS ET À VENIR : DISCUSSION .**

Les efforts déployés par les éleveurs accompagnés par les services techniques des organismes professionnels et soutenus par les scientifiques ont pour objectif de mettre à la disposition des éleveurs un matériel génétique fiable et bien caractérisé. Après 10 années de fonctionnement, il est important, pour poursuivre et optimiser la sélection, d'évaluer le schéma mis en œuvre par l'USOM par l'estimation du progrès réalisé et de la variabilité génétiques restant disponible. Cette petite population requiert aussi une gestion généalogique optimum pour éviter la consanguinité. Des travaux dans ce sens sont en cours.

Par ailleurs, la race ovine Martinik, comme d'autres génotypes ovins de la Caraïbe et de l'Amérique latine, constitue, comparativement à des races non originaires de la Région, une population originale qui peut être étudiée comme un « modèle » pour des aptitudes d'adaptation au milieu, de qualité de la viande et d'autres caractéristiques utiles pour l'espèce. C'est ainsi que des travaux sont engagés dans le domaine de la pathologie : résistance à la tremblante (F. Leimbacher 2002) ou au nématodes gastro-intestinaux, (Grüner et al. 2003) d'autres portent sur la qualité de la viande et sur les conditions de production d'une viande locale appréciée du consommateur (F. Leimbacher, 2001).

Les résultats de ces travaux pourront être utilisés à l'avenir pour orienter le programme de l'USOM et permettre de valoriser au mieux les aptitudes génétiques de cette race dans différents conditions d'élevage où celles-ci pourront s'avérer intéressantes.

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**Table 1 – Selection Base of USOM and production**

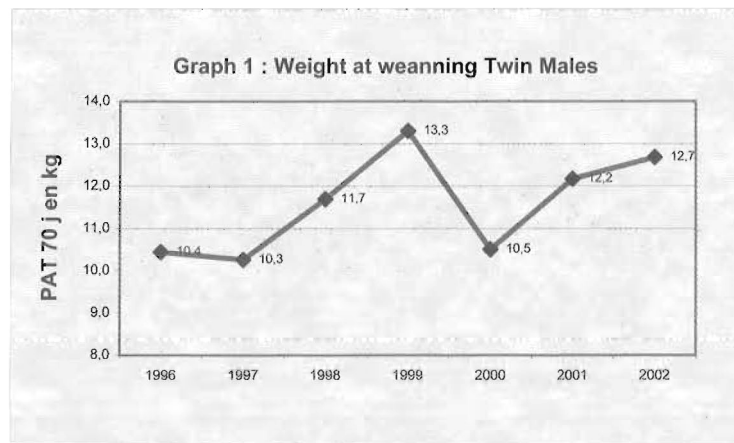
	1996	1997	1998	1999	2000	2001	2002
Number of breeder	6	7	7	6	6	7	10
Ewes at matting	639	656	578	658	624	662	699
Lambings	748	891	642	758	589	834	820
Lambs born	1343	1480	1080	1146	952	1258	1226
Lambs died	142	184	148	168	126	239	138

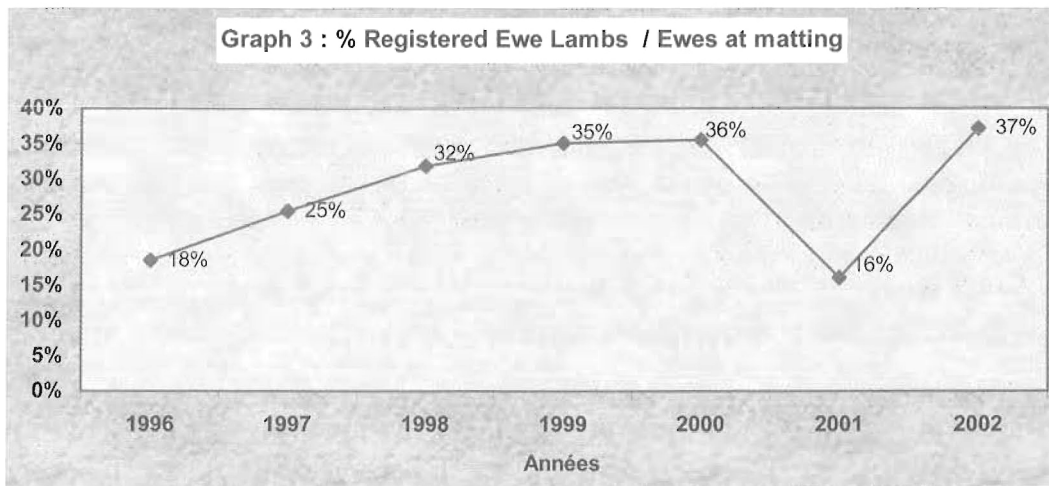
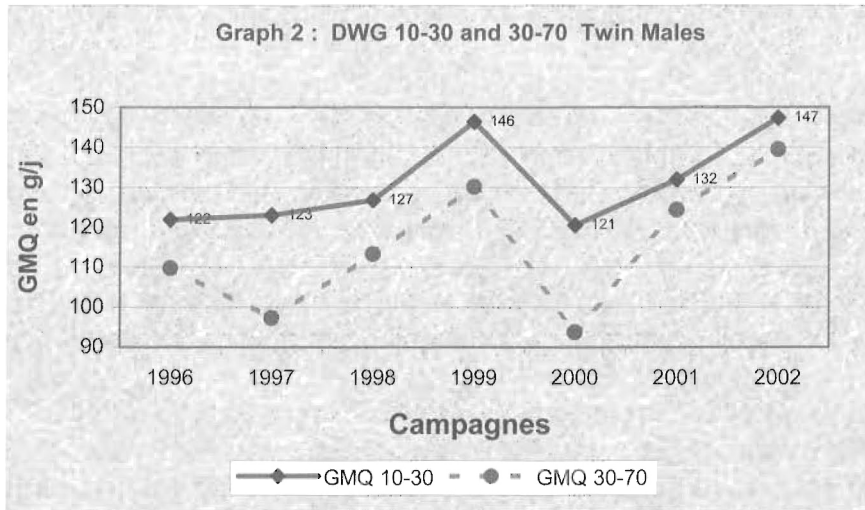
**Table 2 – Selection base and productivity**

	1996	1997	1998	1999	2000	2001	2002
Ewes /Flock	107	94	83	110	104	95	70
Prolificity	180%	166%	168%	151%	162%	151%	150%
Fertility (annual)	117%	136%	111%	115%	94%	126%	117%
Mortality(Before wean)	11%	12%	14%	15%	13%	19%	11%

**Table 3 – Young Rams entered and qualified in RAMS breeding unit**

	1996	1997	1998	1999	2000	2001	2002
Young Rams checked	22	53	35	43	45	45	29
Young Rams qualified USOM	19	29	37	34	48	16	28
Average conformation score/100	68	69	61	58	56	60	61





## LA TRAÇABILITE EN ELEVAGE BOVIN-VIANDE A LA MARTINIQUE, POURQUOI? POUR QUI?

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**RÉSUMÉ:** A la MARTINIQUE, la traçabilité permet de résoudre les problèmes suivants :

- Rechercher des foyers infectieux et les prévenir ainsi que leurs conséquences éventuelles,
- Suivre et organiser les circuits commerciaux,
- Assister la mise en place de démarches « qualité »
- Favoriser la reconnaissance des viandes produites localement,
- Garantir la qualité sanitaire des produits alimentaires et l'information des consommateurs.

Dans cet article, les auteurs s'attacheront à illustrer par des exemples, les actions dans lesquelles ils sont engagés sur le terrain, dans ces différents domaines.

## TRACEABILITY IN BEEF PRODUCTION IN MARTINIQUE : WHAT FOR AND WHO FOR ?

**ABSTRACT:** In MARTINIQUE, traceability allows many useful operations such as: epidemiological surveys to avoid the incidence of pathological hazards, the organisation of commercial circuits, to assist farmers in the production of better quality meat but also for its recognition on the local market, and to provide to the consumer reliable information and safe products for his health. Through examples of their daily involvement on this matter, the authors will try to do their best to illustrate this subject.

## INTRODUCTION

Le scandale de la vache folle, l'apparition des OGM, le clonage et l'utilisation dans certains pays, d'aliments médicamenteux et d'hormones de croissance pour bétail, ont fait de la sécurité et de la qualité des produits alimentaires des priorités pour les consommateurs. A cela s'ajoutent, le développement au niveau mondial, des échanges commerciaux (OMC) du tourisme et aussi de la compétition commerciale.

Les producteurs, comme les industries agro-alimentaires sont dès lors amenés à devoir considérer ces questions sous un angle, non plus spécifique à une seule Nation ou à un seul Pays, mais sous celui d'une problématique plus générale et globale tout en cherchant à conserver l'authenticité et l'originalité propres à leurs produits (Spécialités, Produits de pays, Marques, Labels. G. LINDEN, 2001)

Ceci s'illustre à travers le nombre important de séminaires et de colloques consacrés à cette réflexion (H. MANICHON, 2001) ainsi que par les nombreux articles présentés spontanément par les chercheurs. Devant la multiplicité des thématiques recouvertes par ces

questions dont l'importance et la complexité ne font que commencer d'apparaître, il nous a paru intéressant de décrire de la démarche adoptée à la Martinique pour assurer la traçabilité de la viande bovine produite localement et de montrer son utilité.

#### La traçabilité, outils de base :

La Traçabilité consiste à mettre en œuvre un ensemble de moyens et de dispositifs permettant de suivre un produit de la ferme à l'assiette du consommateur. Elle concerne les produits de base utilisés isolément ainsi que les produits transformés et plus élaborés.

Pour les bovins martiniquais, nous utilisons, conformément à la réglementation nationale en vigueur, *une boucle placée sur chaque oreille et un passeport* édité suite à l'enregistrement dans une base informatique. Chaque boucle est en plastique et comporte un numéro de 10 chiffres précédé des lettres du pays de l'UE ( ex : FR. Le passeport est de couleur rose et comporte tous les éléments sur la filiation et le parcours économique du bovin. Ces deux éléments doivent suivre l'animal dans tous ses déplacements et tout au long de sa vie. La mise en place et la gestion de ces supports est confiée à des organismes (Etablissements départementaux de les Elevages – EDE) agréés par le Ministère de l'Agriculture.

#### Ceci permet de :

##### Rechercher des foyers infectieux

- Lors de la découverte à l'abattoir, de lésions de tuberculose, par exemple, nous possédons, grâce au passeport, l'historique du bovin infecté de sorte que les actions de police sanitaire s'en trouvent facilitées,
- Nous utilisons des prélèvements sanguins faits à l'abattoir pour effectuer des actions d'épidémio-vigilance ou d'épidémio-surveillance. En 2002, 4 bovins atteints de leucose ont ainsi été trouvés permettant un dépistage exhaustif de tous les animaux dans les cheptels où ils avaient séjourné.
- Les enquêtes épidémiologiques pour retrouver des animaux issus d'un cheptel infecté deviennent faciles à réaliser. Ainsi, fin 2001, 3 bovins ayant séjourné en métropole quelques semaines dans un cheptel avec un cas avéré d' ESB puis importés en Martinique ont pu être retrouvés et abattus à titre de précaution.

##### **Prévenir les épidémies :**

- Le suivi des opérations de vaccination ou de traitement est facile à encadrer et nous pouvons relancer les actes de prophylaxies à caractère obligatoire.
- La traçabilité apporte une meilleure sécurité pour ne rechercher et n'éliminer que les animaux effectivement infectés avant que la maladie ne se propage

##### Garantir la qualité sanitaire :

L'outil de base est l'agrément communautaire de l'établissement qui oblige le gestionnaire à mettre en place un système d'enregistrement et d'identification des lots de fabrication. Chaque conditionnement porte ainsi un numéro d'établissement et au minimum une

date de limite de consommation qui nous permet de toujours remonter à l'atelier incriminé. De même sont mentionnées les indications géographiques des lieux de naissance, d'élevage et d'abattage.

La garantie repose sur l'absence ou la présence en très faible quantité de différentes contaminations, qu'elles soient chimiques, biochimiques, microbiennes, parasitaires ou isotopiques.

- L'enregistrement des traitements vétérinaires en élevage permet un meilleur suivi du respect des délais d'attente. Le vétérinaire ou l'éleveur consigne obligatoirement dans un registre, tous les actes vétérinaires.
- Pour contrôler l'efficacité de ce dispositif, nous effectuons régulièrement de façon aléatoire ou ciblée, en cas de suspicion, des plans de contrôle. Nous pouvons citer celui sur un anti-infectieux interdit : le chloramphénicol

En cas de diagnostic positif nous pouvons, en toute transparence, procéder au retrait des denrées contaminées mais aussi remonter toute la filière, afin de localiser le site et identifier les conditions de contamination.

Comme pour les animaux, les procédures de consigne puis de retrait sont, dans ces conditions, mises en place pour l'ensemble des lots fabriqués dans tous les établissements à partir des denrées initialement contaminées.

- Suivre et organiser les circuits commerciaux.

A la MARTINIQUE, la production actuelle de bœuf (1 600 Tonnes abattues à l'abattoir) repose sur l'exploitation d'un cheptel naisseur de 11 000 vaches, de population très marquée Brahman en croisement avec des taureaux de races à viande (Blond de l'Aquitaine ou Charollais) (G. DELAUNAY-BELLEVILLE, F. LEIMBACHER, 2001)

La viande produite localement est identifiée par le consommateur, comme un produit typique et de qualité. Elle bénéficie, à ce titre, d'une forte image de marque, qui se traduit, malgré son prix de vente plus élevé que celui des viandes importées, par une importante demande (M.MERLINI, 2002)

Une coopérative de producteurs bovins (CODEM) a pour mission d'organiser la production, la mise en marché et la valorisation de la viande produite par ses adhérents. Pour cela, les outils de la traçabilité lui permettent d'assurer, la collecte, d'organiser les abattages et la distribution ainsi que la promotion grâce à la définition, en concertation avec les partenaires de la filière (Interprofession AMIV et la recherche) de cahiers des charges précis pour les différentes étapes dans l'élevage des animaux et au suivi de leur application.

**- Favoriser la reconnaissance des viandes produites localement,**

L'Abattoir Départemental de la Martinique a été créé en 1976. C'est un Etablissement public classé pour une capacité de 3000 tonnes et d'une capacité technique de 3500 tonnes par an. Il est géré depuis 1992 par une Société d'Economie Mixte, la SEMAM<sup>o</sup> dont la politique se décline en un ensemble d'objectifs orientés en partenariat avec les collectivités et les représentants professionnels de l'amont comme de l'aval (Schéma 1) et en parfaite application de la législation française en vigueur Celle-ci interdit l'abattage du gros bétail par les détenteurs

d'animaux.

L'abattoir départemental, géré par la SEMAM, est le seul abattoir de l'île habilité à réaliser la transformation de l'état vif à l'état de carcasse pour l'espèce bovine. Dans ce cadre il est conduit à mettre en œuvre toutes les mesures de réglementation sanitaire définies par le Ministère de l'Agriculture (Services de la Qualité) et en particulier celles spécifiques à l'application du principe de précaution pour l'ESB (retraits des organes à risques)

Le système d'information mis en place par la SEMAM complète la traçabilité et la reconnaissance des viandes produites localement et permet d'en garantir les spécifications.

Conformément à la réglementation, la SEMAM ne travaille qu'avec des animaux étant en possession d'un passeport et de boucles. Le processus de traçabilité des différents produits se traduit par une identification informatique (étiquette de traçabilité) ou/et manuelle (marquage au couteau)

A chaque niveau, les informations antérieures sont conservées et d'autres éléments viennent en complément de ces dernières (poids et classification carcasses) l'ensemble étant transmis au consommateur (Schéma 2).

Le logiciel assurant la faisabilité de ce processus appelé ELISA a été élaboré et validé suivant les recommandations du Ministère de l'Agriculture. Il permet de notifier tout élément du produit de son entrée à sa sortie en prenant en compte les interfaces.

- Assister la mise en place de démarches « qualité »

L'INRA soucieux de soutenir cette dynamique professionnelle, a décidé de mettre en place, en collaboration avec les différents partenaires de la filière, un certain nombre d'études ayant pour objectifs :

- La définition de stratégies permettant par la définition de systèmes d'élevage appropriés, la mise en marché de façon régulière et en quantités suffisantes des viandes de qualité et bénéficiant d'une image de marque forte (F. LEIMBACHER, 2001)
- De contribuer à la définition de produits d'appellation contrôlée ou de Marque.
- De contribuer à la définition des cahiers des charges indispensables pour atteindre ces objectifs.

Les travaux engagés portent actuellement sur :

- La définition d'une politique génétique spécifique et rigoureuse basée sur le croisement à partir d'un cheptel « naisseur » de vaches à dominante brahman avec des taureaux Charolais ou Blond d'Aquitaine.
- La recherche de systèmes d'alimentation au pré ou à l'auge tirant le meilleur parti des ressources fourragères locales (prairies, canne à sucre, sous-produits)
- L'adaptation des grilles de classification européennes à la notation des carcasses locales, ceci devant s'accompagner de travaux destinés à préciser les caractéristiques des viandes locales dont leurs qualités gustatives par la réalisation de tests organoleptiques et de dégustations.

- La mise en relation des qualités bouchères des viandes produites dans les différents ateliers et les systèmes de productions mis en place par les éleveurs ((techniques d'alimentation, type d'animaux, races pures ou croisés)

Toutes ces études et opérations ne seraient pas possibles et n'auraient que peu de sens en l'absence des mesures de traçabilité.

Informé le consommateur :

- Avec l'identification pérenne des animaux, le passeport et les inscriptions apposées obligatoirement sur les emballages, le consommateur dispose d'informations sur l'animal, l'élevage, la zone et le mode d'élevage, sur l'établissement de transformation et sur la durée de vie du produit.

Etablies sous le contrôle régulier des services de l'Etat, le consommateur dispose grâce à cette traçabilité, de données fiables capables de lui apporter l'assurance de consommer un produit de qualité et conforme à son attente.

*Pour renforcer ce dispositif de base, les producteurs et les transformateurs peuvent mettre en place des signes de qualité comme les labels, les appellations d'origine ou des marques.*

Cette différenciation d'un produit par rapport à la concurrence a pour but d'entraîner la confiance et de fidéliser le consommateur.

La validité de ces signes repose tout naturellement sur un cahier des charges élaboré avec soin et sur une traçabilité sans faille qui est contrôlée, en plus des services de l'Etat, par un organisme tiers certificateur. Ce dernier permet de renforcer la pression des contrôles (ex : le Label rouge sur la viande de Charolais)

Il convient de noter que l'adoption de ces démarches n'a pas comme objectif d'établir la supériorité d'un produit sur un autre, mais bien plus, de garantir son authenticité par rapport à une attente du consommateur qui reste libre de ses goûts et de ses choix et qu'il est important de respecter si l'on veut valoriser au mieux les spécificités des productions locales.

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Schéma 1 : Les partenaires intervenant dans le processus de la traçabilité

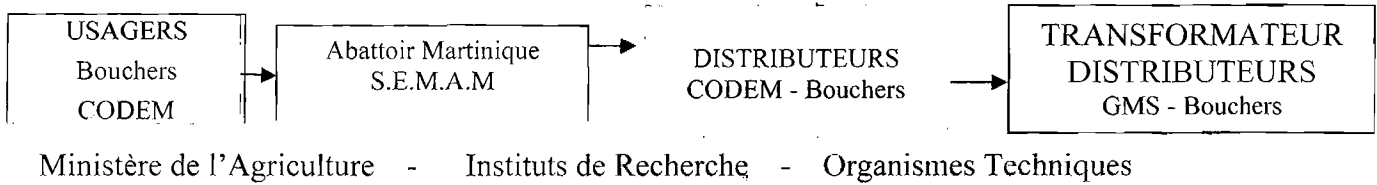


Schéma 2 : Niveaux d'informations intégrant le processus de traçabilité mis en place à la Martinique :

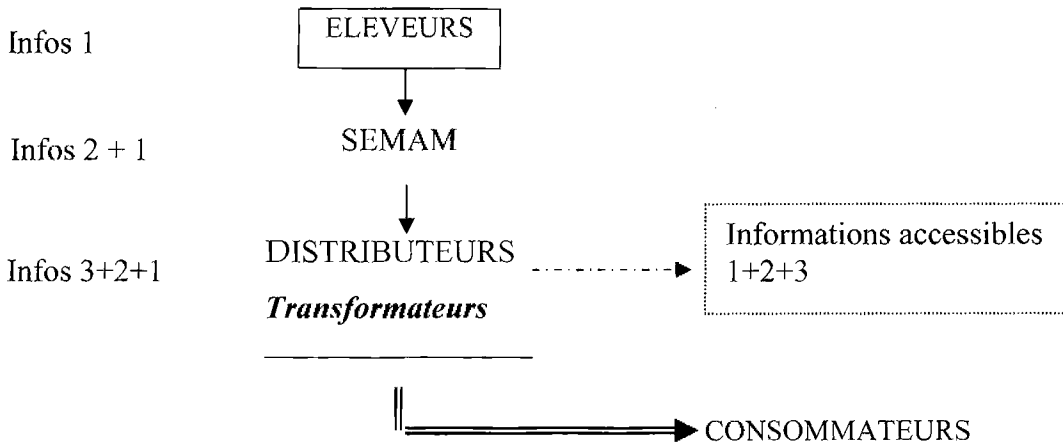
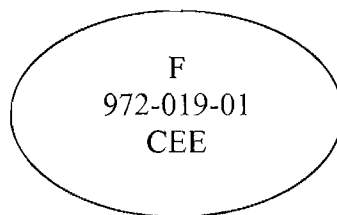


Schéma 3 : Identification d'une structure de transformation



**SOIL MICROBIAL BIOMASS UNDER CONVENTIONAL AND CONSERVATION TILLAGE PRACTICES**

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**ABSTRACT:** Soil management strategies that conserve soil organic matter and hence affect soil microbial biomass are crucial in order to maintain reasonable long-term productivity levels. This paper provides evidence of the effects of conventional vs conservation tillage practices on the microbial biomass in cultivated soil at the UWI Field Station in Trinidad. Over the experimental period, samples of the test soil (St. Augustine series; a loamy clay Orthoxic Tropudults) were collected at a depth of 0-15 cm and microbial biomass C was determined using direct chloroform extraction. Soil organic C and microbial biomass C were generally higher on plots where conservation tillage practices were undertaken. This suggests that practicing conservation tillage could maintain or improve soil quality and productivity in agricultural systems.

SOIL PROPERTIES AFFECTING NITRATE LEACHING IN COTO CLAY

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**ABSTRACT:** Increased nitrogen concentrations in surface and groundwater due to intensive crop production systems have become an environmental and economic concern. Being an anion,  $\text{NO}_3^-$  is not adsorbed by most soils and its leaching is difficult to control. Highly weathered soils may exhibit substantial anion exchange capacity (AEC), which retards the movement of anions such as  $\text{NO}_3^-$  through the profile. However, AEC decreases as soil pH increases by agronomic practices such as liming. A study was conducted to determine the effect of lime application and frequency of N fertigation on  $\text{NH}_4^+$  and  $\text{NO}_3^-$  concentrations on Coto clay. Adsorption isotherms were conducted under three pH levels and nine  $\text{NO}_3^-$  solution concentrations. No significant differences were observed between lime treatments or between fertigation treatments. Results coincide with laboratory studies and indicate little or no nitrate retention capacity for this soil. Average  $\text{NO}_3^-$  concentrations at the 60-80 cm depth, reached  $46.9 \text{ mg L}^{-1}$ , which is higher than the  $45 \text{ mg L}^{-1}$  EPA safe drinking water standard. Despite the presence of high point of zero charge iron oxides, other low point of zero charge minerals reduced the point of zero salt effect in the samples. The occurrence of phosphate and sulfate may have also reduced nitrate retention capacity for this soil. Considering the high permeability of Coto clay, potential nitrate leaching must be considered when establishing a management plan for this soil.

**MICROBIOLOGICAL SURFACE-WATER QUALITY OF THE RIO GRANDE DE AÑASCO WATERSHED IN WESTERN PUERTO RICO**

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**ABSTRACT:** Sediments and the persistence of fecal and streptococcal bacteria in surface waters have been identified as the main water-quality impairments in Puerto Rico. Identification of temporal variations in concentrations and relationships to other water-quality parameters are important in order to understand factors influencing pathogen indicator persistence and sources of contamination. Microbiological indicators (fecal coliforms, total coliforms, and *Enterococcus*) were quantified in five un-sewered rural subwatersheds in the Rio Grande de Añasco watershed in western Puerto Rico. The subwatershed areas ranged from 220 to 1,320 ha with maximum agricultural land-area coverage of 20% and housing dwellings ranging from 435 to 975, in each of the five subwatersheds. Mean values for bacterial indicators such as coliform and *E. coli* were  $\log_{10}$  4.702/100 and  $\log_{10}$  2.404/100 mL, respectively during an 18-month study period. Fecal coliform bacterial concentrations increased from the watershed outlet to upstream areas suggesting that the bacterial source was groundwater seepage from upstream areas. The presence of the pathogenic indicator organisms of the genera *Enterococcus* and *E. coli* was detected in all stations and sampling dates. Variations in hydrologic discharge significantly ( $P < 0.05$ ) positively influenced bacterial indicators. Bacterial diversity evaluation showed six genera and eleven species of coliforms and eight species of *Enterococcus*, which suggests that the possible source of contamination are humans, herbivores and poultry. Sewage seepage from septic tanks and illegal household sewage discharges may be responsible for the water-quality deterioration of the rural subwatersheds.

**MINERALOGY OF A GUANAJIBO CLAY (PLINTHIC PALEUDULTS) PROFILE**

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**ABSTRACT:** Soil samples of Ap, Bt, Btv1, Btv2 and Btv3 horizons of Guanajibo clay were collected, air dried, ground and sieved to pass a 2 mm sieve. The clay fraction of each horizon was separated by centrifugation, dried and analyzed by x-ray diffraction (XRD). Content of free and amorphous iron and aluminum oxides were determined by selective dissolution with dithionate (DCB) and oxalate (OX) solutions. Surface area of whole soil samples was determined by EGME. XRD analysis of the clay fractions indicated the presence of kaolinite, goethite, hematite and gibbsite. Some chlorite may also be present in the samples. The Bt horizon showed very intense kaolinite peaks. The relative intensity of kaolinite peaks decreased in the lower horizons, whereas goethite relative intensity increased. DCB extractable iron content in the Ap horizon was 5.61%, 11.18% in the Bt, 12.10% in the Btv1, 11.77% in the Btv2 and 12.32% in the Btv3. DCB extractable aluminum content in the Ap horizon was 1.30%, 5.76% in the Bt, 4.62% in the Btv1, 3.32% in the Btv2 and 2.32% in the Btv3. Amorphous iron oxide (OX) content for the whole profile ranged from 0.09 to 0.26%, whereas amorphous aluminum content ranged from 0.18 to 0.30%. Surface area of the soil was 21.5 m<sup>2</sup>/g for the Ap horizon, 64.5 m<sup>2</sup>/g for the Bt, 67.9 m<sup>2</sup>/g for the Btv1, 63.7 m<sup>2</sup>/g for the Btv2 and 73.6 m<sup>2</sup>/g for the Btv3.

**FIXED NH<sub>4</sub>: POTENTIAL SUPPLEMENTARY NITROGEN SOURCE AND SINK**

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**ABSTRACT:** Nitrogen (N) remains as the most readily supplemented nutrient in modern agriculture. Techniques to manage this nutrient have often led to its overuse, depletion and potential contamination of agro-ecosystems. Fixed NH<sub>4</sub> which traditionally has been seen as a non-accessible sink for available N is shown to also act as a slow release source pool for N. Release dynamics of fixed NH<sub>4</sub> fractions were investigated in a long term randomized block experiment using short and permanent cropping systems. Results from the first crop harvest and soil samplings showed minimal significance among treatments. The NO<sub>3</sub> pool showed a greater concentration under grass than the other cropping systems. NH<sub>4</sub> dynamics over time revealed important shifts among N pools. All N pools except weakly fixed NH<sub>4</sub> decreased at the second soil sampling (19DAF), indicating either loss (exchangeable NH<sub>4</sub> and NO<sub>3</sub>) or conversion (strongly fixed NH<sub>4</sub>) to weakly fixed NH<sub>4</sub>. Plant influence on fixed NH<sub>4</sub> fractions was minimal due to the short duration, but there was a decline in the weakly fixed NH<sub>4</sub> fraction at the third sampling, reinforcing the importance of that fraction as a potential N source.

**AGRICULTURAL RESEARCH AND DEVELOPMENT: WORKING IN PARTNERSHIPS TO OPTIMIZE LIMITED RESOURCES**

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**ABSTRACT:** For many years the performance of the agricultural sector in the Caribbean has been disappointing. In the past decade, this poor performance has been exacerbated by new global trading rules, which have accelerated the long decline in the production of the traditional crops, which once dominated the economic and social life in the Caribbean. In the wake of this poor performance has been the lack of rural development; whereas many urban dwellers have seen modern developments taking place, most rural areas show symptoms of neglect with the basic human amenities for modern living not provided. This situation will probably continue until agricultural industries can make a more meaningful contribution to the national economies. Agricultural research in the Caribbean is fragmented. Funding of this research has dropped sharply as international aid has become harder to access and government spending has been tightened. CARDI has suffered from these trends, but now realises that the way forward is to collaborate with national, other regional and extra regional agencies. Some examples of CARDI's collaborations are given and CARDI's vision to further develop collaborative efforts is briefly outlined. There are still examples of difficulties in trying to collaborate within the region; indeed there are pressures to compete with each other instead of working together. These pressures need to be overcome if agriculture is to survive and if rural areas are to gain prosperity.

**INTRODUCTION**

The Caribbean Agricultural Research and Development Institute (CARDI) was founded in 1975 to cater for the research and development needs of 12 member countries, namely Antigua and Barbuda, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts/Nevis, St. Lucia, St. Vincent and the Grenadines and Trinidad and Tobago.

In the 1980s and early in the 1990s, CARDI's R&D programmes were well funded with large projects from donor agencies such as USAID, UNDP, CIDA, IFAD, DFID and the European Union. The work was based on the Farming Systems methodology that was very popular at that time and was also actively encouraged by the donors.

The donor funded programmes of the 1980s and 1990s produced many new scientific results and from a scientific point of view were quite successful. There are many examples of this type of work presented at CFCS meetings during the period. A few of these are: Boateng and Lakos (1988), Clarke and Clarke (1989), Francois et al., (1986), Hammerton (1984), Hosein (1992), Jones (1984), Orban and Matadial (1989), Pilgrim and Francois (1986) Rao and George (1986), Rhodes (1991), Robin (1990) and Singh (1984).

## THE POSITION TODAY

The situation with donor funding changed dramatically in the early 1990s and the end of the cold war. It suddenly became more difficult to attract donor funding to the region and also the focus of the donor agencies seemed to shift out of agriculture.

On January 1, 1995, the WTO came into existence with the aim of promoting the expansion of international trade. This seems to have had the effect of making entry of agricultural goods into the Caribbean easier without making the exports from the Caribbean similarly easy. In addition, Sanitary and Phytosanitary Measures (SPS) has emerged as an artificial barrier to exports from the Caribbean agricultural sector. In addition, a new facet of food security laws, Hazard Analysis Critical Control Points (HACCP), has been introduced and accepted by the WTO.

These new global rules have impacted negatively on the performance of agriculture in the Caribbean. The contribution of agriculture to gross domestic product (GDP) has declined into a single digit percentage in many countries. Although it should be recognised that GDP is probably not a good measure of the true performance of agriculture (IICA 2003), the sector's performance has been poor and is probably getting worse. The economies of Caribbean countries were originally based on a vibrant agriculture sector based on traditional export crops such as sugar, bananas, coffee and cocoa.

As the demand for and importance of these export crops has dwindled, so has the quality of rural life. Agriculture in the Caribbean is a rural-based activity and is the only income for a large percentage of rural households. Development of non-agricultural sectors including tourism has led to modern developments in many islands, but these impact mainly on urban life, whereas many rural areas still lack basic amenities such as reliable water and electricity supplies and well maintained, modern roads. One cause of this rural decline is the lack of rural industries. The industries which existed with the traditional export crops contributed considerably to rural infrastructure. However, the replacement crops being grown for food security are not developing along industry lines. This is despite efforts by CARDI and others, but the considerable private sector investment, which is required, is not forthcoming.

Agricultural research in the Caribbean has historically been quite strong as the United Kingdom established the Imperial College of Tropical Agriculture (ICTA) in Trinidad in 1923. ICTA was the successor to an even earlier organisation, the Imperial Department of Agriculture for the West Indies (IDA) which was founded in Barbados in 1898.

By the late twentieth century, Roseboom et al., (2001) identified at least 116 agricultural research agencies in the greater Caribbean (English, French, Spanish and Dutch speaking). This research is highly fragmented with over half the agencies employing less than five researchers. It was also found that between 1986 and 1996 the agricultural research capacity in the Caribbean halted in terms of number of researchers and contracted in terms of expenditures. However, there was still growth in some French speaking countries.

## COLLABORATIVE PARTNERS

CARDI is a good example of the trends noted above. The precipitous decline in donor funding (well over 50%, even without considering and adjusting for inflation) has been compounded by frozen core support from governments. The CARICOM Heads of Government conference in Montego Bay, Jamaica in July 2003 reaffirmed the governments' recognition of



the need for agricultural research and also supported CARDI as an important pillar in the transformation and development of Caribbean agriculture.

Despite this support, CARDI's core (government) funding remained frozen for 12 years from 1991 and has recently taken a small cut. This is also reflective of the global climate since the end of the cold war and the demise of socialism in many countries. These events have seen governments seeking to slash their budgets with the intention of encouraging private investment. As already noted, the Caribbean private sector has not embraced agriculture as an income-earning activity. However, CARDI has been very successful in identifying partners in the private sector who are involved in agricultural production, processing and marketing.

Clearly the way forward is to pool resources and collaborate with other institutes, both regionally and extra regionally. This will also reduce the problems caused by fragmentation. CARDI's list of collaborators is very long. Table 1 shows some of the collaborative links with institutions and technical assistance agencies.

Table 1 lists only collaborators for specific in country projects. It does not include CARDI's large number of regional project collaborators. Some of these are FAO, University of Florida, CARICOM, CAB International, CDB and others. CARDI is also striving to build linkages with the French and Spanish speaking Caribbean and to this end, is discussing a Memorandum of Understanding (MOU) with CIRAD.

It will be noticed that the first collaborator listed in Table 1 for each country is the Ministry of Agriculture. These ministries are considered to be our major stakeholders.

The collaboration and cooperation between CARDI and IICA is resulting in a close operational relationship. IICA has strengths in rural development and extension services and these are complemented by CARDI's strengths in the production and adaptation of technology.

In 2003, CARDI signed an MOU with the University of Florida and this has served to deepen the linkages with that university. This linkage has enabled the continuation of the thrust to tackle the invasive species issue, which was the theme of last year's Caribbean Food Crops Society meeting in Grenada. CARDI and the University of Florida were the prime movers behind a workshop on invasive species held in Port of Spain, Trinidad in June 2004. This workshop followed up on the thrust which commenced in Grenada and is being reported on elsewhere at this conference (Klassen and Davis, 2004).

The deepening of cooperation and collaboration with the University of the West Indies (UWI) is particularly important for CARDI's future development. Because of the freeze in core funding over the years and increase in salary and other costs, CARDI has, by necessity, had to focus on its core competencies in a number of areas including small ruminant development, seed technology, market research, post harvest, root crops, integrated pest management, biometrics, organic agriculture, soil resource management, biotechnology and agribusiness development. A number of other areas of agricultural development, for example, food technology and economics, are strong at UWI. Therefore, CARDI has moved closer to collaboration with the university to fill the gaps which exist in its own competencies, and also to complement its strengths by liaisons with relevant university staff. CARDI has also fed into the university's programmes of work with its staff being involved in teaching at the university and also contributing to the universities research programmes. This relationship is facilitated by CARDI's presence on the UWI campuses in Cave Hill, Barbados, Mona, Jamaica, and St. Augustine, Trinidad and Tobago.

The list of collaborators in Table 1 does not include the many partners in agribusiness who CARDI has identified. It was mentioned above, that private sector investment in agriculture was not considerable. But this does not mean that many small- and medium-sized enterprises do

not depend on agriculture for their incomes, even though large investments from big companies are not too common. Some of the collaborators with small and medium agribusiness are outlined in Table 1.

## SOME COLLABORATIVE PROJECTS

This section will briefly outline a few examples of collaborative projects. A fuller description would require time beyond the limits of this presentation.

Table 2 lists at least one important collaborative project for each member country. In Barbados, the control strategies developed by CARDI for the sugar cane moth borer are saving the industry over US\$1 million per year; in other words this project alone is repaying over one-third of CARDI's annual core budget of about US\$2.8 million.

In Grenada the nutmeg wilt has been of concern for over 60 years and recent trends suggest that the problem is increasing and the industry is under threat. This is a serious problem in a country where 10,000 people are registered nutmeg farmers (perhaps 50% of all households). CARDI's research has discovered the cause of the wilting is a root disease and the pathogen is being identified. Previous studies over the 60-year history of the disease were not successful in identifying the disease as a root rot problem.

CARDI has been working with the Coffee Industry Board in Jamaica for about 20 years. At first, the coffee borer was controlled with chemicals, but in recent years, environmental concerns have led to the need to develop a new control strategy. CARDI has developed facilities to breed and multiply parasites to control the coffee berry borer.

Also in Jamaica, the bauxite company ALPART has been delighted with the work that CARDI has done at the Sam Motta Demonstration and Training Centre. Here, unattractive mined-out bauxite lands have been transformed into green pastures where profitable small ruminant production takes place. This has served as a demonstration for farmers as well as showing that former mining sites do not have to become wastelands.

## FUTURE PROGRESS

To deepen the collaborative process, CARDI is encouraging each of its member country Ministries of Agriculture to set up a National Coordinating Committee for Agricultural Research and Development (NCCARD). CARDI is offering to act as secretariat for these NCCARDs which will bring together all the national bodies involved in agricultural R&D in a formalised structure.

The day of plentiful funding saw the fragmented R&D agencies of the Caribbean competing for the biggest grants. Old habits die hard and some still remain in that mode; others fight to protect their turf or space. However, these habits are declining, but difficulties remain. For example, there are funding sources which invite competitive bids. When CARDI attempts to link-up with a collaborating agency to jointly bid, we are told that the rules do not allow for such collaboration.

Such practices need to be resisted; we are all committed to the survival of agriculture and also to the rural areas becoming as prosperous as some of the urban areas. This will require partnership and collaboration and not competition between limited resources.

Table 1. Some of CARDI collaborators in each of its member countries

Country	Collaborator
Antigua and Barbuda	<ul style="list-style-type: none"> <li>▪ Ministry of Agriculture, Lands, Environment, Marine Resources and Agro-Industry</li> <li>▪ Inter-American Institute for Cooperation on Agriculture (IICA)</li> <li>▪ Gilberts Agricultural and Rural Development (GARD) Centre</li> </ul>
Barbados	<ul style="list-style-type: none"> <li>▪ Ministry of Agriculture and Rural Development</li> <li>▪ Inter-American Institute for Cooperation on Agriculture (IICA)</li> <li>▪ Association of Sugar Technologists</li> <li>▪ University of the West Indies</li> </ul>
Belize	<ul style="list-style-type: none"> <li>▪ Ministry of Agriculture, Fisheries and Cooperative</li> <li>▪ Inter-American Institute for Cooperation on Agriculture (IICA)</li> <li>▪ Citrus Research and Education Institute</li> </ul>
Dominica	<ul style="list-style-type: none"> <li>▪ Ministry of Agriculture and the Environment</li> <li>▪ Inter-American Institute for Cooperation on Agriculture (IICA)</li> <li>▪ Dominica Import and Export Agency (DEXIA)</li> </ul>
Grenada	<ul style="list-style-type: none"> <li>▪ Ministry of Agriculture, Lands, Forestry and Fisheries</li> <li>▪ Inter-American Institute for Cooperation on Agriculture (IICA)</li> </ul>
Guyana	<ul style="list-style-type: none"> <li>▪ Ministry of Agriculture</li> <li>▪ National Agricultural Research Institute (NARI)</li> <li>▪ Guyana Rice Development Board (GRDB)</li> </ul>
Jamaica	<ul style="list-style-type: none"> <li>▪ Ministry of Agriculture</li> <li>▪ Inter-American Institute for Cooperation on Agriculture (IICA)</li> <li>▪ ALPART (Bauxite Mining Company)</li> <li>▪ Coffee Industry Board</li> <li>▪ University of the West Indies</li> </ul>
Montserrat	<ul style="list-style-type: none"> <li>▪ Ministry of Agriculture, Lands, Housing and the Environment</li> </ul>
St. Kitts and Nevis	<ul style="list-style-type: none"> <li>▪ Ministry of Agriculture, Fisheries, Cooperative, Lands and Housing</li> <li>▪ Inter-American Institute for Cooperation on Agriculture (IICA)</li> <li>▪ St. Kitts Sugar Manufacturing Company</li> </ul>
St. Lucia	<ul style="list-style-type: none"> <li>▪ Ministry of Agriculture, Forestry and Fisheries</li> <li>▪ Inter-American Institute for Cooperation on Agriculture (IICA)</li> <li>▪ St. Lucia Rural Enterprise Project</li> </ul>
St. Vincent and The Grenadines	<ul style="list-style-type: none"> <li>▪ Ministry of Agriculture, Lands and Fisheries</li> <li>▪ Eastern Caribbean Trading and Agricultural Development (ECTAD)</li> </ul>
Trinidad and Tobago	<ul style="list-style-type: none"> <li>▪ Ministry of Agriculture, Land and Marine Resources</li> <li>▪ Tobago House of Assembly</li> <li>▪ Caroni Research Division</li> <li>▪ Inter-American Institute for Cooperation on Agriculture (IICA)</li> <li>▪ The University of the West Indies</li> </ul>

Table 2. Some CARDI Collaborative Projects

Country	Project
Antigua and Barbuda	<ul style="list-style-type: none"> <li>▪ Training programmes of the Gilbert Agricultural and Rural Development Centre (GARD); organic agriculture component</li> </ul>
Barbados	<ul style="list-style-type: none"> <li>▪ Control strategies for the sugar cane moth borer for the sugar industry</li> </ul>
Belize	<ul style="list-style-type: none"> <li>▪ Government soybean project; development of systems to manage germplasm and to increase production of improved varieties</li> </ul>
Dominica	<ul style="list-style-type: none"> <li>▪ Pineapple production and post harvest treatment projects in collaboration with Nature Island Pineapple Producers Association (NIPPA)</li> </ul>
Grenada	<ul style="list-style-type: none"> <li>▪ Identification of cause of disease which causes wilting in nutmeg trees / collaboration with Grenada Cooperative Nutmeg Association (GCNA) and Ministry of Agriculture, Lands, Forestry and Fisheries</li> </ul>
Guyana	<ul style="list-style-type: none"> <li>▪ Secretariat and management of Caribbean Rice Development Network (CRDINET); research and other collaborative work with Guyana Rice Board (GRB)</li> <li>▪ Evaluation of improved production systems of jams and jellies; collaboration with CARIRI, UWI and Tandy's Manufacturing</li> </ul>
Jamaica	<ul style="list-style-type: none"> <li>▪ Biological control of coffee berry borer for the Coffee Industry Board</li> <li>▪ Caribbean Centre of USAID/Virginia Tech IPM Collaborative Support Research Programme (IPM CRSP)</li> <li>▪ Demonstration on reclaimed bauxite lands to facilitate small ruminant production (funded by bauxite company, ALPART)</li> </ul>
Montserrat	<ul style="list-style-type: none"> <li>▪ Development of cassava industry in collaboration with Ministry of Agriculture, Lands, Housing and the Environment</li> </ul>
St. Kitts and Nevis	<ul style="list-style-type: none"> <li>▪ Collaboration with Sugar Manufacturing Company (SMC) to identify pests and diseases</li> </ul>
St. Lucia	<ul style="list-style-type: none"> <li>▪ Collaboration with St. Lucia Rural Enterprise Project (SLREP) to facilitate the sustainable development of rural smallholding farming systems through targeted intervention in land resource management</li> <li>▪ Development of rabbit industry; collaboration with Ministry of Agriculture, Forestry and Fisheries and the Organisation of Private Sector Relations (OPSR)</li> </ul>
St. Vincent and The Grenadines	<ul style="list-style-type: none"> <li>▪ Collaboration with Arrowroot Improvement Programme of the Ministry of Agriculture, Land and Fisheries to support the sustainable development of the arrowroot industry</li> </ul>
Trinidad and Tobago	<ul style="list-style-type: none"> <li>▪ Collaboration with IICA, UWI and the Ministry of Agriculture, Land and Marine Resources to develop a control strategy for the Management of Johne's disease in small ruminants</li> <li>▪ Development of saponilla industry; collaboration with CARIRI (Regional)</li> </ul>

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**LAND USE PLANNING FOR AGRICULTURAL DIVERSIFICATION OF SUGAR ESTATES IN TRINIDAD AND TOBAGO**

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**ABSTRACT:** Restructuring of the sugar industry in Trinidad and Tobago has released 12,158 hectares of sugarcane lands for agricultural diversification. Caroni (1975) Limited, a state enterprise sugar company controls 31,000 hectares, representing 25% of the best available arable lands in the country. Soil, land capability and agro-ecological analyses conducted on Caroni (1975) land holdings indicate that 67% of the lands are in Class III and IV, representing good agricultural lands with moderate soil fertility, and 33% of the lands are in Class V, VI and VII, depicting marginal agricultural lands. Continuous sugarcane production with sub-optimal soil fertility management programmes has resulted in soil nutrient and organic matter depletion of lands, soil acidification, and land degradation with a consequent reduction in agricultural productivity. The technical and operational considerations for proposed diversification programmes to root crops, rice, vegetable crops, tropical fruits and livestock in relation to water management, soil technology for heavy clays, crop selection, farmer training, extension, credit and support systems are presented. The implications for food and nutrition security, and sustainable production systems in Trinidad and Tobago are highlighted.

**Key words:** Agricultural diversification, Soil management, Land degradation, Crop selection

**INTRODUCTION**

Since 1978, there has been a plethora of well documented studies of initiatives in Trinidad aimed at restructuring Caroni (1975) Limited into a viable agro-industrial company. The major component of these initiatives mandated Caroni (1975) Limited to organize and deploy its human, financial and physical resources, which are of strategic importance to national agricultural endeavor, to operate a viable diversified agricultural enterprise. However over time, attempts at restructuring Caroni (1975), including sugar operations and diversification into rice, beef, dairy, citrus and coffee have met with limited success, and have not reduced the dependence on state subventions to cover operating costs.

Caroni (1975) Limited through land acquisitions control 31,000 hectares, which represent 25% of the best arable lands in Trinidad. The company up to 2003 utilized 19,640 hectares in sugarcane cultivation both estate and rented to farmers, and 6,400 hectares in crop diversification projects. In 2003, the Government of Trinidad and Tobago, against a background of continuing operating losses, undertook a restructuring of the sugarcane industry, which entailed the cessation of sugarcane cultivation by Caroni (1975) Limited, the downsizing of the sugar industry to 75,000 tonnes, and the voluntary separation of 9,204 daily and monthly paid employees. The framework also mandated the operation of one sugar factory, the production of cane by farmers only with payment based on quality, and the establishment of an Estate Management and Business Development Committee to strategically develop and optimize the land assets of Caroni (1975) Limited. This restructuring exercise has resulted in 12,158 hectares

of Caroni Lands being available for diversified agricultural production, other than sugarcane production.

For most of its history Trinidad and Tobago has devoted the majority of its agricultural resources to producing export commodities principally sugar, cocoa, coffee, citrus and copra. Export agriculture was facilitated by institutional support and preferential marketing arrangements. The Agriculture sector contributed 115 M USD or 1.2% of the GDP (2002), but employs 37,000 or 7.2% of the national labour force. Trinidad and Tobago is a net importer of food, with importation of 267 M USD in 2002. The chief components of these imports are cereals (53.4 M USD); fruits and vegetables (50.9 M USD); animal feeding stuff (23 M USD); dairy products and eggs (44.7 M USD); meat and meat products (21.5 M USD).

The Caroni transformation process provides opportunity for new development options in areas such as nutrition and food security, agro processing, livestock development and environmental protection on strategically important land resources.

## METHODOLOGY OF LAND EVALUATION

Caroni (1975) Limited, through acquisition and consolidation of estates, controls an estimated 31,000 hectares in Central and South Trinidad (Figure 1). These lands represent 7% of the land area of the country but approximately 25% of the best arable lands and hence are of strategic importance to agricultural development.

The acreages, physiographic features and historical land use allocation were reviewed on the basis of section maps, notated cadastral sheets and voluminous land record files. These land records were evaluated and reviewed by examination of aerial photographs and photomosaics for the years (1966, 1980, and 1998) to determine physiographic features, soil boundaries and land use.

A comprehensive soil survey review was undertaken in 2003 to evaluate soil and land characteristics which have potential impact on agricultural transformation. The principal land characteristics of interest included soil fertility constraints, soil erosion risks, soil salinity and land degradation hazards. Soil survey records and, Caroni (1975) Limited technical and research reports, were compiled and analyzed. Sampling and consolidation of data was undertaken to eliminate land data gaps within the sixteen land sections.

A crop suitability analysis was conducted using the crop environmental requirements database (FAO, 1979); soil suitability guidelines for major tropical crops (FAO 1984) and guidelines for land evaluation for rain fed and irrigated agriculture (FAO 1980, 1985).

Lands were categorized within the Trinidad and Tobago Land Capability Survey Protocol (1974), a quantitative land evaluation system with seven land capability classes. Additional subclass descriptions were defined to permit analysis of land use restrictions due to water availability, toxicity, erodibility, land leveling, drainage and irrigation, nutrient availability, soil acidity, compaction/ soil resistance, opportunity days, infield trafficability and accessibility and land clearing.

The digital land database of Caroni (1975) Limited was consolidated, validated and transformed using Arc View GIS, to enable proper geo-referencing of Caroni Land Sections. The Soil and Land Capability attributes from the soil surveys were integrated and analyses performed to determine land capability, crop suitability and land use.

## DISCUSSION

### Land Capability Analysis

The Trinidad and Tobago land capability survey protocol (1974) classifies lands in seven classes based on soil physical, chemical and mineralogical properties and site characteristics. Class I represents the best agricultural lands with a gradation to Class VII representing the lands best suited to forestry or environmental protection. The land capability distribution of Caroni (1975) Limited land holdings is presented in Table 1. There are no Class I and minimal acreages of Class II lands.

Class III represents relatively good soils, suitable for cultivation with intensive practices. Specific management practices related to water availability, amelioration of soil physical properties and soil acidity. These land comprising 9,917 hectares or 31.9% of total acreage were allocated a high priority for agricultural utilization, since the key soil series represented have a high agricultural potential for the production of a wide range of agricultural crops. These series include the Sevilla, Freeport, L'Ebranche, Cunupia and Waterloo soil series.

The area represented by Class IV lands is 10,931 hectares or 35.3% of acreage. Class IV represents agricultural lands, requiring intensive management with subclass limitations of adverse soil water relations and soil fertility. Distinctive soil series represented include the Bejucal and Frederick clays which are imperfectly drained, and the Mc Bean and Washington which are free draining soils, with good chemical properties.

Class V, represent principally lands on undulating topography, prone to soil movement, erosion, infertility and poor water relations. Most of the soils are, vertisols, existing on slopes 5 – 20° and have supported sugarcane cultivation for over 200 years. The acreage is 9009 hectares or 29.6% of land holdings.

Caroni (1975) Limited has very limited acreage of Class VI and VII soils. These lands are used for quarry, pasture or environmental protection.

### Land Use Analysis

Agricultural operations of Caroni (1975) Limited were conducted in 2003 on 24,347 hectares representing 78.5% of total land holdings. Sugarcane cultivation on company lands and rented to farmers engage 19,640 hectares, while citrus, rice and other diversification projects occupied 4,700 hectares (Table 2). Significant non agricultural allocations include residential and housing estates, industrial sites, access roads and community facilities adjacent to sugar estates.

Proposals for potential agricultural land use allocations, consequent to the downsizing of the sugarcane industry in 2003, were formulated on the basis of land capability, soil suitability and strategic impact on food and nutrition security. The analysis indicated that 21,040 hectares have above average agricultural potential and can be retained for agriculture. Sugar cane cultivation exclusively by farmers can continue on 7,480 hectares. Food crops, vegetables, rice and tree crops are recommended to be allocated 10,027 hectares, while livestock production including beef, buffalypso, dairy and small ruminants are allocated 3,530 hectares (Tables 3, 4)

A significant feature of the proposed land use allocation is that diversification projects will be executed on the heavy clay soils of North and Central Trinidad. A detailed assessment of land use restrictions on Caroni (1975) land sections is presented in Table 5. Eleven land



characteristics were evaluated and the analyses indicate that the most severe restrictions to agricultural development include, water management (87.0%), drainage and irrigation infrastructure (80.2%), soil acidity (56.8%), nutrient availability (45.0%) and soil compaction/resistance (34.3%)

Water management and drainage and irrigation infrastructure are key factors in the transformation of lands from sugar cane to food crop production, since they will influence the number of crop cycles per year, choice of crops, crop scheduling, agronomy and hence farm profitability. Additionally amelioration of soil acidity consequent to high Urea use and unbalanced sugar cane fertilization will be a significant challenge to farm managers.

A significant acreage of lands, estimated at 7,000 hectares, is reserved for the development of small farmer plots, allocated to former Caroni (1975) employees, terminated as a result of restructuring of the sugar industry. These farmers will be engaged principally in the cultivation of vegetable and food crops. The land characteristics mandate that comprehensive training of farmers in crop production is a critical success factor. Additionally technical support in water management, extension, agriculture credit and soil testing advisory services are highly recommended for implementation.

#### Implications For Food Security

The Agriculture Sector Reform Programme 2003, provides a framework for greater agricultural production, and a sector which creates self sufficiency in food supply, generates employment, promotes food and nutrition security, reduces the rural to urban migration, and is ecologically sustainable. The agricultural diversification of sugarcane lands is structured in a framework of food production in strategic sectors of food, root crops, vegetables, tropical fruits, legumes and small ruminants. These commodities have been identified and proposed for development as profitable alternatives to utilize the resources currently devoted to sugar cane farming.

Food and Nutrition security policy is based on three components; food availability, food accessibility and household nutrition. The capacity of Trinidad and Tobago to provide adequate amounts of domestic food are a key determinant of food security, and has to be addressed adequately and systematically in agricultural policy formulation. The diversification of Caroni (1975) Limited provides an opportunity to target food production activities to ensure food availability food accessibility and household nutrition security in Trinidad and Tobago.

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Table 1. Land Capability Classification Caroni (1975) Limited

Land Capability Class	Acreage (ha)	%
Class II	38	0.1
Class III	9,917	31.9
Class IV	10,931	35.3
Class V	9,009	29.1
Class VI	1,079	3.5
Class VII	27	0.9
	31,003	100.0

Table 2. Overview of Existing Agricultural Land Use Allocations Caroni (1975) Ltd.

Type of Activity	Hectares	Percentage
Sugarcane (Estate)	15,234	62.6
Pasture	595	2.4
Citrus	1,367	5.6
Wine Making	182	0.7
Rice and Other Food Crops	2,038	8.4
Tree Crops	410	1.7
Aquaculture	115	0.5
Cane Farming	4,406	18.1
Total (78.5% of total acreage)	24,347	100.00

Table 3. Land Use Allocation By Agricultural Activity Types on Caroni (1975) Ltd.

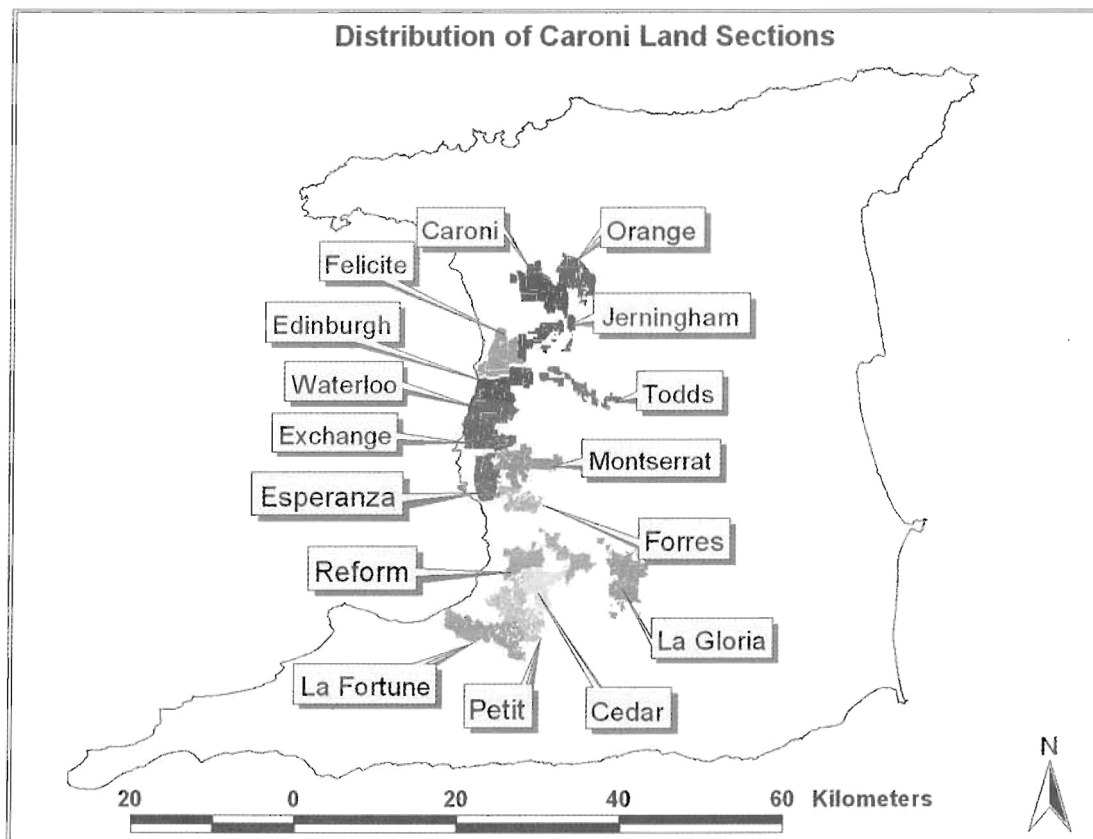
No.	Type of Activity	Hectares	Percentage
1.	Sugarcane	3,076	14.6
2.	Food Crops	2,845	13.5
3.	Rice	3,019	14.3
4.	Livestock	2,246	10.7
5.	Vegetables and Food Crops	1,125	5.3
6.	Citrus	1,093	5.2
7.	Tree Crops	850	4.0
8.	Buffalypso	597	2.8
9.	Forestry	577	2.7
10.	Vegetables	445	2.1
11.	Diary	405	1.9
12.	Small Ruminants	283	1.3
13.	Cocoa	73	0.3
	Subtotal	16,634	79.1
	Rental (Cane Farmers)	4,406	20.9
	Total (67.9%)	21,040	100.0

Table 4. Proposed Agricultural Land Use Caroni (1975) Ltd.

No.	Section	Total Acreage (ha)	Proposed Activity	Land Class Capability	Proposed Acreage (ha)
1.	Caroni	2343	Vegetables and Food Crops Rice	II, IV III, IV	320 1400
2.	Orange Grove	1519	Vegetables and Food Crops	III	299
3.	Jerningham	1229	Vegetables Rice Food Crops	III, IV III III, IV	223 445 198
4.	Todds Road	970	Citrus Tree Crops	III, IV, V III, IV, V	486 121
5.	Edinburgh	1401	Food Crops Dairy Farms	III, IV III, IV	627 405
6.	Felicity	1528	Rice Food Crops Vegetables	III, IV III, IV III, IV	708 192 223
7.	Waterloo	1383	Food Crops Rice	III, IV III	506 465
8.	Exchange	1603	Vegetables and Food Crops Sugarcane (estimated)	III III, IV	506 567
9.	Montserrat	1687	Food Crops Tree Crops Forestry	III, IV, V IV, V, VI V, VI	127 728 71
10.	Esperanza	1281	Small Ruminants Food Crops Forestry	IV, V, VI IV V, VI, VII	283 304 142
11.	Reform/ Williamsville	2346	Food Crops Sugarcane (estimated)	III, IV III, IV, V	607 809
12.	Cedar Hill	989	Sugarcane (estimated)	IV, V, VI	728
13.	Petit Morne	1765	Sugarcane (estimated)	III, IV, V	809
14.	La Fortune 1 & 2	1913	Livestock (beef) Sugarcane (estimated)	III, IV, V III, IV, V	1174 162
15.	La Gloria	1838	Citrus Livestock Food Crops	IV, V, VI IV, V, VI IV, V	607 1072 81
16.	Forres Park	1011	Forestry Food Crops	V, VI, VII II, IV, V	506 202
17.	Mora Valley	670	Cocoa Buffalypso	III, IV III, IV	73 597
	Total	25476			

Table 5. Land Use Restrictions: Caroni (1975) Limited Land Sections.

Restrictions	Hectares	%
Water Management	26,970	87.0
Toxicity/ Salinity	1,178	3.8
Erodability	6,107	19.7
Drainage and Irrigation Infrastructure	24,862	80.2
Nutrient Availability	13,950	45.0
Soil Acidity	17,608	56.8
Compaction/ Soil Resistance	10,633	34.3
Land Clearing	2,542	8.2
Land Leveling	837	2.7
In Field Trafficability	1,116	3.6
Opportunity Days	8,339	26.9



**LA MICROEMPRESA COMO LA ESTRATEGIA DE DESARROLLO DEL SECTOR RURAL DE MÉXICO: ESTUDIO DE CASO LA COMUNIDAD RURAL “SAN RAFAEL IXTAPALUCAN, PUEBLA - MÉXICO.”**

*Carla Vanesa Blandino Jiménez, Programa de Postgrado en Desarrollo Rural, Instituto de Socioeconomía, Estadística e Informática, Colegio de Postgraduados, México*

**RESUMEN:** La microempresa se ha venido convirtiendo en el elemento generador del desarrollo económico, por lo que es importante conocer las principales tendencias con la finalidad de diseñar políticas que permitan ampliar y apoyar la conformación de microempresas en la zona rural. En México existen diferentes tipos de microempresas dentro de las que se destacan las familiares, estas cuentan con capital fijo relativamente bajo, sus técnicas de producción son simples y no hay especialización en la producción. La falta de apoyo a las microempresas sitúa a una gran cantidad de ellas en el sector informal de la economía, sobre todo las que se encuentran en las zonas rurales. Estas microempresas tienen como punto de partida la economía de subsistencia, sobre todo porque combinan la agricultura con alguna actividad de otro sector productivo. El objetivo fundamental es obtener beneficios económicos que incrementen los ingresos familiares. La comunidad en estudio es San Rafael Ixtapalucan, Municipio de Santa Rita de Tlahuapan, Estado de Puebla-México, aquí han surgido individuos emprendedores que se han propuesto implementar estrategias orientadas a incrementar sus ingresos, diversificando sus fuentes de trabajo. En la actualidad en esta comunidad de San Rafael se han creado 101 talleres textiles que funcionan y están organizadas en microempresas familiares. La mano de obra utilizada es fundamentalmente de tipo familiar, esto es, cerca del 80% de la fuerza de trabajo son parientes, sobrinos/as, tíos/as, hijos/as. De manera que la microempresa ha modificado la organización del trabajo familiar. La proliferación de estas microempresas debe ser vista dentro del contexto de una economía en transformación, sobre todo del sector industrial, que abrió nuevas posibilidades de futuros productores aun en zonas rurales como la comunidad de San Rafael Ixtapalucan.

**PARTICIPATORY SURVEY AND TREE CROP PREFERENCES ON ST. CROIX, U.S. VIRGIN ISLANDS.**

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**ABSTRACT:** The number and size of farms in the US Virgin Islands (VI) have steadily declined since 1965 and only 6% of the land remains covered with natural forest or woodland (NASS 2001). Characterizing current production systems by direct observation and soliciting information directly from producers on St. Croix served to involve farmers in project formulation and began an active learning process as the basis for future activities. A participatory survey of farms and home gardens with producers to characterize species composition and geographic description of agriculture on St. Croix was made during the period April through June 2003. Two objectives of the project were to foster conservation of trees on farmland and promote enterprise development with nontimber products in collaboration with local institutions and producers. A geo-referenced (GPS) map point for each farm was also taken to compile with geographic information for the island of St. Croix. Additionally each interview included a walking transect with the producer to observe production practices and provide for informal discussion about land use. Based on survey results and data on soils, vegetation, land use, hydrology and further GIS analyses, a decision support system is under construction. The decision support system will be a useful tool for producers and professionals to determine viable planting sites for desired tree crop species. Project activities also include germplasm collection for native fruit tree domestication and planting to enhance biodiversity within the landscape.

**Key words:** producer interviews, GIS decision support, fruit trees, agroforestry, biodiversity

## INTRODUCTION

A Forest Products survey conducted by collaborative efforts of the RC&D with the VI Department of Agriculture (VIDoA) and USDA Forest Service indicates there is good potential for more agroforestry and application of knowledge about native species and medicinal plants in production systems (VIDoA, 2001). Some of the best candidate species for accelerated domestication are found in home gardens or as the most valued species remaining in farm landscapes.

The Enda-Caribe project in the Dominican Republic developed agroforestry and reforestation projects with farmers that were profitable while increasing tree cover on marginal soils (Hernandez, 1995). These efforts increased availability of fuelwood and timber products for housing and commercial purposes. Jickling and While (1995) concluded from an economic analysis of agroforestry projects in Haiti that tree gardens around homes were a critical component of economic and cultural life. The authors pointed out the potential for greater productivity in home tree gardens with sustained economic and ecologic viability. In an approach to give credence to economic as well as ecologic considerations of agroforestry in Haiti, and an initial premise that trees are crops that could be planted, harvested and sold or used



as any other crop, analysis of a 20 year project showed how a good cash-earning opportunity evolved on terms farmers decided by themselves while providing soil conservation benefits (Murray and Bannister 2004).

The application of GIS and the development of spatial databases are becoming more widespread in rural and community development. Swindell et al., (2000) provide strong arguments for the utilization of full GIS for rural land management. The integration of GIS in farm or household level research efforts to promote sustainable rural development is also becoming more popular. While the development of conventional databases and decision-support systems has been more common in the field of agroforestry, the use of GIS is still relatively new and scarce in the discipline. Ellis et al., (2004) present comprehensive descriptions of computer-based tools used for agroforestry research and development.

The main focus of the tree crop project is multistrata agroforestry with indigenous fruits and crops for home consumption and local markets. Depending on farmer perception and demand, silvopastoral designs will also match goals of the project. The fruits and other non-timber forest products can be used for cottage or value added industry if the labor and market accept development (*e.g.* juice). The survey of existing farms/home gardens to characterize current production, indicate potential participation, and identify potential market products is the component of the on-going research described in this presentation.

## METHODS

Semi-structured interviews (Dillman, 2000) and resource transects with producers (Abbott 1999) took place between April and July of 2003. UF/IFAS and UVI personnel conducted interviews and farm tours with each of 204 agricultural producers on St. Croix. Producer contacts came from a list of licensed farmers supplied by the VI Department of Agriculture. We found that the VIDoA listed just over 400 producers while the US Agricultural Census indicated the number of farmers on St. Croix as 205. From months of repeated effort we found 10% of the producers on the VIDoA list were no longer active in agriculture and that there were a few cases of duplicate names (<1%, usually within family) for the same parcel of land. Our survey thus represents 58% of the active producers listed by the VIDoA and is equivalent to over 99% of the national census count.

The interview/farm tour surveys provided data on species composition, production categories, management practices, land area and site characteristics along with demographic and ownership or lease characteristics. A geo-spatially referenced map point was taken during each interview to confirm the location for correlation with site factors. Among other questions, farmers were asked to indicate their most important agricultural product, preferred tree crops, preferences for future production, and level of interest in small business development.

## RESULTS

Results show mean farmer age (Figure 1) was 56 years (min 27, max 91, median 53), 25% were female and 38% of the farmers interviewed were born on St. Croix. Proportionally a larger number of younger people identify themselves as agricultural producers in comparison to the US mainland and this percentage indicates the potential for intergenerational learning and continued food production on the island. For production, 74% of the producers farm up to 4 ha (10 acres) while 6% farm greater than 41 ha (100 acres) with a median value 2 ha (5 acres); 66%

own the land while 34% lease or have land use permits. The median number of agricultural products per farm was 15 and mean number 12.5. Of the farmers interviewed, 27% stated horticultural crops, 22% tree crops, and 31% animal production were the most important to them. Asked what other products they would like to cultivate, 46% stated they would like to add horticulture crops, 54% would add trees, and 11% would add animals if possible.

Seventy-five percent of farmers have some tree product and 69% of those are fruits. Semi-structured interviews and resource transects across each site with producers showed 64 total tree species cultivated on farms. Mango (48%), avocado (38%), coconut, mamee apple (24% each), and lime (21%) were the most abundant fruit species currently cultivated by producers (Figure 2). [For scientific names, see list in appendix]

When asked what tree species they would plant, 95% wanted something to eat or sell. The species most preferred for future planting, besides mango and avocado, were coconut (9%), mamee apple (9%), papaya (8%), orange, banana, mespel (6% each) and lime (5%) (Table 1).

Top ranked production practices were fertilization (90% organic, 48% inorganic), irrigation (59%), shade (58%), mulch (54%), pesticides (46%), and pasture rotation (45%). Thirty-five percent of the producers practice crop rotation, 26% utilizes organic pest control, and 12% use herbicides. Fish emulsion, seaweed and compost are used by 14% to 15% of the producers. Some farmers (4%) maintained fishponds, rain catchments (39%) and actively managed terraces (9%) in their production systems (Figure 3). The majority learned these practices from their parents (63%) while others were self taught (17%) and fewer learned from school (7%), work (4%), or extension workshops (1%).

The majority of farmers (62%) on St. Croix are not from St. Croix. Of the farmers interviewed, the largest percentages of non-Crucians (not born on St. Croix and neither parent St. Croix born) were from Antigua (15%) and from St. Lucia (11%). Though some differences exist in land access (acquisition), it is most interesting to note that a significantly greater number of Crucians indicated animal production as most important while a significantly greater number of non-Crucians stated horticultural crops were their most important production. Crucians also farmed larger median land area than non-Crucians.

The most important current production varied seasonally for 23% of the agriculturalists. Tomato and cucumbers were ranked most important horticulture crops for 10% (each) of the farmers while the next most important were herbs and cassava (7% each). Top animal production by producers was 21% goats, 18% hair sheep, and 13% poultry. Farmers indicated they cultivated products for use by the family (16%), to sell (21%), or both for family consumption and to sell (54%).

Major concerns for the farmers included water (44%), price of inputs (26%), fencing (20%), theft (20%), and stray dogs (18%). In addition to formal questions, during discussion with producers, more workshops and extension information was voluntarily requested by 7% of the farmers. Though 31% state they have some business underway, 86% of the producers expressed interest in developing or amplifying an agriculturally-based business.

## DISCUSSION

It was evident that agricultural producers on St. Croix valued trees and the majority were interested in growing more fruit or shade trees. Seeing how the ranking of tree types desired by farmers differs from the list of those currently produced indicates the potential for increasing both the abundance and diversity of fruit tree species cultivated on the island. There is clear

interest in small business development and great potential for participation in future tree crop activities.

Conservation of native species and domestication of native fruit crops will require collection and testing of local germplasm. The survey of agricultural production of various farms and gardens provides information on possible seed collection sites as well as an indication of what site qualities characterize favorable conditions for specific species production.

The spatial and relational databases created for this project can serve as a foundation for additional analyses and future studies. Graphical representations of the geographic distribution of specific tree species, species by soil type for example can be viewed to assist decision makers and researchers. Too, the relational database allows complex queries to be formulated for problem solving and decision support. Both professionals and producers could use the decision support system being developed for design of agroforestry practices. Agroforestry designs that combine annual and perennial crops can be employed to enhance food production, conserve soil, sustain agricultural livelihoods, and rehabilitate lands of the USVI.

## ACKNOWLEDGEMENTS

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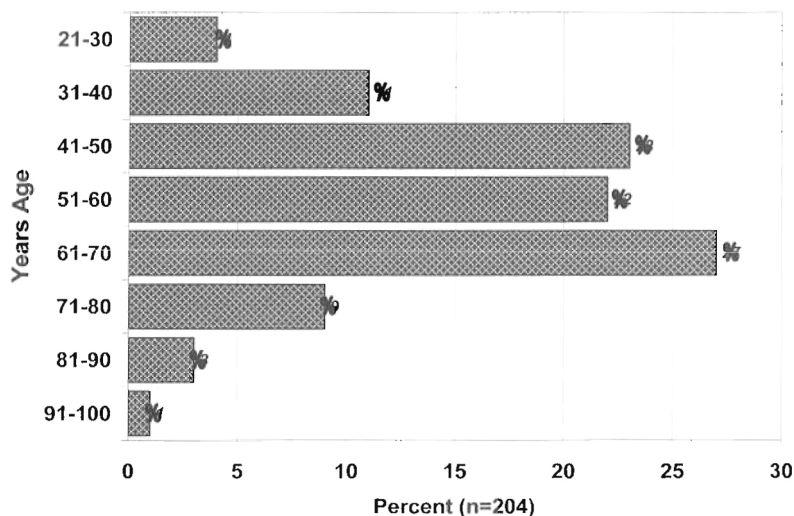


Figure 1. Range of age classes (years) and percentage of 204 farmers interviewed on St. Croix in each age class.

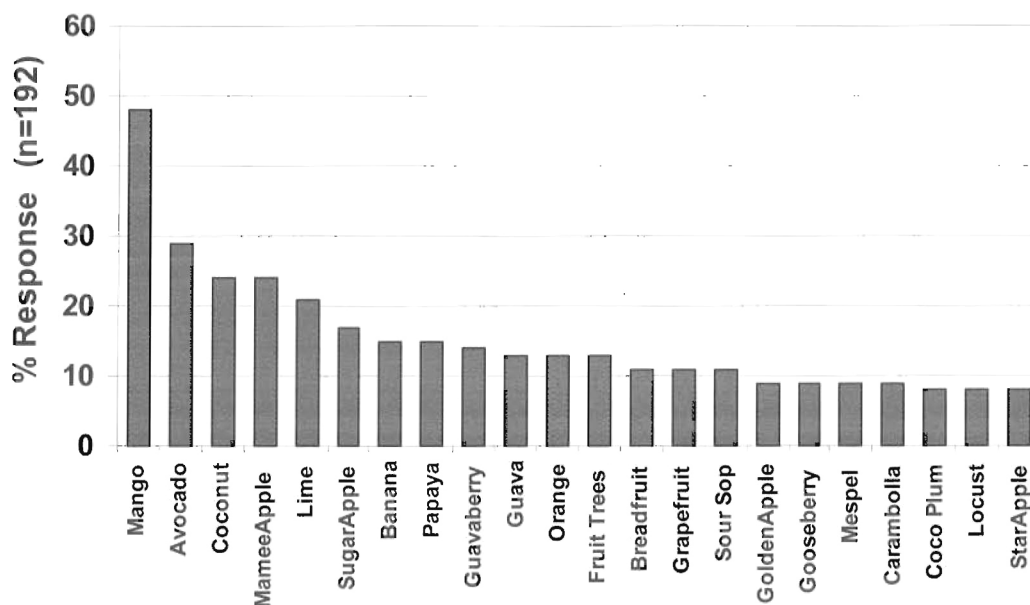


Figure 2. Percent current production of tree crops by interviewed producers on St. Croix.

Table 1. Fruit tree species desired for future planting by interviewed producers on St. Croix, n=118.

Preferred by	Scientific Name	Common Name
18%	<i>Mangifera indica</i> ,	Mango
13%	<i>Persea americana</i> ,	Avocado
10%	Fruit Trees	
9%	<i>Cocos nucifera</i> ,	Coconut
9%	<i>Mammea americana</i> ,	Mamee apple
8%	<i>Carica papaya</i> ,	Papaya
6%	<i>Citrus sinensis</i> ,	Orange
6%	<i>Musa</i> spp.,	Banana
6%	<i>Manilkara zapota</i> ,	Mespel or sapodilla
5%	<i>Citrus aurantifolia</i> (or <i>C. latifolia</i> ),	Lime (Tahiti lime)
5%	<i>Chrysophyllum cainito</i> ,	Star apple/cainito
5%	<i>Artocarpus altilis</i> ,	Breadfruit
5%	<i>Myrciaria floribunda</i> ,	Guavaberry
5%	<i>Chrysobalanus icaco</i> ,	Coco Plum
5%	<i>Passiflora</i> spp.,	Passion fruit
4%	<i>Averrhoa carambola</i> ,	Star fruit or carambola
4%	<i>Annona muricata</i> ,	Soursop
3%	<i>Blighia sapida</i> ,	Ackee
3%	<i>Pimenta racemosa</i> ,	Bay Rum
3%	<i>Anacardium occidentale</i> ,	Cashew
3%	<i>Pouteria campechiana</i> ,	Eggfruit or canistel

Appendix: Common and scientific names, or specific epitaphs, for some of the tree crops observed during 2003 participatory survey on St. Croix, US Virgin Islands.

Common name	Scientific name	Common name	Scientific name
Barbados Cherry	<i>Malpighia puniceifolia</i>	Jamaica Cherry	<i>Muntingia calabura</i>
Bay Rum	<i>Pimenta racemosa</i>	Jamaican Plum	<i>Spondias purpurea</i>
Birchberry	<i>Eugenia lugustrina</i>	Lignum-vitae	<i>Guaiacum officinale</i>
Black Calabash	<i>Enallagma latifolia</i>	Mamey sapote	<i>Pouteria platypus</i>
Black Olive	<i>Bucida buceras</i>	Mammee-apple	<i>Mammea americana</i>
Calabash	<i>Crescentia cujete</i>	Mesple	<i>Manilkara zapota</i>
Coco Plum	<i>Chrysobalanus icaco</i>	Silver Palm	<i>Coccothrinax argentea</i>
Golden Apple	<i>Spondias cytheria</i>	Soursop	<i>Annona muricata</i>
Gooseberry	<i>Phyllanthus acidus</i>	Spicy Guava	<i>Myrcianthes fragrans</i>
Grapefruit	<i>Citrus paradisi</i>	Star Apple	<i>Chrysophyllum cainito</i>
Guava	<i>Psidium guava</i>	Sugar Apple	<i>Annona squamosa</i>
Guavaberry	<i>Myrciaria floribunda</i>	West Indian Locust	<i>Hymenaea courbaril</i>
Ironwood	<i>Krugiodendron ferreum</i>	Jamacian Caper	<i>Capparis cynophallophora</i>

**SUSTENTABILIDAD Y APROPIACIÓN SOCIAL DEL TERRITORIO: EL RETO EN LA REGION ORIENTE DEL IZTACCIHAUTL, PUEBLA Y LA RESERVA DE LA BIOSFERA DE “LA SEPULTURA”, CHIAPAS, MÉXICO, 2004**

*Gerardo Avalos Cacho, México*

**RESUMEN:** En el ámbito rural la polarización social se ha acentuado, haciendo más profunda tanto la pobreza como la pobreza extrema. Actualmente se les encuentra asociadas al deterioro de los recursos naturales, principalmente del bosque, por el uso que hacen de él los campesinos. La historia de la pobreza se sustenta en los despojos de tierras, explotación del trabajo y de los recursos, y cada vez mayor marginación de los beneficios del "Desarrollo Nacional". La región de los volcanes se ubica en el altiplano mexicano, con una topografía que va desde los valles ondulados que inician a los 2,300 msnm, hasta altitudes de más de 5,000 msnm en los picos del Iztaccihuatl y el Popocatepetl. Actualmente, y como parte de la estrategia general de desarrollo sustentable de la región, la Fundación Gregorio con la colaboración de el Centro Regional del Anáhuac de la Universidad Autónoma Chapingo han lanzado la iniciativa ante las autoridades mexicanas para lograr la declaratoria de la región Izta – Popo, como patrimonio natural de la humanidad, por parte de la UNESCO, bajo las siguientes consideraciones: Por otro lado, encontramos que la Reserva de la Biósfera “La Sepultura” en el estado de Chiapas, con una superficie de 167,309 -86-25 hectáreas, fue decretada el 05 de junio de 1995. Actualmente esta reserva cuenta con una dirección, un Programa de Manejo y un Consejo Asesor. La habita un total de 23,145 personas, distribuidas entre 127 localidades, de las cuales 47 son comunidades rurales (ejidos) y 80 son rancherías. Los suelos existentes en la reserva son principalmente de vocación forestal, pero su uso se ha cambiado, históricamente, principalmente por las actividades económicas agrícolas y ganaderas. Que papel es el juegan los habitantes dentro de la reserva o que se interesan por que se reconozca como area natural protegida patrimonio de la humanidad; son un estorbo para la conservación o son sujetos portadores de futuro. En este artículo discutimos los alcances de las posturas. Como pasar de habitantes a Actores sociales que para que se pueda romper el cerco en el cual se encuentran conformado por una red de instituciones y de empresas y saltar a un estilo de desarrollo diferente. Primero romper los cercos ideológico, económico, institucional, organizativo, y político en el cual se encuentran.

**INITIATIVES CONDUCTED BY THE CNASEA CONCERNING LAND POLICY AND AGRICULTURAL DEVELOPMENT. THREE EXAMPLES IN MARTINIQUE**

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**ABSTRACT:** The very sharp reduction in usable farm area in Martinique over the last 30 years has led the local authorities to begin wide-reaching discussions on land management and to become concerned with the development of farm structures and the development of agricultural and rural land resources. The complexity of the land issue in Martinique necessitated the establishment in March 2001 of a mission of the General Council of the GREF to conduct an inventory, identify the causes for these changes and to propose solutions. Due to the CNASEA's level of expertise, it was asked to become involved with 3 projects set up along these lines:

- SIGAM (Système d'information géographique agricole de la Martinique [Martinique Agricultural Geographic Information System]),
- Martinique Crop Observatory,
- Community studies for sustainable agricultural development.

**INTRODUCTION**

The Division of Agriculture and Forestry (DAF) of Martinique manages and controls the financial aid granted to the department's 2,000 farmers. Given the financial stakes, the European Commission and the French government authorities established a quality requirement. So, to obtain better knowledge of the changes in and the occupation of the department's space, to manage financial aid, to compensate farmers fairly in case of hurricanes or tropical storms, to evaluate the actions implemented locally and to determine future projections, the DAF wanted to have a dedicated GIS: the principle of a graphic declaration made every year by farmers on an orthophotographic background was selected. Each year, farmers receive an aerial photo of their farm on which they update the contours of their parcels and their speculations.

In 1999, the CNASEA was asked by the DAF to establish a mechanism and, since May 2001, the date on which the system became operational, it has assisted the different partners. The CNASEA is involved in the management procedure through the collection of agricultural declarations via the DAF and their integration in the information system. Relay Organizations (farmers groups) are involved to assist the farmers in filling out their declaration. At the end of the campaign, they receive data concerning their membership for conducting studies and improving the tracking of farm producers.

To successfully complete this project, the CNASEA revealed very strong constraints for managing concurrency (multi-station environment on an ArcView 3.x platform, exchanges among several sites, complex database), managing large print volumes (particularly with management of widths ways and optimization of print times) as well as the radiometric improvement of the images.

The SIGAM (Martinique Agricultural Geographic Information System) is based on a client-server concept where the geographic (shapefile) and alphanumeric (MySQL) data are

stored in the server. Indeed, the thematic organization of the data (an individual declaration for each annual campaign) and their volume (2,000 farmers – over 10,000 parcels) allow these storage means. To develop the SIGAM geographic functions, the modular structure and the interfaces, the languages Avenue, Delphi and C++ were used.

## THE MARTINIQUE CROP LAND OBSERVATORY

The Martinique Crop Land Observatory was ordered from CNASEA by the Region Prefect in January 2003. Its purpose was to quickly give the municipalities a tool for gaining knowledge of their cropland to support their land policy, particularly with respect to combating the loss of farmland. Its implementation relies on the production of an ATLAS, updated and delivered annually, based on the graphic surface area declarations (SIGAM), a photo-interpretation, experts' opinions (technicians from the chamber of agriculture, municipal resource people) and verifications in the field. It required the mobilization of a project head (Corinne CONCY) and a cartographer (Béatrice PONS). It is 100% financed with public funds (DOCUP 2000-2006).

The ATLAS comprises 5 maps made up of 2,000 orthophotographs augmented by themes borrowed from the TOPO DB. They describe:

- The municipality (general presentation)
- The crop land farmed and declared
- The crop land farmed and not declared
- Wild land
- Total cropland.

The scale of representation is adapted to the shape of the municipalities while remaining under 1/30000th. The results for the year 2003 have already been delivered to the municipalities, to the local unions, to the professional organizations and to the partner agencies (research, Société d'Aménagement Foncier et d'Etablissement Rural – SAFER).

The perspectives offered by the ATLAS include the following:

1. At the municipal level:
  - Delimitation of Protected Agricultural Areas;
  - Implementation of the wild land reclamation procedure;
  - Launch of Grouped Land Planning Operations (OGAF) ;
  - Conduct of land studies for sustainable agricultural development (developed below) ;
  - Assistance with developing Local Urban Planning Programs (PLU) ;
  - Definition of targeted development and facilitation strategies for areas of the territory identified as pilot or priority areas.
2. On a larger scale:
  - Definition of development strategies and development prospects for agricultural land at the municipal community level and for remarkable areas (Irrigation Areas, for example) or for the department.
  - For a given production, the development of global tracking tools in concert with the cooperatives and the farmers groups.



An example of the application of SIGAM and ATLAS results: The municipal studies for sustainable agricultural development

In partnership with SAFER and the Chamber of Agriculture of Martinique, the CNASEA is conducting municipal studies for sustainable agricultural development. They are implemented at the request of the municipalities and are conducted over a 4- to 6-month period under the authority of the mayor who appoints a steering committee that validates the different phases of the study. They complete the trends identified by the ATLAS and rely on a territorial diagnosis aimed at identifying constraints and use conflicts by considering:

- ⇒ the physical environment (climate, natural risks, soil, natural heritage, natural areas to be preserved, infrastructure projects, POS/PLU, AOC areas),
- ⇒ the farms businesses, their operation and their growth, through surveys conducted by the Chamber of Agriculture
- ⇒ the land, its mobility and its owners.

Additionally, a mapping of the territorial stakes is proposed based on the superimposition of the information layers collected.

Following validation by the steering committee, the working group proposes a program of localized initiatives that will be based on the results of the diagnosis. The final report will also be accompanied by a mapping of the priority areas for agricultural maintenance proposed for the delimitation of Protected Agricultural Areas (ZAP).

In Martinique, two studies have been completed (Rivière Salée and Le Robert). In Rivière Salée, public surveys for the implementation of the ZAP and “Wild Land” procedures are underway. Another five studies are underway at Ducos, Saint Esprit, Sainte Anne, Vauclin, and Macouba. Three other studies will be launched by the end of 2004 in Sainte-Marie, Le Prêcheur, and Grand Rivière.

Other examples of CNASEA involvement in the Overseas Departments and Overseas Territories

We can cite:

- Implementation of OGAFs (Grouped Land Planning Operations), in Martinique (4), Guadeloupe, French Guiana and Reunion.
- Regularization of farm land in French Guiana
- Regularization of customary occupants in Mayotte ;
- Preliminary study for the “Priority Sugar Cane Areas in Reunion” study ;

*The presentation documents for these initiatives may be obtained on request from the CNASEA – Regional Delegation of Martinique - Centre d’Affaire Californie 2 - Immeuble Synergie – 97232 Lamentin – Fort de France – Martinique - FWI.*

**REPORT ON WORKSHOP - "FACILITATING SAFER US-CARIBBEAN TRADE: INVASIVE SPECIES ISSUES" PORT OF SPAIN, TRINIDAD, JUNE 2-4, 2004**

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**ABSTRACT:** Over the past decade trade in agricultural commodities and movement of people have increased considerably, and this has resulted in a surge in worldwide movement and establishment of non-indigenous invasive species in the Greater Caribbean Basin. With further trade liberalization likely, the onslaught of invasive species will continue to increase, and the expected gains from increased product trade and movement of people will continue to be offset and undermined by damage caused by introduced alien species. Workshop participants were in agreement that a regional safeguarding strategy is essential to stemming the onslaught of invasives. Progress toward developing a Greater Caribbean Basin safeguarding system could be facilitated by the Caribbean Agricultural Health and Food Safety Agency, which is expected to come into operation in the near future, and which may enter into relevant partnerships.

**Key words:** Regional safeguarding strategy, ecological and economic impacts, trade, invasive alien species, interdiction, collective security, Caribbean, Florida.

## INTRODUCTION

The Caribbean Food Crops Society (CFCS) at its 39<sup>th</sup> annual meeting in Grenada conducted a plenary Symposium titled: "Challenges and Opportunities in Protecting the Caribbean, Latin America, and the United States from Invasive Species" (Klassen et al., 2003). The working definition of the term "invasive species" is that of an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human, animal, or plant health. Immediately following this Symposium, Mr. Byron Blake, CARICOM's former Assistant Secretary General for Regional Trade and Economic Integration, appointed two working groups. One working group was charged with developing invasive species policy recommendations, and the other was charged with identifying scientific and technical projects that should be implemented to meet the invasive species crisis in the Caribbean. Of relevance, also, is the fact that the Free Trade Area of the Americas (FTAA) was under construction by the 34 democracies with negotiations scheduled to be complete by 2005. Therefore, it was felt that a workshop should be held to build on the outcomes of the CFCS Symposium and the two working groups in order to inform negotiators and policy-makers on strategic and operational arrangements needed to counter the surge of invasive species as trade and tourism continue to increase.

## RATIONALE FOR WORKSHOP

1. Trade in agricultural commodities along with movement of people has increased considerably over the past decade. Concomitant with these trends, both the worldwide movement and the establishment of non-indigenous invasive pests have surged.

2. With further trade liberalization on the horizon, such movements of goods, people, and harmful organisms can be expected to increase.
3. The expected gains from increased product trade and movement of people are being offset and undermined by damage caused by introduced alien pests.
4. The WTO/SPS Agreement establishes rules that govern trade, and the regulation of sanitary and phytosanitary issues, including invasive species.
5. Based on the U.S. experience in attempting to exclude entry of invasive species, the WTO requirements (including the diligent application of the SPS Agreement) provide only a very porous barrier to entry of invasive species. Consequently, in 1999 the U.S. National Plant Board (an association of the Departments of Agriculture of the 50 U.S. States) advised USDA-APHIS to place far greater emphasis on offshore safeguarding strategies to supplement actions at the port-of-entry.
6. Since invasive species cannot be excluded solely by stringent measures at ports of entry, a Caribbean regional safeguarding strategy must be developed and implemented in order to prevent invasive species from entering the Caribbean Basin, and to interdict those that do enter.
7. In order for trade in agricultural commodities between the Caribbean and the USA, and the other major trading partners to expand strongly, a regional safeguarding strategy should be part of the Free Trade Area of the Americas Agreement.

#### OBJECTIVES OF THE WORKSHOP

1. To provide a continuing regional platform for Caribbean nations, the USA, and other important trading partners to carry out some of the recommendations developed at the Invasive Species Symposium, Caribbean Food Crops Society, 39<sup>th</sup> Annual Meeting, Grenada, July 2003.
2. To convene a cadre of opinion leaders in an intensive face-to-face mission-oriented dialogue to move beyond rhetoric to consensus on a proactive policy to meet trade-related aspects of the surge of introductions of harmful invasive species into the Caribbean.

#### EXPECTED OUTCOMES

1. Identify and concretize salient issues pertaining to trade and invasive species.
2. Situate these issues within the context of Caribbean negotiating challenges with respect to FTAA and WTO.
3. Develop the outlines of a regional safeguarding strategy.
4. Capture outcomes in a format suited for use in other forum on trade, and related issues.

#### OVERVIEW AND ORGANIZATION OF THE WORKSHOP

##### WORKSHOP SPONSORS AND ORGANIZERS

The Workshop was officially sponsored by eight institutions with seven institutions having a physical presence in the Caribbean region, and the eighth institution being the University of Florida, via its Institute of Food and Agricultural Sciences (IFAS). Specifically,

the sponsoring institutions/organizations were:

1. Caribbean Agricultural Research and Development Institute (CARDI);
2. Caribbean Development Bank (CDB);
3. CAB International (CABI);
4. Food and Agriculture Organization of the United Nations (FAO);
5. Inter-American Institute for Cooperation on Agriculture (IICA);
6. Ministry of Agriculture, Land, and Marine Resources (MALMR) of Trinidad and Tobago;
7. University of the West Indies (UWI); and
8. University of Florida (UF), via its Center for Tropical Agriculture (CTA) and International Agricultural Trade and Policy Center (IATPC) of the Institute of Food and Agricultural Sciences (IFAS).

The generous financial and logistical support provided by these institutions or organizations is further testimony to the recognition of the importance of the Workshop topics. Sincere appreciation was expressed by Workshop organizers and participants to the sponsors during and at the conclusion of the three-day event.

Planning for the Workshop began almost immediately following the July 2003 CFCS conference in Grenada. Planning Committee members were:

- a. Mr. Bruce Lauckner, Mr. Herman Adams, and Dr. Ardon Iton - CARDI;
- b. Mr. Everton Ambrose - IICA,
- c. Dr. Moses Kairo, and Dr. Vyju Lopez - CABI;
- d. Dr. Ranjit Singh - UWI;
- e. Mr. Robert Best - Caribbean Poultry Association/Private Sector; and
- f. Dr. Waldemar (Waldy) Klassen, Dr. Carlton Davis, Dr. Edward (Gilly) Evans, Dr. William Brown, and Ms. Lisette Staal - UF.

The local Organizing Committee was chaired by Mr. Bruce Lauckner of CARDI and consisted of Planning Committee members resident in Trinidad and Tobago. In addition, the CARDI headquarters in Trinidad and Tobago served as the Workshop Secretariat.

## WORKSHOP FORMAT AND TOPICAL SEQUENCING

The Workshop format and topical sequencing consisted of seven highly related components. The first component included a two-part Opening Session consisting of a Round Table Discussion with representatives from the following institutions/organizations:

1. Mr. David Bowen - FAO;
2. Mr. Byron Blake - CARICOM;
3. Dr. Martha Roberts - UF;
4. Dr. Keith Archibald - CARDI;
5. Mr. Aaron Parke - IICA;
6. Dr. Bhoehendrath Teware - UWI;
7. Dr. Moses Kairo - CABI;

8. Dr. Craig Fedchock - USDA/APHIS;
9. Dr. Jeffrey Fisher - US Department of State; and
10. Dr. Alberto Beale - Caribbean Food Crops Society (CFCS).

The second part of the Opening Session included a Feature Address by the Honorable Jarrette Narine, Minister of Agriculture, Land, and Marine Resources (MALMR) of the Republic of Trinidad and Tobago.

The remaining six components were organized around the following themes:

- a. Session I Overview of Key Issues;
- b. Session II Status of Ongoing Regional Initiatives;
- c. Session III Perspectives of Key Trading Partners: Safeguarding Issues and Strategies;
- d. Session IV Synthesis;
- e. Session V Strategies for the Way Forward; and
- f. Session VI Development of an Action Plan.

## OVERVIEW OF WORKSHOP SESSIONS

The focal points of the presentations in the Opening Session's Round Table Panel were essentially two-fold. First, presenters used the opportunity to offer expressions of institutional support and endorsements for the Workshop initiative and second, to present institutional perspectives regarding the theme of the Workshop. The unifying theme of both the representatives of Caribbean-based organizations and non Caribbean-based organizations alike was the necessity of recognizing the threat of the alien invasive species (AIS) problem to the economic and environmental viability of the Caribbean region, and the urgency of a coordinated regional inter-institutional safeguarding strategy. In his feature address, Minister Jarrette Narine of MALMR commented on the timeliness of the Workshop and related activities, in light of the increased efforts of Caribbean islands to export agricultural products to the United States even as that country intensifies its bio-terrorism agenda.

The Minister highlighted the economic costs of some \$US125 million in the case of the pink hibiscus mealybug to the economy of Trinidad and Tobago in 1998. He indicated that this particular AIS was estimated to have caused losses to the Caribbean of some \$US138 million in 1998 (excluding control costs and loss of exports), which is considered a conservative estimate, since that estimate does not include control costs and loss of exports.

Minister Narine suggested a multi-dimensional short and long-term AIS management strategy consisting of the following six components: (1) increasing awareness and improving understanding of the impact of invasive species on agriculture, biodiversity, ecosystems and trade, (2) recognition that alien invasive species should always be treated as a priority issue, requiring immediate national and international action to prevent their entry, (3) minimization of the intentional introduction of invasives, (4) evaluation of the risks of deliberate introductions such as biological control agents, in advance, (5) encouragement and development of action plans to eradicate and manage invasives, and (6) encourage development and the enacting of national legislation and obtaining cooperation to regulate the introduction, eradication, and management of invasives.

## SESSION I: OVERVIEW OF KEY ISSUES

Session I consisted of three formal presentations focusing on key issues relating to the Trade/Invasive Species nexus, and a Private/Public Sector Round Table Forum. The Round Table participants included: *Private Sector Representatives* (1) Regional Poultry Industry (Mr. Robert Best); (2) Livestock Industry (Mr. Ian Leong); (3) Citrus industry (Dr. Stephen Williams); and (4) General Agri-Food Sector (Mr. James Paul); *Public Sector Representatives* (1) Government (Dr. Jerome Thomas); (2) Academics (Dr. Ranjit Singh); and (3) Development Agency (Mr. Everton Ambrose). The consensus emerging from the Round Table Forum was that private sector input and partnership are essential ingredients in an effective regional AIS safeguarding policy and strategy.

One presentation titled, “Invasive Alien Species: A Global Perspective of Issues” was authored by Dr. Sean Murphy of CABI and the Global Invasive Species Program (GISP). This paper pointed out that AIS, although long recognized as threats to agriculture, are now considered one of the leading drivers of biodiversity loss and environmental change. Also, growing world trade and ongoing changes in land use and climate are accelerating the appearance of new AIS problems. One of the poignant messages of the presentation was that the cross-sectoral nature of the AIS issues is requiring new thinking by governments and others in terms of institutional linkages and policy frameworks.

In a presentation titled, “Update on Matters Arising from the Invasive Species Symposium at the 2003 Grenada CFCS Meeting”, Mr. Byron Blake of CARICOM provided an update on the status of recommendations forwarded to the Secretariat following the 2003 CFCS meeting. Mr. Blake informed Workshop delegates that recommendations and supporting documents to CARICOM were actively under review by that body. He further informed the Workshop that discussions regarding a CARICOM-led regional AIS safeguarding strategy was moving forward under the leadership and protocols of CARICOM Ministerial Council for Trade and Economic Development (COTED). However, COTED is in the process of embedding the 2003 CFCS AIS recommendations within the context of establishing a Caribbean Agricultural Health and Food Safety Agency (CAHFSA). COTED was scheduled to have further discussions on the issues during its June 18, 2004 meeting in Trinidad. Workshop deliberations would also be made available to COTED.

The third presentation was by Dr. Edward Evans and was titled, “Trade and Socioeconomic Perspective”. This presentation lamented the confusion on the part of the general public regarding the terminology “invasive species”. Evans contends that this confusion was to a large extent, the result of the historical emphasis on the environmental consequences of AIS, rather than the *causes* of the problem. The point was made forcefully that economic forces play a major role in how “biological pollutants” (AIS) get introduced in the first place, become established, and later spread. The presenter used empirical data to establish strong positive correlations between and among increased global trade flows in merchandise goods, travel and transport, and the increased incidence of AIS. The bottom line is that while trade, in and of itself, may be economically beneficial, the downside is that it increases the risk of the introduction and spread of AIS. The paper made the final argument that those who benefit the most from increased global trade should be the ones made to pay for the cost of any adverse spillovers. Suggestions are offered how this could be operationalized. Discussions centered around the following areas:

1. The need for quantitative data on the impacts of AIS,
2. Greater engagement of the relevant ministries,
3. Stronger and more systematic institutional linkages,
4. Greater community involvement via public awareness,
5. Simplification of terminologies to facilitate communications with wider cross-section of the public and decision-makers, and
6. A well-developed policy framework.

## SESSION II: STATUS OF ONGOING REGIONAL INITIATIVES

The presentation by Dr. Waldemar Klassen was titled, “Invasive Species: A Florida and Third Border Perspective.” The presenter made the point that the volume of movement of AIS is essentially in lock step with increases in trade and tourism, and these are doubling about every five years. Every country in the Greater Caribbean Basin is being overrun by invasive species. Florida, being geographically a part of the Greater Caribbean Basin, is experiencing a similar problem, and cannot be protected unless the entire region is protected. The paper pointed out that estimates are that each year about fourteen species of invasive insects, mites, and ticks become established in Florida, and that the invasion by plant pathogens and harmful plants is similar in magnitude. The point was made forcefully that heavy reliance on inspection at the port-of-entry no longer provides adequate protection, and that a cooperative regional approach to achieve collective security within the Greater Caribbean Basin was a logical approach. The paper proposed five key elements within an AIS safeguarding paradigm for the Greater Caribbean Region, and linked these elements to seven operational modalities for achieving the desired results.

Dr. M. Ian McDonnell of the North American Plant Protection Organization (NAPPO) made a presentation titled, “A Regional Approach to Safeguarding.” The paper outlined the mission of NAPPO and proceeded to suggest some key elements for an effective safeguarding strategy. Among the points made were the following: (1) A regional approach to safeguarding is much more than an organization chart on paper. The mission has to be enthusiastically shared by members; (2) A regional safeguarding approach is only as strong as its weakest link. For this reason, capacity building, information sharing, expertise, and infrastructure are essential; and (3) An important element of a successful regional plant protection, and by implication AIS safeguarding system, is the establishment of a permanent secretariat. Dr. McDonnell pointed out the need to manage the IAS risks at the origin of the commodity in the exporting country, so that clean material arrives at the ports of entry of importing country.

Mr. Everton Ambrose presented a paper titled, “Caribbean Regional Invasive Species Strategy (CRISIS)”. The paper was essentially an overview of the working document, which emerged from the post -2003 CFCS AIS Symposium, and subsequently inputted to COTED of CARICOM Secretariat. The document outlines a framework for regional cooperation and action to deal with invasive species safeguarding in the wider Caribbean. Specific activities to stem the problem of AIS are also identified.

A paper presented by Drs. Gene Pollard and Rupert Pegram, outlined the FAO policy and experiences with respect to AIS issues in the Caribbean. The paper pointed out that FAO has been dealing with AIS since 1952, when the International Plant Protection Convention (IPPC) initially went into force. A comprehensive review of examples of recent AIS into the Caribbean was presented, along with their impacts, and FAO’s interventions to such introductions. They

noted that the Interim Commission on Phytosanitary Measures (ICPM) adopted ISPM 11 Rev.1: *Pest risk analysis for quarantine pests including analysis of environmental risks*. This standard includes details for the conduct of pest risk analysis (PRA) with respect to plant pests to the environment and biological diversity, including those risks affecting uncultivated/unmanaged plants, wild flora, habitats, and ecosystems contained in the PRA area.

Dr. Ranjit Singh presented a paper titled, “The Economic Case for Safeguarding Agriculture and the environment: The Experience of the Pink Hibiscus Mealybug Control Program in Trinidad and Tobago.” The paper reported on a study designed to determine the economic and environmental impact of the pink hibiscus mealybug infestation in Trinidad over the June 1995 to December 1997 period, and the economic feasibility of biological control. The study concluded that: (1) The biological control program generated a social benefit/cost ratio of 8:1 over the 1997-2004 period, and a net benefit of \$222.675 million; and (2) The results were important in providing economic justification for adoption of a biological control program for this AIS, and for mobilizing public financial support for a longer-term intervention strategy.

In a paper titled, “Invasive Species: Implications for Caribbean Intra-Regional Trade” by Dr. Ardon Iton of CARDI and Mr. Everton Ambrose of IICA, the authors examine the implications of AIS for Caribbean intra-regional trade. They pointed out that the Region is faced with a number of AIS that are not widely distributed; but the problem has to do with the regional economic system that is continually moving the species around.

A paper by Dr. Moses Kairo shifted the focus somewhat from production agriculture issues to the broader impact of AIS on the region’s natural resources and the environment. In this paper titled, “Invasive Species: A Caribbean Environment and Natural Resources Perspective”, the following key points were made: (1) Small island states (SIDS) such as those in the Caribbean, are particularly vulnerable to AIS; (2) While historically, attention has tended to focus on the immediate impact of AIS on agricultural production and trade, it is clear that threats to the environment and natural resources are just as important; (3) The Caribbean is considered to be one of the world’s biodiversity hotspots. With many endemic species an AIS has the potential to cause extinction of species; and (4) Establishment of comprehensive and effective AIS safeguarding mechanisms must involve a diverse range of stakeholders. Dr. Kairo’s paper proceeded to examine the risks posed by AIS to marine, freshwater, and land resources including forestry, in the broad context.

AIS intervention and safeguarding Caribbean Basing programs, administered and supported by USDA/APHIS, were reviewed by Drs. Richard Pacer and Carl Castleton. The paper by Pacer was titled, “USDA-APHIS Contribution to Animal Health Safeguarding Programs in the Caribbean”, and the one by Castleton was titled, “APHIS Plant Health Programs in the Caribbean”. The Pacer paper focused on the contributions of that United States government agency to the Caribbean Amblyomma Program (CAP), which has a primary objective, the elimination of the tropical bont tick (TBT) as a major vector of ruminant diseases. Assistance has also been provided to selected Caribbean countries with respect to the development of strategic plans in the eradication programs for classical swine fever (CSF). The paper emphasized the fact that the TBT eradication efforts are carried out by CAP in collaboration with FAO and CARICOM. USDA/APHIS is expected to continue its support for TBT and CSF efforts in the Caribbean, and to leave a legacy of alliances dealing with future animal health diseases. The presentation by Castleton was essentially an overview of the USDA/APHIS plant health interventions in the Caribbean Basin. The following points were made: (1) The agency’s 2001 Plant Health Safeguarding Report recommends more extensive



efforts to detect potential pest problems before they arrive in the US and to initiate offshore mitigation programs; (2) The US now requires the registration of firms involved in the perishable food chain and prior shipment notification and permits are now enforced stringently; (3) USDA/APHIS now considers the first barrier to the introduction of pests in the US to be at the foreign production site, rather than at US Ports-of-Entry; and (4) The challenge is how best to partner with collaborating countries to ensure a sustainable pest mitigation system without impeding the flow of trade.

An overview of AIS interdiction and safeguarding issues within the French Caribbean territories was presented by Dr. Claude Vuillaume of CIRAD. In his presentation Vuillaume made, among others, the following points: (1) The French territories of Guadeloupe and Martinique are confronted with strong constraints to AIS mitigation and safeguarding like the rest of the Caribbean islands, (2) The French islands benefit from specific regulations prohibiting the introduction of some plants, and frontier checks (ports and airports) are the main vehicles for regulating these flows; (3) Regulatory services are heavily oriented toward diagnostic laboratories located in the territories; (4) Research organizations such as CIRAD and INRA collaborate with State services to develop early detection techniques for AIS, biological control and related activities; and (5) AIS monitoring programs are set up within a framework of a broader regional cooperative policy under the umbrella of the French Departments of America (DFA).

Dr. Darius Gabriel, Ministry of Agriculture, St. Lucia presented a veterinary perspective from standpoint of the Sanitary and Phytosanitary Agreement. He reported that in addition to the advent of various exotic pathogens and pests of livestock and poultry, honeybees and bee keeping in the Caribbean have been severely impacted by the arrival on some islands of the Varroa mite and the small hive beetle. The small hive beetle is an African pest that entered Florida in 1998, and it infested various Caribbean islands.

### SESSION III: PERSPECTIVES OF KEY TRADING PARTNERS

Four papers were presented in Session III, all designed to highlight the perspectives of the US as a key trading partner with Caribbean Basin countries. Dr. Craig Fedchok of USDA/APHIS presented a paper titled, "The Caribbean Third Border Initiative and the Role of USDA/APHIS in Trade." Fedchok's paper included the following points: (1) The Caribbean Basin Initiative (CBI) of the US government consists of a targeted package of programs designed to enhance diplomatic, economic, health, education and law enforcement cooperation, and collaboration; (2) The USDA/APHIS mission is an integral part of the USDA's efforts to provide the US with safe and affordable food; (3) The specific rules affecting the role and activities of USDA/APHIS are found in the WTO's Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement); (4) The WTO's SPS Agreement has raised the profile of SPS measures in trade, increased transparency related to its measures, and highlighted the importance of risk assessment in developing SPS measures based on international standards; (5) Specific impact of the SPS Agreement for USDA/APHIS has been to expand the agency's mission from one of protecting to include that of removing unjustified trade barriers; (6) Shifts in agency mission objectives have engendered increased participation in the World Organization for Animal Health (OIE) and the International Plant Protection Convention (IPPC); (7) A key change has been the shift in regulatory focus from a policy of zero risk to one of managed risk and of considering international standards when promulgating any rule; and (8) The combined

effect of these changes resulting from the SPS Agreement has been to further reaffirm and expand the commitment of USDA/APHIS to the Caribbean region to not only protect the US from unwelcome pests and diseases; but also to expand such protection to Caribbean neighbors.

Dr. Robert Balaam a colleague of Dr. Fedchock, presented a paper titled, "USDA/APHIS Offshore Pest Information System." Balaam described the USDA/APHIS Offshore Pest Information System (OPIS) as a process designed to collect, analyze, communicate, and use relevant international information concerning pests that are not known to occur in the US. The objective of the OPIS is to assist the agency in meeting its mission to "safeguard American resources from exotic invasive pests and diseases." The following components of OPIS were identified and elaborated on in the paper: (1) A global pest and disease database; (2) A target pest list; (3) Pest pathway status in foreign countries; (4) Pest interception data from US ports; (5) Communication component; and (6) Initiation of protective and mitigation measures. It was pointed out that a benefit of OPIS has been demonstrated in the Caribbean region through the effective development and establishment of biological control programs for the pink hibiscus mealybug.

The importance of the Florida/Caribbean Basin connection with respect to AIS was captured in a paper by Dr. Martha Roberts of the University of Florida (UF). Roberts' paper was titled, "Impacts of Invasive Species on Agriculture-Related Industries and Natural Resources in Florida: Is There Any Relief in Sight?" Some of the key points made in the paper were: (1) Florida serves as a US sentinel for pest introductions due to the escalation of international trade, and of travelers moving through Florida's twenty-five international seaports and airports; (2) The unique peninsular geography of Florida with a 365 day growing period for plant and animal pests make the state the most vulnerable in the US mainland for AIS introduction and establishment; (3) Economic damage from AIS such as the Mediterranean fruit fly, citrus canker, brown citrus aphid, *Thrips palmi*, citrus leafminer, sweet potato whitefly, leather leaf fern anthracnose, and tropical soda apple, to name a few, have cost the State of Florida and the US federal taxpayers hundreds of millions of dollars to control and eradicate; and (4) Florida has come to the realization that in the case of AIS, prevention is always less costly than eradication or the perpetual management of these pests. Roberts' paper reported on the efforts of the 1999 State-appointed Florida Pest Exclusion Advisory Committee (PEAC) and its work related to the development of an exclusion, detection, and response program for AIS. The paper concluded that for Florida, relief from AIS is more likely to come through US/Caribbean cooperation and coordination in a seamless system of exclusion and prevention, surveillance, early detection, and swift eradication.

The final paper in this Session was presented by Dr. Jeffrey Fisher of the US Department of State. Fisher's paper was titled, "Addressing Invasive Species in Environmental Cooperation Annexes of Free Trade Agreements." Fisher's paper provided a brief review of the increasing number of Free Trade Agreements (FTAs) signed between the US and other countries/regions over the last decade and identified several on the horizon. His paper made the point that while FTAs are seen as a primary vehicle for ensuring market access and economic growth among partners, it should be recognized that these agreements can generate both positive and negative environmental consequences. As a result of this growing recognition Environmental Consultative Mechanisms (ECMs) have been developed, in part, to address some of these potential consequences. ECMs identify priority areas for cooperation, and also establish mechanisms for environmental protection, conservation, and sustainable development. It was first pointed out that the prevention of costly and unintended introduction of AIS as one potential

environmental input of FTAs is an important component of ECMs. The paper discussed the development of ECMs directly relevant to the Caribbean Basin, and how AIS issues may be considered within them.

#### SESSION IV: WORK GROUP SYNTHESIS

The focal point of activities in this Session was the facilitation of a synthesis of the vast amount of information presented in formal papers as well as the capturing of delegate's interventions up to this point in the Workshop. To accomplish these objectives, delegates were organized into three Working Groups with each group instructed to key on specific themes. Group composition was accomplished by a combination of self-selection and assignments. The three groups and their assigned themes were:

- Group I Provide a review of the relevance of the CRISIS document submitted to CARICOM and address areas for improvement - Chair: Mr. Everton Ambrose, IICA.
- Group II Evaluate the role and function of the proposed CAHFSA under consideration by CARICOM with respect to AIS issues - Chair: Margaret Kalloo, CARICOM, Co-Chair: Navin Chandarpal, Government of Guyana.
- Group III Evaluate the relevance of the "Third Border" concept as a value idea for the Caribbean and address how CAHFSA may operate within this context - Chair: Dr. Ranjit Singh, UWI.

Group I Deliberations: After reviewing the CRISIS document, the group concluded that the document is relevant to the needs of the Caribbean region. However, the group commented that the strategy component of the document gave a sense of being more of an operational plan than a strategy plan. Therefore, additional work on further strengthening the document after the Workshop was anticipated. Group discussions and concerns were centered around the following points: (1) Insufficient attention to environmental – including marine - issues; (2) Need to make strategy sector-based; (3) Need for consistency and organic linkage balance between regional and functional country strategies; (4) Need for simultaneous parallel strategies within collaborating countries, since the system is only as strong as its weakest link; and (5) Imperative that given the urgency of the AIS issue, in the region that the proposed strategy be widely vetted at the national level for distillation and broader stakeholder involvement. The group suggested the following two-pronged approach to maximize dissemination of the document in the short-term: (1) A communiqué be produced and the CRISIS document sent as an attachment to each country represented at the Workshop, and shortly thereafter to relevant countries not present; and (2) There should be a pro-active attempt to sensitize the CARICOM Ministers of COTED at the June 18, 2004 meeting regarding AIS issues and the required components for an effective strategy.

Group II Deliberations: The group spent a considerable amount of time discussing the background to the CAHFSA proposal, relative to the requirements of the SPS Agreement of the WTO. This was considered necessary because among other things, the reality was that this was not a totally familiar issue to the delegates. Some of the important clarifications discussed were: (1) Under the WTO's SPS Agreement, each sovereign country has the responsibility for SPS rules and implementation requirements; (2) CARICOM, as a regional body, has no legal

authority to assume the SPS responsibility of its fifteen sovereign member states; and (3) The role of CARICOM (and CAHFSA) is to coordinate, mobilize resources, and provide an effective regional strategy with respect to SPS issues.

The group recognized three critical and related problems of the CAHFS proposal, within the context of the AIS issue. First, the additional difficulty posed by the small size and resource constraints of Small Island States (SIDS). Second, the urgency of the AIS issue, such that immediate attention is required (time sensitivity). Third, the realization that among sovereign states of CARICOM, there is no first line of defense, with the exception of the proposed CAHFSA. The group proposed that: (1) COTED be advised of the importance of the AIS issue and the need for a regional strategy; (2) Encourage and assist COTED in finding ways whereby the CAHFSA system can forge effective partnerships/linkages that would expand the scope of the proposed Agency with respect to AIS safeguarding problems in the Greater Caribbean Area.

Group III Deliberations: The group spent some time addressing the definition of the “Third Border” concept as used within the context of the coining of the concept by the US government, and a lesser-known usage within the Region. The more widely used concept applies to the three physical border frontiers between the US, Canada, Mexico and the Caribbean Sea Territories. The more narrower Caribbean concept includes boundary recognition issues between: (1) Sovereign national entities within the Caribbean Basin; (2) The Wider Caribbean Basin configurations; and (3) Extra-Caribbean entities. The group arrived at the following decisions: (1) The geographical area defined as the “Greater Caribbean Basin” should be considered at the target area for a regional safeguarding systems; and (2) An integrated approach should be adopted with respect to safeguarding animal health, plant health, and food safety. The group suggested that a framework for collaborative safeguarding links should be built around CAHFSA. Within this framework, these links would join CAHFSA as a CARICOM institution, to the Greater Caribbean countries and territories, to the Tri-lateral Commission, to US institutions, and other entities. It was pointed out that the constitution of the proposed CAHFSA permitted the organization to access external funding and to accommodate non-independent territories. The point was also made that key stakeholders representing regional industries, NGOs, and agri-business associations be an integral part of the safeguarding system. The group suggested that one of the first projects undertaken by CAHFSA would be one on data sharing through databases on AIS-related activities. The way forward from that point is to build incrementally on this first project.

## SESSION V: STRATEGIES FOR THE WAY FORWARD

To facilitate this Session, Workshop organizers, with input from delegates, drafted a document suggesting both the procedures and a contextual framework for guiding the discussions and deliberations. First, the document provided an overview of the proposed outcomes of the Workshop. Second, the document proposed that the deliberations be organized around two Working Groups, with each group assigned specific charges. Third, the document provided essential components of an overall framework as contextual guidelines for both groups. The two groups and their designated charges were:

Group I Continuation of discussions on the CRISIS document - Chair, Mr. Everton Ambrose - IICA. Focus should be given to: (1) Identify gaps in the document with respect to

policies and strategies, (2) Explore the involvement of other stakeholders, including environmental, tourism, and others; and (3) Propose specific steps to advance the process.

Group II Examine relevant databases and start-up projects for an AIS safeguarding system - Chair, Dr. Moses Kairo - CABI. Focus should be given to: (1) Specific data information needs; (2) Issues relating to the accessing and sharing of data and information; (3) Problems of interfacing with existing databases; (4) Identification of relevant presentations at the Workshop pertaining to data; (5) Assess the availability of information systems; and (6) Review the two previously developed CRISIS project proposals relating to:

- Timely internet-based tracking of invasive pest interceptions and introductions.
- Develop a Caribbean pest and disease diagnostic system based on distance digital imaging and internet-based communications.

The guiding contextual framework provided to each group consisted of the following components:

1. Technical parameters and operational modalities should be taken into account. In other words, program components should be identified and consideration given to how best to structure them.
2. Consider alternative models for harnessing the capabilities of the region, given knowledge of resource constraints.
3. Explore the appropriateness of alternative collaborative frameworks or partnerships necessary for facilitating the strategy. Special consideration should be given to whether these are national, international, or regional.
4. Consider components of policy requirements, political dimensions, and ways of strengthening the systems. Recognition should be given to the fact that some entities in the region are a long way from having the appropriate regulatory and policy systems. Also, some entities do not have adequate quarantine laws or procedures for risk analysis.
5. Take into account other issues such as critical financial support needs and the challenge of maintaining sustainable funding levels.

In addition to the aforementioned document, Workshop delegates were provided with a draft resolution regarding the AIS issue. The intent here was to have delegates discuss and reflect on the AIS issues and challenges, and to come prepared in the final Session (VI) to offer support or non-support for a resolution on the issues to be communicated to COTED and others.

## SESSION VI: DEVELOPMENT OF AN ACTION PLAN

After three days of plenary Workshop and specific Work Group discussions and deliberations, the Workshop arrived at some general conclusions regarding key elements of a Greater Caribbean action plan for an AIS safeguarding strategy. It was recognized upfront however, by the majority of the delegates, that the term “Action Plan” might have been a misnomer in the sense that the Workshop was acting, in essence, as a “quasi-passive” instrument

in the evolution of a regional strategy. In other words, the Workshop was not designed to develop a specific organizational structure or operational framework for the crafting of a regional AIS safeguarding strategy. Those components, by virtue of the nature of the issues and political/economic dimensions, must by necessity reside with a regionally sanctioned body, such as CARICOM. In its quasi-passive strategy development role, the Workshop would have fulfilled its “action plan” ambitions by bringing together, prioritizing, and rationalizing the essential components of an effective regional AIS safeguarding strategy.

Some of the essential action plan components identified were:

1. A Greater Caribbean Basin-wide approach is a necessary, if not a sufficient, condition to effectively deal with AIS issues in the region.
2. CAHFSA is the logical regional coordinating entity to spearhead the regional AIS safeguarding strategy. However, CAHFSA being specifically a CARICOM serving institution will have to be structured such that its sphere of influence is extended beyond the boundaries of its fifteen member states.
3. Forging appropriate and strategic partnerships with the US and other entities should be assigned high priority in structuring CAHFSA. In so doing, CAHFSA will be better able to mobilize the technical, institutional, and financial resources required for extension of both its scope and effectiveness in coping with the AIS issues.
4. As CAHFSA proceeds with plans for a regional safeguarding strategy, serious efforts must be made from the very outset to address environmental, natural resources, and biodiversity components of trade.
5. As CAHFSA becomes operational, it may be prudent, given the resource constraints, but recognizing the urgency of the AIS problem to start incrementally with the two projects identified in the CFCS Action Plans document and elaborated on by discussion in Group II of Workshop Session V. These were:
  - a. Timely internet-based tracking of invasive pest introductions and interceptions.
  - b. Development of a Caribbean pest and disease diagnostic system based on distance digital imaging and internet-based communications.

Finally, the Workshop delegates voted unanimously that the following resolution and related supporting material be forwarded to CARICOM, and to be brought to the attention of COTED Ministers at the June 18, 2004 meeting in Trinidad.

## RESOLUTION OF THE WORKSHOP ON FACILITATING SAFER US-CARIBBEAN TRADE: INVASIVE SPECIES ISSUES

**Whereas**, participants of the Workshop “*Facilitating Safer U.S.-Caribbean Trade: Invasive Species Issues*” representing the various nations and agencies of the Caribbean Basin, (including U.S., Canadian, and French participants) met in Port of Spain, Trinidad and Tobago, West Indies, June 2-4-, 2004, to discuss matters relating to the growing incidence of the introduction and spread of invasive species as well as consider options for safeguarding the region against such incursions, and

**Whereas**, an “invasive species” is defined to include plants, animals, and other organisms such as microbes that are non-native (alien) to the ecosystem under consideration, whose introduction causes, or is likely to cause, economic or environmental harm, or harm to human health, and

**Whereas**, it is recognized that international trade, defined broadly to include trade in goods, movement of people, and transportation contributes significantly to the national economies of the region, and to the domestic security of the nations; but itself can lead to the spread of invasive species, and

**Whereas**, the introduction and establishment of invasive species through trade and other pathways represents a critical threat to international trade, tourism, economic livelihood, and the health of people, plants, animals, and natural resources in the countries of the region, and

**Whereas**, continued inaction could seriously interrupt trade, imposed undue hardships and burdens on societies, and be detrimental to the environment, and the well being of the region,

**Therefore be it resolved**, that the members of the Workshop on *Facilitating Safer U.S.-Caribbean Trade: Invasive Species Issues* do hereby recognize and affirm that invasive species represent a critical issue to all nations in the Caribbean, and do hereby, respectfully, request the consideration and action by each Government to address this urgent issue in a collaborative, constructive, and timely manner.

### CONCLUDING COMMENTS

According to Workshop records, some twenty different countries were represented by seventy-three participants. Based on feedback provided to the Workshop organizers during and following the event, the general conclusion is that the objectives and expected outcomes of the Workshop were largely realized.

### REFERENCE

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.

## RELEVANT INVASIVE SPECIES FOR THE AGRICULTURAL SECTOR IN PUERTO RICO: IDENTIFICATION OF THE PROBABLE ECONOMIC IMPACT

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**ABSTRACT:** The Agricultural Sector in Puerto Rico from 1998 to 2002 reported an annual mean Gross Agricultural Income (GAI) at farm level of \$718.9 million. During this six-year period the livestock and crop commodities generated a mean gross income of \$390.1 and \$231.0 million, respectively. Dairy production was the most important commodity; it generated an annual mean gross income of \$193.7 million, 26.9% of the total GAI. The principal crops and their mean gross income in millions were: plantain, \$48.6; coffee, \$38.4; ornamentals, \$33.5; bananas, \$13.3; and mango, \$12.8. Besides their economic contribution, coffee, plantain, and bananas have a social and environmental importance because the production areas are located mostly in the central mountain region in Puerto Rico. The agricultural sector is the major source of income and employment in the central mountain area. In this area rise the rivers and lakes utilized as water sources for human and agricultural consumption. The established invasive species, or the ones with establishment potential, that could impact economically the principal agricultural commodities were identified. The invasive species at a pre-entry level identified for the crop commodities are coffee berry borer (*Hypothenemus hampei*); black sigatoka for plantain and banana (*Mycosphaerella fijiensis*); and the mango seed weevil (*Sternochetus mangiferae*). The established invasive species identified for dairy production are the Johnei Disease causal agent (*Mycobacterium avium paratuberculosis*) and the parasite tick (*Boophilus microplus*). This study will emphasize the crop invasive species. The economic impact of the invasive species on the agricultural sector was classified as direct impact to the commodity, the market, and the trade; as indirect impact on the environment, health, and other economic sectors.

**Key words:** Invasive species, Economic impact analysis, Coffee berry borer (*Hypothenemus hampei*), Plantain black sigatoka (*Mycosphaerella fijiensis*), Mango seed weevil (*Sternochetus mangiferae*).

## ESPECIES INVASORAS RELEVANTES PARA EL SECTOR AGRÍCOLA DE PUERTO RICO: IDENTIFICACIÓN DEL POSIBLE IMPACTO ECONÓMICO

**RESUMEN:** El sector agrícola de Puerto Rico del 1998 al 2002 reportó un Ingreso Bruto Agrícola Medio (IBAM) total a nivel de la finca de \$718.9 millones. Durante estos seis años las empresas de animales y subproductos y la de cosechas generaron un IBAM de \$390.1 y de \$231.0 millones, respectivamente. La empresa de mayor importancia en la agricultura de Puerto Rico es la producción de leche, la cual ha generado un IBAM de \$193.7 millones, 26.9% del ingreso total de la agricultura. Las cosechas principales y su IBAM en millones son plátano (\$48.6); café (\$38.4); ornamentales (\$33.5); guineo (\$13.3) y mango (\$12.8). Además de su aportación económica las cosechas de café, plátano y guineo tienen una importancia social y ambiental, ya que la mayor parte de su producción se sitúa en la zona central montañosa de la



isla. El sector agrícola es la fuente principal de empleos en la zona montañosa y allí nacen los afluentes que proveen agua para el consumo humano y agrícola. Se identificaron especies invasoras establecidas o con potencial de establecerse, que podrían impactar económicamente las principales empresas agrícolas. Las especies invasoras identificadas para las cosechas fueron la broca de café (*Hypothenemus hampei*), la sigatoka negra en plátanos y guineos (*Mycosphaerella fijiensis*) y el picudo de la semilla del mango (*Sternochetus mangiferae*). Las especies invasoras identificadas para la empresa de ganadería de leche fueron la enfermedad de Johnei (*Mycobacterium avium paratuberculosis*) y la garrapata (*Boophilus microplus*). Este estudio enfatizará en las especies invasoras con potencial de establecimiento en las cosechas. El impacto económico de las especies invasoras sobre el sector agrícola fue clasificado en posible impacto directo a la empresa, al mercado y a la comercialización, e impacto indirecto al ambiente, a la salud y a otros sectores económicos.

## INTRODUCTION

The Agricultural Sector in Puerto Rico from 1998 to 2002 reported an annual mean Gross Agricultural Income (GAI) at farm level of \$718.9 million (Departamento de Agricultura –PR, 2003, 2001, and 1999). During this six year period livestock and crop commodities generated a mean gross income of \$390.1 (54.3%) and \$231.0 (32.1%) million, respectively. Dairy production was the most important commodity; it generated an annual mean gross income of \$193.7 million, 26.9% of the total GAI. The principal crops and their mean gross income in millions were plantain, \$48.6; coffee, \$38.4; ornamentals, \$33.5; bananas, \$13.3, and mango \$12.8. The percentage contribution of the principal crops to the mean crop gross income was plantain, 21.0%; coffee, 16.6%; ornamentals, 14.5%; banana, 5.7%; and mango, 5.5%.

The total cropland in Puerto Rico is 533,081.0 “cuerdas” (213,232.4 ha), and the total number of cropland farms is 19,030 (USDA, 2000). Coffee is planted on 14.5% of the total cropland and is cultivated on 55.8% of the total farms. Plantains occupy 14.5% of the cropland and are cultivated on 39.1% of the farms. Bananas are planted on 2.3% of the cropland and are cultivated on 21.6% of the farms. Mangos represent 0.5% of the cropland and are cultivated on 1.3% of the farms. Ornamental plants occupy 0.06% of the cropland and are cultivated on 1.2% farms. The Agricultural Census in 1998 reported the existence of 1,932 farms in dairy production; however, for the same year the Dairy Industry reported 403 commercial dairy farms in operation (Cortés, 2004).

Coffee, plantain and banana production areas are located mainly in the mountain region. However, plantains and bananas are cultivated throughout the island. In the central mountain regions they are intercropped with coffee. The principal coffee production area is located in the west-central mountain chain called “Cordillera Central.” The agricultural sector is the major source of income and employment in the central mountain zone. In this area originate the rivers and lakes utilized as water sources for human and agricultural consumption in Puerto Rico. About 250,000 inhabitants in eight municipalities of the mountain region depend directly or indirectly on the coffee commodity (Alamo, 2002). Plantain and coffee are part of Puerto Ricans cultural diet. The commercial mango production area is on the south coast plains; about 80.0% of the production is exported to Europe and to the USA. Ornamentals are grown across the island, frequently in the east central mountains. The dairy farms are concentrated on the north plains of the island.

In fiscal year 2001, Puerto Rico imported \$2,142.6 million in food. In the same year \$66.6 million in agricultural products was exported (Junta de Planificación, 2001). The principal agricultural products exported were mango, tomato and coffee. About 80% of mango production was exported to Europe and USA market. Historically tomatoes producers exported 60% of local production to USA market. About 6% of the coffee production was exported mostly to the specialty coffee market in USA.

There is a pre-entry quarantine in Puerto Rico for the import of plantain to avoid the entrance of the black sigatoka and the moko disease (*Ralstonia solanacearum*). The imports of green coffee to the island have a pre-entry quarantine because of the coffee berry borer.

The island's strategic geographic position and the consumer's acquisitive value allow active trade. The tourism activity in fiscal year 2001 attracted 4.9 million visitors, who spent \$2,728.1 million on the island. (Junta de Planificación 2002). There is one international airport in Puerto Rico (Luis Muñoz Marín) plus six smaller air fields across the island. The main sea ports are located in San Juan, Ponce, Mayaguez, and Aguadilla. There is much cruiser activity, ships departing weekly from the port in San Juan to the Lesser Antilles. In the eastern part of the island there are three ports that handle human and trade transportation from the main island to the islands of Vieques and Culebra. The private vessel traffic in Puerto Rico departs principally from private marinas located in the east (Fajardo), the north (San Juan), the south (Ponce-Salinas) and the west (Lajas-Cabo Rojo). Illegal human trade traffic is reported in the west part of the island coming mostly from the Dominican Republic. This active legal and illegal trade, especially in fresh agricultural commodities, increases the risk of the introduction and spread of invasive species associated with pests and diseases.

Puerto Rico is a Commonwealth of the United States of North America (USA). Due to the political relationship, the USA's international trade policy has direct impact on Puerto Rico's economic growth and development. Furthermore, there is a worldwide trend of market consolidation and the USA is part of this trade policy. The North America Free Trade Agreement (NAFTA), MERCOSUR, and CARICOM are examples of market merger efforts. Also, the Free Trade Area of the Americas (FTAA), whose principal objective is to eliminate barriers to trade and create a single market within the western hemisphere, is expected to be functioning by 2005 (Palacios, 2004).

The political and economic relationship is such that the United States Department of Agriculture (USDA) and the Department of Agriculture of Puerto Rico (DAPR) manage the control policies for invasive species. Most of all the other countries' imports are checked by these two agencies. However, the United States' imports are verified only once.

The Economic Research Service of the United States Department of Agriculture (USDA-ERS 2003) presented a 1999 Executive Order, 13112, which defines an invasive species as one that is nonnative, alien, or exotic to the ecosystem under consideration, and one whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health. Besides, the definition considers costs, benefits or net damage, of an invasive species. Sometimes in some crops, ornamentals, and animal industry, the benefits of these non-native species exceed all the costs involved in controlling their entry or their damage once established.

The rate of introduction of invasive species in Puerto Rico is evident in the results, reported Serrano et al., (2001). They reported that between 1963 and 1999 one to six exotic insects were introduced per year, an average of 1.4 major insect pest species. Most of these introductions came from Caribbean Countries, Central and South America and the United States.

The majority of the interceptions made at the Luis Muñoz Marín International Airport came from the Dominican Republic, Colombia, Costa Rica, Antigua, Barbados, Dominica and Grenada.

The economic impact of those pests and diseases must be estimated, considering market, non market and environmental damages. The Council for Agricultural Science and Technology (CAST), in a 2002 paper, expressed that if non-native species become pests, the economic risks include lost production, diminished quality, increased production costs, decreased flexibility in production/management decisions, and increased risks for human health. Evans (2002), remarked that the research agenda on invasive species has been developed by biological science researchers, and much of the previous “economic” research on invasive species has been conducted by non-economists. As such, the economic analysis suffers either from various methodological problems (e.g., incorrect economic valuation, ignoring non market environmental damages) or from being peripheral to the biological study.

A limitation for the economic impact analysis is that there are several different institutions collecting information regarding pest interception, introduction, spread and control. Although there is a collaboration accord among institutions, the information collected by them is not compiled in a coordinated manner, hence one of the difficulties in assessing what the economic impact could be on the sector if a given pest or disease were introduced.

Although in Puerto Rico there is a great amount of biological data on physiological behavior of pests and diseases, and records of intervention, introduction, and surveillance, this information is unevenly diffused across agencies, scientists and producers (Alamo, 2004). It is necessary to compile the information in such a way as to facilitate exchange of data and experience among groups. A link between crop protection scientists, regulatory plant protection agencies and economists is needed. The groups need to develop a guideline for asking questions that facilitate the gathering and compilation of data for economic impact analysis.

In April 2003, a proposal titled Economics of Managing Invasive Species in Tropical and Subtropical Areas in the United States of America was approved by T-STAR initiative (VanSickle et al., 2003). This proposal includes the regions of Florida USA, Hawaii, Guam and Puerto Rico. The overall objective of this project is to provide decision makers and regulatory authorities with new resources for decisions involving invasive species management programs, including pre-entry quarantine measures and management of established pests. Within this broad objective, there are two specific objectives of the project: development of a comprehensive invasive species risk management framework that incorporates the economic impacts of invasive species; and development of a collaborative interdisciplinary network of institutions and persons involved with invasive species management.

As part of these objectives, a number of case studies will be done in regard to particular invasive species problems in the collaborating regions. The case studies are a key part of the project (Bigsby et al., 2003). They will:

- Provide the basis for studying important regional invasive pest problems.
- Develop applications of economics to the management of invasive species.
- Provide an initial database for the risk management framework being developed in the project, all of which will be available for future studies of invasive species.
- Provide the basis of collaborative networks for invasive species management.

The study presented in this paper pretends to identify priorities and select the relevant invasive species problems that will be analyzed in the case studies for Puerto Rico. The identification of the possible economic impact, direct or indirect as well as market and no

market, will be established for the selected invasive species. The methodology approach for measuring the economic impact is identified.

## OBJECTIVES

1. To initiate the interdisciplinary group link among crop protection scientists, regulatory federal and local protection agencies, and economists.
2. To identify and select the important pest problems and characterization of the pest and its effects on the agriculture of Puerto Rico.
3. To identify the possible economic impact, direct or indirect as well as market and no market, for the selected invasive species case studies.

## METHODOLOGY

The methodology utilized in this study is part of the background paper prepared and circulated by the participating researchers of the project “Economics of Managing Invasive Species in Tropical and Subtropical Areas in the United States of America” (Bigsby et al., 2003). In order to ensure coordination of the project, the development of the case studies will follow this process:

- Preparation and circulation of a background paper on pest risk analysis outlining the types of information that will be required from the case studies.
- Initial identification of important pest problems and characterization of the pest and its effects in the participating regions. Using the background paper, collaborators will identify cases that are important to their particular regions.
- Convening of a workshop to present and discuss potential case studies and provide feedback for the development of the conceptual framework and model.
- Confirmation of case studies.
- Conducting case studies

The background paper on pest risk analysis will outline the types of information required from the case studies. The paper will provide the methodology for the identification and categorization of the possible economic impact.

For the purpose of pest risk assessment, economic effects can be categorized as direct and indirect pest effects, and as market and non-market effects. The direct and indirect categories refer to the way in which the effects of a pest are manifested, and in turn, point to the way in which the effects might be measured. Direct pest effect concentrates on direct impacts of a pest on a host species, and covers host-specific impacts such as yield loss or mortality. It can include a range of hosts such as agricultural and horticultural crops, pasture plants, forests, and controlled or wild environments. Indirect pest effects cover non-host specific impact. These are economically relevant effects that are not directly linked to the effect the pest has on its host. Indirect effects which are created by the presence of the pest, but not specific to the pest-host dynamic, include public health issues, restrictions on traffic flow, key ecosystem function compromised, research requirements, market access problems and tourism. An indirect impact is generally a value that is not tied directly to an area or volume that has been infested as with the direct impact (Bigsby et al., 2003).

Market effects refer to those effects for which the market provides an evaluation of the benefits and costs. Such effects can easily be identified in an existing market. This means that the effects of the pest can be identified in terms of (say) quantities bought and sold, and market prices. The key factor is that there is a market price and that quantities affected can be easily identified and measured (e.g. \$/ton, acres, or volume). Market effects include a range of changes in producer costs and returns, such as direct producer costs, input demands or output, and change in product quality. Market price covers the full range of activities from farmers to processors and exporters. Market effects also cover peripheral changes such as that of market access, where there might be changes in quarantine measures in export markets. Wider economic change might arise from a significant effect such as the loss of a domestic agricultural or tourist sector, which would cause unemployment, and changes in wages, land prices and exchange rates.

Non-market effects refer mainly to those changes for which there are no direct market evaluation. In other words, there is no information on prices, costs, profits or quantities. Examples of such impacting factors include environmental effects and loss of biodiversity. The key factor here is that there is an intuitive understanding that there is a cost being incurred, but a lack of information on what the cost might be. Consequently, a variety of techniques have been developed to measure the value of such effects, i.e., the change in consumer surplus associated with the effect.

The direct, indirect, market and non-market categories combine to form an economic impact matrix. The economic impact matrix is used to identify and classify economic effects. An effect that is economic in nature is one that causes changes to what is done, or that causes a change that is important to other activities.

The types of economic analysis that are available can be categorized according to the scope or level of economic activity that is measured. The FAO (1996) guidelines group economic analysis into partial budget, partial equilibrium, and general equilibrium.

Partial budget analysis, the narrowest in scope, deals with changes in the profits of individual producers. Partial equilibrium analysis is wider in scope than partial budget, dealing with a production sector as a whole rather than with individual producers, and can model the effects of a pest on changes in prices. Partial budget and partial equilibrium analysis can also be termed microeconomic approaches.

General equilibrium analysis is a level higher than partial equilibrium analysis, encompassing an entire economy, and allowing for the effects of a pest on wages, exchange rates and national welfare to be measured. The general equilibrium analysis is a macroeconomic approach. These types of economic analyses form a progression of analytical opportunities that are available as the scope of a potential pest impact increases.

To develop the case studies contact was made with an interdisciplinary group who participated in a workshop with the project's agricultural economics to identify the relevant invasive species problems, discuss and select the potential case studies and provide feedback for the development of the conceptual framework and model. The participants were biologists and economists, local and federal regulatory plant protection agencies, and persons involved with invasive species. Crop protection scientists of the University of Puerto Rico provided the information for pest and disease introductions, spread, hosts and damage. The "Sanidad Vegetal" Division of the Department of Agriculture of Puerto Rico and the Animal and Plant Health Inspection Service (APHIS-USDA) provided information on interceptions, surveillance and spread of the invasive species. Information was gathered in order to select the most important pests and diseases and to characterize of the pests and their effects in Puerto Rico.

The economic impact of the possible effects of the invasive species in the Puerto Rico agricultural economy was categorized as direct and indirect, as well as market and non market. The matrix of the economic impact was developed. A preliminary approach was designed to gather data on the economics and biological data to develop a comprehensive framework for species risk management.

## RESULTS AND DISCUSSION

The regional interdisciplinary group composed of crop protection scientists, regulatory federal and local protection agencies, and economists had a workshop to present and discuss potential case studies and to provide feedback for the development of the conceptual framework and model. The potential invasive species discussed were coffee berry borer (*Hypothenemus hampei*), black sigatoka for plantains and banana (*Mycosphaerella fijiensis*), the mango seed weevil (*Sternochetus mangiferae*), and for dairy production the Johnei disease causal agent (*Mycobacterium avium paratuberculosis*) and the parasite tick (*Boophilus microplus*). The interdisciplinary group pre-selected Puerto Rico's invasive species for the case studies on economic impact.

Researchers of the T-STAR project from the universities of Florida, Puerto Rico, Hawaii, and Guam confirmed the following invasive species case studies: coffee berry borer, black sigatoka for plantains and banana, and the mango seed weevil. The three invasive species selected for the case studies are at a pre-entry level. The characterization of the pests and their effects on the agriculture of Puerto Rico will be discussed in the following order:

### Coffee Berry Borer (*Hypothenemus hampei*)

#### Characterization of the pest (Biology Profile):

The coffee berry borer is a phytophagous insect. The invasion is at a pre-entry level status. It is already established in the nearby Dominican Republic. Puerto Rico has a local quarantine for green coffee with the purpose of decreasing the risk of the introduction of the berry borer.

Direct physical damage on coffee beans due to the berry borer would result in a severe infestation and a yield reduction of 30% to 80% (Franqui, 2003). Chemical control methods would impact environmentally sensitive areas. The possible pathway for the insect introduction could be illegal coffee bean imports. International travel and trade (particularly with the Dominican Republic) have increased the risk of introduction. The pest could be transported on clothes and tools, among other items. Private vessel traffic between Puerto Rico and the Dominican Republic involves a risk of introduction because of the low levels of private port inspections due to limited resources of regulatory agencies

#### Characterization of the Economic Impact:

The coffee commodity is relevant in socio-economic and environmental aspects. This commodity comprises 10,622 farmers and employs 10,000 workers in a region with limited economic activities and high unemployment rates. The possible yield reductions, control costs, and quality changes due to the berry borer will impact farmers' returns, thus affecting employment demand. The specialty coffee exports could be affected. The damage on the bean

due to berry borer could decrease the cup quality. Coffee is grown on steep mountain slope with high humidity. The environment will be impacted due to the combined effect of rainfall and the chemicals, used for control. The rivers and lakes in the coffee production region are a significant source of water for human consumption in Puerto Rico. Chemical control methods will possibly impact the water sources in an environmentally sensitive area. The cost of pre-invasion control management of the watch alert system will increase in government and regulatory agencies.

Table 1 shows the matrix of the economic impact of a possible introduction of the coffee berry borer. The impact matrix shows the expected market, non market under direct and indirect categories as well.

The management approach or policy options to avoid the introduction of the coffee berry borer suggest that border inspections and quarantine activities must be increased because of the active trade of fresh commodities and visitors and the proximity of the Dominican Republic to Puerto Rico. The regulatory agencies will incur costs for surveying, monitoring and other pre-entry watch alert activities. The pre-entry risk management options must be enforced by local and federal government and regulatory agencies.

#### Plantain Black Sigatoka (*Mycosphaerella fijiensis*)

##### Characterization of the pest (Biology Profile):

Black sigatoka is a pathogenic fungus at a pre-entry quarantine status. It is already established in the nearby Dominican Republic and Florida, USA. Puerto Rico has a local pre-entry quarantine for plantains with the purpose of decreasing the risk of the introduction of black sigatoka and the moko disease.

Direct physical damage on foliage and plantains due to black sigatoka introduction will cause a reduction of fruit size and quality, and plant defoliation. Severe infestation will result in a 50% to 100% yield reduction (INIFAP, 1998). International legal and illegal travel and trade (particularly from the Dominican Republic) have increased the risk of introduction. Private vessel traffic between Puerto Rico and the Dominican Republic involves a risk introduction because of the low levels of private port inspections due to limited resources of regulatory agencies. The most important vectors are legal or illegal passengers, contaminated plant material, and weather conditions (winds).

##### Characterization of the Economic Impact:

The plantain and banana commodities are economically the most important crops in Puerto Rico. The possible yield reductions, cost control, and quality changes due to Black Sigatoka introduction will impact farmers' returns, thus affecting the employment demand of rural areas. The aquifers in the production region are a significant source of water for human consumption in Puerto Rico. Chemical control methods would possibly impact the water sources in an environmentally sensitive area. The possible relaxation on phytosanitary measures would allow lower cost of the imported product. In this scenario local producers would face lower prices and potentially lose market share. The pre-invasion control management cost of a watch alert system will be increased in government and regulatory agencies

Table 2 shows the matrix of the economic impact of a possible introduction of Black Sigatoka. The impact matrix shows the expected market, non market under direct and indirect categories as well.

The management approach or policy options to avoid Black Sigatoka introduction suggests that border inspections and quarantine activities be increased because of the active trade of fresh commodities and visitors and the proximity of the Dominican Republic to Puerto Rico, The regulatory agencies will incur costs for surveying, monitoring and other pre-entry watch alert activities. The pre-entry risk management options must be enforced by local and federal government and regulatory agencies.

#### Mango Seed Weevil (*Sternochetus mangiferae*)

##### Characterization of the pest (Biology Profile):

The mango seed weevil (*Sternochetus mangiferae*) is a phytophagous insect at a pre-entry quarantine status. The insect is established on eastern Caribbean Islands. Direct physical damage to fruit seed, reduction in fruit size and quality are the results of the weevil attack (Franqui and Gaud, 2003).

The most important pathways or vectors are contaminated plant (seed), legal or illegal passengers, and trade. International travel and trade of fresh products have increased the risk of introduction. Tourism cruises and private vessels between Puerto Rico and infested eastern Caribbean islands (St. Lucia, Barbados, Dominica, Guadalupe, and Martinique), increase the risk of introduction. Domestic intra-island passengers in the east private and public marinas are not inspected because of the limited resources of local agencies, thus increasing the risk of introduction.

##### Characterization of the Economic Impact

The mango commodity is the most economically important fruit in Puerto Rico Over 80% of the local production is exported to Europe and the United State markets. Possible yield reductions, control costs, quality changes due to the mango fruit weevil will impact farmers' returns, thus affecting employment and wages. In the introduction scenario, local producers would face lower prices and potential loss of market share and loss of the export markets of the United States and Europe due to quarantine. Households' backyard trees will also be affected. The pre-invasion control management cost of the watch alert system will increase. Educational efforts will intensify in government and regulatory agencies.

Table 3 shows the matrix of the economic impact of a possible introduction of the mango seed weevil. The impact matrix shows the expected market, non market under direct and indirect categories as well.

The pre-entry risk management options must be enforced by government and regulatory agencies (local and federal). Considering the active trade of fresh commodities, the visitors on cruises, and the proximity of Puerto Rico and infested east Caribbean islands, border inspections and quarantine activities must be increased. The regulatory agencies will incur costs for surveying, monitoring and other pre-entry watch alert activities.



## RESEARCH APPROACH

To gather economic data on the coffee, mango, plantain and banana commodities and biological data on coffee berry borer, mango seed weevil and black sigatoka, in order to develop a comprehensive risk management framework the following approach has been preliminary planned:

- Use of presence-absence model.
- Coordination with APHIS USDA and Department of Agriculture to survey domestic travelers on private and public vessels to determine probabilities of invasive introductions.
- Partial budget analysis (market and trade).
- Control management scenarios or options, eradication costs.
- Socio-economic and environmental damage evaluation.

## CONCLUSIONS

The T-STAR project Economics of Managing Invasive Species in Tropical and Subtropical Areas in the United States includes the regions of Florida USA, Puerto Rico, Hawaii and Guam. There are two specific objectives of the project: development of a comprehensive invasive species risk management framework that incorporates the economic impacts of invasive species; and development of a collaborative interdisciplinary network of institutions and persons involved with invasive species management. As part of these objectives, a number of case studies will be done in regard to particular invasive species problems in the collaborating regions.

Puerto Rico's interdisciplinary regional group identified three relevant invasive species for the agricultural crops sector. The three invasive species selected for the case studies are: coffee berry borer (*Hypothenemus hampei*), black sigatoka for plantains and banana (*Mycosphaerella fijiensis*) and the mango seed weevil (*Sternochetus mangiferae*). The economic impact of the possible effects of the invasive species in the Puerto Rico agricultural economy was categorized as direct and indirect, as well as market and non market. The matrix of the economic impact was developed. A preliminary approach was designed to gather data on the economics and biological data to develop a comprehensive framework for species risk management.

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Table 1. Coffee Berry Borer Impact Matrix

	Market Impact	Non-Market Impact
Direct Pest Effects	Coffee products (control costs) Trade effects (specially coffee market)	Environmental (water supplies)
Indirect Pest Effects	Socio-Economics (income & employment) Pre and post entry control management	

Table 2. Black Sigatoka Impact Matrix

	Market Impact	Non-Market Impact
Direct Pest Effects	Plantain and banana (control, costs, yield and profit decrease) Trade effects (loss of local market share to imports)	Cultural (Diet)
Indirect Pest Effects	Socio-Economic (lost of income & employment) Pre-entry control management costs	Environment (chemical control affect water quality)

Table 3. Mango Seed Weevil Impact Matrix

	Market Impact	Non-Market Impact
Direct Pest Effects	Mango(control cost yield reduction) Trade effects (market access)	
Indirect Pest Effects	Pre and post entry control management cost	Environmental (chemical control)

**MARKET OPPORTUNITIES FOR PRODUCERS AND MARKETERS OF AGRICULTURAL PRODUCTS: A MARKET ASSESSMENT OF PRE-PACKAGED VEGETABLES IN TRINIDAD**

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**ABSTRACT:** Driven by lifestyle shifts and the need for convenience, the demand and market opportunities for pre-packaged vegetables have substantially changed in the past decade. A survey of customers at six outlets of the major supermarket chain in Trinidad examined the purchasing pattern and demand for four pre-packaged vegetables. The market trends are consistent with those in metropolitan countries, and the potential exists for increasing value and opportunities for all participants along the agri-food chain.

**INTRODUCTION**

A major shift in consumer demand has severely impacted the global agri-food system to the extent that it has transformed the way food is produced, prepared and sold. In particular, the increased popularity of convenience foods has created new challenges and opportunities for the fresh produce market across the globe. Sustainable growth and success within the fresh produce industry is now dependent on ongoing reinvestment by producers, continuous product innovation and the formation of long term partnerships with customers. The fresh-cut produce industry in the Caribbean is in its early stage of development, comparable to the U.S industry twenty years ago. Mott et al., (1998) reported that sales of cut vegetables to restaurants and food service establishments accounted for US\$6 million and sales of packaged salads to supermarkets and other retail establishments amounted to US\$1billion. There is now a growing demand for prepackaged items in Trinidad and Tobago, and with that, opportunities for the agribusiness sector (producers and marketers).

“Convenience foods” encompass a wide range of items that are broadly defined as foods that require minimal preparation. A prepackaged vegetable, often referred to as a “salad mix” belongs to the “Fresh-cut produce” group and represents one category of the convenience food segment. “Fresh-cut produce” is defined as any fresh fruit or vegetable or any combination thereof that has been physically altered from its original form, but remains in a fresh state. All such commodities undergo a process of washing, trimming, peeling, and cutting into suitable sizes for bagging or convenient packaging for purchase by the consumer.

In the United States, the pre-cut produce segment of the market consists of packaged salads, pre-cut vegetables and pre-cut fruits. In recent times there has been an increase in retail sales of fresh cut produce, attributed to a number of factors, including the following:

- The growth in public knowledge and awareness of the link between diet and health, which has increased the demand for fruits and vegetables.
- Lifestyle shifts with the entrance of more women in the work force have increased the demand for foods of high and predictable quality that offer convenience and variety.

- Improvements in technology—advances in post-harvest technology and handling have improved the quality, presentation and shelf life of fresh-cut vegetables at retail.
- Improvements to and expansion in the range of products offered on supermarket shelves.
- Demographics—where greater ethnic diversity implies a greater variety of foods.
- Rising incomes—purchase is driven by taste and preference.
- Rise in two-income families since more women are in the workforce.

The aforementioned changes are not only applicable to metropolitan countries but to Latin America and the Caribbean.

In the absence of market information to support this new food industry in Trinidad, the Caribbean Agricultural Research Development Institute (CARDI) through its Marketing Unit embarked on a study to undertake a market assessment for convenience foods (pre-packaged vegetables) in Trinidad.

## METHODOLOGY

A questionnaire was developed, pre-tested and administered at six Hi-Lo Supermarket outlets to collect data on trends in the market for pre-packaged (ready to cook) vegetables and to estimate the market demand for this commodity in Trinidad. Hi-Lo supermarket is the leading supermarket chain in Trinidad and Tobago. Interviews were also conducted with key industry officials.

A total of 1205 questionnaires were administered to shoppers randomly at six Hi-Lo supermarkets in the following areas: Westmoorings, St Augustine, El Dorado, Arima, Chaguanas, and Gulf City. These Hi-Lo supermarkets are located in densely populated areas in North, South, East, and Central.

The focus pre-packaged (ready to cook) vegetable packs were identified as “callaloo,” “chow mein,” “vegi,” and “patchoi.” A full description of these convenience items and their contents are presented in Figures 1 through 4. To ensure that the respondents were all using the same frame of reference for the pre-packaged vegetables that were the focus of this study, they were shown pictures of the pre-packaged vegetables by the enumerators.

The primary data collected were analysed by Statistical Package for Social Sciences (SPSS) version 7.5.

## RESULTS

### Profile of purchasers of prepackaged vegetables

Of the 1205 questionnaires administered, 67% of the respondents indicated that they purchase prepackaged vegetables. Of these, 78% were female and 22% were male. Ninety-three (93%) of purchasers of prepackaged vegetables provided responses to the question on average monthly household income. From Table 1, which shows the average monthly household income, it can be seen that the majority of respondents—28% who purchase pre-packaged vegetables belong to the greater than TT\$12,999 (US\$2,063) category. Conversely, smaller numbers of respondents in the lower income brackets purchased prepackaged vegetables.

The highest percentages of customers that purchase pre-packaged vegetables were in the 35-44 age categories, with 63% of all purchasers under 45 years of age. Two person households

were the main household types that purchased pre-packaged vegetables accounting for 25% of the sample, with three and four member households accounting for 23% and 21%, respectively.

#### Preference for pre-packaged vegetables by respondents

Of the four pre-packaged vegetable products evaluated, the “callaloo” pack is the most frequently purchased, followed by the “vegi” pack, “chow mein” pack and the patchoi pack (see Table 2). Amongst purchasers, the “callaloo” and “vegi” pack were most popular choice by respondents, 77% and 71% respectively. Shoppers were very aware of the range of pre-packaged vegetables offered at Hi-Lo Supermarkets, with over 50% of respondents indicating knowledge of each of the four prepackaged items.

#### Frequency of purchase of pre-packaged vegetables

Table 3 shows the frequency of purchase of the pre-packaged vegetables in the following categories, weekly, fortnightly and monthly. The “callaloo” pack was purchased most frequently of the four prepackaged vegetables with 362 packs purchased on a weekly basis. These results clearly indicate that the purchase of pre-packaged vegetables is done on a weekly basis, and represents 68.7% of total purchase. This is as against the 20.2% of the respondents who indicated that pre-packaged vegetables were purchased on a fortnightly basis, and 11.2% who did so on a monthly basis. The popularity of the “callaloo” pack can be attributed to its use as part of a traditional Sunday meal in Trinidad and Tobago.

#### Factors and relationships affecting the purchase of pre-packaged vegetables

The purchase of pre-packaged vegetables is driven by convenience as stated by 81% of respondents followed by quality (7%) and food safety (3%).

Sixty percent of married couples purchased pre-packaged vegetables. Of this amount 72% of the respondents belonged to households in which both partners are employed. Cross tabulation analysis on the relationship between: (a) income levels and purchase of pre-packaged vegetables and (b) marital status on the purchase of pre-packaged vegetables showed no correlation between the variables in either of these relationships. In addition, there was no major difference in the purchasing patterns of married couples where both partners worked versus couples where one partner worked (Table 4).

Estimation of Market Size in 2004 for pre-packaged vegetables with specific emphasis on the “callaloo” pack and the “vegi” pack.

The market size estimation gives the value of the current market size for prepackaged vegetables in Trinidad. The market size estimate applied the demand-side formula:

$$Md = nqp$$

Where:

Md = Market size (demand side definition)  
n = penetration (number of customers)  
p = average price paid

q = Total volume purchased per customer in a period (Savvides, 2000)

The annual conversion factor was used to convert market size values to a yearly value. This estimate is used in situations where sensitive company information is not readily available as was the case in this study. Tables 5 and 6 show the elements used in the calculation of this variable.

Based on these surveys, the market size for the “vegi” pack was calculated to be TT\$360,469.79 or US\$57,217.45 per annum, and the market size for the “callaloo” pack calculated to be TT\$211,546.20 or US\$33,578.76 per annum.

## DISCUSSIONS AND CONCLUSIONS

The preliminary market research and market information gathered on pre-packaged vegetables in this study is of value to all participants along the agri-food chain. In particular, the profiling of the consumers and the estimation of market demand is important in identifying opportunities for target marketing. Based on the demand for pre-packaged products in all segments of the market—supermarkets, fast food outlets, and the hospitality industry—production planning and forecasting will be critical to the development and sustainability of the industry.

An illustration of the potential of this industry is seen when a rough estimate of the profit margin on the “callaloo” pack is examined. Based on the wholesale prices of the ingredients (“callaloo” bush, ochroes, pumpkin and pepper; and the packaging material), the mark up is in the vicinity of 30-40%. As such, the production of a wide range of convenience foods for the Trinidad food sector can provide guaranteed markets for farmers for their produce and direct profits for marketers and other intermediaries.

The survey showed that the “callaloo” pack was the most popular prepackaged vegetable pack, related to its use as part of the traditional Sunday meal, where the cleaning and preparation of the vegetables are tedious and time consuming. The consumption of this convenience item has benefited from lifestyle shift, where increasingly women form a major part of the work force and there is a need to reduce meal preparation time. Notwithstanding, the “vegi” pack has the highest market value of TT\$360,469.79 followed by the “callaloo” pack TT\$211,546.20 or US\$33,578.76, “chow mein” pack—TT\$209,419.62 or US\$33,241.21 and “patchoi” pack—TT\$105,165.93 or US\$16,693. The market size (value) for the four pre-packaged vegetables in Trinidad was estimated to be TT\$886,601.54 or US\$140,730.40.

The study showed that the profile of purchasers and factors influencing purchase of pre-packaged vegetables in Trinidad are similar to those of consumers in the metropolitan centres of the world. While purchasers at the six locations of Hi-Lo Supermarkets were generally satisfied with the quality and range of the four products under examination, there are opportunities for expansion, given the changing lifestyle of the modern-day consumers.

The success of this industry now depends on the effective use of market information and the response of participants along the commodity chain to the need for increased production and improvements in the quality of fresh produce. As such, continuous product innovation and the formation of long term partnerships with customers would ensure a sustainable industry.

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Table 1. Average monthly household income of sample survey that purchase pre-packaged vegetables

Income Levels (TT)	Percentage of Income
<\$1,999	3
\$2,000-\$4,999	18
\$5,000-\$7,999	21
\$8,000-\$10,999	15
\$11,000-\$12,999	8
>\$12,999	28

(1\$US=6.3\$TT)

Table 2. Knowledge of pre-packaged vegetable among shoppers that purchase

Pre-packaged vegetable	Awareness	Purchase
Callaloo pack	77	77
Vegi pack	72	71
Chow mein pack	67	65
Patchoi pack	51	50

Table 3. The frequency of purchase of pre-packaged vegetables among respondents

Pre-packaged vegetable packs	Number of packs purchased weekly	Number of packs purchased fortnightly	Number of packs purchased monthly
Callaloo pack	362	106	63
Vegi pack	336	96	56
Chow mein pack	285	83	49
Patchoi pack	215	67	27
Total purchases	1198	352	195
Percentage of Total (1745)	68.65%	20.17%	11.18%

Table 4. Percentage of respondents that purchase prepackages and civil status (married with both partners working versus married one partner working)

Married both partners working (N=352)		Married one partner working (N=135)	
Pre-pack	% Purchase	Pre-pack	% Purchase
Callaloo	75	Callaloo	80
Vegi-pack	68	Vegi-pack	67
Chow mein	63	Chow mein	67
Patchoi	46	Patchoi	50

Table 5. The market size estimation for the ‘vegi’-pack in Hi-Lo Supermarkets in Trinidad

Frequency of Consumption	Sample Population			
	Number of respondents (n)	Average no. of packs purchased (q)	Average Price (p) (TT\$)	Annual Conversion factor
Weekly	336	1.57	\$11.16	52
Forthnightly	96	1.45	\$11.16	26
Monthly	56	1.86	\$11.16	12

Table 6. Market Size Estimation for the ‘Callaloo’ Pack in Hi-Lo Supermarkets in Trinidad

Frequency of Consumption	Sample Population			
	Number of respondents (n)	Average no. of packs purchased (q)	Average Price (p)	Annual conversion factor
Weekly	362	1.34	\$6.99	52
Forthnightly	106	1.42	\$6.99	26
Monthly	63	1.49	\$6.99	12





Figure 2. Chow mein pack



Figure 3. Pakchoi pack



Figure 4. Vegetable pack

**DISTRIBUTION, HOST-PLANT RANGE, AND EFFECTS OF THE NATURAL AND CLASSICAL BIOLOGICAL CONTROL OF AN INVASIVE PEST IN THE DOMINICAN REPUBLIC: THE PINK HIBISCUS MEALYBUG, *MACONELLYCOCCUS HIRSUTUS* (GREEN) (HEMIPTERA: STERNORRHYNCHA: PSEUDOCOCCIDAE)**

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**ABSTRACT:** The Pink Hibiscus mealybug (PHM) has spread in the Caribbean area from Grenada (1995) towards Central America (Belize) and the U.S.A. (Florida and California, 2002-2003), causing losses of millions in US dollars. In 2002, outbreaks of the PHM were confirmed in Haiti and The Dominican Republic (DR) and programs of classical biocontrol (CBC) were initiated. A task force of experts from the Ministry of Agriculture (SEA), The Dominican Institute for Agriculture and Forestry Research (IDIAF), Dominican Agribusiness Consortium (JAD), Universidad Autónoma de Santo Domingo (UASD) y la Universidad Nacional Pedro Henríquez Ureña (UNPHU) liberated parasitoids of the species *Gyranosoidea indica* and *Anagyrus kamali* (Hymenoptera: Encyrtidae), introduced from Puerto Rico with the cooperation of USDA-APHIS. Since August 2002, a team of IDIAF-UNPHU monitored PHM colonies and natural enemies between the national district in the south and the northern coast in order to monitor the population dynamic, % of parasitism, presence of predators and associated ants. The study showed the presence of the PHM on more than 70 host-plant species belonging to 35 families. Also, the pest was disseminated over the area of the study mainly on infested *Hibiscus* spp. and other ornamentals. In all areas there was the omnipresent parasitoid of *G. indica* and in some localities and/or in a lower extent *Allotropa* sp., Hym.: Platygasteridae, incl. hyperparasitoids. Severe outbreaks of PHM were controlled mainly by the coccinellid *Cryptolaemus montrouzieri*, present in the country since 1930s, its voracity interferes with the parasitoids causing that at PHM low densities the parasitoids emigrate to heavily infested plants permitting the PHM populations to recover, especially during the hot season. Associated ants (i.e. *Solenopsis* spp.) spread and protect the PHM against natural enemies. In localities with or without liberation of parasitoids, a tendency of increased parasitism towards a balance level at very low PHM densities was observed, permitting the recovery of the infested plants at generally low levels of hyperparasitism (genus *Procheiloneurus* [Hym.: Encyrtidae] and *Chartocerus* [Hym.: Signiphoridae]). While the PHM has been disseminated over vast areas of the country, no important damages have been reported in agricultural crops due to the establishment of the natural-enemy complex. The CBC proved to be effective to manage populations of invasive pests, whenever the efficiency of the native, non-specific natural-enemy complex is not sufficient.

**FLUCTUATIONS OF ARTHROPOD-PEST POPULATIONS IN 'CHINESE EGGPLANT' (*SOLANUM MELONGENA* L.) CROPS UNDER THE INFLUENCE OF THE PEST MANAGEMENT AND CLIMATE IN LA VEGA, DOMINICAN REPUBLIC**

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**ABSTRACT:** This study was achieved in 2003 in the central province “La Vega” with the objectives of: 1) actualizing the inventory of pest species on Chinese Eggplant (*Solanum melongena* L.), 2) follow the population dynamics under 3 pest management strategies and 3) supporting the natural control with the integration of selective pesticides suitable for Integrated Pest Management (IPM) practices. Three plot studies were established where: T1 = control, without any pest control measure; T2 = integrated management, incl. sprays of relatively selective pesticides based on monitoring and respecting the waiting period and T3 = Conventional, consisting in programmed sprays decided by the farmer. In order to follow up the fluctuations of pest populations, weekly changed yellow sticky cards were placed in each plot (6 replicates) and counts were done every two weeks on randomly chosen plants. The harvest data were taken in 4 subplots (= replicates) and compared with ANOVA. The efficiency of pesticides was established using the comparison of paired mean data. Important pest species like *Thrips palmi* Karny (Thysanoptera: Thripidae) and *Bemisia tabaci* (Genn.) biotype ‘B’ (Hemiptera: Sternorrhyncha: Aleyrodidae) showed the lowest densities in T1 plots, being highest in T3. Nevertheless, with the flower-bud weevil (*Anthonomus pulicarius* Boheman, Coleoptera: Curculionidae) the results were the contrary, being this non-observed pest the main cause for the low harvest results of T1 and T2, even if the productivity in T2 at certain moment was superior than in T3. Due to the fact, that no selective insecticide was found against the weevil, the evaluation of alternatives and the integration of other control methods using a non-selective insecticide at the beginning of the flowering period to manage this pest followed by sprays with selective products are recommended.

## PRELIMINARY STUDIES ON THE ECOLOGY AND MANAGEMENT OF BANANA CROWN ROT FUNGI IN THE DOMINICAN REPUBLIC

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**ABSTRACT:** Banana crown rot (CR) reduces the quality of exporting banana (AAA) in the Dominican Republic. Annual losses of organic bananas are estimated about US\$ 200,000 due to fruit damages caused by CR. So far, CR has been attributed to biotic as well as abiotic factors. To determine the relationship among fungi from washing water and CR symptoms on organic banana we conducted samplings of water in washing stations in organic banana plantation in the Southwest Region of the Dominican Republic. Water samples were collected, processed and isolated on selective Mathur's medium. Isolates of *Colletotrichum* spp., *Fusarium* spp. and *Curvularia* spp. were identified. Isolates of these fungi were inoculated on unripe banana fruits to test for pathogenicity. Isolates of *Colletotrichum* spp. and *Fusarium* spp. caused symptoms similar to CR developed under natural conditions. Currently, the efficacy of organic acids products and other alternative control is being investigated.

**Key words:** Ecology, Banana crown rot, Management, Fungi, Dominican Republic.

### INTRODUCTION

The Dominican Republic is the most important exporter of organic banana (Cavendish AAA) to the European Community Countries, exporting an average of 150,000 boxes accounting for an income of US\$ 55 millions for organic banana growers (Proyecto Mejoramiento de la Calidad del Banano, 2002).

The banana growers, associated to the European Fairtrade Market face numerous problems that cause them to meet only 55% of the market demand. Most of their losses are brought about by shipment rejection at arriving ports, mainly due to Crown Rot (CR) and Fruit Ripening (FR). Growers are at risk of losing the European market if these problems are not corrected promptly (Proyecto Mejoramiento de la Calidad del Banano, 2002).

Banana crown rot has been previously associated to several fungi: *Fusarium roseum*, *Colletotrichum musae*, *Botryodiplodia theobromae*, *Verticillium theobromae*, *Ceratocystis paradoxa* and *Phomopsis* spp., among others (Burden 1967, 1968; Green and Goss, 1963; Lukezic and Kaiser, 1966; Stover, 1972; Snowdon, 1990; Sommer and Donald, 1992; Ploez et al., 1994). Research conducted in Central America by Green and Goos (1963) found that *Fusarium roseum*, *Verticillium theobromae* and *Colletotrichum musae* were the most prevalent fungi.

Research conducted in the French Antilles concluded that isolates *C. musae*, associated to banana flower also caused post harvest diseases of export banana (De Lapeyre et al., 1997, 1998, 2000). Under conventional agriculture, banana crown rot is managed with fungicides, such as thiabendazole, imazalil and bitertanol, among others. With time, fungi associated with banana diseases have developed resistance to most of them (De Lapeyre and Dubois, 1997). Work conducted in the Dominican Republic by White (2000), provided information on the occurrence

of post harvest damage to export banana and attributed that to deficient post harvest management and further infection by species of *Fusarium*, *Colletotrichum*, *Aspergillus*, *Penicillium*, *Alternaria*, *Pestalotia*, *Trichoderma*, *Geotrichum*, *Nigrospora*, and *Curvularia*.

Because of the restrictions and regulations established for organic banana management, growers do not use post harvest chemical treatment but wash the fruits prior to packing with tap water amended with natural latex removers and organic acids. This practice however, has not been experimentally tested to determine if it prevents the growth and dissemination of fungi associated with crown rot.

The objective of this study was to sample, isolate and identify fungi present in the water in washing stations of organic banana fruits, previous to packing and exporting, in the province of Azua, Dominican Republic. As well as determine if these fungi are capable of causing crown rot by pathogenicity test.

## MATERIALS AND METHODS

### Sampling

Sample collections were conducted from May to October, 2003. Four main washing stations, with a capacity of about 5000-10,000 gallons of water, were sampled. Samples were collected every eight days, during four months. Five hundred ml of water per sample were collected in sterilized glass vials. Samples were collected at four points in the station, these were 1) main pipe that feeds the washing tank, 2) tank of latex washing, 3) washing tank with  $Al_2(SO_4)_3$  and 4) pre-packing washing tank. Samples were kept at 15<sup>o</sup> C.; processed after 48 hours and poured into Petri dishes with Mathur's medium.

### Fungal Isolation

Fungal isolations were performed using a modified method by De Lapeyre et al., (2000), who characterized *Colletotrichum* sp. population from banana flowers. Sub samples of twenty-five ml water were taken from the original sample and centrifuged at 4,000 rpm. Aliquots of 200  $\mu$ l of precipitates were evenly dispersed on the surface of Petri dishes with Mathur's medium (( $MgSO_4 \cdot 7H_2O$  2.5 g, 2.7 g  $KH_2PO_4$ , peptone 1 g, yeast extract 1g, sucrose 10 g, agar 15 g, rifampicin 100 mg, ketoconazole 0.8 g, in 1L of distilled water), there were four replicates per sub sample. Plates were incubated for seven days at 25-27<sup>o</sup> C for colony growth counts and identification of fungi.

After populations were counted, we selected representing the predominant cultural types that grew on the medium for further pathogenicity test.

### Pathogenicity Test

To test pathogenicity, we selected five isolates. These isolates were C1 = *Colletotrichum* spp. (lacking setae), C2 = *Colletotrichum* spp. (with setae), F1 = *Fusarium* spp. (with macro and microconidia), F2 = (macroconidia only) and CV1 = *Curvularia* spp. These isolates were transferred to Mathur's medium, for inoculum production. These were inoculated on unripe banana crowns collected at packing sites a day before inoculations. Inocula as conidia suspensions were prepared by scraping the surface of the plate and mixing it in 100cc of sterile



distilled water One hundred  $\mu\text{l}$  of the suspension was used for inoculations. The average conidia concentration inoculated varied with the treatment, therefore, values ranged from  $1.5 \times 10^6$  conidia /ml for *Curvularia* to  $9.1 \times 10^7$  millions for *Fusarium*., whereas isolates of *Colletotrichum* (with and without setae) averaged values of  $3.6$  and  $6.5 \times 10^6$  conidia/ml, respectively.

Before inoculation, banana crowns were surface disinfected with 50% alcohol and then the surface tissue aseptically removed. Each fungal isolate was inoculated on individual banana crowns. After inoculation the surface was covered with plastic polyethylene film (cling wrap) to keep moisture as well as avoid contamination. A randomized complete block design was used with 7 treatments and 5 replications: C1, C2, F1, F2, and CV1. An additional treatment with a mixture of all five fungi was also inoculated. Control treatments were inoculated with sterilized distilled water and covered as indicated above. Inoculated fruits were incubated at  $25\text{-}27^{\circ}\text{C}$  and  $>80\%$  moisture in the dark for 18 days.

Evaluations were conducted after 12 and 18 days; which is a period similar to the shipment from the farms in the Dominican Republic to the European ports. A rating scale developed by De Lapeyre (personal communication, 2003) was used, where 0 = no symptoms, 1 = less than 25 % colonized surface, 2 = less than 50 % of colonized surface, 3 = less than 75 % colonized surface and 4 = more than 75 % colonized surface. Other criteria used were necrotic tissue extension, yellow halo around the crown, premature ripening of fruits, presence or absence of fungal mycelia and exudates on crown surface.

## RESULTS

### Samplings and fungal isolations

Fungi belonging to the species *Colletotrichum* spp., *Fusarium* spp. and *Curvularia* spp. were isolated from different water sources and washing stations sampled.

Isolates of *Colletotrichum* spp. (C1) on Mathur's medium, presented salmon orange spore masses, abundant conidia and acervuli lacking setae. These C1 isolates were the most common. Other isolates of *Colletotrichum* spp. (C2) showed abundant white mycelia, and dark at the center of the colony and with pink borders and acervuli with setae.

Isolates of *Fusarium* spp. (F1) developed yellow pigmented colonies, and abundant macroconidia as well as white mycelia on the surface of the colony. F2 isolates of *Fusarium* spp. developed few macroconidia, abundant microconidia, and yellow to brown color at the center of the colony.

On the other hand, isolates of *Curvularia* spp. (CV1 and CV2) developed few conidia and colonies were dark brown with gray borders and abundant dark mycelia. Table 1 summarizes the results of population counts and fungi isolated for each sample date.

### Pathogenicity Test

Isolates C1 and C2 of *Colletotrichum* spp. and isolate F2 of *Fusarium* spp. caused crown rot on inoculated banana fruits. Symptoms started to develop six days after inoculation. After twelve days, treatments with isolates C1 and C2 were the most affected inducing typical symptoms of crown rot, reaching up to grade 4, the highest level of the scale (Table 2). Furthermore, these isolates produced white mycelium on crown surface, yellow halo around the crown, as well as peduncle and crown necrosis (Figure 1).

Likewise, isolates of *Fusarium* spp. presented crown surface necrosis and fruit yellowing. Nevertheless, for *Curvularia* spp. expressions of symptoms were not clear. Besides, the isolate mixture showed a light crown surface necrosis; while the control treatment produced dark brown exudates on crown surface without yellowing or necrosis, of the adjacent tissue.

Eighteen (18) days after inoculation, isolates C1 and C2 induced complete fruit ripening and necrosis of the crown with abundant white mycelia developing on the surface (Figure 2). The F2 treatment also developed fruit ripening, crown necrosis and white mycelia on the surface. Isolate CV1 did not cause crown rot symptoms but slight necrosis. The mixture of fungal isolates did not cause fruit ripening, but surface rot and yellowing of the peduncles. Banana fruits in control treatment remained green even after eighteen days.

## DISCUSSION

The most predominant isolates sampled at the washing stations in Azua, Dominican Republic were *Colletotrichum* spp. Our results agree with those by De Lapeyre et al., (2000), which indicated that isolates of *Colletotrichum* spp. were the most abundant fungi associated with crown rot and banana flowers. According to literature reports, *Colletotrichum musae* produces abundant conidia and acervuli lacking setae on culture. Isolates C1 obtained in our study had similar cultural characteristics; however, the identity of the species needs to be accurately determined.

According to De Lapeyre et al., (2000) *C. musae* is the most important fungus causing banana post-harvest diseases in the French Antilles.

In many countries, *C. musae*, as well as other fungal species has been reported as an important causal agent of severe banana crown rot (Green and Goos, 1963; Lukezic and Kaiser, 1966; Ogawa, 1968). It is important to notice that fungi isolated were only found in the washing tanks but not from the main pipe that feeds the tanks, which suggests that contamination may occur during transportation of the fruits from the field to the stations. In our study banana crown rot was associated with premature ripening of fruits.

Further research will be conducted to determine the occurrence of crown rot causing fungi in other banana growing areas of the Dominican Republic where crown rot has been associated to shipment losses.

Currently, the efficacy of organic acid products and other preventive treatment is being investigated.

## ACKNOWLEDGEMENTS

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Table 1. Fungal genus and populations collected at the washing stations in organic banana farms. Azua. Dominican Republic.

Sample dates	Washing station	Section	Cfu/ml		
			<i>Colletotrichum</i> spp.	<i>Fusarium</i> spp.	<i>Curvularia</i> spp.
28/07/2003	Finca 6	2	2x10 <sup>2</sup>	0	0
	La Tina	3	“	0	0
10/08/2003	Finca 6	2	2x10 <sup>2</sup>	2x10 <sup>2</sup>	0
	La Tina	3	“	“	0
	La Tina	4	6x10 <sup>2</sup>	0	0
	La Tina 3	2	2x10 <sup>2</sup>	4x10 <sup>2</sup>	0
	La Tina 3	4	6x10 <sup>2</sup>	0	0
26/08/2003	Finca 6	3	0	0	2x10 <sup>2</sup>
	La Tina	3	4x10 <sup>2</sup>	0	0
	La Tina	4	0	4x10 <sup>2</sup>	2x10 <sup>2</sup>
	La Tina 3	3	0	0	“
	La Tina 3	4	0	0	0
	Estebanía	2	0	2x10 <sup>2</sup>	0
	Estebanía	3	4x10 <sup>2</sup>	0	0
14/09/2003	Finca 6	2	2x10 <sup>2</sup>	0	0
	La Tina	4	4x10 <sup>2</sup>	0	0
	Estebanía	2	0	2x10 <sup>2</sup>	0

Section:

2: Tank of latex washing

3: Washing tank with Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>

4: Pre – packing washing tank

Table 2. Disease Reaction based on scale by De Lapeyre (2003).

Treatments	Average
C1	4
C2	3.8
F1	3.2
F2	3.6
CV1	1
Mixture of all	3
Control	0

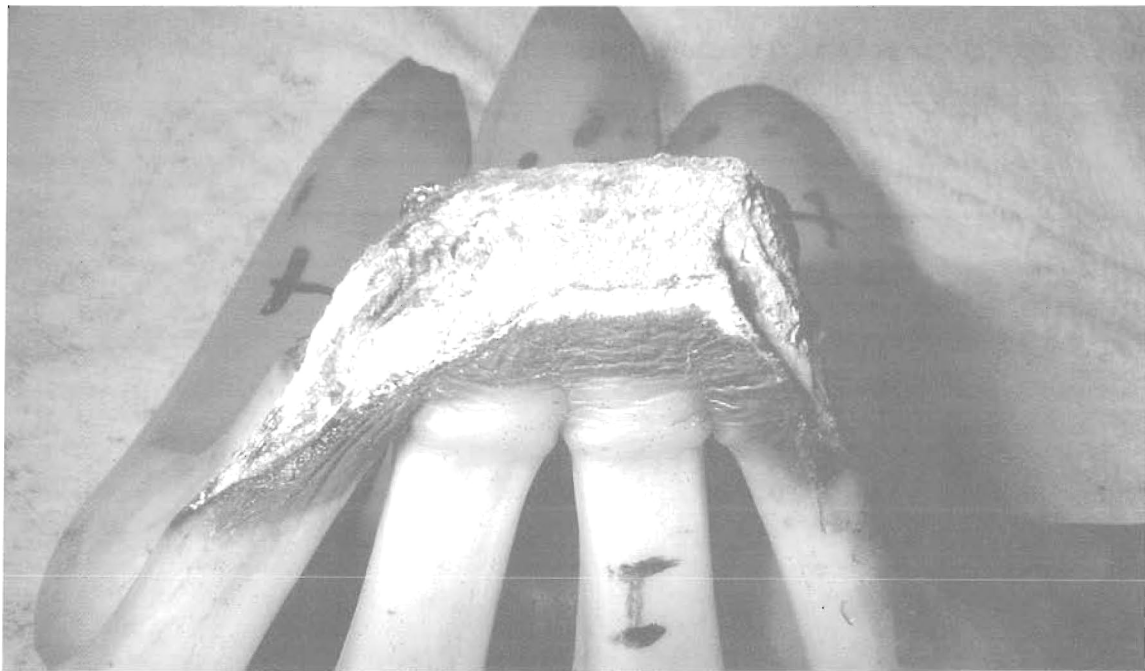


Figure 1. Typical symptoms of crown rot, developed twelve days after inoculation with *Colletotrichum* spp. (C1).



Figure 2. Crown rot development after 18 days. Control treatment is shown at the center of picture.

**BIOTECHNOLOGY, PROSPECTS FOR DEVELOPMENT IN EMERGING ECONOMIES**

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**ABSTRACT:** Throughout history, innovation has driven progress and helped people address the problem of the age. This progress has not been achieved without pain and controversy, at times war and famine and pestilence thwart our best endeavors. Despite setbacks, people in the world over continue to strive to understand the natural world, to pursue truth and beauty, and to create a better world for themselves and their children. Science has a role to play in all these pursuits. However, the very power of the new discoveries in the biological sciences raises fears that these discoveries will not be used wisely. Many believe that they will accelerate the destruction of the natural environment, damage human health, concentrate too much power in the hands of a few global companies, and widen the gap between the rich and the poor, within and between nations. The task of the scholars of today is to analyze where modern science can lead to technical innovation and how these can be used wisely, to improve agriculture productivity, conserve nature resources, and create wealth especially for poor people in developing countries.

**INTRODUCTION**

Powerful tools provided by Biotechnology in recent years have had a profound impact on the food and agriculture sector worldwide. Innovation production and processing methods have revolutionized many traditional systems, and the world's capacity to generate food products for its growing population has evolved at an unprecedented rate.

These developments have naturally been accompanied by radical changes in economic forces and social organization as well as in management of the earth's productive resources. Our very relationship with nature has been overturned by technological advances that enable us not only to determine genetic improvement through selective breeding but to modify living organisms and create novel genetic combination in the quest for strongest and more productive plants animals and fish.

Understanding such developments invariably gives rise to controversy, and arguments for and against their implementation tend to be intense and emotionally charged.

Poverty in a time of plenty: A Paradox.

The annual world agriculture growth rate has decreased from 3 percent in the 1960s to 2 percent in the last decade.

- 2020 Worldwide, per capita availability of food is projected to increase around 7 % .
- Developing countries by 9 percent (Pinstруп-Andersen, and Rosegrant 1999).

The paradox is that despite the increasing availability of food,

- 840 million people or 13 percent of the global population, who are food insecure.

- ✓ 4.5 billion inhabitants of the developing countries
- ✓ Asia 48 percent
- ✓ Africa 35 percent
- ✓ Latin America 17 percent
- ✓ Of these 840 million, at least 200 million are malnourished children.

It is also paradoxical that food insecurity is so prevalent at a time when global food prices are generally in decline.

- World cereal production doubled between 1960.
- 1990 per capital food production increased 37 percent.
- Calories supplied increased 35 percent
- Real food prices fell by almost 50 percent (McCalla, 1998).

The basic cause of the paradox is the intrinsic linkage between poverty and food security. Simply put, people's access to food depends on income.

Poverty is both a rural and an urban phenomenon.

- Over 1.3 billion people in developing countries are absolutely poor, with incomes of US\$1 per day or less per person, while another 2 billion people are only marginally better off (World Bank 1997)
- It is also interesting to note that malnutrition kills 40, 000 people each day.
- 125 million children are affected by vitamin A deficiency.

Ensuring their access to sufficient nutritious food at affordable prices is also an impotent component of global food security strategies.

Research needs to respond these challenges, so as to improve the livelihood of the rural poor and ensure the increased availability of nutritious food at affordable prices for the urban poor.

## FOOD SECURITY

Food security covers both the availability of food at the household level as well as access in terms of purchasing power (FAO 1996)

- Not just production, but also access
- Not just output, but also process
- Not just technology, but also policy
- Not just government, but also people participation
- Not just rural, but also urban
- Not just amount, but also content.



Food production is necessary but not sufficient condition for food security. Focusing on improving the livelihood of smallholder farmers in developing countries is key to environmental protection, poverty reduction, and food security.

## GLOBAL FOOD BASE

Humanity has a narrow food base. Twelve crops account for 95 percent of the plant food base. These are banana /plantain, cassava, corn (maize), groundnut, millets, oil crop, potato, rice, sorghum, soybean, sweet potato, and wheat (Delgado 1999).

There is also an increasing demand for milk and meat in the developing countries, etc. cattle, sheep, goats, pigs and chickens. Fish is also an increasingly important component of the diet in developing countries (FAO 1999).

Globally, meat production increased from 71 million tons in 1961 to 226 billion tons in 1999 (Rosegrant 1999). For developing countries, it increased from 20 million tons to 122 million tons over the same period (Delgado 1999).

## BEYOND THE GREEN REVOLUTION

- Increasing productivity of cereals
- Expanding the area of arable land
- Massive increases in fertilizer use

Attention was given to the following issues.

- Research and development
- Technology transfer
- Human resource development
- Appropriate provision of credit supply and distribution of inputs (seed, water, fertilizer, pesticide)
- Appropriate pricing policies for inputs and outputs and infrastructure.

## Doubly Green Revolution

- Increasing productivity of the major food crops
- Reducing chemical input of fertilizer and pesticides and replacing these with biologically based products
- Integrating soil, water, and nutrient management
- Improving the productivity of livestock

## CHALLENGE OF BIOTECHNOLOGY

### Definition

It is any technique that uses living organisms or parts thereof to make or modify a product, improve plants or animal or develop microorganism for specific uses.

There has been substantial development in biotechnology and genetic engineering in the

last 20 years, which offer new prospects for increased agriculture production. However while biotechnology has the potential to produce crops and livestock that are more efficient, more productive easier to produce and use less agrichemical, consumer acceptance of genetically modified foods will continue to be a challenge for global application of the results of biotechnological research.

According to recent statistics, in 1999 the global area under genetically modified crops was 40 million hectares and this is expected to 85 million hectares in 2003 (6 % of the total arable land.) The recent release of genetically modified rice called golden rice, which is rich in vitamin A, and could cure Vitamin A deficiency of 124 million children worldwide underscore the potential of biotechnology for the future.

#### In Human health

- To understand the genetic basis of diseases  
(Human Genome project) DNA sequencing & RNA data
- Early identification of predisposition to genetic disease (cystic fibrosis and breast cancer, leading to earlier detection and better treatments). Method of identifying cervical cancer, DNA vaccines. (Biochips)
- Genetically inherited diseases
- Diabetes
- Influenza
- AIDS patients
- Medical therapies
- Alzheimer's
- To develop improved diagnostics, drugs and vaccines for their treatment

#### In Agriculture and forestry

- Oral medicine
  - Herbal medicine
    - Taxol is a cancer treatment derived from the bark of a tree.
    - Active components
- It promises new ways to harness and improve ways to diagnose and control the pests and pathogens that damage them.
- Crop Improvement
- Improved diagnosis of pest and diseases
- Tissue culture /Micro propagation techniques
  - Production of healthier plants, allowing for savings in the costs of plant protection treatments
  - Uniformity of phenotypic characteristics in clones produced
  - Uniformity in production
  - Easily reproducible experimental system (hence expected results)
  - Availability of planting material year –round
  - Selection for superior quality
  - Selection for higher production

- Labour is reduced to a minimum between subculture (No weeding, irrigation, spraying, etc while in the lab)
  - Reduced time from planting to harvest
  - Earlier onset of flowering and fruiting (In Musa, Anthurium, pineapple)
- The construction of transgenic plants with improved yields, disease, pest and stress resistance, and /or nutritional quality
  - Characterizing Biodiversity
  - Identification of genetic resources containing useful genetic combination

## Bioinformatics

Research in molecular biology, genomics, sequencing, functional genomics, and comparative genetic are producing large amounts of new genomic data.

## Livestock Improvement

- Improvements in genetic potential
  - Reproduction technologies
  - Health and management practices
  - New Vaccine Delivery Systems
- ✓ In sub-Saharan Africa, animal losses due to disease are estimated to be US \$ 4 billion annually, a quarter of the total value of lives production.
  - ✓ About 73 million people will be added to the world population every year from now until 2020.
  - ✓ Demand for meat in the developing world is projected to double between 1995 and 2020.
  - ✓ World grain production will need to increase by 40% by 2020
    - ❖ Under this scenario, food insecurity and malnutrition will persist in 2020 and beyond.
    - ❖ The need to produce sufficient food for the world's population is urgent, compelling, and complementary to improving human health.

## Microorganisms for cleaning the environment

- Bioagents effective in treating waste.
- Biodegradable plastic is seen as one of green industry most promising products.
- Biological effect of decomposition

## Disadvantages

- Requirement of specialized and expensive facilities
- Skilled staff required

- Potential loss of propagules by early onset of contamination in vitro
- Precise micropropagation condition and protocols must be developed and strictly adhered to
- Requirement that techniques do not introduce genetic instability
- Relatively high cost due to facility and labour-intensive procedures  
This can be offset by large-scale production, high added value of the plantlets, and automation where possible.

## CONCLUSION

The need to produce sufficient food for the world's population is urgent, compelling, and complementary to improving human health.

## RECOMMENDATION

Research needs to respond these challenges, to improve the livelihood of the rural poor and ensure the increased availability of nutritious food at affordable prices for the urban poor.

**THE PAST, PRESENT AND FUTURE OF AGROBIOTECHNOLOGY IN THE CARIBBEAN REGION**

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**ABSTRACT:** Many small farms growing complexes of crops and animals mainly for local consumption, and a few major farms, growing mainly plantation crops for export, characterize agriculture in the Caribbean. Throughout the region, agricultural production has been falling. There is an urgent need for the application of technology, especially in terms of crop improvement. Recently, there is a quiet and growing trend towards using biotechnology to augment the more traditional breeding methods to increase crop yields. Some of the crops being enhanced include hot pepper, anthuriums, papaya, cotton, medicinal plants and even sugarcane by marker-assisted breeding and by transformation. These developments have more-or-less been happening in isolation with Cuba being the most advanced and Haiti the least. Associated with these developments has been an increasing trend towards regional networking with several attempts starting in 1990 and continuing to present. There is at the moment no regulatory/policy biotechnology or biosafety framework in the region although several Caribbean countries (15) are developing regulatory frameworks with the assistance of UNEP/GEF for eventual signing of the CBD Cartagena protocol. Several national and regional bodies e.g. IICA, FAO, CARDI, UWI, IDIAF, and specialists in several Caribbean countries are now joining forces to establish a regional agenda in biotechnology and a Consultative Group for AgroBiotechnology in the Caribbean (CGABC) whose first order of business will be to develop a regional biosafety framework and establish regional projects in agrobiotechnology. The significance of these developments will be discussed.

**INTRODUCTION**

The new millennium is as good a point as any to reflect on where we are coming from as a Caribbean people, and where we are going, as it pertains to the development of agriculture. Agriculture has always been a part of the Caribbean's development. Its modern genesis can probably be found in the large-scale plantations when sugar was "King" because before this, agriculture was at a subsistence level. Agriculture, however, if it is to serve the needs of the Caribbean people, will need to diversify and become more competitive by increased application of (bio)technology.

The Caribbean consists of many island states (24) and other countries (Belize, Guyana, French Guiana and Suriname), which traditionally are considered as part of the Caribbean. The Caribbean is considered to be a "hotspot"- an area with a large percentage of endemic flora and fauna, but with significant impactation and alteration by human activity. The Caribbean has 2.3% endemic plant species and 2.9% endemic vertebrate species on 0.15% of the earth's surface. Only 10% of the natural vegetation remains. The Caribbean "hotspot" includes most of the Caribbean islands and the southern tip of Florida spanning 263,535 km<sup>2</sup> of land and 4.31 million km<sup>2</sup> of ocean. In the Caribbean, the majority of the agricultural crops have their origin elsewhere but there are a lot of local landraces and variations. The Caribbean also has many niche crops such as pimento, ginger, hot pepper, ackee, coffee and nutmeg around which agriculture is

slowly diversifying.

## CHARACTERISTICS OF CARIBBEAN AGRICULTURE

Caribbean agriculture has characteristically been dependent on a few plantation crops e.g. sugarcane, rice and banana although the main agricultural crop differs with country (Table 1). Sugarcane still represents 27% of total crop output in the Caribbean (Mitchell and Ahmad, 2003). Most, if not all of these commodity crops are losing their preferential markets and prices are dropping (e.g. there was a 64%, in real terms, in banana prices between 1990 and 2000) while inputs and market demands are rising. Farm size in the region is characteristically small, and uncompetitive. The planting material tends to be unimproved and diseased. Soil conditions, over the years, have tended to deteriorate due to many years of monocropping without crop rotation or rest. On top of this, there have been relatively low levels of R&D applied to agriculture over the years. Where research is done, it does not get implemented as widely as hoped probably because the linkages between research, primary production, agroprocessing and markets are poor (Bauer, 2002).

Collaboration among researchers in the region has also been low and key opportunities are being missed. Technology urgently needs to be applied to agriculture if yields are to be increased. Increasingly, biotechnology is being applied to Caribbean Agriculture with promising results (Sasson, 2000). If biotechnology is to come to the service of Caribbean agriculture – all these negative characteristics of Caribbean agriculture will have to be addressed.

## AGRICULTURAL PRODUCTION IN THE CARIBBEAN

Agricultural production in the Caribbean has been dropping, when compared to our neighbours: Central America, Andes, Mexico, and the Southern Cone of South America (Figure 1). The reasons for the drop in agricultural production are many but probably include: unfavorable weather, increased disease incidences, new diseases, use of diseased planting material, and deterioration of soil conditions. A few examples will suffice. The citrus tristeza disease was reported in Jamaica from 1959 but severe strains of the virus were discovered in 1992.

The Brown Citrus aphid recently was found in Jamaica and Cuba in 1993 after migration into the Caribbean from Venezuela in 1989 (Edman and Young 1998). Ginger has been grown commercially in Jamaica since 1547 but recently, in 1995, an abnormal incidence of rhizome rot was experienced with a 30% average loss at harvest in 1997 (Chung 1998). This increase in virulent disease strains can be countered by the use of improved plant varieties; produced by conventional or marker-assisted breeding or by transformation. Cultural practices can be improved by the use of biopesticides, organic and biofertilizers and soil ameliorants. The application of biotechnology to agriculture in the Caribbean is beginning to influence productivity but there is a lot more that needs to be done.

## AGRICULTURAL RESEARCH AND DEVELOPMENT IN THE CARIBBEAN

Cuba has the most developed agricultural research and development system in the Caribbean with 60 agencies and 1500-2000 FTE (full-time equivalents) (Roseboom et al., 2001). The rest of the Caribbean has approximately 150 agencies and about 1000 agricultural

researchers conducting research in crop (56%), livestock (13%), natural resource management (14%), forestry (3%), fisheries (5%) and post-harvest (5%) production. Haiti is the least developed. Of the other 26 countries in the Caribbean - 12 had less than 10 FTE, 20 had less than 50 FTE and none had more than 200 FTE. Of the 116 agricultural research agencies that gave data, 84 had <10 FTE and 62 had less than 5 FTE. About a third of the crop research capacity in the Caribbean focuses on traditional export crops: sugar, cocoa, coffee and banana. Another third focuses on vegetable, fruits and ornamentals. The remaining third consists of a broad range of other crops. The relatively small degree of livestock research focuses on small ruminants (26%), cattle (24%), pigs (19%), animal health (13%), animal feed (9%) and poultry (9%) and has produced several tropical breeds (Roseboom et al., 2001).

Biotechnology has been used to augment more traditional Caribbean agricultural research in several key areas (CAFP, 1999; Mitchell and Ahmad, 2003). These include the following:

- Clonal multiplication - for experimental use and for production of large quantities of disease-indexed planting material (micropropagation, somatic embryogenesis)
- Characterization of biodiversity/ Bioprospecting (Molecular biology, Natural Products)
- Increased disease resistance (marker-assisted breeding)
- Biopesticides/ bioinoculants/ biofertilizers – improvement of soils, for organic agriculture
- Diagnostics for disease detection including gemini viruses (molecular biology)
- Increased genetic efficiency (tissue culture, genetic engineering)
- Bioenergy (Fermentation)
- Bioinformatics (Information gathering, analysis and dissemination)
- Biolivestock (Embryo transfer)

Although the Caribbean, as a whole, has been able to develop their agrobiotechnology to an advanced level, several problems remain:

- Uneven and Low capacity – infrastructure, human, and capital
- Low national and international investments in agrobiotechnology R&D
- Low recurrent budgets
- Very low entrepreneurial and innovation training
- IP protection low and underutilized
- Low co-ordination and collaboration between research groups
- No regional policy or regulatory framework for biotechnology or/and biosafety
- Lack of knowledge and use of regional opportunities.

## POLICIES AND REGULATIONS

Biotechnology as a whole does not need to be regulated. Marker-assisted breeding can be used to speed up conventional breeding without needing regulations. With the advent of genetic engineering, however, there are potential risks to human health (allergies) and to biodiversity (especially endemic species) – which is greater in the tropics than in temperate countries – so

there is need for regulations. In every country in which biotechnology has been applied to agriculture, regulations have been adopted. A new variety is released after assessment of agronomic performance, proximate analysis, and antinutritive factors (McHughen, 2002).

Transgenic plants are also assessed in this manner as well as by genetic analysis and biological activity of the inserted DNA including its stability, food equivalency, toxicity and allergenicity trials, yield trials and testing for environmental effects (pathogenicity to other organisms, possibility of outcrossing, gene transfer, interaction with other organisms, invasiveness, etc). Regulations also include plans for containment and eradication in the event of escape (McHughen, 2002). The best biosafety regulations allow for decisions to be made based on the most current health and ecological data.

## WHY THE INTEREST IN GMOs?

World populations are increasing and the amount of arable land is decreasing so the only way to provide enough food for the population is by increasing yields. The yields of the green revolution were achieved by application of expensive inputs and were not conducive to soil fertility. To further increase yields, the plants themselves have to be improved – by breeding, marker-assisted breeding and/or by genetic engineering. Many countries are now growing genetically engineered crops (Figure 2).

The use of genetically engineered crops has increased dramatically because farmers are experiencing greater profit margins. In 1996 there were 3 million ha of transgenic crops and by 1998 this had jumped to 34 million ha. In 1996, in the US alone, there were 15 genetically novel products on the market worth US\$380 million (Izquierdo and Riva, 2000). In 1998, there were 1,300 biotechnology companies in the US, with more than 100,000 employees. In 2003 the global area in GM crops was 67.7 million hectares, grown by 7 million farmers in 18 countries, with a global market value of US \$ 4.5 billion, and an increase of 15% in area over 2002 (James, 2003). Almost one-third of the global transgenic crop was grown in developing countries. Brazil and the Philippines approved planting of GM crops for the first time in 2003.

## PLANT GENETIC ENGINEERING IN THE CARIBBEAN

The first Genetically Modified Organisms (GMOs) were planted in Latin America and the Caribbean (LAC) without any regulations. The first regulations governing the release of GMOs into the environment appeared by the late 1980s – early 1990s in Brazil, Cuba and Mexico. In Mexico – field trials of locally-produced transgenic tobacco potato and chili pepper were authorized in 1980s, but released only in 1995. The reason for the time gap was due to concerns because of the high local biological diversity, insufficient capacity of producers to manage the transgenic crop, and the non-existence of an adequate regulatory framework (Sasson, 2000).

The Caribbean has the local capability to produce transgenic plants in Cuba, Jamaica, Trinidad and Tobago and the USVI (Sasson, 2000; Mitchell and Ahmad, 2003). Field testing of many of these transgenic crops is already being carried out while the transgenic crops in the USVI have already been deregulated (Zimmerman pers comm). The USVI and Puerto Rico, as US states, follow USDA/FDA guidelines. For the rest of the Caribbean there is no regional policy or regulatory framework for biosafety. National policies have not yet been ratified. Transgenic crops in the Caribbean:



- Cuba – sugarcane, banana, plantain, potato, papaya, tomato, corn, sweet potato, rice, coffee, citrus, pineapple
- Jamaica – papaya, cotton, tomato, pepper
- T&T – anthuriums, cacao
- USVI – sweet potato, cassava, papaya

Some introduced traits: resistance to ring spot virus (papaya), enhanced protein content (sweet potato), rust and smut resistance, modified lignin content (sugar-cane), leaf roll virus (potato), gemini virus resistance (tomato), and glufosinate-tolerance (papaya, maize) (Sasson 2000).

#### NETWORKING EFFORTS FOR A REGIONAL STRATEGY IN AGROBIOTECHNOLOGY

Every review done on Caribbean agriculture comes to the same conclusion: although enhancing the scale of agricultural research through regional cooperation and networking is not a new idea, it is one that should be pursued more intensively and with more conviction (Roseboom et al 2001). In the Caribbean, we have much to share with each other, as each country has been developing its own capabilities, often in isolation from each other. Indeed, there has been recognition of this fact, as there has been an increasing trend towards networking within the Caribbean region and this trend is continuing up to the present (Box 1).

Box 1. Regional networks and institutions relevant to AgroBiotechnology in the Caribbean.

<i>Date of inception of initiative</i>	
1942	Interamerican Institute for Co-operation in Agriculture, IICA ( <a href="http://www.iica.int/home.asp">www.iica.int/home.asp</a> ) – now in 34 member countries throughout the Americas from Canada to Chile
1948	University of the West Indies, UWI ( <a href="http://www.uwicentre.edu.jm/">www.uwicentre.edu.jm/</a> ) – three campuses and 12 centres throughout the Caribbean -- serves 15 Caribbean countries.
1975	Caribbean Agricultural Research and Development, CARDI ( <a href="http://www.cardi.org">www.cardi.org</a> ) – produced the Caribbean Agricultural Science and Technology Networking System, PROCICARIBE ( <a href="http://www.procicaribe.org">www.procicaribe.org</a> ) in collaboration with IDB, IICA and 22 member states in 1996. This includes several networks including the Caribbean Agricultural Information Service, CAIS ( <a href="http://www.caisnet.org">http://www.caisnet.org</a> ).
1990	Technical co-operation Network on Plant Biotechnology in Latin America and the Caribbean, REDBIO/FAO ( <a href="http://www.redbio.org/">http://www.redbio.org/</a> ) – 549 labs in 32 LAC countries
1991	Caribbean Biotechnology Network, CBN – directory listed 12 countries and 57 Caribbean biotechnologists (DaSilva and Taylor 1998)
1993	SIMBIOSIS ( <a href="http://www.bdt.org.br/bdt/simbiosis">www.bdt.org.br/bdt/simbiosis</a> ) – initiative of Chile – several countries using this facility. Expanded into the Caribbean in 1998.
1995	IICA Caribbean Regional Centre - <a href="http://www.agroinfo.org/caribbean/iicacarc/">http://www.agroinfo.org/caribbean/iicacarc/</a>
1996	UNU/BIOLAC – has provided 127 fellowships – 21 from Caribbean (Cuba, DR, Barbados) (Daza 1998, Sasson 2000)
1999	REDBIO-Caribbean – 15 countries, 40 Caribbean biotechnologists
1999	Increase in regional agrobiotechnology projects in the Caribbean: OAS 1999-2001 – 4 countries; CARDI Hot pepper - many countries; Gemini viruses – 5 countries

## REGIONAL STRATEGY FOR AGROBIOTECHNOLOGY

In spite of the regional networks presently in place, a regional strategy for agrobiotechnology is still needed. Even the gathering of the data presented in this paper is the result of the present effort towards developing a regional agenda. A concerted effort is needed so that present research and development can be safely utilized. There is, at the moment, no regulatory/policy biotechnology or biosafety framework in the region although several Caribbean countries (15) are developing regulatory frameworks with the assistance of UNEP/GEF for eventual signing of the CBD Cartagena protocol (<http://www.unep.ch/biosafety/>). The regulatory framework in Puerto Rico and the United States Virgin Islands as states of the USA follows USDA/FDA/APHIS guidelines. Other than these countries, Cuba has the most developed working biosafety regulatory framework in the Caribbean. A regional focus can speed up development of a regional biosafety framework (Verastegui et al., 2004, <http://www.unep.ch/biosafety/>). Such a focus will also:

- allow for a coordinated response
- increase national and regional capacity for R&D
- enhance collaboration
- allow for better data capture, analysis and relay
- allow for better planning and utilization of existing and future capacity, and
- allow for development of consistent policy and regulations

## RESPONSE TO WORLD BIOTECHNOLOGY TRENDS BY CARIBBEAN AGROBIOTECHNOLOGISTS AND POLICY MAKERS

Although there are regional agricultural institutions (UWI, IICA, CARDI, FAO) in the Caribbean, it was felt that a biotechnology focus would assist in the further application of biotechnology to agriculture to increase its competitiveness. In March 2004, a group of regional biotechnologists and policy makers, with the support of IICA, met in the Dominican Republic to discuss ways to garner support for Caribbean biotechnology and how to take the opportunity of REDBIO2004 to present a regional agenda. Analysis of previous attempts at biotechnology networking and activities in the region was carried out and key issues were discussed (Mitchell, 2004). The outcome was the commissioning of a discussion paper that was presented at REDBIO2004, under a special work section to initiate a consultation process with the participants from the Caribbean countries, including Cuba to receive their inputs on two initiatives at the draft level; an agenda on agrobiotechnology and the constitution of the Consultative Group for Agricultural Biotechnology in the Caribbean (CGABC). Once the proposals have been finished and discussed with several stakeholders at the national and regional level, they will be taken to regional governments for endorsement after a consultation process.

## THE FUTURE FOR AGROBIOTECHNOLOGY IN THE CARIBBEAN

Several national and regional bodies, as mentioned above, e.g. IICA, CARDI, UWI, IDIAF, FAO and specialists from several Caribbean countries have joined forces to formulate a proposal to establish a regional agenda in biotechnology. It is recognized that biotechnology has to serve the needs of agriculture and therefore its application has to be carefully planned within existing initiatives. Collaboration and co-ordination will encourage funding as economies of scale will be realized. It is proposed that a regional body be created to drive the above process.

The components of a regional agenda should address areas such as the following:

- Information and prospective analysis – bioinformatics, database and webpage development, networking between regional biotechnologists, e-newsletters - information capture, analysis and relay, developing networks with existing agricultural and biotechnology network and information systems.

- Policy and regulations – harmonization of biosafety conceptual frameworks, policy development, involvement of scientists in policy and trade issues, working with regional government mandates.
- Research and development – strengthening of entire science base, collaboration, critical mass of scientists, equipment, projects and discretionary funds, cutting-edge applied to pressing problems, regional projects.
- Capacity building – for S&T, R&D but also in biosafety, policy, law, commercialization, intellectual property and trade related activities, taking advantage of existing opportunities.
- Commercialization and trade – taking developed innovations to the marketplace ensuring that the benefit remains in the country with as wide a base as possible, incubator centres, bio-parks.
- Education and public perception – informing the public about safe use of agrobiotechnology, preparation of educational material: guides, programs and syllabuses.

It is proposed that a Consultative Group for AgroBiotechnology in the Caribbean (CGABC) be established to drive this regional agenda. The success of this agenda will ultimately depend on us and your support is important as we develop as a region – as a Caribbean people.

#### ACKNOWLEDGEMENTS

The present effort towards developing a regional agrobiotechnology agenda as reported in this paper represents the work of many Caribbean Biotechnologists and this paper is written in support of this collaborative effort. Key personnel assisting in this process include Arlington Chesney (IICA, Director of Operations, Caribbean Region and Advisor to the Director General on Caribbean Affairs), Enrique Alaracon (IICA, Costa Rica), Aaron Parke (IICA, Trinidad), Rufino Perez (IDIAF, Dominican Republic), Maria Perez (GEPROP, Cuba), Cyril Roberts (CARDI, Barbados), Malachy Dottin (Grenada) and Pathmanathan Umaharan (UWI, Trinidad and Tobago). The financial and technical assistance of IICA and CTA in this process is gratefully acknowledged. The author also acknowledges with thanks funding from USDA that made the trip to USVI possible and the group presentations at CFCS a success.

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Table 1. Main Agricultural Crops in seven Caribbean countries (as a percentage of total area planted in 2000). Source: ECLAC, Agricultural Development Unit, based on figures of FAO, as given in IICA and ECLAC (2002).

Country	Sugarcane	Rice	Fruit*	Corn	Root and Tubers	Citrus	Vegetables	Coffee
Bahamas	50.1	0	4.9	13.2	2.0	2.4	19.2	0
Barbados	87.7	0	1.8	7.8	0.3	0	2.4	0
Guyana	39.8	51.0	2.9	2.6	2.0	0.9	0.2	0.5
Haiti	2.7	8.4	13.6	43.4	12.2	2.0	0.2	8.7
Jamaica	46.3	0	22.0	2.1	1.7	16.4	3.7	6.1
DR	17.0	19.5	10.2	3.9	4.8	32.5	2.0	32.5
T&T	3.8	86.9	4.6	0.1	0.5	0.4	0.3	0.4

\*Fruit includes bananas

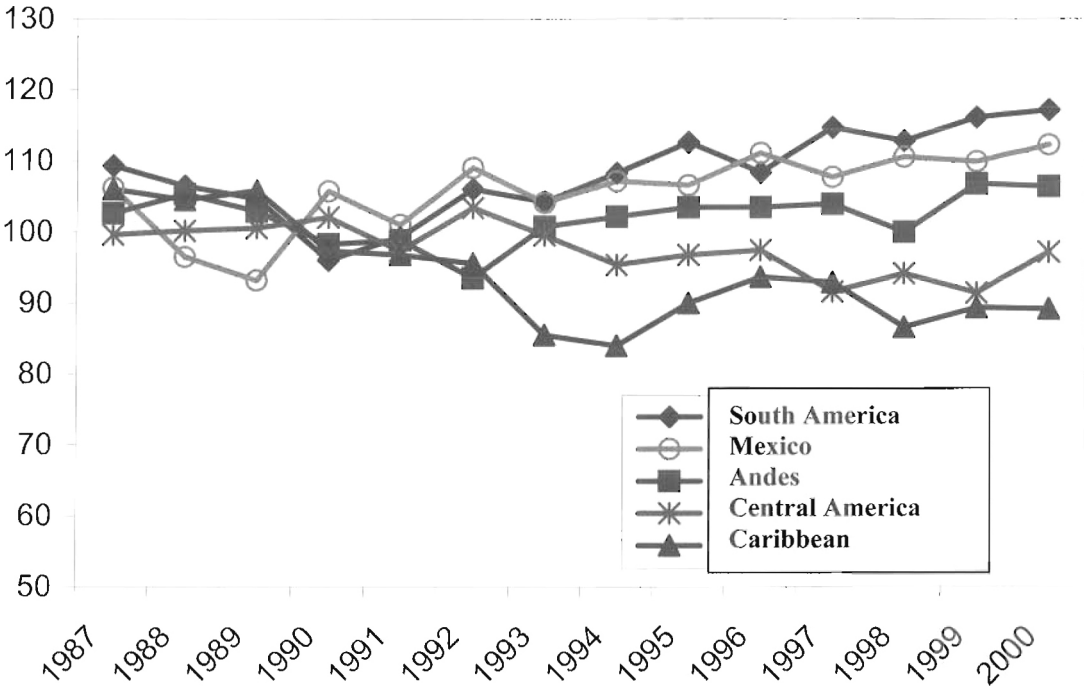


Figure 1. Agricultural production per capita - (includes cereals, root & tubers, meat, milk and eggs) Source: FAO. data, elaborated by the Directorate of Technology and Innovation, IICA

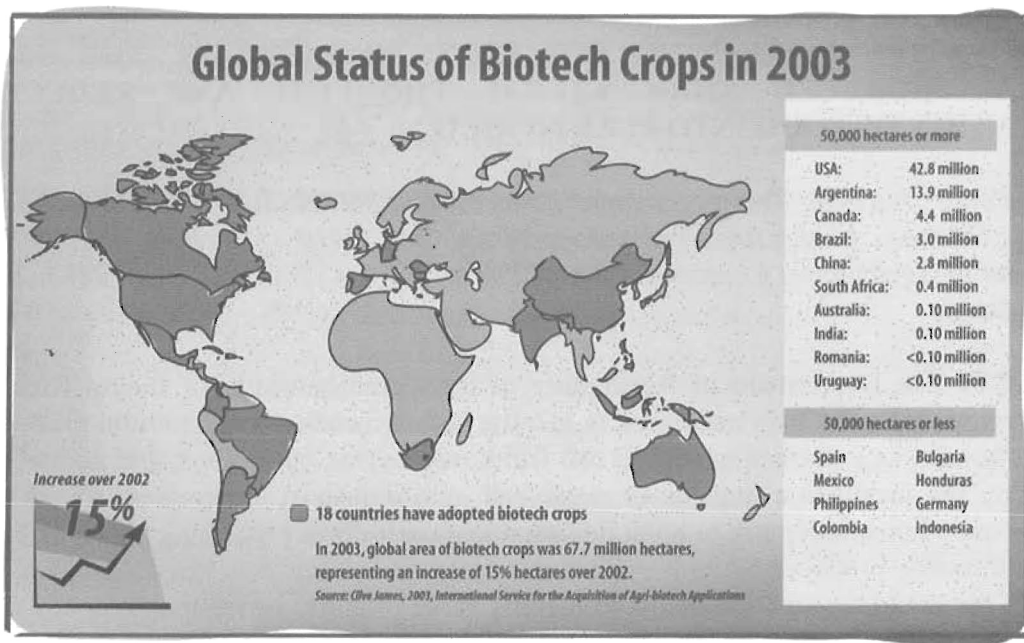


Figure 2. Global Status of Biotechnology Crops in 2003.

**AN INNOVATIVE MARKETING STRATEGY TO INCREASE THE SALE OF  
LOCALLY PRODUCED AGRICULTURAL PRODUCTS AND REDUCE THE  
IMPORTATION OF FOOD INTO PUERTO RICO**

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**ABSTRACT:** The Department of Agriculture of the Commonwealth of Puerto Rico through ASDA developed the Del País trademark to identify locally produced agricultural products. This trademark is used as a marketing tool to sell fruits, vegetables, root crops, and animal products produced by the production nucleus or organized agro-industrial enterprises. ASDA can also license the use of this trademark to bona fide producers as well as processing plants that use more than 65% of locally produced agricultural raw materials. ASDA has developed a publicity strategy to promote the brand through the media to identify these products as fresh and locally produced. The objective of this marketing strategy is to increase the Gross Agricultural Product by 20%. Over the last couple of years the school lunch program administered by the Department of Education has bought over US 25 million dollars' worth of agricultural products through the Del País brand.



**OSMOTIC DEHYDRATION OF PAPAYA USING LOW SUGAR CONCENTRATIONS**

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**ABSTRACT:** Several trials were conducted on the osmotic dehydration of papaya using a low ratio of sugar to cut fruit to produce a dried fruit product with a low weight sugar content. The trial also measured the yield of dried papaya. A range of 15%, 20% and 25% sugar as a percentage of the weight of the cut fruit was used in the process. The papaya used was at the 10-15% yellow skin stage of maturity. The process involved layering the peeled, cubed and blanched fruit with the required quantity of sugar, salt, citric acid, sodium metabisulphite and glucose for 20 hours. The papaya was drained and dried in an electric cabinet drier at 50°C for 16 hours. Results showed yields of 15.6%, 16.0% and 20.5% dried papaya respectively when 15%, 20% and 25% sugar were used in the process.

**SOME COMPARATIVE ASPECTS OF *THRIPS PALMI* KARNY AND *SCIRTOTHRIPS DORSALIS* HOOD, TWO IMPORTANT PESTS OF VEGETABLE CROPS**

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**ABSTRACT:** Density, distribution and damage pattern of *Thrips palmi* Karny and *Scirtothrips dorsalis* Hood were compared in the present study. *T. palmi* distribution extended up to South Florida, USA; while *S. dorsalis* was recently reported from two Caribbean islands, St. Lucia and St. Vincent. Both *T. palmi* and the *S. dorsalis* originated in the tropics. *T. palmi* is a major pest of all vegetable crops, while *S. dorsalis* infests vegetables, fruits and ornamentals. In vegetable crops, *S. dorsalis* commonly occur in pepper and causes significant loss of marketable yield. *T. palmi* population abundance is low on pepper with significant yield loss.

## A COMMERCIAL NEMATODE FOR MOLE CRICKET CONTROL

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**ABSTRACT:** In Puerto Rico, the name “changa” is generally applied to *Scapteriscus didactylus* (Latreille) (Orthoptera: Gryllotalpidae), the most widespread and damaging of the non-indigenous pest mole crickets in Puerto Rico. *S. abbreviatus* Scudder is also established but much less abundant. We conducted a T-STAR project to efficiently release, establish, distribute and evaluate the entomopathogenic nematode, *Stinernema scapterisci* Nguyen and Smart (Rhabditida: Steinernematidae), for controlling *Scapteriscus* spp. mole crickets. The University of Florida negotiated an agreement with Becker Underwood for commercial production of the nematode that is available as the product, Nematac®S. The “mole cricket nematode” has been used effectively to control non-indigenous mole crickets in pastures and turf in Florida since the early 1990s. It parasitizes only *Scapteriscus* spp. in nature and not indigenous mole crickets that are in a different genus, so it is safe to import and release. The level of mole cricket infection, nematode establishment and dispersal, and suppression of mole cricket populations is being quantified. This project provided data on the occurrence and life history of *Scapteriscus* spp. mole crickets and on the efficacy of the nematode product. It assisted in establishing markets for Nematac®S in Puerto Rico and will eventually help distribute the nematode across the island to maintain invasive mole crickets at non-economic levels.

## INTRODUCTION

Mole crickets were first reported from Puerto Rico in the 18th century, the result of a French expedition in 1797 that included 46 insect species. At least one mole cricket specimen was supposedly deposited in the Paris Natural History Museum but none have been located. The first species to have been reported in the 19th century was *Neocurtilla hexadactyla*, under the name *Gryllotalpa hexadactyla*. In the 20th century, Wolcott (1941) stated that the 19th century records should have referred to *Scapteriscus vicinus* and we have not found specimens of *N. hexadactyla* from Puerto Rico in museum collections. Several publications reported that *S. didactylus* (Latreille) (Orthoptera: Gryllotalpidae) arrived in guano shipped from Peru to Mayaguez in about 1850 (Barrett, 1902). Unfortunately, by 1918, economic entomologists in Puerto Rico and elsewhere in the Caribbean concluded that the name of this species should be *S. vicinus*. This name has persisted in the economic entomology literature; however, the correct name is *S. didactylus*. Castner and Fowler (1984) collected this species inland and from several locations near the coasts. *S. abbreviatus* Scudder was recorded in Puerto Rico early in the 20th century (Wolcott, 1924) but there is no indication of how it arrived. It was collected by Castner and Fowler only on the north coast, specifically Isabela, Arecibo, and Rio Piedras. *S. imitatus* was reported in Puerto Rico in the early 1980s and was thought to have been accidentally introduced about 1940. Castner and Fowler collected *S. imitatus* only at Isabela and Arecibo but apparently did not encounter *N. hexadactyla*.

In the early decades of the 20th century, Puerto Ricans blamed damage to many crops on feeding and tunneling by mole crickets, specifically the West Indian mole cricket, *S. didactylus* (Zwaluwenburg, 1918). Currently, it is the most widespread pest mole cricket in the Caribbean, called the “changa” (Nickle and Castner, 1984; Frank et al., 2002; Frank and Walker, 2003). It damages turf, pastures and certain crops, sometimes severely, and was named “the worst insect pest of general agriculture.” *S. abbreviatus* Scudder is also established in Puerto Rico but is much less abundant. There is no mention in the Puerto Rican economic entomology literature of *S. abbreviatus* or *S. imitatus*.

To control the changa, Puerto Rican entomologists imported and established a sphecid wasp, *Larra bicolor* Fab., from Brazil in the late 1930s to early 1940s (Martorell, 1939; Wolcott, 1941). They apparently did not attempt to evaluate its effect on *S. didactylus* populations. Wolcott noted the importance of a wildflower, *Spermacoce verticillata*, called botón blanco in Puerto Rico, as a nectar source for the wasp. However, nobody in Puerto Rico seems to have grown the wildflower to promote wasp populations. Accounts of damage by mole crickets in Puerto Rico declined almost to zero within a few years after the wasp was established. That might indicate effectiveness of the wasp, availability of more effective chemical pesticides, or changes in the pest status of changas. Recently, golf courses in northeastern Puerto Rico reported significant damage due to mole crickets.

The worst pest mole cricket in Florida is the tawny mole cricket, *S. vicinus* (Frank and Parkman, 1999). To control this non-indigenous species and two others in the genus, University of Florida entomologists and nematologists introduced three natural enemies originally from the pest mole cricket's source in South America (Nguyen and Smart, 1989; Parkman and Smart, 1996). One of these beneficials, the nematode *Steinernema scapterisci* Nguyen and Smart (Rhabditida: Steinernematidae), is very effective in controlling the tawny mole cricket. The other two are *L. bicolor* (Frank et al., 1995) and *Ormia depleta* (Wied.), a tachinid fly (Frank et al., 1996).

The nematode is now produced commercially and distributed in the southeastern U.S. and Puerto Rico by Becker Underwood as the biopesticide product Nematac®S (<http://www.beckerunderwood.com/labels/nematac.html>). It is being sold primarily for large-scale use on golf courses and pastures, but is available in small quantities from Gardens Alive. It is not just a biopesticide because it establishes potentially permanent populations. In Florida, it has been detected in substantial numbers eight years after release in pastures and twelve years for golf courses.

The overall goal of this project was to import, release and evaluate the effect of the entomopathogenic nematode, *S. scapterisci*, on *S. didactylus* in Puerto Rico. Specific objectives were to: 1. import the nematode into Puerto Rico, 2. release large quantities on sandy and clay loam soils, and 3. evaluate its effectiveness in controlling the West Indian mole cricket.

## METHODS AND MATERIALS

We collected mole crickets from coastal areas around the island and at inland locations using soap flushes to determine their presence and abundance (Hudson, 1989). University of Puerto Rico research stations at Fortuna, Isabela, and Lajas were also surveyed for mole crickets because they offered logistical support and security. However, since there was no clear evidence of the pests at the stations, we selected other research sites in western Puerto Rico and installed

pitfall traps to continuously monitor the mole cricket populations: Aguada, Aguadilla, Mani, San German, Playa Añasco, Playa Jobos, and Playa Joyuda. A student employee from Mayaguez could visit all of these sites within a single day. A more distant site at Jayuya was added because a resident was willing to operate one trap. The study sites represented a field planted in peanuts, one planted in tomato, three golf courses, a turf farm, a backyard with low quality turf and an occasional vegetable patch, a small organic vegetable farm, a seaside recreational area with low quality turf, and an historic site with turf. Sites with sandy soils were mostly unsuitable for research because of frequent agricultural or public disturbances. However, we applied nematodes on the organic vegetable farm twice in (Aguada) and at an irrigated golf course with clay loam soil near (Aguadilla).

The nematodes were produced by MicroBio, UK and provided by Becker Underwood, Ames, Iowa (<http://www.beckerunderwood.com>) under a use license from the University of Florida, the patent holder. The nematodes were shipped directly to the University of Puerto Rico at Mayaguez, stored for no more than one month at about 10°C, reformulated in water and released. The applications were made in November 2001, May 2002, and November 2003 by using a small truck-mounted 150-gal. spray tank or commercial spraying equipment, without irrigation, early in the morning or late in the afternoon to avoid direct sunlight. Soil conditions were almost perfect due to rain before, during and after the applications at both sites. Plot size varied at the release sites, so the number of nematodes was adjusted to 800 million per acre, the standard amount, and applied in 100 gal. of water per plot (Parkman et al., 1993). Mole crickets were captured in arrays of pitfall traps, removed and identified at 7-day intervals, and examined for nematodes.

Methods were developed for importing, shipping, storing, using, and evaluating the new nematode product, Nematac®S. USDA-APHIS-PPQ permits required to import and release the nematodes were obtained in cooperation with regulatory officials at Riverdale, Maryland and San Juan, Puerto Rico. The project provided assistance to Becker Underwood in obtaining a permit to import commercial quantities of Nematac®S into Puerto Rico. Pitfall traps were constructed and installed at each site to measure and track mole cricket populations (Hudson, 1989). We used five 0.5-acre treatment plots and five untreated plots of the same size, each with a new or reinstalled pitfall trap at or near its center. Mole crickets pitfall-trapped at each of the sites were taken alive to the laboratory, provided with food and water, and held until they died.

Mole crickets that died and contained nematodes were sent to the University of Florida for identification by Drs. Khuong B. Nguyen and Byron J. Adams. It is remarkable that none of the immature mole crickets captured and reared survived to the adult stage. At the organic vegetable site, phorid flies attacked dead mole crickets in the traps and caused rapid decomposition, interfering with the detection of nematodes.

## RESULTS AND DISCUSSION

Soap flush and pitfall trap collections produced additional distribution records and life cycle information for mole cricket species in Puerto Rico. Mole crickets trapped and identified at the release sites were *S. didactylus* (at both sites) and *S. abbreviatus* (at one site). We have not encountered *N. hexadactyla*. Zwaluwenburg (1918) studies of the life cycle of *S. didactylus* in detail and called it *S. vicinus*. These studies note that reproduction may occur throughout the year, although with seasonal peaks of activity. Life cycles of the other two *Scapteriscus* spp. have not been studied in Puerto Rico, although our work provided some data from routine pitfall

trap collections. It is unclear why captured, healthy immature mole crickets could not be reared to the adult stage in Puerto Rico. This kind of rearing is done routinely in Florida with *Scapteriscus* spp (Frank, 1994) and the diet used in Puerto Rico was supplied from Florida.

In December 2001, mole crickets trapped at both study sites were infected in the field by the released nematodes. In 2002, non-pathogenic rhabditid nematodes were obtained from mole crickets collected from six sites. Steinernematid nematodes were obtained only from the two sites where nematodes had been applied. All steinernematid nematodes were *S. scapterisci*. Thus, there is no evidence of a native steinernematid nematode capable of killing *Scapteriscus* spp. mole crickets in Puerto Rico.

Mole crickets infected with *S. scapterisci* continued to be collected from the golf course site through the end of June 2002. Persistence of *S. scapterisci* for over seven months at the golf course site suggests that a population did become established. Research from Florida showed that the nematode is not likely to persist for more than 10 weeks in the soil without passing through host mole crickets. Thus, we have shown that *S. scapterisci* infects and kills *S. didactylus* mole crickets in Puerto Rico.

Nematode applications on the organic vegetable farm failed to achieve establishment twice. Subsequent laboratory studies confirmed very poor survival of the nematodes in that soil. The soil had been enriched with compost to achieve a 6% level of organic matter and probably supported bacteria or fungi antagonistic to the nematodes. One of the sites with clay loam soil also proved unsuitable for the nematodes because it was not irrigated and the mole cricket populations were inconsistent. We are continuing to monitor mole crickets and their nematode infection levels in Puerto Rico. The effect of soil type on the survival of mole cricket nematodes is also being studied.

We have generated significant information that is needed to use biological control for managing pest mole crickets in Puerto Rico. Nematac®S kills West Indian mole crickets and the nematodes persist in irrigated clay loam soils. We also have begun to evaluate the impact on mole crickets of the wasp, *Larra bicolor*. Certainly, the mole cricket nematode can function as an effective natural enemy in Puerto Rico and elsewhere in the Caribbean.

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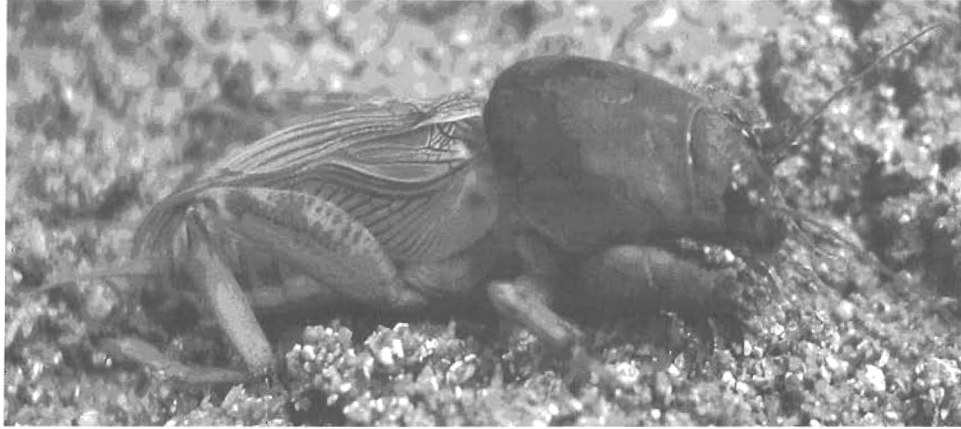


Figure 1. *Scapteriscus didactylus*, the "West Indian mole cricket" or "changa," is thought to have arrived in the West Indies by flying from South America hundreds of years ago (photographed by Luis Collazo).



**CHEMICAL COMPOSITION, IN SITU DEGRADABILITY AND INTAKE OF FORAGE SOYBEAN (*GLYCINE MAX*) AND LABLAB (*LABLAB PURPUREUS*)**

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**ABSTRACT:** Forage soybean (FS; *Glycine max*) and lablab (LL; *Lablab purpureus*) are fast growing legumes with potential to replace alfalfa hay in diets of growing small ruminants. However, the nutritive value of FS and LL conserved as hay has not been documented. The objectives of this study were to determine the chemical composition, in situ DM and NDF degradability, and intake of FS and LL. Both forage species were baled at approximately 20% DM. Triplicate samples (500 g) from each forage were analyzed to determine DM, OM, IM, CP and cell wall components (NDF, ADF, hemicellulose, and ADIN) using standard procedures. Data were analyzed using the ANOVA procedure of SAS and mean separation was conducted with LSMEANS. The in situ degradability study was conducted in a fistulated cow maintained on a grass diet utilizing the suspended nylon bags technique. Triplicate samples of each forage species were incubated after 0, 3, 6, 24 and 48 hrs and analyzed for rate of degradation and DM and NDF disappearance. Data were analyzed using the non-linear model; Degradation =  $a+b*(1 - \exp(-c*t))$ , where; a = soluble fraction, b = degradable fraction, c = rate of degradation, and t = time. Forage intake was determined using 8 post-weaning Boer goats (average 17.71 kg BW). Each forage species was offered as unique diet at 3% of animal LW daily. Goats were fed with legumes (2-d adaptation) and 4-d collection period in a cross-over design with 4 animals per treatment. Forage DM intake data were analyzed using the ANOVA procedure of SAS and mean separation conducted with the Bonferroni t-test. As expected, OM, IM and CP content was similar for both legume species. However, NDF and hemicellulose concentration were lower in FS than in LL (35.74 and 16.05 vs. 46.61 and 32.44%), and hemicellulose and ADIN values were higher (19.70 and .62 vs. 14.16 and 41%). Ruminal DM degradation rate (kd's) was faster in FS (.03) than in LL (.05), but NDF kd values were similar for both forage species (.09). After 48 h of incubation, in situ dry matter disappearance was higher in FS (73.21%) than in LL (59.2%). Hay intake (FS = 439.9 and LL = 428.9 g/d) and intake as % of animal live weight (FS = 2.49, LL = 2.42 %) were similar. Both FS and LL differ in chemical composition and in situ DM degradability rate and disappearance, but forage intake was similar. Forage soybean and LL have potential to replace alfalfa hay in the diet of small ruminants.

**WEED MANAGEMENT ON PERENNIAL PEANUT ESTABLISHMENT**

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**ABSTRACT:** During establishment, perennial peanut (*Arachis glabrata*) is a poor competitor against weeds, a situation that results in rapid weed invasion, low commercial yields and increased production costs. In the absence of registered herbicides, farmers have to rely on hoe weeding, a costly management strategy. The objective of this study was to develop weed control strategies to be used during perennial peanut establishment. Imazethapyr and dimethanamid were used in preemergence applications, whereas clethodim and bromoxynil were used in postemergence applications. Weed composition and density were determined at six and 12 months after planting. Preliminary results indicated that dimethanamid at the highest rate was phytotoxic to perennial peanut accession no. 17095.

**GROWTH RESPONSES UNDER EXTENDED DAYLENGTH OF TROPICAL FORAGES IN ST. CROIX AND PUERTO RICO**

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**ABSTRACT:** Favorable effects of extended daylength on growth of tropical grasses have been found during winter months in subtropical locations. However, the magnitude of this response at lower latitudes either in winter months or year-round has not been explored. A long-term study was initiated in St. Croix (University of the Virgin Islands) and Puerto Rico (Gurabo Research Station) as part of a multi-location research to describe growth responses of tropical grasses 'Pensacola' bahiagrass (*Paspalum notatum*; BG), 'Tifton-85' bermudagrass (*Cynodon dactylon*; T-85), and 'common' guinea grass (*Panicum maximum*; GG). These grasses were planted in July 2002, exposed to 15 h daylength and their rate of establishment was compared. Grasses in St. Croix were slower to establish, compared to grasses grown in PR. Across locations decumbent-growth grasses (BG and T-85) showed sensitivity to daylength but bunch-growth GG did not. Tifton-85 spread faster than BG at both locations. But full spread of planted area was reached earlier for non-exposed plants than those under extended daylength.

**MORPHOLOGICAL CHARACTERISTICS AND GROWTH OF *PANICUM MAXIMUM* CVS TOBIATA, TANZANIA AND MOMBASA IN SOUTHWESTERN PUERTO RICO**

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**ABSTRACT:** High quality forages are needed to support the livestock industry in Puerto Rico. Except for local guineagrass (*Panicum maximum*), little information is available on newly released cultivars (i.e., Tanzania and Mombasa). A study was conducted at the Finca Alzamora of the University of Puerto Rico, Mayaguez Campus. Seedlings (6-wk) of Tobiata, Tanzania, and Mombasa were planted in plots (2m x 4m) in a Consumo soil (Fine, mixed, semi-active, isohyperthermic Typic Haplohumults). After uninterrupted growth for a period of 6-wk, plants were clipped and tillers counted on individual marked plants. Subsequent harvest (dry matter; DM), plant height, and tiller counted from permanently marked plants at 28-d intervals were recorded. At first harvest plant height differed ( $p < 0.05$ ). Plant height of Tobiata, Tanzania and Mombasa were 1.3, 0.8 and 0.60 m, respectively. There were also differences in amount of tillers ( $p < 0.05$ ). Amounts of tiller were 9, 15, and 32 for Tobiata, Tanzania, and Mombasa, respectively. Dry matter yield of Mombasa (92 g/plant) was twice the yield of Tobiata (38 g/plant) and Tanzania (46 g/plant). The high tiller and dense canopy of Mombasa indicates its potential for faster establishment than the other cultivars. Growth habit influence on nutritive value will be discussed.

**PHENOLOGY AND YIELD PERFORMANCE OF GINGER (*ZINGIBER OFFICINALE*)  
IN THE NORTH-WEST COASTAL ZONE OF PUERTO RICO**

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**ABSTRACT:** Ginger (*Zingiber officinale*) is a crop of great potential for the export market and an alternative for small farmers throughout the Caribbean region. In Puerto Rico it is a minor crop, concentrated mostly in the mountain region, however its production can be extended to other regions if irrigation and adequate fertilization practices are implemented. A field experiment was conducted at the north-west coast of the island to evaluate nitrogen fertilization levels applied by fertigation. Four nitrogen fertilization rates, 0, 90, 180, and 270 kg/ha were evaluated. Potassium and phosphorus were applied at a rate of 180 kg/ha. Nitrogen fertilizer was applied at 2, 6, and 8 months after planting. A randomized complete block design with four replications was used. The sample consisted of five plants per plot. Monthly data on leaf and rhizome fresh and dry weight, and yield were collected. Plant emergence was observed at two months after planting. Plant maturity and flowering was observed at six months after planting, two months ahead of the usual maturity time in the mountain region. The highest rhizome fresh weight was attained at seven months after planting. The 0 treatment yielded 3.85 kg/sample, the 90 kg/ha treatment yielded 8.26 kg/sample, the 180 kg/ha treatment yielded 7.11 kg/sample and the 270 kg/ha treatment yielded 6.91 kg/sample. The 180 kg/ha treatment outyielded significantly the 0 treatment during harvesting, however no significant difference was observed among the other treatments.

**PRELIMINARY STUDIES ON THE INFLUENCE OF CARBOHYDRATE  
CONCENTRATION ON CASSAVA GROWTH IN VITRO**

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**ABSTRACT:** Cassava line TMS 60444, which has been used in cassava transformation, was grown under varying sucrose concentrations in vitro. Nodal segments from the cassava were grown on agar gelled Murashige and Skoog salts and vitamins and supplemented with 0, 1, 2, 4, or 6% sucrose. Shoot growth and development were monitored over a five-week period. Sucrose levels of 2% and 4% produced the most active growth and tallest plants. Plant internodal length and leaf size were reduced at the 6% level. This was attributed to the increased osmotic potential of the medium. The elevated sucrose concentration should allow more carbohydrates to be stored in the plant tissue for it to draw on as it becomes photoautotrophic. Though the growth rate was reduced at the 6% sucrose level, the plants may be more adapted to acclimatization ex vitro.

**EXPOSING JUNIOR HIGH STUDENTS TO PLANT TISSUE CULTURE THROUGH AN AFTER-SCHOOL PROGRAM**

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**ABSTRACT:** The 4-H program has historically had its roots in agriculturally related projects. However, the organization has evolved to meet the needs of today's world by offering enrichment programs in areas such as computers and technology in addition to traditional agriculture and home arts. The St. Croix Leatherback Clovers 4-H Club, organized under the auspices of the UVI-CES 4-H program, offers a Biotechnology Project group that is open to junior high and high school students. This club exposes the students to a variety of protocols relating to plant tissue culture. Some of the activities include building DNA models, DNA extraction and purification and aseptic technique. Although some of these activities used special equipment, most of the projects can be done using regular household equipment and supplies. Through these activities, the students are augmenting the knowledge they obtain in school and are also fulfilling the 4-H goal of learning by doing. This program is also exposing students to careers in the fields of plant tissue culture and molecular biology, areas which will continue to relate more and more to plant sciences.

**INTAKE OF FISH BY-PRODUCT SILAGE AS A PROTEIN SOURCE IN THE DIET OF GROWING GOATS**

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**ABSTRACT:** In Puerto Rico, alternative protein sources in diets of growing goats are needed because of the high cost of commercial concentrate (CC). Fermented fish by-products (silage) have been utilized effectively in cattle and sheep as protein supplements. However, there is limited information about the acceptability (intake) of fish by-product silage (FBS) by goats. The objective of this study was to evaluate the intake of FBS by growing goats with grass hay (GH) as a basal diet. Eight growing meat goats (Boer goats) were assigned to two experimental treatments; GH supplemented with FBS (T1), and GH supplemented with a commercial concentrate (T2). Treatments were formulated to be isoproteic (10% PC) and were offered at 4% of the animal live weight. Goats were fed for 2-d (adaptation period) and 5-d of data collection. A crossover experimental design was used with four goats per treatment in each period. Data were analyzed using analysis of variance of SAS. Total feed intake was higher ( $P<.05$ ) in goats consuming GH and CC (551 g/d) than GH and FBS (394 g/d). Grass hay intake was lower ( $P<.05$ ) in T2 than in T1 (254 vs. 327 g/d), but supplement intake was higher (297 g of CC/d vs. 66 g of FBS/d). Total dry matter intake as percentage of animal live weight was also higher ( $P<.05$ ) in goats consuming the GH and CC diet (3.04%) than animals under the GH and FBS (2.16%) feeding regime. In summary, even though the intake of diets containing FBS was lower than diets with CC, goats consumed FBS as a significant portion of their diets. The fermented by-product is an alternative protein source in goat nutrition.



**SOIL COMPACTION AND PASTURE GROWTH UNDER INTENSIVE GRAZING**

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**ABSTRACT:** A study was conducted to investigate soil physical properties in intensively grazed pastures, and response of pasture to various soil loosening techniques. Soil bulk density, water retention and saturated hydraulic conductivity were measured on core samples taken under the fence row and in adjacent heavily trampled pasture at six sites. The pastures were generally not excessively clipped by grazing so that good ground cover was maintained. We found that soil was generally less dense and more permeable, and contained more drainable porosity, under the fence row compared to the heavily grazed areas. At three of these sites, pasture response was evaluated under three soil loosening techniques: paraplow, tine aeration, and tine aeration with soil removal. Pasture response, relative to untilled plots, was not significant. To help explain these results, we measured water infiltration through areas where grass stems emerged from the soil, and in areas where no grass stems emerged. We also measured soil compactibility by dropping a Klegg impact hammer on grass-covered areas and on adjacent bare soil. Water infiltration was greater, and compactibility was less, in the grass-covered areas. Thus, maintaining good pasture stands may act as self-protection against excessive soil compaction under intensive grazing.

**THE INTERNATIONAL SOCIETY FOR TROPICAL ROOT CROPS (ISTRC) – A CARIBBEAN BRANCH**

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The International Society for Tropical Root Crops (ISTRC) was established in 1964 as an autonomous, non-governmental body, after a group of researchers within the University of the West Indies (UWI) in Trinidad and Tobago, conceptualized holding a series of crop-orientated symposia. In view of local relevance “Tropical Root Crops were selected as the first topic. In April 1967, one of the first ever formal meetings on tropical root crops was held at the St. Augustine Campus of the UWI. The benefits were so apparent that there was unanimous call for the formation of an organization to continue such meetings. In 1970 the ISTRC was formally adopted as a legal entity and from that time on has held triennial symposia. The 1970 constitution was revised and replaced in 1985. Establishment of the ISTRC has led to the establishment of World Regional Branches such as the African Society for Tropical Root Crops and the Indian Society for Tropical Root Crops as affiliates. Linkages have also been established with three International Agricultural Research Centers, training and extension Institutions. In an attempt to rekindle and strengthen the Caribbean Branch and possibly have a session designated solely to root crops at the 41<sup>st</sup> CFCS meeting, the Society has decided to promote itself, and in so doing, presents a brief history of the society, its goals and objectives, the crops of focus, its membership, an explanation as to how the executive council functions, the Society Publications and the formation of Regional Branches.