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"Education, Productivity, Rural Development, and Commercialization in the XXI Century"

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AGRICULTURAL PRODUCTS DIFFERENTIATION AN ALTERNATIVE FOR AGRIBUSINESS FOR THE CARIBBEAN AREA: COFFEE DIFFERENTIATION BY ORIGIN

Carmen Alamo, Department of Agricultural and Applied Economics, Texas Tech University, Lubbock, Texas, USA, and University of Puerto Rico

ABSTRACT: The objective of this study is to analyze the differentiation of agricultural commodities as an alternative for farmers in the Caribbean region to increase their competitiveness and profitability in the global market. The results of the demand analysis of coffee differentiated by origin in US will be presented as a case study. The agricultural product differentiation is a direct result of marketing strategies that pursue the increase of product consumption, price, and profits. When homogeneous commodities are transformed into differentiated goods, unique heterogeneous products are offered to consumers. The differentiated goods are best described as close but imperfect substitutes. They perform the same basic functions but have differences in attributes such as type, style, quality, reputation, appearance, and location that tend to distinguish them from each other. The transition from commodity to a differentiated product changes the market structure from a perfect to a monopolistic competition model. Product differentiation leading to differences in prices and market shares are explained by Chamberlin's theories of monopolistic competition and Dixit and Stieglitz's "love for variety". These theories suggest that if a firm produces a product that is distinct from others of the same type and if consumers are better off with added varieties, market power takes place allowing the firm to set the price that will determine its market share. In coffee, the major differentiation process has been the development in association with type, quality, reputation, and denomination of origin. A demand study for differentiated coffee in the United States found that regular and differentiated coffee demand parameters behave as different products (Alamo, 2012), where the coffee differentiated by origin exhibited higher prices than regular coffee. The own-price elasticities, quantity consumed in response to price changes, are also higher than in regular coffee. In the Caribbean, Jamaica Blue Mountain coffee has a successful differentiation by origin charging one of the highest prices in the market. Product differentiation has been undergoing for all types of food and beverage products. For instance, the Caribbean countries and Mexico have been successful in the differentiation by country of origin of rum, tequila, and beer. The Caribbean agricultural production profile overall is characterized by small farm operations with high production cost, and limited and costly land. This profile makes the production of land intensive commodities a challenge, and raises the need for other options. The differentiation of agricultural commodities may be considered as an alternative for farmers in those countries to increase their competitiveness and profitability in the global market. Joint efforts of the production, processing, and marketing sectors are needed to identify products, potential markets, and design differentiation strategies. Joint ventures between the private and public sectors are needed to provide the logistics for identifying potential markets, and marketing strategies, and to provide farmers and processors with the educational and technical tools for a reliable access to markets.

Keywords: Differentiation, origin, coffee, demand, Caribbean

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CARICOM AGRICULTURE TRADE PERFORMANCE RELATIVE TO CANADA – *EX POST AND EX ANTE*

Govind Seepersad, Nkosi Felix, Ranjit H. Singh, and Randel Esnard, The University of the West Indies

ABSTRACT: Preferential agreements are often signed to improve relations of signatories through improved trade of products, services and the movement of citizens. These are accomplished through the removal of trade barriers, such as tariffs, through the facilitation of consultancy services and improvement in policy to encourage Foreign Direct Investment. Further, with the recent signing of the EU/ CARIFORUM Economic Partnership Agreement, the Region's policy makers are now questioning the benefits of trade agreements and are looking at areas where greater focus should be placed. It has been approximately 26 years since the CARIBCAN agreement has been signed. Given the promised benefits of preferential agreements, there should have been better performance in many product sectors which would allow for greater economic growth in the signatory countries. This paper analyzed the economic impact of the CARIBCAN Agreement between Canada and selected CARICOM member states. The industries of Meats, Grains, Fruits and Vegetables were analyzed to assess the agreement's impact on trade. The study used four trade indicators: (i) Revealed Comparative Advantage; (ii) Regional Orientation; (iii) Trade Intensity; and (iv) Trade Complementarity for the analysis. The results include the performance trends during the period 2001 to 2010, showing changes to trade and identified gains and losses to partners. Recommendations of the study can be used to inform future trade agreement negotiations and provide amendments to those currently engaged to ensure greater benefits. The study found:

(i) CARICOM Comparative advantage increased for HS 0306 Crustaceans for the period 2001/10.
(ii) Regional bias was found to be the highest in the trade of HS0302 Fish, fresh or chilled, to Canada.
(iii) Trade Intensity from CARICOM to Canada was highest in the product groups of HS 0714 Manioc, arrowroots and salems (yams) and HS 2208 Spirits liquors.
(iv) Potential for the export of HS 0302 Fish, fresh or chilled, and HS 0306 Crustaceans remained high during the years 2001/10, indicating that CARICOM did not take advantage of this market's demand.

Keywords: Intra-industry Trade, Vertical Intra-industry Trade, Horizontal Intra-industry Trade, Trade Negotiation, Preferential Agreements, CARIBCAN, CARICOM

INTRODUCTION

The CARIBCAN (CARICOM-CANADA) agreement is a unilateral extension by Canada of preferential duty-free access to the Canadian market. The agreement was introduced by the Government of Canada during the 1985 Commonwealth Heads of Government Conference in Nassau Bahamas, to grant Caribbean Countries trade development assistance. Beneficiaries to this agreement include Anguilla, Antigua-Barbuda, Bahamas, Barbados, Belize, Bermuda, the British Virgin Islands, the Cayman Islands, Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts

and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, and the Turks and Caicos Islands.

The major objectives of the CARIBCAN agreement include:

- To enhance Commonwealth Caribbean trade and export earnings
- Improve the trade and economic development prospects of the region
- Promote new investment opportunities; and
- Encourage enhanced economic integration and co-operation

Canada employs a series of import and export controls to manage its supply and demand situation. Import controls are in place for fish, refined sugar, sugar-containing products and peanut butter. In addition, there are management regimes to regulate the supply and prices farmers receive for their poultry, turkey, eggs, and milk products. Further, Tariff Rate Quotas (TRQ's) are in place for dairy, chicken, turkey, and egg industries, as well as pork, margarine and cut roses and a range of vegetables (OTN 2010). Additionally, entry into the Canadian market with fishery products faces very low or zero tariffs; however, there is a high SPS regime for fish, high taxes and controls for tobacco, and the Government directly controls the importation and sales of alcoholic beverages.

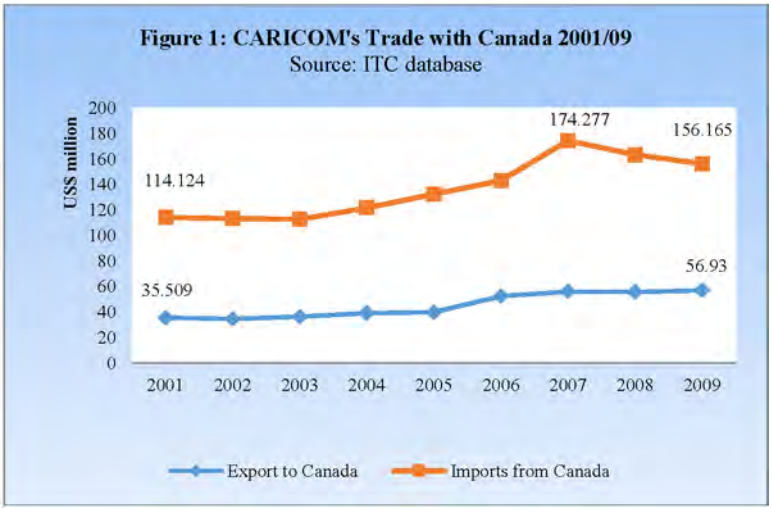
The Rules of Origin (RoO) is another measure which can be used to limit imports into Canada. Under the agreement to qualify for the duty free treatment accorded to Commonwealth Caribbean countries, at least 60% of the ex-factory price of the goods as packed for shipment to Canada must originate in one or more beneficiary countries or Canada. The 60% qualifying content may be cumulated from various CARIBCAN beneficiary countries or Canada. The structure of most CARICOM states restricts the production of competitive products given the high costs of raw materials and therefore limits the market presence of CARICOM products in Canada. In addition to RoO, tariffs are imposed by Canada along with products standards to prevent or limit the movement of harmful products.

Within the agricultural products category, the highest tariffs are placed against imports of Dairy products (237%), Live animals and products thereof (52.7%), Beverages and spirits (8.3%) and Fruits and vegetables (4.8%). The country employs these highly protective regimes, justified on the basis of rural integrity, food security and protection of the health of its populace. Thus, in addition to tariffs, dairy and poultry products are protected through TRQs, SPS and supply management schemes. Where entry is tariff free, as is the case of fish and some processed meats, SPS regulations and ISO standards are applied. The effect of the tariff quotas is the same as the quotas because the over-access tariff rates are very high.

Given the stipulations put in place by Canada, entry into the market can be seen as somewhat difficult, but with a trade agreement signed between Canada and CARICOM, was there any benefit to trade? This paper seeks to quantify the result of the CARICAN agreement through analyzing trade between both partners from 2001 to 2010.

BACKGROUND

The exports of agricultural products from CARICOM to Canada increased from US$35 million in 2001 to US$57 million by 2009 (Figure 1). However, agricultural imports in 2001 were valued at US$114 million which showed a steady increase until 2007 (US$174 million), after which it experienced a slight decrease, ending at US$156 million in 2009 (Figure 1). This revealed an unequal movement in trade between CARICOM and Canada, and also indicated an imbalance in the flow of trade revenue. Although, during the years 2001 to 2010, CARICOM gained a 58% increase in trade value compared to Canada's 36%. The dollar value of Canada's exports to the region was found to be 100% greater than CARICOM's exports to Canada.



These initial findings could suggest that there was little growth in the export of agricultural products to Canada from CARICOM. This could have been the result of the highly protective regimes of Canada, such as SPS and ISO standards which prevent trade of these agricultural products.

METHODOLOGY

For this study trade data was acquired using the International Trade Commission (ITC) database for the period 2001-2010 for one product of the focus groups. Using four trade indices this data was analyzed to access the impact of the agreements with CARICOM and its trade partners: Costa Rica and the Dominican Republic.

Selection of focus groups

For this study agricultural products were separated according to the harmonization system codes (Foreign Trade 2012), which are (i) animal and animal products, (ii) vegetable and vegetable products, and (iii) food stuff. The harmonization (hs) groups were disaggregated to the 4 digit level and the main exported groups in 2001 from CARICOM to Canada were identified. This disaggregation would reduce the possibility of smoothing and therefore allow for an increase in the accuracy of the results. This was done by ranking the value of goods exported, since this represented the economic return to trade and thus possibly the benefit of FTAs. Following this selection method, four trade indices were used for the analysis, which are as follows:

Revealed Comparative Advantage (RCA)

The ***Revealed Comparative Advantage (RCA)*** provides the analysis of one country's exports share in relation to that of the world, and therefore can be used to identify positive or negative changes in export profile. Countries with high RCA are considered to be competitive and export to countries with lower RCAs. Further, countries which experience similar RCA are unlikely to have high bilateral trade intensities unless intra industry trade is involved (Chandran, 2012).

The RCA would provide an indication of how CARICOM's competitiveness in the respective markets changed over time as the result of the FTA. Did the FTA improve comparative advantage given the measures which were agreed on in the aim to improve trade? This index would also allow policy makers to identify which agreement yields the highest benefit, which would guide future trade negotiations.

It is denoted by the formula:

$$\mathbf{RCA_{ij} = (x_{ij}/X_{it})/(x_{wj}/X_w)}$$

Where: x_{ij} = values of country i's exports of product j; x_{wj} = world exports of product j; X_{it} = the country's total exports; X_{wt} = world total exports

A value greater than unity will suggest a revealed comparative advantage, whereas a value less than unity shows a Revealed Comparative Disadvantage.

Regional Orientation Index (ROI)

To identify the concentration of the CARICOM's exports to the markets of Canada the ***Regional Orientation Index (ROI)*** was used. It is used to identify if any bias exists between countries which would indicate greater benefits if those countries were to enter into a FTA. This index tells us whether a country's exports of a product are more oriented toward a particular region than to other destinations (Plummer et al., 2012). Denoted by the formula below it represents the ration of one country's exports to a country of interest to that of that country's exports to the world.

If regional bias increased this would support the creation of future FTA since imports would be redirected to economies where CARICOM producers would benefit given the cost of entry into those markets. This index would also allow the comparison with the RCA, in such a way to identify if exports to a region did indicate some bias. This would be due to the increase in trade competitiveness with an increase presence in one particular market, illustrating gains in trade due to FTA measures.

The formula for the regional orientation index is:

$$\mathbf{ROI_{ij} = (x_{cgr}/X_{cr})/(x_{cg\text{-}r}/X_{c\text{-}r})}$$

Where: x_{cgr}= exports of good g by country c to region r; X_{cr}= total exports of country c to region r; $x_{cg\text{-}r}$= exports of good g by country c to countries outside region; $X_{c\text{-}r}$= total exports of good g to countries outside region r

If the index has a value greater than 1, this implies that the country has a regional bias in exports of the product. Conversely, if the index is less than 1, then the country has no regional bias.

Trade Intensity Index (TI)

The ***Trade Intensity Index (TI)*** was used to measure the level of trade between CARICOM and the respective FTA partners. It is used to determine if the value of trade between two countries is larger or smaller than expected based on their importance in world trade. It simply measures the share of trade between a region and a trade partner as a ratio of the region's total trade share in world trade.

The installments of FTAs are primarily designed to increase trade through the reduction of trade restricting measures with the partner markets. In most cases one partner tends to benefit more, therefore, this indicator would show if exports increased at opposed to non FTA partners, but would also allow further research to be conducted into the reasons for any reduction in trade. Identified areas of the export structure would then be addressed with the aim to increase TI given the presence of such FTAs.

The index is found using the following formula:

$$\mathbf{T_{ij} = (x_{ij}/X_{it})/(x_{wj}/X_{wt})}$$

Where: x_{ij} = the values of country i's exports; x_{wj} = world exports to country j; X_{it} = a country i's total exports; X_{wt} = total world exports.

A value greater than unity indicates larger trade flows than might be expected, which is trade intensity. It has also been found that higher values are more favorable to an FTA.

Trade Complementarity Index

To identify what occurred with the potential for trade, i.e. if potential increased or decreased during the study period. The ***Trade Complementarity Index*** is designed to measure compatibility of trade profiles. It summarizes certain aspects of the sectoral trade pattern. This index measures the degree to which the export pattern of one country matches the import pattern of a region.

This index is initially used in identifying potential FTA partners but would also assist in assessing if the formation of FTAs increases the potential for trade or vice versa. In addition, using this index compared with the TI would provide an indication if the FTA created would provide net trade. If there is low trade intensity but high complementarity net trade would be possible since there is potential to trade. This analysis would allow the investigation of such trade arrangements to address the reasons why CARICOM is not maximizing the utility of the FTA.

The formula for the complementarity index is:

$$\mathbf{C_{cgr} = 1 - ((|(M_{rg}/M_r)-(X_{cg}/X_c)|)/2) \times 100}$$

Where: M_{rg}= imports of good g by region r; M_r = total imports of region r; X_{cg}= exports of good g by country c; X_c = total exports by country c

The index takes a value between 0 and 100, with 0 indicating no overlap and 100 indicating a perfect match in the import–export pattern, i.e. potential for trade.

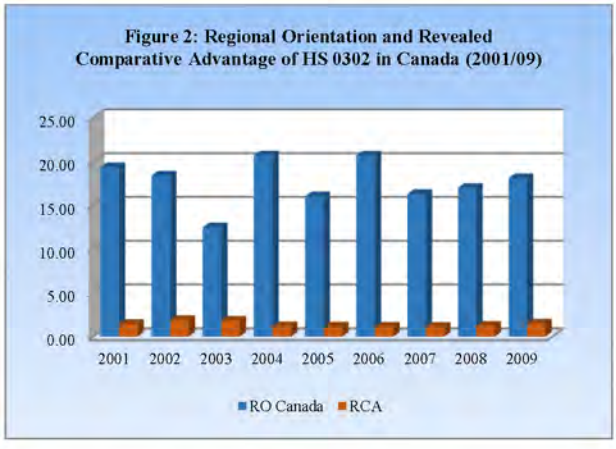
RESULTS AND ANALYSIS

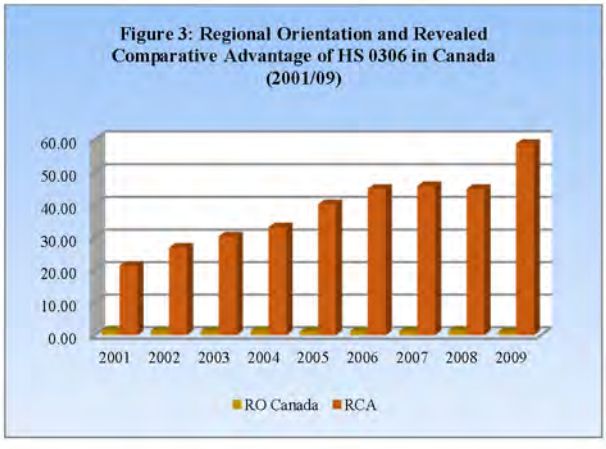
CARICOM and Canada: Revealed Comparative Advantage and Regional Orientation

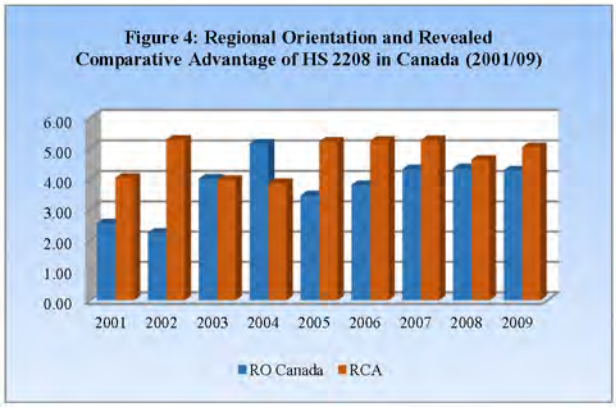
Further examination was done to help explain if there exist any other driving forces for the low trade intensities and the reduced performance. The result show:

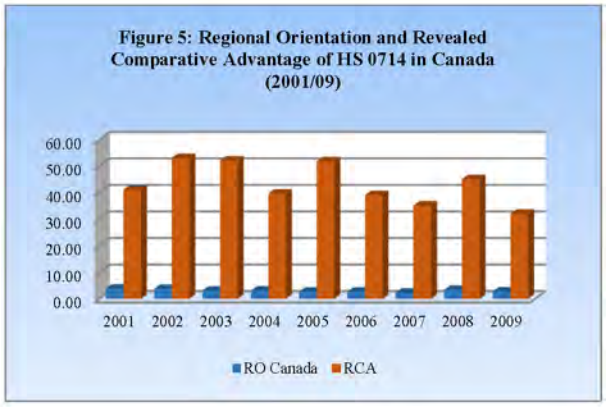
(i) There were no major changes shown except for an increase in RCA of HS 0306 Crustaceans, but regional bias did not increase during the period (Figure 3).

(ii) Regional bias was found to be the highest in the trade of HS 0302 Fish, fresh or chilled, with Canada but were low in HS 0306 Crustaceans and HS 0714 Manioc, arrowroots and salems (yams) (Figures 2 – 5).









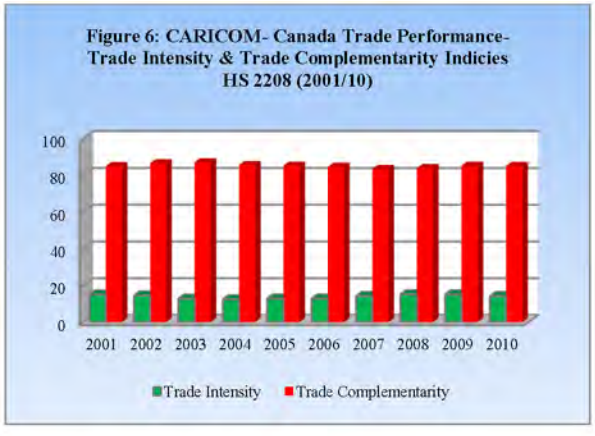
CARICOM and Canada: Trade Intensity and Trade Complementarity Indices

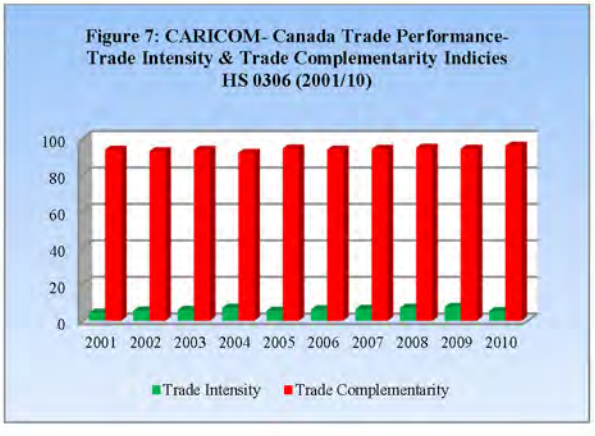
The study examined the major trading commodity between CARICOM and Canada. The results show:

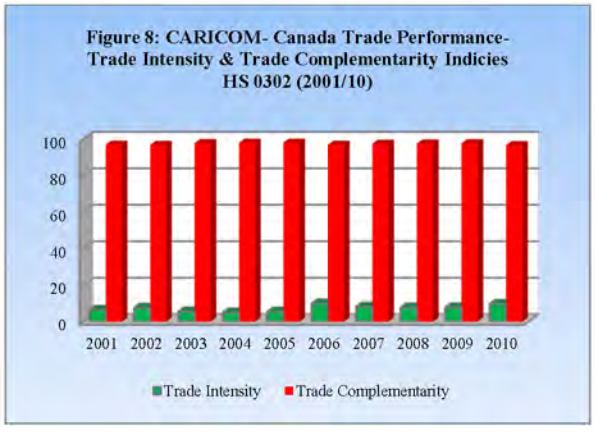
(i) Trade Intensity index was high for HS 0714 Manioc, arrowroots and salems (yams), and HS 2208 Spirits, liquors, but lower in the relationships for HS 0306 Crustaceans and HS 0302 Fish, fresh, whole (Figure 6-9).

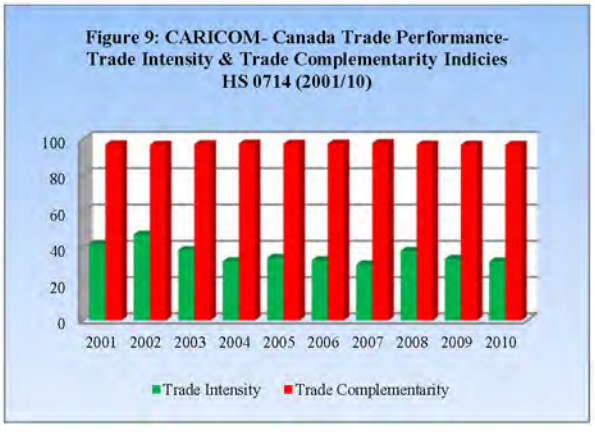
(ii) The trade performance displayed less of decline as the years' progressed which may have been due better developed freight transportation, longer trading / business relationships, traditional business and a better understood business culture – the two recent agreements and differences in language and cultures may have frustrated the process.

(iii) The commensurate high complementarity indices also suggest that there is potential for trade creation and high inter-industry trade. It is well known, however, that there exists a large number of NTB's that substantially limits trade in the Canadian market.









CONCLUSION: Picking up the Pace

This section presents a synthesis of the major findings: the CARICOM-Canada (CARIBCAN) agreement was assessed and provided recommendations for the Way Forward to agricultural stakeholders as to how the industry should be positioned within the larger agreement or how such positioning could be improved through future negotiations of those and other agreements.

1. Conduct further examination of the entry requirements for HS 0306 Crustaceans into the Canadian market, given the increase in CARICOM's Revealed Comparative Advantage but low Intensity index, even though the data shows good potential for trade.
2. Review the factors that are limiting trade to the Canadian market and develop strategies for greater entry and for growth into the market. The demographics of the Canadian market will always translate to high demand for tropical commodities, but capturing and retaining market share will be a critical success factor.
3. Special attention should be placed on developing the commodity groups which displayed high trade Complementarity and Regional Orientation -- HS 0302 Fish, fresh, whole, and HS 2208 Spirits, liquors. Policies and technical cooperation for enhancing quality assurance along the supply chain and upgrades of manufacturing operations and product certification will be important.
4. Focus the negotiation on greater penetration into the Canadian beverage market, given the bias towards Canada in the exports of HS 2208 Spirits, liquors.

It is apparent that negotiation of trade agreements is only part of the formula for success in business expansion. Further, given global competition has been accelerating in intensity with the emergence of new "tigers", and given the relative lack of long-term experience and existence of few strategic alliances amongst CARICOM businesses in the Canadian market, it is recommended that the work be done closer with the trade facilitation units of the Region to foster, nurture and push businesses to capture greater market share. Other countries, e.g. those in Latin America and Asia, are now moving from "galloping" to "trotting" and CARICOM will surely need to catch up in this regard.

Table 1: Summary of Trade Performance of Agriculture with Canada

HS Classification	Revealed Comparative Advantage	Regional Orientation	Trade Pattern	Trade Intensity	Trade Complementarity	Export Potential (TI & TC)
	RCA >1 Advantage	RO>1 Bias for that market	Increasing RCA and ROI means more concentration in that market	TI range 0 – 100 Better close to 100	TC range 0 – 100 Better close to 100	High TC low TI show potential for more trade
'0302 – Fish fresh	1.44 to 1.50	19.35 to 18.11	Increase advantage but decline in market	6.40 to 9.7	97.1 to 97.8	Good potential
'0306 – Crustaceans	21.31 to 58.72	1.55 to 1.11	Increase advantage but decline in market	4.34 to 5.25	93.7 to 94.2	Good potential
'0714 – Vegetables	42.24 to 32.18	3.88 to 2.79	Declines	41.93 to 32.64	97.1 to 96.9	Good trade already taking place
2208 – Alcoholic Beverages	2.55 to 4.29	0.46 to 0.54	Increase advantage but no regional bias	15.04 to 14.1	84.9 to 88.5	Good potential

REFERENCES

International Trade Centre (ITC), 2012. Market Data and Information. Accessed February 26th. http://www.intracen.org/Policy/

OTN, 2010. CARICOM-Canada Negotiations: Prospects for the CARICOM Agriculture and Fisheries Sector. Trade Brief. CARICOM office of Trade Negotiations.

Foreign Trade, 2012. Harmonized System Codes. http://www.foreign-trade.com/reference/hscode.htm

Chandran, Sarah B.P., 2012. Trade Complementarity and similarity between India and ASEAN countries in the context of the RTA. Accessed March 5th. http://mpra.ub.uni-muenchen.de/29279/1/sarathpaper.pdf.pdf

Plummer, Michael G., David Cheong and Shintaro Hamanaka, 2012. Methodology for Impact Assessment of Free Trade Agreements. Asian Development Bank. Accessed February 24th.http://aric.adb.org/pdf/FTA_Impact_Assessment.pdf

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EXPLORING THE EVOLUTION AND PERSISTENCE OF REVEALED COMPARATIVE ADVANTAGE IN THE AGRICULTURAL SECTOR

Damie Sinanan and Roger Hosein, The University of the West Indies

ABSTRACT: This paper explores the dynamics of comparative advantage in the agricultural sector for five CARICOM countries as measured by their export shares and the Balassa index using 3-digit export data for the period 1991 to 2008. The paper calculates and examines the Balassa Index to determine how the pattern of trade within the agricultural sector has changed over the time period using Galtonian Regressions, Markov Chains, Transition Probability Matrices, and Mobility Indices. Based on the findings of the paper several policy recommendations are made.

Keywords: Trade, Revealed Comparative Advantage, Markov Chains, Transition Probability Matrices, Galtonian Regressions

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RETAIL PRICE TRANSMISSION AND PRICE ASYMMETRY IN SELECTED AGRICULTURAL COMMODITIES IN TRINIDAD AND TOBAGO

Asisha Patterson and Govind Seepersad, The University of the West Indies

ABSTRACT: Large structural shifts in the global economy have been causing a dramatic rise in the price of food. From March 2006 to 2007, the food component of the retail price index increased by 19% whilst the overall price index increased by 8%. Sizable and fluctuating price differences have been recorded between wholesale and retail prices. This study looks at the development of retail food prices, the reasons it has been increasing, and the potential impact in terms of food security, and makes a number of policy recommendations. Through time series analysis, price margins and time lags were examined to determine the nature and lag of the response in municipal and retail price changes to wholesale prices. Non-linear hedonic models were estimated using auction price and quality data for specific commodities and markets to examine whether buyers have systematic preferences for specific attributes (volume, market location and timing of sale) and whether they pay significantly different prices for these attributes consistent with their preferences. The results show that the price transmission between wholesale and retail happens in the same week and that price asymmetry (i.e., the different transmission of price increases compared with price decreases) is present for most products. Products characterized by relatively more standardization and homogeneity are shown to have lower retail margins and to behave symmetrically. The results also indicate that buyers have systematic preferences for specific product attributes and that these preferences are implicitly reflected in prices offered in traditional auction markets. The results underscore the need for increased producer supply response to capitalize on the opportunity offered by higher commodity prices by targeting specific attributes and by better timing of the production and marketing undertakings.

Keywords: Food prices, food security, price lags, price margins, price transmission, hedonic price analysis

Proceedings of the Caribbean Food Crops Society. 48:13-20. 2012

VALUE CHAIN ANALYSIS: FEASIBILITY OF EXPORTING FRUITS AND VEGETABLES INTO MARTINIQUE FROM ST. LUCIA

Randel Esnard and Govind Seepersad, The University of the West Indies

ABSTRACT: Insufficient market research and intelligence on the fresh tropical agricultural produce markets in the French Caribbean Overseas Regions (FCOR's) limits the ability of producers and exporters in St. Lucia to effectively explore the opportunities and capture the benefits that exist in these neighboring markets. This study examined the market opportunities for the top six fresh tropical agricultural produce in Martinique, as well as issues that affect market access into the European Union FCOD, which is governed by preferences under the EU-CARIORUM Economic Partnership Agreement. A value chain approach was used to assess St. Lucia's competitiveness in the FCOR market. Utilizing the Economic Competitiveness Coefficient framework developed by Singh et al. (2006), the export price competitiveness for the six commodities identified were computed. The competitor analysis of the major suppliers in the market for the identified commodities show that for selected commodities (yam, tomatoes and grapefruit), less than fifty percent of the supply value was accrued to members of the European Union. The study found that the commodities identified, yams, tomatoes, lettuce, cabbages, grapefruit and sweet peppers, could be successfully cultivated in St. Lucia. The results show that all six commodities will be price competitive in the Martinique market.

Keywords: FCOR, EU-CARIORUM, Competitiveness, Economic Partnership Agreement

INTRODUCTION

Background of the Study

Martinique, Guadeloupe and French Guiana are defined and administered as French Caribbean Overseas Departments (FCOD's), on the same basis as departments of metropolitan France. This colonial tie with mainland France binds these departments to all agreements signed by France and by extension the European Union (EU), formally referred to as the European Communities (EC). The latest of these agreements with economic relevance to members of CARIFORUM (*CARICOM + Haiti + Suriname + Dominican Republic*) is the signing of the Economic Partnership Agreement (EPA) between the EU and the African, Caribbean and Pacific group of states (ACP). The EU-ACP EPA was officially signed on October 15th 2008. This agreement in its entirety relates to further trade liberalization between members of the EU and ACP countries (African, Caribbean and Pacific) and replaces the Lomé Conventions and Cotonou Agreement which existed between these international trading blocs. The former agreements provided preferential market access for members of CARICOM in the form of guaranteed quotas and prices above those dominating on the world market. The EPA is based on reciprocity and the granting duty-free and quota free market access to all countries in the EU.

The close proximity of St. Lucia and Martinique as neighboring islands offers an advantage relative to shipping costs and provides a prospective gateway for St. Lucian traders to capitalize on the EU markets in lieu of mainland France. Of particular interest in the EU is the fruit and

vegetable market in Martinique. This market may not be considered large; however, it relies heavily on imports from mainland France, Costa Rica, Dominica, Spain and Guadeloupe to satisfy local demand. The lack of market research hinders the ability of entrepreneurs from St. Lucia to penetrate this nearby market.

In this regard, this study sought to examine the opportunities that exist in the FCOD's for St. Lucian entrepreneurs. The specific objective of the study are to:

1. Determine the relevant regulation for entry into the EU markets
2. Determine which are the fresh tropical agricultural commodities being imported into Martinique with the best potential for St. Lucian farmers / entrepreneurs
3. Identify the major competitors in the market and;
4. Determine the price competitiveness for the commodities identified in (2) above.

METHODOLOGY

Two models were used for the analysis:

Value Chain

This study used the value chain approach in the analysis for exporting fruits and vegetables from St. Lucia into Martinique.

The Economic Competitiveness Coefficient

The Economic Competitiveness Coefficient (ECC) developed by Singh et al (2006) was used to assess the competitiveness of the top six agricultural imports into Martinique that can be successfully cultivated in St. Lucia for export. The ECC was developed to measure whether a country's exported goods would be competitive when landed in an international market. It measures the difference in the prices and represents the answer as a ratio.
The formula is:

$$ECC = \frac{FLP}{TWP}$$

Where,
FLC = Final Landed price at the market in the foreign country
TWP = Total wholesale price of that same country at the terminal market

When computed values of the ECC>1, these products are considered to be uncompetitive and when values of ECC<1, competitive (Felix, Seepersad and Singh 2010).

RESULTS AND DISCUSSION

Market Access into the EU

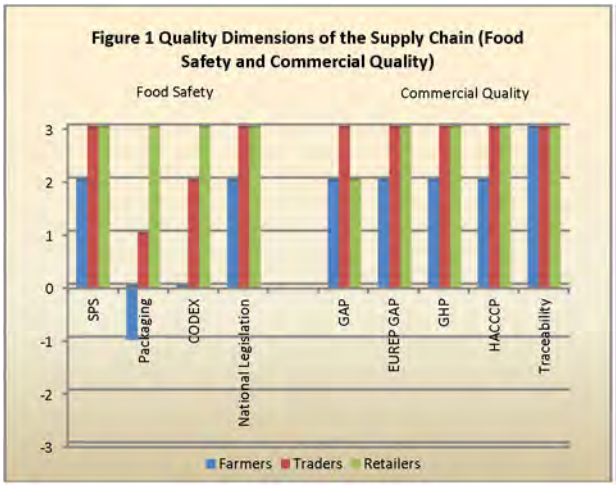
Market access for goods refers to the conditions, tariff and non-tariff measures agreed by trading members for the entry of specific goods into their markets. Aspects of market conditions, tariff schedules and matters pertaining to foreign trade are documented in trading agreements that are WTO compatible. Of relevance to this study is the EU-ACP Economic Partnership Agreement. This new agreement had to be WTO compatible, ensuring reciprocity of trade between the two trading blocs in a reasonable time frame (Bernal, 2008). Under WTO's substantially all trade

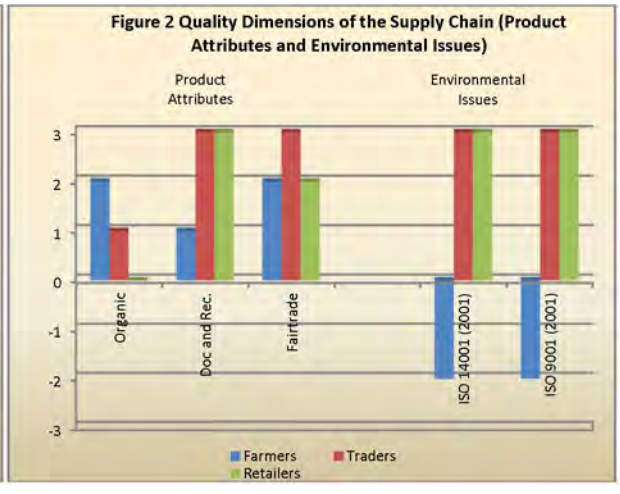
(SAT) standards, this translates into liberalization of close to 90% of all trade between the parties (Economic Commission for Latin America and the Caribbean, 2008). This process is to occur on a phased basis to achieve full reciprocal trade liberalization over a period of 25 years, with the majority within 15 years.

As part of the EPA's National Treatment principle, the EU has committed itself to reduce or eliminate existing Non-Tariff Barriers (NTBs) and to effectively remove all quantitative restrictions on imports. This is expected to minimize the level of discrimination against imports into the EU from the Caribbean Region. This will allow for goods exported from CARIFORUM to be subjected to similar treatment with regards to taxes, fees, and internal charges as those goods that are domestically produced within the EU (Barbados Investment and Development Corporation, 2010).

Market Entry into the EU: Quality and Safety Standards

Being granted market access under the EU-ACP EPA does not automatically translate into market entry or participation in the EU markets. Health, safety and quality standards for products entering the EU markets are now increasingly becoming preconditions for market entry and participation initiatives for exporting countries (dell'Aquilla and Caccamisi, 2007, 267). Reality is that firms willing to engage in international trade with the EU will have to deal with these opportunities for improvement and constraints rising from these standards. These standards apply to every player in the agro-food supply chain, including farmers, cooperatives, manufacturers, processors, food handlers and consumers. An evaluation of the quality dimensions of the key players in the supply chain for exporting into the EU is presented in Figures 1 and 2. Low or negative ratings indicate a need for improvement in upgrading to meet the EU standards.





Tariff Schedules

As an affiliated member of the EU, Martinique's import policy is similar to that of the EU. All imports from non EU countries are subjected to a Community Integrated Tariff (TARIC). The Tariff schedule used in the FCOR's is based on the Harmonized System codes (HS) also referred to as the Customs Cooperation Council Nomenclature (CCCN). This system was introduced by the WTO to provide a standard tariff classification regime for global trade (Barbados Investment and Development Corporation, 2010).

The taxes applied in Martinique include the EU's Common External Tariff (CXT), the Octori de Mer (Local tax), Octroi de MerRégional (National Tax fixed at 2.5%) and the value added tax. The Octroi de Mer and the Octroi de MerRégional are enforced by the Customs Service on imported goods based on their value. Under the COTONOU agreement, between the EU and ACP countries, goods originating from ACP member states are exempted from the CXT (gaining duty free access) provided that a EUR1 certificate is presented with the goods upon entry into Martinique. Import duties are calculated as a percentage of the values of imported goods. The dutiable value of goods entering Martinique is calculated based on the CIF value (Cost, Insurance, and Freight).

Value Chain

The typical costs incurred from the St. Lucia farm gate to the Martinique Terminal was computed to determine the additional value at every point in the supply chain for the commodities identified. Data was obtained from interviews held with farmers, management of the Belle Vue Farmers' Cooperative, shipping agent (CGM/CMA), customs broker, importers and retailers. The cost of production (COP) for the top six (6) fresh tropical agricultural commodities identified in Martinique was obtained from the Ministry of Agriculture in St. Lucia. Actual expenses and industry mark-ups were used for the farmer, exporter, freight, custom brokers, port charges, importer and other services involved in the supply chain to Martinique. A summary of the value chain for yams, tomatoes, cabbage, ssweet pepper, grapefruit and lettuce from St. Lucia to the Martinique market is presented in Table 1. For the commodities identified the cost of production accounts for the highest percentage of the value chain. Exporters, importers and farmers margin represent 17%, 16%, and 15%, respectively, of the final price of the commodity in the terminal market.

Table 1: Summary of Value Chain for various commodities produced in St. Lucia

	Commodities					
Chain Members (Value Added)	**Yams**	**Tomato**	**Cabbage**	**Sweet Pepper**	**Grapefruit**	**Lettuce**
Cost of Production	38%	39%	37%	40%	34%	38%
Farmers mark-up	15%	15%	15%	15%	15%	15%
Exporter Margin	17%	17%	17%	17%	17%	17%
Importer Margin	16%	16%	16%	16%	16%	16%
ECC	0.43	0.64	0.97	0.46	0.95	0.32

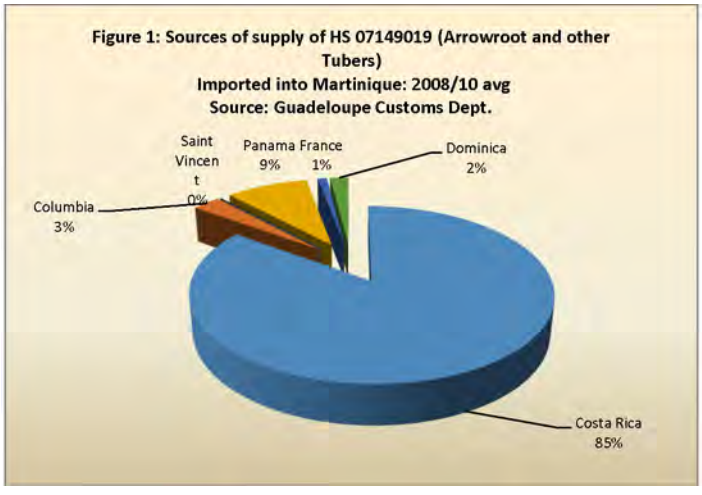
Competitor Analysis

To be able to compete successfully in a market, it is critical to know who the competitors are. The analysis which follows is based on the average import value of the top six (6) fresh tropical agricultural commodities imported into Martinique from 2008 to 2010.

HS 07149019 Roots of Arrowroot, Salep and similar roots and tubers

Non-EU member states account for 99% of the import value of HS 7149019 in Martinique. Costa Rica is the largest supplier of this commodity (85%) into Martinique. Second to China, Costa Rica

is the largest producer of HS 7419019 and the largest exporter into France and is therefore expected to be a highly competitive producer (International Trade Centre, 2011). Dominica and St. Vincent are the only two CARICOM countries who have participated in this market over the past three years, with yams and arrowroot, respectively. Dominica, export into the market over the past three years represent 2% of the market, whereas St. Vincent accounted for only 0.24% in 2008. The suppliers of HS 7149019 into Martinique are shown in Figure 1.



HS 07020000 Tomatoes fresh or chilled

Tomato imports into Martinique for the period 2008-2010 totaled € 1,544,900, of which only 17.02% was originated from EU member states while 64% came from the Dominican Republic. With the exception of Barbados, which accounts for 0.03% of total tomato imports into Martinique during 2008-2010, no other CARICOM country participated in this market. Figure 2 shows the main suppliers of tomatoes into Martinique from 2008 to 2010.

HS 07051900 Lettuce fresh or chilled

Lettuce imports into Martinique from 2008 to 2010 summed up to € 939,900 avg. Majority of the imports being from metropolitan France € 937,752 (99.76%). The other participants in the lettuce import market are Barbados and The Netherlands; together they represent 0.23% of the market.

HS 07049010 White and Red Cabbages

White cabbages can be considered as one of the most successful, highly cultivated crops produced by farmers in St. Lucia. Favorable soil conditions, weather patterns and low risk relative to other products, allow farmers to cultivate the crop successfully. From 2008-2010, data shows that 100% of the cabbages imported into Martinique originated from members of the EU. The sources of supply for HS 7049010 in Martinique are presented in Figure 3.

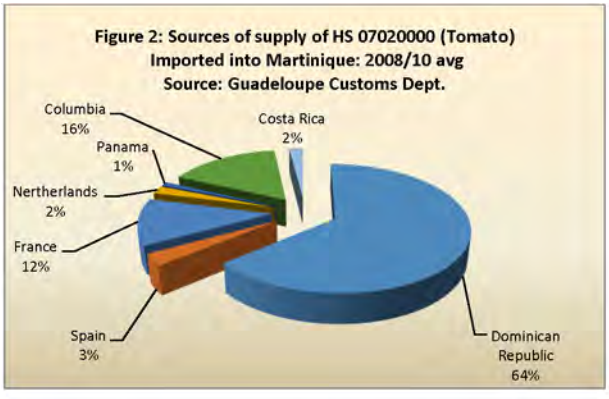
HS 0805400 Grapefruit

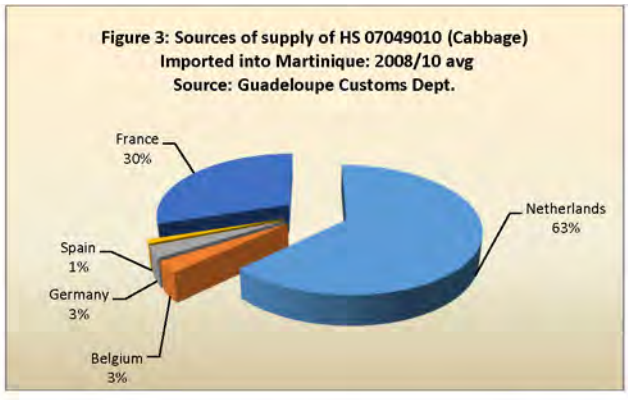
Currently, grapefruit is not cultivated on a large scale by farmers in St. Lucia. The cocoa and coconut estates in St. Lucia account for the majority of the grapefruits produced and sold. Insufficient demand for the commodity in the domestic market results in spoilage of the majority of the grapefruits produced. In this regard, identifying and establishing potential markets for grapefruits can be beneficial to farmers in St. Lucia. The value of grapefruit imports into

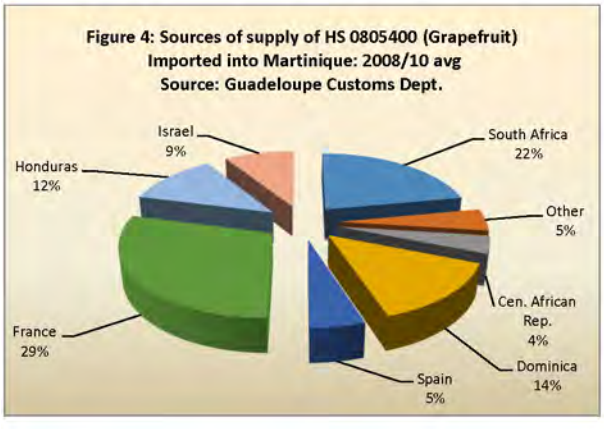
Martinique for the period 2008-2010 summed up to €312,380. Of this total, EU member states account for 34.16%. The major suppliers of grapefruit into Martinique are shown in Figure 4.

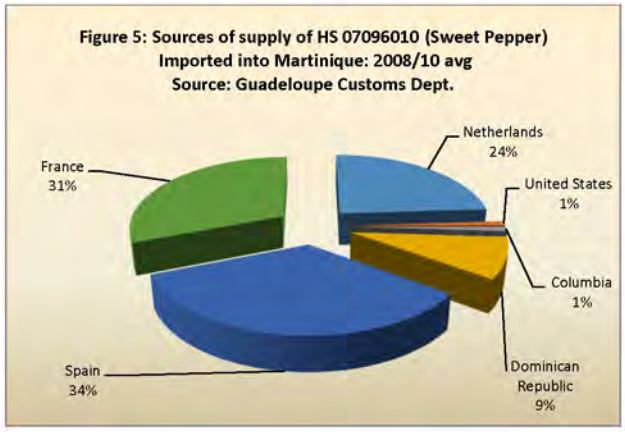
HS 07096010 Sweet Pepper

Sweet pepper production in St. Lucia has been on the increase as a result of advancements in the use of greenhouse technology. Farmer cooperatives in St. Lucia are currently encouraging their members to invest in greenhouse technology and sweet pepper production for the domestic market. Further encouragement in this regard can result in an increase in production of sweet peppers that can be exported. From 2008 to 2010, the total value of sweet peppers imported into Martinique summed up to € 253,500, of which EU member states accounted for 89%. Figure 5 shows the sources of supply of HS 7096010 into Martinique from 2008 to 2010.









Price Competitiveness Analysis

The results for the Economic Competitiveness Coefficient for the fresh agricultural commodities identified were presented using three scenarios.

1. The actual price competitiveness coefficient for the commodities identified;
2. The highest cost of production that will be competitive in the market; and
3. The highest profit mark-up per commodity that will be competitive in the market.

Commodities with an ECC value <1 are considered to be price competitive in the market; the lower the ECC the greater the level of competitiveness. Scenario one shows the actual competitiveness

of each commodity in the market. Scenario two is based on the assumption that all other cost and mark-up margins are held constant while altering the cost of production to the point where the ECC is equal to one. Scenario three is based on the assumption that the cost of production and all other costs involved are held constant while increasing the farmer's mark-up margin to the highest point where the ECC is equal to one. The three scenarios are summarized in Table 2.

Table 2:Summary of Price Competitiveness for commodities produced in St. Lucia for potential exports to the Martinque Market

Commodities	Scenario 1 *ECC at cost of production and 40% margin*	Scenario 2 *Highest cost of production ($/lb) ECC=1*	Scenario 3 Highest *Profit Mark-up (%) ECC=1*	Competitive		Rank
				Yes	No	
Lettuce	0.32	3.04	380	√		1
Orange peppers	0.42	3.8	255	√		2
Yams	0.43	2.53	252	√		3
Yellow Peppers	0.46	3.4	220	√		4
Green Peppers	0.46	3.34	223	√		4
Tomato	0.64	1.84	128	√		5
Cabbage	0.97	0.90	45	√		7

CONCLUSION

The results of this study provided an overview of the fruit and vegetable market in Martinique with a focus on the commodities that can be successfully cultivated in St. Lucia. Furthermore, the analysis shows that the current cost of production for the identified commodities is price competitive in the market and confirms the view that it can be a profitable venture to participate in the EU market which is approximately twenty four miles away from city to city between St. Lucia and Martinique. Given the opportunities identified in the Martinique market it is recommended that the Ministry of Agriculture and farmer cooperatives work in strengthening the link between production agriculture and marketing, and provide adequate training to farmers to help them meet the quality standards set by the EU. Further market intelligence and research is needed to examine competitors in the market so as to develop effective and efficient export strategies to supply the Martinique market.

REFERENCES

Barbados Investment and Development Corporation. 2010. *Market Research Report- Martinique.* Research, Information and Design Services Division, Bridgetown Barbados.

Bernal, Richard. 2008. "CARIFORUM-EU Economic Partneership Agreement negotiations: Why and How." *Journal of Eastern Caribbean Studies* 1-23.

dell"Aquilla, Crescenzo, and Caccamisi.2007"Accessing market Opportunities: quality and safety standards." *In: Agriculture Trade Policy and Food Security in the Caribbean*, edited by J.R Deep Ford, Crescenzo dell'Aquila and Piero Conforti, 263-288. Rome: FAO.

Economic Comission for Latin America and the Caribbean. 2008. "The CARIFORUM-EU EPA: Assessment of issues relating to market access, safeguards and the implication for Regional Integration." Port -of-Spain Trinidad and Tobago, November 26, 2008.

Europa. 2010. Accessed September 30, 2011. http://europa.eu/about-eu/basic-information/index_en.htm

Felix, Nkosi, Seepersad G, and Singh. 2010."Competitiveness Assessment of the USA – Miami Market for Trinidad & Tobago Habaneros." Working Paper, The Caricom Regional Transformation Market Intelligence Report, University of the West Indies St. Augustine Campus, Trinidad and Tobago.

Ford, D. J.R., and Jaque. 2007 "Competitivness, Investment and Caribbean Agriculture." In *Agriculture trade policy and food secuity in the Caribbean*, edited by J.R Deep Ford, Crescenzo dell'Aquila and Piero Conforti, 243-262. Rome: FAO.

International Trade Centre. 2011."*International Trade Centre TRADE MAP."* Accessed November 22, 2011. http://www.trademap.org/Country_SelProduct_TS.aspx

Monke, Eric A., and Scott R. Pearson. 1989. *Policy Analysis Matrix for Agricultural Development.* Accessed September 12, 2011. http://www.stanford.edu/group/FRI/indonesia/documents/pambook/pambook.pdf

Tsakok, Isabelle. 1990. *Agricultural price policy: a practitioner's guide to partial-equilibrium.* New York: Cornell University Press.

Unnevehr, L, and D Robberts. 2003. "Food safety and quality: regulations, trade and the WTO." *Agriculture policy reform and the WTO: Where are we heading?* Capri: FAO. 1-27.

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SISTEMAS DE INFORMACIÓN DE MERCADOS AGRÍCOLAS (SIMA) Y LA CONTRIBUCIÓN AL DESARROLLO DE LA COMPETITIVIDAD AGRÍCOLA EN LA REGIÓN DEL CARIBE

Frank Lam, Instituto Interamericano de Cooperación para la Agricultura (IICA)

ABSTRACT: El reciente incremento en la apertura de los mercados agrícolas y comercio interregional, así como la alta volatilidad en los precios de los principales productos agrícolas y la creciente preocupación de la seguridad alimentaria está cada vez más demandando, por parte de los empresarios agrícolas y las autoridades públicas, a los Sistemas de Información de Mercados Agrícolas (SIMA) a proveer información de mercado oportuna, veraz y confiable. El desarrollo y fortalecimiento de una industria turística en la mayoría de los países del Caribe genera una oportunidad para que las empresas del sector agrícola se vinculen directamente a ese desarrollo con una visión de cadenas de valor de manera competitiva y sustentable. Igualmente, las empresas del sector agrícola juegan un papel fundamental en la provisión de alimentos a la población rural y urbana. En ese sentido, los SIMA deben enfocar sus servicios a las nuevas exigencias de los mercados y sus usuarios. La Organización de Información de Mercados de las Américas (OIMA), con el apoyo del Instituto Interamericano de Cooperación para la Agricultura (IICA) como Secretaría Técnica, ha venido desarrollando un intenso trabajo en la evaluación de la situación de los SIMA en la Región Caribe (14 países) con el objetivo de elaborar una propuesta integral para el Fortalecimiento Institucional de los SIMA y la creación de un Servicio Regional de Información e Inteligencia de Mercados Agrícolas con el fin de contribuir a la creación de una mayor transparencia en el mercado agrícola local y regional, a la identificación de oportunidades de mercado, así como a brindar la información de mercado para la toma de decisiones empresariales y comerciales y decisiones de políticas públicas.

Palabras clave: Agronegocios, Competitividad, Región Caribe, Sistemas de Información de Mercados Agrícolas (SIMA)

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AN EVALUATION OF THE IMPACT OF FREE TRADE AGREEMENTS ON THE COMPETITIVENESS OF THE CARICOM REGION

Nkosi Felix, Govind Seepersad, Randel Esnard, and Ranjit H. Singh, The University of the West Indies

ABSTRACT: Following the creation of the World Trade Organization agreement in 1994, CARICOM entered into a number of other Trade Agreements in order to increase the access of CARICOM's member states into foreign markets. These agreements encouraged the sharing of knowledge, removal of tariffs and non tariff barriers towards the improvement of each partner's trade position. This study examined whether there were gains or losses in CARICOM's trade competitiveness following the entry into effect of two of these free trade agreements: (i) CARICOM-Costa Rica, (ii) CARICOM-Dominican Republic. The study utilized the Relative Comparative Advantage, Regional Orientation, Trade Intensity and Trade Complementarity to examine the performance of major agricultural production segments, such as Sugar, Edible Oils and Textile products. These models were used to assess the changes of trade between partners relative to the world, and also to determine which trade agreement provided the greatest gains. The study examined the changes in performance over a nine (9)-year period (2001-2010), and trends for each of indices were created. According to the study:

(i) CARICOM did not benefit from the agreements signed with Dominican Republic and Costa Rica.
(ii) CARICOM maintained its Comparative Advantage within the exported product groups selected in the study whereas no bias in trade was observed to Dominican Republic and Costa Rica markets.
(iii) Trade Intensity from CARICOM to Costa Rica was shown to be highest in the group of HS 0303 Crustaceans, while it decreased in the other selected groups.
(iv) Trade potential remained high throughout the period 2001/2010, thus showing that CARICOM's exports in the selected groups did not capture any significant market shares in either the Dominican Republic or Costa Rica.

Keywords: Revealed Comparative Advantage, Free Trade Agreement, Trade Negotiation, Export Specialization, Trade Intensity

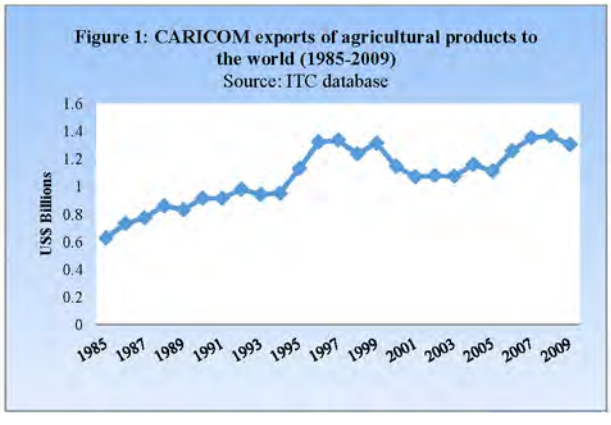
INTRODUCTION

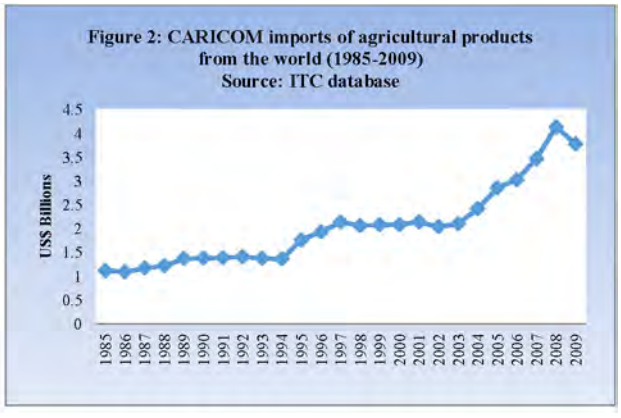
A Free Trade Agreement is a legally binding arrangement signed between two or more countries to establish a free trade area where commerce in goods and services can be conducted across their common borders, without tariffs or hindrances but capital or labor may not move freely (Business dictionary 2012). The agreements between Costa Rica (CR) and CARICOM and the Dominican Republic (DR) and CARICOM focused on areas such as agricultural commodities, processed agricultural products, and textiles. Given the structure of FTA's, certain benefits, namely an increase in trade between partners, was expected.

It has been more than a decade since the signing of the CARICOM-Dominican Republic agreement and eight years since CARICOM entered into a trade agreement with Costa Rica. This study seeks to access the benefits of the CR and DR agreements.

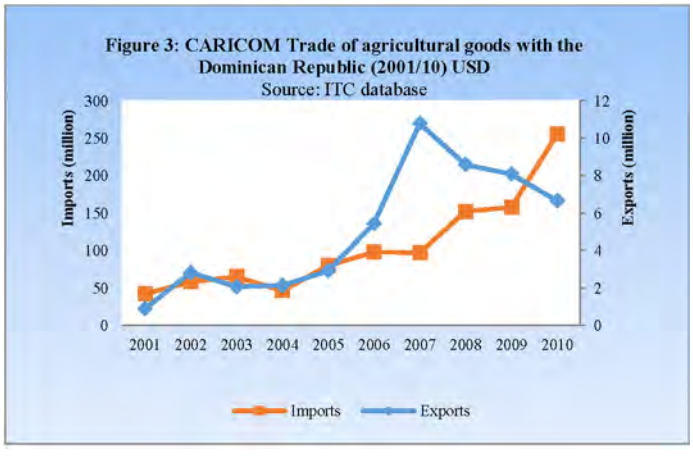
BACKGROUND

The exports of agricultural products from CARICOM to the world increased from US$600 million in 1985 to US$1.3 billion by 2009 (Figure 1). Alternatively, agricultural imports in 1985 were valued at US$1.1 billion (bn) which remained fairly constant until 1994, after which time it experienced a rapid rise to US$1.7 bn (Figure 2). In addition, another substantial increase was noted from 2004 to the end of the period of approximately US$2 bn, ending at US$3.7 bn in 2009. This amount revealed increasing import dependence which was directly related to the WTO agreement of 1994. The CARICOM-Dominican Republic Agreement provisionally entered into effect in December 2001. The Agreement exists between CARICOM and the Dominican Republic and is based on reciprocity and asymmetric trade with the Most Developed Countries (MDCs) and Less Developed Countries (LDCs) of CARICOM, respectively. The MDCs of the region engaged in reciprocal treatment immediately with the DR, whereas the LDCs operated under non-reciprocal trade until 2005.





The fundamental objective of the CARICOM-DR FTA Agreement was to strengthen the commercial and economic relations of CARICOM and the Dominican Republic covering several topics such as the classification of goods for Market Access, Rules of Origin (RoO) and Sanitary and Phytosanitary (SPS) measures. This agreement resulted in trade data showing an increase in imports from DR throughout the period, but exports to DR from CARICOM experiencing a reduction from 2007 to 2010 (USD 4 million) after displaying a similar trend (Figure 3).



The CARICOM-Costa Rica agreement was initiated in 2003 seeking to regulate bilateral trade between the Caribbean Community and Costa Rica, providing liberalized trade and also preferential market access for a wide range of products. It also aimed to create opportunities to build new markets for CARICOM products, promote investment, create jobs, and bring about opportunities for growth and development to the people of the Region.

Under the agreement, most developed countries (MDCs) of CARICOM - Barbados, Guyana, Jamaica, Suriname and Trinidad and Tobago will provide duty-free access to most products from Costa Rica. CARICOM less developed countries (LDCs) - OECS (Organization of Eastern Caribbean States) and Belize, while enjoying duty-free access to Costa Rican markets were not required to grant similar access to Costa Rican products. Once again, Rules of Origin, SPS and Market access classification were covered, but market entry was also restricted by months of the year for specified agricultural commodities. This restriction was done to prevent negative impact on selected segments of the agricultural production base.

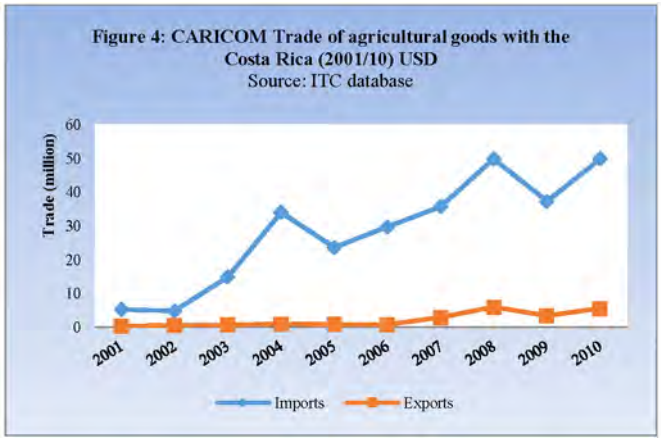


Figure 4: CARICOM Trade of agricultural goods with the Costa Rica (2001/10) USD
Source: ITC database

Imports from CR did exceed CARICOM exports but both showed increasing trends. There was a significant difference in trade volume and also trade revenue. This finding was evident from CR exports moving from approximately USD 5 mn to USD 50 mn (2001/10) whereas CARICOM export was at its maximum in 2008 at USD 6 mn.

METHODOLOGY

Trade data was obtained from the International Trade Commission (ITC) database for the period 2001-2010 for major products traded. By using four trade indices, the data was analyzed to access the impact of the agreements with CARICOM and its trade partners: DR and CR.

Selection of focus groups

The harmonization system (HS) groups were disaggregated to the 4-digit level, and the main products exported over the 2001-2010 period between the Dominican Republic and Costa Rica were identified. This level of disaggregation would reduce the possibility of smoothing and therefore allow for an increase in the accuracy of the results. This accuracy was achieved by ranking the value of goods exported since this represented the economic return to trade and thus possibly the benefit of FTAs. Following this selection method, four trade indices used for the analysis are as follows:

Revealed Comparative Advantage (RCA)

The ***Revealed Comparative Advantage (RCA)*** provides the analysis of one country's exports share in relation to that of the world, and therefore can be used to identify positive or negative changes in export profile. Countries with high RCA are considered to be competitive and export to countries

with lower RCAs. Further, countries which experience similar RCA are unlikely to have high bilateral trade intensities unless intra industry trade is involved (Chandran, 2012).

The RCA would provide an indication of how CARICOM's competitiveness in the respective markets changed over time as the result of the FTA. Did the FTA improve comparative advantage given the measures which were agreed on in the aim to improve trade? This index would also allow policy makers to identify which agreement wouldyield the highest benefit, and which would guide future trade negotiations.

It is denoted by the formula:

$$\mathbf{RCA_{ij} = (x_{ij}/X_{it})/(x_{wj}/X_w)}$$

Where: x_{ij} = values of country i's exports of product j; x_{wj} = world exports of product j ; X_{it} = the country's total exports; X_{wt} = world total exports

A value greater than unity will suggest a Revealed Comparative Advantage whereas a value less than unity shows a Revealed Comparative Disadvantage.

Regional Orientation Index (ROI)

To identify the concentration of the CARICOM's exports to the markets of DR and CR the ***Regional Orientation Index (ROI)*** was used. It is used to identify whether any bias exists between countries which would indicate greater benefits if those countries were to enter into a FTA. This index tells us whether a country's exports of a product are more oriented toward a particular region than to other destinations (Plummer et al., 2012). Denoted by the formula below, it represents the ration of one country's exports to a country of interest to that of that country's exports to the world.

If regional bias increased, this would support the creation of future FTA since imports would be redirected to economies where CARICOM producers would benefit given the cost of entry into those markets. This index would also allow the comparison with the RCA, in such a way to identify whether exports to a region did indicate some bias. This would be concluded if RCA increases for a commodity/group and its ROI increases within trade with an FTA partner, trade diversion would be the result. This would be due to the increase in trade competitiveness with an increase presence in one particular market, illustrating gains in trade due to FTA measures.

The formula for the regional orientation index is:

$$\mathbf{ROI_{ij} = (x_{cgr}/X_{cr})/(x_{cg\text{-}r}/X_{c\text{-}r})}$$

Where: x_{cgr}= exports of good g by country c to region r; X_{cr}= total exports of country c to region r; $x_{cg\text{-}r}$= exports of good g by country c to countries outside region; $X_{c\text{-}r}$= total exports of good g to countries outside region r

If the index has a value greater than 1, this implies that the country has a regional bias in exports of the product. Conversely, if the index is less than 1, then the country has no regional bias.

Trade Intensity Index (TI)

The ***Trade Intensity Index (TI)*** was used to measure the level of trade between CARICOM and the respective FTA partners. It is used to determine whether the value of trade between two countries is larger or smaller than expected based on their importance in world trade. It simply measures the share of trade between a region and a trade partner as a ratio of the region's total trade share in world trade.

The installments of FTAs are primarily designed to increase trade through the reduction of trade restricting measures with the partner markets. In most cases one partner tends to benefit more and therefore this indicator would show whether exports increased as opposed to non FTA partners, but would also allow further research to be conducted into the reasons for any reduction in trade. Identified areas of the export structure would then be addressed in the aim to increase TI, given the presence of such FTAs.

The index is found using the following formula:

$$\mathbf{T_{ij} = (x_{ij}/X_{it})/(x_{wj}/X_{wt})}$$

Where: x_{ij} = the values of country i's exports; x_{wj} = world exports to country j; X_{it} = a country i's total exports; X_{wt} = total world exports.

A value greater than unity indicates larger trade flows than might be expected, which is trade intensity. It has also been found that higher values are more favorable to an FTA.

Trade Complementarity Index

Used to identify what occurred with the potential for trade, i.e. if potential increased or decreased during the study period. The ***Trade Complementarity Index*** is designed to measure compatibility of trade profiles. It summarizes certain aspects of the sector's trade pattern. This index measures the degree to which the export pattern of one country matches the import pattern of a region.

This index is initially used in identifying potential FTA partners but would also assist in assessing whether the formation of FTAs increases the potential for trade or vice versa. In addition, using this index compared with the TI would provide an indication whether the FTA created would provide net trade. If there is low trade intensity but high complementarity net trade would be possible since there is potential to trade. This analysis would allow the investigation of such trade arrangements to address the reasons why CARICOM is not maximizing the utility of the FTA.

The formula for the complementarity index is:

$$\mathbf{C_{cgr} = 1 - ((|(M_{rg}/M_r) - (X_{cg}/X_c)|)/2) \times 100}$$

Where: M_{rg} = imports of good g by region r; M_r = total imports of region r; X_{cg} = exports of good g by country c; X_c = total exports by country c

The index takes a value between 0 and 100, with 0 indicating no overlap and 100 indicating a perfect match in the import–export pattern, i.e. potential for trade.

RESULTS AND ANALYSIS

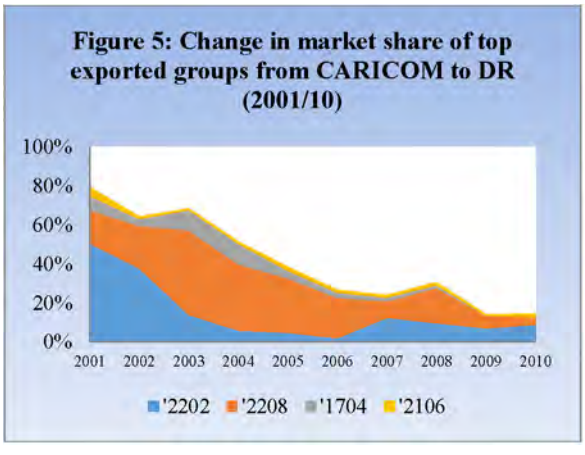
Harmonization System (HS) Groups for analysis

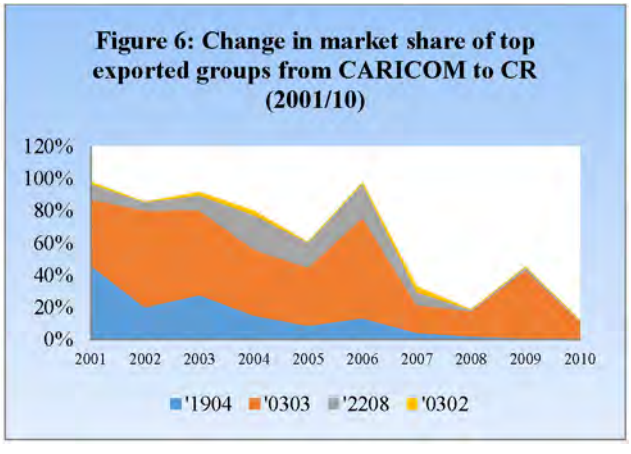
The major agricultural products being traded with the DR and CR were used to determine how the CARICOM market benefited from FTA's. The study found that HS 2202 (Non-alcoholic) and HS 2208 (Alcoholic beverages) dominated exports to DR, as shown in their market shares in total agricultural exports (Table 1). In the case of CARICOM exports to Costa Rica, HS 1904 (Cereal preparations) and HS 0303 (Crustaceans) were the main items with approximately 87% of agricultural exports.

Table 1: Export shares of major agricultural products in 2001 from CARICOM to DR & CR

CARICOM exports to the Dominican Republic	2001	CARICOM exports to Costa Rica	2001
HS 2202	50%	HS 1904	46%
HS 2208	17%	HS 0303	41%
HS 1704	7%	HS 2208	10%
HS 2106	5%	HS 0302	1%

For these commodities, the study found major changes in the value of trade between 2001 and 2010. In the case of exports to DR, the market shares of HS 2202 and HS 2208 were reduced to less than 10% of the 2001 levels (Figure 5). A similar trend was observed for exports from CARICOM to Costa Rica.





In this regard, the RCA, RO, TI and TC were computed in order to identify the gains or losses during the 2001 to 2010 period, given the ongoing existence of the PTAs.

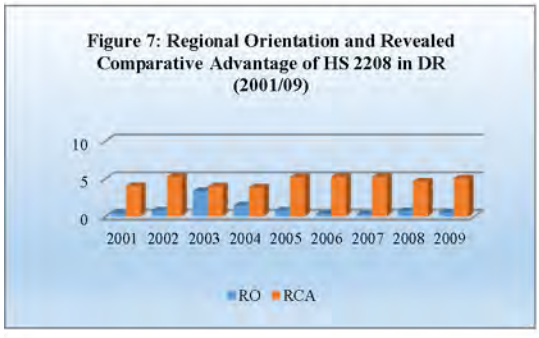
Further examination was done to help explain whether there exist any other driving forces for the low trade volumes at the end of the period and the reduced performance in the markets of DR and CR. In this regard, the study examined the top four commodities exported from CARICOM to DR and CR, through the use of the trade indices: RCA, RO, TI, and TC.

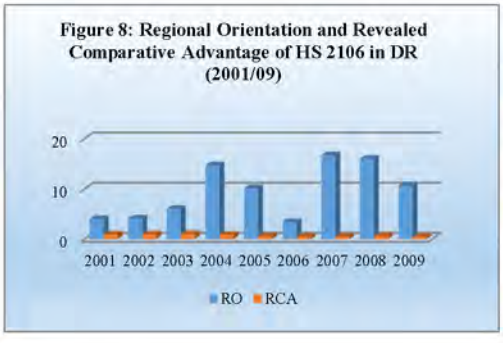
CARICOM- Dominican Republic Trade

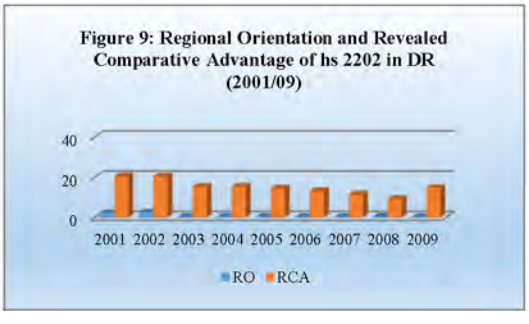
i. **Revealed Comparative Advantage (RCA):** CARICOM maintained a comparative advantage among all the selected groups.
   - RCAs of HS 2106 (**Food preparations nes**), and HS1704 (**Sugar confection**) remained constant during the period 2001/10 (Figures 8 & 10).
   - Fluctuations were shown in HS 2202 (**Non-alcoholic beverages**) and HS 2208 (**Alcoholic beverages**) throughout the years 2001/10 (Figures 7 & 9).

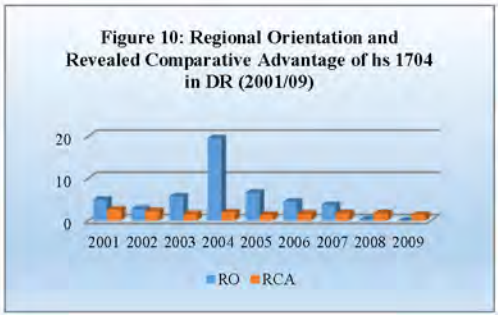
ii. **Regional Orientation Index (ROI):** Regional Orientation decreased among all the selected HS groups, following 2003 indicating a shift in CARICOM exports from DR to other countries.
   - Exports of HS 2106 (**Food preparations nes)** were shown to be biased to DR since RCA and RO >1 (Figures 7 - 10).

Revealed Comparative Advantage and Regional Orientation







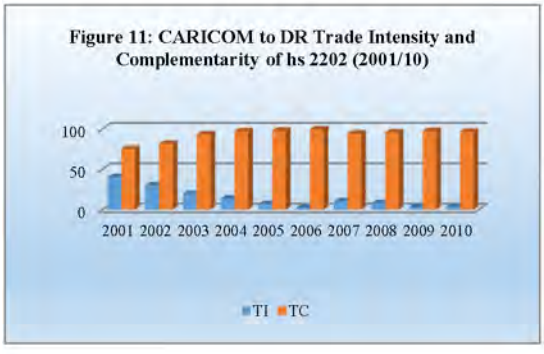


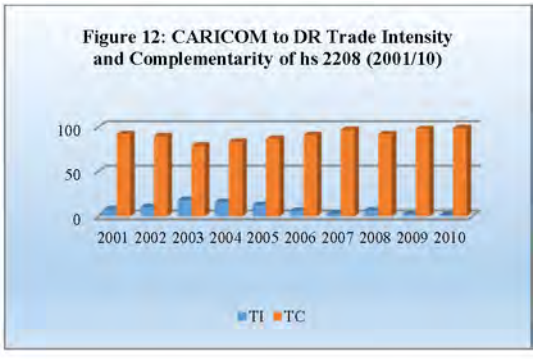
iii. **Trade Intensity Index**: The Trade Intensity index was low for all commodities and declined as the years progressed, thus indicating reduced performance of CARICOM exporters relative to market developments.
   - This finding was most evident in the trade of HS 2202 (**Non-alcoholic beverages**), which experienced a reduction from 40% (2001) to approximately 10% in 2010 (Figure 11).

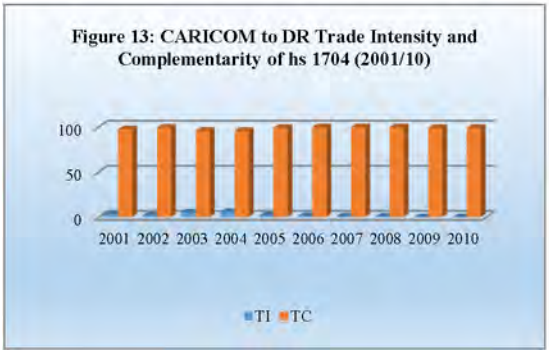
iv. **Trade Complementarity Index**: The commensurate high Complementarity Index suggests that there is potential for trade creation and high inter-industry trade among all of the selected products.

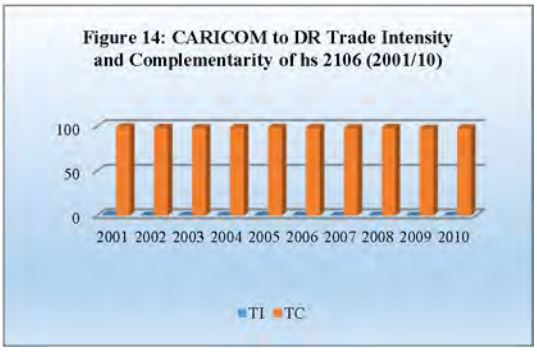
- Trade potential increased in HS 2202 (**Non-alcoholic beverages**) and HS 2208 (**Alcoholic beverages**) during the period 2001/10 (Figures 11 & 12).
- There were no changes in the potential of trade between CARICOM and DR for the exports of HS 1704 (**Sugar confection**) and HS 2106 (**Food preparations nes**) (Figures 13 & 14).

Trade Intensity and Trade Complementarity Indices









Assessing the possible reasons for change in Trade Performance:

In 2004, DR signed the CAFTA agreement which may have led to increased competition due to shifts in trade to the lower cost producers in Central America. The high values of trade in 2001 indicated that CARICOM did not benefit from trade with DR, which was shown by the reduction in trade intensity of all the selected groups. There were clearly no natural blocs created as a result of the FTAs formed.

CARICOM- Costa Rica Trade

i. **Revealed Comparative Advantage (RCA):**

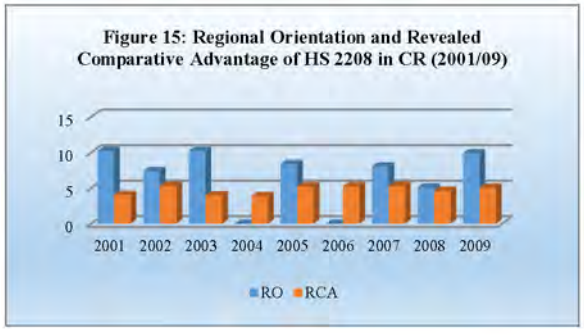
- RCA remained constant for HS 2208 (**Alcoholic beverages**) (Figure 15).
- A reduction in RCA was observed in HS 0303 (**Crustaceans**) following the year 2004 (Figure 16).

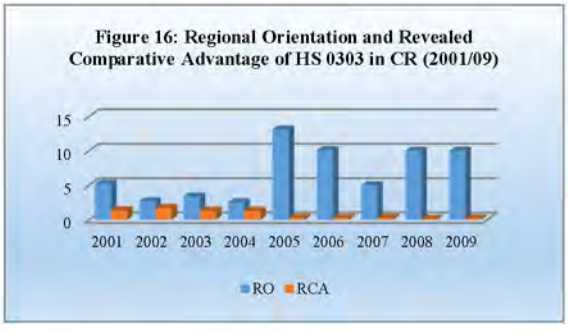
- CARICOM lost its advantage in the trade of HS 1904 (**Cereal preparations**) from the year 2003 (Figure 17).

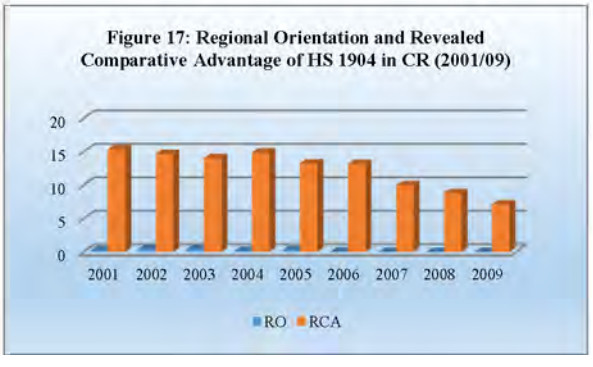
ii. **Regional Orientation Index (ROI):**

- Regional Orientation in HS 0303 (**Crustaceans**) decreased during the period with a fluctuation from 2004 to 2005 (Figure 16).
- There was no orientation within the group of HS 1904 (**Cereal preparations**) (Figure 17).
- Export bias was shown only in HS 2208 (**Alcoholic beverages**) and HS 0303 (**Crustaceans**) which increased following the year 2005 (Figures 15 & 16).

Revealed Comparative Advantage and Regional Orientation







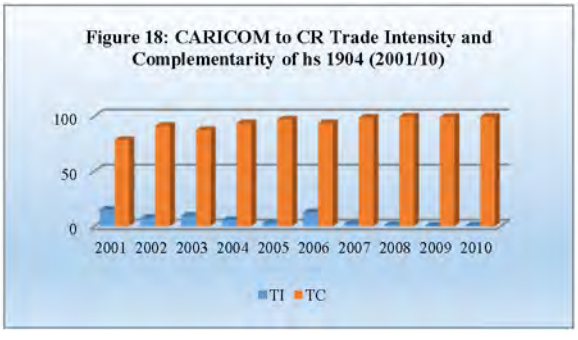
iii. **Trade Intensity Index**:

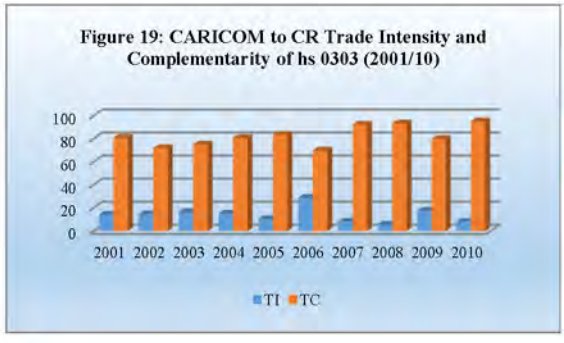
- There was an increase in the intensity of HS 2208 (**Alcoholic beverages**), which decreased from 2005 onwards (Figure 20).
- Fluctuations were experienced in the groups of HS 1904, and HS 0303 (**Crustaceans**) (Figures 18 &19).
- HS 0303 (**Crustaceans**) displayed the highest intensity during the period 2001/10 (Figure 19).
- Trade Intensity increased during the years of 2001, 2003 and 2007 for the group HS 0302 (**Fish, fresh or chilled**) (Figure 21).

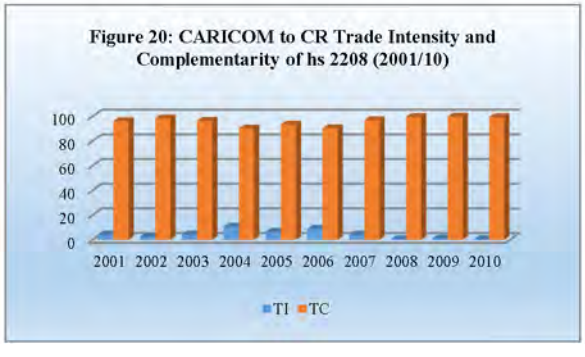
iv. **Trade Complementarity Index**: high levels were shown within all the selected groups, which indicated potential for trade.

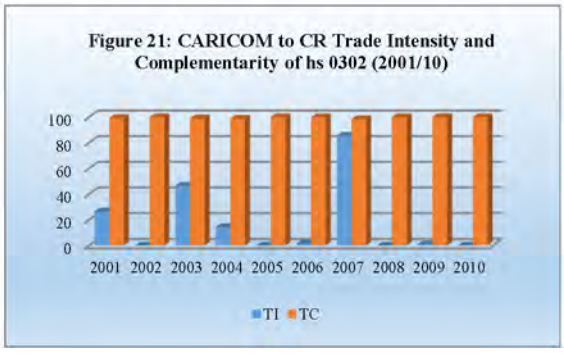
- Complementarity increased during the years 2001/10 in the group of HS 1904 (**Cereal preparations**) (Figure 18).
- There were reductions in HS 0303 (**Crustaceans**) complementarity, indicating increased exports from CARICOM to CR during those years of 2001/06 and 2009 (Figure 19).
- Complementarity fluctuated in the group of HS 2208 (**Alcoholic beverages**), whereas remained constant in HS 0302 (**Fish, fresh or chilled**) from 2001 to 2010 (Figures 20 & 21).

CARICOM and Costa Rica: Trade Intensity and Trade Complementarity Indices









Assessing the possible reasons for change in Trade Performance:

In 2004, CR also signed the CAFTA agreement, which may have directly increased competition and shifted trade to lower cost producers in Central America. The results indicated that CARICOM did not benefit from the FTA since intensity decreased while complementarity remained high. This was supported by the reduction in RCA in addition to lack of regional bias within the period.

CONCLUSION

The results of this study indicate that CARICOM producers were not in a position to benefit from FTAs created. These FTAs would only benefit the consumers by providing a wider range of products which would increase competition in the domestic markets. This would result in an increased dependence on foreign exchange for trade without increasing the regions' foreign exchange revenue. This type of strategy has the potential to erode the agricultural industries within CARICOM, especially in the case of the Lesser Developed Countries.

In order for FTAs to provide benefit to CARICOM producers, there must be a drive to increase their competitiveness which will decrease the sensitive nature of FTAs. Sensitivity relates to the ease of entry or erosion of market share gained by CARICOM as the result of FTAs formed. Policy makers would have to ensure the protection of sensitive industries but at the same time provide initiative to increase levels of resilience from external producers. The use of the indices would provide the identification of potential FTA partners but must also be used to monitor progress in the aim of addressing issues as they appear. This type of analysis would allow for increased attention to the terms and conditions of FTAs to clearly provide strategies for CARICOM producers to access these markets competitively and maintain market position.

REFERENCES

Business dictionary, 2012. Free trade agreement. Accessed April 4th. http://www.businessdictionary.com/definition/free-trade-agreement.html#ixzz1v088pgWJ

International Trade Centre (ITC), 2012. Market Data and Information. Accessed February 26th. http://www.intracen.org/Policy/

Chandran, Sarah B.P., 2012. Trade Complementarity and similarity between India and ASEAN countries in the context of the RTA. Assessed March 5th. http://mpra.ub.uni-muenchen.de/29279/1/sarathpaper.pdf.pdf

Plummer, Michael G., David Cheong and Shintaro Hamanaka, 2012. Methodology for Impact Assessment of Free Trade Agreements. Asian Development Bank. Accessed February 24th.http://aric.adb.org/pdf/FTA_Impact_Assessment.pdf

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AN ANALYSIS OF CONSUMER'S PERCEPTION OF FRUIT JUICE LABELS IN TRINIDAD AND TOBAGO

Govind Seepersad, Asisha Patterson, and Jeanine Eugene, The University of the West Indies

ABSTRACT: Consumers are becoming increasingly concerned with the quality, safety, environmental and social attributes of the foods which they consume. Consumer perceptions of price, quality and value are considered fundamental determinants of buying behaviour and product choice. Policy makers are challenged to ensure that labels are unambiguous and explicit. This study examined the impact of fruit juice labels on the purchasing behaviour of consumers. Choice-based conjoint analysis was used to investigate which packaging and labelling attributes consumers consider important when selecting fruit juices and their willingness-to-pay. The attributes selected were packaging material, nutritional content, health features and presence of organic ingredients, and whether the product was locally produced or imported. The research examined consumer's understanding of the term "freshly squeezed" and how the terms "from concentrate" and "not from concentrate" were distinguished. Results from the study indicated that consumers place positive values on, and are willing to pay, a premium for the Polyethylene Terephthalate (PET) bottle, and even more for the no sugar added trait. Consumers with high environmental interests were more likely to pay a premium for a fruit juice with organic ingredients and a nutritional index on the label. High information seekers are willing to pay more for the nutritional index, compared to what the low information seeker will pay. Younger people are willing to pay more for local products and more than double of what older people will pay for a Polyethylene Terephthalate bottle.

Keywords: Fruit juice labels, conjoint analysis, willingness-to-pay, premium pricing, Trinidad and Tobago

Proceedings of the Caribbean Food Crops Society. 48:34. 2012

OPPORTUNITIES AND CHALLENGES FOR ST. VINCENT AND THE GRENADINES UNDER THE EPA

Elroy Wilson and Govind Seepersad, The University of the West Indies

ABSTRACT: St. Vincent, as part of the Windward Island grouping and by extension an ACP country, exported banana to the United Kingdom under a preferential agreement which allowed them special access to the market. These preferential agreements were established in the banana protocol of the various Lome′ Conventions. Signed in 2008, the new EU-CARIFORUM EPA agreement seeks to liberalize trade and enhance relationships between the EU and CARIFORUM countries. With a noted disparity in income gaps, the EU under this new agreement has established strong components for the development of countries such as St. Vincent and the Grenadines. As an island that depends heavily on agriculture, many commentators seek to highlight the negative effects that this new agreement will have on agriculture, namely bananas, without emphasizing the over-all benefits that can be derived from the other sectors of the economy. This study determined the opportunities that St. Vincent and the Grenadines can capture from the new EPA agreement. The agreement offers smooth and gradual integration in the world market, eradication of poverty, seeks to enhance sustainable growth, increase production and supply, promote structural processing and economic diversification while supporting regional integration. The study also highlights some underlying challenges as a result of the new agreement and their negative implications on the small island developing state if mitigation measures are not put in place to cushion the effects.

Keywords: EU-CARIFORUM EPA, St. Vincent, small island developing states, preferential agreement

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A SOCIOECONOMIC ASSESSMENT AND RISK PERCEPTION OF STAKEHOLDERS ON THE IMPACT OF THE CITRUS GREENING DISEASE / HUANGLONGBING (HLB) IN BELIZE

Malcolm Wallace and Govind Seepersad, The University of the West Indies

ABSTRACT: Citrus Greening Disease is a deadly bacterial disease that affects all citrus varieties. It is rated by most national and international research institutions as the most destructive disease in citrus and to date has led to drastic reductions in production in Asia and Africa and now threatens citrus industries in the western hemisphere. Citrus Greening has been known internationally from its first description in China, as Huanglongbing (HLB), translated as "yellow shoot disease". The disease was confirmed in the Americas in Brazil in 2004. Since then, its presence has been verified in several other major citrus producing countries including: Florida / United States (2005), Cuba (2007), Mexico, Jamaica and Belize (2009). The economic cost implications of HLB have been estimated to far exceed other citrus diseases that have affected the industry in previous years. This study focused on two aspects of the Belize citrus industry: (i) the socioeconomic impact of the disease and (ii) the producers' response to the disease. The convenient sampling technique was used to enumerate stakeholders across the value chain to ascertain their experiences with the impact of the disease on the industry up to December 2011. The risk attitude and risk perception of primary (fruit) producers in the industry was evaluated by using a psychometric test. The results of the study found that the demise of the citrus industry would have negative socioeconomic impact on Belize specifically, citrus producers, agriculture workers, rural citrus producing communities and stakeholders within the citrus industry value chain. Analysis of the logistic regression focused on the significance of three variables: risk attitude (ra), risk perception (rp), and a combination of the two (risk attitude and risk perception) (rarp) on the behavioural outcome of farmers (whether to remain or exit the citrus industry). The results indicated that the variable (rp) (farmers risk perception) has a p-value of 0.030. Farmers risk perception was the only variable with a p-value below the chosen level of significance (0.05). Hence, only risk perception influenced the behavioural outcome.
Despite this threat, an estimated 76% of the farmers were willing to remain in the citrus industry and deal with the challenges presented by HLB. The results also show that 49% of the farmers enumerated were risk-seeking and 66% had employed some form of management for the disease. Overall, HLB was perceived by primary stakeholders as the disease which poses the greatest risk to the citrus industry of Belize.

Keywords: Citrus Greening Disease, Huanglongbing (HLB), Belize Citrus Industry, Risk, Socioeconomic Impact

BACKGROUND TO STUDY

Citrus Greening Disease is a deadly bacterial disease that affects all citrus varieties. It is rated by most national and international research institutions as the most destructive disease in citrus and to date has led to drastic reductions in production across Asia and Africa, and has now been impacting the citrus industries in the western hemisphere. Citrus Greening has been known internationally from its first description in China as Huanglongbing (HLB), translated as "yellow

shoot disease". The disease was confirmed in the Americas in Brazil in 2004. Since then, its presence has been verified in several other major citrus producing countries, including Florida / United States (2005), Cuba (2007) and Mexico (2009).

Within the CARICOM group of countries, HLB was confirmed in Belize and Jamaica in 2009. Belize is the largest producer of citrus in CARICOM, and Jamaica ranks second. The economic cost implications of HLB have been estimated to far exceed those of other citrus diseases that have plagued the industry in the past. In this regard, this study focused on two aspects of the industry in Belize: (i) the socioeconomic impact of the disease, and (ii) the producers' response to the disease. The study employed the convenient sample technique, enumerating stakeholders across the value chain to get their experiences on the impact of the disease up to December 2011. The risk perception of primary (fruit) producers in the industry was done by using a psychometric test.

Citrus is the second largest agricultural industry in Belize, after sugarcane, with an area of approximately 27,977 hectares under cultivation. Belize is ranked 29th and 19th in the world in orange and grapefruit production, respectively, and produced 237,200 tonnes of oranges and 36,000 tonnes of grapefruits in 2010. Exports of citrus and citrus products comprise 13 percent of agricultural GDP and 30 percent of manufacturing GDP. The leading value added export - Frozen Concentrate Orange Juice (FCOJ) totalled 29,369 tonnes (US$ 46,465,000) in 2008 and 20,428 tonnes (US $15,945,000) in 2009. Growth in citrus exports over the last ten years averaged 24% per annum, making it the fastest growing agricultural industry in Belize (FAOSTAT, 2012).

STUDY OBJECTIVE

This study specifically sought to:

1. Assess the risk attitude and risk perception of farmers regarding HLB and the significance of risk attitude and risk perception in influencing farmers' decisions to remain or exit the Belize citrus industry, and
2. Determine the socioeconomic impact of the HLB disease on the Belizean citrus industry.

INTRODUCTION

Citrus Greening Disease / Huanglongbing (HLB): Citrus Greening is a deadly bacterial disease that affects all citrus varieties. It has been known internationally, from its first description in China, as Huanglongbing (HLB, translated as "yellow shoot disease"). It was presumed to originate in China during the 1890s (A. Batool et al., 2007). According to Lin (1956), the first epiphytotic conditions of HLB were noticed in Chaoshan and Yuenchung districts of Fukien province in 1925. The disease was later reported in South Africa in 1929 as "yellow branch disease", and later called "greening", which refers to Stylar end greening on fruits infected with HLB. Lafleche and Bove established that a bacterium-like organism was associated with HLB in 1970.

The bacterium, '*Candidatus Liberibacter asiaticus*' (Las) is vectored by an insect called the Asian citrus psyllid, *Diaphorina citri* Kuwayama. The Candidatus part of the bacterium's name indicates that it cannot be cultured. Two other related forms of the disease are known of African and South American origin, '*Candidatus* L. africanus' (Laf) and '*Candidatus* L. americanus' (Lam), respectively, all of which are also vectored by the Citrus Psyllid.

HLB reduces the quantity and quality of citrus fruits, eventually rendering infected trees unproductive. In areas of the world affected by HLB, the average productive lifespan of citrus trees has dropped from 50 or more years to 15 years or less. Citrus trees in established orchards usually decline within three to five years after becoming infected. In addition, experiments by national and international research institutions to date have found no cure for HLB (Centro de Citricultura Sylvio Moreira, 2007).

RISK AND PSYCHOMETRIC TESTING

Risks are defined as the potential that a chosen action or activity (including the choice of inaction) will lead to an undesirable outcome. The notion implies that a choice of having an influence on the outcome exists (or existed). Psychometric testing is concerned with the theory and technique of psychological measurement, which includes the measurement of attitude and perceptions of individuals with regards to incidents of risk. During the literature review, researchers found no studies documenting farmers' risk attitudes or perceptions towards the risk posed by HLB in the citrus industry of Belize or any other CARICOM country.

METHODOLOGY

MEASURING SOCIOECONOMIC IMPLICATIONS

Measuring the socioeconomic implications of HLB on Belize places specific focus on those characteristics that seem to be highly significant or classified as vital roles which the industry performs in the national economy, i.e. contributions to foreign exchange earnings, GDP, employment, and the rural economies of the citrus-producing districts of Belize. In order to determine the socioeconomic impact of the HLB disease on the Belizean citrus industry, two strategies were employed. Guide questions were used to facilitate consultations with industry personnel throughout the value chain. Secondary data was obtained from the Belize Citrus Growers Association.

MEASURING THE CITRUS FARMERS' RESPONSE TO RISKS

The study utilized a structured questionnaire to determine the influence of farmer risk attitude and risk perception on the behavioural outcome.

The questionnaire focused on two main dimensions:

i. The first dimension addressed risk attitude, looking specifically at the content of the crisis and the impact of the risk (HLB). More specifically, it speaks to a farmer's interpretation of the risk content and how much he dislikes that risk content.

ii. The second dimension addresses risk perception and reflects the likelihood that the content of the risk actually becomes manifest. Specifically, it deals with farmers' interpretation of the chances of his citrus farm becoming exposed to the content of the risk (HLB).

The dimensions: risk content and the likelihood of exposure are directly related to the two fundamental drivers of decision behavior under uncertainty. The behavioural outcome is driven by farmers risk attitudes, risk perceptions and the interaction between them. Convenient sampling was used to enumerate farmers in the major citrus producing areas of Belize within the following categories: large (> 200 acres), medium-sized (50 – 200 acres) and small (< 50 acres).

ANALYTIC MODEL USED IN THE ANALYSIS

The Logistic Regression model was used for data analysis. This model was used because it allows for prediction of the outcome of a categorical variable (a variable that can take on a limited number of categories) based on one or more predictor variables. With logistic regression, the researcher is predicting a dichotomous outcome, i.e. splitting of a whole into exactly two non-overlapping parts ("yes" vs. "no").

The entire behavioural outcome space, which contains the possible behaviours of farmers was postulated to be driven by farmer risk attitudes, risk perceptions and also the interaction between them. Specifically, the analysis sought to determine whether the decision to remain or exit the citrus industry was influenced by their risk attitude, risk perception and the interaction between the two terms.

The equation took the form of: $BS=B_1 = RA_i + RP_i + RA_i * RP_i$ (1)

Where;

BS is the behavioural outcome space, reflecting the set of farmers' behaviours,

B_1 is the behavioural outcome of farmer i.

RA_i is the risk attitude of farmer i.

RP_i is the risk perception of farmer i.

The strengths of logistic regression are as follows:

1. It is robust; the independent variables do not have to be normally distributed or have equal variance in each group.
2. It does not assume a linear relationship between the independent variable and dependant variable; in reality, relationships among variables are not always linear.
3. Explicit interaction and power terms can be added; in reality, there is interaction between independent variables which may not be picked up in other models.

DATA ANALYSIS

The primary data from questionnaires was collated, coded and analyzed by using the Statistical software package STATA version 12.0.

RESULTS OF THE STUDY

SOCIOECONOMIC IMPACT OF THE HLB DISEASE ON THE BELIZEAN CITRUS INDUSTRY

The study found that approximately 3,917 persons were employed by the Belize citrus industry, and overall, the industry contributed US$ 59 million to the national economy in 2009/2010. At the local level, the citrus directly contributes to the socioeconomic development of the Stann Creek, Teledo, Cayo and Belize districts through employment, infrastructure and sustenance of the local economy. HLB represents a direct threat to the livelihood of farmers and farm families. The demise of the industry can result in the stagnation or reversal in social and economic gains advanced by the Belize citrus industry over many decades. The disease also leads to decimation of citrus trees impacting negatively on the rural landscape.

The contributions of the industry were as follows:

(i) **Employment:** Approximately 491 farms made up the producer component of the industry. Farm operations employ 2,352 persons, 807 being permanent and 1,545 being temporary or seasonal labor used in cleaning and harvesting of the fruit. Citrus processing factories employ 1,074 persons, 218 in permanent, and 856 as temporary workers.

(ii) **Capital:** US $59 million contribution to the national economy with an estimated 10% of citrus earnings injected directly into the rural communities of Stann Creek, Teledo, Cayo and Belize districts.

(iii) Maintenance of the economic integrity of 36,920 acres of Belize countryside in the Stann Creek, Teledo, Cayo and Belize districts.

(iv) Employment of a large number of professionals includes, farm and industry managers, processors, engineers, and financial managers.

(v) Sustaining industries involved in hardware, construction, large scale machinery and other support services.

The study also found that the stakeholders in Belize had differing views of the threat posed by HLB and actions that should be employed in its management and control. The intensity of management measures at the production level, and policy initiatives to protect the industry were largely dependent on stakeholder perception of the severity of the risk posed by the disease. Most importantly, the survival of the industry was largely dependent on farmers' decision to remain or exit the industry.

RISK ANALYSIS

This section presents the results of risk attitude and risk perception of farmers on HLB and the significance of risk attitude and risk perception in influencing farmers' decision to remain or exit the Belize citrus industry. A total of 67 farmers were surveyed and the data obtained from these farmers were used in the analysis. The result of the logistic regression is presented in Table 1.

Table 1: Results of Logistic Regression–Belizean Citrus Farmers' Attitude toward Risk

Number of observations = 67
Wald chi^2 (3) = 16.64
Log likelihood = -34.533092
Prob > chi^2 = 0.0008

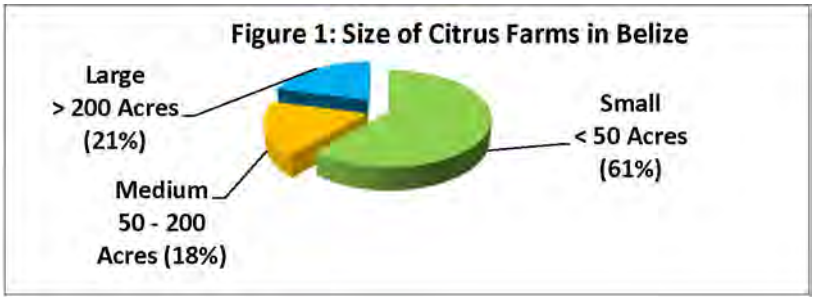
bo | (Behavioral Outcome)	Coef.	Std. Err	z	P>|z|	Comment
ra | (Risk Attitude)	-0.1434283	0.210536	-0.68	0.496	Not Significant
rp | (Risk Perception)	-1.041263	0.4808818	-2.17	**0.030**	Significant at the 5% level
rarp | (Interaction Term)	0.1992465	0.1099753	1.81	0.070	Not significant

The level of significance chosen for the logistic regression was 0.05 (5%).

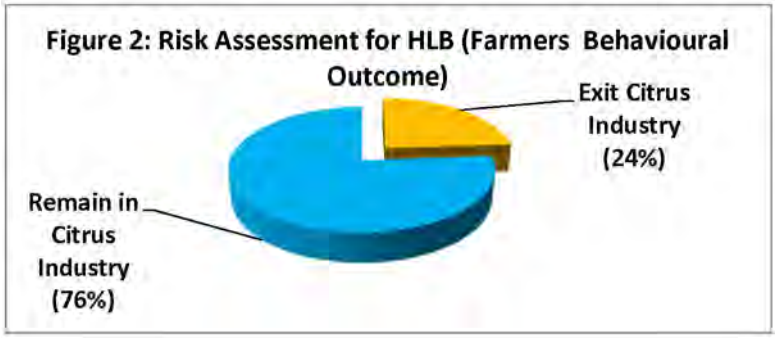
The Wald Chi-Square statistic was used to test whether at least one of the predictor's regression coefficients is not equal to zero. The model has a Wald Chi-Square (3) of 16.64, which indicates that the variables are significant at the 5% level. The number in the parentheses indicates the degrees of freedom of the Chi-Square distribution used to test the Wald Chi-Square statistic and is defined by the number of predictors in the model (3). The p-value of 0.0008 was less than the chosen level of significance of 0.05 (5%).

Three variables were used in the logistic regression: risk attitude (ra), risk perception (rp) and an interaction term [risk attitude (ra) and risk perception (rp)]. The variable (ra) (farmers' risk attitude) has a p-value of 0.496 > 0.05; hence the variable was not significant and did not influence the behavioural outcome. The variable (rp) (farmers' risk perception) has a p-value of 0.030 < 0.05; hence the variable was significant and influenced the behavioural outcome. The variable (rarp) (interaction term) has a p-value of 0.070 > 0.05; hence the variable was not significant and did not influence the behavioural outcome.

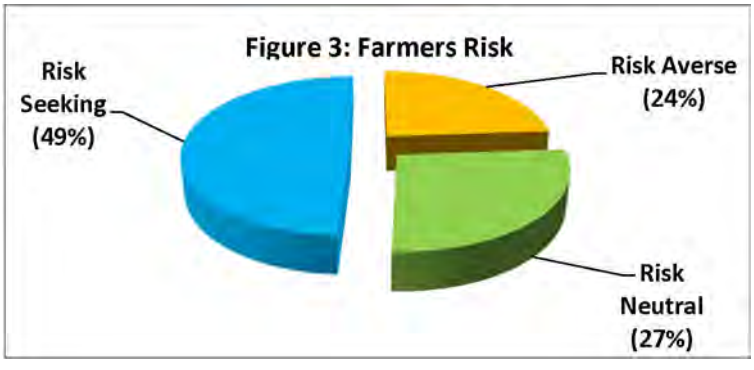
Farm Size: The study solicited the opinions of small, medium and large farmers. Overall 61% of the farmers surveyed were small farmers; 18% were medium sized; and 21% were large farmers (Figure 1).



The Behavioural Outcome of Farmers Surveyed: With respect to the farmers' response to the risk posed by HLB, a total of 24% of the farmers surveyed indicated that they would exit the citrus industry and 76% of the farmers indicated that they would remain in the citrus industry regardless of the HLB infestation (Figure 2).

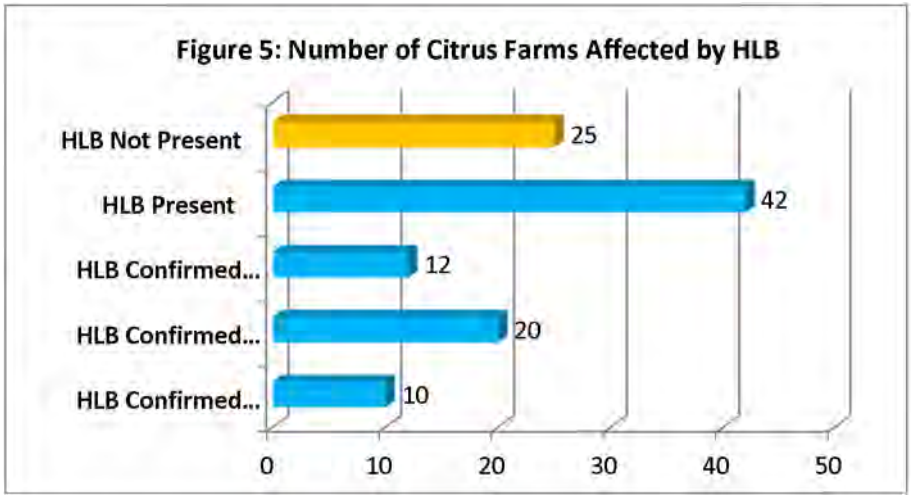


Farmers' Risk Attitude: The study utilized a series of questions which assessed farmers' attitude towards risk. The results indicate that 49% of the farmers surveyed were risk-seeking, 27% risk neutral, and 24% risk averse (Figure 3).



HLB Management: All farmers were asked whether they practiced any form of management for HLB or were part of the Citrus Growers Association (CGA) HLB management programme. Overall, 34% of the farmers surveyed indicated that they employed no management measures for HLB and 66% indicated that they employed management's programmes or were part of the CGA's HLB management programme (Figure 4).

Citrus Farms Affected by HLB: Farmers were asked to indicate whether their farms were affected by HLB. The results show that HLB was present on 42 of the 67 farms involved in the survey. There were 10 confirmations in 2009. In the case of 2010, there were 20 confirmations, while in subsequent year 2011, there were 12 confirmations of HLB present on farmer holdings (Figure 5).



DISCUSSION AND CONCLUSION

Farmers of the citrus industry of Belize were fully informed of the destructive nature of HLB at the production level and its effects throughout the industry value chain through educational programmes primarily facilitated by the CGA. At the production level, infected orchards experience increased fruit drop, lopsided fruits and increased tree mortality within three to five years, especially in younger groves. Fruits affected by HLB were of a reduced quality, i.e. lower brix content. Fruits also affect citrus juice processing activities because they lack uniformity in shape. This lack of uniformity reduces the output efficiency at the processing plant which translates into reduced export of FCOJ, the primary contributor to agricultural exports, agriculture GDP in Belize. Stated succinctly, HLB may result in reduced earnings for all stakeholders throughout the value chain and may negatively affect the livelihoods of farm owners, workers and the rural economy in general.

Analysis of the logistic regression model indicated that the variable risk perception (the likelihood of farmers getting the disease) was the only significant variable contributing to the behavioural outcome, i.e. farmers' decision to remain or exit the citrus industry. Despite the information communicated to farmers about the disease and early signs of its effects on farmers' holdings, the study found that 76% of the farmers were willing to remain in the citrus industry regardless of prevailing and anticipated circumstances.

The evaluation of farmers' attitude towards risk indicated that almost half (49%) of the farmers were risk-seeking. This finding is reflected in the high percentage of farmers who decided to remain in the industry regardless of the challenges presented by HLB. With regards to HLB management, 66% of the farmers surveyed indicated that they employed management measures either individually or as participants in the CGA's HLB management programme. However, 34%

of the farmers did not implement measures to control HLB, and among the 66% of farmers who implemented a HLB management programme, the required frequency of application of insecticides and fertilizers were less than optimal. A significant number of farmers indicated that the lapse in their HLB management programme was because of financial constraints.

At present, HLB threatens the livelihood of farmers, agriculture workers, the rural and national economy of Belize, and results in reduced earnings for all stakeholders along the citrus industry value chain.

RECOMMENDATIONS

The management of HLB in Belize requires policy initiatives which facilitate the inclusion and effective involvement of all industry stakeholders. Specifically, policies should provide support to the HLB management programmes implemented by the CGA and the Citrus Greening Task Force of the Belize Agriculture Health Authority (BAHA).

Consultations with industry stakeholders revealed that budgetary allocations from government and the private sector were inadequate to fund an effective HLB management programme. Hence, efforts should be made to seek additional funding, combine available resources, and continue collaborations with international partners to increase the effectiveness of national programmes.

At the production level, educational programmes on HLB should continue to increase farmers' overall awareness of the disease and further address the issues of risk attitude and perception. In addition, every effort should be made to encourage the participation of all farmers in the national HLB management programme. Most importantly, researchers and industry professionals should develop cost effective strategies for HLM management that can be utilized by resource-poor farmers.

In the immediate future, focus should be placed on vector control, farmer awareness, and training of technical staff. Overall, focus should be placed on research and development of an Integrated Pest Management (IPM) solution for HLB.

REFERENCES

Ministry of Agriculture & Fisheries & Government of Belize, *The National Food & Agriculture Policy (2002-2020)*, April 2003.

Food and Agriculture organisation of the United Nations FAOSTAT *http://faostat.fao.org/site/339/default.aspx* (2012).

Citrus Growers Association, *42nd Annual Report,* 2008/2009.

Statistical Institute of Belize, *Belize Economic Report,* 2009.

Proceedings of the Caribbean Food Crops Society. 48:44-69. 2012

EXPORTING U.S. WINE TO THE DOMINICAN REPUBLIC

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ABSTRACT: The project's objective was to assess the emerging wine market of the Dominican Republic with the goal of identifying potential for exporting U.S. wine. Data Collection: The data were collected through the following activities:

- in-depth interviews with wine importers, restaurant, hotel, and resort managers
- wine consumer survey
- examination and assessment of retail price points and shelf allocation
- examination of wine lists
- examination of promotional and informational materials related to wine

Main Findings: Wine consumption began to experience rapid growth in the 1990s, surpassing an annual sale of over 100,000 cases to approximately 500,000 cases in the year 2000 (Hernandez, 2004). By the year 2001, beer and wine had experienced a 55% average growth (Mendez, 2002), and by 2007, wine consumption alone was estimated to be 7 million liters annually, valued at more than U.S. $18 million dollars, with an expectation to grow (ProChile, 2010). Wine's popularity in the Dominican Republic is growing rapidly. Researchers found that increase in discretionary incomes and growing number of international tourists contribute greatly to this growth. As the largest Caribbean economy, the Dominican Republic averages about 6% in economic growth each year. In 2009, the gross domestic product (GDP) was estimated at $45.6 billion, with the per capita GDP of $ 8,648 , a much higher amount in terms of Purchasing Power Parity (PPP) than in previous years (U.S. Department of State, 2010). According to the U.S. Department of State (2010), tourism, transportation, communication, and finances comprise about 54% of the nation's GDP; it is expected that employment in travel and tourism industries will continue to increase. U.S. wines have increased their presence in the Dominican Republic due to increased exposure to consumers, changing consumption patterns, and lower transportation costs. Carlo Rossi is currently the best-known U.S. brand among the Dominican population. Overall, other than a few higher-end California wines, consumers are not generally willing to pay much for U.S. wines, as there is strong competition with Rioja wines. Although wine from various wine regions of the world is available in the Dominican Republic, the market is currently dominated by wine from Spain and Chile. According to the GAIN report of 2011, the U.S. has 14% of the total wine market share, after Spain (36%), Chile (27%), and Italy (15%). Argentina holds 5% and other markets 3% of the remaining market share. Almost all available wine in the DR is controlled by importers. The vast majority of importers interviewed agreed that the current wine market in the Dominican Republic is saturated. The U.S. high-end wines present the best market potential and a few importers indicated they are open to negotiate on these high-end wines. Retail is by far the biggest potential for imported wines, as the vast majority of Dominican consumers purchase wine for personal consumption or as a gift at supermarkets or liquor stores. All-inclusive resorts represent about 30% of the wine market in the DR. These resorts import wine directly and almost exclusively in bulk, mainly from Spain.

Keywords: wine market assessment, demand analysis, wine consumer survey, Dominican Republic

INTRODUCTION

With its recent growth in tourism and wine consumption, the Dominican Republic has potential for importing U.S. wine. The current project's objectives were to conduct an assessment of this emerging wine market with the goal of identifying the potential for exporting U.S. wine, which in turn, can benefit the economies of both countries. To meet the objectives, a combination of qualitative and quantitative data were collected through the following activities: in-depth interviews with wine importers, restaurant, hotel, and resort managers in the Dominican Republic; Dominican wine consumer survey; examination and assessment of retail price points and shelf allocation; examination of wine lists, and examination of promotional and informational materials.

Traditionally, beer and spirits have been the preferred alcoholic beverages, especially among rural, lower-income populations. In recent years, however, the market for wine is on the rise in the Dominican Republic. In 2010, for example, the annual growth of wine consumption in the Dominican Republic was 13.2%, compared to the previous year. Although wine from various regions is available in the Dominican Republic, the market is currently dominated by wine from Spain (36% of the market share) and Chile (27%). Within the last few years, U.S. wines have increased their presence in the Dominican Republic due to increased exposure to consumers, changing consumption patterns, and lower transportation costs. Carlo Rossi is currently the best-known U.S. brand among the Dominican population. Overall, other than a few higher-end California wines, consumers are not generally willing to pay much for U.S. wines, due to strong competition with Spanish and Chilean wines.

OBJECTIVES

The project's objectives were to conduct an assessment of the emerging wine market of the Dominican Republic with the goal of identifying potential for exporting U.S. wine, which in turn, can benefit the economies of both countries. Specifically, the project included the following three objectives:

- To conduct an assessment of the Dominican Republic wine market, with the specific assessment of the wine distribution system, the local wine consumers, as well as on-premise (restaurants/hotels/resorts) and off-premise (supermarkets/liquor stores) wine consumption trends
- To conduct the market analysis of the Dominican Republic wine market

MARKET ASSESSMENT

a. Country Overview

The Dominican Republic is located in the middle of the Caribbean Islands and comprises the eastern 2/3 of the island Hispaniola, with Haiti bordering on the west. The nation covers approximately 18,704 square miles and consists of a maritime tropical climate with a diverse terrain ranging from semi-arid plains to tropical rainforests (U.S. Department of State, 2010). The second largest Caribbean nation after Cuba in population, its people represent mixed, European and African ethnicities, with most living in urban areas. Approximately 9.65 million people live in the country. With an annual growth rate of 1.5%, it is estimated that by the year 2015, the

Dominican Republic population will reach 10 million. Due to its unique history and location, the country is influenced by strong multiculturalism, with the largest foreign minority group being Haitians. It is estimated that approximately 100,000 U.S. citizens live in the Dominican Republic, many of whom are dual nationals. Spanish is the primary language spoken.

b. Wine

Traditionally, beer and spirits, including rum, whiskey, brandy, gin, and vodka, have been the preferred alcoholic beverages, especially among rural, lower-income populations. In recent years, however, the market for wine is on the rise in the Dominican Republic. Retailers interviewed all agreed that wine consumption in the Dominican Republic has increased considerably within the last ten years - a finding which supports the documented growth of the wine market in the Dominican Republic by existing literature. Wine consumption began to experience rapid growth in the 1990s, surpassing an annual sale of over 100,000 cases to approximately 500,000 in the year 2000 (Hernandez, 2004). By the year 2001, beer and wine had experienced a 55% average growth (Mendez, 2001), and by 2007, wine consumption alone was estimated to be 7 million liters annually and valued at more than U.S. $18 million dollars, with an expectation to grow (Prochile, 2010).

Today, people with higher incomes tend to be the major buyers and consumers of wine in the Dominican Republic. Researchers found a noticeable trend in urban areas among those with higher incomes, who are decreasing their rum consumption and increasing whiskey, scotch, and wine consumption. Men are identified as the main wine purchase decision makers, but men and women consume wine equally. Researchers found that the female segment of consumers is actually growing, and women are influencing decisions on what types of wine to drink.

The most popular grape varieties in the market today are Cabernet Sauvignon, Merlot, and Tempranillo. Although white wine and sparkling wine is popular among female drinkers, the consumption of dry red wine by far surpasses the overall consumption of white, rosé, sparking, and other types of wine.

c. The Growing Wine Market

Wine's popularity in the Dominican Republic is growing rapidly. Researchers found several factors that have contributed to this development. First, the Dominican Republic's growing economy has led to an increase in discretionary incomes. As the largest Caribbean economy, the Dominican Republic averages about 6% economic growth each year. In 2009, the gross domestic product (GDP) was estimated at $45.6 billion, with the per capita GDP of $ 8,648 , a much higher amount in terms of Purchasing Power Parity (PPP) than in previous years (U.S. Department of State, 2010).

This growing economy is dominated by services and fueled by an increase in tourism. According to the U.S. Department of State (2010), tourism, transportation, communication, and finances comprise about 54% of the nation's GDP, and it is expected that employment in travel and tourism industries will continue to increase. Since the Dominican Republic is one of the top Caribbean tourist destinations welcoming millions of tourists annually, the increase in palate preferences from more European and American tourists has also influenced the demand for more wine.

Several reasons have been identified as contributing factors to the growth of the wine market. First, the economic growth has stimulated an increase in the number of restaurants and media sources promoting wine consumption across the country. For example, fine dining and gourmet restaurant chains that include wine on their menus have become abundant. Restaurant managers interviewed reported that the growth of these establishments and the increased popularity of eating out in general have led to an increased interest in wine among Dominicans. Specialized chefs, magazines, and cooking shows on television have also contributed to an increased interest in wine.

Secondly, the cultural exposure to wine by Dominicans who interact with families in other parts of the world –particularly Spain– has also influenced the demand for wine. Several interviewees mentioned that many Dominicans perceive wine as a "democratic" beverage that is included in more social activities, and as a result, is present throughout the country -findings which support previous research (Prochile, 2010).

Third, major wine importers, such as *Suarez* and *El Catador*, make continuous efforts to educate consumers on the culture of wine through tastings, educational programs, and wine clubs. The popularity of gourmet clubs, in which Dominicans can participate in a food and wine experience, is also growing. Wine importers reported that higher income populations are interested in learning about wine and tobacco, particularly in the capital, Santo Domingo. As Dominicans make changes to their lifestyle, they are also learning more about wine's health benefits.

Lastly, because of its location, size, economy, and Free Trade Agreements almost half of the total food and drink consumed in the country is imported. According to the USDA Foreign Agricultural Service (2002), "53% of the imported products are from the United States" (Mendez, 2002, p. 2). Dominicans have increased their interest in the consumption of imported products in general and the Dominican Republic's Free Trade Agreements have opened the market to a greater variety of imported goods from different countries. With reference to the wine market, currently only one local brand of wine is available in the Dominican Republic and 99% of the overall wine market is imported ("Vertiginous Increase," 2008).

d. Competitive Environment

Although wine from various wine regions of the world is available in the Dominican Republic, the market is currently dominated by wine from two majors regions: Spain and Chile. Both Spain and Chile hold approximately 30% each of the available wine market, according to the wine importers interviewed. These findings support previous research from Mendez (2009), which documented that these two leaders supply over 4.5 million liters total to the Dominican Republic. In addition, the wine importers estimated that Argentina provides about 25% of Dominican wine imports, while France, the U.S., Australia, and New Zealand collectively comprise the remaining 15% of wine market.

Wines from Spain are valued most because of the country's historical and cultural connection with the Dominican Republic. For example, personnel from the Dominican restaurant *Pat'e Palo* reported in the interview that older consumers are loyal to Spanish wine regions and producers, which they consider more "traditional." Younger consumers, on the other hand, tend to be more adventurous and try wine from non-traditional regions, such as the United States. The Dominican

Republic also recently approved new importation regulations that have eased the taxation of Spanish wines, and as a result, they have become even more competitive in the market.

Chile, on the other hand, has quickly become a market leader largely due to aggressive marketing and strong promotional support that many Chilean wine producers provide to importers. Wine importers indicated that many Chilean wine producers invite Dominican Republic importers to their production facilities in Chile and organize training courses for Dominican Republic wine importers to learn about and promote their products. In turn, Dominican Republic wine importers then organize similar training session for retail managers to educate them about the Chilean wine. For example, one importer, *Suarez*, provides a 95-hour course for retailers, which consists of four modules: basic wine knowledge, basic viticulture and enology course, tasting, and commercial aspect of wine business.

Chilean wine producers also actively pursue marketing strategies for in-store tastings at supermarkets and liquor stores to promote exposure to their brands. These producers provide large investments in point-of-sales promotions. Interviewees reported that these strategies, along with consumers' perceptions and leaning toward fruiter and more "trendy" wines, place Chilean wines at an advantage in the market.

American wines have also increased their presence in the Dominican Republic due to increased exposure to consumers, changing consumption patterns, and lower transportation costs. As the most important trading partner with the Dominican Republic, "the United States supplied almost 1 million liters of wine to the Dominican Republic in 2007, valued at over $1.7 million" (Mendez, 2009, p. 3).

Carlo Rossi is currently the best-known U.S. brand among the Dominican population, and interviewees indicated the perception that "Carlo Rossi brought U.S. wine to the Dominican Republic market" through its exclusive importer, *La Bodega*. *Beringer White Zinfandel* is another association many Dominicans have with U.S. wine, and several retail managers reported that this brand, along with several Washington state wines, have increased in popularity lately. The results of the interviews also suggest that although traditional wine consumption has been influenced by Europe, an emerging trend indicates that high quality California wines (typically on the higher end of the price spectrum) have substituted part of the French and Italian wine market in the Dominican Republic.

Overall, other than a few higher-end California wines, consumers are not generally willing to pay much for U.S. wines, as there is strong competition with Rioja wines. In terms of potential, the industry should focus on younger wine consumers, as they are more likely to experiment and try American brands, contributing to their popularity in the Dominican Republic.

e. Major Outlets for Purchase

Dominican consumers currently purchase wine from several major off-premise and on-premise sources.

Off-premise:

- Supermarkets

On-premise:

- All-inclusive resorts and hotels

- Liquor Stores
- Specialized retailers (*colmados*)
- Specialized distributors/importers
- In-city and business hotels
- Restaurants/ bars

f. Retail

Retail is by far the biggest potential for imported wines, as the vast majority of Dominican consumers buy wine for personal consumption or as a gift at supermarkets or liquor stores. These findings support previous research from Mendez (2002), which noted that supermarkets in the Dominican Republic are "growing in number and size" (p. 1) and represent about 30% of the retail market. In 2001, there were over 600 supermarkets and mini marts in the Dominican Republic, most of which were located in Santo Domingo and Santiago, and the number of supermarkets continues to grow nationwide today. Since supermarkets reach mostly the middle and upper classes with higher incomes and remain the main means to distribute most imported food products in the Dominican Republic, researchers confirmed these are definitive target markets for wine.

Lower-income Dominicans tend to purchase their food and beverages at *colmados* - small mom-and-pop independent grocery stores. Although supermarkets tend to offer better selection, product variety, and prices, many lower-income people purchase groceries at these *colmados* because of proximity, quantity of items needed, and personal relationships with the people who run the *colmado*. Researchers observed that wine can be found in these types of stores but with low variety and typically higher prices. Consumers reported that would occasionally buy wine at these outlets mainly for convenience.

g. All-Inclusive Resorts and Hotels

All-Inclusive resorts represent another 30% of the wine market in the Dominican Republic. Numerous resorts are scattered along the coastline of the Dominican Republic. These resorts are an important source of wine sales. As tourism and vacation experiences have increased over the last decade, most of the visitors to these resorts are international travelers from European countries and North America, with a few local Dominicans visiting, as well. The resort's price range and clientele affect the type of wine available to visitors.

In-city and business hotels, on the other hand, represent only about 2% of the Dominican wine market. These hotels tend to sell wine served only at wedding receptions and banquets, unless they possess a high-end restaurant. Researchers found these businesses also tend to purchase their wine from local importers, which supported earlier findings by Mendez (2009).

h. Importers (Specialized Distributors)

Importers, or specialized distributors, represent about 20% of the wine market in the Dominican Republic. These businesses import wine from a variety of countries and regions and then distribute their product to retail outlets, resorts and hotels, or their own stores. Importers often feature their products through special events, such as showrooms, wine bars, and featured wine tastings, and provide valuable education and exposure to consumers. The Dominican Republic has five major importers that currently dominate the market: *El Catador, S.A., Marcas Premium, S.A., Manuel Gonzalez Cuesta, Sucs C por A, Alvarez y Sanchez, C por A*, and *Vinos S.A.*

i. Restaurants

Restaurants represent about 20% of the wine market in the Dominican Republic. Although restaurant sales have declined lately relative to off-premise sales at supermarkets and liquor stores, restaurants (and particularly upscale restaurants) still represent an important source of wine sales in the Dominican Republic. As a general rule, restaurants sell wine by the glass and by the bottle. However, by-the-glass programs are rare and not very popular. In the Dominican culture, orders in restaurants usually include ordering a bottle of wine, rather than buying wine by the glass. Consumers can find wine at a variety of restaurants, although greatest wine quality, variety, and availability will be found at upscale restaurants. Overall, researchers found that restaurants have the best potential for high-end wine sales in the Dominican Republic.

j. Supermarkets

Since retail represents one of the major channels of the wine distribution system, research was conducted on retailer shelf allocation and price points. Researchers observed that retailers organize their wine inventory mainly by wine color and by the country of origin, with the largest portion of shelf allocation given reds and to Spanish wines. For example, *Nacional*, one of the largest supermarket chains in the country, allocates six aisles (out of a total of 8 wine aisles) to red wine. Of these six red wine aisles, two aisles are Spanish wines, two aisles are Chilean wines, one aisle is French/Italian wine, and one aisle is reserved for wines from the U.S., Argentina, and other regions. Only one aisle (about two rows) is allocated for white wines, and another aisle is split between rosé wines, which represent about 2/3 of the wines in the aisle, and alternative packaging wines, which represent another 1/3 of the wines in the aisle.

Researchers also observed that wine is packaged mostly in traditional 750 ml glass bottles. Tetra-pack and plastic bottles are present in retail outlets, but this packaging represents roughly less than 5% of the total production represented in supermarkets and liquor stores. Small, six-pack or 180 ml bottles were scarcely represented, and it was indicated by several supermarket beverage managers that these smaller packing options are sold mostly during lunchtime due to the beverage size and screw top convenience. Overall, however, consumers feel very resistant about screw tops, and this type of closure is virtually not present in the market. Interviewees indicated that Dominican consumers feel very strongly about traditional cork closures. Beverage managers also indicated that wines with traditional design labels tend to sell better. The Spanish wines that sometimes utilize wordy, busy labels seem to be at a disadvantage. However, no research exists as of yet to verify this observation.

Researchers examined wine prices in retail settings, and noted that a wide price range is evident - from 200 pesos (approx. $5.25) on the lower end to as high as 3,000 pesos (approx. $78. 6) on the higher end. For reference, the exchange rate as of October 11, 2011 is 1 Dominican Peso equals 0.0262 U.S. dollar.

The most common price for a daily consumption red wine is around 400 pesos. Retailers who priced over 400 pesos experienced a noticeable decline in sales. All retailers interviewed noted that within the last year, they experienced a noticeable decrease in overall profit sales, but not in

volume sales. *Nacional*, for example, indicated that within the last year their wine sales increased in volume by 33%. However, these wines tended to be priced cheaper.

Dominican retailers are allowed to purchase wine directly from the producer, with no involvement of wine importers. *Grupo Ramos*, for example, imports certain brands directly to its chain with exclusive rights to represent these brands. At the same time, however, the company also carries most known brands, which they purchase through importers. Retailers typically purchase through importers those brands that are well represented in the market in order to remain competitive with other retailers. For example, 70% of *Grupo Ramos's*, inventory is Spanish wines because the owners of the business are Spanish and have established business contacts in Spain. The other 30% of their inventory includes wine from other regions. Currently *Grupo Ramos* carries two lesser known U.S. brands with the specific strategy to compete with Carlo Rossi: Cutler Creek, which presents 75% of their inventory of American wines, and Glen Ellen, which represents the other 25%.

When importing wines directly from producers, retailers indicated that they tended to mark-up wines as much as 60%. Wines purchased through an importer, however, tended to only have a price mark-up of 25-30%. Researchers confirmed the following estimated commercialization margins in the Dominican Republic, a finding that supported earlier research by Mendez (2009):

- Importer: 40% – 50%
- Retailer: 25% – 30%
- Restaurant: 100 – 300%, depending upon the original cost of wine

k. All-Inclusive Resorts and Hotels

Over 80% of hotels in the Dominican Republic are all-inclusive businesses (resorts). These resorts vary considerably in clientele, cost, and amenities offered, which is reflected in the wines carried. For example, researchers found upscale resorts typically have an extensive wine list with wines represented from the major wine regions of the world. Many of the mid-range resorts offering all-inclusive food and beverages, on the other hand, only carry a few wines.

Researchers found resorts import wines directly and almost exclusively in bulk from wine producers mainly in Spain, and these wines tend to be priced between $0.80 and $3.00 per liter. Bottled wine is also imported and available through "al-a-carte" menus. However, this option is not very popular among patrons at all-inclusive resorts.

To obtain information on wine sales and allocation, researchers visited two all-inclusive resorts in Bavaro: the upscale hotel *Iberostar Grand Hotel* and *Iberostar Punta Cana Hotel*. *Iberostar Grand Hotel* can accommodate 475 guests. At the time of the interview (August 2011), the resort had 54% occupancy rate (255 guests). November is typically the high season for clientele. This upscale resort maintains an all-inclusive wine list featuring wines from 14 countries, including 26 wines from Spain, Chile, Argentina, Australia, France, South Africa, and other countries. *Iberostar Grand Hotel* also maintains a large non-inclusive wine list, including 25 white wines and 19 red wines.

Red wine is the most popular type of wine consumed at *Iberostar Grand Hotel*. Rosé and sparkling wine are also popular. To welcome guests to the resort, for example, hotel personnel provide Cava, a sparkling Spanish wine that is typically cheaper than champagne.

Iberostar Grand Hotel's sommelier makes the wine and food choices, which the wine manager then requests from suppliers. Suppliers to this resort include *El Catador, Bodega,* and several suppliers from Spain and Miami.

The average clientele consumption of wine by volume includes 97 bottles of wine at the *Iberostar's* restaurant and 35 bottles of wine for the all-inclusive package option. Interviewees noted that most people drink cocktails as part of the all-inclusive package but will often order a bottle of wine when they dine at the restaurants. Ordering a bottle of wine not included in the package, however, is typically seen as a special occasion.

Like *Iberostar Grand Hotel*, the second hotel that the researchers visited, *Iberostar Punta Cana Hotel*, also offers visitors an upscale resort experience. However, this resort has a much greater capacity for visitors. Two restaurants at this resort offer all-inclusive food and drinks; however, the wine is only from Spain, and guests can only choose from either white or red wine. There are three more restaurants at the resort where guests can buy food and wine. These restaurants have more extensive wine lists and provide a more upscale experience for visitors.

The other 20% of the total hotel market in the Dominican Republic is comprised of in-city hotels. In-city hotels' major clientele includes in-house guests, local business people, wedding receptions, and banquets. Researchers found that most in-city hotels purchase wine through local importers. Legally, hotels are allowed to purchase wine directly from wine producers. However, producers require full order payment in advance, while local importers provide credit, thus creating more advantageous conditions for hotels. In-city hotels often partner with local wine importers in an effort to educate consumers about wine. For example, the *Fiesta* hotel features promotional tastings and manages its own wine club, featuring live music and tastings on Friday nights. In the past, in-city hotels tended to add a substantial mark-up to their price of their wine, but the trend now is to lower the mark-up to attract more local customers.

l. Importers (Specialized Distributors)

Almost all available wine in the Dominican Republic is controlled by importers. Orders are placed through direct contact with supermarkets and liquor stores, and importers will then pay a slot fee to retailers to carry their brand. Importers indicated that they negotiate promotional costs with the producers and value those producers who invest in promotional materials and point-of-sales and continuously provide promotional campaigns for their products. Slot fees, as well as promotional budgets, can be negotiated and are usually paid by the wine producer as well.

The purchasing options between retailers, importers, and producers have created double competition in the market since retailers can buy directly from both importers and producers. Producers require direct payment for their product, whereas importers provide credit. As a result, although supermarkets, hotels, and restaurants can import directly from producers, most utilize importers because of attractive credit lines these importers offer.

El Catador, S.A., a family business established in 1976, is the largest importer of wine and beverages in the Dominican Republic. Today it imports about 80% of the total Dominican wine market. This company meticulously decides what wine it will carry. In fact, the Vice President personally decides when wine will be imported and which brands will be carried. Wine choices tend to be based on quality and tested by the staff and President. Other factors that influence *El Catador's* decision to import a wine include brand recognition, willingness of the wine producer to provide support, training, and promotional materials, and the overall relationship the brand establishes with *El Catador*.

Traditionally, this company imported wine mainly from Spain. However, researchers found that as preferences of consumers have changed, *El Catador* has changed its allocation of imported wine inventory to the following:

Chile – 50 – 55%
Spain – 25 – 28%
Argentina – 15%
United States – 6 – 8%
France and Australia – about 5%

Interviews with *El Catador* revealed that wine from Chile and Argentina is perceived as trendy and becoming more popular, particularly because these countries offer a high quality product at a cheap price and lead aggressive promotional strategies with many tastings and advertisements.

U.S. wines also have a good reputation at *El Catador*. The most popular wines this company imports include Robert Mondavi and Woodbridge and Beringer White Zinfandel, as growth is occurring with rosé wines and sweeter styles, particularly with younger consumers. Washington state wines are also making some inroads and increasing sales with *El Catador*. Washington is the only other significant U.S. wine region represented at *El Catador* outside California.

El Catador has four stores: two in Santo Domingo, one in Santiago, and one in La Romana. About 35% of its wine is sold on-trade to hotels and restaurants. About 32% is sold to retail stores, and about 22% is sold through direct sale at its own stores. The percentage between on-trade and off-trade sales has changed significantly, researchers found, due to the demand growth in the retail sector. In the past *El Catador* experienced about 75% on-trade sales and 25% off-trade sales. However, now *El Catador* notes that on-trade and off-trade sales are about 50% each, most of which occurs within supermarket chains, such as *El Nacional,* which is its principal client.

A large portion of *El Catador's* marketing policy involves wine education. The company offers many levels of classes for sommeliers, retail store managers, hotel managers, and individual consumers. Classes range from introductory to advanced and focus on education about wine regions and types. These classes are offered at a fairly inexpensive price, which attracts more clients. *El Catador* indicated that wine tastings are offered at these classes, hotels, and restaurants tend to be very popular. Wine producers will often provide the wine or other promotional support for these classes.

Although researchers met with several major local importers for this project, including the largest importer - *El Catador* – due to logistical difficulties in meetings organization, researchers were

unable to meet with all importers. The following background information on the remaining four importers has been provided from the USDA Foreign Agricultural Service (Mendez, 2009):

Marcas Premium, S.A. was established in 1993 to import and distribute quality wine brands. Currently this company is the exclusive representative for wine, distilled, and liquor from California, France, Scotland, Italy, Chile, Argentina, Spain, and Australia. It is also one of the importers of U.S. wine, including Kendall Jackson, Ferrari Carano, and Arbor Mist.

Manuel González Cuesta, Sucs. C por A was formally established in 1945 and carries over 70 imported brands, including labels from the U.S. It is the currently exclusive distributor of the Ernest and Julio Gallo winery.

Alvarez y Sánchez, C por A was established in 1979 and publicly states that one of its objectives is to "contribute to improve the quality of living of Dominican families" (p. 6). The company represents over 50 wineries, including Simi and Marimar Torres from the U.S., and has indicated it continues to look for additional ways to increase supply from the United States to the Dominican market.

Lastly, *Vinos, S.A.* was established in 1980 and purchased by the Brugal Group in 1995, one of the major rum producers in the Dominican Republic. This company's portfolio includes more than 150 brands, including wine, vodka, cognac, gin, brandy, whiskey, cider, and mineral water. It is the only company of its kind with two regional distribution centers –one in Santo Domingo and another in Santiago. In addition to four specialty stores, the company has a wine club, Le Connoisseur, whose focus is to educate, to inform, and to promote wine consumption through wine courses and new product launching.

m. Restaurants

Wine options and pricing at restaurants varies by restaurant and clientele. Prices depend in part on supply channels. Most restaurants work with importers and buy wine through them. However, restaurants sometimes purchase wine directly from grocery stores if they need wine immediately or have needs that their main distributor can't supply.

Researchers found that high-end restaurants tend to be the primary carriers of wine, particularly more expensive wine, whereas restaurants in the mid-price and lower-price range place little emphasis on wine. Moderately priced restaurants, for example, tend to carry relatively cheap Spanish or Chilean wines and overall provide only a very few brands for their customers to choose.

Wine sold by the glass is dominated by wine from Chile and Spain, but by-the-glass programs are typically not very popular because they are perceived as expensive. Restaurant interviewees indicated, however, they have started seeing many Chilean producers pursue the by-the-glass option.

To obtain data on restaurant wine sales, researchers met with personnel from two major restaurants in Santo Domingo: *Taboo Bamboo* and *Pat'e Palo*. *Taboo Bamboo* is an atypical business. Once it operated as a traditional restaurant, but today is it rented mostly for banquets and celebrations, a business approach that they have found profitable. The restaurant's capacity is 400 people at a

time. Clients are shown a list of available wines, most of which are bought directly from *El Catador*. Researchers found that *Taboo Bamboo* carried a wide range of wines, including from the U.S. However, *Taboo Bamboo* indicated they do not deal directly with small importers, as it is cheaper for them to buy their wine, beverages, and other food products from a large importer.

Personnel interviewed indicated that during the last four years, they have noted a rapid growth in the consumption of sparkling and rosé wines. Future trends, they noted, will depend on the tastes and options available from distributors. Overall, *Taboo Bamboo* indicated they clearly focused on wine as an important aspect of their business.

Pat'e Palo is an upscale restaurant whose clientele consists mostly of wealthy Dominican and tourists. The restaurant's capacity is 325 people on the weekends and 235 people during the week. Like *Taboo Bamboo*, *Pat'e Palo* relies heavily on the major Dominican importer, *El Catador*, for its wine inventory and signs a yearly contract with the business to secure its supplies. "It would not be hard to change a supplier," interviewees noted, "if you have a solid reason for it." However, currently *Pat'e Palo* utilizes a small price mark-up of 1.7 – 1.8%, which is much lower than the average Dominican mark-up on wine of 2.5 – 2.7%. "Government duties tend to be high, which pushes prices for all wines up significantly," interviewees noted. *Pat'e Palo* is concerned that pushing prices too high would results in consumers viewing the restaurant as overpriced. As pricing and sales stand now, the restaurant grosses 500,000 pesos (approx. $13,000) in wine sales per night.

Clientele are shown a large wine list, with wines from many countries. Wines are listed by region first, which shows how dominant the region is in respect to wine sales. The wines are then sorted by color and style. Regular consumers, the manager indicated, know the menu and the wine. *Pat'e Palo's* clientele wine consumption by country includes the following:

Spain – 35%
Argentina and Chile – 35% (and growing)
France – 10%
United States – 5%
Other regions – 15%

Pat'e Palo's owner is present every night, and the manager has weekly meetings with staff to educate them about wine. At these meetings, the sommelier will share information about wine and staff will have an opportunity to taste it so that they can make suggestions to visitors. Overall, white and sparkling wines have very little demand in this restaurant, but *Pat'e Palo* is expecting to grow and double their wine sales in the next 18 months.

DATA COLLECTION AND ANALYSIS

Quantitative data were collected via the intercept method at supermarkets, liquor stores, and local malls. For data collection purposes, the researchers contracted a local university - *Universidad Dominicana O&M*. Undergraduate students majoring in marketing were trained by the contracted instructor to personally distribute pen-and-paper questionnaires to customers who purchased wine at supermarkets and liquor stores. A quota of 500 completed questionnaires was requested.

The researchers provided the instructor with a detailed training script with proper procedures for data collection. A full script of the data collection training instructions can be found in *Appendix A*. Specifically, the instructions stipulated that the training should begin with a brief introduction of the project to students. Students were then instructed on how to properly approach potential respondents, introduce the purpose of the project, emphasize the anonymous nature of the questionnaire and voluntary participation, and ask for their willingness to participate in the survey in exchange for a small token of appreciation. Incentives for participation (cork key chains in gift packaging), as well as 550 blank questionnaires, pencils and clipboards were purchased by Texas Tech University (through cost-sharing) and mailed to the Dominican Republic to facilitate the data collection process.

The data were collected at five supermarkets, eight liquor stores, and two local malls with smaller wine stores. The students collecting data were permitted to be in the wine sections of the stores. They approached potential respondents while they were making their selections of wine. In the malls, students approached customers outside the wine stores. Customers were generally willing to participate in the survey and a very low rejection rate was reported.

a. The Questionnaire

A one-page questionnaire was developed based on previous wine consumer research. Questions included wine preferences, wine consumption and wine purchasing behavior, as well as basic demographic information. The questionnaire was originally developed in English; then translated into Spanish by two independent bilingual individuals. Using the iterative process of back-translation (Brislin, 1970), the Spanish language instrument was translated back into English by separate individuals (not the ones making the English to Spanish translation) and then compared to the original English version to ensure adequate correspondence in the two versions.

b. Dominican Wine Consumer

The population of interest was wine consumers in the Dominican Republic. Because of the exploratory character of the study, a non-probability, purposive sample was used. A purposive sample includes subjects selected on the basis of specific characteristics or qualities (Wimmer & Dominick, 2003), in this case –wine consumers. The sample was limited to people who purchased wine at a supermarket or a liquor store in the Dominican Republic and identified themselves as wine consumers. A total of 482 valid surveys were collected and used for data analysis.

The socio-demographic characteristics tested were gender, age, education, and income. The sample consisted of more males (65.6%) than females (34.4%). The gender split in the consumer data was consistent with the observations from the qualitative data. Most of the interviewed industry professionals also noted that in the Dominican Republic men generally represent a higher percentage of wine consumers.

The majority of the consumers were aged between 20 and 60 years old and three-quarters of the respondents were younger than 50 years of age. The sample was well balanced in terms of different age categories, with about 20 to 30% of respondents in each age group between 20 and 60 years of age. However, there were very few younger (under 20 years old) and older (over 61 years of age) participants.

Respondents had higher education and income levels than the general population in the Dominican Republic. Sixty-two percent have earned either an undergraduate or graduate degree. Only 10% of the respondents had not attended college. Participants' income levels were also substantially higher than the general Dominican population. Thirty percent of the respondents reported that their monthly household income exceeded 80,000 Dominican Pesos (DOP) (an equivalent of approximately US$2,070/month). Only 13.7% of the sample reported earning less than DOP20,000 (approx. US$518) monthly. For reference, the Dominican Republic per capita GDP is US$721/monthly (The World Bank, 2011). Over 70 percent of the sample reported monthly income above the average GDP per capita. Table 1 summarizes the socio-demographic profile of the sampled population of the Dominican wine consumer.

Table 2 provides an overview of Dominican consumer wine preferences and their wine consumption behavior. The most preferred alcoholic beverage was beer, which is not surprising, given that historically, beer and spirits have been preferred alcoholic beverages in the Dominican Republic. The results of the current study, however, clearly demonstrate the increasing wine consumption pattern in the Dominican Republic, previously noted by government reports and repeatedly mentioned in the qualitative interviews. In the consumer surveys, wine was named the second most consumed alcoholic beverage, which overpassed preferences for spirits by 16.4%. The respondents were asked about their wine preferences in terms of the wine color (red, white, or rosé) and wine sweetness (dry or sweet). The majority (75.1%) reported preferences for red wine, followed by preferences for white (17%) and rosé wines (7.9%). When asked about preferences in terms of wine sweetness, more respondents (59.5%) prefer dry wines and fewer consumers (40.5%) prefer sweet wines.

Further comparison of consumers who prefer dry wine and those who prefer sweet wines revealed that consumers who prefer dry wine tend to buy more bottles of wine per month (4.7 bottles on average) than those who prefer sweet wines (4.3 bottles on average). Consumers who prefer dry wines also spend more money on wine monthly (DOP929, approximately US$24.1) than consumers with preferences for sweet wines (DOP775, approximately US$20.1). As indicated earlier, overall, the vast majority of consumers prefer red wines, regardless of their preferences for dry or sweet wines. However, those who prefer sweet wines tend to also like rosé/blush wines, and those who prefer dry wines tend to like white wine more. More males (66.5%) prefer dry wines than females (33.5%), and more women (53.6%) give preference to sweet wines than men (46.4%). Women are also more loyal to rosé/blush wines than men. With regards to age, the wine literature generally shows that preference for dryer wines is an acquired taste. Findings from this research support this idea –the majority of younger consumers preferred sweet wines, whereas older consumers indicated preference for dryer wines.

In terms of the general wine consumption behavior, the vast majority (84.2%) reported that they consume wine at least once a week. Ten percent reported daily wine consumption. The majority of consumers who consume wine at least once a week are those who prefer dry and red wines. Only 2.7% of the overall sample indicated they drink wine less than once a month. Those with higher education and income levels tend to drink wine more often.

The analysis of purchasing and spending behavior is summarized in Tables 3 and 4. Table 3 represents consumer purchasing behavior of wine in the Dominican Republic. Table 4 demonstrates the average spending on wine (bottles and money) by Dominican consumers. On

average, the respondents consume 4.5 bottles of wine per month and spend about between DOP100 and DOP4500 (US$2.6–118.4) on wine monthly. The average bottle of wine that consumers purchase costs DOP213.56 (US$5.56). This number is consistent with the findings from the qualitative interviews, where the average price per bottle was indicated as a range of US$3-10.

The majority of respondents (68.5%) buy wine at supermarkets, with the second largest outlet being liquor stores (22.8%). A very small percentage of consumers buy their wine at local *colmados* or restaurants/hotels. More men than women buy wine at restaurants and bars and those buying wine at hotels and restaurants tend to be consumers with higher levels of education and income.

One of the important aspects of any successful marketing and promotional program is the development of information sources that consumers mostly rely upon. Therefore, the survey asked where the respondents get their information about wine. The traditional word-of-mouth (that is, recommendations by friends and relatives) was found to be the most popular source of information, followed by information at supermarkets. Of particular value were retail displays and tastings at supermarkets. Radio/TV ads, as well as server recommendation at a restaurant were perceived as a lesser value. However, consumers with higher incomes, as well as older consumers, value servers' recommendations and media ads more than consumers with lower incomes and younger consumers. Women were found to rely on information from friends and relatives more than men. Men, on the other hand, indicated that tasting at supermarkets were their most relied upon source of information about wine.

In naming preferences for wine from specific wine regions, consumers ranked Chile as number one, followed by Spain, France, Italy, USA, Argentina, Australia/New Zealand. Again, these findings were consistent with the market share that most importers indicated in the qualitative interviews. In ranking the quality of wine from different regions, respondents ranked U.S. wine lower than wine from Chile, Spain, France, Italy, Argentina, and Australia.

Notably, U.S. wine was ranked higher among people with higher monthly incomes, especially those with incomes over DOP100,000 (US$2,590). Although these more affluent consumers still ranked Chile and Spain as the most preferred regions, the USA was ranked third. This is an important finding and needs to be taken into consideration in future marketing programs by the U.S. wine industry, as this group of consumers should be considered as the primary target market. This group also reports that wine is their most preferred alcoholic beverage –61.5% of people within this income segment indicated they consume wine more often than spirits and beer. They prefer dry and red wine over other types of wine. These consumers also drink wine more often, spend significantly more money on wine monthly, as well as buy more expensive wine. For example, the average price of a bottle of wine for consumers whose monthly household income exceeds DOP80,000 (US$2,070) was DOP252 (US$6.54), while consumers whose monthly income is less than DOP40,000 (US$1,035) on average spend DOP170 (US$4.51) on a bottle of wine.

These findings also support the results of the interviews, where several importers mentioned they were ready to expand their portfolios for new U.S. wines, but only for more expensive wines, as they would be targeting more affluent consumers who seek more variety and a larger selection.

Table 1. Socio-Demographic Characteristics of the Sampled Population (*N* = 482)

Characteristic	Number of Respondents	Percent
Gender		
Male	316	65.6
Female	166	34.4
Age		
Under 20	6	1.2
21 - 30	106	22.0
31 - 40	120	24.9
41 - 50	134	27.8
51 - 60	93	19.3
61 +	23	4.8
Education		
High school not completed	14	2.9
High school graduate	20	4.1
Vocational / technical school	15	3.1
Some college / not completed	132	27.4
Undergraduate degree	221	45.9
Post-Graduate degree	80	16.6
Monthly Family Income		
Under RD20,000 (Under US$518)	66	13.7
RD20,000 – RD40,000 (US$518-$1,035)	105	21.8
RD40,000 – RD60,000 (US$1,035-$1,550)	87	18.0
RD60,000 – RD80,000 (US$1,550-$2,070)	78	16.2
RD80,000– D100,000 (US$2,070 $2,590)	50	10.4
Over RD100,000 (Over US$2,590)	96	19.9

Table 2. Dominican Consumer Wine Preferences and Consumption Behavior ($N = 482$)

Characteristic	Number of Respondents	Percent
Which alcoholic beverage do you consume most often?		
Beer	209	43.4
Hard Liquor	97	201.
Wine	176	36.5
How often do you consume wine?		
Daily	50	10.4
Several times a week	189	39.2
Once a week	167	34.6
About once a month	30	6.2
Less than once a month	13	2.7
Special occasions only	33	6.8
What type of wine is your favorite?		
Red wine	362	75.1
White wine	82	17.0
Rosé / Blush wine	38	73.9
Do you prefer wine that is dry or sweet?		
Sweet	195	40.5
Dry	287	59.5

Table 3. Dominican Consumer Wine Purchasing Behavior ($N = 482$)

Characteristic	Number of Respondents	Percent
Where do you most often purchase your wine?		
Supermarkets	330	68.5
Liquor stores	110	22.8
Colmados	13	2.7
Restaurants / Bars	25	5.2
Hotels	4	0.8
Online / Mail Order	0	0
Wine from which region do you prefer most?		
Chile	243	50.4
Spain	132	27.4
Argentina	16	3.3
USA	24	5.0
France	36	7.5
Italy	28	5.8
Australia / New Zealand	3	0.6
Where do you go to find information about wine?		
Friends' / Relatives	235	48.8
Supermarkets	106	22.0
Server at restaurant	17	3.5
Retail Displays	76	15.8
Tastings at supermarket	26	5.4
Radio / TV	22	4.6

Table 4. Average Spending on Wine by Dominican Consumers ($N = 482$)

Characteristic	Minimum	Maximum	Mean	SD
Approximately how many *bottles of wine* do you consume per month?	1.0	15.0	4.5	2.6
On average, *how much* do you spend on wine per month?	DOP100.0 (US$2.6)	DOP4500.0 (US$116.8)	DOP866.9 (US$22.5)	DOP668.7 (US$17.4)

MARKET ASSESSMENT

The demand analysis has been conducted based on the following objectives of the project:

- Forecast increase in demand for wine
- Conduct consumer surveys to identify qualities valued most and key factors that affect purchasing decisions
- Analysis on how this knowledge can increase demand for U.S. wine

In recent years, consumption of wine in the Dominican Republic has been exhibiting some inconsistency. However, in the last two years, it showed strong positive growth. Between 2009 and 2010, the annual growth of wine consumption in the Dominican Republic was 13.2% (GAIN Report, 2011). The forecast of increased consumption for 2011 is quite convincing based on the actual numbers for the first six months. GAIN's report estimates 3% increase in wine consumption for 2011. Figure 1 shows changes in wine consumption during the last five years.

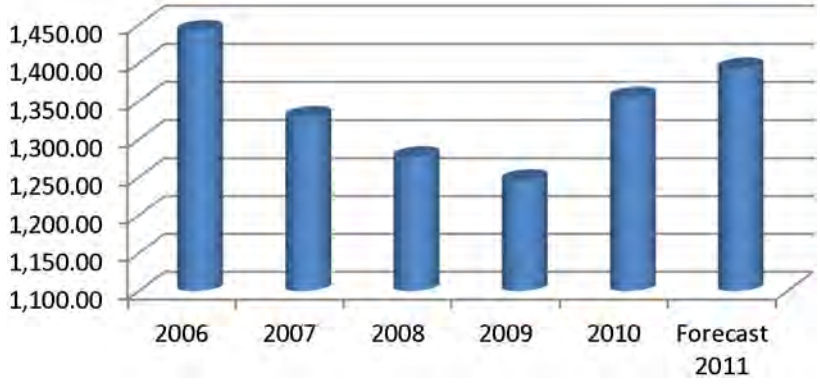

Figure 1. Dominican Republic's Total Wine Consumption, 2006-2011

A different view of wine consumption appears when comparing local wine consumption and imported wine consumption. Local wine is perceived by Dominican Republic consumers to be of low quality wine and so preferences are higher for imported wine. Figure 2 clearly shows the overall trend of increasing consumption of imported wine. In 2010, the proportion of consumed imported wine was 75% relative to total wine consumption (GAIN, 2011). Therefore, imported wine is an important commodity for Dominican Republic consumers.

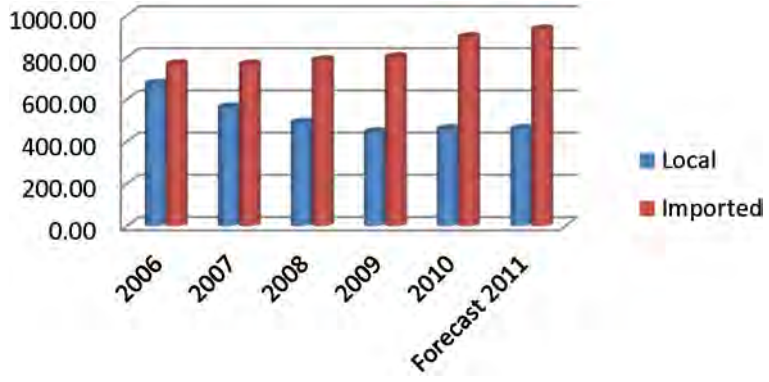

Figure 2. Wine Consumption: Local versus Imported, 2006-2011

According to the GAIN report of 2011, the United States has 14% of total wine market share, after Spain (36%), Chile (26%), and Italy (15%).

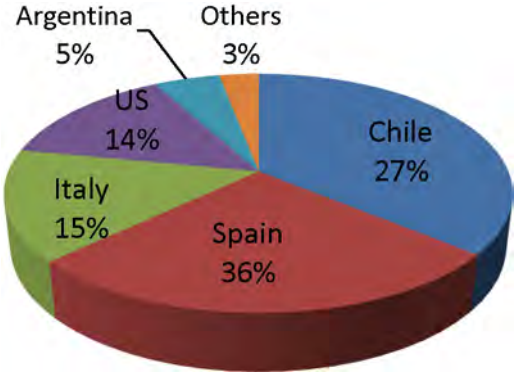

Figure 3. Market Share of Wine Importers in the Dominican Republic, 2010

However, an outlook of wine consumption across the last five years by the country of origin provides some additional information about market share dynamics across the countries.

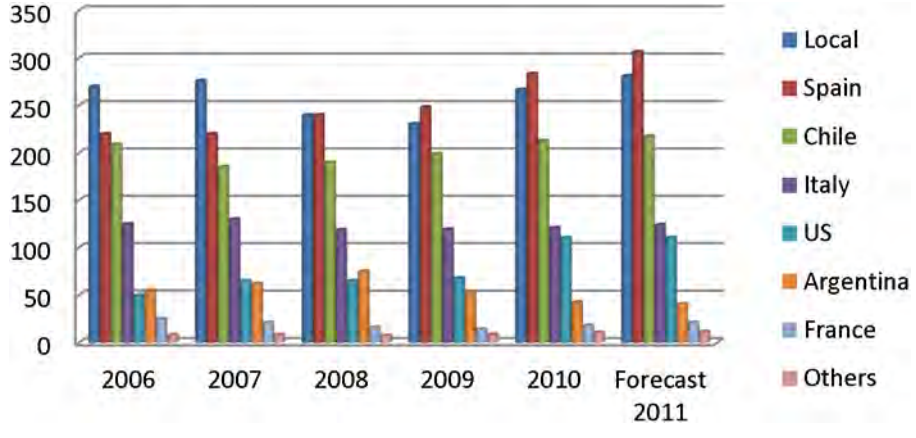

Figure 4. Wine Consumption by Country of Origin, 2006-2011

Spain historically has been the leading exporter of wine to the Dominican Republic (Figure 4). Chile is a close second. United States exports have increased recently and currently the U.S. has almost reached Italy in terms of the amounts of exports to the Dominican Republic. The United States' market share has increased dramatically (by 62.5%) from 2009 to 2010. However, the competition within the Dominican Republic wine market is tough and Argentina is another U.S. competitor in this market. Argentina is behind the United States in terms of exports, but its aggressive marketing policy may lead to the future increase in demand for Argentinian wine.

An outlook of the current situation in population growth and income growth of these two groups will help to assess the future trend of demand for wine in these two areas. The population of the Dominican Republic is growing at a fast pace. According to the World Bank, between 1990 and 2009, the population of the Dominican Republic has increased by 2.72 million people and showed a growth rate of 36.9%. As seen from Figure 5, this population growth comes mainly from the growth of the adult population over 19 years of age. This segment of population represents active wine consumers. Thus, the growth in this segment represents a growing trend in wine demand from local consumers.

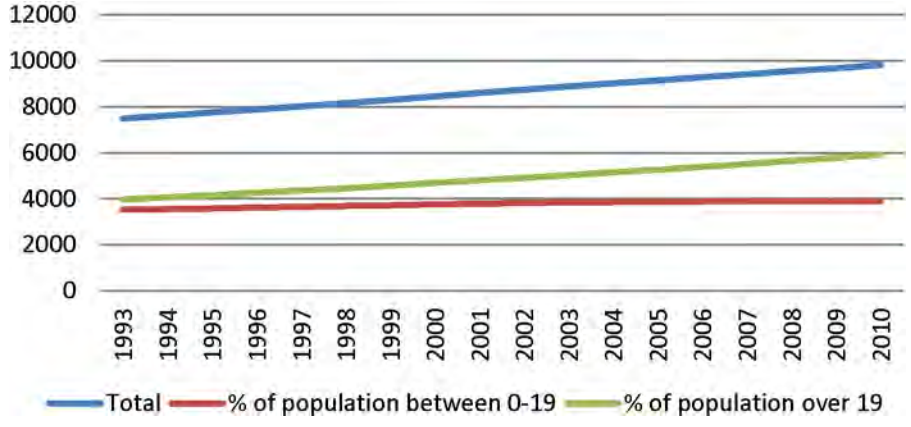

Figure 5. Population Growth by Age, 1993-2010

An important determinant of demand is gross domestic product (GDP) per capita. In 2010, the GDP per capita in the Dominican Republic was $8,647.72 (The World Bank, 2011) Since 1990, the GDP per capita in the Dominican Republic has increased by 208%, showing a substantial increase in purchasing power of Dominican Republic's consumers. With the increase in personal budgets, consumers allocate a larger proportion of their personal budgets to wine purchases. An increase in personal budgets leads to a higher standard of living, which in turn, leads to a change in the tastes of consumers. These changes are observable in the wine market of the Dominican Republic.

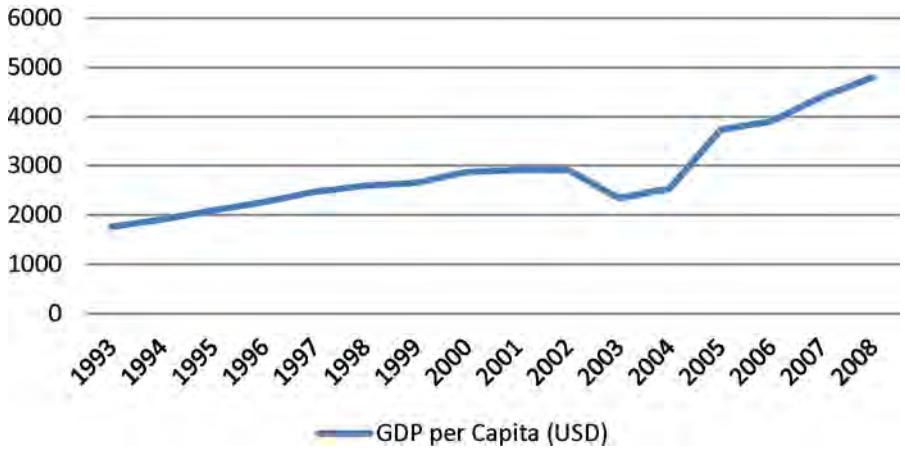

Figure 6. Per Capita Gross Domestic Product, 1993-2008

Today, the number of people who prefer red wine has increased substantially in the Dominican Republic. In 2010, 62% of Dominican wine consumers preferred red wine, about 32.5% preferred white wine, and 5.5% preferred rosé (GAIN report, 2011). Figure 7 shows that overall consumption of all wine has increased over the 5-year period. The GAIN report found that the largest increase of 19 percent was exhibited in the consumption of rosé wine, followed by an increase of 16 percent in the consumption of red wine.

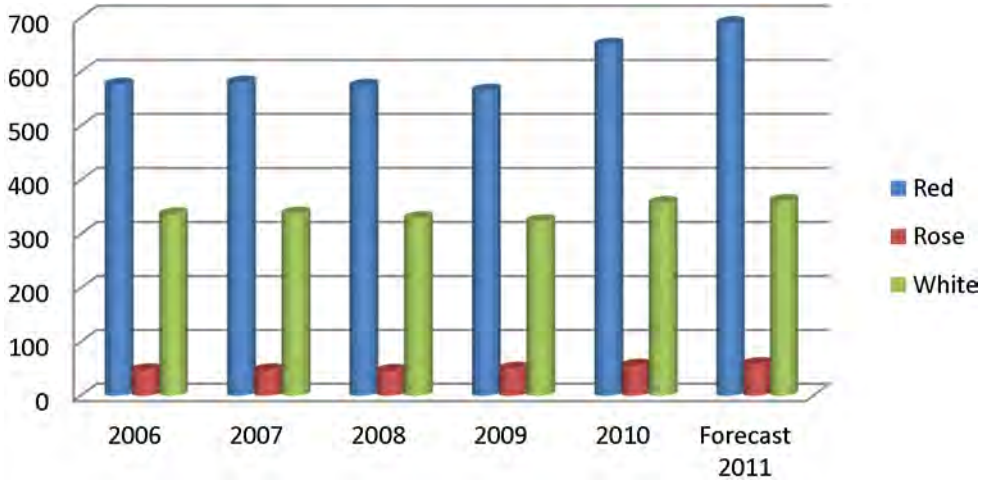

Figure 7. Consumption by Type of Wine, 2006-2011

The analysis of consumer surveys collected for the current project reveals that 75.1 percent of respondents prefer red wine, 17 percent prefer white wine, and 7.9 percent prefer rosé/blush wine. Overall, the split in consumer preferences for wine by color found by the current research is consistent with the previous findings identified in the GAIN report. Further comparison between the current study (2011) and the GAIN report (2010) also revealed an increase in consumer preferences towards red wine.

Wine consumers in the Dominican Republic recognize five categories of wine: light wine, sparkling wine, fortified wine, light aperitifs and others. Figure 8 shows wine consumption by category for the years 2006-2011. As seen from the Figure 8, still light wine has been the most popular category and the consumption of this type of wine has started to grow since 2009. Sparkling wine is the second most popular category of wine and its consumption is also growing. Light aperitifs category is the third largest growing category. Consumption of fortified wine is low and is not increasing. The current study's consumer data of the Dominican wine market showed that 59.5 percent of consumers prefer dry wine and 40.5 percent sweet wine.

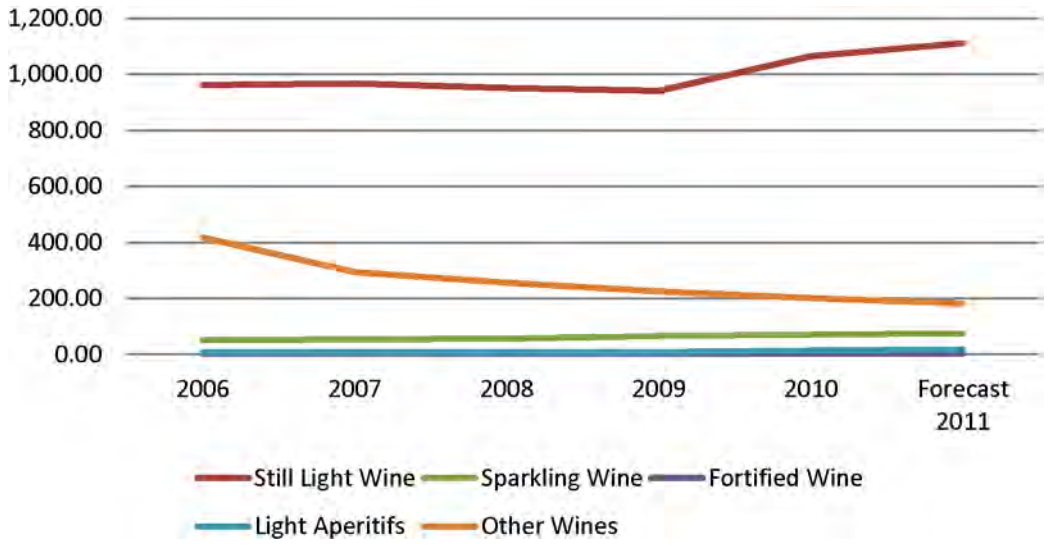

Figure 8. Dominican Republic's Wine Consumption by Category, 2006-2011

There are two main groups of consumers in Dominican Republic: local consumers and tourists. Local consumers consume around 55% of all imported and locally produced wine in the Dominican Republic. Of the 55% consumed by locals, around 30% of wine is being purchased at the super/hypermarkets and liquor stores. The majority of wines offered at super/ hypermarkets and liquor stores are from Spain, Chile, and the U.S., and the average price per bottle ranges between $3 and $10. Local consumer purchasing wine at super/hypermarkets and liquor stores is the fastest growing segment.

The current study's analysis of consumer surveys collected at supermarkets, liquor stores, and local malls has shown the changing patterns of consumption. As income goes up, consumers consume wine of a higher quality and more often. According to the survey, 39.2 percent of respondents consume wine several times a week and 34.6 percent consume wine once a week, with 21.4 percent of respondents consuming four bottles of wine per month and 20 percent of respondents consuming three bottles of wine per month. The majority of consumers purchase their wine at the supermarkets (68.5%) followed by liquor stores (22.8%).

When asked about preferences for wine from specific wine regions, consumers ranked U.S. wine as number five after Chile, Spain, France, and Italy. In ranking the quality of wine from different regions, respondents ranked U.S. wine lower than wine from Chile, Spain, France, Italy, Argentina, and Australia.

Another 20% out of the 55% of wine consumed by local consumers is purchased at specialized distributors. These distributors often promote their products through showrooms, wine bars, and wine tasting events. Wine purchases at distributors' shops attract middle to higher income clientele. A variety of wine is offered here and prices range from middle to high. The remaining 5% out of the 55% of wine consumed by local consumers is purchased from restaurants and hotels. Consumers purchasing wine in restaurants and hotels are typically Dominican businessmen who participate in business events that take place at restaurants or hotels.

Another large group of consumers of the overall wine market are tourists. Tourists consume around 45% of all wine in the Dominican Republic. The number of tourists visiting Dominican Republic in 2010 has increased by 3.3% compared to 2009 (ETN, 2011). Dominican Republic welcomed over 4 million visitors in 2010. The U.S. has been the Dominican Republic's largest market for tourism over the last six years with over one million U.S. visitors in 2010. The overall growth in tourism continues and the tourism industry is expanding to accommodate the growing number of tourists from the U.S. and Europe.

The majority of tourists stay at all-inclusive resorts while visiting the Dominican Republic. Visitors of all-inclusive resorts consume around 30% of all imported wine. Tourists at the resorts consume mostly low-quality inexpensive wine from Spain, Chile, and the U.S. The price of wine offered at the all-inclusive hotels ranges between $1.00 – 2.00 per liter.

A smaller number of tourists and business travelers visit business hotels and restaurants in the Dominican Republic at the non-resort locations. Together this group of travelers represents around 15% of the overall wine market that hotels and restaurants represent together. Out of the 15%, wine consumption at the restaurants represents around 14% and consumption at the hotels, around 1%.

The numbers presented above lead to the conclusion that the largest wine-consuming group in the Dominican Republic are local customers with average to high levels of income, followed by a smaller group of business travelers and foreign tourists. This group of foreign tourists are those who travel on their own and tourists of the upscale all-inclusive resorts, where a variety of branded wines are available.

In conclusion, currently, the demand for U.S. wine is growing in the Dominican Republic. In terms of preference for wine from a specific region, Dominican consumers ranked U.S. wine after historically traditional wines from Chile, Spain, France, and Italy. However, when it came to rating the *quality* of wine by region, Dominican consumers rated the quality of U.S. wine lower than the quality of wine from other countries. The fact that local Dominican consumers perceive U.S. wines as lower quality wine is a particular concern and needs to be addressed in future marketing and promotional programs.

Because of strong competition on the supply side from competitors like Spain, Chile, Italy, and Argentina, the United States can capture additional market share by holding an aggressive promotional wine strategy. The United States can increase the demand for U.S. wine and capture a larger market share in the Dominican Republic by applying marketing and promotional policies tailored to this specific market.

The majority of the demand comes from customers of supermarkets, hypermarkets, and liquor stores. These consumers look for wine with prices that range between DOP100 and DOP400 (US$2.70 – US$10.81). Those that consider quality in wine, purchase wine on the higher end of the price spectrum. U.S. wine priced within this range is likely to be the most popular in the short-run for this group of consumers. As the personal income increases, the consumers will be more willing to purchase more expensive wines.

Business travelers and foreign tourists demand quality and variety. Wines with a higher price range ($25-$125) will be in demand for this category of consumers, and although this category is much smaller relative to the supermarket/liquor store category, it will contribute its share to an increase in overall demand.

There is an established wine distribution system within Dominican Republic. Four large distributors supply U.S. wine to the Dominican Republic: *El Catador, Vinos SA, Manuel González Cuesta,* and *Alvarez & Sánchez.* During the interviews, three distributors indicated an interest and willingness to expand purchases of higher quality wines not only from California, but also from other U.S. states. The growth in tourism and in personal income of Dominican Republic's middle class will increase wine consumption and will lead to an increase in demand for wine in the Dominican Republic.

CONCLUSIONS

Retail is by far the biggest purchase venue for imported wines, as the vast majority of Dominican consumers buy wine for personal consumption or as a gift at supermarkets or liquor stores. Since supermarkets reach mostly the middle and upper classes with higher incomes and remain the main means to distribute most imported food products in the Dominican Republic, they are important target outlets for wine. All-inclusive resorts represent about 30% of the retail wine market in the Dominican Republic. Numerous resorts are scattered along the coastline of the Dominican Republic and over 80% of hotels in the Dominican Republic are all-inclusive businesses. These resorts import wines directly and almost exclusively in bulk from wine producers mainly in Spain, and these wines tend to be priced between $0.80 and $3.00 per liter.

Almost all available wine in the Dominican Republic is controlled by importers. Orders are placed through direct contact with supermarkets and liquor stores, and importers then pay slot fees to retailers to carry their brand. Importers indicated that they negotiate promotional costs with the producers and value those producers who invest in promotional materials and point-of-sales and continuously provide promotional campaigns for their products. Slot fees, as well as promotional budgets, can be negotiated and are usually paid by the wine producer as well.

With regards to export potential and recommendations to the industry, the vast majority of importers interviewed agreed that the current wine market in the Dominican Republic is saturated.

Spain and Chile continue to be the U.S. primary competitors. Most importers indicated that they do not currently add new brands to their portfolio.

Despite this finding, researchers concluded that U.S. high-end wines present the best market potential in the Dominican Republic, and a few importers indicated that they are open to negotiate a new addition of these wines in their upper-level price segments. Findings from the consumer data also support the idea that the primary target market for the U.S. wine industry should be Dominican consumers with higher education and income levels. These consumers prefer wine over spirits and beer; drink wine several times a week; buy wine more often and spend more money on wine than other groups of consumers. Dry red wine is their top preference. Especially important is the fact that U.S. wine was ranked higher among more affluent consumers. Although this group still ranked Chile and Spain as the two most preferred regions, the USA was ranked third. They also perceived the quality of U.S. wine higher than the other groups. Clearly, these consumers represent potential and should be considered as the primary target market for U.S. wine. The best approach to introduce new wines to the Dominican Republic is to work with one of the major importers, as they are familiar with the market, common distribution channels, and promotional and marketing activities that increase sales. The DR-CAFTA agreement signed in 2004 provides an advantage to U.S. wine by making it duty free since 2010.

In conclusion, the U.S. wine industry can capture additional market in the Dominican Republic and increase the demand for U.S. wine by applying aggressive marketing and promotional policies tailored to this specific market. However, it will need a substantial financial and personnel commitment over an intended period of time.

REFERENCES

Brislin, R. W. (1970) Back-translation for cross-cultural research. *Journal of Cross-Cultural Psychology, 1*, 185 - 216

Dottin, M. (2011). USDA Foreign Agricultural Service, GAIN Report. *Dominican Republic wine market brief*

Global Travel Industry News, (2011). *Dominican Republic tourism reports record visitor numbers,* Retrieved on November 10, 2011 from http://www.eturbonews.com/21137/dominican-republic-tourism-reports-record-visitor-numbers

Hernandez, X. (2004). Instituto de Comercio Exterior, Department of Economics and Commerce. *Wine market in the dominican republic.* Santo Domingo: Spanish Embassy. Retrieved from http://www.icex.es/staticFiles/NS%20Vino%20RDominicana_7450_.pdf

Instituto de Comercio Exterior (2008). *Vertiginous increase of wine consumption in the Dominican Republic.* Retrieved from http://www.icex.es/

Mendez, W. A. (2002). USDA Foreign Agricultural Service, GAIN Report. *Dominican republic retail food sector report* (DR2032). Retrieved from http://www.fas.usda.gov/gainfiles/200211/145784622.pdf

Mendez, W. A. (2009). USDA Foreign Agricultural Service, GAIN Report. *Dominican republic wine market brief* (DR9001). Retrieved from http://gain.fas.usda.gov/scriptsw/AttacheRep/legacy.asp

ProChile. (2010). *Wine market research – Dominican Republic*. Santo Domingo. Retrieved from http://www.chilealimentos.com/medios/Servicios/noticiero/EstudioMercadoCoyuntura2010/Jugos/vino_republica_dominicana_junio_prochile.pdf

Suarez, C. G. (2009). USA Foreign Agricultural Service, FAIRS Country Report. *Dominican republic: Food and agricultural import regulations and standards – narrative* (DR9011). Retrieved from http://gain.fas.usda.gov/scriptsw/AttacheRep/legacy.asp

The World Bank, Data by country, Dominican Republic, Retrieved on October 13, 2011 from http://data.worldbank.org/country/dominican-republic

U.S. Department of State. (2010, June 7). *Background note: Dominican Republic.* Retrieved from http://www.state.gove/r/pa/ei/bgn/35639.htm

Wimmer, R. D., & Dominick, J. R. (2003). Mass media research: An introduction (7th ed.). Belmont, CA: Thomson/Wadsworth.

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SUSTAINABLE PRODUCTION PRACTICES AT THE COMMUNITY LEVEL IN BARBADOS AND THE EASTERN CARIBBEAN

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ABSTRACT: The Sub-Regional Office of the Caribbean of the Food and Agriculture Organization (FAO-SLC) facilitated the collation of information on sustainable production practices in Barbados, Antigua and Barbuda, Dominica, St. Kitts/Nevis, St. Vincent and the Grenadines, Grenada and St. Lucia. The study, carried out by the Caribbean Agricultural Development and Research Institute (CARDI) on behalf of the FAO, aimed to identify the use of some of the 'tried-and-tested' methods in order to promote them by making them available to the wider agricultural community in the Region. This is in keeping with FAO's sustainable crop production intensification (SCPI) objective, which aims to increase crop production per unit area, taking into consideration all relevant factors affecting productivity and sustainability, including social, political, economic and environmental impact. In the current study, 'sustainability' included environmental, financial and socio-economic elements. Current practices were determined via on-farm observation and inquiry, as well as by reviewing marketing and legislative protocols. Activities of over 2000 producers were drawn from individual interviews, field inspections, Extension Officer reviews, and structured group sessions. Whilst several practices were seen to be endemic and common to all seven countries, there were subtle inter- and intra-island differences. Results indicate that in all countries, sustainability was more commonly defined in terms of environmental aspects by way of soil and water conservation, and 'sustainable' practices dealt with land clearing, erosion reduction and soil improvement. Additionally, water conservation as opposed to rainwater harvesting and storage was a central pursuit. Appropriate cropping patterns and other farming practices were largely determined by geography. There was a reasonable level of understanding of the benefits of biodiversity as related to sustainability. Interestingly, there were some practices which were not as widespread that could be expanded, and others that were widespread but not effectively executed. Several recommendations are presented based on the amalgam of practices recorded, on the areas of land use, soil quality, water use and reuse, environmental sustainability, and financial sustainability.

Keywords: sustainable crop production practices, environmental sustainability, financial sustainability

BACKGROUND

One of FAO's Organizational Results in the 2010-11 biennium was the promotion of strategies for Sustainable Crop Production Intensification (SCPI)[1] in countries of Latin America and the Caribbean. In addition, at several workshops and meetings, FAO (and other organizations) were

[1] SCPI – increase in crop production per unit area, taking into consideration all relevant factors affecting productivity and sustainability, including social, political, economic & environmental impact.

requested to capture existing practices, technologies and models of sustainability, and to make these available to the wider agricultural community. As a result, FAO facilitated a survey in seven countries under a Letter of Agreement (LOA) with the Caribbean Agricultural Development and Research Institute (CARDI). The baseline survey collated information on sustainable agricultural practices at the community level in Barbados, Antigua and Barbuda, Dominica, St. Kitts/Nevis, St. Vincent and the Grenadines, Grenada and St. Lucia. It was recognized that sustainability in the context of Small-Island Developing States (SIDS) needed to consider Climate Change and in this regard, agriculture must be 'climate-start', i.e. it must minimize agriculture's contribution to greenhouse gases, and/or it must increase carbon sequestration.

Farmers and producers in the Caribbean Region have long been practicing conservation agriculture and integrated farming systems, including both crop and pest management. Sustainable, as it refers to agriculture, involves more than the study of relationships between organisms and their environment. It has been defined as "an integrated system of plant and animal production practices having a site-specific application that will last over the long term whilst satisfying human needs efficiently using natural resources, demonstrating financial viability and enhancing the quality of life for farmers and society as a whole." The Conceptual Model therefore took into consideration environmental sustainability, financial sustainability and economic sustainability.

MATERIALS AND METHODS

Information for the baseline survey was gathered in a number of ways. On-farm data was collected via structured interviews conducted by trained and experienced Field Assessors, using standardized survey instruments. The selection process was guided by interviews with a number of stakeholders: the Ministries of Agriculture, Producer organizations, NGOs, and Environmental Management officials. Meetings with focus groups were organized, and the following was undertaken

- a review of the documented holdings/producers in the administrative district
- determination of the major types of potential/actual environmental degradation to which the area is prone with regard to:
    - soil (quality/quantity)
    - water (quality/quantity)
    - air-borne pollutants
    - flora/fauna interaction (biodiversity)
- assessment of the economic importance of the major products emanating from the district – to select the success factors (financial sustainability)
- integration of the enterprises within the community

The overall aim was not to determine the prevalence or statistical significance of the practices but rather to seek out even isolated cases of sustainable operation. Sampling was guided by the question "what are the tried-and-tested practices, models and technologies used by producers?" By focusing on the answers to the question, the inquiry resulted in a more thorough "analysis of the current situation to identify the starting points for a program/project" or baseline study. Since the natural environment is critical to sustainability issues, the farms / agribusinesses surveyed were initially categorized by districts; and by covering all the districts, all geographic scenarios were captured. Further segregation was based on geographic features that affected the likely conservation practices.

All of the seven assessors had over 20 year field experience within their respective countries of operation, and augmented the data gathered during the selection process. The selected interviewees within each district reflected the range of product mixes, tenure patterns and marketing arrangements. Discussions with the producer groups (crop/livestock farmers, fisher-folk), district extension officers, and produce buyers/consignees, supplemented by the assessor's familiarity with the sector, directed the selection process.

A field assessor in each of the seven countries alerted the respective Ministries of Agriculture and interacted with key Extension staff and Producer Organizations to launch the project. Activities of over 2000 producers were recorded, drawn from individual interviews, field inspections, Extension Officers reviews and structured group sessions. Discussions with the producer groups (crop/livestock farmers, fisher-folk), district extension officers, and produce buyers/consignees; supplemented by the assessor's familiarity with the sector provided the following details.

RESULTS

The findings of the survey are reported in line with the Conceptual Model, specifically Environmental Sustainability (Soil and water management, Crop selection, Carbon footprint), Financial Sustainability (GAP training, Marketing, Land tenure) and Economic Sustainability (Farmers and their communities; Policy level support). It is noteworthy that there were instances where the Assessors' "production sites" did not meet the "sustainability criteria" agreed to by the team. Common examples involved instances of terracing or composting that were not technically correct and thus were not deemed to be sustainable.

Environmental Sustainability

There were several practices that are common throughout the seven countries constituting the baseline territories.

Soil Managment

Soil management was a common feature on farms. Most of the farmers, Extension Officers and Ministry Officials equated sustainability with land quality and quantity, so there was a heavy concentration on soil conservation and improvement. Soil management was analyzed by using eighteen interrelated criteria (Table 1).

Table 1. Sustainable practices involving soil management across seven countries

1. SOIL MANAGEMENT (Soil quantity, quality)	Perceived Frequency[2]
1.1 Appropriate Land clearing technique used (to maintain biodiversity, conserve soil)	2
1.2 Appropriate Building site selection	1
1.3 Building layout	2
1.4 Terracing	1
1.5 Contour ploughing	1
1.6 Crop cover	2
1.7 Direct planting (reduced on slopes to reduce soil loss by erosion)	1
1.9 Drainage (soil conservation, reduced runoff rate)	1
1.10 Ameliorant/incorporate	0
1.12 Green manure	1
1.13 Nutrient recycling	1
1.14 Composting	2
1.15 Crop rotation	3
1.16 Appropriate tillage (minimum soil disturbance)	2
1.17 Vermiculture	0
1.18 Soil fauna/flora (increased soil micro flora and fauna)	0

Unlike the continental CARICOM States and the larger islands, the Eastern Caribbean States were not engaged in significant farmland expansion. Hence the land-clearing techniques considered were related to seasonal land clearing. There were, nonetheless, isolated instances of the unsustainable use of bulldozers and subsequent burning. Land clearing methods ranged from the use of hand tools, grazing sheep, and selective thinning to motorized cutting machines. The multiplicity of methods was evident between and within countries.

Conservation practices included low soil exposure by selective tree cutting and understory slashing. Burning was avoided and the cut material windrowed. In Grenada and the mountainous Windward Islands, there was selective thinning and the planting of spreading crops, green cover, windrowing and using the cut vegetation to reinforce contour-protective bunds. Subsequently, the protection of cleared land included practices such as terracing, contour ploughing, crop cover and direct planting. Contour ploughing and terracing were listed as practices in St. Kitts and Barbados, but there are significant variations in terms of technical correctness and efficacy. Contour ploughing, independent of bed preparation on the contours, and subsequent good crop cover, reduce the efficacy of the practice. In St Vincent, of the 35 producers with recordable soil sustainability features, 19 practiced contour ploughing and planting. Soil management in the less mountainous islands was primarily about holding moisture, avoiding wind erosion and improving fertility.

Soil loss through erosion by water was the most prevalent concern. Many of the contour beds were not properly drained and subsequently developed weak bunds that broke free long streams of

[2] Legend: perceived frequency of occurrence, **0** = absolutely no evidence of practice/technology, **1** = 1-25%, **2**= 26-50%, **3**=51-75%, **4** =76-100%

muddy water. In St. Kitts, one farmer was forced to adjust his contours to allow water flow to a nearby ghaut/ravine, which allowed the water to flow in a specified direction rather than filling and breaking the banks during heavy rains. In the Scotland District of Barbados, contour planting and the use of fruit trees for soil stabilization was evident.

Improved drainage was a common practice recorded. Apart from the traditional drainage procedures (box drains, furrows, and trenches), some producers avoided the same wheel tract on unpaved roads, which somewhat mitigated erosion from fast-flowing miniature streams.

Soil protection was augmented with soil quality improvement through the use of ameliorants. Green manures (e.g. guinea grass) were used in all the countries. Nutrient recycling by incorporating animal and green manures was extensively reported. Manure incorporation varied from on-farm collection and subsequent spreading to animal droppings whilst grazing. Field grazing by livestock was also used for weed control.

Composting was listed as an activity but only a small percentage of the farmers carried out composting using proper technical execution. There was deviation from the actual practice leading to the use of green manures and mulch from material that was listed as composted. The most comprehensive composting operations were recorded from Grenada, where true compost (*friable organic material that can be used as a soil amendment or as a medium to grow plants*) and compost teas were prepared to nutrient-rich specifications.

There were instances of appropriate crop rotation with crop choice reflecting different nutrient uptake regimes, differing feeding depths and dissimilar pest profiles. The soil was measurably improved in some cases due to the fertility increases, lowered pest loads and improved friability. Tables 2-A and 2-B highlight typical rotations encountered on St. Vincent and Dominica, respectively. However, there was significant evidence in some countries that the rotations were based on economic factors and not crop husbandry. Same-family rotations involved high value crops that had similar pest/disease and nutrient profiles, and the expected agronomic and soil improvement gains were not necessarily obtained.

Appropriate tillage varied from minimum, to dust mulches, and to sub-soiling. Tillage variations were often incorporated with other operations like deep planting, fallow and manual land clearing. Documented examples from Antigua and Barbuda indicated that two farms in the South West district (volcanic sandy loam soils) used minimum tillage as effected through ploughing every three years. In Barbados it was noted that most of the "organic" farmers routinely minimize tillage/compaction by using small hand-push tillers. Direct planting as a means of limiting soil disturbance and reduced tillage was in evidence in St. Kitts/Nevis, St. Lucia, Grenada and St. Vincent and the Grenadines. The method was confined to appropriate crops such as cucurbits, papaya, roots and tubers, plantain, and banana.

Table 2-A. Recorded Crop Rotations on selected farms in St Vincent

Crops / Sequence in St. Vincent
Melons → Peanuts → Ochroes
Carrots → String Beans → Cabbage
Tomatoes → Sweet Potatoes →Yams
Cucumbers → Tomatoes →Lettuce
Cucumbers→ Carrots → Eddoes → Cabbage
Sweet Potatoes → Yams → Eddoes
Sweet Potatoes → Tomatoes → Yams
Yams & Eddoes → Tomatoes → Ginger
Tomatoes & Cabbage → Eddoes → Yams →Tannias
Sweet Potatoes → Yams → Eddoes

Table 2-B. Recorded Crop Rotations on selected farms in Dominica

Crops / Sequence in Dominica
Carrots → String Beans → Cabbage
Dasheen → Ginger→Yam
Bananas → Tannia →Bananas
Ginger → Passion Fruit →Pineapple

Vermiculture, although a technology popularized by Cuban volunteers in the Region, was not a practice recorded outside of Antigua and Barbuda where an enterprising farmer had developed a product range including worm compost. The Antiguan Farmer had done trials with local species but found them inefficient. He imported the California red worm in 1992 and always raised them in bins. They have not been able to move beyond his compost bins. This recorded method of rearing is significant in light of the designation of the red worm as an invasive species. The Field Assessors noted that while the deliberate introduction or reintroduction of soil fauna/flora was not a recognizable feature, many producers avoided inorganic chemicals that were believed to reduce soil biodiversity.

Water Management

Water management is at the heart of island-based agricultural adaptation with respect to Climate Change. If mitigation is about greenhouse gases, adaptation is about water. Common water management practices include rainwater harvesting (e.g. the use of water directed from guttering on farm buildings with subsequent storage), water reuse, and conservation.

Rainwater harvesting varied across the countries. In Barbados, within development project areas, well-water was supplied thereby reducing the urgency of water catchment at the farm level. In St. Kitts, ponds and wells were the major water source in the St. Peters project and Mansion. In Antigua and Barbuda, ponds and dams were the direct concerns of many producers. In St. Lucia watercourse protection had been given greater prominence post Hurricane Tomas, whilst water-

harvesting initiatives were on stream in Region 3. On-farm ponds were replenished directly from rainfall or indirectly through springs/artesian sources.

Table 3. Sustainable practices involving water management across seven countries

2. WATER MANAGEMENT (Water quantity, quality)	Perceived Frequency[3]
2.1 On site water course protection (maintaining banks etc)	0
2.2 Deliberate Riverine stabilization (maintaining flow direction)	0
2.3 Harvesting	1
2.4 Collection from guttering	1
2.5 Direct Collection from rainfall	1
2.6 Adequate Drainage (to limit waterlogging/flooding)	1
2.7 Irrigation method (efficient use of water)	3
2.8 Mulch (protecting soil moisture)	2
2.9 Green cover	1
2.12 Dispensing to animals (efficient presentation, proper storage)	2
2.14 Reuse	0
2.15 Reduction (low flow taps)	0
2.17 Bio-cleansing (use of organisms to remove contaminants)	0
2.18 Water treatment/settling	0

The mode via which the available water got into irrigation systems varied between and within islands. The breakdown in St. Lucia was as follows: about 80% of the farms in Regions 7 and 8 were Rainfed; in most regions 10% of the holdings sourced gravity flow water from a stream/river; 15% used drip; and 80% of protected agriculture structures used overhead systems. The European Union - Government of St. Lucia irrigation project in the community of Delcer provided water for Region 6, and also to the environs during dry periods.

The irrigation method provided an opportunity to conserve water, with most producers in Barbados using drip systems. The rare occasion when sprinkler systems were deemed to be sustainable was highlighted by the account of an Antiguan farmer who swore that the system improved pest and disease management, particular for the control of the diamondback moth on cabbage. The sprinklers were used in the evening, when the adult moths were most active, and the water apparently disrupted them from settling on the crop. The plausibility of that system would be dependent on the augmenting of the irrigation water with a pesticide and the creation of a more humid microclimate against diseases like powdery mildew. Sprinklers can be sustainably used in pasture management, particularly if solar powered pumps are used.

A striking feature in most countries was the general absence of farm buildings except in the case of poultry and pig enterprises. Most cropping activities were a distance away from the producer's residence. Collection of rainwater in containers directly or from guttering, for farm use was not a major activity. Interestingly, in Dominica rainwater was considered an important resource and was harvested from rooftops of farmhouses using traditional bamboos and the storage drums protected with a fabric covering. The water was used for domestic and agricultural purposes. Dispensing of

[3] Legend: Same as for Table 1.

water to animals and the use of water for cleaning was considered acceptable in terms of efficiency. Many producers reused water from pen-cleaning for crop "fertigation".

Mulch as a means of conserving water was widespread and included the use of plastic. In Barbados mulching was used to varying degrees. A few growers covered nearly the entire cropping area while others just used strips. Inorganic, mainly fabric or plastic mulches, were common; however, some "organic" growers were using organic mulches such as coconut fibre and green waste from the solid waste plant in Barbados.

Apart from the conservation of water, there were a number of practices that improved the quality of the water that was either utilized in situ or allowed to run-off. In all the countries there was acknowledgement of the links between land-based operations and fish culture. Pollutants generated on land eventually reach the sea and can cause irreparable damage.

Cropping Patterns

Combined soil and water management involved the use of green covers and judicious cropping patterns (Table 4). Generally crops were selected based on an understanding of the soil type and nutrient status. Trees were used as borders between plots and as windbreaks. Fruit trees were intercropped with short-term crops such as pumpkin and squash. In Antigua and Barbuda, carrots and beets are grown in sandy loam soils best suited to the physical requirements of the crop.

Table 4. Sustainable practices involving cropping patterns across seven countries

3. CROPPING PATTERN	Perceived Frequency[4]
3.1 Crop appropriate for area/slope	2
3.2 Proper plant growth habit	2
3.3 Crop rotation	3

In Grenada, large plants (fruit trees) were used in steeper areas, and a good mix of annuals and perennials (different families and root depths, etc) were planted to obtain good coverage. In all of the countries there were examples of appropriate crop selection. In Dominica, within and outside of the Carib Territory, the planting of specific crops was carried out taking into account their ability to reduce erosion, maintain soil nutrient balance and keep the soil intact.

Biodiversity

Very few of the farmers, interviewed on the basis of the sustainable practices on their farm, had monocultures. In most farms bees, butterflies and wasps were observed. The borders around and beyond the farms had endemic mixes of plants and weeds. The biodiversity displayed on, and proximal to, farms was indicative of a strategy through which a wide mix of products is used to hold customers and as a means of financial security. Some of the diversity was deliberately organized to explore synergies. A pineapple farm boasted no less than 20 different fruits trees and a range of crops, including sorrel, cucurbits and beans. That farm also had bee hives/ pollinators, which were sometimes rented to other farmers.

[4] Legend: Same as for Table 1.

One farm with banana as the main crop had it intercropped with cassava; additionally, there were rows of corn and sweet potato, interspersed with pineapple and yams. Many farmers used biological insecticides, and a few used limited organophosphate pesticides only at planting time. Most farmers depended on a mix of cultural practices to control pests, including crop rotation and intercropping (Table 5). In Dominica, many of the farmers used biological control methods based on plant extracts grown on the farm. Testimony to the low use of inorganic pesticides was the observed abundance of beneficial insects and pollinators. In Dominica as well was the one documented case of small-scale sericulture. None of the documented instances of land clearing by producers included mangroves. Mangrove trees are specially adapted to being submerged in saltwater and thus provide detritus needed to fuel the important food chain of the mangrove ecosystem. Producers and fisher-folk operating in its environs understood the coastal stabilizing role played by mangrove.

Table 5. Sustainable practices involving biodiversity across seven countries

4. BIODIVERSITY	Perceived Frequency[5]
4.1 Land clearing method (retaining flora and fauna)	2
4.2 Avoidance of monogenic strains/lines	0
4.3 Product mix (complex agro-ecological zone)	1
4.4 Bio/cultural pest management	1

Carbon Footprint

Energy efficiency and renewable systems were apparently not on the radar of most producers (Table 6). All farmers and fisher-folk interviewed used fossil fuels for pumps, tractors, engines, etc. One farm with an integrated aquaculture-hydroponics system used electricity to pump recycled water from the tilapia fishpond to vegetable beds and back to the fishpond. The owner in Antigua reported that government policy did not allow use of co-generated solar powered equipment. Upon verification, it was found that a relevant piece of legislation permitted only the Public Utilities Authority to produce power. However, Grenada reported cases of solar- and wind-powered generators being used for honey extraction, water pumping, refrigeration, lighting and produce grinding/processing.

Worldwide, the post-Kyoto response with regard to sustainability of production would be the adoption of climate-neutral technologies. Already, key exports of Fairtrade bananas require the use of environmentally-friendly techniques (e.g. use of petroleum-based agrichemicals derived from petroleum products. In Barbados, where solar water heating is commonplace, there was minimal use of alternative energy on farms. Many of the respondents noted they were weighing the cost of the investment.

[5] Legend: Same as for Table 1.

Table 6. Sustainable practices involving carbon footprint across seven countries

5. CARBON FOOTPRINT	Perceived Frequency[6]
5.1 Reduced Fossil fuel use	0
5.2 Reduced Electricity use	0
5.3 Renewable energy use	1
5.4 Solar	1
5.5 Wind (energy generation)	1
5.6 Waste reduction/less landfill use	0

Water Disposal

For the crop farmers, waste was not a major issue. Generally most farmers ploughed the crop residue back in (Table 7); those that had pigs used it as feed. Crop wastes (including carrot tops) were also used as mulch. Some farmers gathered the crop residues into a heap, let it dry, and then burned it to reduce pest problems (e.g. sweet potato). *These findings reinforced the observation that composting is one of the most misunderstood operations on Caribbean farms*. An appropriate composting process must be used in order to ensure that pests and pathogens that are harmful to humans and plants are destroyed. The process depends on the composting conditions (temperature, aeration, etc.) as well as on the duration of survival of pathogens and pests.

Table 7. Sustainable practices involving waste disposal across seven countries

6. WASTE DISPOSAL	Perceived Frequency[7]
6.1 Use of crop residue/waste/entrails	3
6.2 Composting	2
6.3 Scrap metal/building material	0
6.4 Waste water	1

Instead of drying and burning to reduce contamination, the material could have been composted. On one organoponics farm, fish waste was used to fertilize on-land crops as part of the overall system of growing plants in composted organic material.

Livestock farmers generally viewed daily-generated waste as manure. Often, the manure was collected (gratis) and taken off-farm to be used by crop farmers, although increasingly farmers sold the manure if they were not growing any crops themselves. Several farmers recognized the threat to their operations posed by waste originating from inputs such as plastic containers and packaging. Apart from the impact of leached material on soil and water quality, they recognized the potential health risk. Inorganic waste disposal posed a bigger challenge. The absence of plastic recycling, except in Barbados, made the disposal of containers an issue. Other than for Grenada, there were no documented cases of the current reuse of spent oils/fuel.

[6] Legend: Same as for Table 1.

[7] Legend: Same as for Table 1.

Financial Sustainability

The greatest threat to the sustainability of production in all the islands was in the sphere of finance. Legislative and incentive mixedsignals, fewer stratified markets to reward for environmentally sound production, and weak financing arrangements all conspire to reduce producer efficacy.

Most farmers were trained in Good Agricultural Practices (GAP), if not GAP-certified. GAP training increased the likelihood that sustainable practices would be part of the farmer's routine.

The inter-island differences in the quality or strength of marketing arrangements were noticeable (Table 8). On all islands, farmers reported having verbal contracts with hotels, restaurants, supermarkets and hucksters. Cooperative membership in some cases was linked directly to market access, with particular reference to supplying the hospitality industry. Common to the countries was the fact that often there was no formal contract arrangement.

Table 8. Sustainable practices involving marketing arrangements across seven countries

7. MARKETING ARRANGEMENTS	Perceived Frequency[8]
7.1 Contract sales	0
7.2 Listed consumers	2
7.3 Cooperatives	1
7.4 Value chain involvement	1
7.5 GAP certification	0
7.6 Standards-driven production (Fairtrade, etc)	1

A few interviewees were members of farmers' groups, but these were found to be ineffective in arranging markets, with the exception of Windward Islands Farmers' Association (WINFA) and Caribbean Farmers Network (CaFAN). WINFA banana farmers had access to the Fairtrade market. Apart from the impact on financial sustainability that Fairtrade brings, there is the emphasis on ethical, environment-friendly production. Fairtrade has a direct impact on environmental sustainability and socio-economic soundness. The social premium earned by Fairtrade farmers redounds to the benefit of entire communities.

Very few farmers supplied government institutions with vegetables on a continuous basis. A few interviewees were retailers as well as producers and had stalls at public markets. Farmers reported dissatisfaction with the inordinate delays in payment by corporate buyers and retail chains. Their financial sustainability rested with the cash turnover from farm-gate sales to hucksters. A few instances of entrepreneurial creativity included one farmer who sold his vegetables to persons in his community, even dropping off vegetables to members that were confined to their homes.

[8] Legend: Same as for Table 1.

Tenure

Security of tenure was one of the key determinants of sustainability (Table 9). Willingness to guard the natural resources in the agricultural arena was directly proportional to the vested interest in the farm or holding. Farmers without secure title found it difficult to make long-term choices; there was always the temptation to take the short-term. Long-term leases, freehold, and well-monitored rental agreements formed the basis of sustainable agribusiness models.

Table 9. Sustainable practices involving tenure across seven countries

8. LAND TENURE	Perceived Frequency[9]
8.1 Freehold	2
8.2 Leasehold	2
8.3 Rental	1
8.4 None	1

A significant number of farmers rented lands from the government, whilst there were those with freehold interest and others in various stages of regularization. Because of the nature of this study focusing on producers who utilized sustainable practices, high levels of freehold and secure tenure were encountered. The general farming populations had less secure tenure. If St. Lucia was taken as an example, there was a trend towards increase in family-owned lands and more private rental/lease agreements. The lack of clear title had implications for access to/availability of financial resources (e.g. bank loans) to capitalize operations.

Socioeconomic Sustainability

The interviewed farmers were all recognizable members of the various communities and involved in farmers' groups, village councils, sporting groups, etc. One farmer in Antigua and Barbuda reported that the farmers with contiguous plots helped each other at planting and harvesting. Other less structured community-based groups did not have this level of cooperation. Fewer than 2% of direct interviewees stated that a number of persons in their respective communities assisted with short-term labour when extra hands were needed. Although the majority of producers were well entrenched in their communities, the major market for their produce is located outside of their local communities.

Table 10. Sustainable practices involving social impact across seven countries

9. SOCIAL IMPACT	Perceived Frequency[10]
9.1 Integration into neighbourhood	2
9.2 Community involvement	2

[9] Legend: Same as for Table 1.

[10] Legend: Same as for Table 1.

The overall sustainability of activities in agriculture was confined by State-wide support through legislation, incentives and disincentives. The possible amalgam of policies can be exemplified with reference to St. Kitts and Nevis. Support services to the farming community come primarily from the Department of Agriculture and allied Institutions such as CARDI, IICA, and Taiwanese Agricultural Technical mission of the ROC. The more recent policies to be amended in support of Sustainable Agriculture include the Land Development Act of 1991 (provides a contract of tenancy under the Agricultural Small Holdings Act Chap. 87 of the Laws of St. Christopher and Nevis), the National Conservation and Environment Protection (Amendment) Act, 1996, and the National Conservation and Environmental Conservation Act (1987).

The group interview phase of project implementation unearthed no instances of overt social incompatibility with the exception of the growing of illegal crops, notably *Cannabis* spp. The sustainability of production whether land-based, aquatic or marine, does not appear to be threatened by adverse community reaction. The integration of fishing activities and shared beachfront access with the Tourism industry points to a lessened degree of inter-sectoral conflict.

DISCUSSION

The Study, carried out under the SCPI umbrella and in keeping with FAO's 'Save and Grow' approach[11], aimed to facilitate and promote the use of some of the tried-and-tested methods. To overcome the challenges inherent in feeding a growing world population there is no option but to intensify crop production. Given the constraints farmers face, in order to grow, agriculture must learn to save. This level of crop production intensification must be built on farming systems that offer a range of productivity, socio-economic and environmental benefits to producers and to society at large. Agriculture must, literally, return to its roots by rediscovering the importance of healthy soil, drawing on natural sources of plant nutrition, and using mineral fertilizer wisely. A genetically diverse portfolio of improved crop varieties that are resilient to climate change and smarter precision technologies for irrigation would also be needed. It was recognized that to encourage smallholders to adopt SCPI, fundamental changes would be needed in agricultural development policies and institutions.

The work of Climate Scientists in the Caribbean has reemphasized the importance of rainfall and water resources to regional agriculture. Island agriculture is totally rainfall driven; whether from recharged underground sources, surface-flows or direct precipitation. The expected variability in terms of rainfall quantity and intensity will increase the vulnerability of these small states and further threaten the viability of their agriculture. Sustainability models, incorporating water management as well as related soil management issues, will be the *sine qua non* of agriculture development strategies.

Globally, agriculture directly accounts for about 14 percent of greenhouse gas emissions (methane from animal digestion and nitrous oxide from agricultural soils, etc.), and indirectly for another 17 percent due to the fact that agriculture is a major driver of deforestation and land-use change. The sector holds a large mitigation potential, mainly through reduced deforestation, soil management and increased productivity.

[11] http://www.fao.org/ag/save-and-grow/

The Baseline study was in sync with the five pillars of sustainability, viz Increased productivity, Reduced risk, Conservation of resources, Viability, and Social acceptability. The utility of this snapshot of current sustainable practices was in its capacity to point to areas for intervention or strengthening of existing efforts. As a baseline, it provided information on what practices were used in which islands with an overview approximation of the frequency of occurrence from on-island assessors.

The Conclusions and Recommendations are provided in Table 11.

It is noteworthy that the current sustainable practices are still part of an *ad hoc* approach. The study considered close to two thousand holdings/operations by GPS survey, geography, agricultural district, and importance of the major crop/product, yet there were no examples of operations utilizing a full set of sustainable practices across environmental, financial and socio-economic spheres. *One of the most important uses of this study could be the reintroduction of Good Agricultural Practices with a focus on Climate-smart agriculture that could, in one fell swoop, ensure the viability of the sector in a comprehensive way.*

Table 11. Conclusions and Recommendations

Conclusions	**Recommendations**	**Remarks**
The reported practices can be the first step in the transition to developing a National Adaptation Programme of Action (NAPA) or Nationally Appropriate Mitigation Actions (NAMA).	Use the current tried-and-tested sustainable practices as the foundation for comprehensive, climate-smart agricultural strategies as part of NAPA	The Ministries of Agriculture in the targeted countries have not comprehensively addressed adaptation or mitigation issues with regard to Climate Change
Land: With regard to the environmental dimension of sustainability across all the Islands -land clearing is approached with knowledge of the consequences of soil loss and the need for soil protection. The requisite soil cover, avoidance of steep exposed slopes, minimum tillage and direct planting of appropriate crops are well-understood	- Site preparation should be conducted with minimum soil disturbance/loss - Cut vegetation should be windrowed and/or composted - Properly constructed terraces on slopes of <15% - Direct planting of fruit trees on sloping land - Contour drainage - maintain appropriate green cover during fallow	Flexibility by the State, with regard to the interpretation of land zoning regulations, has exacerbated inappropriate slope management.

Conclusions	Recommendations	Remarks
Soil quality: Improvement of soil quality appears to be lagging behind, although green manures are used and nutrients recycled. Composting remains a largely misunderstood concept and some of the acclaimed crop rotations are based solely on financial considerations, and not agronomic reality.	- Use of green manures - Crop rotations that involve less closely related plants that proportionately utilize different nutrients and have different pest complexes e.g. Cucumber-tomato-lettuce - Appropriate/Minimum tillage - Effective composting	Soil/growth media improvement is a linchpin of sustainable agriculture and will be key to water and nutrient availability.
Water use: Water harvesting / conservation are limited to using low flow irrigation techniques. Several instances of the use of potable water directly from State mains were recorded. If water availability is going to be a limiting factor in the near future, then those practices will be difficult to sustain. When State-managed water sources were used (as in ponds, dams and other catchments), on-farm conservation was often lacking. There was evidence of head-end leaks in drip irrigation systems that negated the conservation gains of using a low flow technique. Absence of a reliable method of determining plant water needs can result in over-watering when using drip systems. Poor choice of emitter, mismatched pumps, long lateral lines and lack of compensation for uneven terrain suggest the need for remedial interventions in a number of cases.	- On-farm storage of rainwater - Effective use of low flow emitters, drip irrigation - Use of green/artificial mulch - Practical soil moisture tests (e.g. “feel tests” with an auger) - Fixed receptacles for animal watering - Low flow taps for washing equipment/produce/machinery - Adequate drainage to avoid water-logging - Solar-powered sprinkler systems for pastures or soiling grasses.	The consensus of the University of the West Indies’ Climate Studies Group, as at the end of 2011, is that rainfall will be a significant variable as the climate changes, thereby impacting water availability.

Conclusions	Recommendations	Remarks
Water reuse / recycling: Four islands listed water reuse/recycling of water especially in livestock rearing operations, yet there was room for improvement. Poultry and pig operations were often better organized than ruminant rearing. Sustainability concerns should be assessed prior to farm building construction to facilitate aspects such as directed runoff and storage from guttering.	- Farm buildings constructed to direct and store water from guttering. - Reuse of water in livestock operations (e.g. use of grey water for pasture irrigation)	The increase in protected agriculture structures (such as row covers, shade-houses and enclosed greenhouses) provides new opportunities for recycling water use even in non-hydroponic systems
Environmental sustainability: Only Grenada had a comprehensive planned approach to a green economy that included legislation and stated commitment to reduce carbon footprint. Dominica had some farm-based alternative energy systems. Waste reduction and the consequent relief on landfills was not a feature identified during the study	- Ministries of Agriculture promote and incentivize climate-smart agriculture via sustainable practices as mentioned herein - Refocus on Good Agricultural Practices (GAP) as a mechanism for livelihood protection and nutrition security as opposed to an imposition for international trade	As part of nationwide environmental sustainability initiatives, the role of agriculture as a significant steward of the natural environment should be prominently projected
Financial sustainability: Examples of environmentally-sound, sustainable practices were seen, but financial sustainability aspects were less evident. The apparent exclusion of producers from a number of value-chains is cause for concern. With the exception of producers belonging to a handful of farmers' organizations and the	- Continued promotion of the Value Chain approach with a concentration on looped value chains to include by-product and end-product utilization - Proper Record Keeping as part of a regimen of business monitoring - Maintain a customer database	A major feature of financial sustainability is proper accounting for the resources utilized. Proper agricultural records incorporate more than just financial information; all major decisions can be traced through accurate and timely entries. Decision-making is thus better informed,

Conclusions	Recommendations	Remarks
cooperatives, the others depended on very loose verbal agreements at best. Formal, structured arrangements for the marketing of non-traditional vegetables and fruits still pose a problem. Bananas in the Windward Islands and onion in Barbados are two of the more developed value chains. The incorporation of VINCYKLUS, the agri-business cluster in St Vincent and the Grenadines is a potential source of improvement.	- Keep the community informed about production and sustainability issues	including decisions on contractual arrangements.

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TRENDS IN FERTILIZER CONSUMPTION IN PUERTO RICO

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ABSTRACT: Modern agriculture must strive to maximize yields, crop quality, and profit in the most sustainable manner. The rational use of fertilizer is one of the most influential factors affecting these traits. In this paper, we examined trends in fertilizer consumption at the global and local scales and described the causes for trends in fertilizer consumption in Puerto Rico. World fertilizer consumption has more than quadrupled since the 1960s. Fertilizer consumption in most regions is either stable or increasing, with the biggest share of increase occurring in Asia. In contrast, fertilizer consumption in Puerto Rico was -2,740 t/yr, between 1990 and 2006. Fertilizer consumption rates in Puerto Rico lag behind those of other countries in Latin America and elsewhere. Linear regression analysis demonstrates that the decrease in annual fertilizer consumption is primarily related to reductions in agricultural land-area (as defined by the Food and Agriculture Organization), and to a minor extent, lower fertilizer rate applications. The latter suggests that most farmers are not fertilizing to maximize yields. The decrease in fertilizer consumption in Puerto Rico could be a symptom of the gradual loss in competitiveness of the Island´s agricultural sector.

Keywords: fertilizer consumption, fertilization of tropical crops, sustainable agriculture

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TRENDS IN FERTILIZER PRICES IN PUERTO RICO

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ABSTRACT: World food demands in the next 50 years will depend on increased agricultural productivity. Stabilization of the world agricultural land area suggests that the productivity must be achieved via higher crop yields that will require increased inputs, especially fertilizers. Higher crop yields represent the greatest means for reducing per-unit production costs. Knowledge of the precise nutrient input levels required to achieve optimum economic yields requires knowledge of product and fertilizer prices. In Puerto Rico, the sale and consumption of fertilizers in the past years has been strongly influenced by changes in the prices of fertilizer raw materials and blends. This fluctuation has created the public perception for the need to reduce the fertilization levels to lower production costs. Yet, objective methods have not been published that demonstrate the economic optimum nutrient rates (EONR) required to ensure adequate returns on investment. A relationship between the production area dedicated to specific commodities and fertilizer consumption demonstrates that many farmers are not fertilizing to maximize yields. The objective of this work is to discuss some factors influencing increase of prices during 2007 and 2008, and to relate these factors to prices at farm level in the USA and Puerto Rico. In Puerto Rico, urea, ammonium sulfate (AS), triple superphosphate (TSP), diammonium phosphate (DAP), muriate of potash (MOP), and potassium sulfate (SOP) prices were relatively stable from 1994 to the middle of 2005 with a price index change (relative to 1994) of 1 to 1.13. A comparison of on-farm urea prices between Puerto Rico and seven other Latin American countries and USA for 1995 to 1998 reveals that prices in Puerto Rico were always 32% higher in Puerto Rico. In Puerto Rico from October 2005 to January 2006, on-farm fertilizer prices increased dramatically and continued in ascending mode up to July 2008. During this time period, the mean annual change in price for urea, SA, DAP, TSP, MOP and SOP was 82%/yr. High fertilizer prices peaked in the winter of 2008, after which time prices reached a minimum and stabilized in March 2009. This same pattern was observed worldwide as indicated by fertilizer freight on board (FOB) prices. As of 2011, the mean fertilizer price index was 3.03. Between 1995 and 2009, the rate of change in urea farm price was similar in Puerto Rico and the USA, but not for AS, which was lower in the USA. The data suggests that Puerto Rico has historically had higher fertilizer prices than other Latin American countries and the USA, yet the rate of change in fertilizer prices has been similar between Puerto Rico and USA. Factors influencing projected changes in fertilizer prices that will be discussed are natural gas and crude oil prices, world fertilizer production capacity versus demand, expansion of bio-fuel producing areas, increased global wealth, dollar value for foreign fertilizer products, and transportation costs.

Keywords: fertilizer prices, cost of nutrients, soil fertility, sustainable agriculture

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WATER STATUS AND GROWTH OF PLANTS IN PVC CYLINDERS INSTALLED VERTICALLY IN THE FIELD

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ABSTRACT: Increasing the efficiency of irrigation water use is critical in water-scarce countries such as Barbados. Planting in pots can ensure that most of the applied irrigation water is available exclusively to the target plant, but plant growth may be restricted due to large fluctuations in soil moisture availability and temperature, reduced rooting volume and pot drainage issues. Planting in open-ended PVC cylinders installed vertically in the field should help to ensure that applied water remains largely within the root zone of the target plant, while avoiding many of the problems associated with potted plants above the soil surface. This study assessed the effects of planting in buried PVC cylinders on water status and growth of two crop species (sweet pepper and bean) in a heavy clay soil. A split-plot experimental design was used with two main plot (height of cylinder protruding above the soil: 0 and 3 cm) and three sub-plot (buried depth of cylinder: 0, 15 and 30 cm) treatments. Cylinders (internal diameter: 16cm) were hammered into loose dry soil. Irrigation was applied as needed to supplement rainfall by manual sprinkling with a garden hose. Soil moisture status and plant growth were not significantly affected by the height of cylinder above the soil surface. As the length of buried cylinder increased, moisture content in the top 5 cm of soil within the cylinder also increased and ponding was often observed in the 30 cm cylinders. Plant growth was not significantly affected in the 15 cm cylinders but was reduced for both crops in the 30 cm cylinders. Excessive rainfall during the study period resulted in supra-optimal soil moisture conditions within the buried cylinders. Significant effects on soil penetration resistance suggested that there was soil compaction within the PVC cylinders, which was likely due to hammering during the installation process and/or swelling of soil within the cylinders on re-wetting. This approach appears to have some potential for increasing the efficiency of irrigation water use and is likely to be beneficial under low rainfall conditions with more precise water application.

Keywords: tissue moisture content, water potential, dry mass ratio, greenness index

INTRODUCTION

Barbados is listed as a water-scarce country and strategies have been outlined to enhance the management of existing water resources and increase the efficiency of water use (Government of Barbados 2007). Although Barbados is an extreme example, the majority of Caribbean territories suffer varying degrees of water stress and scarcity on both a seasonal and inter-annual basis. Agricultural enterprises are the largest consumers of water and there is a need to increase water use efficiency in agriculture as developmental needs compete for fresh water supplies (FAO 2007). As populations increase, programs to encourage urban and peri-urban horticulture (UPH) are advocated in many developing countries (FAO 2010). An important option in UPH is the growing of plants in containers, which can potentially impact water requirements.

Planting in pots can improve water use efficiency by ensuring that water is applied to the target plant while reducing or eliminating losses due to surface run off and the watering of weeds and

non-crop areas. Decreased plant growth and transpiration are associated with reduced container size for potted plants, although the relationship between transpiration and available soil moisture content appears to be unaffected (Ray and Sinclair 1998). Restrictions in rooting volume due to container size can result in several physiological and morphological changes, including effects on plant biomass production, partitioning, plant water relations, nutrient uptake, leaf chlorophyll content, branching, flowering and yield (NeSmith and Duval 1998).

Apart from pot size, container geometry, growing media selection and the length of time the plant stays in the container have been identified as factors that can affect plant growth and development (NeSmith and Duval 1998). A reduction in the flexibility of irrigation scheduling is expected as container size becomes smaller and the porosity of the growing media increases. Excessive root zone fluctuations in soil moisture and temperature and root growth problems in relation to the presence of a perched water table at the base of the pots are abiotic features commonly associated with container-grown plants (Mathers et al. 2007). The perched water table is a water-saturated zone at the base of the container, which further reduces rooting volume in container-grown plants. The impact of the perched water table is reduced as the depth of the container increases.

Negative effects of abiotic factors on container-grown plants can be reduced by planting in open-ended PVC containers (cylinders) which are buried in the ground. Fluctuations in root zone moisture and temperature will be reduced because of the buffering capacity of the surrounding soil, and the presence of a perched water table can be minimized by controlling the interface between the growing medium in the container and field soil. In this study, the effects of planting in buried PVC cylinders on water status and growth of two-crop species (sweet pepper and bean) were assessed on a heavy clay soil in Barbados. The effects of container depth below and above the surface of the soil were investigated with the aim of identifying possible effects of this technique on soil-water availability and plant growth.

MATERIALS AND METHODS

This study was conducted under field conditions at the University of the West Indies, Cave Hill Campus, Barbados, on a heavy clay (black) soil with planting in raised beds. Two crops were grown:

1. Sweet pepper (*Capsicum annuum*, 'King Arthur'), planted 26th November 2010 and harvested 8th February 2011.
2. Bean (*Phaseolus vulgaris*, 'Green Crop') was planted 15th February and harvested 25th March 2011.

The soil was cultivated manually to obtain a fine tilt and beds (90 cm wide) separated by furrows (30 cm wide) were prepared. PVC cylinders (16 mm inner diameter, 3 mm thick wall) were cut to the required lengths (3, 15, 18, 30, 33 cm) and hammered vertically into dry soil on 25 November 2010. A split-plot experimental design was used with four replications (blocks). There were two main plot treatments (height of PVC above the soil):

1. 0 cm PVC above soil
2. 3 cm PVC above soil

Within each main-plot treatment, three subplot treatments (depth of PVC below the soil) were applied:

1. 0 cm PVC below soil
2. 15 cm PVC below soil
3. 30 cm PVC below soil

Each sub-plot consisted of six plants, with a spacing of 30 cm between plants within a sub-plot, 45 cm between sub-plots in the same bed, and 60 cm between plants on adjacent beds. One plant was planted within each buried PVC cylinder and in the corresponding bare soil area for the Control treatment (0 cm PVC above and below soil surface). Plants were irrigated by using a garden hose daily mornings, and a soluble fertilizer (NPK 20:20:20) was applied weekly at the recommended rate using a watering can. Seedlings were sprayed with pesticides in the early growth stages as needed to reduce pest damage. For sweet pepper, the experimental area was covered with bird netting (25% shade) to reduce bird damage during the fruiting stage. After termination of the sweet pepper crop, all crop residues were removed and the area was replanted with bean after one week, using the same experimental design.

Plant height and number of leaves were determined weekly from 9th January to 4th February 2011 for sweet pepper, and from 8th March to 22nd March 2011 for bean. Soil moisture content (v/v, %) was determined by using a soil moisture probe (Model EC5, Decagon Devices Inc., USA). The 5-cm-length probe was inserted vertically into the soil within and just outside the area bounded by the PVC cylinder and at corresponding locations in control plots. Soil moisture determinations (two replications per sub-plot) were made in the afternoons (4:00 pm) on 27th January and 4th February 2011 for sweet pepper, and on 8th, 16th and 22nd March 2011 for beans. Leaf greenness index was determined periodically using a chlorophyll index meter (Field Scout CM1000, Spectrum Technologies Inc., USA). Measurements were made on the topmost fully expanded leaf between midday and 2:00 pm afternoons with bright sunshine. Five readings were taken per leaf with the instrument held 5-10 cm from the leaf, and two leaves were sampled per sub-plot. Greenness index is calculated as a dimensionless number between 0 and 999 based on leaf reflection of red and infrared light wavelengths.

At the termination of each crop, shoots were harvested by cutting at the base of each plant and dry mass components were determined after drying plant parts in an oven at 80°C for one week. Both fresh and dry mass were determined for leaves of the harvested bean plants. Leaf water potential was determined for bean plants at the time of harvesting using a pressure chamber (Model 3005, Soil Moisture Equipment Corporation, USA). The terminal leaflet of the topmost fully expanded leaf was used, and two plants were sampled per plot between 4.00 and 4.30 pm. Soil penetration resistance (0- to 20-cm depth) was determined using a penetrometer (SC900, Spectrum Technologies, Inc., USA) a few days after harvesting the bean plants. Measurements were made at 8 cm from the remaining root stubble (within the PVC cylinder zone) with the soil at field capacity following overnight rainfall, and two determinations were done in each sub-plot. Data were analyzed using statistical analysis software (GenStat Discovery Edition 3, VSN International, UK).

RESULTS AND DISCUSSION

Excessive rainfall during the sweet pepper crop reduced the number of observations made compared to those made during the bean crop. Height of PVC cylinder above the soil surface did not significantly affect any of the parameters measured in this study, and data were pooled for the two main-plot treatments (0- and 3-cm height of PVC cylinder above soil surface). The presence of the 3-cm height of PVC cylinder above the soil surface was expected to trap and retain more water within the PVC cylinder because of reduced runoff losses. Results for both bean and sweet pepper crops suggest that there was no particular advantage of having the PVC cylinders extend above the soil surface under the conditions of this study. Irrigation water applied in this study appears to have been sufficiently uniform and of mild intensity to avoid excessive runoff on plots, or greater ponding within the raised PVC cylinders. Plant canopies were also observed to cover the diameter of the PVC cylinder, reducing any direct entry of irrigation water to the soil surface at the base of the plant.

For measurements within the PVC cylinder zone, moisture content of the top 5 cm of soil increased as the depth (length) of the PVC cylinder below the soil surface increased (Figure 1). Soil water content within the 30 cm PVC cylinder was about 28% higher than that in soil where no PVC cylinders were present. There was a tendency for soil moisture content to also increase as PVC cylinder depth increased for measurements outside the PVC cylinder zone; however, the effects were not significant (Figure 1). It is likely that water conserved within the PVC cylinders can slowly become available outside the PVC cylinders. This is comparable to the traditional technique of applying irrigation water within earthen pots buried in the field, where water seeps slowly into the surrounding soil and plant water use efficiency is increased (Bainbridge 2002).

Shoot dry mass was not significantly affected by planting in the 15 cm PVC cylinders for sweet pepper or bean compared to the corresponding control treatments (Figure 2). Plant growth of bean was greater than that of sweet pepper in 0 cm (control treatments) and 15-cm PVC cylinder. Growth of both bean and sweet pepper was severely reduced by planting in the 30-cm PVC cylinders, and shoot dry mass was reduced by 56% for bean and 36% for sweet pepper compared to the controls (Figure 2). Shoot dry mass was similar for bean and sweet pepper when grown in the 30-cm PVC cylinders. There was a strong negative correlation between shoot mass of bean and soil moisture content in the top 5 cm soil (Table 1). Soil moisture retention within the 30-cm PVC cylinders was most likely supra-optimal for plant growth. Excessive root zone moisture is likely to reduce soil aeration, which can have adverse effects on root respiration, water and nutrient transport, and soil nitrogen (Scott and Renaud 2007).

In comparison with the control treatment, plant height and number of leaves for bean were not significantly affected by planting in the 15 cm PVC cylinders, but were reduced in the 30 cm PVC cylinders (Figures 3, 4). The effect on number of leaves per plant was more severe and occurred earlier than the effect on plant height. No significant effects of the treatments were observed in leaf greenness index (data not shown); however, this is based on a limited number of observations made over the period. It may also have been useful to sample leaves at different points in the canopy (not only the topmost fully expanded leaf). Periodic root flooding has been shown to reduce plant height, leaf production and leaf chlorophyll content in field bean (Pociecha, Kościelniak, and Filek 2008).

Leaf moisture content of the bean plants was not significantly affected by height of PVC cylinder above the soil surface or by growing in the 15-cm PVC cylinder, but was reduced for plants growing in the 30-cm PVC cylinders compared to the control plants (Table 2). Reduced root water absorption and transport to the shoot system can lead to wilting under flooded soil conditions (Scott and Renaud 2007). Results of leaf moisture content determinations support the conclusion that the soil moisture content was supra-optimal for plant growth in the 30-cm PVC cylinders. However, no significant effects of the treatments on leaf water potential were observed (data not shown), which may be related to the time of sampling of leaflets for water potential determinations. The ratio of reproductive parts to shoot mass ratio (pods/shoot mass ratio) was negatively correlated with leaf water potential in bean and positively correlated with soil moisture content in the top 5 cm soil (Table 1). Earlier partitioning of shoot dry mass into reproductive structures may have been caused by stress conditions in the 30-cm PVC cylinders.

Soil penetration resistance measured within the PVC cylinder zone increased with soil depth for all treatments with values within the 15- and 30-cm PVC cylinders being significantly greater than those for the control treatment except at the 2.5-cm soil depth (Figure 5). These results suggest that there was significant soil compaction within the PVC cylinders (15- and 30-cm depth). Soil penetration resistance was highest within the 15-cm PVC cylinders, over the 10.0 to 12.5 cm soil depth range and within the 30-cm PVC cylinders over the 17.5 to 20.0 cm soil depth range (Figure 5). Soil compaction within the PVC cylinders may have been caused by the process of hammering the cylinders into the dry soil and/or by soil expansion within the cylinders on watering. There was a strong positive correlation between the penetration resistance in lower soil layers (at and beyond 15.0-cm depth) and soil moisture content in the top 5 cm soil (Table 3), suggesting that compaction contributed to impeded drainage within the PVC cylinders. Correlations between soil penetration resistance and shoot dry mass, leaf/shoot dry mass ratio and pod/shoot dry mass ratio were also consistent with the suggestion that plant stress within the PVC cylinders could have been caused by soil compaction (Table 3).

CONCLUSION

Soil moisture content increased within PVC cylinders that were inserted vertically in the soil, and the effect was greater for longer PVC cylinders that reached greater depths. Effects of height of the PVC cylinder above the soil surface were not significant. Plant growth of bean and sweet pepper was negatively associated with soil moisture content in the top 5 cm soil. Soil compaction within the PVC cylinders could have restricted drainage leading to supra-optimal soil moisture conditions in the root zone. This technique (tube-culture) may be useful for increasing the efficiency of irrigation in very dry areas or seasons. Further studies are needed to optimize cylinder size and walls, installation procedures and rooting media so as to obtain the maximum benefits.

REFERENCES

Bainbridge, David A. 2002. "Alternative Irrigation Systems for Arid Land Restoration." *Ecological Restoration* no. 20 (1):23. doi: 10.3368/er.20.1.23.

FAO. 2007. "Agriculture and water scarcity: a programmatic approach to water use efficiency and agricultural productivity." In: FAO, Rome (Italy). Agriculture and Consumer Protection Dept. ftp://ftp.fao.org/docrep/fao/meeting/011/j9206e.pdf (accessed January 2009).

———. *Growing Greener Cities: Cities of despair – or opportunity?* FAO 2010. Available from http://www.fao.org/ag/agp/greenercities/pdf/GGC-en.pdf.

Government of Barbados. 2007. *Global Excellence, Barbados Traditions: The National Strategic Plan of Barbados 2006 – 2025*. Barbados: Ministry of Economic Affairs & Development, Government of Barbados.

Mathers, H.M., S.B. Lowe, C. Scagel, D.K. Struve, and L.T. Case. 2007. "Abiotic Factors Influencing Root Growth of Woody Nursery Plants in Containers." *HortTechnology* no. 17 (2):151-162.

NeSmith, D. S., and J. R. Duval. 1998. "The effect of container size." *HortTechnology* no. 8 (4):495-498.

Pociecha, Ewa, Janusz Kościelniak, and Władysław Filek. 2008. "Effects of root flooding and stage of development on the growth and photosynthesis of field bean (Vicia faba L. minor)." *Acta Physiologiae Plantarum* no. 30 (4):529-535. doi: 10.1007/s11738-008-0151-9.

Ray, Jeffery D., and Thomas R. Sinclair. 1998. "The effect of pot size on growth and transpiration of maize and soybean during water deficit stress." *Journal of Experimental Botany* no. 49 (325):1381-1386. doi: 10.1093/jxb/49.325.1381.

Scott, H. D., and F. G. Renaud. 2007. "Aeration and Drainage." In *Irrigation of Agricultural Crops*, 195-235. USA: ASA, CSSA, SSSA.

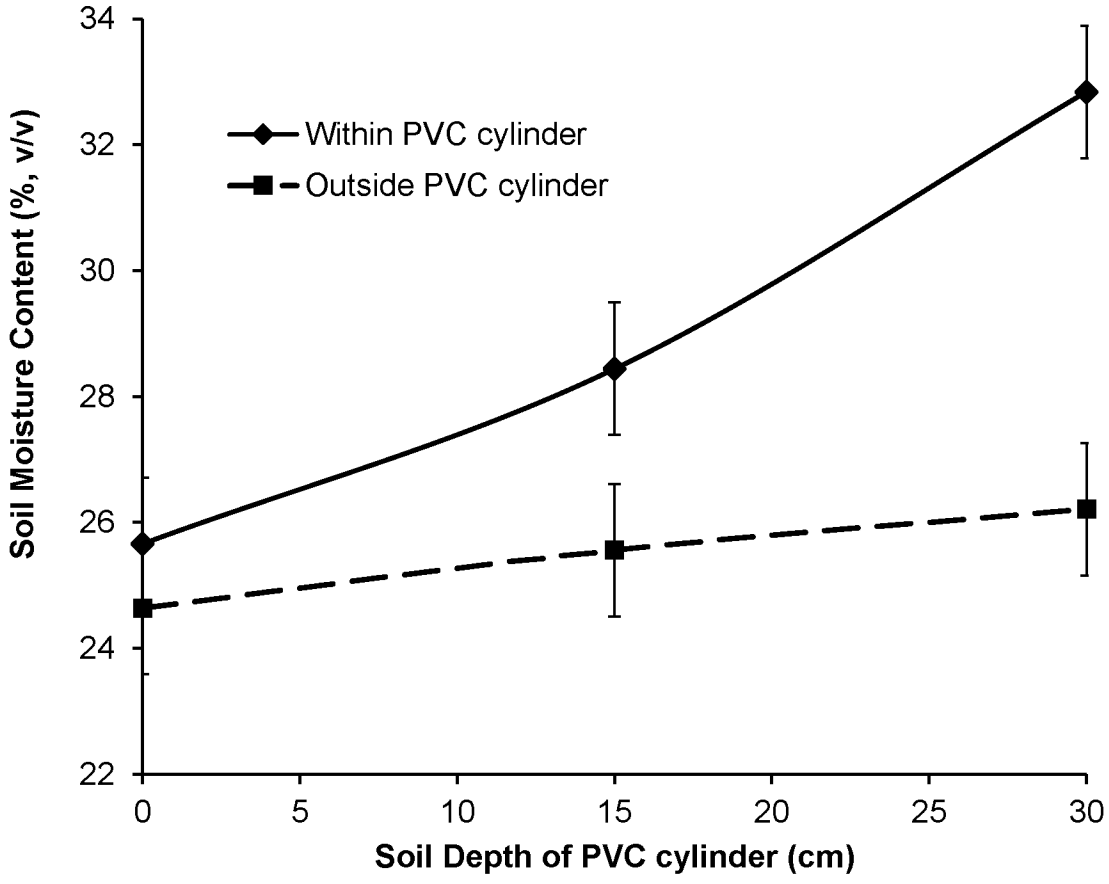

Figure 1: Soil moisture content in the top 5 cm soil within and outside the perimeter of buried lengths of vertically-installed PVC cylinders that reach varying soil depths. Control values were obtained by corresponding measurements close to and away from the plant. Measurements were made on five occasions during the growth of sweet pepper and bean crops.

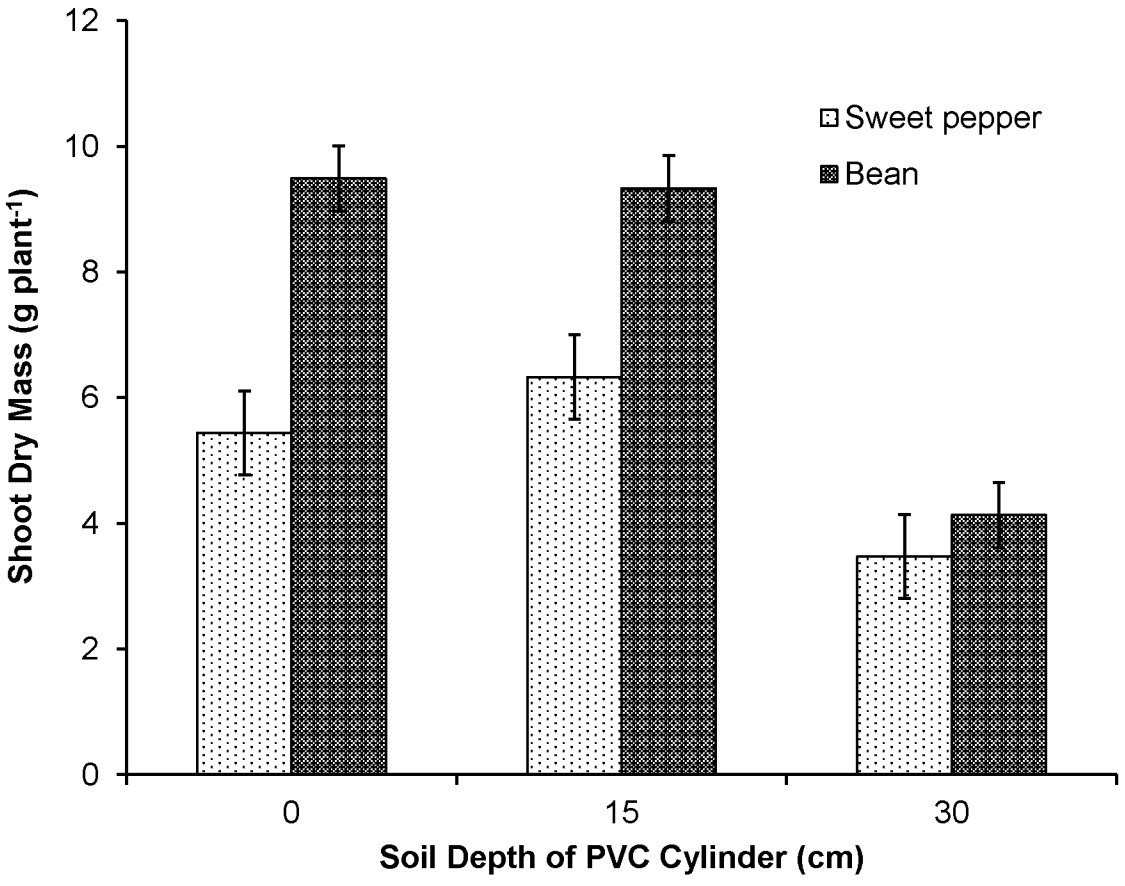

Figure 2: Shoot dry mass of sweet pepper and bean plants grown within buried lengths of vertically-installed PVC cylinders that reach varying soil depths. Control plants were grown in unenclosed soil (0-cm PVC cylinder length).

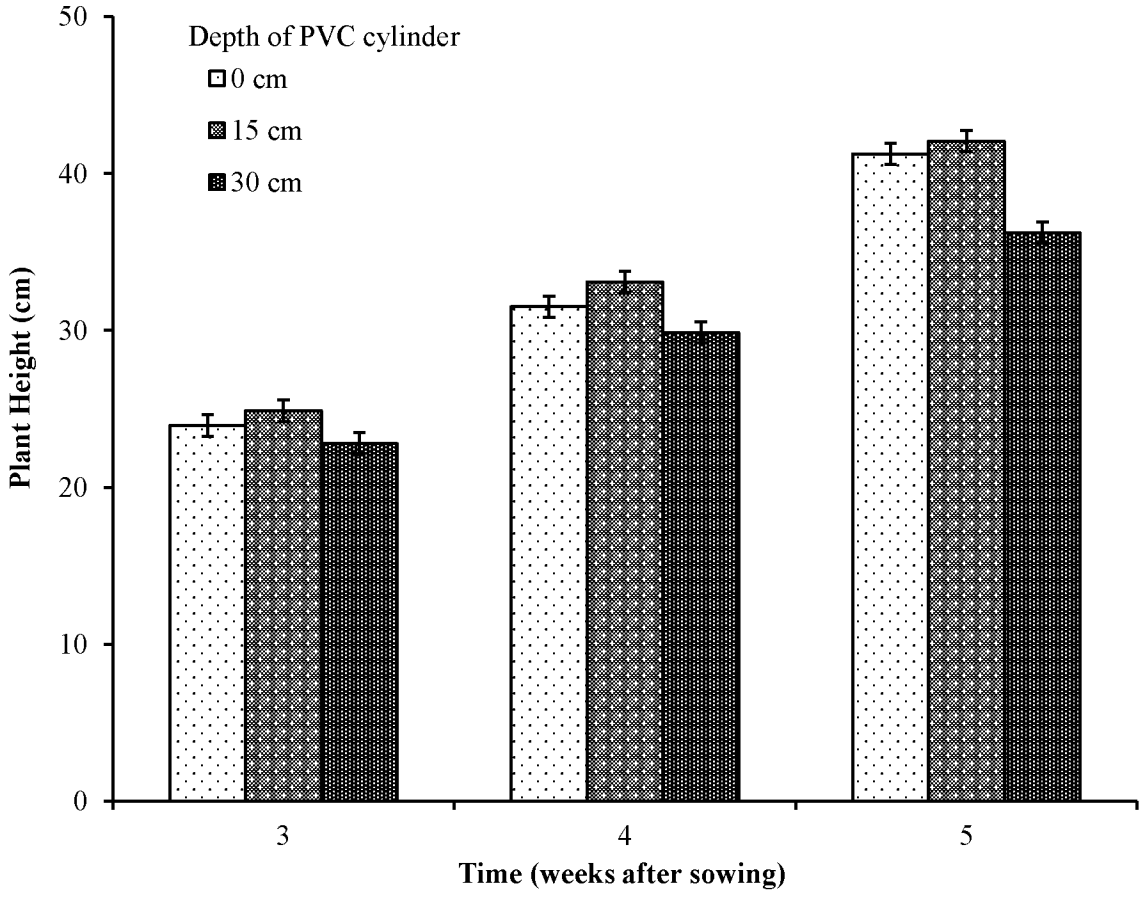

Figure 3: Plant height of bean plants 3-5 weeks after sowing within buried lengths of vertically-installed PVC cylinders that reach varying soil depths. Control plants were grown in unenclosed soil (0-cm PVC cylinder length).

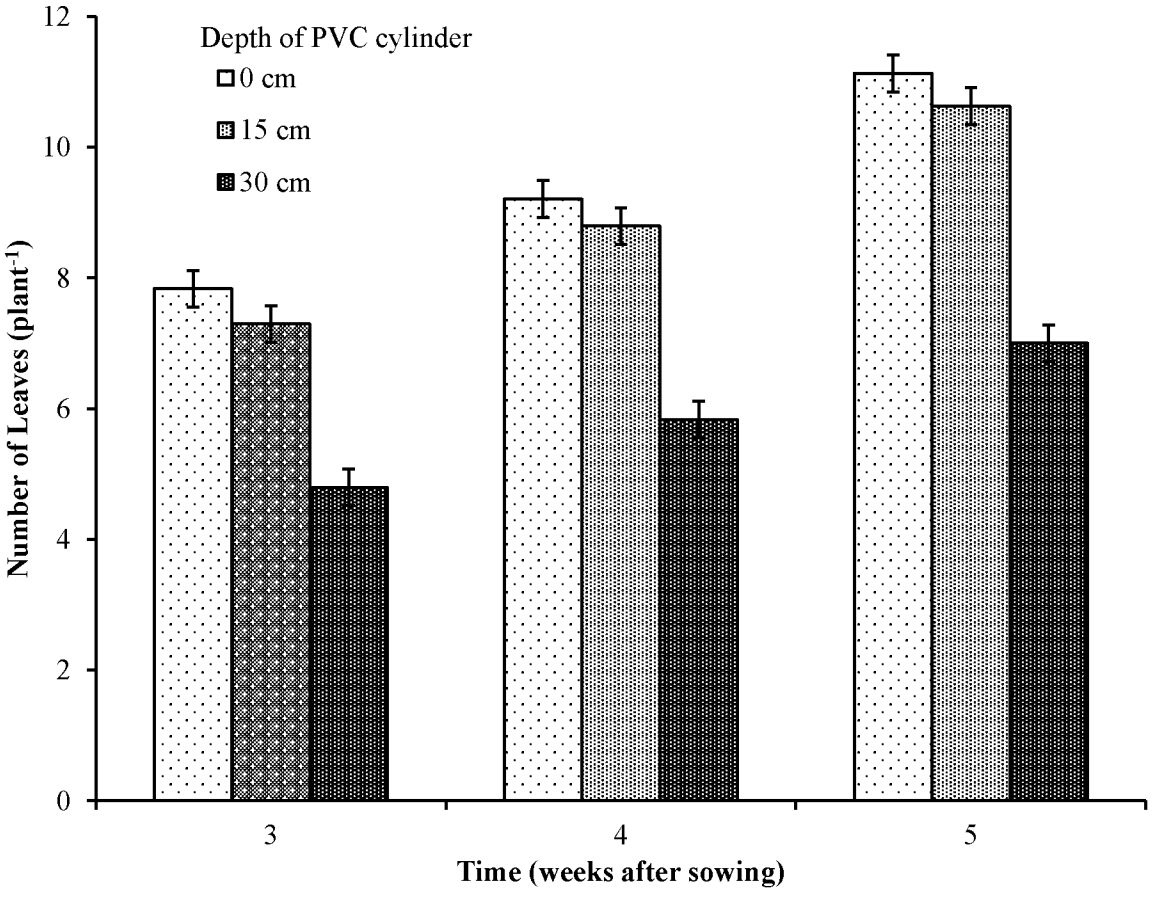

Figure 4: Number of leaves of bean plants 3-5 weeks after sowing within buried lengths of vertically-installed PVC cylinders that reach varying soil depths. Control plants were grown in unenclosed soil (0-cm PVC cylinder length).

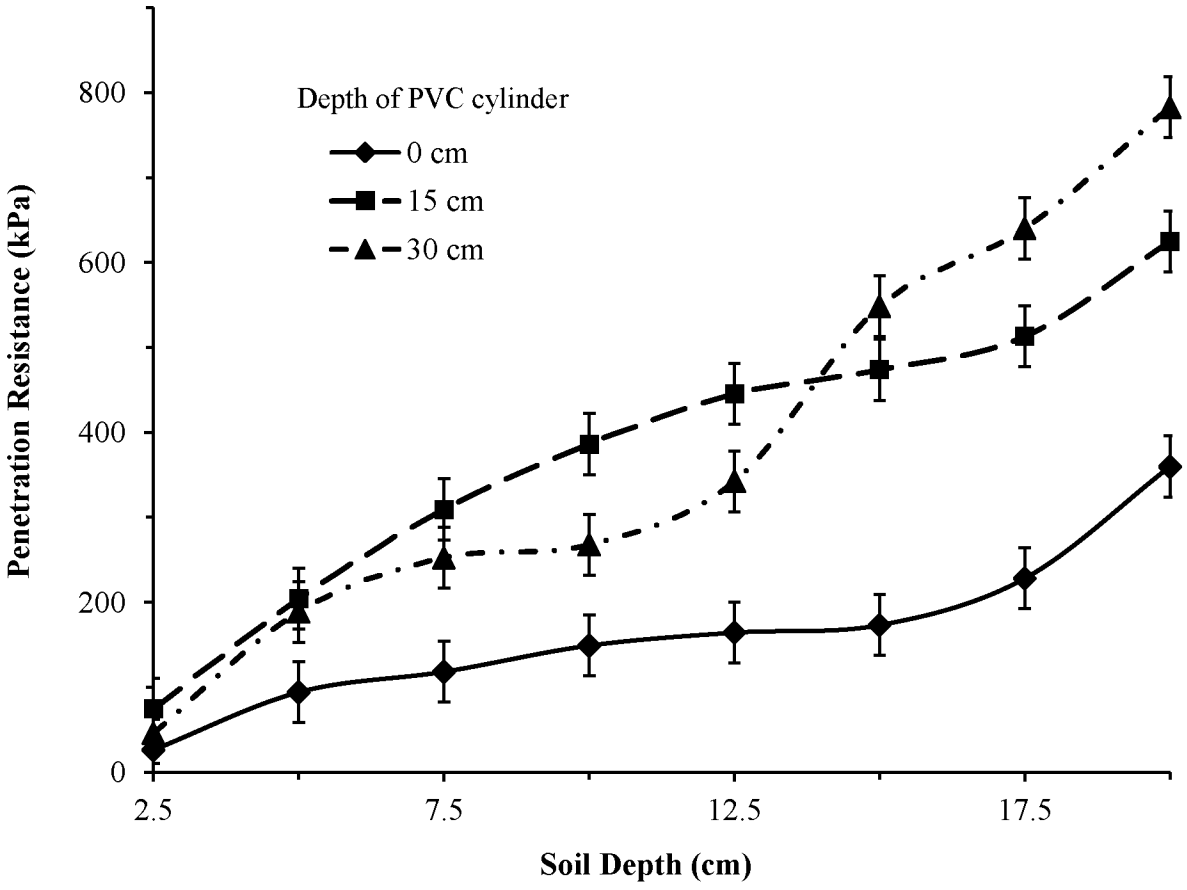

Figure 5: Soil penetration resistance vs. soil depth within buried lengths of vertically-installed PVC cylinders that reach varying soil depths. Control values were obtained in unenclosed soil (0-cm PVC cylinder length).

Table 1: Correlation matrix for shoot mass, pods/shoot mass ratio, leaf water potential and soil moisture content for the bean crop.

	Pearson's Correlation Coefficient (r)		
	Shoot mass	Pods/Shoot mass ratio	Leaf Water Potential
Pods/Shoot mass ratio	-0.56**	1	
Leaf Water Potential	0.27	-0.50*	1
Soil MC % (top 5 cm)	-0.76**	0.51*	0.18

*, ** Values significant at the 5% and 1% significance levels, respectively.

Table 2: Leaf moisture content per unit dry mass (g g^{-1}) of bean plants as affected by growth in PVC cylinders extending to varying depths below and heights above the soil surface

PVC Above soil (cm)	PVC Below soil (cm)			
	0 cm	15 cm	30 cm	Mean
0	6.58	6.59	5.42	6.20a
3	6.92	6.93	5.88	6.57a
Mean	6.75a	6.76a	5.65b	

*Means in the same column or row with a common attached letter are not significantly different from each other by Fischer's Protected LSD Test.

Table 3: Correlation matrix between soil penetration resistance at various soil depths and soil moisture content, shoot dry mass, leaf/shoot dry mass ratio and pods/shoot dry mass ratio for the bean crop.

Soil Depth (cm)	Pearson's Correlation Coefficient (r)			
	Soil MC % (top 5 cm)	**Shoot dry mass**	**Leaf/shoot mass ratio**	**Pods/shoot mass ratio**
2.5	0.18	0.09	-0.34	0.04
5.0	0.41*	-0.20	-0.22	0.25
7.5	0.22	0.00	-0.45*	0.26
10.0	0.21	0.14	-0.50*	0.12
12.5	0.35	-0.04	-0.28	0.13
15.0	0.67**	-0.47*	-0.05	0.41*
17.5	0.73**	-0.57**	-0.18	0.61**

*, ** Values significant at the 5% and 1% significance levels, respectively.

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INVENTORY OF GREENHOUSE GASES EMISSIONS FROM THE AGRICULTURAL SECTOR FROM SURINAME

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ABSTRACT: The changing patterns of climate have severe impacts on the ecological and economical dimensions of agricultural productivity. Due to shifting population patterns, movement of insect populations, more dramatic shifts in daily temperature regimes, and other large scale ecological changes that come with climate, agriculture production will be more severely impacted by climate. Therefore, under the United Nations Framework Convention on Climate Change (UNFCCC), each country must annually conduct a national Greenhouse Gases Inventory of its anthropogenic emissions by sources and sinks. In order to ensure consistency, transparency and comparability of estimates among countries, the estimation and reporting of emissions must follow methodological guidance developed by the Intergovernmental Panel on Climate Change (IPCC 1997-200, 2006). While the Revised 1996 IPCC Guidelines presents the basic methods on default parameters, Good Practice Guidance (IPCC 2000) contains more complex approaches which require detailed country specific data on different variables. In the year 2011, the Ministry of Labor, Technology and Environment (ATM) conducted an inventory study to assess greenhouse gases emissions and the approaches applied to estimate emissions for the agricultural sector in Suriname during the period 1994-2008. The source categories investigated included enteric fermentation in domestic livestock, livestock manure management, rice production, and biomass burning. Collection of activity data for the realization of this inventory, concerning the agricultural sector, was based on official data of the National Statistical Office, and the Ministry of Agriculture in Suriname. Greenhouse Gas emissions were computed by using IPCC 2006 software program. Emissions were analyzed by using descriptive statistics and regression analysis to predict Greenhouse Gass emissions from agricultural sources. Results revealed that the total greenhouse gases emissions reached 952.57 Gg CO_2 eq. in 2008. About 41.8 % (398.58 Gg CO_2 eq.) of these emissions has originated from rice cultivation. The emissions under the Surinamese conditions consist mainly of emission from enteric fermentation, manure management, rice cultivation, agricultural soils, indirect N_20 emissions of livestock, and field burning of rice agricultural residue. During the period 1994-2008, GHG emissions from agriculture decreased by 30.6%, which was linked to reduced dairy and cattle population and reduced rice cultivation. The study concludes that GHG emissions in the sector of agriculture remain important, and that proper assessment is required for sound climate change adaptation and mitigation policies especially for rice cultivation.

Keywords: Greenhouse Gases, Climate Change, Agricultural source categories

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DIRECT LEACHING OF SPENT MUSHROOM COMPOST (SMS) FOR SEEDLING CULTURE

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ABSTRACT: Seedling culture in chemically active media presents challenges due to phytotoxicity associated with high contents of soluble salts. A greenhouse study was conducted to investigate the effect of direct leaching on the suitability of spent mushroom substrate (SMS) as a seedling nursery media. Germination, growth and nutrition characteristics of cucumber and hot pepper were compared among leached SMS (SMSL), unleached SMS (SMSU) and promix (PM) in a factorial design with three replicates. Seedling media significantly affected germination of hot pepper seeds, which was reduced to < 30% for the SMSU. Cucumber seeds showed > 90% germination across all media used. Across both crops, over the growing period, plants grown in SMSL showed consistently, and in most cases significantly ($P< 0.05$) greater heights and stem diameters than those in the SMSU and PM. Chlorophyll index (CI) was greatest for the unleached SMS and lowest for promix. At no time was there a significant difference in CI between the leached and unleached treatments. A similarly lower dry matter was shown for the unleached treatment compared to that of the others. Leached SMS resulted in either better or equal growth responses to PM, with the added advantage of not having to be fertilized.

Keywords: spent mushroom substrate, seedling growth, chlorophyll index, incubation media

INTRODUCTION

Nursery production of important horticultural crops has been a common practice and continues to play a major role in providing vigorous, disease-free plants towards sustainable crop production. Root medium's physical and chemical properties affect seedling quality and hence field performance. Nappi and Barberis (1993) indicated that an ideal potting medium should be free of weeds and diseases, heavy enough to avoid frequent tipping over and yet light enough to facilitate handling and shipping. The media should also be well drained, yet retain sufficient water to reduce frequent watering. Other parameters to consider include cost, availability, consistency, and stability over time. Special attention should also be given to media chemical properties such as pH, electrical conductivity (EC), cation exchange capacity (CEC), carbon to nitrogen (C:N) ratio as they all play vital roles in seedling survival.

Commercial peat and peat-based products have dominated the market for seedling media due to their desirable properties including high water holding capacity (WHC), high porosity and low bulk density (BD) allowing developing roots ease of penetration into the medium as well as ease of removal from the seedling tray at transplanting. Such media are only limited by poor fertility, which traditionally would be supplemented. In recent times, because of increasing demand and rising cost for peat, as well as questionable availability related to environmental constraints (Abad et al., 2001), the search for alternative high quality, low cost substrates is increasing.

Selection of appropriate media components is critical to successful production of transplants. Spent mushroom substrate (SMS) has been proposed as a stable organic based material with great potential as a seedling media substrate or component (Ahlawat and Sagar, 2007). Romaine and Holcomb (2001) indicated that fresh SMS properly sized by sieving, leached of salts and blended with vermiculite acts as an ideal growth medium for plants and offers exceptional aeration, porosity, WHC and nitrogen (N). It acts as a conceivable alternate to peat in soilless media. SMS and other composts possess phytotoxic properties that may limit and affect seedling growth. Electrical conductivity has been identified as potentially the most significant of these properties (Eudoxie and Alexander, 2011; Sanchez-Monedero et al., 2004). It has been shown that salts decline substantially and have no detrimental effect on plant growth within a week after planting with regular watering (Romaine and Holcomb, 2000). However, the response may vary dependent on crop type. Additionally, leaching of salts also reduces SMS fertility, which may cancel a most significant advantage this seedling media possesses over peat-based products. The extent to which direct leaching influences seedling germination and response remains mostly unanswered. This paper reports on a trial that sought to determine the potential for direct leaching of SMS (in trays) and its effects on seedling germination and growth in unfertilized culture.

MATERIALS AND METHODS

Spent mushroom substrate was obtained from a local commercial mushroom operation, with the major substrates being sugarcane bagasse and poultry litter. The SMS was air dried and along with the commercial peat (Premier Promix BX, Premier Horticulture Inc., Quakertown, PA), screened to pass a 6.25 mm mesh. Spent mushroom substrate and PM were added to 72-well seedling trays to make three treatments; PM, SMSU and SMSL. The latter was prepared by supplying water to the trays until drainage EC was < 2 dS/m. Media treatments were seeded to two crops (cucumber and hot pepper) in a 3×2 factorial design with three replicates.

The treatments were laid out in a completely randomized pattern in an unheated Perspex covered greenhouse. Germination was performed under ambient conditions protected under shade cover allowing 60% sunlight. Trays were exposed to natural sunlight 72 hrs after germination. Seedling trays were irrigated daily with a pressurized spray bottle. Additionally, the peat treatments were fertigated once weekly with water containing a soluble fertilizer (Bayfolan Forte) at 50 mg N/L. Germination percentage was determined by counting the number of germinated seeds after 72 hrs and 14 days for cucumber and hot pepper, respectively. Plant growth and quality parameters; plant height, diameter and CI were measured from the first week after germination and at weekly intervals throughout the study. Plant height was measured with a ruler, diameter with a digital caliper, 1 cm from the base of the stem (only for cucumber), and CI with a field scout chlorophyll meter (CM 1000 Spectrum Technologies, Inc. Plainfield, IL). Upon attaining commercial transplanting size, four and five weeks for cucumber and hot pepper respectively, 20 plants, including roots, were removed from the middle of the tray, excess media washed off and weighed to determine fresh weight. Plants were further dried in a force draft oven at 65° C for 48 hrs to determine dry weight.

Electrical conductivity and pH of the media were measured in a water extract (media: distilled water ratio of 1:5) (TMECC, 2001). For water soluble nutrients, phosphorus (P) and total available nitrogen (TAN) were determined colorimetrically. Potassium (K) was measured by atomic absorption spectrophotometry. Total N was determined by the Kjeldahl method according to

Bremner (1996) and total organic carbon (TOC) by loss on ignition at 430° C for 24 hrs (Navarro, et al., 1993). The C/N ratio was determined mathematically from the percentages of its components. Physical properties of each treatment were determined by using procedures described by TMECC (2001). Porosity (TPS) was determined by saturation under zero tension. The mass of water at saturation was divided by the bulk volume. Aeration porosity or air space (AS) was similarly measured after saturation. Samples were left to drain at 4 kPa on a tension table for 48 hrs. Bulk density (BD) was determined by dividing the oven dried weight of each substrate by its bulk volume. Water holding capacity (TWHC) was measured gravimetrically, after saturating and allowing substrates to drain naturally under the influence of gravity.

Media evaluation was subjected to repeated measures ANOVA (GenStat Discovery Edition 4), with means separated by Fisher's protected LSD test at $p < 0.05$.

RESULTS AND DISCUSSION

Media Properties

Spent mushroom substrate pH changed slightly after leaching, increasing from 6.32 to 6.40 (Table 1). The SMS media was slightly acid, whilst the peat was moderately acid and outside the ideal media range (Abad et al., 2001). The low pH posses a fertility concern, as macronutrients are not readily available at this pH (Jones and Jacobsen, 2005). However, peat products are generally devoid of nutrients as indicated in Table 1 and require supplemental nutrition to ensure vigorous healthy transplants, a cost that potentially can be alleviated through the use of composts including SMS. Leaching resulted in a large reduction in the EC of the SMS, although the value remained outside the upper acceptable range. A target EC of < 2 dS/m was used as Brady and Weil (2008) indicated that most plants can tolerate salt concentration in that EC range without growth limiting effects. The commercial peat product was the only media that satisfied the acceptable criteria. Leaching also reduced the primary nutrient concentrations in the SMS, but the values remained well above the acceptable range. In this case the fertility of the SMSL was still superior to that of the PM. Carbon to Nitrogen ratio was higher for the PM compared to that of the SMS treatments. The values for the SMS treatments suggest that this media may still be active and may continue to decompose during use. Bernal et al. (1998) indicated that a C:N ratio of < 12:1 indicates maturity and such compost shows little further active decomposition. However, decomposition should be minimal because of small quantities used and short incubation period.

Physical properties were similar across all three media with only BD being in the acceptable range. Air space was very low for all media, whilst WHC was moderate. The two latter properties are not expected to present a limitation because the root volume is very small allowing for gaseous exchange throughout the root zone, and the watering regime ensured that seedlings were adequately watered.

Germination and growth parameters

Seed germination was non-significantly ($P > 0.05$) different across the three media for cucumber but SMSU resulted in a significantly ($P<0.05$) lower germination for hot pepper (Figure 1). Germination was reduced to < 30% for the SMSU, although it continued after the 14 day cut off period. The seeds were inhibited by phytotoxic properties in the SMS. This was alleviated in the

SMSL media, which supports the hypothesis that EC was the main source of phytotoxicity. Medina et al. (2009) reported reduced seed germination with increased compost composition in the media, with the reason being high salinity. Leaching not only alleviated the salinity but also apparently stimulated seed germination, with the SMSL treatment recording a higher germination percentage. Tomati et al. (1993) showed that composted materials favour rooting, rooting initiation and root biomass development. Visually, germination of hot pepper seeds occurred first in the SMSL media, one to two days before those in the PM.

Seedling diameter increased with time for all media. There was no significant ($P > 0.05$) difference between PM and SMSL, whilst the SMSU showed significantly lower plant diameters at two and three weeks after germination (Figure 2). Compost phytotoxic effects were evident and restricted plant growth and development. Seedling growth rate was lower only for SMSU. Eudoxie and Alexander (2011) reported similar effects for unleached SMS sown to tomatoes. A similar trend was observed for plant height for both crops (Figure 3). The performance of the SMSL compared to that of the SMSU supports the hypothesis that salinity was the main phytotoxic property and reducing media EC to < 2 dS/m resulted in alleviating that limitation. Additionally, the SMSL was not fertilized, indicating that inherent fertility was satisfactory for the seedling incubation period. This is a significant advantage which would save the grower not only fertilizer but labour and operational costs.

Chlorophyll index, which is strongly correlated to tissue N content (Wood et al., 1992), showed an opposite pattern to the plant growth indices across seedling media. Unleached SMS resulted in the highest CI in cucumber, but the values were non-significantly different from SMSL (Figure 4). Table 1 shows that both SMSL and SMSU contained high levels of primary nutrients including N, which would have improved plant nutrition status. At week 4 the fertilized PM recorded the same CI as the SMSU, the former media showing an increasing trend, whilst the latter decreasing. Weekly fertilizer applications eventually increased CI for the PM treatments whilst fertility was gradually reduced in the two SMS media, because of plant uptake and also leaching associated with watering. Unleached SMS resulted in significantly lower CI for hot pepper than the other media. The lower readings may be attributed to stunted growth and phytotoxic effect associated with the SMSU media. For hot pepper, SMSL showed the highest CI, but the value decreased with time similarly to that of cucumber.

Dry matter showed similar variation among the three media for both crops. Unleashed SMS resulted in significantly ($P < 0.05$) lower dry matter than PM and SMSL, the latter two being non-significantly different.

CONCLUSION

Direct leaching lowered SMS media EC, whilst retaining adequate fertility. Germination percentage as well as growth indices were similar for SMSL and the fertilized PM, both being significantly higher than the SMSU. Seedling growth, especially hot pepper, was affected by SMSU media, although chlorophyll index was higher for the SMS treatments in both crops. Leached SMS was shown to produce similar or better quality seedling than fertilized PM. Additionally, EC was shown to be an effective diagnostic measure of compost suitability as seedling media.

REFERENCES

Abad, M., P. Noguera, and S. Bures. 2001. National inventory of organic wastes for use as growing media for ornamental potted plant production: case study in Spain. *Biores. Technol.* 77, 197-200.

Ahlawat, O.P. and M.P. Sagar. 1997. Management of spent mushroom substrate. National research Centre for Mushroom (ICAR), Chambaghat, Solan. http://nrcmushroom.org/Bul-SMS.pdf.

Bernal, M.P., C. Paredes, M.A. Sánchez-Monedero and J. Cegarra. 1998. Maturity and stability parameters of compost prepared with a wide range of organic wastes. *Biores. Technol.* 63, 91-99.

Brady, N. C. and R. R. Weil. 2008. The Nature and Properties of Soils. 14 ed. Pearson-Prentice Hall, Upper Saddle River, NJ.

Bremner, J.M. 1996 Total Nitrogen. p. 1085-1122. *In* D.L. Sparks, et al. (eds.), Methods of soil analysis. Part (3). chemical methods, SSSA, ASA, Madison, Wisconsin.

Eudoxie, G.D. and I.A. Alexander. 2011. Spent mushroom substrate as a transplant media replacement for commercial peat in tomato seedling production. *Journal of Agricultural Science* 3 (4), 41-49.

Jones, C. and Jacobsen, J. 2005. Plant nutrition and soil fertility. In Nutrient Management. Montana State University Extension Service. http://landresources.montana.edu/NM/Modules/NM%202%20mt44492.pdf

Medina, E., M.D. Paredes, M.D .Perez-Murcia, M.A. Bustamante and R. Moral. 2009. Spent mushroom substrates as component of growing media for germination and growth of horticultural plants. *Bioresource Technol.* 100, 4227-4232.

Nappi, P. and R. Barberis. 1993. Compost as growing medium: chemical, physical and biological aspects. *Acta Hort.* (ISHS) 342, 249-256.

Navarro, A.F., J. Cegarra, A. Roig and D. García. 1993. Relationships between organic matter and carbon cnotents of organic wastes. Bioresource Technol. 44, 203-207.

Romaine, C.P. and E.J. Holcomb. 2001. Spent mushroom substrate: a novel multifunctional constituent of potting medium for plants. *Mushroom News* 49, 4-15.

Sánchez-Monedero, M.A., A. Roig, J. Cegarra, M.P. Bernal, P. Noguera, M. Abad, and A. Antón. 2004. Composts as media constituens for vegetable transplant production. *Compost Sci. Util.* 2, 161-168.

Test methods for the examination and composts and composting (TMECC). 2001. USDA, USCC.

Tomati, U., E. Galli, R. Buffone, J. Cegarra Rosique and A. Roig. 1993. Compost in Floriculture. Acta Hort. (ISHS) 342, 175-182.

Wood, C.W., D.W. Reeves, R.R. Duffield and K.L. Edmisten. 1992. Field chlorophyll measurements for evaluation of corn nitrogen status. *Journal of Plant Nutrition*, 15 (4), 487-500.

Table 1 Selected properties of seedling media

Property	PM	SMSU	SMSL	IM[a]
pH	5.15	6.32	6.40	5.3 - 6.5
EC (dS m^{-1})	0.43	9.53	1.84	< 0.5
C:N Ratio	123	27.3	28.5	20 - 40
TAN (mg kg^{-1})	17.3	608	211	100 - 199
P (mg kg^{-1})	106	660	379	6 - 10
K (g kg^{-1})	0.26	4.73	1.36	0.15 - 0.25
BD (g cm^{-3})	0.15	0.25	0.25	< 0.40
AS (%)	7.79	8.18	8.18	20 - 30
WHC (%)	42.5	48.5	48.5	60 - 80

PM = promix, SMSU = unleached spent mushroom substrate, SMSL = leached spent mushroom substrate, IM = ideal media, EC = electrical conductivity, TAN = total available nitrogen, BD = bulk density, AS = air space, WHC = water holding capacity

[a] Ideal media according to Abad et al. (2001)

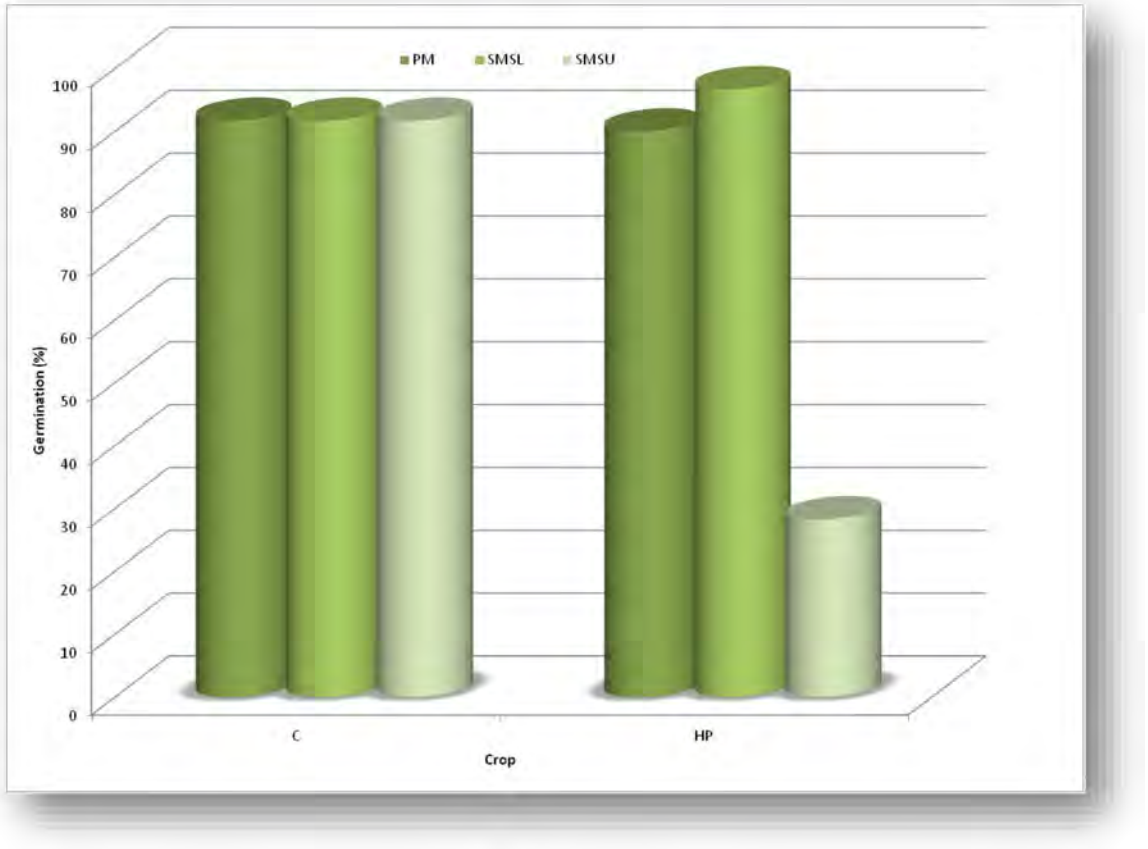

Figure 1. Seedling germination for cucumber (C) and hot pepper (HP) planted in promix (PM), leached SMS (SMSL) and unleached SMS (SMSU)

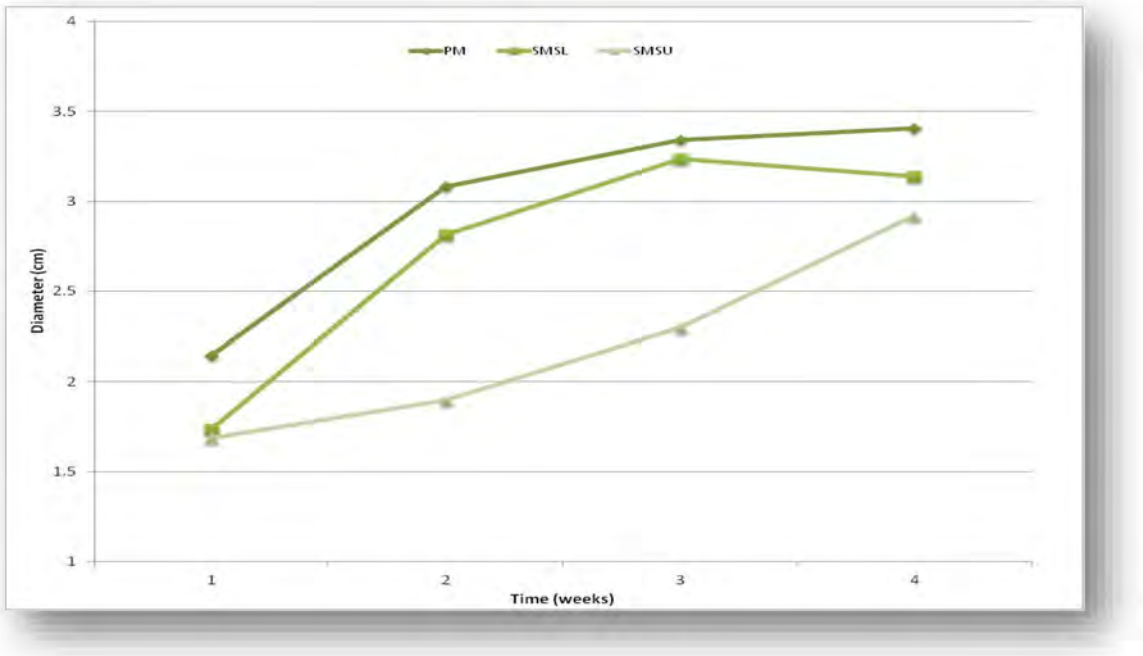

Figure 2. Influence of seedling media on cucumber plant diameter.

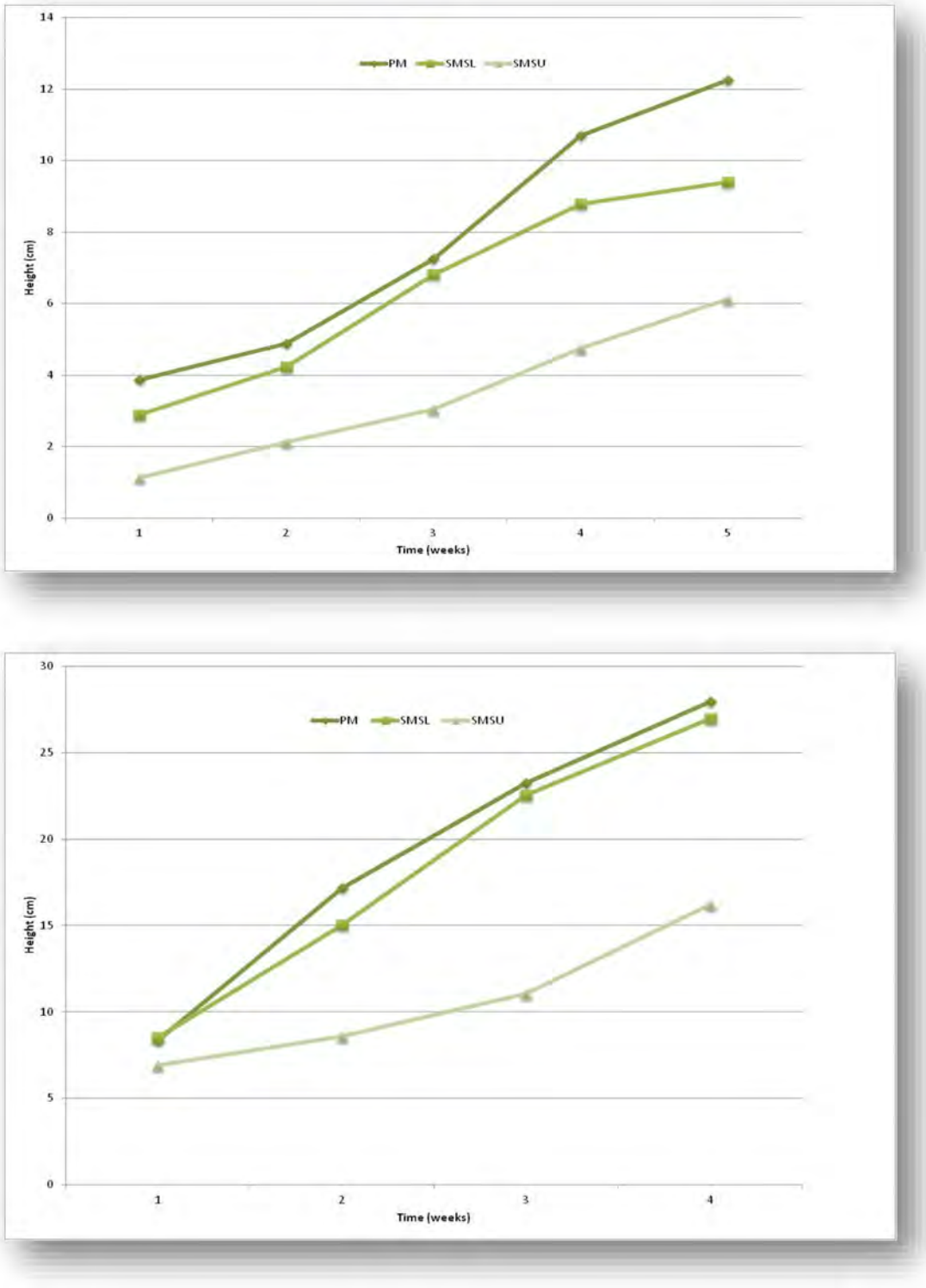

Figure 3. Influence of seedling media on hot pepper (A) and cucumber (B) plant height.

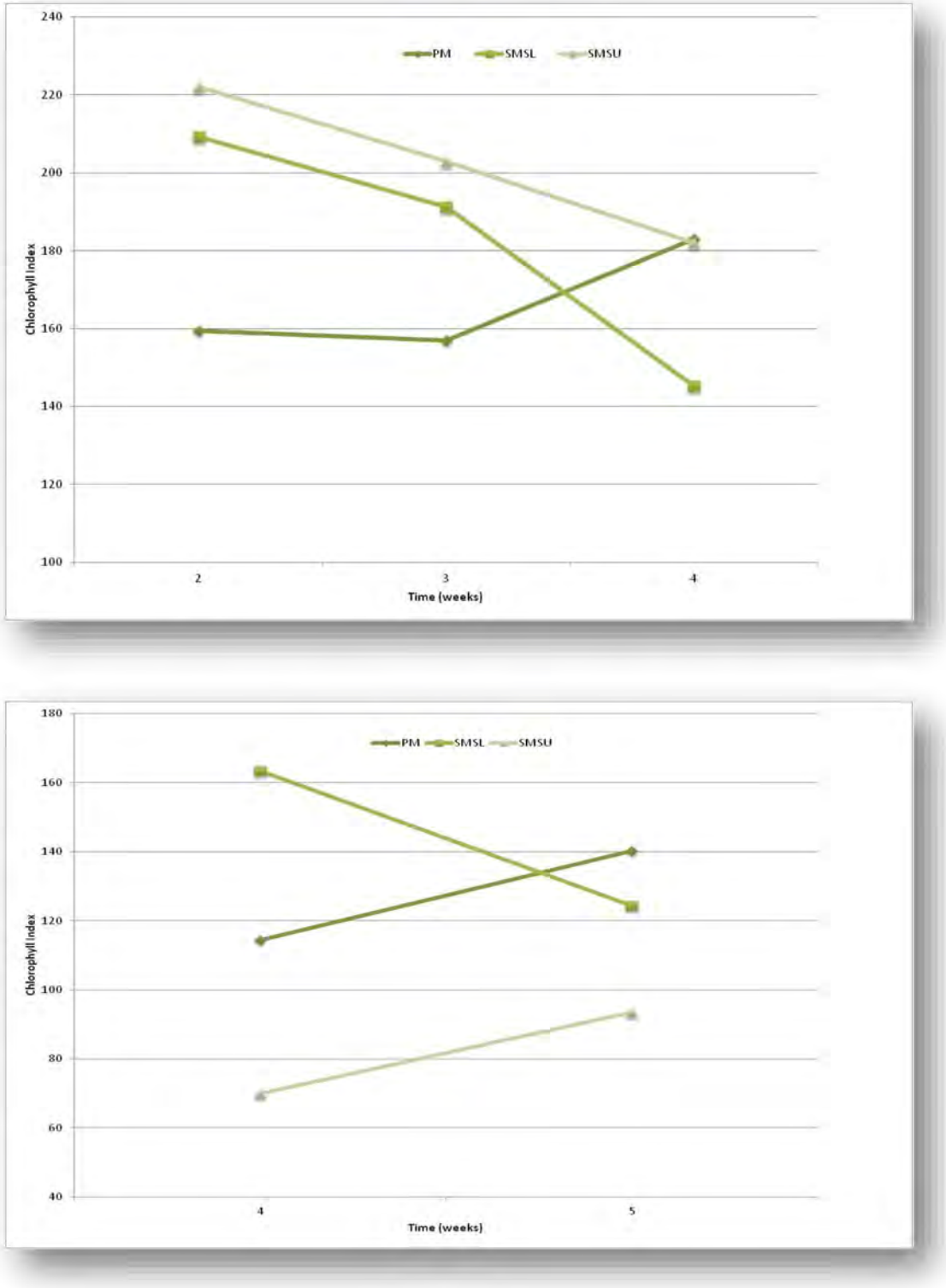

Figure 4. Influence of seedling media on cucumber (A) and hot pepper (HP) chlorophyll index.

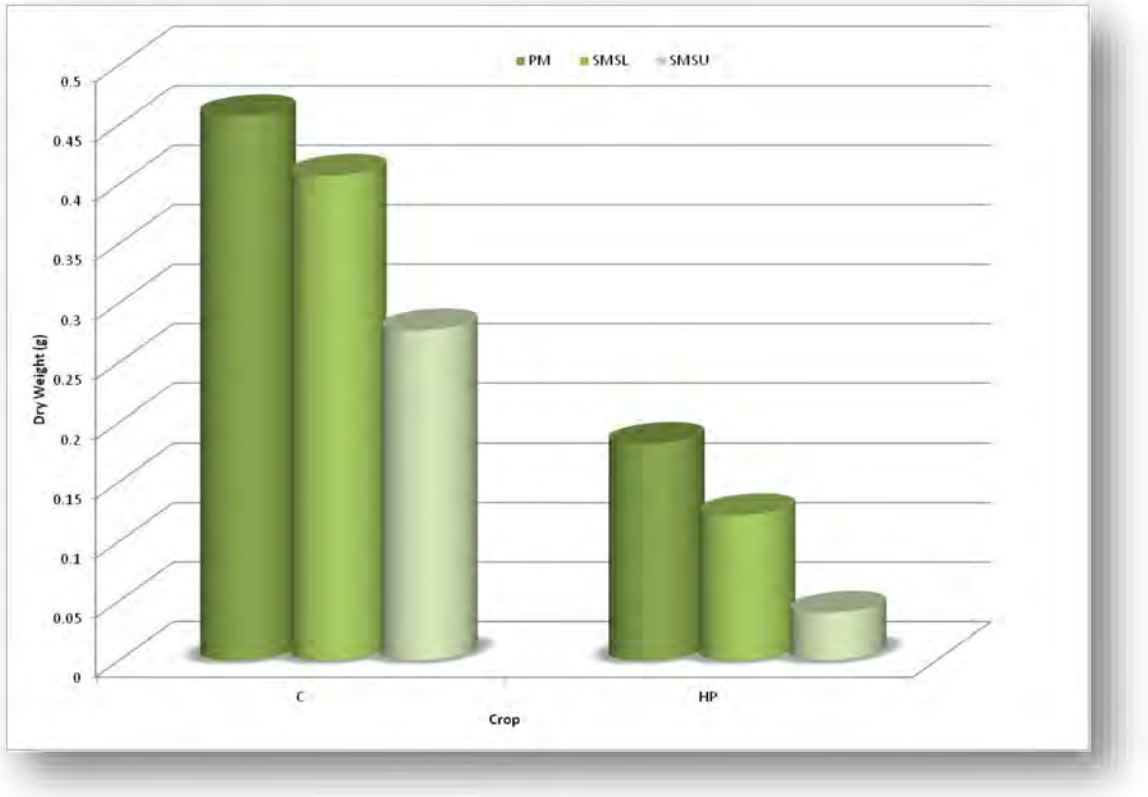

Figure 5. Influence of seedling media on cucumber(C) and hot pepper (HP) dry weight.

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HEAVY METAL TOXICITY ON ANTIOXIDANT ENZYMES, ULTRASTRUCTURE AND EXPRESSION OF HSP70 IN DIFFERENT TISSUES OF *CHANOS CHANOS* (MILK FISH) OFF KAATTUPPALLI ISLAND, SOUTHEAST COAST, INDIA

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ABSTRACT: The impact of heavy metals on the antioxidant enzymes, ultrastructure and expression of HSP70 in different tissues of *Chanos chanos* (Milk fish) was studied. From preliminary observations the distribution of heavy metals was recorded in the following order Fe > Zn > Cu > Pb > Cu> Cd. Sampling sites off Kaattuppalli Island were chosen and designated as polluted and less polluted based on the distribution of heavy metals. Further fish collected from polluted sites showed increasing oxidative enzymes such as Lipid peroxidase, Superoxide dismutase, Catalase, Glutathione peroxidase, Glutathione-S-transferase and Reduced glutathione in gills and liver. Scanning electron micrographs clearly revealed damage within the interfilamental regions and fusion of primary and secondary lamellae as well as complete loss of primary lamellae in the fish collected from polluted sites. Transmission electron microscopic examination of gills showed swelling and enlargement of necrotic cells and more large vacuoles; disintegrated chloride cells were seen. Similarly, hepatocytes in liver showed more electron dense lipid droplets, enlarged nuclei and nuclear membrane damage, detachment of ribosomes from the surface of RER and swollen blood sinus of fish collected from polluted sites. These changes were reflected in the over expression of HSP70 in gills and liver of fish collected from polluted sites, confirmed by Immunofluorescence and Western blotting.

Keywords: Antioxidant, ultrastructure, immunofluorescence, heat shock protein, *Chanos chanos*

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THE PROTECTED AGRICULTURE INFORMATION NETWORK (PAINET): EVALUATION OF CULTURAL PRACTICES FOR INDETERMINATE BELL PEPPER PRODUCTION UNDER PROTECTIVE STRUCTURES IN DOMINICAN REPUBLIC, NICARAGUA, HONDURAS, COSTA RICA, AND EL SALVADOR

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ABSTRACT: The PAINet is a free-of-charge network created to share experiences, research results, and general information on protected agriculture. Bell pepper (*Capsicum annuum*) was chosen as the first model crop for the network because it has become one of the main agricultural commodities for exporting into the U.S. and the European Union from Central America and the Caribbean. To guarantee constant supply and quality, small and medium-size growers use passively-ventilated protective structures like greenhouses and high tunnels. The main goal of those structures is controlling the growing environment, reducing pests, and improving fruit quality and yields. Nevertheless, small and medium-size growers cannot afford using electric or diesel fans and cooling systems to lower temperatures and relative humidity, which causes increased fruit sun-scalding, lowered fruit number and size, and thus increased postharvest losses (as high as 35% in some colored peppers). For this reason, three types of studies were carried out at the participating countries to determine the effects of cultural practices on yield and postharvest quality in indeterminate bell pepper grown under protected environments. These studies included plant spacing, pruning practices, and use of sun protectants. With regards to pruning types, Spanish pruning (no flower removal on each node) and Dutch pruning (only one flower was left per node) were used. Also, one and two stems were compared for Dutch pruning. The collected variables were plant height, marketable and non-marketable fruit number and weight, and fruit postharvest quality. From the preliminary results in the Dominican Republic, marketable and non-marketable fruit number and weight were the highest at 30 cm between plants, whereas the Dutch pruning showed the highest marketable fruit weight and number. For fruit quality traits, the combination of Dutch pruning and 25 cm between plants and the combination of Spanish pruning and 30 cm between plants resulted in the highest fruit weight, length, diameter, and thickness. Another study in the same location dealt with the effects of flower pruning and number of stems on yield and postharvest quality of indeterminate bell. Three pruning levels were used for this experiment: pruning up to the 10th, 15th, and 20th nodes in combination with one and two stems. The number of fruit, fruit yield, and number and weight of non-commercial fruit were the highest for plants with two stems. The combination of one stem and pruning either to the 10th or 15th node resulted in the highest fruit weight, length, diameter and thickness. In Costa Rica, the Spanish pruning had the highest fruit number and total yield. With regards to sun protectants, the use of calcium carbonate reduced losses due to sun scalding from 58% to 6% in Honduras.

Keywords: High tunnels, screen houses, sustainability

Proceedings of the Caribbean Food Crops Society. 48:114. 2012

FUTURE VISION AND INNOVATIVE PILLARS FOR AGRICULTURAL EXTENSION AND AGRICULTURAL POLICY IN SUPPORT OF FOOD SECURITY AND FARMERS' WEALTH IN CARICOM WITH IMPLICATIONS FOR THE AFRICAN, CARIBBEAN AND PACIFIC (ACP) STATES: 2012 TO 2033

Gary Wayne Garcia, The University of the West Indies

ABSTRACT: The objectives of the paper were to present the rationale [the PROBLEMS] for the suggested approach [The 5 PILLARS] for Agriculture Policy, Extension and Food Security, to describe the resources [the RESOURCES] that we have available to us and to describe the five (5) pillars of this suggested approach. The RESOURCES that we now have to build on are (1) the SMALL FARMS: These small farms have been an undervalued resource that can be transformed as (a) they exist and have persisted over the decades without support and investment and (b) they have persisted within the farm families and rural communities; (2) the ACCUMULATED KNOWLEDGE of the World's Agricultural Research, Extension Experiences, Methodologies and Skills developed over the last 150 years or so that have remained mainly within the Universities, Government Departments, Research Institutes and the World Bank Agricultural CGIAR System; and (3) the INTERNET and the "future vision" of the directions that the Internet will now take in facilitating worldwide Education, Communication and Trade. The FIVE [5] PILLARS of the suggested strategy should be [1] Emphasis on improving the production and profitability of the existing Small Farms, [2] Cooperative Farmer Marketing and Local and Regional Product Branding, [3] Linking Agricultural Development Banking and Agricultural Policy to Agricultural Extension, [4] National and Regional Consumer Education, and [5] Efficient use of the Internet in Agricultural Extension in a Future Simulated world. The suggested concluding mantra was:

1) Eat what you grow and produce!
2) Produce and grow what you eat!
3) Agriculture Development must be based on the Local Markets with the Export Markets providing the extra income!
4) Production systems based on the use of sustainable energy!
5) The Tropical Farms must be net producers of Energy!
6) Produce those Food Crops, as much as possible, that can be ratooned or do not have to be replanted each season!
7) Sustainable Food Production Systems should be based on solar radiation and forages!
8) Farmers must be involved in the Value Added Chain, with the farmers focusing on Production and with the support of Local Branding and Collective Marketing!

A practical way forward was suggested and what this would mean for Agricultural Education within the University of the West Indies System was outlined.

Proceedings of the Caribbean Food Crops Society. 48:115-123. 2012

IMPORTANCE OF BREADFRUIT GROWN IN HOME GARDENS IN ST. VINCENT AND THE GRENADINES

Micahel Gloster[1] and Laura B. Roberts-Nkrumah[2], [1]Ministry of Agriculture, St. Vincent and the Grenadines, [2]University of the West Indies, St. Augustine, Trinidad and Tobago

ABSTRACT: St. Vincent was the first recipient of the breadfruit introductions to the Caribbean more than 200 years ago. Since then, the crop has become an important staple that is produced for both the domestic and export markets. The crop is grown both on farms and in home gardens, but there is no information on total levels of production or consumption. A survey was conducted in St. Vincent and the Grenadines in 2009 to determine the level of breadfruit production in home gardens and the contribution to household diets. Data are presented on tree population, germplasm diversity, levels of breadfruit consumption, methods of utilisation and factors influencing consumption. The information provided has implications for the future expansion of the breadfruit industry in St. Vincent and the Grenadines.

Keywords: Home garden, levels of consumption, utilization, germplasm diversity, tree population

INTRODUCTION

Breadfruit [*Artocarpus altilis* (Parkinson) Fosberg] which has been grown throughout the Pacific islands since ancient times (Zerega, Ragone, and Motley 2004, 761) was introduced to the Caribbean by Captain William Bligh in 1793 to enhance food supplies (Powell 1977). St. Vincent was the first recipient of the breadfruit introductions to the Caribbean and today, a sucker of one of the original trees still stands in the Botanic Gardens where the first introductions were planted. In 1993, there was bicentennial celebration of its introduction. Since then, the crop has become an important staple that is produced for both the domestic and export markets. Breadfruit is an important carbohydrate source which has high levels of consumption in St. Vincent and the Grenadines (SVG), it is part of the national dish, and annual breadfruit festivals are held.

Breadfruit is grown for the local market and also for regional and international markets but there are no commercial orchards. All supplies are harvested from home backyard gardens, scattered trees on farm lands, river banks, or marginal lands. Given the emphasis on food security, and the role that breadfruit has played historically, it is important to determine the level of local consumption and the contribution of home garden to supplies for this use. According to the last agricultural census (Agricultural Census 2000, 110) there were 349 farm holdings growing breadfruit for home consumption; however, levels of production from home backyard gardens have not been documented in St. Vincent and the Grenadines.

In 2008, the Ministry of Agriculture, Forestry and Fisheries (MAFF) held a home/backyard garden competition as part of the National Agro-based, Industrial Exhibition (NAIE) to promote food security among home owners. Subsequently, the 2009 Home/Background Gardening Programme was implemented by MAFF in response to the rise in food prices during the year. Since breadfruit is a common plant in Vincentian home gardens, a survey was undertaken to determine the level of breadfruit production in home gardens, and its contribution to household diets.

MATERIALS AND METHODS

A survey was conducted among 57 out of a total of 96 home/backyard gardeners distributed throughout St. Vincent and the Grenadines during the months of June and July 2009. These home/backyard gardeners were actively involved in the Ministry of Agriculture, Forestry and Fisheries home/backyard garden programme and they were selected from the three agricultural regions (Table 1). The island is divided into three Agricultural Regions, which are sub-divided into nine Agricultural Districts. Agricultural Region 1 consists of Districts 1, 2, and 3; Agricultural Region 2 includes Districts 4, 5 and 9; and Agricultural Region 3 includes Districts 6, 7, and 8. A questionnaire was used to collect data from home garden owners (Figure 1).

Table 1: Number of respondents interviewed by Agricultural Regions in St. Vincent and the Grenadines, 2009.

Agricultural Region	No. of Respondents interviewed	Percent
1	17	29.8
2	34	59.6
3	6	10.5
Total	57	100

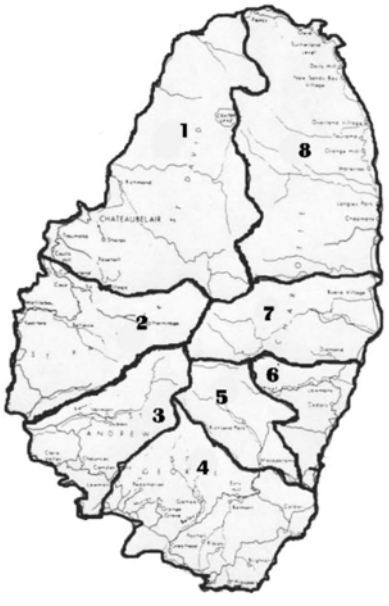

Figure 1: The Agricultural Districts of St. Vincent.

Data were collected on demographics, tree population, germplasm diversity, and levels of consumption. Data were collected by the telephone from participants on the Grenadines islands of Canouan and Bequia, while on Union Island and the mainland, St. Vincent, interviews were conducted during home visits. Coding of the questionnaire was done for easy entry of the data. The data were then entered and summarized in Microsoft Excel 2007 and analyzed by using SPSS Computer Software.

RESULTS

1. Demographics of respondents

Among respondents, 63% were female and 37% were male. The household size of 53% of the gardeners was three to six persons, while 19% had households with less than three persons, and 14% had household with seven to 12 persons. There were no households with more than 12 persons. Figure 1 shows household size and number in all Regions.

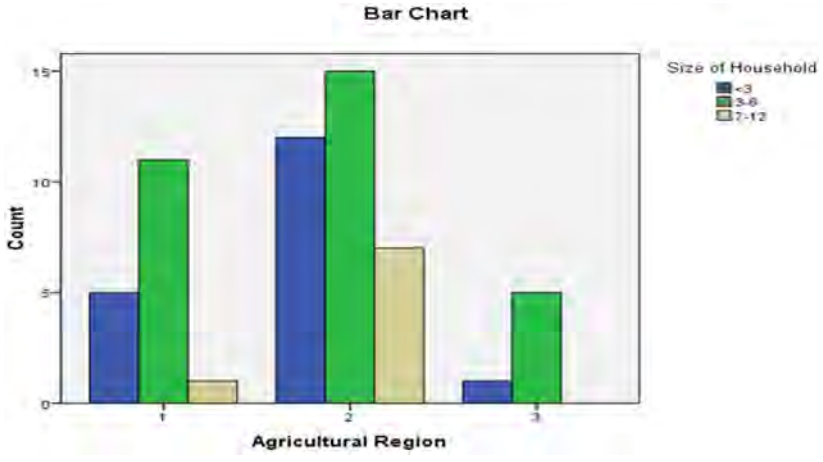

Figure 1: Size of household per Agricultural Regions.

There was little difference in the property status of home/backyard gardener in St. Vincent and the Grenadines, with 83% of respondents being property owners, 12% relatives of the property owners, and only 5% were tenants. None of the respondents were relatives of tenants (Figure 2).

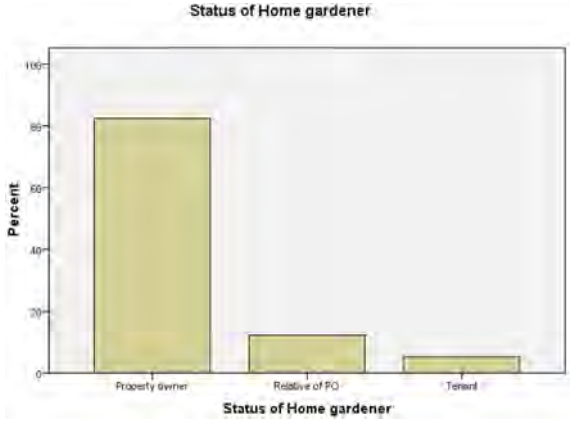

Figure 2: Ownership status of home gardeners.

2. Number of breadfruit trees in home gardens

The number of breadfruit trees in home gardens varied among respondents with 61% reporting that they had no trees in the garden, 23 % had one tree, 14% had two to five trees, and 2% had more than five trees. Among Agricultural Regions, 60% of respondents with no trees were in Agricultural Region 2 with the least in Agricultural Region 3, 14%. Agricultural Region 1 had the highest amount of respondents with one tree, 54%, whereas Agricultural Region 3 had none (Figure 3).

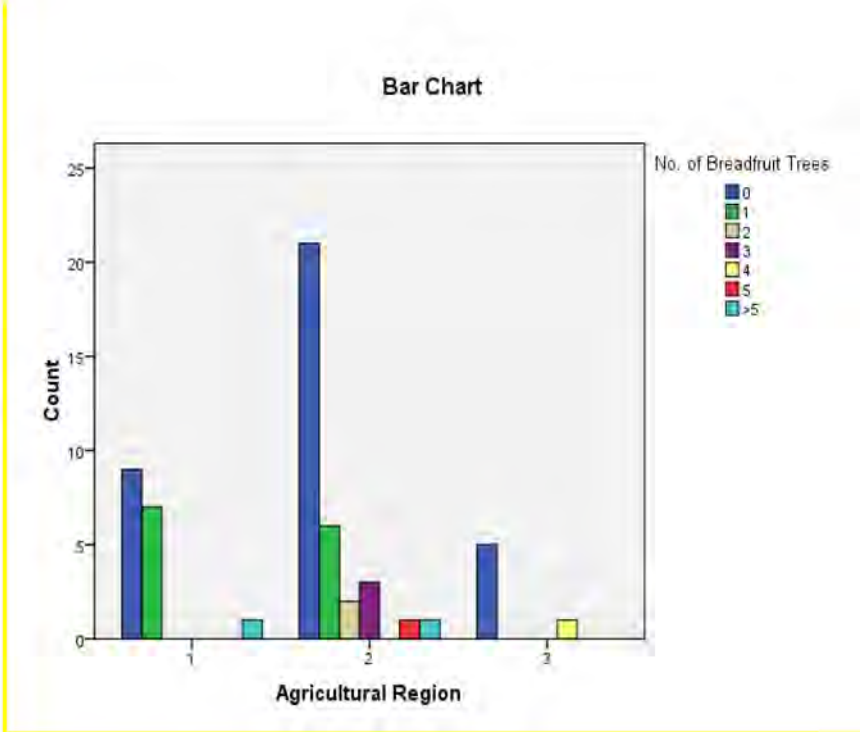

Figure 3: Number of breadfruit trees in home gardens in St. Vincent and the Grenadines.

Among those who had no trees, 63% indicated they would like to have a tree whereas 37% did not want a tree (Figure 4).

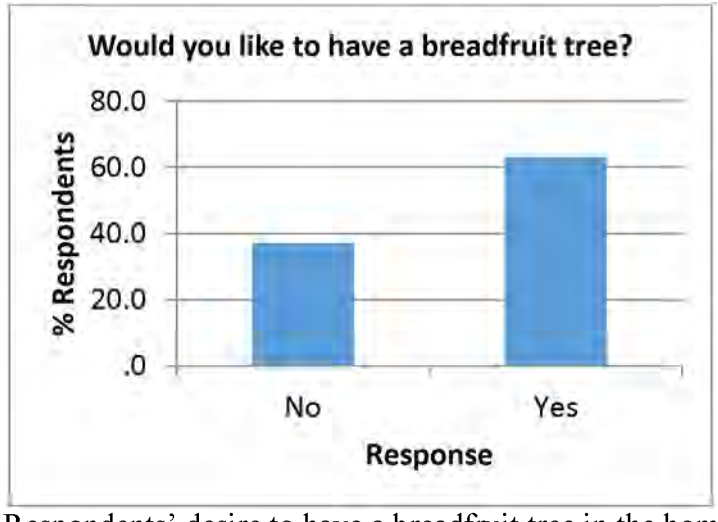

Figure 4: Respondents' desire to have a breadfruit tree in the home garden.

Among those who did not want a tree, the most common reasons were inadequate space (40%), tree size (20%), the tree causes damage to houses (13%), and they already had trees on their farms (13%) (Figure 5).

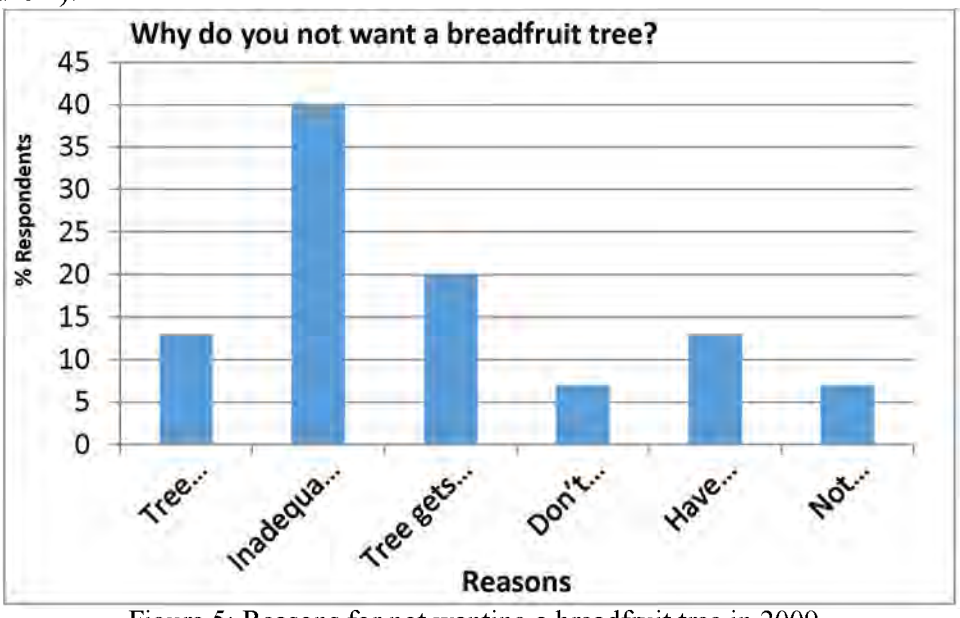

Figure 5: Reasons for not wanting a breadfruit tree in 2009.

3. Germplasm diversity in home gardens

'Creole/Common' was the most prevalent breadfruit variety in home gardens since it was reported by 80% of the respondents with breadfruit trees, whereas 'Kashee', 'Dessert', and 'Cocobread' were the less common. Other varieties reported by home gardeners included 'White Bread', and 'Captain Bligh' (Figure 6).

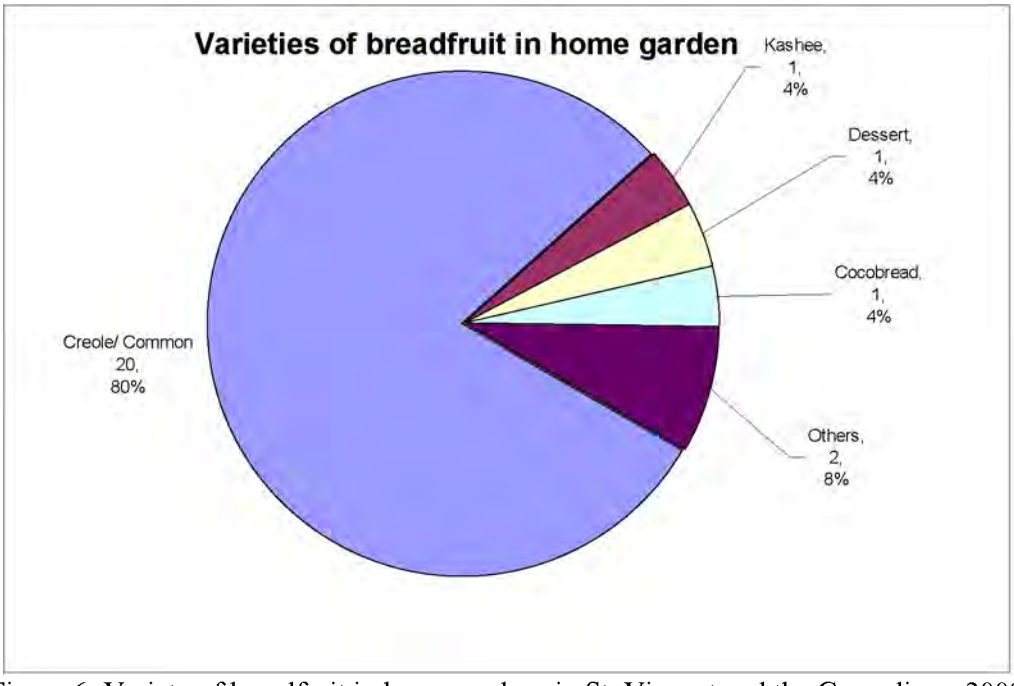

Figure 6: Variety of breadfruit in home gardens in St. Vincent and the Grenadines, 2009.

Among respondents with more than two breadfruit trees, 67% indicated they had no favourite varieties, whereas 37% indicated that they preferred 'Creole/Common' (Figure 6). Within agricultural districts, only respondents in Districts 3 and 9 indicated that they had no favourite variety, whereas those in District 3 indicated Creole/Common (Figure 6).

4. Consumption of breadfruit

Breadfruit was consumed in all households of the home gardeners. Breadfruit was consumed most commonly at the main meals, especially for lunch (36 %) whereas it was not commonly consumed as a snack (Figure 7).

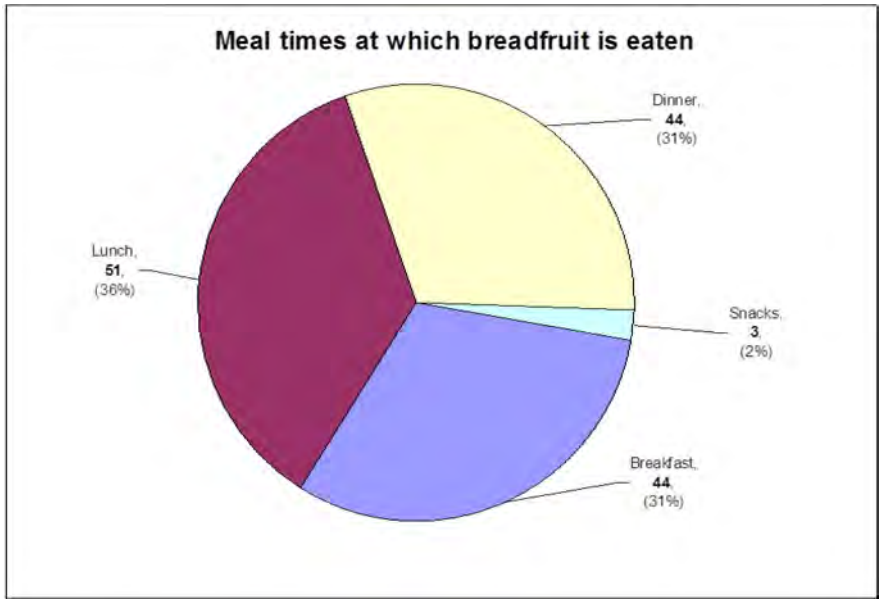

Figure 7: Meals at which breadfruit is eaten by respondents in households, 2009.

Among respondents with breadfruit trees, breadfruit was harvested from home gardens mainly for home consumption, as gifts for or for sale (Figure 8). An average of five to six fruits with a mean weight of 1.4 kg (3 lb) per fruit was harvested weekly from each home garden. Fruits are harvested 12 months of the year, with August being the main month and February the least productive (Figure 9). Therefore, approximately 92.4 kg (203 lb) (66 fruit) was harvested annually from home gardens and with 39% for home consumption and a mean household size of four persons, the estimated annual per capita consumption was 9 kg.

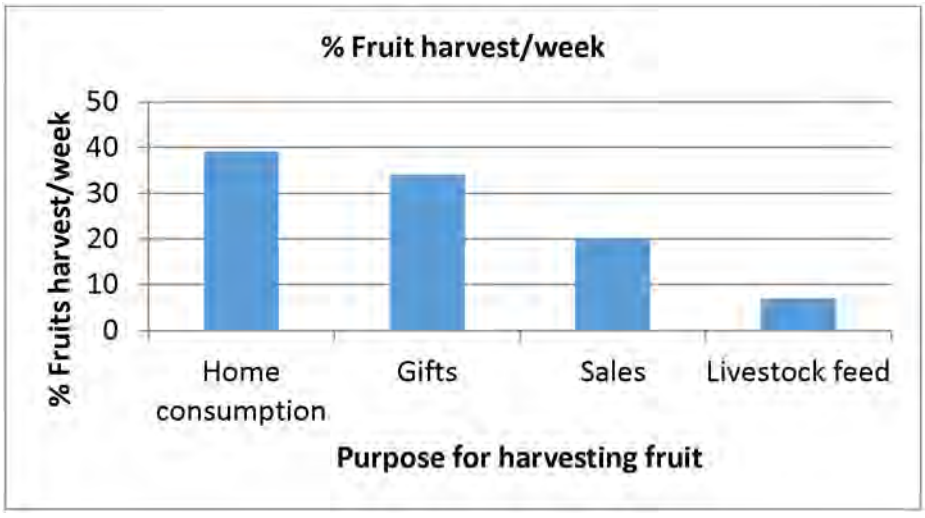

Figure 8: Purpose for harvesting breadfruit.

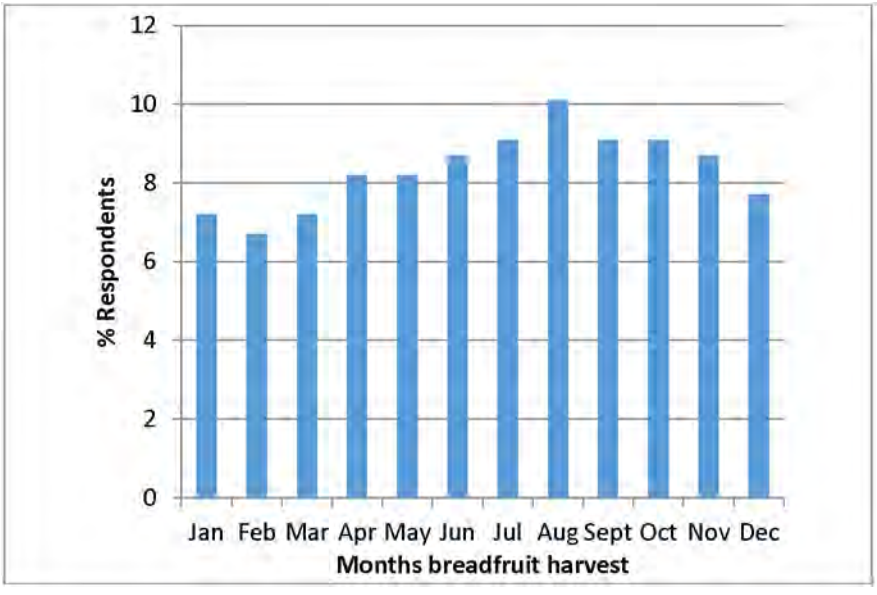

Figure 9: Months during which breadfruit is harvested from home/gardens.

DISCUSSION

The results from the survey showed that with regards to demographics the number of home/backyard gardens is well distributed throughout the three Agricultural Regions and nine Agricultural Districts in St. Vincent and the Grenadines. Most of these home/backyard gardeners are found in Agricultural Region 2, Region 1, and Region 3, respectively.

Size of household was not large, with most having three to six, and fewer than three persons. There was no household with more than 12 persons. This finding was similar throughout Agricultural Regions and Districts.

Regarding sex, most respondents were females, with the highest proportions in Agricultural Regions 2 and 3, respectively. This findingmay have been because of men being the main provider in the household, worked outside the home, whereas the women worked at home. This supports the Agricultural Census 2000, which reports a ratio of male to female agricultural holders of 72% to 28%, respectively. Most home gardens were on owner-occupied or family-owned properties. Lack of property ownership might be related to the absence of breadfruit trees in home gardens.

The major factors which seemed to influence the presence of breadfruit trees in home gardens were the availability of environmental conditions suitable for breadfruit growth and development, the availability of adequate space and access to fruit from trees owned by the respondents but growing elsewhere. Tree population in home gardens was quite variable among respondents, most of whom had no breadfruit trees in their home gardens. These were mainly respondents who were living in The Grenadines, where the very low rainfall and poor soil conditions do not meet the requirements for breadfruit growth. Most of these respondents would like to have a tree. For respondents whom did not have and did not want a tree, tree size in relation to the size of the garden appeared to be the main limitation, whereas other respondents had alternative access to fruit from trees on their farms.

Among gardeners with breadfruit trees, most had one tree, and this may have been mainly because of inadequate space, and tree size, which may have limited the ability to accommodate more than one breadfruit tree. Additionally, tree populations also varied greatly among agricultural regions. Agricultural Region 1, which is located on the leeward side of the island, had the most respondents with one tree. This may have been influenced by lower rainfall pattern and less fertile soil. In contrast, most respondents with two or more trees were in Agricultural Region 2, which has the best soil and climatic conditions for breadfruit production, whereas Agricultural Region 3 had the least. These results were similar to those reported in the Agricultural Census (2000), which showed that 42.3%, 36.2%, and 21.4% of holdings reporting breadfruit trees were in Agricultural Regions 2, 1, and 3, respectively.

Knowledge of breadfruit variety in home gardens among respondents was limited, even though Roberts-Nkrumah (1996) had previously reported that 25 varietal names were used in St. Vincent to identify 22 specimens. These specimens showed differences in tree and leaf morphology, and in external and internal features of the fruit; differences in eating quality were also described by local informants. In this survey, among respondents with two or more varieties, there was favorite or varietal preference as was reported in Trinidad by Roberts-Nkrumah and Badrie (2004). For those who had a preference, 'Creole'/'Common' was the favourite. This preference was similar in all Agricultural Regions and Districts, and this variety seems to be the same as the 'Yellow' breadfruit which was reported by Roberts-Nkrumah (1996) as the favourite throughout the Caribbean.

The appreciation of breadfruit as a food crop was very high because it was eaten in all households, and at all major meals. Similarly, in Trinidad, Roberts-Nkrumah and Badrie (2004, 271) reported that breadfruit had the status of a highly appreciated staple among its consumers, and most ate breadfruit at lunch and dinner. These are two major factors for promotion of breadfruit production in St. Vincent and the Grenadines, because they indicate a high demand and available local market for the fruits.

In terms of level of consumption, approximately five to six breadfruits are harvested for home consumption weekly. However, Agricultural Census (2000) reports only 27% of holdings with breadfruit use it for home consumption, whereas 73% was sold. Fruits for consumption are available throughout the year, and there is no seasonality in production, even though the number of fruits harvested per week is lowest during the driest period. Annually, 180 to 216 lb of fruits may be harvested from each home garden. This has potential for food security both for the households with trees and those which receive fruit as gifts or through purchase. Breadfruit in home gardens can also enhance food security because they are also a source of income to the home. Therefore, breadfruit is a good alternative for Irish potatoes, which is a major imported carbohydrate source in St. Vincent and the Grenadines.

CONCLUSIONS

Breadfruit is a crop of significant importance with potential for food security, generation of income, and consumption on St.Vincent and the Grenadines. The fruit which is well-appreciated by Vincentians, is available year round. There is no preference for any specific variety. Although breadfruit is generally well distributed on mainland St. Vincent, there is a shortage of trees in The Grenadines, especially the southern Grenadines. However, home backyard gardening can play an important role in genetic conservation and production of breadfruit; therefore, this should be encouraged. Research will have to be done to address some of the constraints to growing breadfruit in home gardens. Also, the Ministry of Agriculture will have to play a role in promoting and developing a structured programme with incentives and support for the establishment of breadfruit in areas in which they can grow but their presence in home gardens is low.

ACKNOWLEDGEMENTS

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REFERENCES

Central Planning Division. 2001. St. Vincent and The Grenadines Population and Housing Census Report

Ministry of Agriculture, Lands, and Fisheries. 2002. Agricultural Census 2000.

Powell, D. 1977. *The Voyage of the Plant Nursery, HNS Providence, 1791 – 1793. Econ. Bot.* 31: 387-431.

Roberts-Nkrumah, Laura. B., and Neela Badrie (2004) Breadfruit Consumption, Cooking Methods and Cultivar Preference Among Consumers in Trinidad, West Indies. *Food Quality and Preference* 16: 267-274.

Roberts-Nkrumah, Laura B.1996. Towards a Description of the Breadfruit Germplasm in St. Vincent. Fruits vol. (52): 27-35.

Zerega, Nyree, J. C., Diane Ragone, and Timothy J. Motley. 2004. "Complex Origins of Breadfruit (*Artocarpus altilis* Moraceae): Implications for Human Migrations in Oceania." *American Journal of Botany* 91(5): 760-766.

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ASSESSMENT AND CHARACTERIZATION OF DAMAGE BY HURRICANE TOMAS TO MAJOR TREE CROPS WITH SPECIAL EMPHASIS ON BREADFRUIT (*ARTOCARPUS ALTILIS*) AND BREADNUT (*ARTOCARPUS CAMANSI*) IN ST. LUCIA AND ST. VINCENT AND THE GRENADINES

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ABSTRACT: Tree crops are an important component in the agro-ecosystem of some Caribbean territories for food and income-generation. However, there has been no assessment of the nature of the damage caused to these crops by hurricanes to which the region is prone. In November 2010, a reconnaissance survey was conducted on 44 holdings in St. Lucia and in St. Vincent and the Grenadines (SVG) following the passage of hurricane Tomas in October 2010 to assess and characterise the damage done to major fruit tree crops with special emphasis on the food crops, breadfruit and breadnut. Damage ranged from slight branch breakage and defoliation to complete uprooting of breadfruit, breadnut, nutmeg, cocoa, citrus, avocado, coconut and mango. Nutmeg appeared to be the most susceptible species and mango the least susceptible to wind damage. Breadfruit appeared to be more susceptible than breadnut, especially to the most severe types of damage. Severity of damage might be partially due to morphological features such as dense canopies and shallow root systems with production systems, management practices and site characteristics as possible contributory factors. The findings from this survey suggest the need for further research to improve approaches to characterisation and assessment of wind damage on tree crops and to develop suitable management strategies to minimise the effects of wind stress.

Keywords: home gardens, production systems, consumption, tree morphology, pruning, site characteristics

INTRODUCTION

The Caribbean lies in the hurricane belt, therefore, it has a history of being affected annually by this weather phenomenon. Hurricane activities vary greatly throughout the region in frequency and intensity, with the more northerly islands experiencing more storms than those in the south (Haites et al. 2002, and Piekle et al. 2003). Locations south of 10° N latitude are generally considered to have less than a 1% chance of being affected by hurricanes whereas coastal communities north of 10° N latitude are at a much higher risk (Piekle et al. 2003). The Windward Islands are just north of this latitude and experience major storms that devastate homes, physical infrastructure, and agriculture. Between 1980 and 1990, five tropical storm systems of varying intensity affected St. Vincent and the Grenadines, but none of these storms were direct hits (National Environmental Advisory Board and Ministry of Health and the Environment, 2000 and Haites et al. 2002), while St. Lucia, Dominica and Grenada also individually experienced serious storms throughout 1990 to 2007 (Hurricane City 2012). It is predicted that climate change will cause more frequent storms of greater intensities (Haites et al. 2002 and Bueno et al. 2008).

Hurricanes have a major impact on agriculture, a significant pillar of socio-economic development in the Caribbean, because it is climate-dependent and vulnerable to natural disasters. Apart from banana, tree crop-based industries are among the most vulnerable agricultural enterprises and

could experience complete devastation from a single hurricane. In 2004, Hurricane Ivan destroyed over 85% of Grenada's nutmeg (*Myristica fragrans*) crop which threatened to wipe out the entire industry (European Union all ACP commodities programme Caribbean region, 2010). Other major fruit tree crops in the Caribbean include mango (*Mangifera indica*), cocoa (*Theobroma cacao*), avocado (*Persea americana*), coconut (*Cocos nucifera*), ackee (*Blighia sapida*), citrus (*Citrus* spp.), breadfruit (*Artocarpus altilis*), and breadnut (*Artocarpus camansi*). Although breadfruit is more widely utilized than breadnut in the region, both are considered underutilized food crops based on their potential to contribute to the food security. Additionally, while cocoa and nutmeg are traditional export crops, breadfruit and breadnut, with the other tree crops, are among the non-traditional export crops which are important for agricultural diversification.

Hurricane Tomas, the 19th named storm and 12th hurricane of the 2010 Atlantic hurricane season, affected several islands of the Caribbean from 29th October to early November (Hurricane City 2012). Tomas brought winds of up to 207.2 km h^{-1} (80 mph), more than 25 cm (10") of rain and surges of 0.3 to 0.9 m (1 to 3') above normal tide levels (Hurricane City 2012). Hurricane Tomas passed just south of St Lucia and just north of St. Vincent and the Grenadines on Saturday October 30th resulting in loss of lives and significant damage to homes and crops, including tree crops with breadfruit trees reported to have been particularly affected. Crane et al. (1994, 22) reported that the response to hurricane damage varied among fruit tree species and even among cultivars of a single species. Although tree crops are important in the Caribbean, the effects of hurricane on them have not yet been reported. Therefore, this study was undertaken to provide preliminary information on the nature of damage caused by Hurricane Tomas and some factors associated with vulnerability to damage among tree crops in the region, with special reference to breadfruit and breadnut.

MATERIALS AND METHODS

From November 11 to 16, 2010 a reconnaissance survey was conducted in the islands of St. Lucia and St. Vincent and the Grenadines following the passage of Hurricane Tomas. The study was conducted in locations which were accessible by road after the hurricane. A questionnaire was directly administered to 44 respondents across the islands. The sample of respondents was selected based on accessibility and willingness to participate in the study. All respondents were required to satisfy at least one of the following criteria - home owners with fruit tree(s) in back yard; land owners with fruit trees and farmers who cultivates fruit trees.

Respondents were asked about the species of fruit trees growing on their property, types of damage caused by Hurricane Tomas and management of the trees prior to the hurricane. Observations were made on trees owned or managed by respondents and on those that were growing along roadways, gullies and other locations. Direct observations made on damaged trees included the level of damage to the foliage, main branches and trunk, and tree anchorage. The respondents were also asked about the purpose for which they grew breadfruit and breadnut. Information was also collected on site characteristics.

RESULTS

Species and number of damaged trees

Data were collected on 2070 trees from 44 locations across the islands of St. Lucia and St. Vincent and the Grenadines. Eight fruit tree species, breadfruit, breadnut, cocoa, avocado, mango, citrus, nutmeg and coconut were identified by respondents among the damaged trees. Cocoa was the most abundant species in the survey with 1760 trees, followed by breadfruit with 222 (Table 1).

Table 1: Species and number of damaged trees identified in the survey

Fruit Tree Species	Number
Cocoa	1760
Breadfruit	222
Breadnut	19
Citrus	19
Mango	15
Avocado	14
Coconut	11
Nutmeg	10

The trees of each species were not randomly distributed. For example, although cocoa was the most abundant tree in the survey, this species occurred at only three locations and most of the trees were grown on a single large farm. In contrast, all the respondents in the survey owned, managed or produced at least one breadfruit tree and some also had breadnut trees.

Types of damage

Six types of damage were observed in the survey and all tree crops were affected by at least five types of damage. The extent to which each type of damage affected the trees varied between species. Cocoa and nutmeg were the only two species in which defoliation/fruit loss/slight branch breakage was not the leading type of damage (Figure 1). Moderate branch breakage and severe branch breakage were the next most frequent types of damage in most species, especially in cocoa. All species had uprooted trees, with partial uprooting ranging from 20% in nutmeg to 6.7% in mango. Breadfruit and breadnut experienced 12.6% and 10.5%, partial uprooting respectively. Nutmeg (30.6%) and breadfruit (17.6%) appeared to be the two most vulnerable species to complete uprooting. No mango tree was affected by complete uprooting suggesting that it was the least vulnerable to this type of damage and was followed by breadnut (5.3%), avocado (7.1%) and coconut (9.1%).

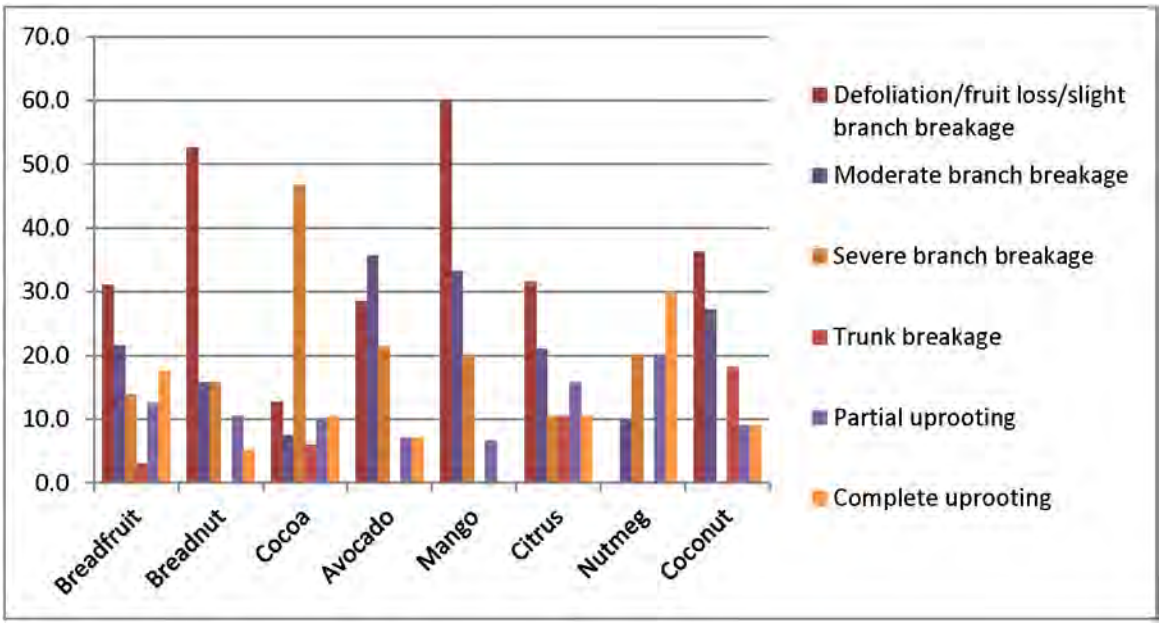

Figure 1: The percentage of trees damaged by type of damage

Purpose for growing breadfruit and breadnut

Breadfruit and breadnut were both used as food at home and sold by 69% of the respondents. Among respondents 21% use these crops only for home consumption, and 10% only for sale. Therefore, 90% of respondents grew breadfruit and breadnut as food for home consumption whereas 79% also sold fruits (Figure 2).

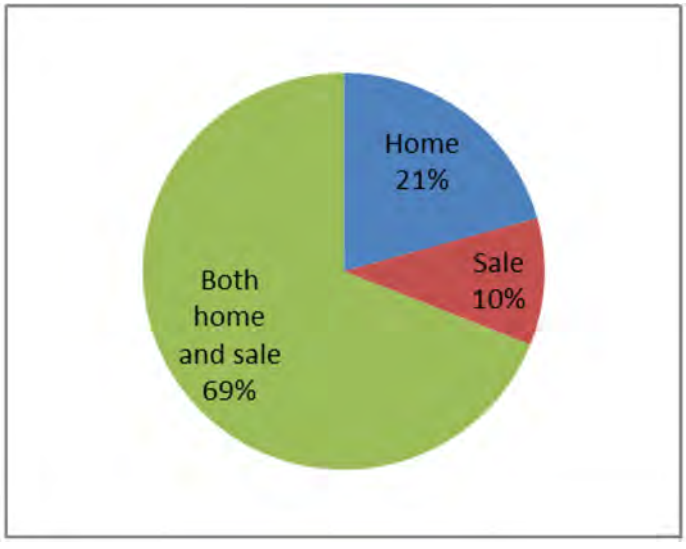

Figure 2. Purpose for growing breadfruit and breadnut

Breadfuit and breadnut production system and tree management

No pure stand production system was reported for breadfruit or breadnut. Backyard production, which was reported by 34.1% of the respondents, was the dominant production system, followed by border crop (25%) and mixed cropping with tree crop (15%) (Figure 3). Only 14% of respondents did some form of pruning in the last year before the hurricane.

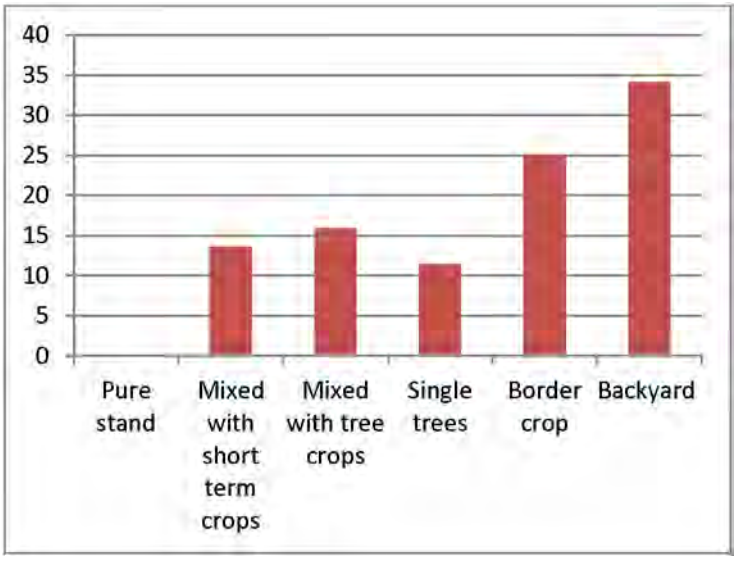

Figure 3: Production systems for breadfruit and breadnut

Site characteristics

Of the sites visited during the survey 63.6% were moderate to steeply sloping, and 68.2% were exposed. Moderately sloping and exposed, and flat to gently sloping and exposed sites each accounted for 27.3% of the sites, whereas 13.6% of the total number of sites was steeply sloping and exposed. Among the sheltered sites, 15.9% was moderately sloping, followed by flat to gently sloping 9.1% and steeply sloping 6.8% (Figure 4).

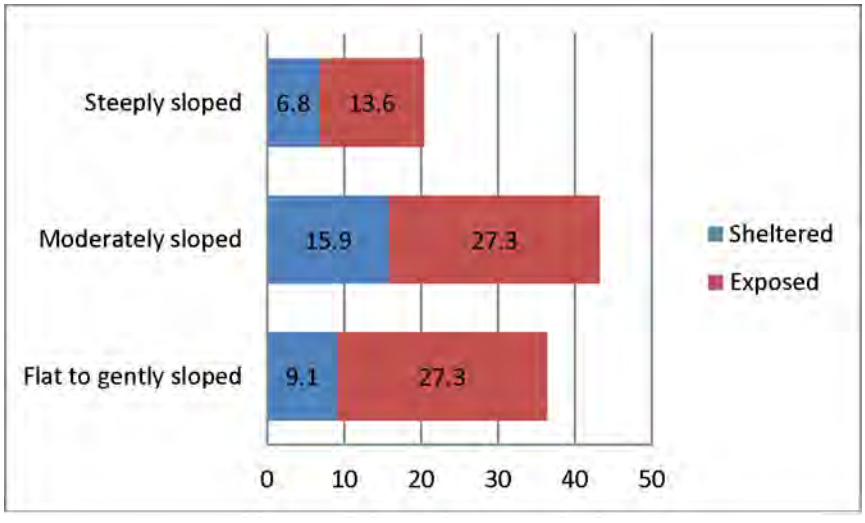

Figure 4. Site characteristics

DISCUSSION

In this reconnaissance, eight species of fruit trees were identified among the tree crops that were damaged by Hurricane Tomas in St. Lucia and in St. Vincent and the Grenadines. All eight species were vulnerable to hurricane damage but the types of damage varied. Duryea et al. (1996) and Crane et al. (1994) found that species responses to hurricane winds were associated with morphological features including size, canopy architecture and plant root system. These plant-related characteristics seem to have influenced the species' responses in this study, but the production systems, and site features could have exacerbated the severity of damage in species such as breadfruit.

Nutmeg showed greatest vulnerability to complete uprooting, followed by breadfruit, a feature which could be linked to their relatively shallow root systems and large, dense canopies. The marked difference between breadfruit and breadnut in this type of damage could also be explained partially by the typically denser canopy on breadfruit trees (Roberts-Nkrumah, 2004). Dense canopies present more resistance to the passage of wind than open canopies; therefore, they are more susceptible to wind damage. Crane et al. (1994) showed the effectiveness of tree height reduction by pruning as a protective measure against hurricane damage. Pruning could be used both for canopy height reduction and for thinning. The results showed that pruning was not a common practice among the farmers and homeowners in this survey. However, during the hurricane, defoliation and branch breakage due to the brittleness of breadfruit and breadnut wood could have acted as a type of pruning which reduced the risk of toppling in both of these species compared with nutmeg.

Another factor that could account for the relatively greater susceptibility of breadfruit than breadnut to wind damage is the difference in their root systems. The incidence of complete toppling was the second lowest in breadnut, after mango. Breadnut trees grown from seedlings with a tap root system which should offer better support to wind- stressed trees. On the other hand, breadfruit cultivars in the Caribbean are seedless; therefore, they are propagated by vegetative methods which lead to the development of a shallow adventitious root system. This root system would be less able to support a tree with a tall, dense canopy when subjected to severe wind stress. While most species experience defoliation and slight branch breakage, trunk breakage in coconut was mostly likely related to its top-heavy trunk, which would have allowed the entire wind load to be concentrated at the top of the tree and led to snapping of the trunk.

Among the farmers and homeowners interviewed in this study, both breadfruit and breadnut, two closely related species, were grown as food crops, primarily for home consumption but also for sale by a large proportion of respondents. Breadfruit is an important carbohydrate staple especially in St. Vincent (Gloster and Roberts-Nkrumah. 2012), while breadnut is used as a vegetable protein source (Roberts-Nkrumah 2005; Graham and Negron de Bravo 1981). Given these important roles of food and income which are both critical to food and nutrition security, it is necessary to devise strategies to protect these two species and other useful or economically important tree crops from hurricane damage.

Many sites on which the trees were grown were exposed to wind and a significant proportion was also on sloping land, two conditions that would encourage hurricane damage. Given that a high percentage of the land in both countries is sloping, and that many farmers would not have access

to land in sheltered sites, the only other measures that could be taken to minimize damage from hurricane strength winds would be the use of windbreaks and timely pruning to control tree height. In the Caribbean, tree crops are grown mainly in backyard gardens, mixed fruit orchards and, on a limited scale, in single fruit orchards (Francis 2001). The production systems used by the respondents suggested that, with the exception of cocoa, for most of the other species, including breadfruit and breadnut, a few trees were grown on farms and in backyards without any protection from wind, which would also contribute to tree damage by hurricanes.

CONCLUSION

The results of this study suggest species differences in susceptibility to wind damage due to hurricanes. Both plant and management factors might contribute to this susceptibility and should be further investigated. This need exists especially for tree crops that are important as sources of food and income, such as breadfruit and breadnut, but it is also important to elucidate in other useful tree crops, particularly those that are of economic importance. The relatively lower level of damage evident in mango trees observed in this study supports the traditional recommendations for its use for windbreaks.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance and support of the following groups. The United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC) and the Ministries of Agriculture of St. Lucia and of St. Vincent and the Grenadines for providing ground transportation and logistical support throughout the survey. The Department of Food Production, Faculty of Food and Agriculture of The University of the West Indies for providing financial support. Sincerest gratitude is also extended to all respondents for participating in the survey.

REFERENCES

Brokaw, Nicholas V. L., Lawrence R. Walker. 1991. "Summary of the Effects of Caribbean Hurricanes on Vegetation." *Biotropica* 23(4a): 442-447.

Brooks, J. R. 1946. "Hurricane Damage to Commercial Fruit Trees in Dade County." *Proceedings of Florida State Horticulture Society 59:149-151.*

Bueno, Ramón, Cornella Herzfeld, Elizabeth A. Stanton, Frank Ackerman. 2008. "The Caribbean and Climate Change: The Cost for Inaction." Stockholm Environment Institute—US Center Global Development and Environment Institute, Tufts University.

Crane, Jonathan, Carlos Balerdi, Richard Campbell, Carl Campbell and Seymour Goldweber. 1994. "Managing Fruit Orchards to Minimize Hurricane Damage." Hortechnology Jan/Mar.

Duryea, Mary L., George M. Blakesiee, William G. Hubbard, Ricardo A. Vasquez. 1996. "Wind and Trees: A survey of Homeowners after Hurricane Andrew." *Journal of Arboriculture* 22(1).

European Union all ACP Commodities Programme Caribbean Region. 2010. "Grenada Nutmeg Sector Strategy." St. Georges, Grenada.

Francis, Judith. 2001. "The Fruit Industry in the Caribbean Production, Processing, Marketing and Future Prospects." *COMUNIICA, Año* 5, N°16, 2001, p. 48-59.

Gloster, Michael, Laura Roberts-Nkrumah. 2012. "The importance of breadfruit grown in home gardens in St. Vincent and the Grenadines" Working Paper, Faculty of Food and Agriculture, The University of the West Indies.

Graham, Horace, Edna Negon de Bravo. 2006. "Composition of the Breadfruit." *Journal of Food Science* 46(2).

Haites, Erik, Dennis Pantin, Marlene Attzs, James Bruce, and Jamie MacKinnon. 2002. "Assessment of the Economic Impact of Climate Change on CARICOM Countries."Margaree Consultants.

Hurricane City. 2012. History of Hurricanes in the Lesser Antilles. Accessed December 17, 2012. http://www.hurricanecity.com/

Mississippi State University Extension Service. 2010. "Repairing Storm-damaged Shade, Ornamental, and Fruit Trees."

National Environmental Advisory Board and Ministry of Health and the Environment. 2000. "Initial National Communication on Climate Change; St. Vincent and the Grenadines."

Piekle, Roger A., Jose Rubiera, Christopher Landsea, Mario L. Fernandez, Roberta Klein. 2003. "Hurricane Vulnerability in Latin America and the Caribbean: Normalized Damage and Loss Potentials." *Natural Hazards Review* (August).

Roberts-Nkrumah, Laura. 2004. "Management Implications of the Distribution of Fruit Set on Breadfruit (*Aartocarpus altilis*) Trees. *Acta Hort. (ISHS)* 632:201-207

Roberts-Nkrumah, Laura. 2005. "Fruit and Seed Yields in Chataigne (*Artocarpus camansi* Blanco) in Trinidad and Tobago." *Fruits* 60(6)

Schmale, Matthias, Bekele Geleta. 2010. International Federation of the Red Cross and Red Crescent Societies. Emergency Appeal: Caribbean; Hurricane Tomas

Terrelonge, Sophia C. 2007. "Sustainable Development and Climate Change in the Caribbean." Department of Economics. The University of the West Indies, Mona Campus

The United Nation Development Programme (UNDP) Barbados and Organization of the Eastern Caribbean states (OECS). 2007. "Post-disaster Early Recovery in a Caribbean Small Island the Case of Hurricane Ivan in Grenada (2004): Best Practices and Lessons Learned."

The World Bank, 2005. Latin America and the Caribbean Risk Management Unit. "Grenada: A Nation Rebuilding: An Assessment of Reconstruction and Economic Recovery one year after Hurricane Ivan."

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EFFECT OF INDOLE-3-BUTYRIC ACID ON THE PROPAGATION OF GUAVA (*PSIDIUM GUAJAVA* L.) BY STEM CUTTINGS

Alicia Parris, Rajendra P. Maurya, Jeff Chandler, Francis Lopez, The University of the West Indies, and Edme Henry, Soil Conservation Unit, Ministry of Agriculture, Barbados

ABSTRACT: A study was conducted at the Soil Conservation Unit, Haggatts, St. Andrew, Barbados, in May – July, 2011, to investigate the effects of Indole-3-Butyric Acid (IBA) on the propagation of guava using different types of stem cuttings. Planting materials were collected from a local cultivar of fully grown mature, vigorous, healthy, disease-free tree from the fruit orchard at Haggatts. The experiment was laid out as a split-plot Randomized Block Design with five different concentrations of the rooting hormone (0, 1500, 2000, 2500, and 3000 ppm IBA) and three types of stem cuttings (softwood, semi-hardwood and hardwood). The basal end of each cutting was wounded and immersed in the desired strength of the growth hormones for 20 minutes. After treatment, the cuttings were planted in propagation bins in a 'Promix' growing medium under mist-house conditions. The maximum sprouting (34.2%), maximum number of leaves (3.17), maximum number of shoots (1.50) and longest shoot length were observed in the treatment of 2000 ppm of the hardwood cuttings. In general, the hardwood cuttings performed better over semi hardwood and softwood cuttings. The results of the present study have some potential for multiplication of true-to-type plants and can be beneficial for fruit growers and nurserymen.

Keywords: Guava, stem cutting, Indole-3-butyric acid, promix

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AN INVESTIGATION INTO THE CAUSES OF A REDUCTION IN THE PRODUCTION OF SPECIFIC AGRICULTURAL CROPS (CITRUS, TANNIA AND AVOCADO) IN DOMINICA

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ABSTRACT: For decades, the agricultural sector of most CARICOM states produced primarily banana, sugar and rice for export to European markets. Agricultural diversification was promoted during the last three decades through regional and national organizations as a means of broadening the income base of farming enterprises. The island of Dominica is no exception and today the agricultural sector continues to contribute to foreign exchange earnings, employment and GDP. However, over the last two decades the banana industry, the biggest contributor to agricultural GDP experienced accelerated deterioration due to the removal of preferential market access by the European Union. Concurrent to these developments, there was a resurgence of diversification efforts through the Ministry of Agriculture between 1995 and 2005. Farmers were again encouraged to invest in other agricultural commodities among them citrus, tannia and avocadoes. However, production and trade data between 1990 and 2010 show a gradual reduction in the production of banana and of critical importance, reductions were also evident in the production of citrus, tannia and avocado. A clear relationship can be established between the collapse of the banana industry and loss of the colonial premium. However, commodities such as citrus, tannia and avocado which have experienced relatively secure regional markets through the huckster trade have also experienced a similar decline. This parallel decline of banana and these other commodities has reduced Dominica's agricultural GDP. In this regard, research was conducted to identify the cause of current reductions in production of citrus, tannia and avocado in Dominica. The research proposed a causal hypothesis that the reduction in banana production resulted in a reduction in production of the other crops despite diversification efforts that recommended them as a replacement for banana. The study found that the proposed hypothesis was accepted and highlighted that abandonment of mixed farming systems, deterioration of infrastructure (Packing facilities and Feeder Roads) and a decline in chemical input supplies provided by the banana industry were the primary reason for decreased levels of production in other commodities.

Keywords: Agricultural diversification, GDP, Dominica, Banana, Preferential Market Access, Colonial Premium

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CULTURAL PRACTICES FOR TOMATO, BELL PEPPER, AND STRAWBERRY PRODUCTION UNDER PROTECTED CULTURE IN FLORIDA

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ABSTRACT: Previous and current work has illustrated the advantages of protected agriculture in Florida for crop diversification and yield earliness, water use, and soilless culture to avoid fumigation. Studies were conducted to assess the performance of strawberry, tomato, and bell pepper under high tunnels and screen houses in west-central Florida. In strawberry, three cultivars were planted in open fields and high tunnels and the data indicated that early and total yield increased by 35% and 57%, respectively, in the high tunnels compared to that in the open fields. For tomato, high tunnels provided an opportunity to produce the crop earlier than under field conditions due to the protection against cold weather. Similarly, the crop outperformed open field production during the warm months of the year when managed in soilless media. In bell pepper, the response to different soilless media and container types was studied in a screen house. The media used were pine bark, coconut coir, perlite, and potting mix combined with boxes (19 L/plant), bags (8 L/plant), and pots (8 L/plant). Results showed no interaction among factors for early yield with treatments filled with pine bark, coconut coir, and potting mix having the highest early yields. There was no yield difference among plots planted in different container types. The use of high tunnels and screen houses in Florida might benefit growers by: a) improving earliness and providing a competitive edge in the market; b) minimal use of sprinkler irrigation for freeze protection, hence reducing fruit damage and fuel or electricity costs of water pumping; c) decreased incidence of foliar and fruit diseases, which are disseminated by rain drops, leading to less fungicide applications; and d) opportunity for alternative production systems, such as intense intercropping and soilless culture to reduce fumigation practices.

Keywords: High tunnels, screen houses, protected agriculture, sustainability

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EFFECTS OF BOTANICAL NEMATICIDES (AZADIRACHTIN AND *ALLIUM SATIVUM* L. EXTRACTS) ON BANANA PLANTS INFESTED WITH *RADOPHOLUS SIMILIS*

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ABSTRACT: Banana is severely affected by the root-burrowing nematode, *Radopholus similis,* which reduces yields by more than 50%, lengthens the time to fruiting and decreases the productive life of fields. Traditional controls for *R. similis* are expensive and many useful nematicides are prohibited because of fair trade agreements. Two botanical compounds displaying nematicidal activities, Azadirachtin (Neem X) and *Allium sativum* L. extracts (Garland), were used as alternative nematicides and their efficacy at reducing nematode density and preventing banana yield losses were determined. From the results, reductions in *R. similis* density in the roots and soil were significantly greater in plants treated with the synthetic nematicide, Mocap (96.4% and 92.6%) than those treated with Neem X (50.4% and 25.2%) and Garland (23.9% and 37.3%). The results also indicate that banana yields were comparable in both the synthetic and botanical nematicides. The advantages of using botanical nematicides and their effects on banana production in Windward Islands are discussed.

Keywords: *Allium sativum* L., Azadirachtin, *Musa* sp., *Radopholus similis*

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THE DEMAND AND PROSPECTIVE OF AGRICULTURAL HIGHER EDUCATION IN THE CARIBBEAN

Lydia Ori and Henry R. Ori, University of Suriname

ABSTRACT: The vital contribution of agricultural research to rapid expansion of food and agricultural production in developing countries has been long recognized. More recently, it has been seen that agricultural research can and must also play a key role in ensuring that increases in production are obtained in a manner that does not damage the environment, and thus jeopardize future production potential. In February 2008, The Inter American Development Bank (IADB) and the Caribbean Council of Higher Education in agriculture (CACHE) signed an agreement which formalized a grant of a non-reimbursable technical cooperation. This grant allowed CACHE to implement a study of the capacities and specializations of the human resources in the agricultural sector of five participating Caribbean countries: Barbados, Dominican Republic, Guyana, Suriname and Trinidad and Tobago. The goal of this project was to improve the competiveness of the regional agricultural sector required in a globalized environment while taking advantage of the existing diversified human resources of the five participating countries. However, the emphasis of this study is placed on assessing the demand and prospective of agricultural higher education in Guyana and Suriname. The sample population included staff agricultural institutions in Guyana and in Suriname. A two-part questionnaire was designed and validated by an expert panel. The survey design consisted of demographic data and questions on work experiences in agriculture. The second part included questions concerning competencies needed for their agricultural activities. The respondents were asked to rate each question on a four-point likert scale. In the demographic part of the questionnaire open ended questions were used. Results indicated that in Guyana and Suriname: (1) several research staff are lacking skills/knowledge in various subjects/fields in agriculture; (2) capacity building in graduate training is needed in several disciplines, including biotechnology, business and technology, mycology, animal production, forest conservation, agro-forestry, protected cultivation, sustainable agriculture, organic farming, virology, soil physics, field trial statistics, marketing and plant-insect interactions; (3) More women should be selected and accommodated for training and careers in the agricultural sector; (4) The HRM department at the Universities of Guyana and Suriname should promote development of people and competency, and enable better service for staff departments and faculty members, and should develop a strong HRM strategy to guarantee a competent and skilled agricultural sector. Overall recommendations included the (1) establishment of a National Selection Committee on institutional strengthening and capacity building in the Agricultural Sector; (2) Development of a HRM policy and use instruments (development, appraisal, incentives, coaching, etc.) for the agricultural sector;(3) Establishment of a Ph.D. master class where young scholars will be prepared for several Ph.D. stages; and (4) Promotion of management development in the agricultural sector (policy makers, researchers, extension professionals and NGO's).

Keywords: CACHE, Capacity Building, Agricultural Education

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LA METODOLOGÍA CAMPESINO-A-CAMPESINO APLICADA A UN PROYECTO DE DESARROLLO COMUNITARIO PARTICIPATIVO EN DESSOURCES, HAITÍ

Georges F. Félix y Andrea Pérez, Silent Grace Foundation, Puerto Rico

RESUMEN: La Fundación Silent Grace de Puerto Rico está llevando a cabo una serie de proyectos que contribuyen al desarrollo comunitario participativo en una comunidad haitiana. La comunidad de Dessources expresó la agricultura como una necesidad de alta prioridad que se extiende a corto, mediano y largo plazo para construir la soberanía alimentaria a nivel local. La agroecología como paradigma para la producción de alimentos con la menor cantidad de insumos externos es la vía a la soberanía alimentaria y económica de pequeños agricultores. Al observar los ecosistemas naturales y aplicar los conceptos básicos de la ecología a la agricultura, podremos desarrollar sistemas de producción adaptados a la región que respeten las técnicas, preferencias y prácticas locales, siendo designado el modelo de extensión agrícola Campesino a campesino (CAC) sobre el del extensionismo clásico de los centros de investigación. La metodología CAC se establece en cinco pasos: (1) diagnóstico participativo, (2) intercambio de experiencias entre facilitadores y agricultores, (3) entrenamiento de promotores en agroecología, (4) difusión de las prácticas agroecológicas por parte de los promotores, y (5) monitoreo y evaluación mediante indicadores de sostenibilidad escogidos de manera participativa. Hasta la fecha la Fundación Silent Grace ha logrado completar satisfactoriamente los primeros dos de estos cinco pasos y se apresta para culminar el tercer paso durante un viaje de campo en 2012. Entre los resultados preliminares que se han obtenido se pueden mencionar la identificación de tres tipos de agricultores en función de la tenencia de la tierra, a saber, aquellos que poseen un terreno propio y lo cultivan, aquellos que no tienen título de propiedad pero ocupan un predio para producir alimento, y aquellos que no poseen tierra pero trabajan en el predio de otro propietario al cual le rinden parte de la cosecha. También se realizó un inventario de la diversidad de plantas útiles en los jardines de la comunidad y se identificaron las mujeres como principales utilizadoras y manejadoras de los espacios caseros como fuente de alimento, condimentos y medicinas. Por esta razón el entrenamiento de promotores en agroecología será facilitado en equidad de género (50% mujeres/50% hombres) a un grupo de líderes comunitarios dispuestos y comprometidos con el proyecto de soberanía alimentaria colectivo. Por último, y a medida que se adelanta en la producción agroecológica de alimentos en la comunidad, se irán desarrollando indicadores de sostenibilidad de manera participativa que ayuden a definir, evaluar y monitorear el éxito del proyecto agrícola de Silent Grace en Dessources según la perspectiva de los propios miembros de la localidad. La transparencia en la documentación del proyecto permite que cualquier persona particular, investigador u organización pueda entender y apreciar la evolución del proceso de conversión agroecológico en este particular estudio de caso de manera que se pueda rendir aplicable a proyectos de desarrollo y/o investigaciones similares en Haití o la región caribeña.

Palabras claves: Desarrollo comunitario participativo, Metodología campesino a campesino, Agroecología, Haití

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UTILISATION DE PLANTES DE COUVERTURE POUR LE CONTROLE DES ADVENTICES EN VERGER A LA MARTINIQUE

Christian Lavigne, CIRAD, Martinique

RÉSUMÉ : Introduction. A la Martinique, la pression de l'agriculture sur l'environnement est forte et se manifeste par une pollution chimique importante des sols et des eaux de surface comme de profondeur. Les résidus d'herbicides, notamment de glyphosate, constituent une part importante des pesticides retrouvés. L'érosion des sols est également une préoccupation majeure des acteurs de la filière agricole. Une des perspectives les plus prometteuses pour la protection de l'environnement consiste à associer aux vergers une couverture du sol vivante et pérenne. Cette couverture doit être facilement contrôlée, malgré les conditions climatiques tropicales humides qui ont un effet favorable, en permanence, sur la croissance des adventices. La couverture herbacée, composée d'espèces choisies, devra répondre à un cahier des charges établi avec la participation des producteurs de fruits. On recherchera une vitesse importante de recouvrement du sol afin que les espèces sélectionnées s'établissent avant les adventices, une hauteur maximale atteinte inférieure à une trentaine de centimètres pour permettre une circulation aisée de la main d'œuvre et des véhicules, une facilité de fauchage mécanique en raison de la topographie généralement difficile des vergers de l'île. Matériel et Méthodes. Nous avons évalué 20 espèces maintenues en culture pure sans adventices, choisies parmi les Poacées et les Fabacées, sur leur capacité à couvrir le sol, leur production de biomasse aérienne et racinaire, leur hauteur maximale atteinte et leur capacité à tolérer un entretien par fauchage. L'expérimentation a été réalisée sur un sol brun rouille à halloysite. La pluviométrie moyenne est de 2500 mm par an, avec une saison sèche peu marquée. Résultats. Les espèces évaluées couvrent une large gamme de traits fonctionnels qui permettent d'obtenir des connaissances génériques sur la relation entre la plante de couverture et l'arbre. L'évolution du pourcentage de recouvrement du sol montre que certaines des espèces testées, légumineuses comme graminées, atteignent un recouvrement du sol de 85 à 100 % environ 9 semaines après plantation. La hauteur en fin de croissance varie de 20 à 250 cm. Les biomasses aérienne et racinaire varient de 2 à 50 T de matière fraîche par ha. Certaines espèces ne montrent aucune repousse après un fauchage et sont écartées. Conclusions. Quelques espèces présentent les qualités recherchées, sans toutefois les posséder toutes. Les graminées à port nain telles que *Paspalum notatum* cv. Pensacola apparaissent les plus indiquées, avec la réserve de la concurrence potentielle exercée à l'encontre des arbres par un système racinaire puissant. La légumineuse *Neonotonia wightii* cv. Cooper est également une bonne candidate, mais elle est plus lente à s'installer et relativement volubile. Perspectives. L'idéal recherché est une couverture herbacée pluri-spécifique, qui serait composée d'un mélange incluant à la fois une ou plusieurs graminées gazonnantes et une ou plusieurs légumineuses non volubiles et capables d'une fixation symbiotique de l'azote. Les travaux à venir évalueront le comportement d'une telle strate herbacée. Les espèces seront choisies dans la flore locale de légumineuses et de graminées indigènes ou naturalisées pour éliminer les risques de plantes invasives.

Mots-clés **:** verger, tropical, herbicide, enherbement, légumineuses, graminées

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LE RICA, UN DISPOSITIF EUROPEEN DE SUIVI TECHNICO-ECONOMIQUE DES EXPLOITATIONS AGRICOLES EN COURS D'IMPLANTATION AUX ANTILLES FRANÇAISES

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RÉSUMÉ : Le concept du Réseau d'Information Comptable Agricole (RICA) date de 1965 et sa mise ne œuvre remonte à 1968 dans les états membres de la Communauté Economique Européenne de l'époque. Il s'agit aujourd'hui d'une enquête effectuée par les états membres de l'Union européenne. Les services chargés dans l'Union de gérer le RICA collectent chaque année des données comptables à partir d'un échantillon d'exploitations agricoles situées dans l'Union européenne. Dérivé des enquêtes nationales, le RICA est la seule source de données micro-économiques harmonisées, les principes comptables étant les mêmes dans l'ensemble des pays. Les exploitations sont sélectionnées, en fonction d'un plan d'échantillonnage établi pour chaque région de l'Union, pour participer à l'enquête. La méthodologie utilisée vise à fournir des données représentatives selon trois critères: la région, la classe de dimension économique (CDEX) et l'orientation technico-économique (OTEX). Le RICA ne couvre toutefois pas l'ensemble des exploitations agricoles de l'Union mais uniquement celles ayant une dimension suffisante pour pouvoir être considérées comme professionnelles. Si l'Espagne et le Portugal ont intégré leurs régions ultrapériphériques (RUP) dans le RICA dès leur intégration à l'Union européenne en 1986 (les Canaries, les Açores et Madère), ce n'est qu'à partir de 2003 que la France va être sollicitée par l'Union pour intégrer ses RUP dans le dispositif. Depuis 2009, des tests de faisabilité du RICA ont été entrepris notamment aux Antilles françaises pour une entrée officielle de ces régions dans le RICA européen, envisagée à l'horizon 2012. Cette perspective a nécessité quelques adaptations pour prendre en compte un tissu d'exploitations agricoles de CDEX en moyenne inférieure à ce qu'on retrouve sur le continent européen. Ces adaptations ne peuvent s'effectuer qu'à la marge, le dispositif devant demeurer homogène sur l'ensemble du territoire de l'Union. Toutefois le passage à un environnement agricole tropical a obligé à prendre en compte une nouvelle nomenclature de produits. Les comptabilités disponibles pour les catégories d'exploitations agricoles visées sont moins nombreuses et relativement moins précises compte tenu de la diversité productive plus fréquente au sein des exploitations sur ces territoires insulaires. Même si la méthodologie est aujourd'hui rodée et précise, la mise en place du RICA dans ces conditions très spécifiques requiert vraisemblablement d'un appui scientifique et de moyens d'enquêtes complémentaires tel que cela a été le cas durant de nombreuses années suite à sa mise en place initiale en France, de façon à ce que l'outil joue pleinement son rôle d'aide à la décision à l'échelle du territoire. Enfin à travers cette extension du RICA aux Antilles françaises, c'est la construction d'une expertise européenne de réseau d'information comptable agricole qui s'opère en contexte tropical et insulaire. Celle-ci pourra demain être un savoir-faire valorisable dans le bassin caribéen voire à l'égard de nos partenaires d'Amérique tropicale.

Mots-clés : Agriculture, Union Européenne, Guadeloupe, Comptabilité agricole, suivi technico-économique

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FARMERS' PERCEPTIONS ON SELECTED SOCIO-ECONOMIC AND AGRICULTURAL PRODUCTION ASPECTS AND THEIR RELATION WITH THE AGRICULTURAL EXTENSION SERVICE IN SURINAME

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ABSTRACT: The government of Suriname has prioritized development of sustainable agricultural production in Suriname, especially in the rural areas, and has integrated the millennium development goals in their strategies and policy vision (Van Eeckhout, 2008). Policymakers, scientists and entrepreneurs (including farmers) are convinced that the agricultural sector in Commewijne has potential to assist Suriname in realization of the millennium goals in 2015 so that poverty will be reduced in communities in Commewijne, and sustainable agricultural activities must play an important role in the development of this district. To get an overall view of the farmers' perspective on the socio-economic problems, the quality of the Agricultural Extension service, and the bottlenecks with regard to all aspects of agricultural production, a base line agricultural survey was developed, modified and validated by a panel of experts. With this instrument one hundred farmers were interviewed in Commewijne and the data was analyzed using SPSS statistics. Findings revealed the following problems: (1) drinking water is a problem for many farmers in this district; (2) the standard of living is low; (3) shortage of water in the dry season; (4) excessive water on the agricultural soils in rainy periods; and (5) high price fluctuations for agricultural products. Findings also reveal that farmers are experiencing problems with: (1) pest and disease management; (2) farm bookkeeping; and (3) insufficient technical information about plant cultivation, and crop protection. Furthermore, farmers felt that the information from field extension staff was insufficient with regard to pesticide education, fertilization, good agricultural practices, integrated pest management (IPM) and with irrigation and drainage aspects. Recommendations include training for farmers in: GAP, FFS, weed knowledge and weed control, farm bookkeeping and farm administration, pesticide education and pesticide control, fertilizer education and fertilizer deficiencies of crops, and use of sustainable cultivation systems (mulching, compost, IPM, etc.). Furthermore, recommendations also include training of the field extension staff on technical aspects of agricultural production.

INTRODUCTION

Commewijne is one of eleven districts of Suriname. The district is situated on the right banks of the Suriname River, and to the east of Paramaribo. Commewijne borders on the north to the Atlantic Ocean. To the west it borders the districts of Marowijne and Wanica; and to the South district Para and to the east the district of Marowijne. The capital is New Amsterdam. Commewijne is the third most populated district in Suriname. The coastal area in Commewijneis is intensively cultivated. Matapica is a very important nature reservation. The population of this district is about 25.088 inwoners (2006). Commewijne has a land area of 2353 km^2 which is less than 2% of Suriname's total land area (van Eeckhout, 2008).

Climate

There are four climate seasons in the district in Commewijne as is the case in all the other districts in Suriname. The seasons include the big and small dry seasons and the big and small rainy seasons. The average temperature over the whole year is 27^0 C. The relative humidity in Commewijne is not different from that of the rest of the coastal area of Suriname. In the dry period, the relative humidity lies between 75 to 80% and in the rainy season between 80 to 85%. The relative sunshine fluctuates in the dry season from 65 and 75% and in the rainy period between 45 and 50%. The average relative sunshine is 58%. The average wind force over the whole year is 1.2 on the scale of Beaufort. The average yearly rainfall fluctuates from 2200 to 2300 mm.

Common Soils in Commewijne

Commewijne is one of the oldest cultural areas of Suriname. It is situated in the Young coastal zone area, and the fertile clay was also the reason that Commewijne was known as the largest district with big plantation agriculture. This is also why this plantation agriculture has maintained itself the longest. In the district, there are sand-clay-and swamp soils. However, the majority portion of Commewijne consists of clay, followed by swamp and sand. Along the East-West Connection, more sandy-soils are situated.

Irrigation and Drainage systems in Commewijne

The drainage system in Commewijne has been deteriorating throughout the years. This deterioration is caused mostly by the lack of maintenance and lack of expansion. In addition, there are some problems with the functionality of the system. The causes of malfunction include:

1. The drainage and irrigation systems are poorly maintained, resulting in great crop losses, waterlogging, soil salinity or water shortages.
2. No proper divided system for agricultural- or urban use.
3. The spatial planning in Commewijne is inadequate and not divided in different land-uses. Throughout the years, more people are living in Commewijne and a part of Commewijne has been slowly developed into a town.
4. Farmlands are very scattered over the district of Commewijne. There are some parts of concentration of farmers, but even then the distances are great. This makes it difficult to organize farmers, give them access to information, access to markets and proper working drainage systems.
5. The cooperation between the farmers is very difficult; that is why the drainage system as a polder-model; polder model is when everyone is working together to benefit each other. It is not a success. Problems with soil salinity, especially during the dry season, when there is a shortage in water.

Socio-economic situation in Commewijne

There are also aquaculture activities on a small and midsize scale. The majority of the economic activities are taking place at the East-West connection and the banks of the Suriname and Commewijne rivers. Aside from aquaculture, fisheries and agriculture, Commewijne has also some wood sawmills for furniture factories. In the last few years, tourism has become important in this district, due to the building of the bridge over the Suriname River.

Agricultural Extension Status in Suriname

In Suriname, extension work started around 1935 by individual institutions. The scope of these services was very limited due to lack of technicians, equipment and poor communication. In 1956, the Ministry of Agriculture (MOA) established the division for Agricultural Extension. For organizational purposes the country has been divided into three regions: Region East, Region Central and Region West. Each region has a regional coordinator and resort-and rayon leaders. In the 1960s and 70s the Extension Service was in full operation.

Since 2004, the Farmers Field School (FFS) and the Good Agricultural Practices (GAP) approaches are being used as a tool to increase farmer's knowledge and skills in the various subjects. Resort leaders and sub-resort leaders generally have leadership at extension activities within the region or the resort. In the past, this position was meant only for people with minimal Community College training in agricultural sciences (Ori and Ori, 2011).

The main tasks of an Extension Agent at the MoA include:

1. Transfer of appropriate agriculture technology and related information to the farmer.
2. Collecting statistics on crops, land, animals, fruits and vegetables for statistical purposes.
3. Training farmers on the principles and concepts of GAP, and monitoring agricultural activities of farmers (trace back system, etc).

Communications with agricultural producers usually take place through the radio or newsletter but have an incidental character. Visits to farmers do not take place that often because of budget limitations. There is no compensation for the use of private transport and there are no incentives to extension personnel for visiting the farmer's field. It happens that the agricultural producers contact the extension agents when needed. Since the introduction of Good Agricultural Practices (GAP) and Farmers' Field Schools (FFS), the communication with farmers has been intensified since 2003 (Agricultural Sector Plan, 2006).

Training in GAP

In February 2003 a project was being financed by a loan of the IDB in the frame of the Agricultural Health and Food Safety Program. Since this program was implemented, the farms of the producers have been registered and information of their cultivated crops has been submitted on a regular basis to the MoA. Emphasis has been placed on registration of the amount and usage of chemicals on a specific, by LVV designed form. A computer program then processes this information, so that the specialists at the MoA get information on the type, the amount and the frequency of use of chemicals used on planted crops. The ultimate goal of the program has been to provide safe food production. The objective of the FFS is to provide active agricultural producers with more knowledge about the ecology and "Integrated Crop and Pest Management" (Agricultural Sector Plan, 2006).

Research Methodology

The sample population involved in this study consisted of 100 farmers in Commewijne engaged in agricultural production in various parts of Commewijne. Farmers were identified from a list of contact farmers provided by the MoA and the "Stichting SAV" (Foundation Women in Agriculture) in cooperation with the Extension Service of the MOA in Suriname. It was required that selected farmers were actively involved in some aspect of agricultural production.

This study was conducted as a descriptive survey. The questionnaire was designed, and developed by the researchers keeping in mind the job requirements for the farmer. A validation panel was used to validate the questionnaires. It was tested for reliability and validity.

Members of these similar populations had served as panelists during the validation process. Comments from the validation panelists were incorporated in the questionnaires before interviewing the target population.

Data was collected by using a questionnaire for each farmer respectively. Questionnaires were organized and administrated by trained enumerators. Follow-up procedures included e-mails and telephone calls to the respondents. Each questionnaire was coded. Categories were developed for the open ended questions of the instrument.

Descriptive statistics such as percentages and frequency counts were applied to measure some of the variables. The data was analyzed based on their relationship to one of the specific objectives of the study. The data was analyzed using computer software Statistical Package for Social Sciences (SPSS) and Microsoft Excel.

RESEARCH FINDINGS

Demographics

From the data, it can be concluded that the majority of farmers are older than 40 years. The number of men and female participants who were engaged in agriculture was the same in the Hulp, Welbedacht en Nieuwzorg. However, more male farmers were engaged in agriculture in Tamaredjo and Alkmaar. Survey results reveal that the majority of farmers in Tamaredjo and Alkmaar were javenese while there were more creole farmers living in Nieuwzorgweg and Sinabo. Land area of most farmers varied from 1-3 ha. Because income from agriculture is limited or uncertain, farmers prefer to get other jobs to get a fixed income. This is the reason why most farmers are labeled as part time farmers. They work on an average of 3-3.5 hours a day in agriculture on their land while full timers work for 6-6.5 hours a day in their fields. The survey also revealed that there are more full-time farmers in Welbedacht, Commewijne, De Hulp, Sinaba en Nieuw Zorg than in Alkmaar and Tamaredjo.

Both full-time and part-time farmers worked only with their family on the farm. Usually, no outside labor is being sought since these farmers in general cannot afford to pay labor on a daily basis.

Most farmers from Commewijne have completed a primary or secondary education. This means that training and training tools need to be designed on a very low educational level. Most farmers do not hire labor to assist them in the fields. More than half of the farmers earn a monthly income of less than US $500 while the rest of the farmers earned a monthly income ranging from US $ 500 to US $1,000. Only about 1/4 of the farmers' income is 100% earned in agriculture. The majority of farmers earned an income which relies for 40% to 50% on agriculture. The crops that were frequently planted in the last 2-3 years by the farmers included:hot pepper, eggplant, bittergoar, antruwa, cabbage, tomatoes, cucumber, paprika, cassava, parsley, green onions, string beans, sweet pepper, green beans, and greens, pumpkin and tomatoes. Aside from these crops, the farmers also cultivated fruits such as oranges, papaya, watermelon, limes, and tangerines, and bananas. Results indicated that farmers often did not know what variety of crop they planted. Usually they get the information from other farmers who have already gained good experiences with these crop varieties. Farmers are mostly relying for agricultural information on their personal experiences. They also get their information from other farmers, NGO's and TV.

The majority of farmers used the telephone as a means of communication. More than half of the respondents prefer to communicate on a one-to-one basis with each other. They also like to communicate about agricultural matters at meetings.

Living Conditions

The majority of problems which farmers face include:

1. Absence of a drinking water distribution net
2. Improperly maintained waterways or channels, resulting in problems of waterlogging during the rainy season and water shortage in the dry season.
3. Financial problems, such as a low monthly income
4. Difficulties to purchase agricultural inputs of equipment as a result of the long distances farmers have to travel
5. Power failures on a regular basis
6. Fluctuations in the wholesale buyer-prices of the agricultural products
7. Unfertile soils (according to farmers)
8. No or limited garbage collecting service
9. Absence of telecommunication
10. No medical services
11. No recreation
12. No title on land (land property rights)

Eighty percent of farmers in Commewijne are born in Commewijne. The reason why some farmers have re-located themselves in this district is because of their work and or their spouse who is from Commewijne.

Water management

The irrigation/drainage capacity in Commewijne is not adequate. All farmers in Commewijne are experiencing problems with excessive water and/or water shortages. Water shortages occur very often in the dry season, and excessive water occurs in the rainy season.

To solve these problems, farmers need to include measures such as:

1. Establishment of a good drainage system
2. Investing in water pumps
3. Placing of a well
4. Clearance of vegetation in the channels and raising the embankments of the channels

However, it is also noted that many farmers are not concerned with solving the problem. A sustainable solution for this problem of excessive water or water shortages in the fields can be reached if the irrigation/drainage system is adequately maintained. The Ministry of Public Works is in charge of the maintenance of the primary infrastructure.

Production aspects

The training needs in vegetable farming include knowledge of proper:

1. Seeding methods/techniques of planted vegetables.
2. Timing of vegetable planting
3. Iirrigation requirements of planted vegetables in both rainy and dry seasons throughout the year.
4. Agro-ecology concepts to use legumes with regard to nitrogen cycle.
5. Soil conservation measures.
6. Organic production.
7. Crop protection guidelines for vegetables.

Training needs in crop protection include farmers' understanding of:

1. The causes of diseases of planned crops.
2. Usage of weed chemicals in planted crops.
3. Identification of insect/pest in planted crops.
4. Usage of control measures of insect/pest of planted crops.

CONCLUSIONS

1. The farm family is the main source of farm labor in Commewijne.
2. Total land area of farmers varied from 0.1 to 6 ha; the planted area varied from 0.1 to 1 ha.
3. There is little contact among farmers, researchers, and extension field workers.
4. Farmers lack competency in agricultural practices to increase their agricultural production.
5. The majority of farmers earn an income of less than US $500 a month.
6. They rely mostly on their personal experiences as a source of agricultural information.

RECOMMENDATIONS

1. Farmers need more training in agricultural practices to produce more qualitative agricultural products.
2. There should be better communication among national agricultural research institutions, researchers, field extension agents and farmers.
3. Farmers should invest in a more adequate infrastructure on their land in order to enhance quality and production.

4. The Agricultural Extension Service needs to be strenghtened in its services to farmers.
5. The living conditions of farmers in Commewijne need improvement.

REFERENCES

Ministry of Agriculture (2006). Agricultural Sector Plan, Projectteam. ASP. Final Concept, Paramaribo, Suriname.

Ori, L and Ori, H. (2011). Capacities and Specialization of the Human Resources in the Agricultural Sector in Suriname. A Report presented to the Caribbean Council of Higher Education in Agriculture, Paramariobo, Suriname.

Van Eeckhout, K. (2008). District Strategisch Ontwikkelingsplan.www.decentralisatie.org/20dlgp/c26_DSOP_Wanica_rev.pdf

World Bank. (2006). Agriculture and Achieving the Millenium Development Goals, Washington, DC, www.ifpri.org/.../agriculture-and-achieving-millennium-development-goals.

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INVESTIGATION OF THE EFFECTS OF MYCORRHIZAL FUNGI ON CADMIUM ACCUMULATION IN CACAO

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ABSTRACT: Currently, increasing emphasis is being placed on the contamination of cacao beans by heavy metals, particularly cadmium (Cd). Since the primary source of Cd contamination in cacao has been attributed to metal-contaminated soils, it is becoming crucial to develop strategies to minimize its uptake. Recent studies have shown that mycorrhiza could contribute to the immobilization of Cd in soils, thereby decreasing Cd toxicity to plants. A preliminary pot trial study was designed to determine whether mycorrhizal fungi in the form of bio-fertilizers could be used as a method of soil remediation, to inhibit Cd uptake by cacao plants. Roots of cuttings of a single variety and age of cacao were grown with and without a commercial bio-fertilizer, in a Cd-spiked, sterilized soil in pots, in randomized blocks in a greenhouse. The experiment was conducted over a period of four months, with replicates of plants being sacrificed and analyzed monthly, to determine the Cd contents of leaf and stem samples. Microscopic examinations were also done to detect mycorrhizal infection of roots of bio-fertilizer treated and control plants. Paired data analysis demonstrated that cacao plants treated with the mycorrhizal bio-fertilizer accumulated significantly higher ($p<0.05$) levels of Cd in both leaves and stems than non-mycorrhizal-treated plants for the period of the study. The higher Cd concentrations found for the mycorrhizal treatment may have resulted from an increase of Cd absorption into the plants by soil mycelia, known to spread several centimeters around the plant roots. This investigation, while preliminary, indicates that the variety of cacao plant used with the commercial mycorrhiza used accumulates significantly higher levels of Cd in their leaves and stems than non-mycorrhizal plants.

Keywords**:** Mycorrhiza, bio-fertilizer, cadmium, cacao

INTRODUCTION

There are increasing concerns over the intake of excessive Cd in contaminated food crops, which may be toxic to animals, including humans (Welch and Norvell, 1999). It can cause abdominal cramps, headaches, vomiting and diarrhea (ATSDR, 1993) and in severe cases, kidney tubule damage, anemia and severe loss of bone minerals (Reilly, 2002). The levels of heavy metals, particularly Cd in cacao beans, have been of concern for many years (BCCCA, 1996). Concentrations of Cd in cocoa powders and liquors made from cacao beans and used in chocolate production are gaining public significance (Mounicou et al., 2002, 2003; Dahiya et al., 2005; Jalbani et al., 2009). International legislative bodies, as well as chocolate manufacturing countries have introduced new Cd regulations for the protection of the health of their consumers (FSA, 2009; Ducos et al., 2010; ICCO, 2010).

An investigation by Lee and Low (1985) reported high levels of Cd in raw cacao beans. It was speculated that Cd present in cacao beans is due to uptake by cacao plants from Cd contaminated soils (Fauziah et al., 2001; Mounicou et al., 2003; Beckett, 2009). Such soil contamination can be treated using various technologies, including physical (Evanko and Dzombak, 1997) and chemical treatments (Mahabadi et al., 2007). However, low-cost and low-impact biological techniques such as the application of microorganisms and microbial products have been receiving increasing attention for soil remediation (Leyval et al., 2002; Doumett et al., 2008; Karimi et al., 2011). Soil microorganisms such as mycorrhizal fungi have been shown to restrict or enhance heavy metal uptake (Joner et al., 2000; Janoušková et al., 2005; Hildebrandt et al., 2007). Mycorrhizal hyphal mats act as barriers against metal transport across root cell walls, thereby reducing metal uptake by plants (Gaur and Adholeya, 2004; Andrade and Silveira, 2008). In addition to sequestration of heavy metals in the vacuole of the fungal cells, extracellular heavy metal chelation by secreted mycorrhizal exudates appear to provide barriers to heavy metal absorption by plant roots (Göhre and Paszkowski, 2006; Muthukumar and Bagyaraj, 2010). Recent studies have shown that mycorrhiza could also contribute to the immobilization of Cd in soils, thereby decreasing Cd toxicity to plants (Janoušková et al., 2005; 2006). As a result, it is possible that this approach can also apply to cacao plants, minimizing or preventing Cd uptake throughout its tissues.

Thus the main objective of this research is to determine whether mycorrhizal fungi could be used as an alternative method of soil remediation to inhibit Cd uptake in cacao.

MATERIALS AND METHODS

For this study a pot trial was designed to assess the effectiveness of mycorrhizal fungi in the form of bio-fertilizers on the minimization of Cd uptake in cocoa.

Rooted cacao cuttings of a single variety and stage of maturity (approx. one month) were obtained. At the start of the trial, five samples of cuttings were taken for analysis to determine their initial levels of Cd, in addition to the mycorrhizal colonization of roots of plants. A commercial mycorrhizal preparation (MycoApply® Micronized Endo bio-fertilizer, Oregon, USA) was used to supply mycorrhiza to the roots of cacao cuttings. Mycorrhizal non-inoculated (Control, Treatment A) and inoculated (Treatment B) rooted cacao cuttings were then planted in sterilized Cd-spiked soil (10 µg/g) in polyethylene bags.

The experiment was set up in a completely randomized design, with five replications per treatment for a period of four months in a naturally illuminated greenhouse, where plants were watered periodically. Each plant was placed on a heavy-duty polystyrene plate, to minimize cross-contamination from excess irrigation water on the floor. Each month, plants were sacrificed for analysis, where leaf and stem Cd levels were determined by flame atomic absorption spectrometry (FAAS) on a Varian SpectrAA 880 (Australia), and the mycorrhizal infection of bio-fertilizer-treated roots through a clearing and staining procedure, as outlined by Koske and Gemma (1989).

The differences in Cd levels between the non-inoculated and inoculated mycorrhizal treatments were evaluated using pair data analysis (p 0.05). Statistical software Minitab (version 16), 2010 was applied.

RESULTS AND DISCUSSION

Cadmium Accumulation in Mycorrhizal vs Non-Mycorrhizal-Treated Cacao Plants

Tables 1 and 2 illustrate the mean Cd concentration of leaves and stems per gram of plant dry weight (DW), respectively, for treatments A and B, during each month of the experimental period.

Table 1. Mean Leaf Cd Concentrations per gram of Plant DW for Treatments A and B over four months.

Treatment	Mean Cd (µg/g)/g in leaves (DW) ± SD for each month			
	1	2	3	4
A	0.86±0.13	5.45±0.62	12.15±0.65	13.16±1.20
B	1.43±0.32	8.92±1.49	15.40±0.82	16.41±1.72

Table 2. Mean Stem Cd Concentrations per gram of Plant DW for Treatments A and B over four months.

Treatment	Mean Cd (µg/g)/g Stem DW ± SD for each Month			
	1	2	3	4
A	2.06±0.39	6.73±0.19	9.36±0.54	7.37±0.56
B	3.77±0.86	12.29±0.25	12.30±2.34	9.57±0.41

Paired data analysis demonstrated that cacao plants treated with the mycorrhizal bio-fertilizer accumulated significantly higher ($p<0.05$) levels of Cd in both leaves and stems than non-mycorrhizal plants for the period of the investigation. These results are contrary to those reported to show decreases in Cd uptake by mycorrhiza (Janoušková et al., 2005; Janoušková et al., 2006). However, plants grown with mycorrhiza may show enhanced Cd uptake and root-to-shoot transport (Vogel-Mikus et al., 2005; Göhre and Paszkowski, 2006), as found in our preliminary study.

Even though this difference in Cd uptake can be attributed to the presence of mycorrhiza in the commercial mycorrhizal preparation, results from mycological analyses over the four-month study period showed that none of the roots sampled were infected. It is possible that low infection rates of the roots by the mycorrhiza may not have allowed their true effects to be realized within the four months of our trial. However, intra-radical mycorrhizal colonization may be reduced by high heavy metal levels in soils (Liao et al., 2003), and high soil Cd can reduce the mycorrhizal infections of roots in such soils (Tullio et al., 2003; Andrade and Silveira, 2008). It is thus possible that the soil Cd concentration used in this experiment may have had a similar affect on colonization of mycorrhiza in the roots of the cacao plant.

It must also be noted that the mycelia of mycorrhiza do not propagate only in the root cortex of the host plant, but also in the soil around the root (Neumann and George, 2009). Thus, the significantly higher Cd concentrations found for the mycorrhizal treatment may have resulted from

an increase of Cd absorption into the plants by soil mycelia, known to spread several centimeters around the plant roots (Gowariker et al., 2009).

CONCLUSION

This investigation, while preliminary, indicates that the variety of cacao plants treated with the commercial mycorrhiza accumulated significantly higher levels of Cd in the leaves and stems than non-treated plants. Consequently, mycorrhiza in the form of bio-fertilizers may not be effective treatment to minimize Cd accumulation in cacao plants. However, it is possible that other mycorriza and cacao plants may behave differently, as found in other plants and should be further investigated.

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REFERENCES

Agency for Toxic *Substances and Disease Registry (ATSDR). 1993. Toxicological Profile for Cadmium*; U.S. Department of Health and Human Services, Public Health Service, Atlanta, Georgia.

Andrade, S.A.L., and A.P.D. Silveria,. 2008. Mycorrhiza Influence on Maize Development under Cd Stress and P Supply. *Braz. J. Plant Physiol. 20*, 39-50.

Beckett S.T. 2009. Industrial Chocolate Manufacture and Use; 3rd ed.; Wiley-Blackwell: Iowa.

BCCCA (Biscuit, Cake, Chocolate and Confectionery Alliance). 1996. *Cocoa Beans: Chocolate Manufacturers' Quality Requirements*; 4th ed.; Association. Cocoa Research: UK

Dahiya, S., R. Karpe, A.G. Hegde, and R.M. Sharma. 2005. Lead, Cadmium and Nickel in Chocolates and Candies from Suburban Areas of Mumbai, India. *J. Food Compos. Anal. 18*, 517–522.

Doumett, S., L. Lamperi, L. Checchini, E. Azzarello, S. Mugnai, S. Mancuso, G. Petruzzelli, and M. Del Bubba. 2008. Heavy Metal Distribution between Contaminated Soil and Paulownia Tomentosa, in a Pilot-Scale Assisted Phytoremediation Study: Influence of Different Complexing Agents. *Chemosphere. 72* (10), 1481-1490.

Ducos S., M. Hamester, and M. Godula. 2010. ICP-MS for Detecting Heavy Metals in Foodstuffs: The Technology can Analyze 50 Samples in an Hour. http://www.foodquality.com/details/article/809781/ICPMS_for_Detecting_Heavy_Metals_in_Foodstuffs_.html?tzcheck=1

Evanko, C.R., and D.A. Dzombak. 1997. Remediation of Metal-Contaminated Soil and Groundwater; *GWRTAC Technology Evaluation Report, TE-97-01*, Ground-Water Remediation Technologies Analysis Center, Pittsburgh, PA.

Fauziah C.I., A.R. Zaharah, S. Zauyah, and A.R. Anuar. 2001. Proposed Soil Heavy Metal Reference Values to be used for Site Assessment. Proceedings of Brownfield 2001: *First National Conference on Contaminated Land, Petaling Jaya:* The Institution of Engineers, Malaysia.

FSA (Food Standards Agency). 2009. Chemical Contaminants Interested Parties Letter: Environmental Contaminants (Inorganic contaminants). http://www.food.gov.uk/multimedia/pdfs/envirocontam 0703.pdf

Göhre, V., and U. Paszkowski. 2006. Contribution of the Arbuscular Mycorrhizal Symbiosis to Heavy Metal Phytoremediation. *Planta 223* (6), 1115-1122.

Gowariker,V., V. N. Krishnamurthy, S. Gowariker, M. Dhanorkar, I. Paranjape and N. Borlaug. 2009. *The Fertilizer Encyclopedia*. Hoboken: John Wiley & Sons.

Hildebrandt, U., M. Regvar, and H. Bothe. 2007. Arbuscular Mycorrhiza and Heavy Metal Tolerance.*Phytochemistry 68* (1), 139-146.

ICCO. (International Cocoa Organization). 2010. What is the Situation Regarding Cadmium, Lead and Copper in Cocoa Beans? http://www.internationalcocoaorganisation.net/\ questions/cadmium.htm

Jalbani, N., T.G. Kazi, H.I. Afridi, and M.B. Arain. 2009. Determination of Toxic Metals in Different Brands of Chocolates and Candies, Marketed in Pakistan. *Pak. J. Anal. Environ. Chem. 10*, (1-2), 48-52.

Janoušková, M., D. Pavlíková, T. Macek, and M. Vosátka. 2005. Arbuscular Mycorrhiza Decreases Cadmium Phytoextraction by Transgenic Tobacco with Inserted Metallothionein. *Plant Soil. 272* (1), 29-40.

Janoušková, M., D. Pavlikova, and M. Vosatka. 2006. Potential Contribution of Arbuscular Mycorrhiza to Cadmium Immobilisation in Soil. *Chemosphere 65* (11), 1959-1965.

Joner, E., R. Briones, and C. Leyval. 2000. Metal-Binding Capacity of Arbuscular Mycorrhizal Mycelium. *Plant Soil.226* (2), 227-234.

Karimi, A., H. Khodaverdilou, M. Sepehri, and M.H. Rasouli-Sadaghiani. 2011.Arbuscular Mycorrhizal Fungi and Heavy Metal-Contaminated Soils. *Afr. J. Microbiol. Res. 5* (13), 1571-1576.

Koske, R. E., and Gemma, J. N. 1989. A Modified Procedure for Staining Roots to Detect VA mycorrhizae. *Mycol. Res. 92* (4), 486-488.

Lee C.K., and K.S. Low. 1985. Determination of Cadmium, Lead, Copper and Arsenic in Cocoa, Semi-Finished and Finished Chocolate Products. *Pertanika.* 8(2), 243-248.

Leyval, C., K. Turnau, and K. Haselwandter. 1997. Effect of Heavy Metal Pollution on Mycorrhizal Colonization and Function: Physiological, Ecological and Applied Aspects. *Mycorrhiza. 7*, 139-153.

Liao J.P., X.G. Lin, Z.H. Cao, Y.Q. Shi, and M.H. Wong. 2003. Interactions between arbuscular mycorrhizae and heavy metals under sand culture experiment. *Chemosphere* 50:847-853. 50(6):847-53.

Mahabadi, A. A., M.A. Hajabbasi, H. Khademi, and H. Kazemian. 2007. Soil Cadmium Stabilization using an Iranian Natural Zeolite. *Geoderma 137* (3-4), 388-393.

Mounicou, S., J. Szpunar, R. Lobinski, D. Andrey, and C.J. Blake. 2002. Bioavailability of Cadmium and Lead in Cocoa: Comparison of Extraction Procedures Prior to Size-Exclusion Fast-Flow Liquid Chromatography with Inductively Coupled Plasma Mass Spectrometric Detection (SEC-ICP-MS). *J. Anal. Atom. Spec. 17*, 880-886.

Mounicou, S., J. Szpunar, D. Andrey, C. Blake, and R. Lobinski. 2003. Concentrations and Bioavailability of Cadmium and Lead in Cocoa Powder and Related Products. *Food Addit.Contam. 20* (4), 343-52.

Muthukumar, T., and D.J. Bagyaraj. 2010. Use of Arbuscular Mycorrhizal Fungi in Phytoremediation of Heavy Metal Contaminated Soils. In *Proceedings of The National*

Academy of Sciences India Section Biological Sciences, Allahabad: National Academy of Science, India, pp 103-12.

Neuman, E. and E. George. 2009. The effect of arbuscular mycorrhizal root colonization on growth and nutrient uptake of two different cowpea (*Vigna unguiculata* [L.] Walp.) genotypes exposed to drought stress. *Emir. J. Food Agric.* 21 (2): 01-17

Reilly, C. 2002. Transition metals. In *Metal Contamination of Food: Its Significance for Food Quality and Human Health;* 3rd ed.; Blackwell Publishing: U.K., 8, pp 160-165.

Tullio, M., F. Pierandrei, A. Salerno and E. Rea. 2003. Tolerance to cadmium of vesicular arbuscular mycorrhizae spores isolated from a cadmium-polluted and unpolluted soil. *Biol Fertil. Soils.* 37, 211–214.

Vogel-Mikus K., D. Drobne and M. Regvar. 2005. Zn, Cd and Pb accumulation and arbuscular mycorrhizal colonisation of pennycress *Thlaspi praecox* Wulf. (Brassicaceae) from the vicinity of a lead mine and smelter in Slovenia. *Environ. Pollut.* 133: 233-242.

Welch, R.M. and W.A. Norvell. 1999. Mechanisms of Cadmium Uptake, Translocation and Deposition in Plants. In *Cadmium in Soils and Plants;* Singh, B., McLaughlin, M. J., Eds.; Kluwer Academic: Netherlands, 6, pp 125-126.

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EVALUATION OF SINGLE EXTRACTION METHODS FOR PREDICTING SOIL BIOAVAILABLE NITROGEN (N), PHOSPHORUS (P) AND POTASSIUM (K) TO CACAO (*THEOBROMA CACAO* L.)

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ABSTRACT: Trinidad and Tobago is known as an exclusive producer of fine or flavour cacao beans for which demand exceeds supply. Several initiatives have been undertaken to increase production and they include rehabilitation of old, abandoned farms, establishment of new farms and provision to farmers of cacao varieties that are new and improved. The success of these initiatives, however, is dependent on numerous factors, an important one being the nutrient status of the soil. Nitrogen (N), Phosphorus (P) and Potassium (K) are essential elements that are classified as macronutrients because of the large amounts required by plants. Soil bioavailability of nutrients provides a good indication as to whether the soil can adequately supply nutrients to the plant. Numerous single extraction methods are available to determine the soil bioavailability of N, P and K in soils but have not been previously reported for use in cacao. This research evaluates the Bray P1, Morgan, Mehlichs #1 & #3, Olsen's Sodium Bicarbonate, Ammonium Bicarbonate – Diethylene Triamine Pentaacetic Acid (AB-DTPA), Calcium Chloride ($CaCl_2$) and Potassium Chloride (KCl) extraction methods for the prediction of N, P and K bioavailability in soil to cacao. Correlation analysis between extractable N, P and K and total N, P and K content of cacao tissues will be done to evaluate the best extractant to represent soil bioavailable N, P and K. The extractant that best predicts the bioavailable N, P and K in soil for cacao will then be used to determine the effect(s) that soil treatments for the reduction of soil bioavailable cadmium will have on the bioavailability of N, P and K to cacao plants.

Keywords: Bioavailaility, nitrogen, phosphorus, potassium, cacao, extractants

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TRENDS IN PHENOLIC CONTENT AND ANTI-OXIDANT CAPACITY DURING MICRO-FERMENTATION OF COCOA BEANS

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ABSTRACT: Trinidad and Tobago produces exclusively fine/flavour cocoa which possesses unique flavour attributes and as such fetches premium prices in the world market. Typically, after cocoa beans are fermented and dried, they are stored in warehouses until sold for export. The beans, which are placed in jute sacks, may spend long periods in storage which can extend several months. During this period, cocoa beans may be subjected to insect infestation which can severely compromise the quality of the beans and consequently the price at which they can be sold. In an effort to reduce insect infestation, cocoa beans were stored in an environment with increased concentrations of CO_2, a known and widely used fumigant. Since Trinidad and Tobago's cocoa is prized for its flavour, any treatments applied to the beans must not adversely affect its flavour. Therefore, this study was conducted to investigate the effects of changing the storage atmosphere on the final flavour of cocoa products. The altered environment was achieved by storing beans in airtight GrainPro Cocoons™ where CO_2 was applied in the form of dry ice pellets. Beans were stored for a period of four months and were sampled at one month intervals. The sampled beans were used to make cocoa liquors from which flavour volatiles were extracted. The volatile compounds were extracted by using Solid Phase Microextraction (SPME) and quantified using Gas Chromatography. Preliminary trials have shown that over the four-month storage period in the altered environment the concentration of volatiles responsible for fine flavour increased. Since CO_2 storage did not produce off-flavours and, in fact, has a desirable effect on cocoa flavour, it can be adopted as an insect control and flavour enhancement method.

Keywords: Cocoa, storage, flavor, CO_2, SPME

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OVERVIEW OF RESEARCH ON INVASIVE SPECIES IN THE CARIBBEAN

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ABSTRACT: Invasive species are a serious constraint to agriculture in the Caribbean and global movement of people and goods has increased the incidence of exotic invasives. This problem was recognised by the Caribbean Food Crops Society (CFCS) in 2003, when the society organised a special one-day seminar entitled "Challenges and Opportunities in Protecting the Caribbean, Latin America and the United States from Invasive Species". Since 2003, invasive species have remained at the forefront of CFCS meetings with special invasive species seminars or sessions being scheduled at all but one of the 10 annual meetings from 2003 to 2012. The proceedings for the CFCS meetings for the years 2003-2011 were examined for papers reporting research on invasive species; the programme of abstracts for 2012 was also examined. The total number of presentations at CFCS annual meetings from 2003 to 2012 is 1,111; of these, 231 (20.8%) are on invasive species research. For the period 2003 to 2007 this study lists all the invasive species on which research was reported at CFCS meetings. For the period 2008 to 2012; besides listing the invasives on which research was reported, the countries of study are identified. Also in 2008, 2009, 2010 and 2011 there were several presentations listing invasives of concern or importance. These lists are reproduced here. During the 2003 to 2007 period the three invasives which appear to have captured the most research efforts were Bacterial Wilt, Chilli Thrips and Pink Hibiscus Mealybug. From 2008 to 2012 research efforts on invasive species appear to have stepped up to an even higher level with the following seven receiving the most attention: Black Sigatoka, Chilli Thrips, Citrus Greening, Coffee Berry Borer, Fruit flies, Fusarium Wilt and Red Palm Mite.

Keywords: Caribbean Food Crops Society proceedings, agricultural pests and diseases.

INTRODUCTION

There are a number of important constraints which are proving to be obstacles to the need to improve agricultural production in the Caribbean and thus increase the Region's food sovereignty. The need for greater food sovereignty has become more apparant as global food prices have risen sharply over the last five years, a trend which is expected to continue. The English-speaking CARICOM countries now have an annual food import bill of around US$4 billion. The situation is much the same in many of the French-and Spanish-speaking Caribbean countries that rely largely on imports from Europe and mainland America to meet their food requirements.

Most of the constraints to increasing food production are well known. Climate change, natural disasters, praedial larceny and labour intensive systems are all serious obstacles. Just as serious, if not moreso, are the losses of production due to pests and diseases, many of which are caused by invasive species. With the world now quite literally a global village, movement of people and goods has brought renewed problems and exotic invasives, lacking natural enemies in the local environments, are often extremely disruptive to food plants and animals.
Unlike some of the other constraints to food production, pests and diseases caused by invasives require research efforts by regional agricultural scientists. Recognising this, the Caribbean Food

Crops Society (CFCS) brought the issue of invasive species to the fore in 2003. In that year, at the 39th Annual Meeting of the CFCS in Grenada, the University of Florida organised a one-day seminar entitled "Challenges and Opportunities in Protecting the Caribbean, Latin America and the United States from Invasive Species". At this seminar a number of research papers were presented on efforts to contain pests and diseases caused by invasive species. At most of the Annual Meetings since 2003, the CFCS has had at least one session (usually a full day) devoted to invasive species; this year 2012, the 48th Annual Meeting of CFCS is the 10th meeting (including the Grenada meeting) since the Society brought the issue of Invasive Species to the fore. In this time most of the work in the Caribbean on Invasive Species has been presented in either oral or poster form at the CFCS Annual Meetings.

METHODOLOGY OF THE OVERVIEW

The proceedings of the CFCS Annual Meetings for the years 2003 to 2011 (Caribbean Food Crops Society 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011) were all examined for presentations on invasive species. Also examined was the Programme and Abstracts for the 2012 Caribbean Food Crops Society Annual Meeting. These examinations attempted to identify the total number of presentations at these meetings, the number of these presentations which were on invasive species and the number of the invasive species presentations which were research presentations. The definitions of 'presentation', 'invasive species presentation' and 'invasive species research presentation' are not straightforward and the numbers of each identified must necessarily be somewhat subjective and another author doing a similar study may not come up with the exact number found in this study. An attempt to define these three terms follows.

Presentation

This includes both oral and poster methods of delivery. Items in the proceedings (full presentation and abstract only) and items listed for delivery in 2012 were defined as presentations with the exception of panel discussions and welcome and opening remarks at the start of the meetings or at the start of special sessions. The contributions of feature speakers were also not usually defined as a presentation unless the speaker gave a scientific type presentation.

Invasive species presentation

This is a subset of the total number of presentations; those which related to invasive species. However, it was certainly not easy to determine whether a pest or disease is 'invasive'. Even some of the CFCS sessions devoted to invasive species included papers on observation or control of what may not actually be 'invasive'. The following criteria were decided upon:

- Any insect or other animal attacking a crop or farm animal was considered invasive
- Weeds were considered invasive if they were defined as such even if they were not affecting agricultural production
- Animals were considered invasive if they were defined as such even if not affecting agricultural production
- Marine and aquatic invasives if they were defined as such (including marine and aquatic plants)
- Nematodes were usually not considered invasive unless defined as such

- Thrips were usually considered invasive unless specifically identified as native.

Invasive species research presentation

This is a subset of invasive species presentations. It was found to be easier to define what was 'not research' and any presentation which was not identified as 'not research' was considered to be a research presentation. Usually these were considered as 'not research':

- Strategies for management of invasives, including safeguarding measures
- Surveillance, unless research on a surveillance methodology
- Listing or cataloguing of invasives
- Training or technical assistance initiatives
- Diagnostic and identification tasks
- Information systems
- Progress reports on projects/activities
- Pest status reports
- Reports on research efforts
- Risks analysis
- 'How to' guides
- Methods of spread
- Identification of threats.

ANALYSIS

Using the above definitions, Table 1 indicates the number of presentations, invasive species presentations and invasives species research presentations for all CFCS meetings during 2003-2012. Table 1 also indicates whether there was an invasive species symposium or session at the meetings. Under the above definitions there were 1,111 presentations at the CFCS between 2003 and 2012, of which 231 (20.8%) were identified as 'invasive species research presentations'. Attempts were made to identify all the invasives in these 231 presentations. This was sometimes quite a difficult task as some presentations identified the invasive not as the causal agent, but as the symptom or disease (e.g. anthracnose, wilt, rot). The lists of invasives identified were broken into two 5-year periods, 2003 to 2007 and 2008 to 2012. For the first 5-year period (2003 to 2007) the country of research was not identified. For the second 5-year period (2008 to 2012) attempts were made to identify the countries of the research which were reported in the papers.

As it is easier to define a common name from a scientific name rather than vice versa, common names are used in the summary tables that follow. It should be mentioned, however, that language differences caused problems, particularly as the scientific names were not always given.

Table 1 CFCS meetings since 2003: location, number of presentations, number of presentations on invasive species and number of presentations on invasive species research.

Year	Country	Invasive species session	No of presentations	No of presentations on invasives	No of these research
2003	Grenada	Yes	77	33	21
2004	US Virgin Islands	No	72	17	6
2005	Guadeloupe	Yes	126	44	22
2006	Puerto Rico +	Yes	142	60	44
2007	Costa Rica	Yes ++	98	23	18
2008	Florida, USA	Yes	156	58	32
2009	St Kitts	Yes	85	30	19
2010	Dominican Republic	Yes	155	36	26
2011	Barbados	Yes	110	27	22
2012	Cancun, Mexico	Yes ++	90	23	21
Total			1,111	351 (31.6%)	231 (20.8%)

\+ Data do not include the presentations at the West Indies Agricultural Economics Conference held jointly with CFCS

++ Invasives species session was not a full day.

Invasives situated at CFCS meetings between 2003 and 2007

Table 2 identifies the invasives which were researched as reported in CFCS presentations from 2003 to 2007. From the initial invasive species symposium in Grenada, 13 researched invasives are listed. At the 2004 meeting in the U.S. Virgin Islands, the CFCS did not schedule a special invasive species session, research studies were on eight invasives; this number rose to 13 in 2005 and to 23 in 2006, a meeting which had a total of 142 presentations, the highest number during the 2003 to 2007 period. In 2007 the number of invasives studied was 13.

Table 2. Lists of invasives identified in invasive species research presentations at CFCS Annual Meetings from 2003 to 2007.

Years	Invasive species	Years	Invasive species
2003	Amblyomma Tick	**2006**	Anthracnose
	Asian Pigeon Pea Pod Fly		Bacterial Leaf Spot
	Bacteria Root Rot		Bacterial Wilt
	Bacteria Wilt		Banana Leaf Borer
	Coffee Berry Borer		Black Sigatoka
	Exotic termites and ants		Chilli Thrips
	Lobate Lac Scale Insect		Citrus Blackfly
	Mole Cricket		Coffee Leaf Miner
	Papaya Mealybug		Cycad Scale
	Pink Hibiscus Mealy Bug		Fruit flies (including W.I. fruit fly)
	Poinsetia Root Rot		Invasive weeds
	Sugarcane Moth Borer		Lethal Yellowing
	Yam Anthracnose		Melon Thrips
			Mites
2004	Bacterial Cranker		Mole Cricket
	Banana Crown Rot Thrips		Nutsedge
	Chilli Thrips		Pigeon Pea Pod Fly
	Coffee Berry Borer		Pink Hibiscus Mealybug
	Melon Thrips		Potato Blight
	Palm Leaf Skeletonisers		Powdery Mildew
	Pink Hibiscus Mealybug		Watergrass
	Rats		White Grub
2005	Ants	**2007**	Black Sigatoka
	Armoured Scale		Bovine Dematophilus
	Bacterial Leaf Spot		Bovine Tuberculosis
	Bacterial Wilt		Chilli Thrips
	Cactus Moth		Classical Swine Fever
	Fruit flies		Coffee Leaf Minor
	Leaf Blight		Cucumber Mosaic Virus
	Mole Cricket		Fruit flies
	Snails and slugs		Itch Grass
	Sweet Potato Grub		Invasive weeds
	Thrips(including Chilli Thrips and Western Flower Thrips)		Potato Y Virus
			Red Palm Mite
	Whitefly		Sweet Potato Weevil

Invasives studied at CFCS meetings between 2008 and 2012

From 2008 onwards many presentations listed what were considered 'important' invasives. Although most of these presentations were not classified as research presentations, these lists are reproduced here as a comparison between what were identified as 'important' invasives and what invasives were being researched.

At the Florida CFCS meeting, Roberts (2008) listed what she considered as 19 important invasives in the Caribbean and Wicher et al. (2008) of CIRAD listed five important invasives to the French Caribbean. These lists are reproduced in Table 3, along with a list of invasives studied in the invasive species research presentations, together with the country of that research; there were 25 invasives researched.

The number of presentations in St. Kitts at the CFCS meeting in 2009 was much less than in 2008 with a consequent reduction in number of invasives researched. The 13 which were named in research presentations are listed in Table 4; this table also lists the important recent invasives according to IICA (Thomas, 2009); important invasives and major threats listed by CARIBVET (Trotman, 2009) and the working groups set up by the Caribbean Plant Health Directors (Fortune, 2009).

Table 3. Important invasives according to Roberts and Wicher et al. and invasive species research presentations at the CFCS Annual Meeting, 2008.

Important invasives according to Roberts	**Wicher et al. (French Caribbean)**	**Invasives researched Pest/invasive**	**Country of research**
Avocado Laurel Witt	Black Sigatoka	Avocado Root Rot	Dominican Republic
Banana Streak Virus	Fruit flies	Basil Downey Mildew	Florida, USA
Black Sigatoka	Lethal Yellowing	Black Sigatoka	Puerto Rico
Cattle ticks	Moko	Broad Mite and White Fly on pepper and eggplant	Florida, USA
Chilli Thrips	Sugarcane Yellow Leaf Curl	Chilli Thrips	Florida, USA
Citrus Root Weevil		Citrus Tristeza Virus	Dominican Republic
Coffee Berry Borer		*Cladosporium tenuissimum* (fungus on taro)	Puerto Rico
Cucurbit viruses		Cogongrass	Florida, USA
Elephant Grass		Coffee Berry Borer	Dominican Republic
Giant African Snail		Coffee Leaf Minor	Puerto Rico
Imported Ornamental Clams		Corn Silk Fly	Florida, USA
Mexican Bromeliad Weevil		Downy Mildew (watermelon)	Dominican Republic
Orange Rust of sugar cane		Erythrina Gall Wasp	Florida, USA
Para Grass		Giant African Snail	Barbados
Passionvine Mealybug		Melon Thrips	Florida, USA
Pepper Bacterial Spot		Northern Corn Leaf Blight	Florida, USA
Red Palm Mite		Nutsedge	Florida, USA
Silverleaf Whitefly		Red Palm Mite	Jamaica; Trinidad; USA
Tomato Late Blight		Parasites in goats	Florida, USA
		Phytophthora Blight	Florida, USA
		Phytophthora Root Rot	Florida, USA
		Red Hibiscus Mealy Bug	Florida, USA
		Proba distant, plant bug	Florida, USA
		Squash Vein Yellowing	Florida, USA
		Tomato Yellow Leaf Curl Virus	Florida, USA

Table 4. Important invasives according to IICA; important invasives and major threats according to CARIBVET; working groups set up by Caribbean Plant Health Directors and invasive species research presentations as reported at the CFCS Annual Meeting 2009.

IICA	CARIBVET		Caribbean Plant Health Directors
Important recent invasives	**Important invasives**	**Major threats**	**Working Groups**
Black Sigatoka	Avian Influenza	Foot and Mouth Disease	Giant African Snail
Classical Swine Fever	Bovine Tuberculosis	Mad Cow Disease	Palm Pests (including Red Palm Mite)
Giant African Snail	Brucellosis		Tephritid Fruit Flies
Lethal Yellowing	Classical Swine Fever		
Lime Swallow Tail Butterfly	Leptospirosis and Rabies		
Lionfish	Tropical Bont Tick		
Low Pathogenic Avian Influenza	West Nile Virus		
Moko			
Pink Hibiscus Mealybug			
Red Palm Mite			

Invasives researched	
Pest/invasive/disease	Country of research
Ambrosia Beetle	Florida, USA
Chilli Trips	Florida, USA
Citrus Root Weevil	Puerto Rico
Foliar diseases in bitter gourd	Dominican Republic
Fungi on exotic tropical fruits	Puerto Rico
Fungi on mango	Puerto Rico
Passionvine Mealybug	Trinidad
Red Palm Mite	Trinidad
Rice Blast Disease	Guyana
Sweet Potato Weevil	St Kitts
Taro Leaf Blight	Puerto Rico
Trunk Girdling Larva	Belize
Uredosporas on frangipani	Puerto Rico

In 2010 the CFCS Annual Meeting was provided with a list of important animal diseases in Haiti (Gongora, 2010). This list is reproduced in Table 5, together with the 16 invasive problems presented in invasive species research papers at that meeting.

In 2011, Serra et al. (2011) gave a long list of recent invasives and new threats to agriculture; there were also invasive concerns of CARIBVET (Trotman, 2011), the Global Environment Forum (GEF)/CABI Marine Invasive Alien Species project (Budoo, 2011), USDA/APHIS in the Greater Caribbean Safeguarding Initiative (Lemly, 2011) and a list of major virus diseases of banana (Lockhart, 2011). Krauss (2011) identified a number of important, and not desirable, human induced invasives; most of which were connected to pets for humans. Table 6 lists all of these invasives and threats as well as detailing the 17 invasives researched in the CFCS Annual Meeting's invasive species research presentations.

This paper was written before the Proceedings of the 2012 CFCS Annual Meeting were available, but an examination of the programme of abstracts suggested research on 16 invasives were to be

presented. These are listed in Table 7. However, it should be noted that sometimes presentations in the programme of abstracts do not always appear in the final proceedings, usually because the presenter did not attend the meeting. Thus the 2012 list does not necessarily so accurately reflect the presentations as the lists for earlier years.

Table 5. Important animal diseases in Haiti and invasive species research presentations as reported at CFCS Annual Meeting, 2010.

Important animal diseases in Haiti (Gongora)	**Invasives researched**	
	Pest/invasive	**Country of research**
Anthrax	Anthracnose in mango	Dominican Republic
Avian and Swine Influenza	Anthracnose in pigeon pea	Dominican Republic
Classical Swine Fever	Asian Citrus Psyllid	Florida, USA
External and internal parasites	Avocado Laurel Wilt	Florida, USA
Gumboro Disease	Black Sigatoka	Dominican Republic
Newcastle Disease	Citrus Greening	Brazil; Belize; Dominican Republic and Florida, USA
Rabies		
Teschovirus encephalomyelitis	Citrus Leprosis	Jamaica
	Coffee Berry Borer	Puerto Rico
	Coffee Leaf Minor	Dominican Republic
	Frosty Pod Rot (identified as a risk)	St. Lucia
	Fruit fly in citrus	Puerto Rico
	Fusarium Wilt	Dominican Republic
	Giant African Snail	Trinidad
	Orange Rust of Sugar Cane	Florida, USA
	Red Palm Weevil	Florida, USA
	Sweet Potato Weevil	Dominican Republic

Table 6.Lists of invasives and threats and invasive species research presentations as reported at CFCS Annual Meeting, 2011

Invasive concern/threats		Invasive researched	
Invasive	**Listed by**	**Pest/disease/invasive**	**Country of research**
New World Screenworm	CARIBVET (Trotman)	Aquatic weeds	Florida, USA (identified 33 'major' and 32 'minor' invaders)
Lionfish	GEF/CABI (Budoo)		
Aquarium algae	Krauss *		
Cats	Krauss	Black Sigatoka	Guadeloupe; Martinique
Dogs	Krauss	Chilli Thrips	Florida, USA
Rats	Krauss	Citrus Greening	Jamaica
Red Eared Slider	Krauss	Eumusae Leafspot	Guadeloupe; Martinique
Water Thyme	Krauss	Frosty Pod Rot (surveillance)	Trinidad
Banana Bracht Mosaic Virus	Lockhart +	Fruit flies	All Caribbean
Banana Bunchy Top Virus	Lockhart	Fruit rot diseases on pepper	Guyana
Banana Mild Mosaic Virus	Lockhart	Fusarium Wilt (Panama Disease)	Florida, USA
Banana Streak Virus	Lockhart	Lionfish	Bahamas
Cucumber Mosaic Virus	Lockhart	Moko Disease	Jamaica
Anthracnose of pigeon pea	Serra	Palm diseases (Fusarium Wilt)	Florida, USA
Bacterial Panicle Blight	Serra	Lethal Yellowing, Texas Phoenix Palm Decline)	
Bean Common Necrotic Mosaic Virus	Serra	Red Palm Mite	Trinidad
Brown Leaf Spot	Serra	Red Stomach Worm	Guadeloupe
Citrus Greening	Serra	Scales and whiteflies (Croton Scale, Ficus Whitefly, Rugose Spiralling Whitefly)	Florida, USA
Citrus Tristeza Virus	Serra		
Citrus Viroids	Serra		
Fusarium oxysporium (wilt)	Serra	Thrips on yard long beans	Dominican Republic
Gummosis	Serra	Tropical Bont Tick	All Caribbean
Lethal Yellowing	Serra		
Mango Leafhopper	Serra		
Pepper Weevil	Serra		
Pests on ficus	Serra		
Pigeon Pea Pod Fly	Serra		
Passionvine and Coffee Mealybugs	Serra		
Red Palm Mite	Serra		
Stackburn Disease	Serra		
Taro Leaf Blight	Serra		
Anastrepha grandis	USDA/APHIS (Lemly)		
Cotton Seed Bug	USDA/APHIS (Lemly)		
Fruit flies	USDA/APHIS (Lemly)		
Lepidoptera	USDA/APHIS (Lemly)		
Red Palm Weevil	USDA/APHIS (Lemly)		
Tuta absoluta	USDA/APHIS (Lemly)		

* Krauss was reporting on human-introduced invasives

\+ Lockhart was reporting on major virus diseases of banana invasive research

Table 7. List of invasives included in the invasive species research presentations at the 2012 CFCS Annual Meeting according to the programme of abstracts

Pest/invasive researched	Country of research
Black Sigatoka	Tobago
Cauliflower Mosaic Virus	United States Virgin Islands
Citrus Canker	Florida, USA
Citrus Greening	Belize; Florida, USA and Puerto Rico
Coffee Berry Borer	Puerto Rico
Corbisculea flumina (a clam)	Puerto Rico
Invasive anthropods	Puerto Rico
Mexican Bromeliad Weevil	Florida, USA
Mimosa pellita and *Melaleuca quinquenervia*	Puerto Rico
Mulato Grass	Florida, USA
Papaya Mosaic Virus	United States Virgin Islands
Papaya Ring Spot Virus	United States Virgin Islands
Parasites in goats	Florida, USA
Pepper Weevil	Florida, USA
Red Palm Mite	Florida, USA and Trinidad
Thatching Grass *	Puerto Rico

* Thatching Grass was described as a useful invasive

CONCLUSION

The lists presented give some indication of the concerns and threats posed by Invasive Species over the last decade. Although there have not been comparative studies on the economic losses caused by invasives, these almost certainly are a very significant percentage of production costs for agriculture. There are also environmental and social concerns and losses to marine interests.

Perhaps during 2003 to 2007 the following three invasives captured the most research efforts: Bacterial Wilt, Chilli Thrips, Pink Hibiscus Mealybug.

From 2008 to 2012, research efforts probably stepped up to an even higher level with the seven following invasives receiving the most attention: Black Sigatoka, Chilli Thrips, Citrus Greening, Coffee Berry Borer, Fruit flies, Fusarium Wilt, Red Palm Mite.

REFERENCES

Budoo, D (2011). Achievements of GEF/CABI Marine IAS Project and the Way forward. Proceedings 47th Annual Meeting, Caribbean Food Crops Society, St Michael, Barbados (in preparation).

Caribbean Food Crops Society (2003). Proceedings 39th Annual Meeting, Grande Anse, Grenada.

Caribbean Food Crops Society (2004). Proceedings 40th Annual Meeting, St John, United States Virgin Islands.

Caribbean Food Crops Society (2005). Proceedings 41st Annual Meeting, Gosier, Guadeloupe.

Caribbean Food Crops Society (2006). Proceedings 42nd Annual Meeting, Carolina, Puerto Rico.

Caribbean Food Crops Society (2007). Proceedings 43rd Annual Meeting, San José, Costa Rica.

Caribbean Food Crops Society (2008). Proceedings 44th Annual Meeting, Miami Beach, Florida, USA.

Caribbean Food Crops Society (2009). Proceedings 45th Annual Meeting, Frigate Bay, St Kitts and Nevis.

Caribbean Food Crops Society (2010). Proceedings 46th Annual Meeting, Boca Chica, Dominican Republic.

Caribbean Food Crops Society (2011). Proceedings 47th Annual Meeting, St Michael, Barbados (in preparation).

Fortune, M (2009). Caribbean Plant Health Directors Forum – rationale and activities. Proceedings 45th Annual Meeting, Caribbean Food Crops Society, Frigate Bay, St Kitts and Nevis, 49 - 53.

Gongora, V (2010). Implications of the 2010 earthquake in Haiti for safeguarding the Caribbean against animal diseases. Proceedings 46th Annual Meeting, Caribbean Food Crops Society, Boca Chica, Dominican Republic, 57 - 62.

Krauss, V (2011). Trade in pet, aquarium and terrarium species as a significant source of invasive alien species in the wider Caribbean Region. Proceedings 47th Annual Meeting, Caribbean Food Crops Society, St Michael, Barbados (in preparation).

Lemly, J (2011). Achievements of Greater Caribbean Safeguarding Initiative and the way forward. Proceedings 47th Annual Meeting Caribbean Food Crops Society, St Michael, Barbados (in preparation).

Lockhart, B (2011). Major virus diseases that threaten banana production in the Caribbean Region. Proceedings 47th Annual Meeting, Caribbean Food Crops Society, St Michael, Barbados (in preparation).

Roberts, M R (2008). T-Star initiatives in support of invasive species efforts in the Greater Caribbean Region. Proceedings 44th Annual Meeting, Caribbean Food Crops Society, Miami Beach, Florida, USA, 57 – 68.

Serra, C (2011). Impacts of recently emerged IAS and major threats to the Dominican agriculture. Proceedings 47th Annual Meeting, Caribbean Food Crops Society, St Michael, Barbados (in preparation).

Thomas, C (2009). The nexus of agricultural diversification, food security and safeguards against invasive alien species. Proceedings 45th Annual Meeting, Caribbean Food Crops Society, Frigate Bay, St Kitts and Nevis, 62 - 64.

Trotman, M (2009). The CARICOM Chief Veterinary Officers group: rationale, vision, terms of reference and modus operandi. Proceedings 45th Annual Meeting, Caribbean Food Crops Society, Frigate Bay, St Kitts and Nevis, 62 – 64.

Trotman, M (2010). CARIBVET: the Caribbean animal health network: a tool to facilitate control of emerging and exotic animal disease threats. Proceedings 46th Annual Meeting, Caribbean Food Crops Society, Boca Chica, Dominican Republic, 73 – 78.

Trotman, M (2011). Achievements of CARIBVET and the way forward. Proceedings 47th Annual Meeting, Caribbean Food Crops Society, St Michael, Barbados (in preparation).

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REDUCING THE PARASITE BURDEN IN GOATS WITH TROPICAL LEGUMES

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ABSTRACT: The objective of the experiment was to evaluate the effects of supplementing bahiagrass hay (BG; *Paspalum notatum*) with perennial peanut (PP; *Arachis glabrata*), soybean (SB; *Glycine max*), cowpea (CP*; Vigna unguiculata*) and lespedeza (LES; *Lespedeza cuneata*) on infection by *Hemonchus contortus* and *Eimeria* sp. in goats. Forty naturally infected male kids (kiko x Spanish, 8 mo old, 23.8 ± 5.2 kg) were blocked by weight, placed in pens (two or three per treatment) and fed diets containing BG hay alone or BG hay supplemented with PP, SB, CP and LES at 50% of the diet. Body weight (BW) was measured on two consecutive days at the beginning and end of the trial. On day 0 and every seven days thereafter for 4 wk, blood-packed cell volume (PCV), fecal egg counts (FEC) and BW were recorded. Data was analyzed as a completely randomized block design. The model included the effects of treatment, week, and their interaction. The PDIFF statement of SAS with Tukey adjustment was used to evaluate means. Feeding PP, SB or LES hay ($P<0.05$) reduced gastrointestinal nematode FEC compared BG alone, but LES had the least values ($P<0.01$). Goats fed LES had lower ($P<0.01$) Eimeria FEC compared to to those with BG alone, and similar tendencies were evident for goats fed PP and SB ($P=0.08$, $P=0.06$). Legume supplementation increased PCV ($P<0.05$) compared to BG alone. There was no effect on average daily gain (ADG) for all treatments. We conclude that feeding LES resulted in the greatest reduction in total FEC and it also increased PCV. Feeding PP and SB reduced total FEC to a lesser extent and also increased PCV.

Keywords: Goat, parasite, legume, *Hemonchus*

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THE INVASIVE SPECIES *METAMASIUS CALLIZONIA* (MEXICAN BROMELIAD WEEVIL) PROBLEMS AND PROSPECTS

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ABSTRACT: The Mexican bromeliad weevil, *Metamasius callizona*, is an invasive bromeliad-eating weevil in Florida that has been destroying native bromeliad populations. Twelve of Florida's 16 native species are susceptible to attack by the weevil. All of Florida's native bromeliads are epiphytic and provide habitat for a myriad of organisms, some of which are precinctive. The best studied and most devastated of Florida's bromeliads is *Tillandsia utriculata*, a tank bromeliad that collects and holds water in the axils of its leaves. The water supports aquatic microcosms that are complex and composed of numerous and diverse organisms, several which are specialists in the phytotelmata of *T. utriculata*. Because of the weevil, Florida may lose up to12 species of bromeliads and nine to 19 invertebrates that rely on *T. utriculata* for their existence. One species of bromeliad (*T. simulata*) and up to five of the invertebrates that associate with *T. utriculata* are precinctive to Florida. As well, habitat and water sources will be removed from the canopy; in one study, 87% of a *T. utriculata* population was destroyed by the weevil in six months and more than 16,000 liters of water was removed from the canopy. Beginning in 1992, several searches were made for a classical biological control agent to control the weevil. No specialist parasitoids or other regulatory agents were found for *M. callizona*, but a parasitoid was found on a related species of bromeliad-eating weevil, *M. quadrilineatus*, in Honduras in 1993. The parasitoid is a tachinid fly, *Lixadmontia franki*, and is a specialist of bromeliad-eating weevils. The fly readily parasitizes *M. callizona* in the laboratory and we have been maintaining a fly colony reared on *M. callizona*. In 2007, we received permission to release the fly and, after several releases, we have had only a single recovery. To improve post-release monitoring methods, we are studying the antennal response of *L. franki* to bromeliad and host weevil volatiles to build a better detection method. In Florida, the weevil has greater abundance on *T .utriculata* than on another large, once widespread species, *T. fasciculata*. In Central America, *T. utriculata* grows in the presence of the weevil without the devastation experienced in Florida. Preliminary studies have begun to understand the differences between host species (*T. fasciculata* versus *T. utriculata* in Florida) and varieties (*T. utriculata* in Florida versus *T. utriculata* in Central America) and how these differences affect the weevil's demographics. Such research may lead to the development of a variety of *T. utriculata* in Florida that is more resistant to the weevil. The weevil is also a pest of ornamental bromeliads and pineapple. The research we do in Florida will be useful to natural resource conservation and the pineapple production industry, particularly in the event that *M. callizona* might colonize and become established in un-infested lands, such as Puerto Rico which have a rich bromeliad fauna and a pineapple industry.

Keywords: Bromeliads, bromeliad-eating weevils, phytotelmata, classical biological control, host plant resistance, invasive species

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EVALUATION OF THE POTENTIAL INVASIVENESS OF MULATO GRASS IN FLORIDA

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ABSTRACT: Mulato (*Brachiaria* sp.) is the first hybrid of the *Brachiaria* species and was introduced into Florida in 2002 as potential forage for livestock. The objective of this research project was to evaluate the potential invasiveness of Mulato in Florida. Experiment 1 was a greenhouse study to test the persistence of Mulato under different periods of flooding conditions. The plots were saturated with water above the field capacity from 0 to 21 d in 7 d increments. Increasing flooding period decreased forage production ($P = 0.03$, SE = 5, 57% decrease from 0 to 21 d) and decreased the stand ($P = 0.08$, SE = 7, 33% decreased from 0 to 21 d). It was noted that 67% of the plants could recover after 21 d of flooding. Increasing flooding period decreased seed production ($P = 0.01$, SE = 14, decreased 43% from 0 to 21 d flooding) during the experimental period (90 d), but did not affect seed germination ($P = 0.83$, SE = 7, Mean = 3%). The low seeding germination rates indicated that Mulato has limited capacity to reproduce by seeds in a range of soil moisture conditions. Experiment 2 was a field trial to evaluate the effectiveness of different herbicides to control Mulato. Glyphosate (3.3 kg/ha) was the most effective among the herbicides tested with 90% control. In experiment 3, Mulato pastures were grazed by beef heifers at different stocking rates (4, 8, and 12 heifers/ha) and plots were harvested at different regrowth intervals (2 or 4 wk) and stubble heights (2.5, 7.5, and 12.5 cm). There was a quadratic response of increasing stocking rates on forage accumulation ($P = 0.03$, SE = 4, Mean = 106, 128, and 188 kg/ha/d for 4, 8, and 12 heifers/ha, respectively) and linear decrease in average daily gain of beef heifers ($P = 0.01$, SE = 0.4, Mean = 0.28, 0.26, 0.10 kg/d for 4, 8, and 12 heifers, respectively). Decreasing the harvest stubble height on Mulato plots decreased linearly ($P = 0.03$, SE = 7) the stand from 90 to 72% ground cover. In experiment 4, the persistence of Mulato and Tifton 85 bermudagrass (*Cynodon* sp.) was compared in plots planted in northern latitudes in Florida (29° N). There was greater ground cover one year after establishment for Tifton 85 than Mulato II perennial ($P < 0.10$, SE = 3, Mean = 73 vs. 36% for Tifton 85 and Mulato II, respectively). Two years after planting, Mulato had 12% cover, whereas Tifton 85 had 73% cover ($P < 0.001$, SE = 6). It is likely that Mulato may be an annual or biannual productive forage in northern latitudes in Florida. In conclusion, Mulato is a feasible forage for livestock in Florida with limited potential to be invasive due to the decreased seed production and germination, and reduced persistence under variable management conditions.

Keywords: Mulato, forage, persistence

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BIOLOGY AND MANAGEMENT OF SMUTGRASS (*SPOROBOLUS* SP.) IN SUB-TROPICAL AND TROPICAL REGIONS

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ABSTRACT: Smutgrass (*Sporobolus indicus*), a native of tropical Asia, is a serious perennial weed that affects many improved perennial grass pastures in Florida and throughout the southeastern United States. The two varieties of smutgrass predominant in Florida are small smutgrass (*Sporobolus indicus* var. *indicus*) and giant smutgrass (*Sporobolus indicus* var. *pyramidalis*). Seed germination experiments were conducted to determine the impact of environmental conditions on seed germination and emergence of smutgrass varieties. Temperature, water stress, and depth of burial were the factors that influenced germination; light and pH had little impact. Germination of small smutgrass and giant smutgrass was reduced at 33/24 C and 22/11 C, respectively. Small and giant smutgrass germination was inhibited at water potentials below -0.2 Mpa and when small smutgrass seed was placed below the soil surface. Emergence of giant smutgrass seeds did not occur below 3 cm. Impact of soil pH was tested for competitive ability of bahiagrass with smutgrass varieties. At the recommended soil pH level of 5.5, giant smutgrass was four times more competitive than bahiagrass, and bahiagrass was two times more competitive than small smutgrass. The three field experiments initiated in 2008 evaluated the effect of integrated long-term management strategies using both cultural and herbicide inputs for giant smutgrass control in bahiagrass pastures. Burning did not have a significant impact on long-term control. In 2011, no differences were observed when hexazinone was integrated with tillage or hexazinone was combined with nitrogen, compared to sequential or single applications of hexazinone. Trends in the data indicate that a sequential application of hexazinone may be better than introducing tillage. Nitrogen application after two weeks of hexazinone appears to have greater impact on reducing smutgrass re-infestation than hexazinone alone. Sequential hexazinone applications, when applied at 0.56 kg ha^{-1} or greater, tended to result in increased control as compared to single applications. It was concluded that environmental conditions present during summer or fall season favor growth of both smutgrass varieties. Giant smutgrass was more aggressive and competitive than bahiagrass and sequential applications of hexazinone may have more impact that implementing tillage practices in providing long-term smutgrass control.

Keywords: seed biology, germination, soil pH, competition, hexazinone, weed control

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REDUCING THE INVASIVE POTENTIAL OF THE BIOFUEL CROP NAPIERGRASS BY DEVELOPING SEEDLESS CULTIVARS

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ABSTRACT: Biofuels produced from lignocellulosic feedstocks are likely to displace substantial amounts of petroleum. The biofuels industry has identified napiergrass (*Pennisetum purpureum* Schum.) as one of the most productive feedstocks for lignocellulosic biofuel production in the southern US. Napiergrass also called elephantgrass has been introduced to all tropical and subtropical areas of the world because of its ability to produce large amounts of high quality forage biomass. However, napiergrass produces large amounts of wind-dispersed seeds and is listed as invasive (Category I) by the Florida Exotic Pest Plant Council. Plant propagation and establishment of new napiergrass plantings occurs through vegetative plant parts. Therefore, unlike most seeded crops, seed production is not necessary for napiergrass biomass production and its suppression will significantly reduce its potential for invasiveness. Pearl millet (*Pennisetum glaucum* L.) is one of the most drought-tolerant C4 grasses. Interspecific hybridization between napiergrass (tetraploid) and pearl millet (diploid) is expected to result in triploid hybrids with male and female sterility which will eliminate production of wind-dispersed seeds. Tall, stress-tolerant parents were chosen with the goal to generate interspecific hybrids with good productivity and persistence as well as male and female sterility. We produced more than 3000 triploid, interspecific hybrids between napiergrass and pearl millet. Phenotypic variability present in these hybrids allowed selecting seedless lines which produced similar or higher biomass amounts as the seed-producing napiergrass cultivar Merkeron. We will present data describing the seedless nature of the interspecific hybrids, their biomass yield and related traits during 2010 and 2011 under irrigated or non-irrigated conditions. The development of a genetic transformation protocol for sterile, interspecific hybrids, and the introduction of a flowering suppressor gene through transgenic technology will also be described.

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APPLICATION OF HIGH FIDELITY PCR IN THE PLANT DISEASE DIAGNOSTIC LAB

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ABSTRACT: To compare the sensitivity of High-Fidelity (Hi-Fi) and standard PCR in detecting plant pathogens in symptomatic host plant tissue, four DNA extraction methods were tested in conjunction with a standard and two Hi-Fi PCR protocols. The DNA extraction methods were: 1) Extract-N-Amp Plant Kit (Sigma-Aldrich); 2) DNeasy Plant Mini Kit (Qiagen), 3) CTAB buffer, and 4) lithium chloride Shorty buffer. Symptomatic tissues (i.e. leaf, petiole and root tissue) from selected diagnostic samples were submitted to each extraction method. DNA samples were then used for each PCR protocol applying species-specific primers: 1) Standard PCR; 2) Hi-Fi PCR using LongAmp enzyme; and 3) Hi-Fi PCR Taq+Accuzyme. DNA quantification using spectrophotometry indicated Extract-N-Amp and Shorty methods yielded the highest DNA amounts with lower purity. Both Hi-Fi PCR protocols were more sensitive than standard PCR. The Accuzyme protocol detected targeted plant pathogens in all samples using the DNeasy and Extract-n-Amp methods, whereas the standard protocol detected the pathogen only in leaf samples by using the DNeasy kit. This study demonstrates that Hi-Fi PCR provides a highly sensitive tool for molecular diagnostics *in planta*, and that the DNA extraction method influences PCR sensitivity.

Keywords: molecular diagnostic techniques, PCR, Hi-Fidelity PCR, pathogen detection

INTRODUCTION

The introduction of significant numbers of plant pathogens into Florida and Puerto Rico go unrecognized due to limitations in visual and current molecular protocols to identify regulated species. This year the plant diagnostic clinic at the University of Puerto Rico received on average 100 samples from various crops every month. Only 5% of those samples were sequenced for species identification. Another 10% of the samples were diagnosed as unknown etiology and remain unidentified. In addition, numerous plant diagnostic samples processed by clinics within the Florida Plant Diagnostic Network are diagnosed as "no pathogens found" (Palmateer, personal communication). Some of these samples may in fact be infected by a pathogen, thus emphasizing the need for more sensitive and effective measures for plant diagnostics.

Although a plant may exhibit symptoms that indicate the presence of a bacterial, fungal, or viral pathogen, in many cases no such symptoms exist, even though the pathogen may still be present in a latent state and go undetected by plant inspectors and diagnosticians. Environmental factors such as temperature and moisture are extremely critical in the disease process and more often than not pathogens remain dormant in plant tissue (Swanson et al., 2007). During this phase of dormancy it can be very difficult to isolate the pathogen using conventional diagnostic methods (i.e. tissue plating on artificial media), which may lead to a misidentification due to the presence of secondary fungi and bacteria or false negatives, either of which could be catastrophic in situations involving select agents. In addition, many pathogens are obligate parasites and cannot

be cultured on artificial media, thus requiring molecular diagnostic techniques like the Polymerase Chain Reaction (PCR) for confirmation. However, plant cellular contents (organic and inorganic compounds), including host genomic DNA can interfere with the efficiency of standard PCR (Vickers and Graham 1996; Vincelli and Tisserat 2008; Wilson 1997), making the diagnosis of plant disease directly from plant tissue using the PCR is extremely difficult and one of the most common limiting factors for obtaining accurate results.

The polymerase chain reaction (PCR) has become widely used since the discovery (Chien et al. 1976) and subsequent use of heat stable DNA polymerase for *in vitro* replication of DNA (Saiki et al. 1988). This alleviated the tedious task of adding fresh DNA polymerase at the beginning of each PCR cycle (Mullis & Faloona 1987), which led to the automation of the procedure through the production of programmable thermocyclers. The PCR is now used routinely to amplify DNA for phylogenetic studies (Chaverri et al 2005; Dettman et al. 2006; Stewart et al. 1999; Crous et al. 2001; Palmateer et al. 2003), genomic analysis (Arneson et al. 2008; Nadeau et al. 1992; Lashkari et al. 1997), plant disease diagnosis (Yokomi et al. 2008; Trout et al. 1997), and is used to examine genetic diversity within populations of plant pathogens (Zhang et al. 2005; Urena-Padilla et al. 2002; Winton et al. 2006). However, the Standard PCR is not efficient at producing long sequences, and is generally not able to produce sequences of more than 5 kb (Barnes 1994). The High-fidelity PCR (=Long PCR), which incorporates a second heat-stable DNA polymerase with 3'-exonuclease activity, has been shown to produce longer sequences than standard PCR, with a product size of up to 35-kb (Barnes 1994). The addition of the proofreading enzyme to the reaction containing an n-terminal deletion mutant of *Taq* polymerase was shown by Barnes (1994) to remove mismatched base pairs, allowing strand synthesis to proceed. The use of the proofreading enzyme alone did not amplify the target DNA, which may have occurred because of the degradation of the primers by the 3'-exonuclease activity of the enzyme when used in excessive amounts (Barnes 1994).

In addition to producing longer sequences than the Standard PCR, the High-fidelity PCR has been shown to efficiently amplify target DNA while in the presence of large amounts of genomic DNA, which can be from a host organism or from the target organism. Vickers and Graham (1996) were able to use a High-fidelity PCR protocol utilizing a DNA polymerase mixture containing *Taq* polymerase and a heat stable DNA polymerase with proof reading ability *(Pwo)* to amplify a single copy gene (*Bar*), a marker for the selection of transgenic plants, while in the presence of Barley genomic DNA. The High-fidelity PCR consistently amplified the target gene, while the Standard PCR only occasionally produced results. The High-fidelity PCR has also been shown to detect bacterial infections and microbial associations in numerous arthropod species. Jeyaprakash and Hoy (2000) demonstrated that the High-fidelity PCR was more sensitive than the Standard PCR in detecting *Wolbachia* infections in arthropods. When plasmids containing the *wsp* gene were amplified while in the presence of arthropod DNA, the High-fidelity PCR consistently amplified 1 fg of plasmid DNA containing the *wsp* gene while the Standard PCR could detect 1 ng of plamid.

Hoy et al. (2001) also showed that the High-fidelity PCR was more sensitive than Standard PCR in detecting the citrus greening pathogen '*Candidatus* Liberibacter asiaticus' while in the presence of genomic DNA from citrus psyllids, citrus trees, or citrus psyllid parasitoids. Furthermore, the High-fidelity PCR has been used to detect and characterize a new Microsporidium species from the predatory mite *Metaseiulus occidentalis* (Nesbitt) (Becnel et al. 2002), to identify and distinguish two parasitoids of the brown citrus aphid (Persad et al. 2004), to examine the microbial

diversity of *Metaseiulus occidentalis* and its prey, *Tetranychus urticae* (Hoy and Jeyaprakash 2005), and to amplify 16S ribosomal sequences of endotoxin producing bacteria in varying amounts of dust mite DNA (Valerio et al. 2005).

Plant disease diagnosticians rely on rapid and sensitive pathogen detection methods as a tool in their diagnostic arsenal. Our current research seeks to improve existing *in planta* molecular detection methods by comparing successful detection of pathogen DNA using several commonly used DNA extraction methods coupled with standard or High-Fidelity (Hi-Fi) PCR protocols using species specific primers for select pathogens. Hi-Fi PCR utilizes a proof reading DNA polymerase with *Taq* polymerase to increase product sizes as well as the sensitivity of the PCR reaction. It has been used to successfully detect *Candidatus* Liberibacter asiaticus in the psyllid vector *Diaphorina citri* (Hoy et al. 2001) and several pathogens from orchid tissue (Cating 2010). In the current study we demonstrated that Hi-Fi PCR is more sensitive than standard PCR in detecting *Phytophthora nicotianae* in symptomatic tissue of *Spathiphyllum*

OBJECTIVES

Both the Florida Extension Plant Diagnostic Clinic at the Tropical Research & Education Center and the diagnostic clinic at the University of Puerto Rico, Juana Diaz receive diseased plant samples representing a multitude of pathogens. These clinics serve their function as a valuable resource for the agricultural community by providing pathogen identification and disease management recommendations where appropriate. At the same time they are a viable means for researchers to monitor plant pathogen populations in the surrounding areas. We used this opportunity to investigate the following research objectives and thus the following procedures relied on both clinics for plant samples analyzed.

1) Compare DNA extraction methods including DNeasy Plant Mini Kit (Qiagen), Extract-N-Amp Plant Kit (Sigma-Aldrich), CTAB buffer with chloroform extraction and ethanol precipitation and Shorty buffer with isopropanol precipitation.

2) Determine whether the High-Fidelity PCR is more sensitive than the Standard PCR in detecting fungi, bacteria, and viruses from naturally infected plant species.

MATERIALS AND METHODS

DNA was extracted by using DNA extraction protocol 3 (below) and amplified by using the Standard PCR and High-fidelity PCR protocols (explained below) and the results compared. To quantify the differences between Standard and High-fidelity PCR, serially diluted plasmid DNA (1000 ng to 1 fg) will be spiked with 10 ng of plant genomic DNA. Two negative controls will be used, one containing the plant genomic DNA alone, the other without DNA. All reactions will be replicated three times.

DNA extraction protocols

The following protocols (1 and 2) were used to extract genomic DNA from plant host tissue.

1) Plant DNA: 3.866 g of leaf tissue was frozen in liquid nitrogen and ground in 8 ml of CTAB buffer (2% cetyltrimethylammonium bromide, 100 mMTris pH 7.5, 20 mM EDTA, 1% polyvinyl pyrrolidone, and 1.4 M NaCl) for 10 min and aliquoted into eight tubes. The samples were then incubated at 60ºC for 16 h. After two chloroform extractions, the eight DNA aliquots were combined into four and precipitated in 2-propanol and resuspended in 100 µL sterile water. All samples were pooled to make a 400 µL sample of genomic orchid DNA. Plant DNA was quantified by using an Eppendorf BioPhotometer G131 V1.35 (Eppendorf, Hamburg, Germany).

2) The leaf spot fungus *Pseudocercospora odontoglossii* was isolated from a *Cattleya* hybrid and identified based on morphological characters (Ellis 1976; Crous and Braun 2003) and host. Single spores were grown on V-8 juice agar for two weeks at 25° C under artificial light at 12L:12D photoperiod. A section of mycelium approximately 2 X 2 cm was scraped from the surface of the plate with a sterile wooden applicator stick and placed in a 0.5-mL tube. Then 100 µL of Extraction Solution (Extract-n-Amp, Sigma-Aldrich, St. Louis, MO) was added and the sample ground for 5 min with a sterile plastic pestle and heated to 95° C for 10 min. We added 100 µL of dilution solution (Extract-n-Amp, Sigma) to the sample; then the sample was briefly vortexed. Finally, 30 µL of the extracted DNA was added to 270 µL of sterile water (Harmon et al. 2003).

In order to compare the use of the High-fidelity PCR and the Standard PCR in the diagnosis of plant diseases, several types of commonly cultivated tropical foliage plants were inoculated with bacterial and fungal pathogens by using standard procedures. The DNA from these plants was extracted by using protocol 3:

3) A cork borer (~6 mm in diameter) was used to cut a section of plant material. The plant section will be placed in a 0.5-mL tube and the tissue will be frozen in liquid nitrogen and ground with a sterile plastic pestle for 5 min, after which time 100 µL of extraction solution (Extract-n-Amp, Sigma-Aldrich) will be added and heated to 95° C for 10 min. Then 100µL of dilution solution (Extract-n-amp, Sigma-Aldrich) will be added, and the sample briefly vortexed. Finally, 30µL of the extracted DNA will be added to 270 µL of sterile water (Harmon et al. 2003). After DNA extraction, the Standard and High-fidelity PCR reactions will be performed using the following protocols with the appropriate primers.

Total Plant RNA Extraction

Total plant RNA was extracted using a modified RiboPure Kit protocol.

Homogenization:

1. Homogenize 0.1 g of tissue samples in Liquid nitrogen using sterile pestle and mortar.
2. Re-suspend in 500 µl of TRI Reagent.
3. Incubate the homogenate for 10 min at room temp.
4. Centrifuge at 13,000 rpm for 15 min at 4° C and transfer the supernatant to a new tube.

RNA Extraction:

1. Add 100 µL of BCP to 1 mL of homogenate and mix well.
2. Incubate the homogenate for 10 min at room temperature.
3. Centrifuge at 13,000 rpm for 15 min at 4° C
4. Transfer aqueous phase to a new 1.5-mL micro centrifuge tube.

Final RNA Purification:

1. Add 200 µL of 100% ethanol and mix immediately.
2. Pass the sample through a Filter Cartridge.
3. Wash the filter twice with 500 µL of Wash Solution. Centrifuge one minute at 8,000 rpm.
4. Transfer the filter to a new eppendorf tube.
5. Elute RNA with 50 µL Elution Buffer and freeze until concentration reading.

Standard PCR protocol

Standard PCR will be performed using DNA extracted from inoculated plants and plants with suspected diseases in a 25 µL reaction volume containing 2.5 µL of 10X PCR Buffer +Mg (Boehringer, Mannheim, Germany), 200 µM dATP, dGTP, dCTP, and dTTP, 400 pM of primers ITS4 and ITS5 (White et al. 1990) for fungi, and 16S primers (Weisburg et al. 1991) for bacteria and .2 units of *Taq* DNA polymerase (Bioline, Taunton, MA). Samples will be covered with 50µL of sterile mineral oil and amplified using the following temperature profile: (i) 94°C for 5 min; (ii) 35 cycles consisting of denaturing at 94° C for 30 s, annealing at 53° C for 30 s, and extension at 72° C for 1 min. (the described annealing temperature is for the fungal primers).

High-fidelity PCR protocol

High-fidelity PCR will be performed by using DNA extracted from inoculated plants and plants with suspected diseases in a 50 µL reaction volume containing 50 mM TRIS, pH 9.2, 16 mM ammonium sulfate, 1.75 mM$MgCl_2$, 350 µL dATP, dGTP, dCTP, and dTTP, 800 pmol of primers ITS4 and ITS5 (white et al. 1990) for fungi and 16S primers (Weisburg et al. 1991) for bacteria, 1 unit of Accuzume (Roche Molecular Biochemicals) and 5 units *Taq* DNA polymerase (Bioline) (Barnes, 1994). Samples will be covered with 100 µL of sterile mineral oil and amplified using three linked temperature profiles (i) 94° C for 2 min; (ii) 10 cycles consisting of denaturing at 94° C for 10 s, annealing at 53°C for 30 s, and extension at 68°C for 1 min; (iii) 25 cycles consisting of 94° C for 10 s, annealing at 53° C for 30 s, and extension at 68° C for 1 min plus an additional 20 s during each consecutive cycle (Hoy et al. 2001; Jeyaprakash and Hoy 2000) (the described annealing temperature is for the fungal primers).

Molecular cloning for DNA sequencing

In order to confirm the identity of the obtained PCR product, the target DNA sequences will be cloned using the TOPO T/A cloning kit (invitrogen, Carlsbad, CA) and sent for sequencing to the ICBR at the University of Florida, Gainesville, Florida. Before ligation into the cloning vector, PCR products will be cleaned using the QIAquick PCR purification kit (Qiagen, Valencia, CA) following the manufacturer's recommendations and eluted in 50 µL of sterile glass-distilled, glass-collected water. A 3' A-overhang will be added to the PCR product after purification to facilitate ligation into the cloning vector by mixing the 50 µL DNA sample with 5.75 µL 10X High-fidelity

buffer (50 mM TRIS, pH 9.2, 16 mM ammonium sulfate, 1.75 mM $MgCl_2$), 100 mMdATP, and 1 unit *Taq* polymerase (Bioline). The reaction will be placed in a thermocycler at 72°C for 45min. The product will be immediately cloned into the TOPO T/A cloning vector following the manufacturer's recommendations (Invitrogen Corporation, Carlsbad, CA), and *Escherichia coli* cells will be transformed with the recombinant plasmid. *E. coli* colonies will be selected from plates containing X-GAL, IPTG, and ampicillin and grown overnight in LB broth containing ampicillin at 37°C. Plasmids will be extracted using the Qiagen Plasmid Mini Prep Kit (Qiagen, Valencia, CA) and digested with *Eco*RI restriction enzyme followed by gel electrophoresis on a 2% agarose TAE gel stained with ethidium bromide to confirm the correct size of the insert.

RESULTS AND DISCUSSION

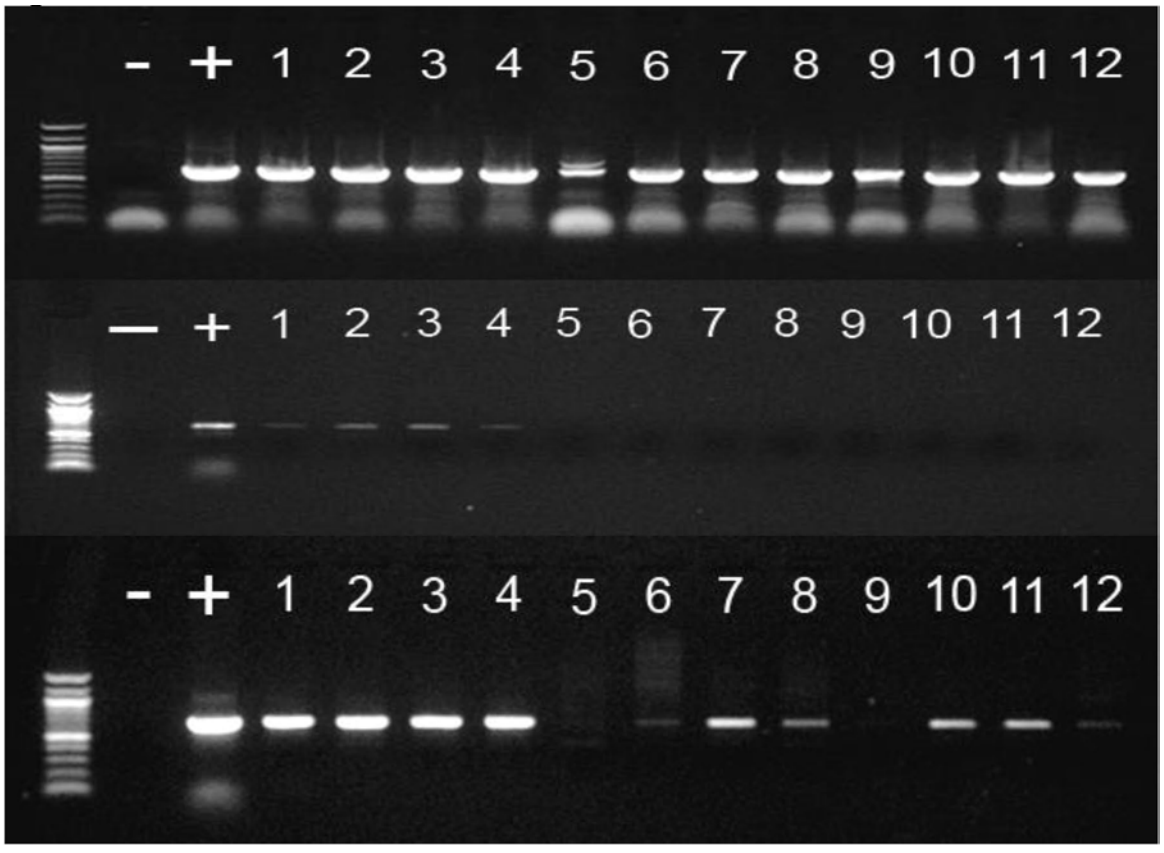
With the Extract-n-Amp and CTAB extractions only Hi-Fi PCR using Accuzyme coupled with DNAeasy and Extract-N-Amp extraction positively detected *P. nicotianae* DNA in all samples of all tissues (Figure 2). Accuzyme Hi-Fi PCR also produced positives for the majority of samples using CTAB extraction. LongAmp Hi-Fi PCR detected the pathogen for the majority of samples for all DNA extraction methods except the Shorty protocol (Figure 2). Standard PCR only detected the pathogen for leaf samples using Dneasy extraction. Extraction with Shorty buffer did not produce any positive detection of the pathogen from any sample save a single leaf sample using Accuzyme Hi-Fi PCR.

These results indicate that Hi-Fi PCR is a more sensitive in detecting pathogen DNA from symptomatic host tissue samples. Our study also indicates that a quick DNA extraction method like the Extract-N-Amp kit produces similar results as a longer method like the DNeasy Kit, even though DNA purity may be lower. The Extract-N-Amp protocol also requires minimal tissue processing.

The advantage of Hi-Fi PCR is that it is similarly easy to run as Standard PCR and does not require special equipment, making it less costly than other molecular detection methods that confer increased detection sensitivity, like real-time PCR. When combined with species-specific primers, this detection method enables diagnosis of specific pathogens directly from plant tissue in a matter of hours, which is especially useful for time sensitive disease problems.

In the future we plan to implement the Hi-Fi detection method for other important pathogens in south Florida, including citrus greening, lethal yellowing of palms, and laurel wilt of avocado.

Figure 1.

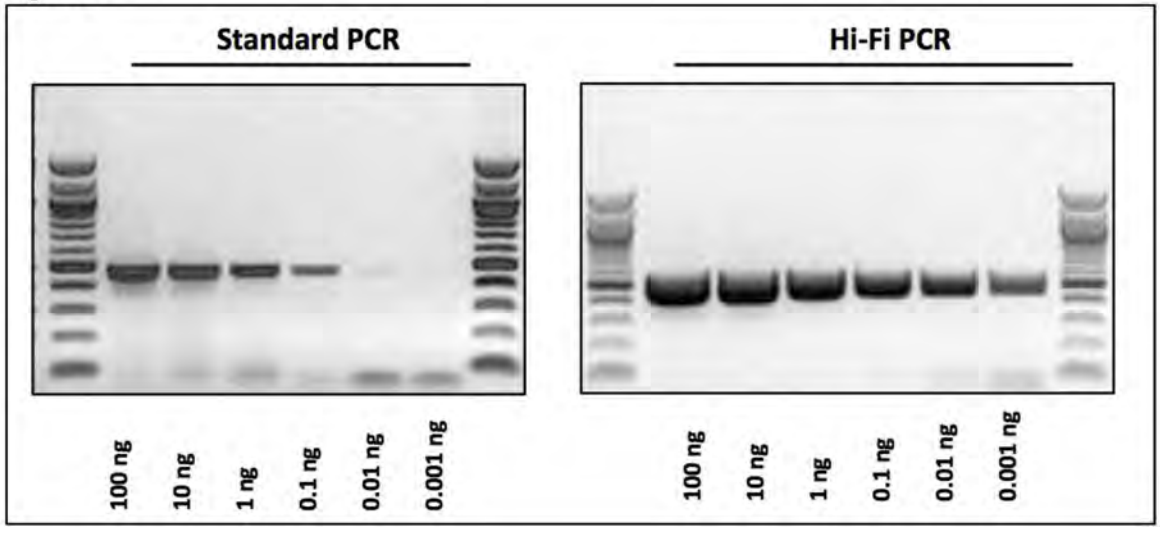


Only Hi-Fi PCR using Accuzyme coupled with DNAeasy and Extract-N-Amp extraction positively detected *P. nicotianae* DNA in all samples of all tissues. Accuzyme Hi-Fi PCR also produced positives for the majority of samples using CTAB extraction. LongAmp Hi-Fi PCR detected the pathogen for the majority of samples for all DNA extraction methods except the Shorty protocol. Standard PCR detected only the pathogen for leaf samples using Dneasy extraction. Extraction with Shorty buffer did not produce any positive detection of the pathogen from any sample save a single leaf sample, using Accuzyme Hi-Fi PCR.

Table 1. Average DNA quantity and purity ratio for four different DNA extraction methods on symptomatic leaves, petioles and roots of *Spathiphyllum* sp. inoculated with *P. nicotianae*

	Leaves		Roots		Petioles	
	DNA quantity (ug/ml)	Purity ratio	DNA quantity (ug/ml)	Purity ratio	DNA quantity (ug/ml)	Purity ratio
Qiagen	1.74	1.70	1.08	1.64	0.81	1.82
Extract-N-Amp	13.05	0.80	22.02	0.89	16.62	0.86
CTAB	16.71	1.86	8.26	1.72	2.05	1.87
Shorty buffer	7.66	0.99	4.29	1.22	1.56	1.25

Figure 2



ORSV Primers: (expected band of 474 bp) with Tm 48°C.
CP-Forward 1: 5' ATGTCTTACACTATTACAGACCCG'3
CP-Reverse 1: 5' GGAAGAGGTCCAAGTAAGTCC '3

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REFERENCES

Arneson, N., Hughes, S., Houlson, R., and Done, S. 2008. Whole-genome amplification by degenerate oligonucleotide primed PCR (DOP-PCR). CSH Protocols doi:10.1101/pdb.prot4919

Barnes, W. M. 1994. PCR amplification of up to 35-kb DNA with high fidelity and high yield from λ bacteriophage templates. *Proc. Natl. Acad. Sci.* 91:2216-2220.

Becnel, J. J., Jeyaprakash, A., Hoy, M. A., and Shapiro, A. 2002. Morphological and molecular characterization of a new microsporidium species from the predatory mite *Metaseiulus occidentals* (Nesbitt) (Acari,Phytoseiidae). *Journal of Invertebrate Pathology* 79:163-172.

Cating, R.A., J. Hong, C.S. Stiles, A.J. Palmateer, and E. Dickstein. First report of bacterial soft rot caused by Dickeya chrysanthemi on Vanda orchids in Florida. *Plant Disease*

Chaverri, P., Samuels, G.J., and Hodge, K. T. 2005. The genus *Podocrella* and its nematode-killing anamorph Harposporium. *Mycologia* 97:433-443.

Chien, A., Edgar, D. B., and Trela, J. M. 1976. Deoxyribonucleic acid polymerase from the extreme thermophile*Thermus aquaticus*. *Journal of Bacteriology* 127:1550-1557.

Crous, P. W., Kang, J., and Braun, U. 2001. A phylogenetic redefinition of anamorph genera in *Mycosphaeraella* based on ITS rDNA sequence and morphology. *Mycologia* 93:1081-1101.

Crous, P. W., and Braun, U. 2003. Mycosphaerella and its anamorphs: 1. Names published in *Cercospora* and *Passalora*. Centraalbureau voor Schimmelcultures, The Netherlands.

Dettman, J. R., Jacobson, D. J., and Taylor, J. W. 2006. Multilocus sequence data reveal extensive phylogenetic species diversity within the *Neurospora discreta* complex. *Mycologia* 98:436-446.

Ellis, M. B. 1976. More Dematiaceous Hyphomycetes. CAB International, New York, NY.

Harmon, P. F., Dunkle, L. D., and Latin, R. 2003. A rapid PCR-based method for the detection of *Magnaporthe oryzae* from infected perennial ryegrass. Plant Dis. 87:1072-1076.

Harrison, N. A. and M. L. Elliot, 2007. Texas Phoenix Palm Decline. EDIS PP#243

Harrison, N. A. and M. L. Elliot, 2008. A Lethal Phytoplasma Disease of *Sabal palmetto* on Florida's Central West Coast. University of Florida – IFAS, Fort Lauderdale Research and Education Center July 2008 research report.

Hoy, M. A., Jeyaprakash, A., and Nguyen, R. 2001. Long PCR is a sensitive method for detecting *Liberobacter asiaticum* in parasitoids undergoing risk assessment in quarantine. *Biological Control* 22:278-287.

Hoy, M. A., and Jeyaprakash, A. 2005. Microbial diversity of the predatory mite *Metaseiulus occidentalis* (Acari: Phytoseiidae) and its prey, *Tetranychus urticae* (Acari: Tetranychidae). *Biological Control* 32:427-441.

Jerardo, Alberto. 2006. Floriculture and Nursery Crops Outlook, FLO-05. Economic Research Service, United States Department ofAgriculture.

Jeyaprakash, A., and Hoy, M.A. 2000. Long PCR improves *Wolbachia* DNA amplification: *wsp* sequences found in 76% of sixty-three arthropod species. *Insect Molecular Biology* 9:393-405.

Lashkari, D. A., McCusker, J. H., and Davis, R. W. 1997. Whole genome analysis: experimental access to all genome sequenced segments through larger-scale efficient oligonucleotide synthesis and PCR. PNAS 94:8945-8947.

Lawson, R.H. 2002. Viruses and their control. In: Orchid pests and diseases. Ed. Watson, J.B. American Orchid Society, Delray Beach, FL.

Lee SC, Chang YC. 2006. Multiplex RT-PCR detection of two orchid viruses with an internal control of plant nad5 mRNA. Plant Pathology Bulletin 15: 187-196.

Mullis, K. B. and Faloona, F. A. 1987.Specific synthesis of DNA *in vitro* via a polymerase-catalyzed chain reaction. *Methods Enzym.* 155:335-350.

Nadeau, J. H., Bedigian, H. G., Bouchard, G., Denial, T., Kosowsky, M., Norberg, R., Pugh, S., Sargeant, E., Turner, R., and Paigen, B. 1992. Multilocus markers for mouse genome analysis: PCR amplification based on single primers of arbitrary nucleotide sequence. *Mammalian Genome* 3:55-64.

Palmateer, A. J., McLean, K. S., and Morgan-Jones, G. 2003. Concerning *Phomopsis gossypii*, the causal organism of boll rot of cotton. *Mycotaxon* 87:157-172.

Persad, A. B., Jeyaprakash, A., and Hoy, M. A. 2004. High-fidelity PCR assay discriminates between immature *Lipolexis oregmae* and *Lysiphlebus testaceipes* (Hymenoptera: Aphidiidae) within their aphid hosts. *Florida Entomologist* 87:18-24.

Roche Titan One Tube System by Roche Diagnostics Corp., Chicago IL.

Saiki, R. K., Gelfand, D. H., Stoffel, S., Scharf, S. J., Higuchi, R., Horn, G. T., Mullis, K. B., and Erlich, H. A. 1988. Primer-directed enzymatic amplification of DNA with a thermostable DNA polymerase. *Science* 239:487-491.

Schaad, N.W., Frederick, R.D., Shaw J., Schneider, W.L., Hickson, R., Petrillo, M., and Luster, D.G. 2003. Advances in molecular based diagnostics in meeting crop biosecurity and phytosanitary issues. *Annu. Rev. Phytopathology* 41:305-324.

Stewart, E. L., Liu, Z., Crous, P. W., and Szabo, L. J. 1999. Phylogenetic relationships among some cercosporoid anamorphs of *Mycosphaerella* based on rDNA sequence analysis. *Mycol. Res.* 103:1491-1499.

Swanson, J.K., Montes, L. Mejia, L., and Allen, C. 2007. Detection of latent infections of *Ralstonia solanacearum* race 3 biovar 2 in geranium. *Plant Disease* 91:828-834.

Trout, C. L., Ristaino, J. B., Madritch, M., and Wangsomboondee, T. 1997. Rapid detection of *Phytophthora infestan*s in late-blight infected potato and tomato using PCR. *Plant Dis.* 81:1042-1048.

Urena-Padilla, A. R., MacKenzie, S. J., Bowen, B. W., and Legard, D. E. 2002. Etiology and population genetics of *Colletotrichum* spp. Causing crown and fruit rot of strawberry. *Phytopathology* 92:1245-1252.

Vickers, J. E., and Graham, G. C. 1996. A protocol for the efficient screening of transformed plants for *bar*, the selectable marker gene, using the polymerase chain reaction. *Plant Molecular Biology Reporter* 14:363-368.

Valerio, C. R., Murray, P., Arlian, L. G., and Slater, J. E. 2005. Bacterial 16S ribosomal DNA in house dust mite cultures. *J. Allergy Clin. Immunol.* 118:1296-1300.

Vincelli, P and Tisserat, N. A. 2008. Nucleic acid-based pathogen detection in applied plant pathology. *Plant Dis.* Vol. 92 No.5:660-669.

Weisburg, W. G., Barns, S. M., Pelletier, D. A., and Lane, D. J. 1991. 16S ribosomal DNA amplification for phylogenetic study. J. Bacteriol. 173:697-703.

White, T. J., Bruns, T., Lee, S., and Taylor, J. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. Pages 315-322 In: PCR Protocols: A guide to methods and applications. M. A. Innis, D. H. Gelfand, J. J. Sninsky, and T. J. White, eds. Academic Press, San Diego, CA.

Wilson, I. G. 1997. Inhibition and facilitation of nucleic acid amplification. *Appl. Environ. Microbiol.* 63:3741-3751.

Winton, L. M., Hansen, E. M., and Stone, J. K. 2006. Population structure suggests reproductively isolated lineages of *Phaeocryptopus gaeumannii*. *Mycologia* 98:781-791.

Yamane, Y., Oyama, K., Iuchi, E., Qgawa, H., Suzuki, T., Natsuaki, T. 2008. RT-PCR detection of *Odontoglossum* ringspot virus, *Cymbidium* mosaic virus and Tospoviruses and association of infections with leaf-yellowing symptoms in Phalaenopsis. *J. Phytopathol.* 156: 268-273

Yokomi, R. K., Mello, A. F. S., Saponari, M., and Fletcher, J. 2008. Polymerase chain reaction based detection of *Spiroplasma citri* associated with citrus stubborn disease. *Plant Dis.* 92:253-260.

Zhang, J. X., Fernando, W. G. D., and Remphrey, W. R. 2005. Genetic diversity and structure of the *Apiosporina morbosa* populations on *Prunus* spp. *Phytopathology* 95:859-866.

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ECONOMIC POTENTIAL OF PRODUCING TAHITI LIMES IN SOUTHERN FLORIDA IN THE PRESENCE OF CITRUS CANKER AND GREENING

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ABSTRACT: Currently the U.S. is the largest single country importer of fresh limes absorbing close to 20% of global trade of limes and lemons in 2009. Of the 365 thousand metric tons of limes consumed in the USA in 2010; imports accounted for about 99%. The vast majority (more than 90%) of the lime import is supplied by Mexico—the world leading producer and exporter of limes- with the remainder being sourced from suppliers in Central and South American countries. The overwhelming dependence on imports to satisfy domestic demand for fresh limes was not always the case. As recently as 1990 the US satisfied more than half of its domestic needs from local production with production occurring in the extreme parts of south Florida (Miami Dade County) and parts of southern California. The noticeable shift in degree of lime self sufficiency is attributed to several factors. Among such factors were increased foreign competition, devastating hurricane and outbreaks of pests and diseases. The latter, considered to be the worst of the three, involved the discovery of two devastating citrus diseases present in Florida, namely citrus canker and citrus greening. Efforts to rid the production areas of citrus canker led to an aggressive program of eradication beginning in 2002 involving the destruction of all citrus trees grown in Miami Dade County and enforcement of regulations prohibited the growing of any citrus trees (commercial or otherwise). Although since 2006 the program has been abolished, after being deemed cost-ineffective, and production restrictions removed, growers have been reluctant to restart production because of substantial losses they incurred and uncertainty surrounding growing the crop in the presence of the diseases. However, recent events are causing many of the growers to take a second look at the prospects of producing and reentering the market for Tahiti limes. For one, supplies of limes from Mexico have been experiencing frequent interruptions causing shortage of limes on the domestic market and consequential rise in prices. In addition demonstration plots of Tahiti limes at the University of Florida Tropical Research and Education Center, Homestead, which were planted in 2006, have shown that reasonable yields of Tahiti limes can be obtained despite the presence of the diseases. And finally, disappointing returns from other tropical fruits are forcing many growers to actively search for profitable alternatives. Given the renewed interest in Tahiti lime production, the aim of this paper is to assess the downside risks involved in producing limes in the southern Florida region in the presence of these two invasive species. To account for the uncertainty associated with the presence of the diseases, use is made of stochastic budgeting technique and Monte Carlo simulation involving the modeling of stochastic prices and yields. The investigation is carried out for a hypothetical 5-acre lime orchard in southern Florida. The probability of the Net Present Value (NPV) being positive (an indicator of profitability of the investment) is investigated.

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MODELING THE CONTROL SPREAD OF INVASIVE SPECIES (*MIMOSA PELLITA* AND *MELALEUCA QUINQUENERVIA*) OVER HETEROGENEOUS LANDSCAPES IN PUERTO RICO

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ABSTRACT: The spread of an invasive species depends, among other things, on the nature of its dispersal strategies and on the characteristics of the environment it invades. The present study takes into account the interaction of these two factors to run spatially explicit simulations of the dispersal rate of two invasive plant species (*Mimosa pigra* and *Melaleuca quinquenervia*) in Puerto Rico. The overall goal is to understand —and help decide on— the best way to control their rate of spread. *Suitability map.* Two spatially-indexed data sets were used to estimate the suitability maps. The first is a vector layer indicating the presence or absence of each species in the surveyed pixel. The second is a complete temperature, precipitation, altitude, and geology set of raster layers for Puerto Rico. A logistic regression was estimated in R using presence/absence as the dependent variable and the other variables as explanatory variables. Standard errors were corrected to take into account spatial autocorrelation. The estimated model was then used to predict the likelihood that the invasive species will be present in each pixel given the values for the explanatory variables in that pixel. This number between 0 and 1 can be interpreted as an index of how suitable each pixel is for the invasive species. The suitability data were then exported to a computational framework (MDiG) for modeling purposes. *Rate of spread.* The rate of spread was modeled on MDiG using cellular automata to simulate short distance dispersal and draws from several probability distributions to simulate long distance dispersal. The impact of the environment on the survival of the invasive species is modeled with the use of the suitability map. Both modeling components are set up in a GIS framework known as GRASS. After calibrating the model, several Monte Carlo simulation experiments were run: one for each control measure and one in which no control measure was applied. A per-pixel cost was estimated for each control measure. Each Monte Carlo experiment consisted of repeating the simulation 100 times. The average infested area and the average control cost for PR was computed for each of these experiments. Treatments were then ranked according to their cost-effectiveness. The choice of treatment and the decision of where to apply the treatment had an impact on the cost-effectiveness of the control measures. *Other products.* The work on suitability maps was also used to compute elasticities with respect to each of the explanatory variables. These results were used to predict the suitability map corresponding to the new environmental conditions present after a hypothetical climate change exercise. On the other hand, modeling spread with MDiG had performance issues, especially when running Monte Carlo experiments. Because these problems were difficult to solve within MDiG, a new modeling environment was developed from scratch. It is written in C++ and is loosely coupled to GRASS. In addition, a hydrologic model of Puerto Rico was built to serve as the basis for a module aimed at modeling seed dispersal by hydrochory.

Keywords: invasive species, dispersal, heterogeneous environment, modeling, control, Puerto Rico

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FIRST REPORT OF BLACK SIGATOKA DISEASE (CAUSAL AGENT *MYCOSPHAERELLA FIJIENSIS*) FROM TOBAGO

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ABSTRACT: Black Sigatoka Disease of Bananas/Plantains (causal agent *Mycosphaerella fijiensis*) has been reported in Trinidad since 2003. This is a leaf spot disease, and infected plants generally produce reduced yield of poor quality fruit. Heavily infected plants may produce no yield at all. It is the most serious disease of bananas/plantains, and control entails expensive application of chemical fungicides. Tobago was surveyed in May 2005 and the disease was not detected on the island. Quarantine measures were put in place to prevent its introduction in Tobago. However, after recent reports of disease symptoms in isolated areas on the island, another survey was conducted from December 13 to 16 2011. Results showed that Tobago is infected with the disease but levels of infection vary in different parts of the island, thus suggesting that introduction in Tobago occurred recently. This is the first report of the disease in Tobago. The impact of Black Sigatoka Disease on the banana/plantain industry in Tobago, the estimated time and pathways of introduction together with a proposal for the management of the disease on the island are discussed.

INTRODUCTION

Black Sigatoka Disease of Bananas/Plantains has been reported in Trinidad since 2003 (Fortune *et al.*, 2005). This is a leaf spot disease (Plate 1) and infected plants generally produce reduced yield of poor quality fruit. Heavily infected plants may produce no yield at all. It is the most serious disease of bananas/plantains and control entails expensive application of chemical fungicides.

Tobago was surveyed by the Scientists of the Research Division, Ministry of Food Production, Land and Marine Affairs (MFPLMA) in May 2005 and the disease was not detected on the island. However, in recent times, there have been reports of symptoms of Black Sigatoka Disease in isolated areas on the island. It was important for Tobago to be surveyed again for the following reasons:

- To determine whether the island has retained its disease-free status
- To eradicate, if possible, any early signs of the disease
- A regional study is underway among scientists in the Caribbean to determine the spread of the disease in the region. Knowledge of the status of Tobago is vital for an understanding of the dynamics of spread.
- Internal Plant Quarantine arrangements between Trinidad and Tobago may have to be revised depending on the status of Tobago. Restrictions on trade in Bananas and Plantains may have to be lifted.

MATERIALS AND METHODS

The survey was conducted on a district basis. There are eight districts in Tobago and Table 1 indicates the dates on which each district was covered together with the local officers who assisted with the survey. In each district, the main roads were sampled every 2 to 3 km. Known Plantain and Banana farmers in each district were also visited. Samples were taken at all sites where leaf symptoms appeared. In all, 35 sites were sampled.

Table 1. Districts in Tobago included in survey, dates surveyed and relevant Tobago officers.

District	Date Surveyed	Main Tobago Officers Involved
Bethel	Tuesday 13th December 2011	Mr. Terrence Pope, Mr. Kenta John, Ms.Casey-Marie Boucher
Plymouth	Tuesday 13th December 2011	Mr.TerrencePope, Mr.Kenta John, Ms.Casey-Marie Boucher
Mt. St. George	Tuesday 13th December 2011	Mr.TerrencePope, Mr. Kenta John, Ms.Casey-Marie Boucher
Runnemede	Wednesday 14th December 2011	Ms.Casey-Marie Boucher, Ms. Duke, Mr. Kenta John,
Goldsborough	Wednesday 14th December 2011	Ms. Casey-Marie Boucher, Ms. Duke, Mr. Kenta John,
Belle Garden	Wednesday 14th December 2011	Ms.Casey-Marie Boucher, Ms. Duke, Mr. Kenta John,
Roxborough	Thursday 15th December 2011	Ms.Casey-Marie Boucher, Ms.JemDuke, Mr. Kenta John, Mr.Terrence Pope, Ms. KadieRobinson
Charlotteville	Thursday 15th December 2011	Ms.Casey-Marie Boucher, Ms.JemDuke, Mr. Kenta John, Mr. Terrence Pope, Ms.KadieRobinson

The level of infection at sites was noted using the following criteria:

- Youngest leaf with visible symptoms. Black Sigatoka symptoms on leaves 1 to 3 indicate severe infection.
- The stage of infection present. The presence of stages 4 and 5 on young leaves indicate a high level of infection.
- The presence of Yellow Sigatoka symptoms. The presence of Yellow Sigatoka indicates that Black Sigatoka has only recently been introduced in the area (within the last two years). Black Sigatoka usually displaces Yellow Sigatoka in time.

During the diagnostic procedure, slides for microscope examination were prepared using (1) the quick method of lifting fungal structures with clear sticky tape (Scotch tape) and placing same on a glass slide with cotton blue in lactophenol stain, and (2) the scraping of epidermal tissue of lesions and staining with cotton blue in lactophenol stain and covering with a glass cover slip. The slides were then examined for diagnostic *Mycosphaerella Fijiensis* conidiophores and conidia.

RESULTS AND DISCUSSION

The results of the survey are presented in Table 2. Black Sigatoka Disease was found to be widespread in Tobago. Of the 35 sites visited, 28 were positive for the presence of the disease. Infection levels were noticeably lighter in the Crown Point/Bon Accord area where some sites showed no symptoms of the disease (Map 1). In the North Eastern regions of the island, also, infection levels were light. Heaviest infection levels occurred in the mid-western part of the island from Buccoo to Runnemede. This area includes the most populous part of Tobago and its main town of Scarborough.

Both Black and Yellow Sigatoka symptoms were observed at sites in Runnemede, Belle Garden and Roxborough, all areas generally northeast of the populous areas of the island. The presence of Yellow Sigatoka suggests relatively recent introductions of Black Sigatoka in the area as Black Sigatoka tends to replace Yellow Sigatoka in two to three years.

From the results, the following may be inferred:

- Disease introduced from Scarborough port. The light infection in and around the airport at Crown Point and the seaport at Charlotteville suggests minimum traffic of diseased material in these areas.
- Disease may have been introduced two to three years ago, based on the presence of Yellow Sigatoka and large areas of light infection.
- The slow spread to the northeast of the island may be due in part to the prevailing wind direction, which blows from North-East. Wind is a major method of spread of the disease.
- Man has been a major vector for rapid spread.
- Quarantine needs to be improved on the island. Since its introduction in Trinidad in 2003, Tobago has been notified about the Black Sigatoka threat, extensive training of agricultural officers, quarantine officers and farmers were done and internal plant quarantine measures between the two islands were devised.

RECOMMENDATIONS

Black Sigatoka Disease is far too widespread at this time to attempt any eradication programme. Farmers traditionally do not apply any pesticides to control leaf diseases in *Musa* spp. in Tobago. To save the industry in the island, an aggressive management programme should be implemented. To this end, the following is recommended:

- A massive education and public awareness campaign needs to be implemented in the short term.
- Extension Officers to work closely with farmers for the coordinated development of management strategies. For control of this disease, it is important that large areas be controlled together as opposed to the individualism of farmers, bearing in mind the fact that the disease is transmitted by wind, water and human movement.
- A functioning diagnostic laboratory for pests and diseases needs to be developed on the island.
- Protocols for internal plant quarantine between the islands need to be developed to prevent subsequent waves of introductions of this and other exotic pests.
- Serious borer problems in Charlotteville were discovered (Plate 2) and assessed to be the major limiting factor to production in that area. This and other pests and diseases in *Musa* also need to be addressed for the development of the industry.

Table 2. Results of Tobago Survey for Black Sigatoka Disease (BS), 13-16 December 2011. YS=Yellow Sigatoka

DATE	LOCATION	TOWN	VARIETY	SIGATOKA STATUS
13/12/11	Store Bay Local Road	Crown Point	Plantain	Negative
13/12/11	Milford Road	Bon Accord	Plantain	Negative
13/12/11	Hope Farm Vet. Lab	Mt. St. George	French Plantain	Positive BS
13/12/11	Lp # 519 Village St. no. 2	Mt. St. George	Plantain	Positive BS
13/12/11	#29 Bacolet Point	Bacolet	French Plantain	Positive BS
13/12/11	Lp # 441 Windward Rd	Mt. St. George	Moko fig	Negative
13/12/11	Lp # 519 Mt. St. George Main Rd	Mt. St. George	Plantain	Positive BS
13/12/11	Studley Park Dump Rd	Mt. St. George	French Plantain	Positive BS
13/12/11	Belmont Branch Rd	Mason Hall	Plantain &Lacatan	Positive BS
13/12/11	Adelphi Rd	Mason Hall	Plantain	Positive BS
13/12/11	LP # 131 Tablepiece Rd	Los Coteaux	Lacatan	Positive BS
13/12/11	Dent Land Trace	Los Coteaux	Plantain	Positive BS
13/12/11	Fort Bennett Junction	Black Rock	Banana	Positive BS
13/12/11	#3 Cocrico Avenue	Buccoo	Horse Plantain	Positive BS
13/12/11	Lp # 4 A Evelina Tr. Audrey Gardens	Bon Accord	Lacatan	Positive BS
14/12/11	Richmond Main Rd	Richmond	Plantain	Positive BS
14/12/11	Lure Station	Goldsborough	Plantain &Lacatan	Positive BS
14/12/11	Goldsborough	Goldsborough	Plantain (Chico)	Positive BS
14/12/11	Runnemede Main Rd	Runnemede	Gros Michel	Positive BS
14/12/11	Runnemede Local Rd	Runnemede	Plantain &Lacatan	Positive BS Positive YS
15/12/11	Lp # 760 Belle Garden Main Rd	Belle Garden	Lacatan	Positive BS Positive YS
15/12/11	Lammy Rd	Lammy Rd	Plantain &Lacatan	Positive BS
15/12/11	Lp # 265 Roxborough Main Rd	Roxborough	Lacatan	Negative Positive YS
15/12/11	Lp # 902 Delaford Main Rd	Delaford	Lacatan	Negative
15/12/11	King's Bay Main Rd	King's Bay Main Rd	Plantain &Lacatan	Negative
15/12/11	Lp # 04286 Speyside Main Rd	Speyside	Lacatan	Positive BS
15/12/11	Charlotteville	Charlotteville	Plantain	Positive BS
15/12/11	Hermitage Main Rd	Hermitage	Plantain &Lacatan	Positive BS
15/12/11	L'anseFourmi Main Rd	L'anseFourmi	Lacatan, Silk, Gros Michel	Positive BS Positive YS
15/12/11	Bloody bay Main Rd	Bloody Bay	Plantain	Positive BS
15/12/11	Bloody bay Main Rd	Bloody Bay		Positive BS
15/12/11	Bloody Bay Main Rd	Bloody Bay	Plantain	Negative
15/12/11	Lp # 418 Castara Main Rd	Castara	Plantain &Lacatan	Positive BS
15/12/11	Louis D'or	Louis D'or		Positive BS
15/12/11	Lamby Rd		Banana	Positive BS

Map 1. Heavy and light infection areas of Black Sigatoka Disease in Tobago. Heavy infection areas are designated when sites sampled were consistently infected, disease symptoms were frequently visible on leaf number 3 and no symptoms of Yellow Sigatoka Disease were observed.

Plate 1. Field with heavy infection of Black Sigatoka Disease in Central Tobago.

Plate 2. Severe Borer infestation of Banana stool in Charlotteville, Tobago. Stool toppled and broke at base from infestation. Brown/black necrotic areas are tunnels made by the borer. Borer larva in centre indicated by pointed finger.

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REFERENCES

Fortune, M.; Gosine, S.; Chow, S.; Dilbar, A.; St. Hill, A.; Gibbs, H. and Rambaran, N. (2005) First Report of Black Sigatoka Disease (Causal Agent *Mycosphaerella fijiensis*). *Plant Pathology* 54, 246.

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RESEARCH UPDATE ON MANAGEMENT OF THE RED PALM MITE, *RAOIELLA INDICA* (ACARI: TENUIPALPIDAE)

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ABSTRACT: The red palm mite, *Raoiella indica* Hirst, is an important pest of coconuts, date palm, other palm species, and bananas in different parts of the world. Previous to its arrival in the New World, the mite was found in India, Philippines, Mauritius, Reunion, Malaysia, Israel and Egypt. *Raoiella indica* was found in Martinique and St. Lucia in 2004. During 2005, the mite was found in Dominica and during 2006 on the islands of Trinidad, Guadeloupe and Saint Martin, and in Puerto Rico. The mite spread to other islands in the Caribbean basin as well as to Florida, Venezuela, Brazil and Mexico. Research efforts were made to determine the host plants of these mites in the new world as well as sampling requirements. This effort was followed by testing effectiveness of acaricides both in coconuts and bananas. We screened different natural enemies for their effectiveness as predators of the red palm mite, and concluded that the phytoseiid mite, *Amblyseius largoensis*, was a key predator of *R. indica*. Studies were conducted on its reproduction and survival when preying on *R. indica*. We discuss the possibility of using pollen as an aid for augmentation of predator populations and fertilizer regimes to slow down mite development on its host plants.

Keywords: mites, coconuts, red palm mite, predators, acaricides

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RED PALM MITE, *RAOIELLA INDICA* HIRST (ACARI: TENUIPALPIDAE): A THREAT TO MORICHE PALM (*MAURITIA FLEXUOSA*) IN THE NARIVA SWAMP OF TRINIDAD

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ABSTRACT: The Red Palm Mite, *Raoiella indica* (Acari: Tenuipalpidae), is a severe invasive pest that affects economically and ecologically important plants in nurseries, landscape areas as well as plants in the natural environment of Trinidad and Tobago. It is a threat to a range of plant species within the Nariva Swamp inclusive of Arecales (Arecaceae; palm species) and Zingiberales (Heliconiaceae, Musaceae, and Zingiberaceae). The Nariva Swamp located along the east coast of Trinidad is an Environmental Sensitive Area and designated as a wetland of international importance. Within the swamp 10 of the 22 indigenous palm species exist. These palms comprise a major component of the vegetative biodiversity under different ecological environment. In order to capture the distribution of palm species and to determine the incidence of Red Palm Mite, the swamp was divided into coastline, intermediate and inland areas. GPS data were used to map the accessible palm clusters found in the three areas. Clusters of the 10 palm species together with coconut (*Cocos nucifera*) were surveyed at three different canopy levels to determine the incidence of the mite on the fronds. Moriche Palm (*Mauritia flexuosa*) a species of the Palm Swamp Forest, was the only indigenous palm found to be severely affected by the mite. All growth stages of this palm were found with high populations of mites and showed symptoms of yellowing and necrosis. Natural enemies found associated with the mite included low population levels of the predatory mite *Amblyseius largoensis* (Acari: Phytoseiidae) and lacewing (Chrysopidae). By extension, the existence of animals that are dependent on the Moriche Palm for food and habitation are threatened. These animals include Psittacidae, (blue and gold macaw (*Ara ararauna*), red-bellied macaw (*Ara macao*), yellow-headed parrot (*Amazona ochrocephala*) and the orange-winged parrot (*Ara manilata*) and Parotlets). Under greenhouse conditions, potted six-month-old Moriche Palm seedlings were infested by placing 50 field collected Red Palm Mite adult females on two marked leaves per plant to confirm the susceptibility to the mite. High populations of mites were found on the abaxial, adaxial and petiole surfaces of the Moriche Palm after three months. The severely infested seedlings exhibited symptoms of yellowing, necrosis and 10% death of plants. Healthy seedlings are important for the natural regeneration and sustainability of the Moriche Palm in the swamp. The high incidence of Red Palm Mite on Moriche and other hosts within the swamp could have resulted from the infestation of the large coconut plantations cultivated along the coastline forming a strip about 300 m wide and 22 km long that separates the Swamp from the Atlantic Ocean.

Keywords: Keywords: Mites, Invasive species, Nariva Swamp, Palm species, Moriche Palm, *Raoiella indica*

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A CITRUS GREENING REHABILITATION PROGRAM: DISEASE SURVEY, ASIAN CITRUS PSYLLID POPULATION MANAGEMENT, NATURAL ENEMY PROTECTION, AND IMPLEMENTATION OF OTHER DISEASE MANAGEMENT STRATEGIES TO AMELIORATE IMPACT, AND THE CREATION OF A NURSERIES CERTIFICATION PROGRAM FOR PRODUCTION OF FREE DISEASE PLANTS

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ABSTRACT: Citrus greening associated with *Candidatus* Liberibacter asiaticus (CLA) was first detected in November 2009 in northwest Puerto Rico. In this study five symptomatic and symptomless sweet oranges, lime, grapefruit, mandarin and "criollo" orange were collected in 23 municipalities. Disease incidence was high in sweet oranges and mandarins at Isabela and oranges from Santa Isabel, where tree decline was observed. Total DNA was extracted from midribs with DNeasy Plant Mini Kit, (Qiagen, Gmbh. Hilden, Germany). Polymerase chain reaction (PCR) with primers OI1 and OI2 was performed, and an amplicon of approximately 1160 bp was obtained. Six percent of the samples (total of 546) were positive for the bacterium *Candidatus* Liberibacter asiaticus. Until 2012 the disease was not detected in Arecibo, Cayey, Guanica, Ciales, Morovis, Sabana Grande, Utuado, Villalba and Yauco. Fourteen percent of 330 samples were positive for Citrus Tristeza Virus. The Asian Citrus psyllid (ACP) in addition to its role as the vector of CLA, also affects the host by sap removal causing leaf distortion and curling of the young growth of the developing shoots. In Puerto Rico natural enemies, such as the ladybird beetles (ladybugs) and the parasitic "avispilla" *Tamarixia radiata* have been identified. Foliar applications of seven commercial insecticides were evaluated in a lemon orchard 'Tahiti' located in the EEA of Juana Díaz: (1) azadirachtin (32 oz ai/gal); (2) zeta-cypermethrin (0.05 lb ai/acre); (3) dimethoate (16 oz ai/acre); (4) imidacloprid (7 ai oz/acre); (5) spinetoram (0.188 lb ai/acre); (6) spirotetramat (0.31 lb ai/acre); (7) abamectin (20 oz ai/acre); and an un-sprayed control. In a replicated experiment consisting of three randomized blocks, with four trees per treatment. Results indicate that imidacloprid, abamectin, permethrin, and spinetoram decreased the number of ACP adults, and are potentially the most effective. Abamectin, spinetoram and permethrin were the most effective against immature psyllids. The effect of these pesticides on the natural enemies varied. Azadirachtin and spirotetramat resulted in low mortality of adult ladybeetles, comparing favorably with the control. Imidacloprid, abamectin and azadirachtin were the less detrimental to ACP parasitoid *T. radiata*. Replicated field experiments were planted in 2010 to determine the effect of guava as a barrier crop and mechanical barrier, and *Murraya paniculata* as a trap plant treated with the systemic imidacloprid at monthly intervals. Significant reductions were found in the number of adults of the psyllid when treated *Murraya paniculata* was located near Tahiti lime. A certification program to produce disease-free citrus seedlings and clean stock is being implemented. Protocols for the detection of citrus canker, citrus tristeza, citrus variegated chlorosis, citrus black spot and citrus greening are included. Producing disease-free plants from mother trees which have been indexed and certified for the absence of graft-transmissible pathogens, and effective management of ACP populations are essential to restore citrus production.

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EL ROL DE CONTROLADORES NATURALES DE PLAGAS ARTRÓPODAS CLAVES EN IMPORTANTES VEGETALES ORIENTALES Y EL POTENCIAL DE SU INTEGRACIÓN

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RESUMEN: Los vegetales orientales son de mucha importancia socio-económica para las zonas productoras dominicanas con un valor de exportación mayor a US$60 millones anuales. Debido a las altas tasas de rechazo de vegetales exportados (residuos de plaguicidas y anteriormente a plagas cuarentenarias) fue necesaria la evaluación de plaguicidas selectivos y/o de baja toxicidad/residualidad de origen orgánico, microbiológico o químico-sintético, lo que serviría para establecer un programa MIP en dichos vegetales. Desde el año 2003 hemos realizado más de 12 ensayos en fincas de productores en el marco de un proyecto financiado por el Consejo Nacional de Investigaciones Agropecuarias y Forestales y el apoyo de la Universidad Autónoma de Santo Domingo y productores (ADEXVO). En estudios iniciales se compararon tres sistemas de manejo fitosanitario en vainitas chinas (*Vigna sesquipedalis*), berenjena china (*Solanum melongena*) y Cundeamor (*Momordica charantia*): 1) Control Natural (sin tratamientos), 2) Plaguicidas selectivos alternados y/o de baja toxicidad (MIP), y 3) Convencional (prácticas del productor). Mediante conteos periódicos y trampas amarillas pegantes se dio seguimiento a poblaciones de los principales fitófagos (áfidos, trípidos, moscas blancas, cicadélidos, moscas minadoras, crisomélidos, polillas, entre otras) en función de enemigos naturales asociados (chinches antocóridos, crisópidos, taquínidos, microhimenópteros), pudiéndose elaborar un inventario amplio de artrópodos asociados a vegetales orientales. Se pudo constatar que las poblaciones significativamente más altas de trípidos y levemente de moscas blancas fueron registradas en parcelas convencionales, adjudicándose este efecto a la resurgencia de plagas debida a la reducción de enemigos naturales y eventualmente resistencias a determinados plaguicidas. Sin embargo, solamente en parcelas convencionales se obtuvieron resultados aceptables en cantidad y calidad de los vegetales, debido a que los dos otros sistemas no pudieron controlar plagas normalmente consideradas como secundarias por su fácil manejo en sistemas convencionales, como el Picudo de la berenjena (*Anthonomus oraapis*). En vainitas, berenjenas chinas y cundeamor se lograron incorporar plaguicidas sintéticos novedosos y otros a base de aceites vegetales (*Azadirachta indica*, *Annona muricata*, *Melaleuca* sp., *Citrus* spp.) y microbiológicos (*Beauveria bassiana*, *Entomophthora* sp. *Bacillus thuringiensis*, *Trichoderma* sp., *Saccharopolyspora spinosa*). Algunos de estos productos empleados no mostraron alta eficiencia sobre los organismos meta (artrópodos o enfermedades foliares), pero con pocas excepciones, no afectaron severamente a los principales enemigos naturales evaluados. La integración de controladores eficientes en los sistemas de producción de importantes vegetales orientales se percibe actualmente limitado por altos requerimientos de calidad, la falta de concientización y de estudios bio-ecológicos y sobre métodos de cría masiva de especies promisorias como chinches depredadores (*Orius insidiosus*, míridos, coccinélidos, sírfidos, crisomélidos, parasitoides de áfidos, entre otras).

Palabras clave: Vegetales Orientales, plagas artrópodas, MIP, plaguicidas selectivos, Controladores biológicos

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MANAGEMENT PROGRAM AGAINST PEPPER WEEVIL, *ANTHONOMUS EUGENII* CANO, AN ECONOMICALLY IMPORTANT PEST OF PEPPER

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ABSTRACT: The pepper weevil, *Anthonomus eugenii* Cano, is an economically important pest of pepper. It attacks all varieties of pepper. It is essential to understand initiation of infestation of pepper weevil in pepper field to develop an effective management program against this pest. Eggs are laid inside flower buds and pepper fruits. On hatching, larvae develop inside the fruits rendering them unmarketable. Chemical control is targeted for the control of adult weevils. Thiamethoxam is effective in reducing adult pepper weevils. Management program containing thiamethoxam, oxamyl and pyrethroids provided significant reduction of pepper weevil compared to other programs using organophosphates, carbamates and pyrethroids alone. Collection of fallen fruits and their immediate destruction reduced the number of pepper weevil adults per plant. *Catolaccus hunteri* Crawford, a hymenopteran parasitoid, was found effective in reducing adult emergence in the laboratory condition.

Keywords: Pepper weevil, chemical control, biological control, cultural control, biology

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FIBROLYTIC ENZYMES AND LIQUID UREA EFFECTS ON CHEMICAL FRACTIONS, RAM VOLUNTARY INTAKE AND NUTRIENT DIGESTIBILITY OF TROPICAL GRASS HAY

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ABSTRACT: Experiments assessed the effect of application of fibrolytic enzymes [untreated hay (control), hay treated with Promote^{NET} or with Biocellulase^{A-20}] on chemical composition, voluntary intake (VI), digestibility of various chemical fractions of guineagrass hay (GH) (*Panicum maximum* Jacq.), applied by spraying 24 h prior to feeding. A follow-up study evaluated hay treated with Biocellulase^{A-20}, liquid urea (LU; 16% N) and a control measure previously described as old world bluestem hay (DAH; *Dichanthium annulatum*). For both studies nine mature crossbred rams [26.8 kg mean body weight (BW)] were used in a 3x3 Latin Square design, with 18 d periods. Daily hay offerings were at 3.5% of BW on a dry matter (DM) basis. Enzymes and LU treatment increased contents of DM and crude protein (CP) in both hays relative to the untreated hay. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicellulose concentrations showed a tendency to be lower through enzymatic treatments and LU ($P=0.06$). Intake of DM of hays treated with Biocellulase^{A-20} and Promote^{NET} (1139 and 938 g DM/d, respectively) exceeded that of the control (921 g DM/d), nd similarly for LU 1089 g DM/d. The VI of CP, NDF and ADF were higher for hay treated with Biocellulase^{A-20}, than for GH untreated or that treated with Promote^{NET}, but not for LU. Rams fed enzyme-treated hay had higher ($P<0.05$) DM intake as a percentage of BW when compared to those fed untreated GH or DAH (4.06 Biocellulase^{A-20}, 3.15 Promote^{NET} and 2.86% control). Significant increases over the control were observed in digestibility of three other fractions for GH and DAH treated with Biocellulase^{A-20} and Promote^{NET} (CP, 3.23 and 3.18; NDF, 7.96 and 4.31; ADF, 7.69 and 7.9 percentage units). Dry matter, CP and ADF digestibilities did not differ ($P>0.05$) between enzymatic treatments, while NDF digestibility was higher ($P<0.05$) for GH and DAH treated with Biocellulase^{A-20}. Enzyme treatments or LU have positive effects on chemical fraction of mature tropical grass hays.

Keywords: Fibrolytic enzymes, liquid urea, chemical fractions, voluntary intake, tropical grass hay

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COST EFFECTIVENESS OF GONADOTROPIN RELEASING HORMONE (GNRH)-BASED AND EXOGENOUS PROGESTERONE/CIDR-BASED TIMED ARTIFICIAL INSEMINATION USING ESTRADIOL BENZOATE (EB) OR GNRH AS OVULATION SYNCHRONIZING AGENTS IN DAIRY CATTLE IN THE TROPICS

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ABSTRACT: A 2x2x2 factorial arrangement of treatments in a completely randomised block experimental design (CRBD) was used to evaluate the effect of two different TAI protocols, exogenous progesterone/CIDR- or GnRH-based and two ovulation synchronisation agents GnRH or EB on pregnancy rate in cows and heifers. Animals assigned to GnRH-based protocols were given an injection of GnRH (100 µg GnRH) on day 0, $PGF_{2\alpha}$ (25 mg) on day 7 and 48 hours later were given either GnRH (100 µg; GnRH-G; n=43) or Estradiol benzoate (500 µg, GnRH-E; n=40). Animals assigned to the CIDR-based treatments were treated with a progesterone insert (CIDR) alone for seven days and an injection of $PGF_{2\alpha}$ (at CIDR removal d 7), and 48 hours later were given either an injection of GnRH (CIDR-G; n=55) or Estradiol benzoate (CIDR-E; n=47). All animals were artificially inseminated, 60-72 hours after the injection of $PGF_{2\alpha}$. Pregnancy status for cows and heifers were assessed using transrectal ultrasonography 25-35 d after insemination. The mean pregnancy rate was 37.2 ± 8.2% and did not differ with type of TAI protocol, ovulation synchronizing agent, parity, or the interaction among treatments. Low pregnancy rates (25%) were observed in heifers placed on GnRH-based TAI protocols regardless of the ovulation synchronizing agent. The cost of establishing a pregnancy with GnRH- and CIDR-based protocols ranged between $26-29 and $48-50, and $39-47 and $30-37 in cows and heifers, respectively. In dairy cattle herds with poor reproductive performance, CIDR and GnRH-based TAI protocols may be a cost effective approach of increasing pregnancy rates in heifers and cows, respectively.

Keywords: Timed Artificial Insemination, Fertility, Pregnancy, Tropics, Cost

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NEO-TROPICAL ANIMALS

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ABSTRACT: The main objective of this paper was to describe a way forward for the development of intensive production systems for neo-tropical animals. A rationale was presented for this as well as for the justification for the use of the term "Neo-tropical Animals" in lieu of "Amazonian Wildlife or Fauna". About 30 plus species (exclusive of aquatic animals) have been highlighted for the development of intensive production systems and the rationale was given for their selection. A conceptual framework for the development of Intensive Production Models for these species was suggested. This conceptual framework is applicable to Mammalian, Avian and other terrestrial species. The main elements of this approach is to get a better understanding of (i) the factors affecting the production of the specific species in question (nutrition, reproduction, health, environment and economic), and (ii) linking these to their interaction with the physiological states of the species in question. The above has been premised on having gotten a better understanding of the anatomy and physiology of the species' digestive and reproductive systems. This approach has worked with the Agouti (*Dasyprocta leporine*), Lappe/Labba (*Agouti paca*), Peccary (*Tayassu tajacu/Pecari tajacu*) and the Capybara (*Hydrochoerus hydrochaeris*). In concluding, it was suggested that for successful intensive production systems to be developed, there must be the synigerism between Conservation, *in situ* Management, *ex situ* Production and Utilization. This approach has proven successful with the North American Buffalo (*Bison bison*).

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REPOSITIONING TRADITIONAL STAPLES (ROOTS AND TUBERS) IN THE FOOD BASKET OF THE CARIBBEAN: A CASE STUDY FOR CARDI

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INTRODUCTION

Roots and tubers are described as plants yielding starchy roots, tubers, rhizomes, corms and stems which are used mainly for food, livestock feed and also for manufacturing into starch, alcohol and fermented beverages (FAO, 1994). There are more than 30 species of roots and tubers grown worldwide. However, only a few make an important contribution to world food production, global food and nutrition security, income generation, and poverty alleviation. The most important crops in this group are cassava (*Manihot esculenta* Krantz), sweet potato (*Ipomoea batatas*), yams (*Dioscorea* spp.), and the aroids (*Collocasia esculenta* and the *Xanthosomas)*. These are considered major staples and produce large quantities of dietary energy for significant populations in the developing world. Cassava is reportedly the most important in the group and the most important source of calories in the tropics after rice and maize (FAO, 1998).

Roots and tubers are basic food sources but they also function as sources of income in many countries and are therefore important for rural livelihoods. The crops are mainly produced by small farmers using traditional labour intensive methods of production, resulting in low levels of productivity and sub-optimal yields which limit profit margins.

The agricultural sector in the Caribbean Region is influenced by global factors, particularly the rise in price of imported staples and their reduced availability. Carmichael et al. (2009) reported that although CARICOM's food security may not be compromised by a lack of food availability, there are issues of concern related to trends of declining food production and increasing imports (and the related expenditure of scarce foreign exchange). The CARICOM Region imported more than US $5 billion in cereal and cereal products in 2010 (Figure 1). The consumption of roots and tubers is affected by dietary preferences, urbanization trends and relatively cheaper alternative starches e.g. grains and cereals. Carmichael et al. (2009), also reported a reduction in the production of staples over the past decade, particularly as the demand for wheat and wheat-based products increased because of the change in consumer preferences. Roots and tubers, in spite of their superior nutritional qualities as complex carbohydrates, are being replaced by processed refined carbohydrates which are easier to prepare and use. This trend, which continues, has serious implications for the availability of basic staples in the face of both the rising prices of imported wheat and wheat-based products and the cost associated with importation. These costs also include the issue of food miles and low carbon food production and delivery considerations.

Roots and tubers have been identified by decision makers as an integral component for food security/sovereignty for the Region. CARICOM signaled its desire to reduce food imports and several Caribbean countries also established similar national targets.

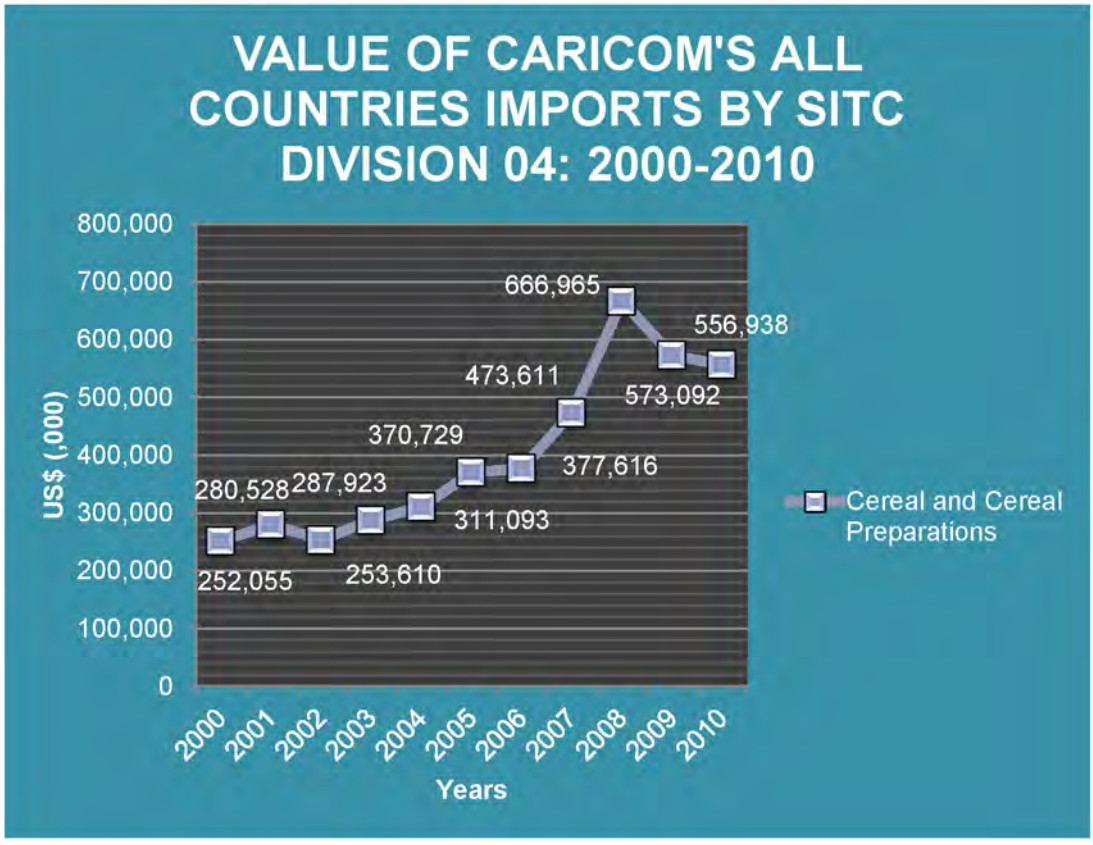

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Figure 1. Value of CARICOM imports for cereals and cereal preparations 2000-2010.

OBJECTIVES

The objectives of this paper are to:

- Discuss the status of the world root and tuber industry
- Conduct a comparative review of the regional industry
- Discuss the CARDI Roots and Tubers Programme and its major achievements
- Make recommendations for repositioning the industry towards greater sustainability, particularly economic competitiveness

Current status of roots and tubers

Roots and tubers are a major source of food in many developing countries. However, levels of production and use vary between countries and regions. Almost 36 million hectares of land in developing countries are reportedly planted in these crops (FAO, 1997). Asia is the main producing region (Figure 2) followed by Africa and Latin America. China is the most important sweet potato producer (90% of global production); Nigeria is the main producer of yams, and Brazil produces the most cassava. Small farmers in China, who have traditionally cultivated sweet potato for human consumption, now process roughly half of their annual harvest of 118 million mt (1995-97 value) into animal feed (Scott et al., 2000). On a 16-year (1995-2010) average, CARICOM produced only 0.29% of the world's production of roots and tubers (Figure 2). A slight increase was seen in 2010 to 0.38%.

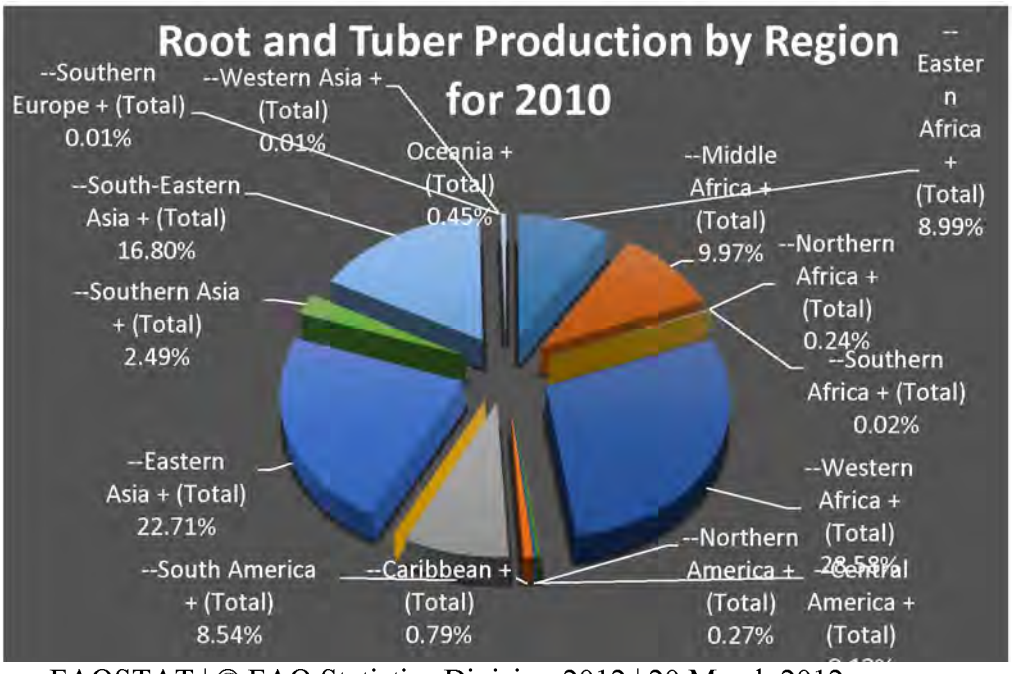

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Figure 2: World root and tuber production (Source FAO).

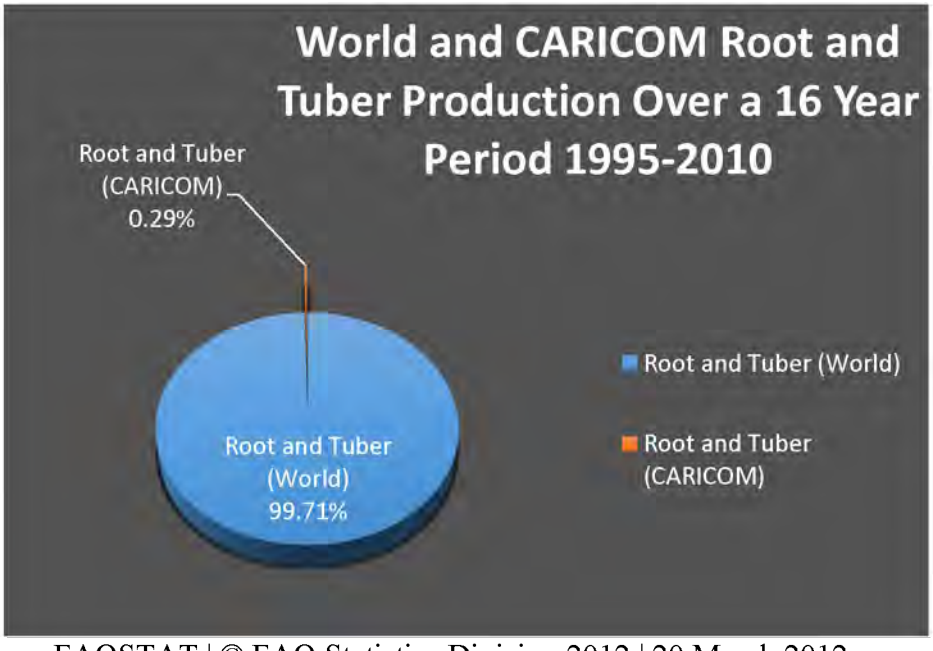

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Figure 3. World and CARICOM root and tuber crop production.

Internationally, several organizations have made significant contributions to roots and tubers development. Foremost among these are the Consultative Group on International Agricultural Research (CGIAR) Centers: the International Centre for Tropical Agriculture (CIAT) and the International Potato Centre (CIP), which have world germplasm collections of cassava and sweet potato, respectively, and the International Institute for Tropical Research (IITA) located in Nigeria which services the research needs of farmers in Africa. Both the *Instituto de Investigaciones de Viandas Tropicales* (INIVIT) and the *Instituto Dominicano de Investigaciones Agropecuarias y Forestales* (IDIAF) focus on all the targeted root and tuber crops in this paper and cater their research specifically to the needs of farmers in Cuba and the Dominican Republic. The National Agricultural Research Center for Kyushu Okinawa Region (KONARC) in Japan, conducts research on sweet potato, where breeding new varieties is a priority activity. The Latin America and Caribbean Consortium to support Cassava Research and Development (CLAYUCA) in Colombia is now a well established and functional organization engaged in supporting cassava development in the region and beyond. CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement) is a French research centre working with developing countries to tackle international agricultural and development issues and is known for its work on yams. The functional areas for the various Institutions are shown in Table 1.

Table 1. Institutions and their research focus

Institution	Cassava	Sweet Potato	Yams	Aroids
CIAT	X			
CIP		X		
IITA	X	X	X	X
INIVIT	X	X	X	X
IDIAF	X	X	X	X
KONARC		X		
CLAYUCA	X	X		
CIRAD			X	

In the CARICOM Region, roots and tubers (cassava, sweet potato, yams and aroids) have been produced for centuries mainly by small farmers. There is significant germplasm in each country which is produced mostly for human consumption. There is some degree of income generated through Intra-regional and international trade. There is also limited value addition. The changing global environment, particularly the unavailability of imported cereals, has resulted in the increasing importance of roots and tubers for food and fuel.

Roots and Tubers Programme in CARDI

As outlined in its Medium Term Plan, CARDI's work in roots and tubers is guided by its mandate for the Research and Development of these commodities given in the Regional Transformation Programme for Agriculture (RTP) of 1996. Industry development would take the value chain approach where all stakeholders are involved in the process as shown by the Commodity Development Chain below (Figure 3).

CARDI embraces the 'New Agriculture' concept recognised by CARICOM Heads of Government, where industry development spans the entire value chain, is market-oriented and acknowledges the importance of linkages with other productive sectors. This industry development is also influenced by appropriate technological processes and measures.

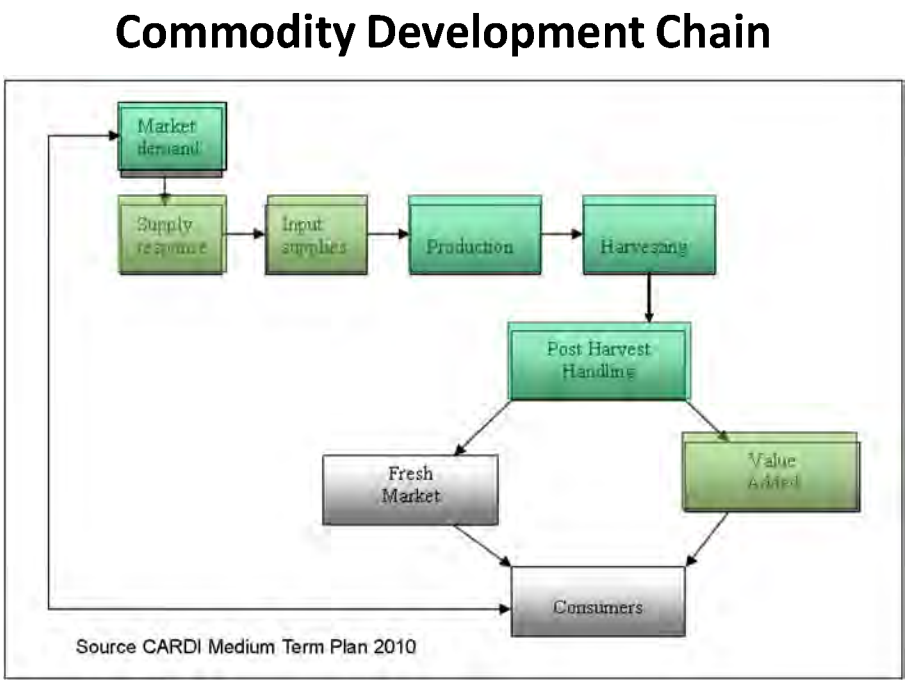

Figure 3. Commodity Development chain

The objective of the Roots and Tubers Programme in CARDI is "To support the development of a commercially viable and sustainable regional root and tuber crop industry that facilitates the improvement of livelihoods and overall food and nurtrition security/sovereignty". This objective would enable the institute to contribute to the development of roots and tubers industries through the development of fresh production and value-added technology. Over the years, the Institute has been involved in various aspects of research and development in respect to roots and tubers. The major achievements are reported here under.

Germplasm introduction, evaluation, and conservation

CARDI's work in cassava dates back to the 1980s in the Barbados Unit. New accessions from CIAT were introduced and evaluated for use in the production of animal feed. Planting material of the selected varieties was multiplied and the production technology transferred to farmers.

Again in the 1980s, white yam (*Dioscorea alata*) was introduced from INRA and evaluated for yield and tolerance to anthracnose. During this period, there was also a virus-tested yam multiplication project through tissue culture. This was centered in Barbados and planting material was distributed to 12 countries.

In 2003, improved cassava varieties were again introduced from CIAT and evaluated at the CARDI Unit in St. Vincent and the Grenadines. The selected high yielding varieties are multiplied in vitro and distributed to farmers in the Region.

CARDI collaborated with CIP (2003-2010) to obtain appropriate varieties of sweet potato for introduction and evaluation as to their suitability for fresh consumption and processing into value added products. Several of these are currently being evaluated across the Region.

The Institute is currently collaborating with the Secretariat of the Pacific Community (SPC) on a European Union-funded project to introduce, breed and evaluate aroids (dasheen, tannia), which would be adapted for climatic changes and new commercial uses.

Germplasm collections in gene banks, mainly of sweet potato, can be found in several CARDI Units. In addition, the Institute is collaborating with the Ministry of Agriculture in St Vincent and the Grenadines for the storage of cassava, sweet potato and aroid planting material at its tissue culture laboratory.

During the period 1982-86, the Institute executed a project funded by the European Development Fund on the genetic improvement of aroids in Dominica, Trinidad and Tobago, Grenada, St Lucia, and St Vincent and the Grenadines. The goal was to identify superior clones based on yield, disease tolerance /resistance and adaptability.

Under the Caribbean Plant Genetic Resources Network (CAPGERNET), CARDI is collaborating with the Ministries of Agriculture to regenerate, conserve, multiply, and disseminate landraces of sweet potato (Trinidad and Tobago), and cassava (Guyana).

Improved production and productivity

CARDI Units are involved in the demonstration of improved technologies for root and tuber production. Technology has been transferred through seminars, workshops, field days, publications. Several fact sheets produced by the Institute's scientists have been used by farmers and extension agents in crop production. The most recent publications include a sweet potato technical manual and a cassava technical bulletin.

Sweet potato varieties for local and export markets have been characterized in Jamaica, St. Vincent and the Grenadines, and St Kitts and Nevis. In addition, suitability of varieties for various Agro Ecological Zones (AEZ) has been determined in Jamaica and Antigua.

Among the post harvest characteristics determined has been curing technologies to extend the shelf life of sweet potato in Jamaica. It was also established that the cyanide levels (0.34 – 1.72 mg/kg) of six introduced high yielding cassava varieties (after processing) are within FAO/WHO CODEX permissible levels of 10 mg/kg.

Integrated Pest Management

The integrated pest management in sweet potato was one of the more successful projects undertaken by the Institute. This multi-country project was done in association with Virginia

Technical Institute and was executed from the CARDI Jamaica office. Results included the development of control measures for *Cylas formicarius* and Phyllophaga spp, two main sweet potato pests, in the Region. The adoption of this technology led to increased production and export of sweet potato in St Vincent and the Grenadines and Jamaica. Pesticide residue analysis showed that the treatment enabled compliance with food safety regulations.

Value addition initiatives

Under a CARICOM/Japan project, 34 regional sweet potato varieties were evaluated for their suitability for processing into flour, paste, juice and fries. The germplasm came from Jamaica, St. Vincent and the Grenadines, St. Lucia, St. Kitts and Nevis, Trinidad and Tobago and Barbados. At the Food Science laboratory, University of the West Indies, St. Augustine, they were analysed for brix and dry matter percentages: low brix gives the products a better colour and a low to medium dry matter content is desirable for fries and chips.

In collaboration with the University of the West Indies, CARDI was able to evaluate 21 sweet potato varieties from St Vincent and the Grenadines. Complete proximate analyses were done of the flours and starches produced from the varieties. The information gathered will be used in determining processing suitability.

The Scientific Research Council (SRC) in Jamaica was contracted by CARDI to evaluate the processing capability for the ten most popular sweet potato varieties on that island. The resulting information was made available to the marketers and processors.

In Montserrat, training in cassava value addition exposed participants to making the traditional cassava bread and other new products (pizza, quiche). The acquisition of processing equipment by the Ministry of Agriculture prompted the Institute to initiate the training session to ensure sustainability of the cassava industry on that island.

In addition, CARDI conducted an evaluation of introduced cassava varieties in St Vincent and the Grenadines to determine their suitability for processing into farine —the preferred cassava product. This research resulted in the selection of six varieties introduced for further production.

Capacity building

Apart from several training workshops organized by CARDI scientists, the Institute has been collaborating with regional and international organizations to train farmers and technicians in root and tuber technologies throughout the value chain. Under the CARDI Caribbean Food Corporation (CFC) project, farmers and officers from Barbados, Dominica, Jamaica, St. Vincent and the Grenadines, and Trinidad and Tobago were exposed to cassava micro-propagation, production and processing practices at CLAYUCA in Colombia. The root and tuber farmers of St Kitts and Nevis also benefitted from a collaborative project between CARDI and the Florida Association for Volunteer Action in the Caribbean and the Americas (FAVACA) through training in pest management.

Collaborative Linkages

In keeping with its value chain approach, the Institute convened a workshop for sweet potato stakeholders in St. Vincent and the Grenadines in 2006. Participants included farmers, agro-processors, extension officers, policy makers and researchers from various institutions, agencies, Ministries of Agriculture, Farmers' Groups in the Bahamas, Barbados, Guyana, Jamaica, St. Vincent and the Grenadines, and Trinidad and Tobago. The aim was to formulate a regional sweet potato work programme.

The Institute also recognizes the value of its partners in its efforts to develop the root and tuber industry. Strategic alliances have been forged with regional entities, e.g. Barbados Agricultural Development and Marketing Corporation (BADMC), the SRC (Jamaica), the University of the West Indies (UWI) St. Augustine Campus and the Trinidad and Tobago Agribusiness Association (TTABA), which are all involved in product development. CARDI has also been collaborating with CLAYUCA, CIP and CIAT for improved germplasm and training. Under the CFC project, the Ministries of Agriculture, Farmers' Groups and NGOs in the project islands of Barbados, Dominica, Haiti, Jamaica, St Vincent and the Grenadines, Trinidad and Tobago have partnered with CARDI for the successful implementation of the project entitled, *"Increased Production of Root and Tuber Crops in the Caribbean through the Introduction of Improved Marketing and Production Technologies"*.

Strategic repositioning of roots and tubers in the agriculture sector of the region

"One key to successful strategic repositioning of a technology or commodity is recognizing that success involves innovative change and requires advocacy, capacity building and marketing" (Onyango, 2011). As explained by the author, advocacy involves selecting the correct strategic partners. In this regard, the Institute has established important strategic alliances with national, regional and international organizations. The emphasis placed on strengthening farmers' groups and industry clusters within current projects is part of this process of building multi stakeholder platforms that facilitate innovation. As a consequence, the major stakeholders will be sensitized as to the importance and potential of roots and tubers to the Region's food and nutrition security needs and the potential for providing an acceptable financial return for the agrientrepreneurs involved.

Since improving the competence of the players along the value chain is pivotal to sustainable development of the industry, CARDI is working to build the capacity of technicians, producers, processors and marketers. This emphasis on human resource development will facilitate research, technology transfer, and fuel the innovation process. For example, it is recognized that there is an increasing role for plant breeders to assist in the development of climate-ready plants, given the imperatives of efficient plant genetic resources conservation, and management in the context of climate variability and change. The vital role of the policy makers in the repositioning process has been noted and, indeed, appropriate measures are being developed to engage the region's decision makers in the science policy dialogue. Their contribution to advocacy and promotion is indispensable.

Onyango (2011) also notes, "The first step in promoting any crop is the provision of quality seed". Recognising this, CARDI, through the CFC project, has focused on the production and distribution

of high quality planting materials of roots and tubers. Sustainability is ensured by the construction of plant propagating facilities in the targeted project countries. The project being implemented under the CARICOM/Japan agreement also targets the production of clean planting material for distribution to farmers.

Product development, value addition and processing are all important in the value chain and subsequently the repositioning process. As consumers are encouraged to transition from imported grains and cereals and consume more traditional staples for health and wellness reasons as well as the attainment of food and nutrition security, there will be a growing demand for processed products from these traditional staples. This increased demand for processed products will therefore require the industry to diversify the range of products available.

The marketing of fresh and processed products could greatly affect the repositioning of the roots and tubers highlighted in this paper. A lack of market access would negatively impinge on industry development. The policy decision to achieve 25% of food and nutrition security, and the selection of roots and tubers as a major supplier of starch, should address the question of market availability and accessibility.

CONCLUSIONS

The Caribbean Agricultural Research and Development Institute, as the only agricultural Research and Development Institute in the CARICOM Region, and given the importance that roots and tubers play and would continue to play in the lives of the region's people, is taking up the responsibility for leading the process of repositioning the industry.

Scott et al. (2000) noted that cassava, sweet potato, and yam will remain important commodities in the coming years, particularly in many of those poorer regions and countries that merit broader international support in their efforts to increase food production, reduce rural poverty, and improve food security while protecting the environment.

The successful involvement of the private sector in research and development has been demonstrated by CLAYUCA (Ospina, 2000). This role should not be underestimated and needs to be further tapped to exploit the substantial research and development capacity and extensive supply chains, infrastructure development and market penetration which this sector can access. By *working together*, one of CARDI's strategic pillars, these stakeholders can contribute more effectively towards the goals and objectives of the repositioning process.

The availability of molecular tools would provide the opportunity for the development of more suitable varieties for the changing environment and with acceptable production, productivity and consumer characteristics for the emerging challenges particularly in terms of climate change, increasing pest pressures, and rapidly declining soil fertility.

REFERENCES

Caribbean Agricultural Research and Development Institute.2008. CARDI Medium Term Plan 2008-2010 Improving Lives Through Agricultural Research.

CARICOM, 2010. Caribbean Regional Food and Nutrition Security Policy. CARICOM Secretariat. Georgetown, Guyana.

Carmichael C, Jacque A, Francis D. 2009. Investing in Food and Nutrition Security - Identifying Potential Investment Opportunities in the Agriculture and Food industries in CARICOM. Port of Spain, Trinidad: IICA.

Food and Agriculture Organisation, 1994. Definition and classification of commodities. Roots and Tubers and derived products.

Food and Agriculture Organisation, 1997. Appendix 4 – Global production and consumption of roots and tubers. A TAC Secretariat desk study prepared in support of the Inter-Centre Review of Root and Tuber crops research in the CGIAR.

Food and Agriculture Organisation, 1998. Food and Agricultural Industries, Storage and processing of Roots and Tubers in the Tropics.

Food and Agriculture Organisation, Sub-Regional Office for the Caribbean, Barbados 2011. Summary of Proceedings of Regional consultation on policy and programmatic actions to address high food prices in the Caribbean, Port of Spain, Trinidad and Tobago, 13-14 June 2011.

Food and Agriculture Organization of the United Nations (FAO). 2012. FAOSTAT. Statistical database of the Food and Agriculture Organization of the United Nations. Rome, Italy: FAO.

O'Hair S. 1990. Tropical root and tuber crops.p 424-428.In Janick and J.E.Simon (eds), Advances in new crops. Timber Press, Portland, Or.

Onyango A M O. 2011. Strategic repositioning of Agrobiodiversity in the horticulture sector for sustainable development in Africa. CTA and FARA Agricultural innovations for sustainable development, Accra, Ghana.

Ospina B. 2000. CLAYUCA: Latin American and Caribbean Consortium to support cassava research and development. In Proceedings of the 6th Regional Cassava workshop, Ho Chi Minh City, Vietnam.

Scott, G.J.R., Best M., Rosegrant and Bokanga M. 2000. Roots and Tubers in the Global food system: A vision statement for the year 2020. Printed in Lima, Peru, International Potato Center.

Scott G, Rosegrant M W, Ringler C. 2000. Roots and Tubers for the 21st Century Trends, Projections, and Policy Options. Food, Agriculture, and the Environment Discussion Paper 31, International Potato Center, Lima, Peru.

Technical Advisory Committee, CGIAR. 1995. Desk Study, prepared by the TAC Secretariat. Global Production and Consumption of Roots and Tubers. 36 pages.

Proceedings of the Caribbean Food Crops Society. 48:208. 2012

ASSESSMENT OF PRODUCTION ISSUES IMPACTING FOOD SECURITY AND EXPORTS: A CASE OF SWEET POTATO IN ANTIGUA AND BARBUDA

Gregory Robin and Bradbury Browne, CARDI, Antigua and Barbuda

ABSTRACT: Expansion in the acreage of sweet potato cultivated in Antigua and Barbuda resulting from promotions aimed at increasing food and nutrition security and foreign exchange earnings has led to changes away from traditional cultivation practices. Planting has switched from the beginning of the rainy season to mainly year-round cultivation. Early observations were that year-round cultivation results in variable yields that are influenced by planting times. However, results from recent experiments conducted by Caribbean Agricultural Research and Development Institute between July 2008 and December 2011, to assess the effects of variety/ accessions, time of planting and agro-ecological zones on commercial sweet potato production, show that yields are significantly higher in the period October to March than in April to September. Yields were also influenced by crop variety and locations. These results provide more precise information for planning expanding sweet potato cultivation to cater for increased emphasis on food security and export.

Proceedings of the Caribbean Food Crops Society. 48:209-212. 2012

'PUJOLS' Y 'CAMUY' VARIEDADES DE *IPOMOEA BATATAS* ADAPTADAS AL CARIBE

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RESUMEN: Pujols' y 'Camuy' son variedades comerciales de *Ipomoea batatas* recientemente liberadas para uso comercial por la Estación Experimental Agrícola de la Universidad de Puerto Rico. Pujols es del tipo tropical con pulpa color amarillo claro. Camuy es de pulpa blanca. En ambas variedades las raíces reservantes están concentradas en la base de la planta, mientras que la producción de estas a lo largo de los tallos rastreros es insignificante. Estas características facilitan la cosecha mecanizada. Para Pujols el promedio de peso por raíz individual es de 414 a 623 g, mientras que para Camuy varía de 253 hasta 510 g. El largo del ciclo de cultivo es de 140 a 150 días. Cuando a ambas variedades se les aplicó los herbicidas clomazone, dimethenamid y clethodim no se observó fitotoxicidad. Los sólidos insolubles en alcohol (de 65 a 78%) son similares a los de otras variedades de uso en el Caribe. Ambas variedades son susceptibles a *Cylas formicarius*; sin embargo, no se ha observado ataque importante de *Euscepes postfasciatus*. Ambas variedades han sido cultivadas en campos infestados con nematodos, y menos del 5% de las raíces reservantes mostraron grietas indicativas de daños por el nematodo *Rotylenchulus reniformis*. Los daños causados por el nematodo *Meloidogyne incognita* fueron insignificantes a lo largo de las evaluaciones. Ninguna de las variedades se ha observado con síntomas de virus. Sin embargo, durante el curado el hongo *Diplodia* spp. se detectó afectando las raíces de Camuy. Ambas variedades se han producido con éxito comercial en Oxisoles, Mollisoles, Inceptisoles y Ultisoles en Puerto Rico.

Palabras clave: Batata, camote, boniato, *Ipomoea batatas*, sweet potato

INTRODUCCIÓN

A *Ipomoea batatas* se le conoce como batata, boniato o camote en los países de habla española del Caribe y de Mesoamérica. En inglés se conoce como "sweet potato", y en francés como "papate douce". En la Región del Caribe las variedades del tipo tropical son las preferidas. El tipo tropical describe variedades que combinan raíces tuberosas con cáscara de color rosado a púrpura, con pulpa color blanco, crema o amarillo cristalino y una dulzura al paladar que se percibe entre los tipos no-dulces y el tipo de postre (este último por lo general de pulpa anaranjada) (Hernández-Carrión et al., 2010). La Estación Experimental Agrícola de la Universidad de Puerto Rico ha liberado para uso comercial las variedades de batata 'Pujols' y 'Camuy' las que están adaptadas para producción en la Región del Caribe.

DESCRIPCIÓN HORTÍCOLA DE LAS VARIEDADES

Pujols es una variedad tipo tropical liberada para uso comercial en 2010 (Ortiz et al., 2010). Sus raíces tuberosas son de cáscara color púrpura y su pulpa es color amarillo pálido. Las raíces tuberosas de Camuy también son de cáscara color púrpura y su pulpa es blanca. Camuy fue liberada

para uso comercial en 2011. Ambas variedades fueron seleccionadas para producto fresco sin procesar.

El crecimiento de las plantas de Pujols es rastrero mientras que las plantas de Camuy tienden a ser semierectas particularmente al inicio del ciclo de siembra. Ambas variedades producen sus raíces tuberosas en la base de las plantas. La producción de raíces tuberosas a través de los tallos alargados es mínima. Estas características son deseables para la mecanización de la cosecha. Pujols y Camuy fueron identificadas como prometedoras cuando se evaluó su potencial para cosecha precoz. Cosechadas a los 105 y 120 días después de la siembra, Pujols y Camuy resultaron mejores productoras que la variedad testigo (Cuadro 1).

Posterior a los ciclos iniciales de selección, las características de rendimiento y de calidad de raíz tuberosa se evaluaron en parcelas de validación. En todas las pruebas de validación se usó riego por goteo. En términos generales, Pujols y Camuy mostraron rendimientos significativamente mayores o iguales a los de las variedades testigos (Cuadro 2). La calidad física de las raíces tuberosas de Pujols y de Camuy siempre fue superior a la de los testigos. Muchas de las raíces tuberosas de las variedades testigos mostraron rajaduras, daño excesivo de nematodos y alta variación en tamaño.

Los rendimientos más altos de Pujols se obtuvieron cuando se cosechó por lo menos 140 días después de la siembra. Para Camuy se recomienda cosechar a los 150 días. Estudios más específicos han demostrado que estas variedades se pueden cosechar tan temprano como 120 días después de la siembra con rendimientos aceptables (González-Vélez, 2003). La cosecha temprana, sin embargo, puede afectar negativamente los contenidos de azúcar y de almidón, y el color de la pulpa. Los contenidos de azúcar y de almidón, así como el color de la pulpa son atributos de calidad importantes para mercadear raíces tuberosas no elaboradas.

Para la batata los sólidos insolubles en alcohol son una medida indirecta del contenido de almidón (Walter Jr. et al., 1997). Las raíces tuberosas se analizaron para los sólidos insolubles en alcohol y los resultados mostraron que estos son similares a los de otras variedades de batata tipo tropical, variando de 65% a 79% (Cuadro 3).

Pujols y Camuy son susceptibles al picudo de la batata (*Cylas formicarius*). El daño causado por este insecto aumenta cuando las raíces tuberosas que están listas para cosechar se mantienen en el campo. En ocasiones se observaron las larvas del gorgojo de la raíz (*Diaprepes abbreviatus*) dañando la raíces tuberosas. Algunos minadores y enrolladores de las hojas afectan a las plantas, pero son fácilmente controlados con insecticidas aprobados para uso en este cultivo. Ninguna de estas variedades ha mostrado síntomas de virus. Para detalles sobre las autorizaciones de uso de Pujols y Camuy puede referirse al *Journal of Agriculture of the University of Puerto Rico*.

Cuadro 1. Rendimiento, número de raíces reservantes por planta y peso promedio de la raíz reservante para Pujols y Camuy cosechadas a los 105 y 120 días después de la siembra.

Cosecha Días después de siembra	Variedad	Rendimiento kg/m de surco	Raíces por planta núm.	Peso raíz reservante g/raíz
105	Pujols	1.7	4.3	122
	Camuy	1.8	4.1	136
	Testigo	0.7	2.5	79
120	Pujols	2.8	3.7	233
	Camuy	3.3	5.5	184
	Testigo	0.9	3.1	90

Cuadro 2. Rendimiento y peso promedio de la raíz reservante de Pujols y Camuy en pruebas de validación.

Localización	Variedades evaluadas núm.	Variedad	Rendimiento kg/ha	Peso raíz reservante g/raíz
Isabela	9	Pujols	47,000	416
		Camuy	43,173	253
		Testigo	43,769	379
Corozal	8	Pujols	37,197	414
		Camuy	36,901	373
		Testigo	26,276	442
Juana Díaz	4	Pujols	35,633	599
		Camuy	30,543	442
		Testigo	37,954	549
Juana Díaz	4	Pujols	52,655	623
		Camuy	30,666	510
		Testigo	12,909	448

Cuadro 3. Porcentaje de sólidos insolubles en alcohol en raíces tuberosas de Pujols y Camuy.

Variedad	Localidad de siembra	
	Gurabo	Juana Díaz
	---------- % ----------	
Pujols	67	79
Camuy	65	73
Testigo	68	67

REFERENCIAS

González-Vélez, A., 2003. Genotipos de batata con potencial de cosecha precoz sembrados en distintas épocas en la zona central de Puerto Rico. *J. Agric. Univ. P.R.* 87(3-4):105-112.

Hernández-Carrión, T., C.E. Ortiz, R. Montalvo-Zapata y L.E. Rivera, 2010. Sugars in tropical-type sweet potato varieties of Puerto Rico. *J. Agric. Univ. P. R.* 94(1-2):205-209.

Ortiz, C.E., E. Acevedo-Borrero, M. Díaz-Rivera, M. de L. Lugo-Torres y R. Vélez-Colón, 2011. Release of 'Pujols': A tropical-type sweet potato. *J. Agric. Univ. P.R.* 95 (1-2): 111-115.

Walter Jr., W.M., W.W. Collins, V.D. Truong y T.I. Fine, 1997. Physical, compositional, and sensory properties of french fry-type products from five sweetpotato selections. *J. Agric. Food Chem.* 45:383-388.

RECONOCIMIENTO

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EVALUATION OF THE CURING TECHNIQUE TO REDUCE POSTHARVEST LOSSES IN SWEET POTATO

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ABSTRACT: The production of sweet potatoes (*Ipomoea batatas* Lam.) in Jamaica and the Caribbean has been lucrative for many years. The acceptance of sweet potato as a major staple is linked to its high nutritional quality, relative ease of production and the high productivity of the crop. A serious constraint that has been affecting the industry is the lack of appropriate post-harvest techniques that can prolong the shelf-life of the commodity. With the absence of suitable post-harvest techniques, sweet potatoes break down quickly in storage due to water loss and the invasion of roots by pathogens; resulting in loss of revenue and food. One of the most recommended methods for successfully storing sweet potatoes is curing. Curing is the process of wound healing by exposing harvested roots to heat (30° C, 90-95% RH) for a period of seven days (Mackay, Palomar and Sanico, 1989). The trial conducted used a replicated factorial design to evaluate the effect of curing and fungicidal dips on the shelf-life of five popular local sweet potato varieties grown in Jamaica. The treatments were: curing —cured and non-cured; fungicide —Dichloran (Botran® 75WP), Thiabendazole (Mertect®), water as control; and variety —Clarendon, Eustace, Fire-on-Land, Ms Mac and Quarter Million. Samples were stored over a period of 140 days. Results indicated that the rate of weight loss was less in cured roots when compared to non-cured roots. Considerable varietal effects were also observed in terms of storage quality; however, the fungicides used did not appear to make a significant difference. Proximate analyses and organoleptic (sensory) tests were also conducted to assess the quality of the sweet potatoes at various stages of storage. The implications of results on recommending suitable post-harvest techniques for sweet potato are discussed.

Keywords: Curing, post harvest techniques, sweet potato

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EFECTO DEL TIPO DE MATERIAL DE SIEMBRA (ESTACAS Y PLANTITAS) EN LOS RENDIMIENTOS DE YUCA EN SANTIAGO RODRÍGUEZ, REPÚBLICA DOMINICANA

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RESUMEN: El cultivo de yuca para la elaboración de casabe es la principal actividad y una de las pocas fuentes de ingresos para los productores de la Línea Noroeste de la República Dominicana. Sin embargo, las variedades cultivadas son amargas y poco productivas (rendimiento promedio entre 6 y 8 t/ha). La productividad de la yuca puede ser duplicada si se mejoran las prácticas de manejo y el material genético. El uso de plantitas puede reducir el ciclo de cultivo y el tiempo de competencia con las malezas, permitiendo rendimientos mayores. Esta investigación tuvo por objetivo evaluar el efecto del tipo de material de siembra (estacas y plantitas) en los rendimientos de cinco variedades de yuca para procesamiento de casabe. Se realizó en La Lima Palmarejo, Santiago Rodríguez, República Dominicana en el período de marzo 2007 a junio 2008. Se utilizó un diseño en bloques completos al azar con arreglo factorial de los tratamientos y cuatro repeticiones. Las variables analizadas fueron peso fresco de raíces (t/ha), número de raíces/ha, peso de catibía (t/ha) y número de tortas de casabe/ha. La interacción variedad*tipo de material solo fue significativa ($p<0.05$) para el número de raíces por hectárea. El mayor número de raíces lo tuvieron las variedades SM 805-15, CM 6740 y Tai-8 producidas por plantitas, con 142,480, 140,576 y 105,360 raíces/ha, respectivamente. Para el peso fresco de raíces hubo diferencias ($p<0.05$) entre las plantitas (25.42 t/ha) y las estacas (20.86 t/ha). En cuanto al peso de catibía hubo diferencias ($p>0.05$), entre las plantitas (15.73 t/ha) y las estacas (12.50 t/ha). Para el número de tortas no se encontraron diferencias significativas ni entre los tipos de material ni entre las variedades. Se concluye que en la zona de Palmarejo, las plantitas incrementaron los rendimientos de yuca, independientemente de las variedades.

Palabras claves: Plantitas de yuca, estacas de yuca, casabe, variedades de yuca

INTRODUCCIÓN

El cultivo de yuca para la elaboración de casabe es la principal actividad y una de las pocas fuentes de ingresos para los productores de la sierra de Santiago Rodríguez y la Línea Noroeste de la República Dominicana. En esta zona cada año se siembran unas 16,000 tareas (1,000 ha) de yuca para la elaboración de casabe, con un rendimiento promedio de apenas 6 a 8 (t/ha). Estos bajos rendimientos obligan a muchos procesadores de casabe a comprar yuca en otras localidades e incluso en Haití (Nicolás Almonte 2010, comunicación personal).

La industria del casabe es una actividad importante para muchas comunidades rurales ubicadas en las provincias Santiago Rodríguez y Dajabón. Solo en la zona de Monción se estima que esta actividad genera cerca de 600 empleos directos y alrededor de 4,200 indirectos. Además, diariamente requiere cerca de 2,000 quintales de yuca para la elaboración de casabe, recibiendo solo cerca del 25% de esa cantidad (Nicolás Almonte 2010, comunicación personal). La limitada

oferta de yuca para el procesamiento de casabe, entre otros factores, estás relacionada con los bajos rendimientos de las variedades utilizadas.

Los productores de yuca para casabe utilizan variedades amargas poco productivas. El material de siembra lo obtienen de la cosecha de otros productores de la misma zona u otras localidades. Por lo general, este material (con mezcla varietal y dudosa calidad fitosanitaria), es amontonado por largos periodos a pleno sol, reduciéndose su capacidad de brotadura y la posibilidad de producir una planta vigorosa. En ese sentido, López (2002) señala que los factores bióticos (plagas) y abióticos (clima y suelo) influyen significativamente en la calidad del material de siembra, provocando su degeneración y pérdida total de la capacidad productiva de la variedad. Según la FAO (2004), el 32% del incremento potencial de la productividad está relacionado con la variedad y la calidad del material de plantación.

La producción de plantitas de yuca antes de la siembra permite al productor hacer una buena selección de los tallos, garantizando alta pureza varietal y rendimientos cercanos al potencial del genotipo utilizado. También las plantitas, al tener un sistema radicular formado, aseguran en corto tiempo el establecimiento de una plantación vigorosa, con mayor capacidad de competir con las malezas (Lozano *et al.,* 1984).

Esta investigación tuvo por objetivo evaluar el efecto del tipo de material de siembra (estacas y plantitas) en los rendimientos de cinco variedades de yuca (cuatro dulces y una amarga) para el procesamiento de casabe.

MATERIALES Y MÉTODOS

El ensayo fue realizado desde marzo 2007 a junio 2008, en la finca de una productora de yuca de La Lima, Palmarejo, Santiago Rodríguez ubicada entre los 19° 24´ N y 71° 20´ O. La temperatura media anual 23° C y la pluviometría promedio anual 1,125 mm. El tipo de suelo es franco arenoso.

Se utilizó un diseño en bloques completos al azar con arreglo factorial de los tratamientos, con cuatro repeticiones. Se empleó una parcela experimental de 20 m^2, con un área útil de 8 m^2. El marco de siembra fue de 1.0 m entre hileras y 0.5 m entre plantas. Los factores en estudio fueron: variedades de yuca [cuatro dulces introducidas desde Colombia (CM-6921, CM-6740, TAI-8 SM-805-15) y una amarga local (Negrita)] y tipo de material de siembra (estacas y plantitas). A los datos se les realizó análisis de varianza y separación de medias por rangos múltiples de Duncan. Las variables analizadas fueron peso fresco de raíces tuberosas (t/ha), número de raíces/ha, peso de catibía[12] (t/ha) y número de tortas de casabe por hectárea.

Para la preparación del terreno, se hizo un control manual de malezas y un corte de arado con bueyes. Las estacas utilizadas como material de siembra fueron obtenidas de tallos sanos con 15 meses de crecimiento vegetativo y una longitud entre 60 y 80 cm, a los cuales se les eliminó los extremos. Los tallos se cortaron en trozos entre 15 y 20 cm de longitud, para asegurar por lo menos siete yemas en cada estaca. Antes de la siembra, fueron tratadas con manzate a razón de 3.2 g por litro. Se sembró una estaca por postura, de acuerdo con el marco seleccionado. Las plantitas fueron producidas por el método de multiplicación rápida (Valdez y Pérez, 2008). Se aplicó un fertilizante

[12] Catibía: producto del rallado de la yuca exprimido y tamizado que se utiliza para hacer casabe

orgánico (Bokashi) a razón de 10 t/ha a los 65 días después de plantadas (ddp). Para el control de malezas, se realizaron tres desyerbos manuales a los 60, 90 y 120 ddp. El ensayo se realizó en condiciones de secano. La cosecha se realizó a los 547ddp (15 meses).

RESULTADOS Y DISCUSIÓN.

Peso fresco de raíces

El análisis de varianza no mostró diferencias $p>0.05$ para la interacción variedad*tipo de material, indicando que las variedades tienen un comportamiento independiente del material de siembra utilizado. Cuando se usó plantitas como material de siembra las variedades en general produjeron mayor peso fresco de raíces tuberosas (Tabla 1). No hubo diferencias entre las variedades ($p>0.05$).

Tabla 1. Peso fresco de raíces promedio por tipo de material de siembra

Tipo de material	Peso fresco de raíces (t/ha)
Plantitas	25.42 a
Estacas	20.86 b

Medias con la misma letra no difieren estadísticamente (Duncan $p\leq 0.05$)

Número de raíces tuberosas

Se encontraron diferencias significativas para la interacción variedad*tipo de material ($p<0.05$). El mayor número de raíces lo tuvieron las variedades SM 805-15, CM 6740 y Tai-8 producidas por plantitas, siendo iguales entre sí (Tabla 2). Los menores números de raíces se obtuvieron con TAI-8, cuando se sembró por estacas, este resultado es significativamente diferente a los demás tratamientos. La variedad Negrita fue la única que produjo igual número de raíces cuando se sembró con ambos materiales de siembra.

Tabla 2. Número de raíces promedio por tarea, por variedades y tipo de material de siembra

Variedad	Tipo de material	Número de raíces por hectárea
SM 805-15	Plantitas	142,480 a
CM 6740	Plantitas	140,576 a
Tai-8	Plantitas	105,360 ab
CM 6921	Plantitas	101,584 bc
CM 6740	Estacas	99,376 bc
CM 6921	Estacas	73,280 bcd
Negrita	Estacas	73,280 bcd
Negrita	Plantitas	72,656 bcd
SM 805-15	Estacas	62,272 cd
Tai-8	Estacas	58,800 d

Medias con la misma letra no difieren estadísticamente (Duncan $p\leq 0.05$)

Peso de catibía

La interacción variedad*tipo de material no fue significativa, ($p>0.05$), indicando que el tipo de material tiene un efecto independiente de las variedades para esta variable (Tabla 3). Se encontró diferencia significativa en el material de siembra ($p<0.05$). La siembra con plantitas produjo el mayor peso de catibía. No hubo diferencia entre las variedades ($p>0.05$).

Tabla 3. Peso promedio de catibía por tipo de material de siembra

Tipo de material	Peso de catibía (t/ha)
Plantitas	15.73 a
Estacas	12.50 b

Medias con la misma letra no difieren estadísticamente (Duncan $p\leq 0.05$)

Número de tortas

No se encontraron diferencias significativas para la interacción entre el tipo de material de siembra y las variedades ($p>0.05$).

CONCLUSIÓN Y RECOMENDACIONES

En la zona de Palmarejo, las plantitas usadas como material de siembra de yuca incrementaron los rendimientos, independientemente de las variedades.

Como la siembra con plantitas requiere humedad inicial, se recomienda usarlas a la entrada de los periodos de lluvia.

REFERENCIAS

López, J. 2002. Semilla vegetativa de yuca. En: La yuca en el tercer milenio. Sistemas modernos de producción, procesamiento, utilización y comercialización. Compilado por B. Ospina y H. Ceballos. Centro Internacional de Agricultura Tropical. Cali, Colombia p. 48-75.

Lozano JC; Pineda B; Jayasinghe V. 1984. Effect of cutting quality on cassava performance. En: Symposium of the International Society for Tropical Root Crops, 4th Centro Internacional de la Papa (CIP) Lima Perú.

Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO) 2004. Proceedings of the validation fórum on the global cassava Development Strategy. Vol 4.

Valdez C., J. y Pérez P. J. 2008. Multiplicación rápida de plántulas de yuca en invernadero. Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF). Santo Domingo, DO. 28p.

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THE CONTRIBUTION OF THE AROIDS —DASHEEN (*COLOCASIA ESCULENTA*), EDDOE (*COLOCASIA E. ANTIQUORUM*) AND TANNIA (*XANTHOSOMA SAGITTIFOLIUM*)— TO LIVELIHOOD AND NUTRITION SECURITY IN THE CARIBBEAN: THE CASE OF ST. VINCENT AND THE GRENADINES

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ABSTRACT: Traditionally, aroids [dasheen (*Colocasia esculenta*), eddoe (*Colocasia e. antiquorum*), and tannia (*Xanthosoma sagittifolium*)] have formed the basic staples of the diets of many Caribbean people, especially the rural poor. However, the westernization of diets has had an impact on the consumption of these more traditional aroids. This is evidenced by the continued increase in the Region's food import bill, estimated at over US$4 billion in 2010 (FAO, 2011). These roots and tubers contain complex carbohydrates, are high in fibre and have a lower caloric content than the imported staples. In addition, their production is dominated by rural small farmers. This makes them good candidates for a food and nutrition security plan that supports several farm families in the Region. It is recommended that the production and consumption of the aroids should be promoted in the Region as one means of reducing the Region's dependency on imported carbohydrates, the rising food import bill, and possibly to abate some of the ill effects associated with the "nutrition transition"(Durrant, 1987). This study attempts to examine these concepts by looking at a farmers' group in St. Vincent and the Grenadines in the Eastern Caribbean, which has successfully linked food and nutrition security while improving the livelihood of its farmers through the production and export of dasheen. The data shows an increasing trend in production and export over the period 2005–2010 and this impacted positively on agriculture's contribution to the country's gross domestic product.

INTRODUCTION

Traditionally, the roots and tubers group, of which the aroids are a part, formed the carbohydrate base of the diets for many of the Caribbean people, especially the rural poor. However, the westernization of diets has had a negative impact on the consumption of these more traditional crops. This is evidenced by the continued increase in the Region's food import bill, estimated at over US$4 billion in 2010 (FAO, 2011).

Over the last ten years, the Governments of Caribbean countries, including St. Vincent and the Grenadines, have actively embarked on an agricultural diversification program to reduce the reliance on the traditional production and export of bananas. This program has included renewed emphasis on root crops, including taro (dasheen) (McGregor et al., 2011). The authors also noted that this increased regional focus on crop diversification, coupled with increasing demand from Caribbean ethnic communities in overseas markets, has resulted in at least a five-fold increase in taro exports from the Region for the ten-year period.

Nigel Durrant (1987) stated, "Generally the production and consumption of indigenous roots and tubers have been declining over the last two decades and this trend has been ascribed to a wide variety of factors. Among these factors, the most important would seem to relate to the limited forms in which root crops may be consumed – given the low levels of processing technology". More than two decades since Durrant's statement, we seek to examine the contribution of the aroids to the livelihood and nutrition security of the people of St. Vincent and the Grenadines.

These roots and tubers contain complex carbohydrates, are high in fibre and have a lower caloric content than the imported staples. Despite their high starch content, edible aroids also provide other nutrients such as protein, potassium and calcium.

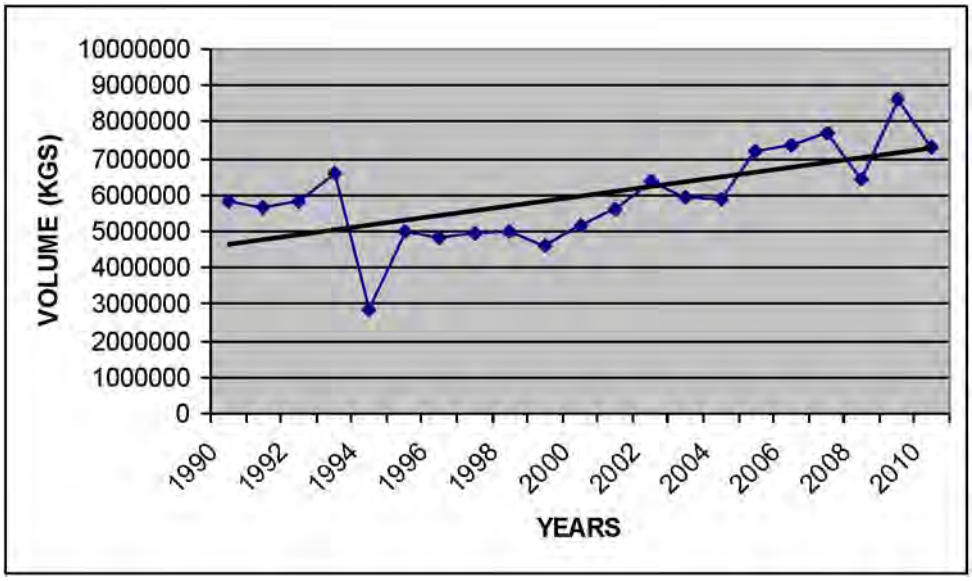
As in most of the Caribbean, the production of these roots and tubers in St. Vincent and the Grenadines (SVG) is dominated by rural small farmers, many of whom operate on marginal lands where many other crops will not thrive. This makes them good candidates for a food and nutrition security plan. Some development experts have recommended that the production and consumption of the aroids should be promoted in the Region as one means of reducing the Region's dependency on imported carbohydrates and reducing the rising food import bill.

This study therefore examines these concepts by reviewing the production and export of the aroids in SVG. An attempt is made to estimate the volume available for per capita consumption over the period 1990-2010. The contribution of dasheen production and export to the livelihood of some aroid farmers of St. Vincent and the Grenadines is also examined.

Trends in the production and export of aroids

The aroids, dasheen (*Colocasia esculenta*), which is also called Taro; eddoe (*Colocasia e. antiquorum*); and tannia (*Xanthosoma sagittifolium*) have a long production history in SVG. In recent years, in addition to the regional trade, dasheen has been exported extra-regionally mainly to the United Kingdom, Canada and France. In 2009, the latest year for which world production of Taro figures were available, SVG's production represented only 0.04% of the world production (FAOSTAT, 2012).

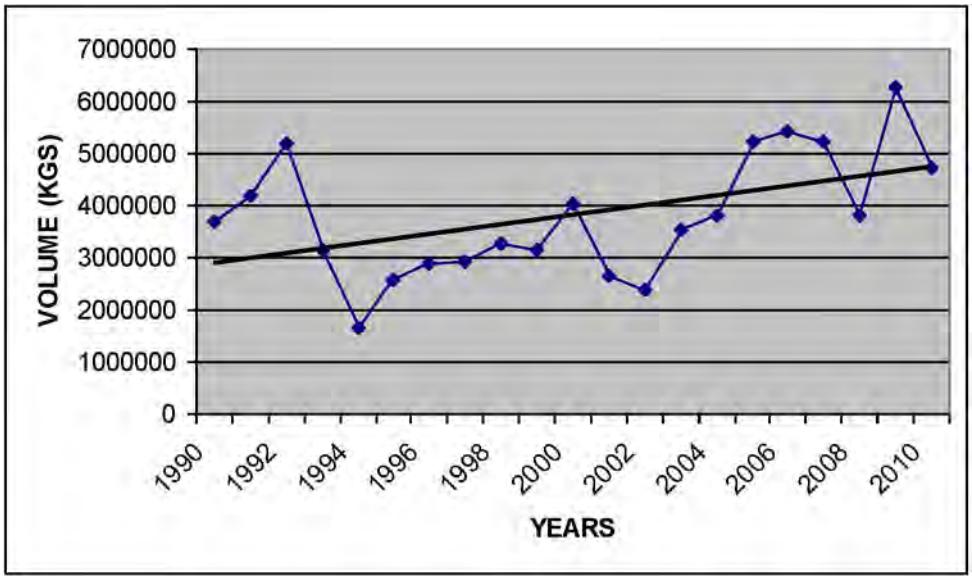
Figure 1 illustrates the production of the aroids for the period 1990-2010 for SVG. It shows that production fluctuated over the period. However, the trend line has a positive slope. Production in 2010 represents a 26% increase over 1990's production.



Source: Ministry of Agriculture SVG

Figure 1: SVG aroid production (kg) for the period 1990–2010

Figure 2 illustrates the volume of the aroids exported for the period 1990-2010. The lowest level of exports was recorded in 1994, which was also the lowest production year. Exports in 2010 represent a 29% increase over the export volume in the 1990s. In terms of value, exports in 2010 were 39% higher than in 1990 (EC$7,808,082 and EC$5,707,000, respectively). It should be pointed out here that in 2010, dasheen exports represented 54% of the value of aroid exports for St. Vincent and the Grenadines.



Source: Ministry of Agriculture SVG

Figure 2: SVG aroid exports (kg) for the period 1990–2010

Consumption patterns of aroids

Food security has been defined in many different ways. However, there appears to be some consensus of the three basic pillars:

- Food availability
- Access to food
- Food quality and appropriate utilization of food

Food availability relates to people having enough food grown so that the population of a country (in this case SVG) can be adequately fed. This study addresses food availability. However, as in most developing countries, the incidence of postharvest losses in SVG is high and, in the absence of a reliable estimate of the postharvest losses for the aroids, this factor is not included in the calculations.

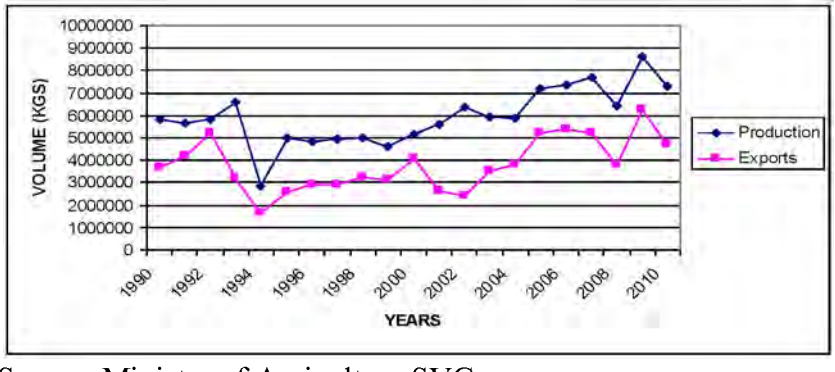
The following equation is used to estimate the availability of aroids for consumption:

CV = DP + I - E

where
CV = Consumption availability volume
DP = Domestic Production
I = Imports
E = Exports

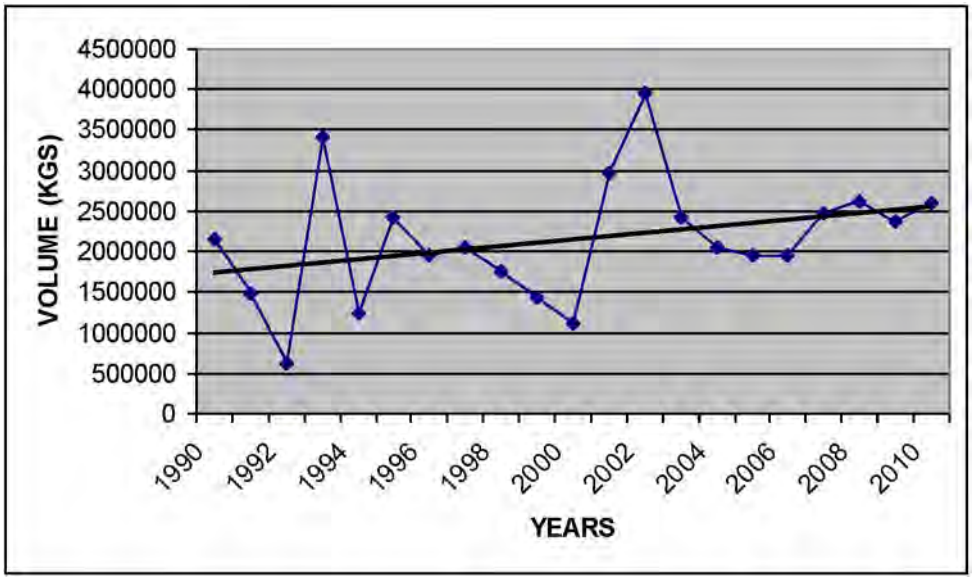
In the case of SVG, aroids are not normally imported, so this equation becomes: CV = DP - E

Figure 3 illustrates the production and exports of the aroids for the period 1990-2010. The area between the two lines represents the CV, that is, the volume available for local consumption. Figure 4 presents the same data for the period under review with a trend line added. As is observed in this graph, the volumes available for consumption fluctuated from year to year, with the highest level of aroids available for consumption in 2002 (3,959,550 kg). In 1992, the lowest level of aroids available for consumption was recorded (617,909 kg).



Source: Ministry of Agriculture SVG

Figure 3: SVG production and exports of aroids (kg) for the period 1990–2010



Source: Ministry of Agriculture SVG

Figure 4: SVG available aroids for consumption (kg) for the period 1990–2010

For the purpose of this study, per capita availability of the aroids for consumption is given by the following equation:

Per capita availability = Total available for consumption/total population

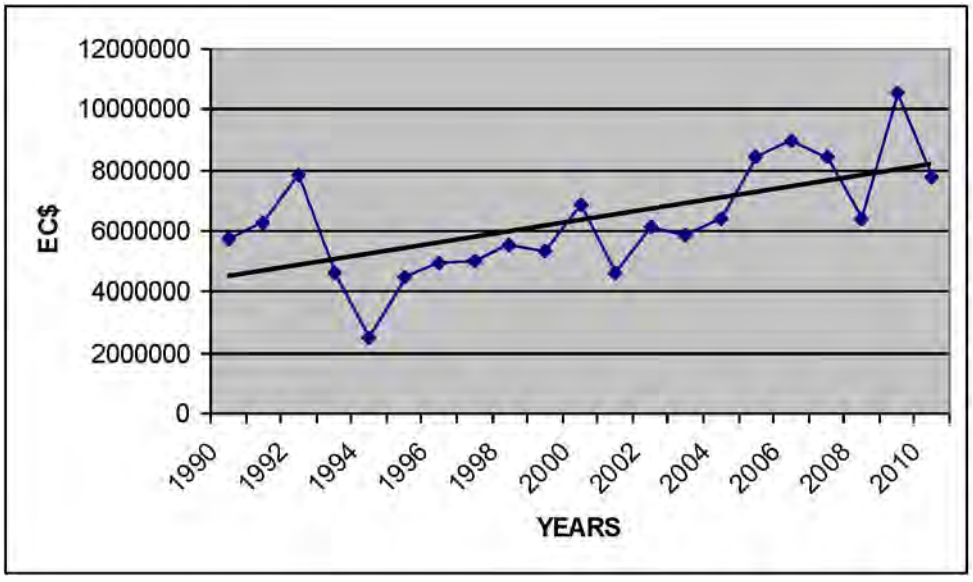
However, as is observed in Table 1, the per capita availability of the aroids in each year was higher than the availability in 1991. In 2010, the per capita availability was 86% higher than it was in 1991. From an availability perspective, the aroids were more available to the population in 2010 than they were in 1991.

Year	Total population	Total aroids available for consumption (kg)	Per capita availability (kg)
1991	106,499	1,480,091	14
2001	106,253	296,772	28
2005	100,747	1,962,184	19
2010	98,964	2,591,404	26

Table 1: Per capita aroid availability SVG for the period 1991 – 2010

Contribution of aroids to the country's economy

With the disappearance of preferential trading agreements in the 1990s, many Caribbean countries, including SVG, embarked on diversification strategies. The export of aroids to extra regional markets, such as the United Kingdom, was an option pursued by SVG. Figure 6 illustrates the export earnings from aroids for the period 1990-2010. As can be observed in this graph, there was a general increasing trend for the period. The export earnings in 2010 was 37% higher than in 1990. Therefore, the aroids have contributed to the economy overall for the period under review by earning valuable foreign exchange.



Source: Ministry of Agriculture SVG

Figure 5: SVG's export earnings from aroids for the period 1990–2010

Contribution of farmers' group

In St. Vincent and the Grenadines, the Farmers' group, Eastern Caribbean Trading Agricultural and Development Organization (ECTAD), has contributed significantly to the livelihoods of rural farm families by organising them into an entity through which they can benefit as members of a group**.** ECTAD is a registered, non-profit, rural development, farmer-based organization which was started in 1995. The vision is for farmers to operate their farms as businesses, thus improving the livelihoods of the mainly rural poor farm families. Areas of activities include capacity building of farmers, marketing and information sharing. The Organization operates through farm clusters within which farmers work together and support each other in production and marketing.

The group mainly collaborates with the Food and Agriculture Organization (FAO), Caribbean Agricultural Research and Development Organization (CARDI), and the St Vincent and the Grenadines Ministry of Agriculture.

ECTAD has five target crops: sweet potato, eddoes, dasheen, yams and ginger. To date, the most successful export crop has been dasheen. Export efforts began in 2004 in response to the need of neighbouring Grenada, whose agricultural sector was devastated by hurricane Ivan. The farmers from ECTAD supplied approximately 2,000 boxes (100,00 lb) of produce weekly to the Grenada Marketing Board. Inspired by this success, the Organization made trial shipments of dasheen to the United Kingdom in 2005. It was a collaborative effort of several entities, a local businessman provided boxes for the shipment; villagers facilitated packing and transport; and ECTAD organized financial support for shipping. The Technical Centre for Agricultural and Rural Co-operation (CTA) has funded training workshops in postharvest handling and packing. The price the farmers received increased from US thirty to seventy cents per pound.

In an attempt to gather information on the contribution of dasheen to the farmers' livelihoods, questionnaires were administered to a sample of 30 dasheen producers on the windward side of the island where dasheen production predominates.

The questions attempted to capture information on the length of time the producers were in dasheen production, their perception of the contribution of the undertaking to their income and standard of living, and the use of different production and marketing practices/options. Demographic data on age, sex and size of household were also collected. The analysis of the data was done using the statistical package SPSS.

Survey results

Of the 29 respondents that completed the question on gender, 15 were male and 14 female. None of the farmers were in the under twenty-five-year-old category. Over seventy percent of the farmers were between the ages of thirty-six and fifty-four. Also worthy of note is that only about seventeen percent were over fifty-five years old.

The respondents were predominantly members of ECTAD (>85%). Only one person was not a member of that group. Twenty-nine persons indicated the length of time they had been producing dasheen, with a minimum and maximum of three and thirty years, respectively. The average years in production were 15.59. The respondents each had more than a decade of dasheen production experience. All the respondents indicated that they grew dasheen for the market.

The responses suggest that production can be considered to be still in a traditional mode, without soil testing, or irrigation and in mixed stands (Table 2). In the case of labour for production and marketing, respondents used both family and hired help, with ninety-three percent of the respondents (N = 30) using family labour whereas ninety-seven percent used both. In the contemporary competitive agribusiness environment, most farmers will have their soil tested so that the appropriate fertilizer can be applied for the targeted crop.

Production issues	% Yes	% No
Crop grown as mixed stand	100	0
Crop grown as pure stand	0	100
Crop grown with irrigation	0	100
Crop grown by rain feed method	100	0
Do you test your soil before planting	0	100
Do you fertilize your dasheen	100	0

N = 30

Table 2: Production practices summarized

Ninety-three percent of the respondents identified price as a determining factor for their harvesting decisions. None of the respondents harvested their entire crop at once, and the availability of labour does not seem to influence harvesting decisions.

Seventy percent of the respondents (N = 30) thought that their income increased from the sale of dasheen. Further, eighty-seven percent obtained more than fifty percent of their income from

dasheen production and marketing and they also indicated that their standard of living improved as a result of dasheen production. This is an important finding when one looks at the average size of the household. Twenty-nine persons responded to the question pertaining to household size. The mean household size was five with a minimum and maximum of two and ten, respectively.

One important, noteworthy element of the programme was that the farmers eliminated the middleman and did the packing and postharvest handling themselves. This resulted in a higher price to the farmer. Since production and marketing activities were centralised in the villages, employment was created in the rural community. Farmers are now shipping in branded boxes labelled "Caribbean Small Farmers".

The export of dasheen from St. Vincent and the Grenadines has increased over the years, with the maximum export occurring in 2006. More farmers went into dasheen production, mainly because the main export crop, banana, was on the decline.

As the preceding data (Figure 3 and Figure 5) illustrate, dasheen production, export and earnings increased from 2004 to 2010, corresponding to the period when ECTAD farmers started producing and exporting.

The operation, which started out benefitting approximately 60 farm families, now impacts more than 200. Prices increased from EC thirty cents per pound to as much as EC$1.80 in the dry season when dasheen was scarce. The regional markets (mainly Trinidad and Tobago, Barbados and Grenada) were always important, but France and Great Britain became significant also (Table 3).

Table 3 Dasheen export from St. Vincent and the Grenadines 2006–2010 (kg)

	2006	2007	2008	2009	2010
United Kingdom	188,886	105,680	221,337	271,082	129,270
France	30,304	16,264	13,110	19,057	12,958
United States	111,174	110,150	40,878	98,460	51,170
Trinidad and Tobago	1,125,685	1,343,713	825,193	1,065,647	951,052
Barbados	22,825	23,260	16,152	17,420	14,751
Grenada	*60,756*	11,894	2,909	773	2,847

CONCLUSION

From the data presented, it could be concluded that there is a sufficient volume of aroids available for consumption by the population of St. Vincent and the Grenadines. Although large quantities are exported, a lot is consumed locally. The aroids, particularly dasheen, are making a positive contribution to the livelihoods of rural farm families. This was evidenced by the increase in prices to the farmer, employment opportunities generated and a general improved standard of living, where farmers could build houses and purchase vehicles (personal communication from the Secretary of ECTAD Group, Greggs). The survey also revealed a perception of a better standard

of living as a result of selling dasheen. It is hoped the farmers' group will be strengthened so that the farmers can continue to enjoy all the benefits that accrue from working together.

REFERENCES

Durrant, N. 1987. The Pre-eminence of roots and tubers in the diets of the Caribbean peoples. The Courier No. 101. Jan/Feb 1987. p89. European Union Commission

Food and Agriculture Organisation, Sub-Regional Office for the Caribbean, Barbados. 2011. Summary of Proceedings of Regional consultation on policy and programmatic actions to address high food prices in the Caribbean. Port of Spain, Trinidad and Tobago, 13-14 June 2011.

Food and Agriculture Organization of the United Nations (FAO). 2012. FAOSTAT. Statistical database of the Food and Agriculture Organization of the United Nations. Rome, Italy: FAO

McGregor A. et al. 2011 Pacific island taro market access scoping study, The EU-Funded Facilitating Agricultural Commodity Trade Project.

Ministry of Agriculture St. Vincent and the Grenadines, 2010. Statistical Unit

Personal communication from the Secretary of ECTAD Group, Greggs

Scott, G.J., R. Best, M. Rosegrant, and M. Bokanga. 2000. Roots and tubers in the global food system: A vision statement to the year 2020. A co-publication of the International Potato Center (CIP), Centro Internacional de Agricultura Tropical (CIAT), International Food Policy Research Institute (IFPRI), International Institute of Tropical Agriculture (IITA), and International Plant Genetic Resources Institute (IPGRI). Printed in Lima, Peru: International Potato Center.

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PROFILING THE REGION'S SWEET POTATO VARIETIES FOR VALUE ADDED PRODUCT DEVELOPMENT

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ABSTRACT: Diversifying the range of products available to consumers is important to promote increased production and consumption of sweet potato. The development of the local value added industry, however, requires information on the chemical/nutritional properties of these popular local lines so that the products for which they are best suited can be identified. CARDI, in collaboration with the National Agricultural Research Center for Kyushu Okinawa Region (KONARC), Japan, The University of the West Indies and other key stakeholders, have made efforts to determine the proximate composition (protein, sugars, fat) and physiochemical properties (solubility, viscocity, pasting temperature) of some popular regional varieties. Results indicate the potential of the varieties to make a range of products including flour, paste, juice and fries. These results are discussed within the context of expanding the current value added product development for sweet potato.

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TENDENCIAS EN LA COMPRA DE ALIMENTOS EN PUERTO RICO, 1993-2009

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RESUMEN: Este estudio analiza los cambios que ha habido en las compras de alimentos en la familia en Puerto Rico. En el año 2009 el gasto mensual promedio en alimentos para consumo en el hogar fue de $495. En el 2007 el 55% de los consumidores indicó que compraba solo lo necesario mientras en el 2009 este valor aumentó a 63%. En el 2007, el 25% de los entrevistados indicó estar comprando menos de lo que compraba antes; en el 2009, 56% de los consumidores mencionaron igual tendencia. En el 2007 el 12% de los consumidores compraba productos genéricos, mientras en el 2009 ya los compraba el 26%. El 36% revisaban las hojas de precios especiales. En el 2008 el 40% decidía el lugar para realizar sus compras considerando las hojas de precios especiales de los establecimientos comerciales, mientras que en el 2009 el 46% utilizaba estas como referencia. Las familias que hacían sus compras con dinero que recibían de ayudas gubernamentales (Tarjeta de la Familia) aumentaron de 31 a 41%. El 37% sale menos a comer fuera. El uso de las marcas genéricas ha aumentado a 26%. El 49% lleva una lista para hacer la compra. El precio es el criterio más importante que utilizan los consumidores para decidir qué compran por primera vez, 45%. La frecuencia de las compras de relleno ha variado de 3 a 6.6 veces al mes, mientras el gasto aumentó de $19 a $31 en cada compra. El 60% de los consumidores paga en efectivo su compra de relleno.

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L'AGRICULTURE AUX ANTILLES FRANÇAISES : VERS UN RETOUR AUX PRODUCTIONS DESTINEES AU MARCHE LOCAL ?

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RÉSUMÉ : L'agriculture aux Antilles Françaises à l'instar d'autres îles de la Caraïbe, a maintenu, depuis la période coloniale, quelques monocultures, la canne à sucre et la banane. Aux côtés de cette agriculture exportatrice, les agrosystèmes multi-espèces sont aussi très anciens mais ont longtemps fonctionné de façon isolée et sur la base de savoirs populaires locaux notamment à travers les jardins familiaux ou "jardin créole", sur lesquels a longtemps reposé l'essentiel de l'approvisionnement vivrier des ménages. D'un point de vue socio-économique, la densification de la population locale et la rurbanisation corollaire conjuguées aux récentes tensions sur les marchés internationaux des denrées alimentaires de base génère un nouvel intérêt pour ces agrosystèmes. Aujourd'hui, la nécessité d'une diversification professionnelle de l'activité agricole aux Antilles est admise, reconnue voire soutenue compte tenu des impasses agronomiques, environnementales ou économiques dans lesquelles se trouvent les filières agro-exportatrices organisées. L'exiguïté des territoires entraîne de nombreux conflits d'usage dans la gestion du capital foncier. Les besoins en terres à bâtir dans un contexte d'augmentation de la population, l'importance des enjeux de protection des milieux naturels soulèvent, en effet, de nombreuses questions en matière d'aménagement, de préservation et / ou de restauration des continuités écologiques et plus largement de gestion des territoires. L'agriculture est un secteur consommateur d'espace et ce, pour l'ensemble des productions agricoles. Aux Antilles, l'agriculture connaît de lourds héritages avec la prépondérance des cultures destinées à l'exportation et gourmandes en surfaces, la canne à sucre et la banane surtout. La gestion des territoires mais aussi des pratiques agricoles associées à ces monocultures sont très clairement remises en cause depuis la crise de la chlordécone en 2006 et depuis la crise sociale de 2009 décriant les cultures d'exportation pour leur caractère polluant et intensif et appelant à un retour aux productions traditionnelles et à des pratiques plus respectueuses de l'environnement. Cette volonté de retour vers des productions destinées au marché local, en réponse aux exigences d'une demande sociale qui semble de plus en forte (consumérisme engagé, agriculture de proximité, respect des fonctionnalités écologiques des agrosystèmes et services associés), est-elle aujourd'hui visible dans le paysage agricole des Antilles Françaises? Cet article vise à repérer et à analyser ces évolutions. Nous nous appuyons, pour ce faire, sur une observation spatiale et temporelle des surfaces agricoles, en raisonnant à l'échelle du territoire. Les méthodes utilisées sont qualitatives et quantitatives par superposition de couches d'informations dans un Système d'information Géographique. Notre réflexion s'établit en deux temps. Nous commençons par rendre compte des tendances générales de l'évolution des systèmes agraires antillais, avec un focus sur la dernière décennie, de 2000 à 2010. Nous nous interrogeons ensuite sur les déterminants de ces changements notamment d'une réappropriation de l'espace agricole par les productions destinées au marché local.

Mots-clés : Agriculture, Antilles Françaises, production agricole de proximité, surface agricole, évolution spatio-temporelle

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AN OVERVIEW OF TAIWAN TECHNICAL MISSION AGRO-PROCESSING PROJECT IN ST. KITTS & NEVIS

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ABSTRACT: The sugar industry had been the main production activity and source of income in St. Kitts & Nevis since colonial times; most people worked in the sugar factory. Sugar workers faced severe economic difficulties when the St. Kitts Sugar Manufacture Company (SSMC) closed down in 2005. Thus, the Ministry of Agriculture of St. Kitts & Nevis in collaboration with the Taiwan Technical Mission initiated the Agro-processing Project in order to ameliorate the hardships that this created. The Agro-processing Project renovated the SSMC soil analytical laboratory to establish an agro-processing unit at Needsmust, St. Kitts and opened in May of 2006. This project educated and empowered the people of the Federation through four primary goals. First is Research and Development; we use local agricultural produce to generate healthy, natural goods, which add value to local agricultural industry. It also successfully introduced dehydration technology to the local people. Second is Education; we hold training courses and workshops for farmers, students and local producers, who are interested in agro-processing. Third is providing Consultation to local agro-processors; the Project unit serves as a platform to provide food processing technology information and packaging materials for local agro-processors and farmers. As a result, there is increased agro-processing business in the Federation. The last and most important goal is Sustainability; we use locally grown fruits to produce healthy, natural juices (limeade, sugar cane, sorrel and star fruit), dried fruits (jujube, mango, pineapple and star fruit), snacks (plantain chips and roasted peanut) and yogurt. Availability of our products to the public in St. Kitts & Nevis is generating income, which provides support to the Project and helps make it sustainable. Another part of this agro-processing project involves showing the people of St. Kitts & Nevis additional methods for preserving agricultural produce and thereby added opportunities for financial independence. Through this project we have collaborated with local farmers, some of whom are doing quite well in their various fields. By implementing the four goals, we hope to see this project expanded, remain sustainable and to benefit the people of the Federation. At the conclusion (Year 2012), agro-processing project will be transferred to a local government program to continue facilitating this processing plan. This project demonstrated the possibility to transform the agricultural produce into valuable products and to enhance the food security efforts on the small islands of the Caribbean.

Keywords: Agro-processing, Sustainable, Education

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GROWTH AND YIELD RESPONSE OF SWEET PEPPER CULTIVARS IN THE US VIRGIN ISLANDS

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ABSTRACT: Sweet pepper (*Capsicum annuum* L.) is a major vegetable for producers in the US Virgin Islands and is grown for fresh market. Challenges in sweet pepper productions in the US Virgin Islands are high cost of labor and management, limited water resources, weeds, diseases and pests, limited land and natural disasters. This study was conducted at the horticultural field plots of the University of the Virgin Islands Agricultural Experiment Station in growing seasons of 2011-2012. The objective of the research was to conduct field evaluations of sweet pepper cultivars that are suitable to grow in the local soil and climate of the islands. Thirteen cultivars, 'Aristotle', 'California Wonder', 'Declaration', 'Dulce', 'Intruder', 'Jupiter', 'Mecate', 'Naples', 'Sweet Cherry', 'Sweet Banana', 'Sweet Savannah', 'White King', and 'Vanguard' were tested in the field. Cultivars selected with the traditional lobe or bell shape fruits as well as longer, pointed shape known as banana peppers. Specialty 'colored' peppers, orange, yellow and red were also tested. Transplants of all the pepper cultivars were planted into rows four feet apart. Spacing in plants was one foot within the row. The trial was laid out by using a randomized complete block design with three replications. 'White King' was the early maturity cultivar (65 days) and produced the highest total marketable yield (33.4 oz/plant). 'Aristotle' produced biggest fruit (5.8 oz). 'Intruder' fruits were smallest (1.1 oz.) and maturity of 76 days. 'Sweet Cherry' produced smallest fruit (0.48 oz.) and lowest yield (8.7 oz/plant) expected from the cherry type. Fruits were graded by size and condition. No serious pests and diseases were observed in the crop. All thirteen cultivars set fruits during the season and were rated good or excellent in disease tolerance, yield, taste and adaptability. Frequent rainfall during the growing period affected quality production at some extent. This paper presents results on plant growth, marketable yield, marketable fruit weight and maturity of thirteen cultivars of sweet pepper.

Keywords: *Capsicum*, marketable yield, peppers, production, specialty

INTRODUCTION

Sweet pepper (*Capsicum annuum* L.) is an important fresh-market vegetable crop in the U.S. Virgin Islands. 2007 Census of Agriculture (2007 Census of Agriculture, 2009) reported that production and acreage planting of peppers have been increased in the U.S. Virgin Islands (Table 1). Vegetable variety trials have always been a component of the Horticulture Program at the University of the Virgin Islands Agricultural Experiment Station and several varieties of sweet peppers have been tested in the 80s and 90s (Ramcharan C., 1981; Palada et al., 1993). There is continuous need for new variety testing in sweet peppers for high yield, production, marketability, insect pests and disease resistance and overall suitability to grow in the U.S. Virgin Islands. Several reports on variety trials of sweet peppers are available in the literature, which includes bell types, specialty 'colored' peppers and banana type (Rowell et al., 2001; Evans et al., 2006; Hutton and Handley, 2007; Juroszek and Tsai, 2009).

The main objective of the current study was to conduct field trials of sweet pepper cultivars for growth, adaptability and yield potential in the U.S. Virgin Islands conditions.

MATERIALS AND METHODS:

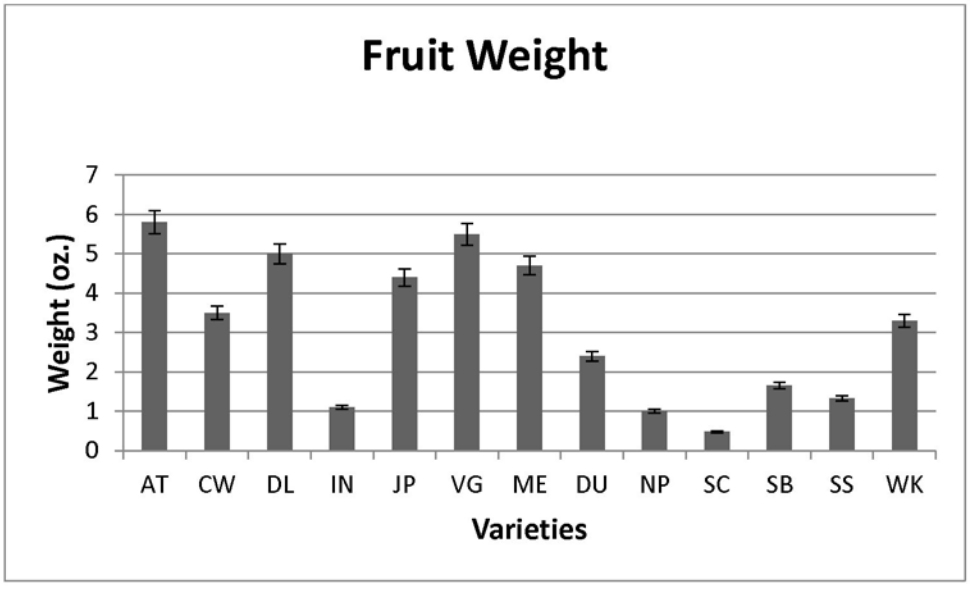
Experiments were conducted in field plots at the University of the Virgin Islands Agricultural Experiment Station, Kingshill in growing seasons of 2011-2012. Thirteen cultivars traditional bell type fruits, long pointed banana types and specialty colored peppers selected. 'Aristotle' (AT), 'California Wonder' (CW), 'Declaration' (DL), 'Intruder' (IN), 'Jupiter' (JP), 'Mecate' (ME), 'Vanguard' (VG), and 'White King' (WK) were the bell types. Specialty peppers 'Naples' (NP), 'Sweet Cherry' (SC), 'Dulce' (DU), and two banana types, 'Sweet Banana' (SB) and 'Sweet Savannah' (SS) were selected for the study. Seeds were procured from Stokes Seeds Co., NY and planted in seedling trays containing 'Pro Mix' potting mix. Seedlings were transplanted in the field approximately six weeks after germination. Plots were consisted of three rows spaced four feet apart, with 12 plants per row and spaced one foot between the plants within a row. The experimental design was a randomized complete blocks, with three replications. Plants were drip irrigated two to three times in a week (Figure 1). Data collected from plants #2-11 from center row on maturity were plant height, fruit weight, marketable fruits (US#1), and yield from six harvests. Fields were periodically scouted and monitored for insect pests and diseases by the Extension entomologist. One application of Malathion and Venom was used to control insect pests. No preplant fertilizers were applied. A complete fertilizer 20-20-20 was applied during the experiment through drip irrigation system (fertigation) to provide a total of 120 lb N, 80 lb P_2O_5 and 80 lb K_2O per acre. Weekly irrigation was applied as needed (Berke et al., 2003).

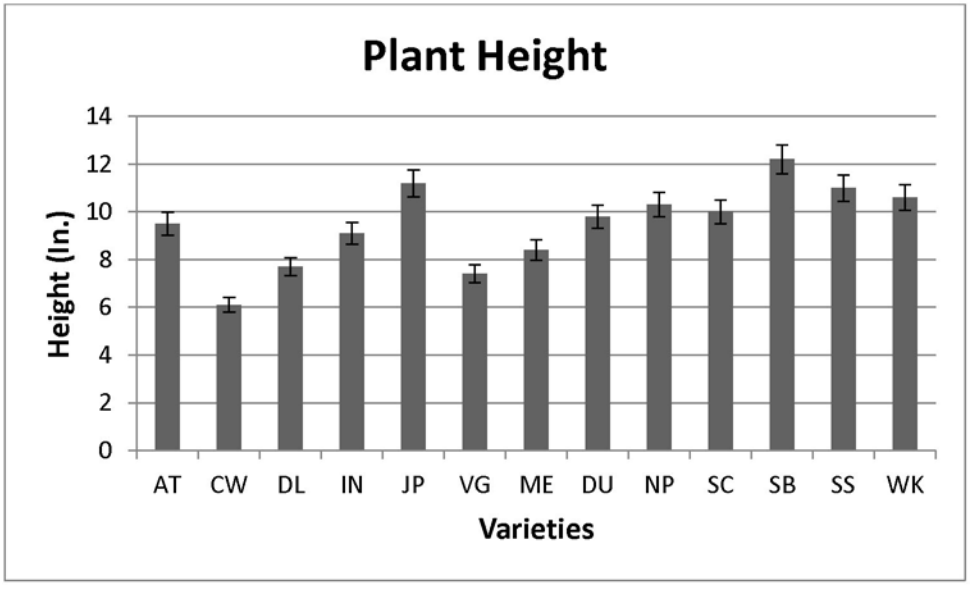
RESULTS AND DISCUSSION

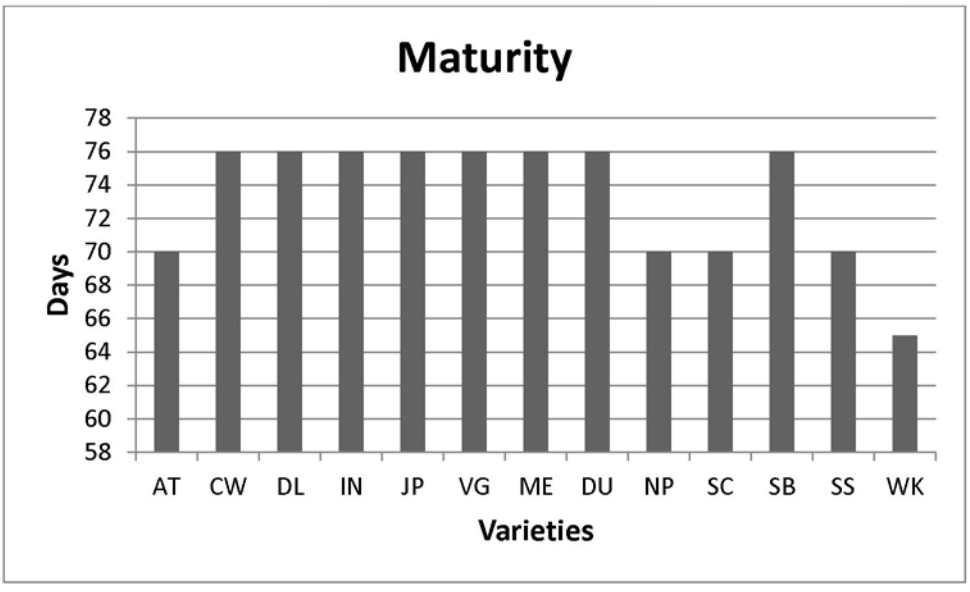
All thirteen cultivars performed well and produced fruits in the USVI soil and climate conditions. Peppers were harvested as they reached marketable size (firm and full size) at green color stage before turning color to yellow or red. Marketable fruits were separated from culls and then counted and weighed. Number of culls was recorded as sunscald, small, misshapen, and damaged. Data on marketable yield (US#1), fruit weight, plant height and maturity are presented in Table 2. Grading of harvested peppers was done according to United States Department of Agriculture's standards (United States Standards for Grades of Sweet Peppers, 2005). 'White King' was the first variety harvested among the bell types. 'White King' produced the highest total marketable yield (33.4 oz/plant) and early maturity (65 days). 'Aristotle' produced biggest fruit (5.8oz.). 'Intruder' fruits were smallest (1.1 oz.) and maturity of 76 days. 'Sweet Cherry' produced the smallest fruit (0.48 oz) and lowest yield (8.7 oz/plant) in cherry type. No serious diseases occurred during the trial; however, much of the common pests, such as hornworms, armyworms, stink bugs, and leafminer were observed. Venom and Malathion were effective in keeping the pest population low.

Field evaluations of sweet pepper varieties have been reported in the literature (Evans et al., 2006; Hutton and Handley, 2007; Rowell et al., 2001; Juroszek and Tsai, 2009). Earlier reports on sweet pepper variety trials conducted in the U.S. Virgin Islands indicate that 'Jupiter', 'California Wonder' and 'Yolo Wonder' performed best under local growing conditions (Ramcharan C., 1981; Palada et al., 1993). In the current study, all bell types tested were blocky, green, orange, red and yellow color and also, specialty peppers such as cherry and banana types. Results suggest that the cultivars may have production potential to fulfil local market needs for fresh peppers grown

locally, if consumers are interested on special color, taste, or are interested in the fresh local peppers. Banana types may have the potential for processing or pickling peppers. The program shall continue testing new sweet pepper cultivars for high yield, production, marketability, insect pests and disease resistance and overall suitability to grow in the U.S. Virgin Islands.







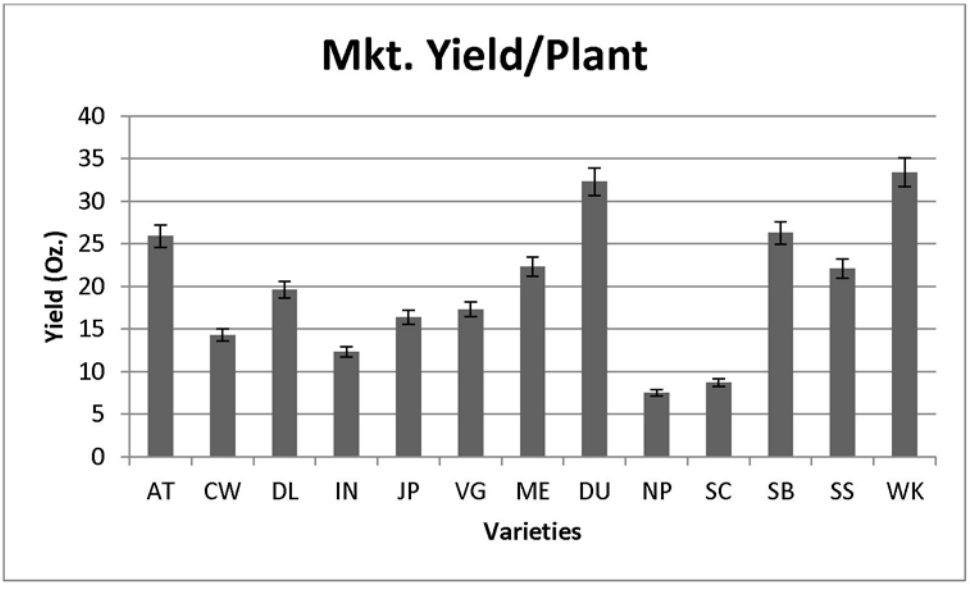


Table 1: Production and acreage of peppers in the U.S. Virgin Islands*.

Year	Production (lb)	Planting (acres)
2002	14,750	8
2007	31,475	12
*2007 Census of Agriculture, 2009		

Table 2: Growth, marketable yield and fruit weight of sweet pepper cultivars grown at UVI-AES.

Cultivar	Type	Avergae Fruit Weight (oz)	Maturity (days)	Marketable yield/plant (oz)	Plant height (in)
Aristotle (AT)	Bell	5.8	70	25.9	9.5
California Winder (CW)		3.5	76	14.3	6.1
Declaration (DL)		5	76	19.6	7.7
Intruder (IN)		1.1	76	12.3	9.1
Jupiter (JP)		4.4	76	16.4	11.2
Vanguard (VG)		5.5	76	17.3	7.4
Mecate (ME)		4.7	76	22.3	8.4
White King (WK)		3.3	65	33.4	10.6
Dulce (DU)	Jalapeno	2.4	76	32.3	9.8
Naples (NP)	Italian	1	70	7.5	10.3
Sweet Cherry (SC)	Cherry	0.48	70	8.7	10
Sweet Banana (SB)	Banana	1.66	76	26.3	12.2
Sweet Savannah (SS)		1.37	70	22.1	11

Fig. 1. Field production of peppers at research plot at UVI-AES.

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REFERENCES

2007 Census of Agriculture. Virgin Islands of the United States Territory and Island Data. February 2009. United States Department of Agriculture. National Agricultural Statistics Service.

Berke, T.G., L.L. Black, R.A. Morris, N.S. Talekar, and J.F. Wang. 2003. Suggested Cultural Practices for Sweet Peppers. *Asian Vegetable Research and Development Center (AVRDC),* Shanhua, Tainan. AVRDC pub # 99-497R.

Evans, W.B., C.E. Coker, K.E. Cushman, T.E. Horgan and K.L. Paridon. 2006. Selecting Highly Colored Bell Peppers for Fresh-market Specialty Growers. *HortScience* 41 (4) 1075.

Greenland R.G. and L. Besemann. 1996. Pepper performance trial. Oakes Irrigation Research Site, Carrington Research Extension Center, North Dakota State University Oakes, ND

Hutton, M.G. and D.T. Handley. 2007. Bell pepper cultivar performance under short, variable growing season. 2007. *HortTechnology* 17 (1): 136-141.

Juroszek P. and H-H. Tsai. 2009. Yields of organically grown sweet pepper cultivars and lines during the hot-wet and cool-dry season in the tropics. *HortTechnology* 19 (2): 418-422.

Palada, M.C, S.M.A Crossman and C.D. Collingwood. 1993.Yield performance of vegetable varieties in the U.S. Virgin Islands 1988-1982. Agri. Exp. Station, Univ. of the Virgin Islands Technical Bul. No. 5.

Petersen, A.C. 1987. Yield results of vegetable variety evaluation trials in the U.S. Virgin Islands. V.I. Perspective Agric. Research Notes, Vol.2 (1): 16-18.

Ramcharan C. 1981. Virgin Islands tomato, pepper and eggplant variety trials in 1978-79. V.I. Agri. Exp. Station Technical Bul. No.3.

Rowell B., R.T. Jones, W. Nesmith, A. Satanek and J.C. Snyder. 2001. Bacterial Spot Resistance, Yield, and Quality of Bell and Specialty Peppers. *HortTechnology* 11(4) 648-657.

United States Standards for Grades of Sweet Peppers. 2005. USDA Agricultural Marketing Service, Fruit and Vegetable Division, and Fresh Products Board. P.8

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INFLUENCIA DEL PERÓXIDO DE HIDRÓGENO (H_2O_2) SOBRE EL NIVEL DE CLOROFILA EN PIMIENTO ITALIANO (*CAPSICUM ANNUUM* L.)

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RESUMEN: El objetivo del ensayo fue valorar el efecto del Peróxido de Hidrógeno (H_2O_2) en la solución de fertirrigación (oxifertirrigación) sobre el nivel de clorofila en hojas de pimiento verde italiano, *Capsicum annuum* L. Las plantas del ensayo se cultivaron en un sistema de hidroponía pura, colocada en unos depósitos que contenían agua y los elementos nutritivos necesarios para el desarrollo del cultivo. El nivel de clorofila en las hojas se determinó usando un medidor manual de clorofila (Minolta SPAD-502). Se aplicaron tres dosis de H_2O_2 al agua de la solución nutritiva (0.75, 1.5 y 3.0 mM de H_2O_2/L), que se compararon con un Testigo al cual no se le aportó H_2O_2. Existe una diferencia altamente significativa en los valores de clorofila a lo largo del tiempo pero esa diferencia es escasamente significante cuanto se comparan los niveles de peróxido aquí estudiados. De acuerdo a estos datos se puede concluir que la cantidad de clorofila en las hojas de la planta es resultado de un proceso fisiológico que depende más de la edad de la planta que de los valores de oxigenación en los sistemas radiculares.

Palabras clave: Peróxido de Hidrógeno (H_2O_2), pimiento, clorofila, SPAD

ABSTRACT: The purpose of this experiment was to analize the effect of different dosis of Hydrogen Peroxide (H_2O_2) in nutritive solution (oxigation) on the level of chlorophyll in the leaves of pure hydroponics italian pepper, *Capsicum annuum* L., placed in containers with water and necessary nutrients for crop development. The chlorophyll level of the leaves was determined with a manual chlorophyll meter (Minolta SPAD-502). Three different H_2O_2 dosis (0.75, 1.5 and 3.0 mM/L) were applied which were compared to a test without H_2O_2. There was a highly significant difference in the chlorophyll values througthout time, but that difference is barely significant when the studied H_2O_2 levels are compared. Based on the data we can conclude that the level of chlorophyll in the leaves results from a physiologycal process where the age of the plant is more important than radicular systems oxygenation values.

Keywords: Hidrogen Peroxide (H_2O_2), pepper, chlorophyll, SPAD

INTRODUCCIÓN

La cantidad de vegetales (tomates, calabacines, fresas, pimiento, etc.) que se está produciendo en invernaderos con o sin suelos, usando soportes como lana de roca y fibra de coco, o hidroponía sola, está en aumento continuo.

Los nutrientes se suministran vía la solución nutritiva, y para mantener una adecuada humedad en tan pequeño volumen radicular se aumenta la secuencia de riegos hasta hacerla superior a diez riegos /día. Cuando se usan soportes y a raíz desnuda la solución es permanentemente circulante.

Este nivel de humedecimiento permanente en los sistemas radiculares y una elevada temperatura en el medio climático del invernadero, hacen que la difusión de oxígeno en el medio radicular pueda llegar a ser un factor limitante del crecimiento porque limita la respiración radicular, y consecuentemente reduce las cosechas, en algunas plantas.

La ausencia de oxígeno (anoxia) o los bajos niveles del mismo (hipoxia) reducen la absorción de agua y minerales con las consecuentes repercusiones en la parte aérea de la planta. Hay diferencia entre especies y variedades, ya que hay plantas que están preparadas para vivir en medio de encharcamiento permanente (manglares) y otras por el contrario pueden sufrir severas restricciones en un medio escasamente aireado (tomate).

Está muy poco estudiado, y no se conoce prácticamente nada sobre los requerimientos de oxígeno de las plantas cultivadas, especialmente en un medio de desarrollo radicular limitado. El motivo es porque en un medio natural como es un suelo agrícola el determinar las interacciones con los microorganismos, la fijación de nutrientes y la medición misma del parámetro objeto de estudio presentan una notable dificultad. Por lo estudiado hasta ahora hay una gran diferencia en lo que respecta a la sensibilidad a la falta de oxígeno en las raíces para diferentes especies de plantas.

Por otra parte, se sabe que la aplicación de ciertos fertilizantes nitrogenados (nitratos) pueden aliviar periodos de deficiencia de oxígeno en el sistema radicular (Veen, 1988), posiblemente debido a que actúan como aceptores de electrones. Por ello la planta podría, ante un proceso de anoxia, tomar el oxígeno de la reducción de los NO_3 a NO_2. Por ello, para iniciarse en conocimiento de este factor (oxígeno) en la producción agrícola los investigadores realizan las experiencias en invernadero y a ser posible sin suelos, usando hidroponía pura.

El pimiento es una planta angiosperma de la Familia Solanaceae, género *Capsicum*, especie *annuum*. El pimiento se cultiva de varias maneras según su destino. El pimiento para pimentón se ha cultivado tradicionalmente directamente en el campo. El pimiento típico de asar o pimiento Lamuyo ha sido objeto de cultivo en invernadero fundamentalmente. Las variedades de pimiento verde para freír o pimiento italiano se han cultivado por varias técnicas.

En los últimos años, se han empezado a probar los cultivos sin suelo y con sistemas de riego cerrados (cultivos hidropónicos) que tienen como objetivo básico el reciclaje de la solución nutritiva. Una de las limitaciones de los cultivos hidropónicos es el aporte de oxígeno a la solución nutritiva, ya que la hipoxia en el sistema radicular puede producir diferentes alteraciones en las plantas como clorosis, disminución del crecimiento, reducciones en la cosecha, necrosis y asfixia radicular. La oxifertirrigación es la técnica mediante la cual se agrega oxígeno al agua de los cultivos hidropónicos (Zaballa, 2003).

La base de la oxifertirrigación es la concentración de oxígeno disuelto en las soluciones nutritivas. Su presencia favorece la absorción de los nutrientes (Bonachela *et al.*, 2010), promoviendo el desarrollo radicular (Carazo *et al.*, 2007), al mejorar el transporte activo del potasio (Shin y Schachtman, 2004). Así mismo, el suplemento de oxígeno en las raíces les ayuda a desechar los iones tóxicos y a tolerar la presión osmótica elevada (Raviv *et al.*, 2008). La oxifertirrigación es además, una tecnología considerada sostenible, por su eficiencia en el uso del agua y nutrientes, así como por la reducción en la contaminación causada por la intensificación de los cultivos (Macías *et al.*, 2010).

MATERIALES Y MÉTODOS

El material vegetal son plantas de pimiento italiano o pimiento verde de freír *Capsicum annuum* L. El sistema de cultivo es hidroponía pura (plantas flotadas en agua). Para ello se utilizan unos depósitos de PE negro, redondos, de una capacidad aproximada de 64 litros. Se coloca una lámina de 5 cm de poliestireno expandido (EPS), a la cual se le realizan perforaciones para la colocación de las plantas. Las plantas de pimiento se colocan dentro de unos vasos plásticos perforados, de este modo las raíces pueden desarrollarse en el medio. Las tapaderas permanecen flotando y tapadas a su vez con un plástico negro.

Los depósitos se rellenan con una solución nutritiva (SN) preparada en un tanque de 1000 l en el mismo lugar del ensayo. Este tanque se coloca a una altura superior a la de los depósitos para que puedan ser rellenados por gravedad, cuando el nivel de los mismos descienda. Para prevenir la aparición de hongos, bacterias, algas, etc., el depósito de la solución nutritiva se pinta de negro con lo que se evita la entrada de luz y por consiguiente se disminuye el desarrollo de estos microorganismos. Todos los depósitos, tanto el testigo como los Tratamientos se rellenan con la misma SN (Tabla 1).

Tabla 1. Valores analíticos de la solución nutritiva (SN).

Elemento	*N*	*P*	*K*	*Ca*	*Mg*	*Fe*	*Mg*
mg/L	300	8.2	56	41	12	372	229

A cada uno de los Tratamientos se le adiciona el H_2O_2 que sea necesario para alcanzar las concentraciones que se muestran a continuación.

- T: Testigo solo SN. Si agua oxigenada
- T1: (SN + 0.75 mM/l H_2O_2).
- T2: (SN + 1.5 mM/l H_2O_2).
- T3: (SN + 3.0 mM/l H_2O_2).

Se parte de un H_2O_2 al 50% en riqueza y con esta se prepara una disolución al 5% para sea más fácilmente manipulable. La aplicación de las distintas concentraciones de H_2O_2 se lleva a cabo con una jeringuilla milimetrada. Estas aplicaciones se hacen dos veces a la semana. Para controlar que las dosis en los depósitos sean las correctas se utilizan tiritas de peróxido que nos dan un valor muy aproximado de la cantidad en mg/L disuelta de H_2O_2.

En cada depósito se alojan cuatro plantas de pimiento. De cada tratamiento se realizan cuatro replicaciones (cuatro depósitos). En total cada tratamiento consta de 16 plantas. Mediante análisis químicos periódicos, se controla la SN para poder aplicar nueva cantidad de SN para que la planta pueda disponer de los nutrientes necesarios para su desarrollo normal. La medición de la clorofila en las hojas se determina con un Minolta SPAD-502, realizándose cinco tomas de datos a lo largo del tiempo del cultivo. De cada planta se toman cinco medidas y se realiza la media.

RESULTADOS Y DISCUSIÓN

Los valores medios obtenidos se muestran en la Figura 3 y Figura 4.

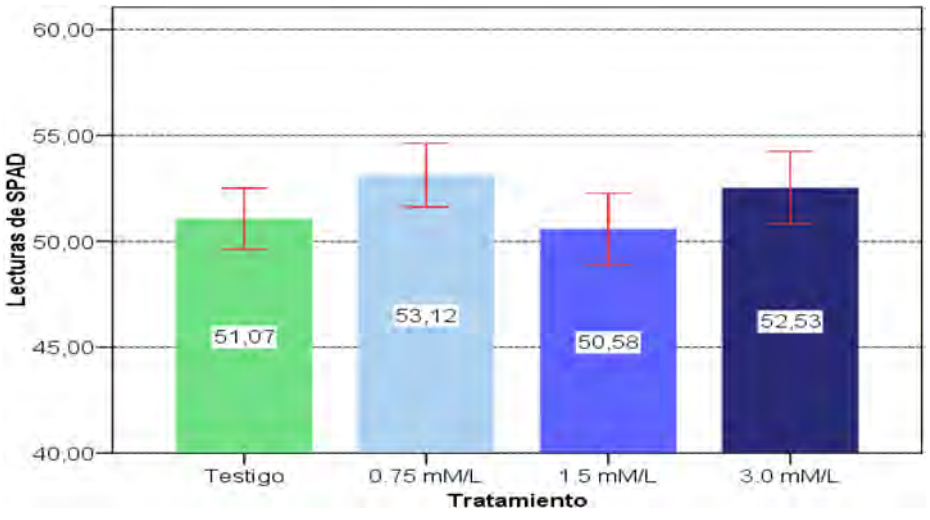

Figura 3. Valores medios de la variable SPAD según los tratamientos ensayados

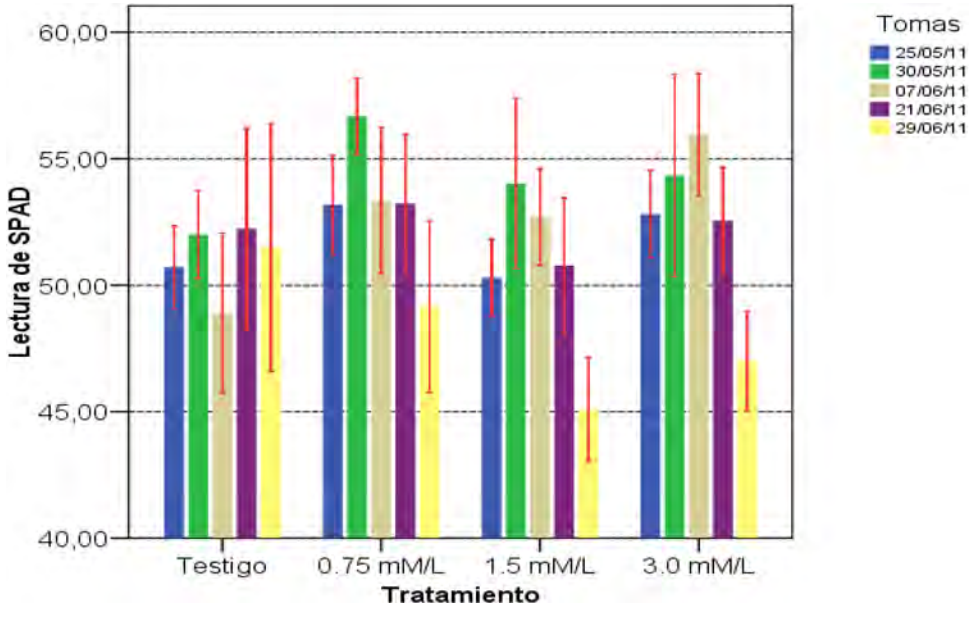

Figura 4. Valores medios de la variable SPAD según los Tratamientos a lo largo del tiempo del ensayo.

Existen solamente diferencias significativas entre el Tratamiento 1.5 mM/L y el Tratamiento 0.75 mM/L (Sig. < 0.05). Entre el resto de Tratamientos y el Testigo no existen diferencias.

CONCLUSIONES

Concluimos que la aplicación de agua oxigenada a las soluciones de fertirrigación para mantener la sanidad correcta de las mismas y evitar el crecimiento indeseado de algas y posterior atasco de los goteros no influye significativamente en el proceso de ganancia/pérdida de clorofila, en los niveles aquí estudiados. El proceso de ganancia clorofílica es un proceso fisiológico que depende más de la edad de la planta, en nuestro caso que del nivel de oxigenación, siempre y cuando no se produzca una anoxia severa.

REFERENCIAS

Afek, U; Orenstein J. and Nuriel, E. Using HPP (Hydrogen Peroxide Plus) to Inhibit Potato Sprouting During Storage. *American Journal of Potato Res.* (2000) 77: 63-65.

Alvaro, J.C.; Soraya Moreno; Fernando Dianez; Milagros Santos: Effects of peracetic acid disinfectant on the postharvest of some fresh vegetables. *Journal of Food Engineering* 95 (2009) 11-15.

Andre Dias De Azevedo N A., Jose Tarquinio Prisco, Joaquim Eneas Filho, Jand-Venes Rolim Medeiros, Eneas Gomes-Filho. Hydrogen peroxide pre-treatment induces saltstress acclimation in maize plants. *Journal of Plant Physiology* 162 (2005) 1114-1122.

Badellino, C., Christiane Arruda Rodrigues, Rodnei Bertazzoli: Oxidation of pesticides by in situ electrogenerated hydrogen peroxide: Study for the degradation of 2,4-dichlorophenoxyacetic acid. *Journal of Hazardous Materials* B137 (2006) 856-864.

Bhattarai, S.P., Ninghu Su and David J. Midmore: Oxygation unlocks yield potentials of crops in oxygen limited soil environments. Primary Industries Research Centre, Faculty of Arts, Health and Sciences, Central Queensland University, Rockhampton, Queensland 4702, Australia.

Bonachela, S.; J. Quesada; R.A. Acuña; J.J. Magán; O. Marfá: Oxyfertigation of a greenhouse tomato crop grown on rockwool slabs and irrigated with treated wastewater: Oxygen content dynamics and crop response. *Agricultural Water Management* 97 (2010) 433-438.

Capra, A.; B. Scicolone: Assessing dripper clogging and filtering performance using municipal wastewater. *Irrig. and Drain.* 54: S71–S79 (2005).

Carazo, N.; D. López; M. Peleato; O. Marfà; R. Cáceres: Oxifertirrigación de rosa: Contenido de nutrientes en flor cortada. XI Congreso SECH. Albacete 2007.

Coosemans, J.: Control of algae in hydroponic systems. ISHS Acta Horticulturae 382: iv international symposium on soil and substrate infestation and disinfestation.

Elmer, W.H.: Preventing spread of Fusarium wilt of Hiemalis begonias in the greenhouse. *Crop Protection* 27 (2008) 1078-1083.

Gil, P. Ferreyra, R. Effect of the injecting hydrogen peroxide into heavy clay loam soil on plant water status, net CO_2, assimilation biomass, and vascular anatomy of avocado tree. *CileanJAR* 69 (1) 97-106. 2009.

Gislerod, H.R. and R.J. Kempton: The oxygen content of flowing nutrient solutions used for cucumber and tomato culture. *Scientia Horticulturae* 20 (1983) 23-33 23.

Jubany-Marí, T., S. Munné-Bosch, L. Alegre. Redox regulation of water stress responses in field-grown plants. Role of hydrogen peroxide and scorbate. *Plant Physiology and Biochemistry* 48 (2010) 351e358.

Kerley, M.S., G. C. Fahey, Jr., L. L. Berger, J. Michael Gould, And F. Lee Baker: Alkaline Hydrogen Peroxide Treatment Unlocks Energy in Agricultural By-Products. 1985, Volume 230, pp. 820-822 SCIENCE

Kitis, M. Disinfection of wastewater with peracetic acid: a review. *Environment International* 30 (2004) 47-55.

Larson, K. Fooding mineral nutrition and gas exchange of mango tree. *Scientia Horticulturae* 52 (1992) 113-124.

Lawrence J.: Ozone in drinking water treatment: A review. The science of the Total Environment. 7 (1977) 99-108.

Marfa, O., R. Cáceres, S. Guri. Oxyfertigation: a new technique for soilless culture under mediterranean conditions. ISHS Acta Horticulturae 697: International Symposium on Soilless Culture and Hydroponics

Menzies, J.G.; Bélanger, R.R.: Recent advances in cultural management of diseases of greenhouse crops. *Canadian Journal of Plant Pathology* 18: 186-193. 1996.

Nakayama, F.S., D.A. Bucks. Water quality in drip/trickle irrigation: A review. *Irrigation Science* 1991.12. 187-192.

Rav-Acha, C., M. Kummel, I. Salamon and A. Adin. The effect of chemical oxidants on effluent constituents for drip irrigation. *Wat. Res.* Vol. 29, No. 1, pp. 119-129, 1995.

Sahin, U., Omer Anapali, Mesude Figen Donmez, Fikrettin Sahin. Biological treatment of clogged emitters in a drip irrigation system. *Journal of Environmental Management* 76 (2005) 338–341.

Shin, R. and Daniel P. Schachtman. Hydrogen peroxide mediates plant root cell response to nutrient deprivation. Edited by Clarence A. Ryan, Jr., Washington State University, Pullman, WA, and approved April 30, 2004.

Slusarski, C. The use of disinfectants for controlling a soilborne foot and root rot disease complex on greenhouse tomatoes in the rockwool open culture system. ISHS Acta Horticulturae 532: International Symposium on Chemical and Non-Chemical Soil and Substrate Disinfectation

Tanaka Goki; Yamashita Yohei; Nakabayashi Kazushige: Effect of Supersaturation of Dissolved Oxygen on the Growth of Tomato Plants and Nutrient Uptake in Hydroponic Culture. Journal of Society of High Technology in Agriculture: ISSN: 0918-6638. VOL.13; NO.1; PAGE.21-28(2001).

Urrestarazu, Miguel; Mazuela, Pilar Carolina: Effect of slow-release oxygen supply by fertigation on horticultural crops under soilless culture. *Scientia Horticulturae* 106 (2005) 484-490.

Vines J.R.L.; Jenkins P.D.; Foyer C.H.; French M.S.; Scott I.M. Physiological effects of peracetic acid on hydroponic tomato plants. *Annals of Applied Biology* Volume 143, Number 2, 1 October 2003, pp. 153.

Proceedings of the Caribbean Food Crops Society. 48:244-250. 2012

INFLUENCIA DEL PERÓXIDO DE HIDRÓGENO (H_2O_2) EN EL CALIBRE DEL FRUTO DE PIMIENTO (*CAPSICUM ANNUUM* L.)

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RESUMEN: La adición de Peróxido de Hidrógeno (H_2O_2) en sistemas de hidroponía pura puede resultar en la mejora del cultivo al oxigenar la solución nutritiva (SN) del fertirriego, entre otros beneficios. En el presente trabajo se estudió el efecto de distintas dosis de este peróxido sobre el calibre del fruto del pimiento (*Capsicum annuum* L.). Los calibres se establecen según Norma del Ministerio de Agricultura en el BOE, correspondiente a la trasposición normativa europea para pimiento verde fresco de consumo REGLAMENTO CE Nº 1455/1999 de la COMISIÓN de 1 de Julio de 1999. Los resultados muestran que el Nivel 1 (0,75mMol/L) se comporta como el Testigo, y el de 1,50 mMol/L tiene un efecto mínimo sobre los calibres. El Nivel 3,0 mMol/L disminuye el Calibre 1 aumentando notablemente el Calibre II y el Destrío. Nuestra recomendación es que no se superen los niveles de 1,50 mMol/L de H_2O_2 en las soluciones nutritivas.

Palabras clave: Oxifertirrigación, *Capsicum annuum*, Calibres, Peróxidos

ABSTRACT: The addition of Hydrogen Peroxide (H_2O_2) in pure hydroponics systems can result in the improvement of the crop by oxygenating the fertigation nutrient solution (NS), among other benefits. We studied the effect of different doses of this peroxide on the size of pepper fruit (*Capsicum annuum* L.). Gauges are set according to the Ministry of Agriculture Policy in the BOE, corresponding to the trasposed european rules for fresh green pepper consumption, Regulation EC No 1455/1999 of the COMMISSION of July 1, 1999. The results show that Level 1 (0.75 mMol/L) behaves as the Test; meanwhile, 1.50 mMol/l has a minimal size effect. The Level 3.0 mMol/L decreases the Level 1 but increase notably Level II and Destri. The recomendation is not to exceed 1.50 mMol/L concentration in nutrient solutions.

Keywords: Fertigation, *Capsicum annuum*, gauges, Hydrogen Peroxide

INTRODUCCIÓN

El pimiento dulce (*Capsicum annuum* L.) o pimiento italiano verde para consumo directo es uno de los más importantes frutos del mundo. Este se usa ampliamente en la nutrición humana debido a su notable contenido en antioxidantes, vitaminas y otros fotoquímicos de interés (Marín et al., 2004). Tiene una alta importancia en la dieta humana debido a su versatilidad ya que puede ser consumido fresco en ensaladas, cocinado, deshidratado, como especia, etc. (María et al., 2010).

Por otra parte, el incremento de la población mundial obliga al sector agrario al continuo incremento de la producción agrícola y singularmente al uso de tecnologías, como el riego, que conllevan el consumo de un *input* cada vez más escaso: el agua. La reducción de las

disponibilidades cuantitativas y cualitativas de este elemento es un reto de primera magnitud para el futuro agrícola.

La adopción de tecnologías que ahorren agua en los cultivos de riego, por el aumento de la eficiencia de los sistemas de riego, y la mejora de la sanidad general de los cultivos parece que son las claves por donde, en un futuro inmediato, debe explorar el conocimiento agrícola para la obtención de las cosechas que esa población mundial le demanda. (Cason, 1991; Triantfilis et al., 2002).

Muchos autores (Doorenbos, J., Kassam, A.H., 1979) han descrito con precisión lo que se entiende por eficiencia en el uso del agua en los sistemas de riego, siendo un *item* imprescindible en todos los programas de las escuelas de ingeniería agrícola que estudien riego. Como ejemplo valga la cita de Hood (2002) que la define en términos de maximizar el retorno agrario minimizando el impacto medioambiental por unidad de volumen de agua utilizada. En definitiva, como puntualiza Michael (1997) se trata de incrementar la producción agrícola por unidad de volumen de agua, por unidad de superficie y por unidad de tiempo.

La eficiencia puede mejorarse con el uso de técnicas como el riego por goteo o los sistemas de microaspersión, siendo el primero de los citados un método que ha alcanzado una notable expansión en la mejora de dicha eficiencia (Bosland, P.W., Votava, E.J., 2000). Esta técnica produce, en pimiento, un elevado *ratio* de cosecha por unidad de superficie y volumen de agua frente a otros sistemas tradicionalmente usados, por ejemplo inundación (Cuenca, 1989). Las ventajas e inconvenientes de esta técnica o método de riego son hoy de consulta fácil en cualquier manual de riego por lo que se obvia su consideración, solo reseñar que estos sistemas requieren, como premisa inicial, un alto costo de instalación y un mantenimiento técnico meticuloso y preciso, a veces solo al alcance de técnicos especialistas (Orihuela, 2002).

Otra técnica de manejo, en un sistema de riego, para aumentar la eficiencia en el uso del agua es reducir las dosis hasta someter a las plantas a un cierto nivel de estrés hídrico bordeando el concepto que se conoce como NAP (Nivel de Agotamiento Permisible) para el cultivo en cuestión (Ngouajio, M., Wang, G., Goldy, R.G., 2008).

Otra posibilidad es usar una técnica de hidroponía pura. Es decir mantener en aguas estancas el cultivo. Esta técnica debe de ir acompañada de un proceso de oxigenación del cuerpo de agua donde crece el cultivo, porque de lo contrario se produciría una anoxia radicular. Esta técnica se llama hidroponía pura con oxifertirrigación y es el objeto de nuestro estudio. En ella usamos, para mantener una normanoxia radicular, peróxidos (H_2O_2, en nuestro caso) en diferentes dosis para ver el efecto del mismo en la calidad de la producción.

Otra posibilidad ya muy extendida en las plantaciones de riego por goteo es la aplicación sistemática del peróxido de hidrógeno para mantener las tuberías de riego libre de "vivos" y evitar así su atasco. El uso sistemático que ya se está haciendo de los peróxidos nos induce a preguntarnos si estos peróxidos tienen influencia en ciertos parámetros de calidad agronómica de la producción. Para responder a esta pregunta se planteó el presente experimento. En este caso estudiamos la influencia de ciertos niveles de H_2O_2 sobre el parámetro calibre del pimiento.

MATERIALES Y MÉTODOS

2.1.- Lugar del ensayo

El objetivo del ensayo es valorar el efecto de distintas dosis de H_2O_2 sobre el calibre de los frutos de la producción de plantas de pimiento (*Capsicum annuum* L.) en un sistema de hidroponía pura con oxifertirrigación.

El experimento se llevó a cabo en los invernaderos de la Escuela Politécnica Superior de la Universidad de Huelva (España) sita en Palos de la Frontera (Huelva), Campus La Rábida.

2.2.- Diseño experimental

El material vegetal elegido son plantas de pimiento italiano, conocido como pimiento verde de freír, *Capsicum annuum* L. El sistema de cultivo es hidroponía pura en oxifertirrigación (plantas flotadas en agua). Para ello se utilizan unos depósitos de PE negro, redondos, de una capacidad aproximada de 64 litros. Se coloca una lámina de 5 cm de poliestireno expandido (EPS), a la cual se le realizan perforaciones para la colocación de las plantas. Las plantas de pimiento se colocan dentro de unos vasos plásticos perforados, de este modo las raíces pueden desarrollarse en el medio acuoso. Las tapaderas permanecen flotando y tapadas a su vez con un plástico negro.

Los depósitos se rellenan con una solución nutritiva (SN) previamente preparada en un tanque de 1000 litros, en el mismo lugar del ensayo. Este tanque se coloca a una altura superior a la de los depósitos para que estos puedan ser rellenados por gravedad, cuando el nivel de los mismos descienda. Para prevenir la aparición de hongos, bacterias, algas, etc., el depósito de la solución nutritiva (SN) se pinta de negro con lo que se evita la entrada de luz y por consiguiente se disminuye el desarrollo de estos microorganismos. Todos los contenedores, tanto el Testigo como los Tratamientos se rellenan con la misma SN (Tabla 1).

Tabla 1. Valores analíticos de la solución nutritiva (SN).

Elemento	N	P	K	Ca	Mg	Fe	Mg
mg/L	300	8.2	56	41	12	372	229

A cada uno de los Tratamientos se le adiciona el H_2O_2 que sea necesario para alcanzar y mantener las concentraciones de este peróxido que se muestran a continuación.

- T: Testigo (SN). Sin agua oxigenada
- T1: (SN + 0.75 mM/l H_2O_2)
- T2: (SN + 1.5 mM/l H_2O_2)
- T3: (SN + 3.0 mM/l H_2O_2)

Se parte de un H_2O_2 comercial al 50% en riqueza. Con esta se prepara una disolución al 3-5% para que sea más fácil su manipulación. En cada contenedor se alojan cuatro plantas de pimiento y de

cada Tratamiento se realizan cuatro replicaciones (cuatro depósitos), en total cada Tratamiento consta de 16 plantas.

2.3.-Colección de datos y tratamiento estadístico

A lo largo del cultivo se realizaron cinco recolecciones de fruta o tomas de datos. De todos y cada uno de los pimientos obtenidos (1559) se determinó: el peso de la unidad, su longitud y el diámetro o calibre en la parte más ancha del mismo. El tratamiento estadístico de los datos se realiza con el programa estadístico SPSS-15.0 bajo licencia de la Universidad de Huelva.

2.4.- Valoración de los datos

La inmensa mayoría de los países se rigen por normas comunes cuando se trata de establecer normativas de calibrado de este producto, o en todo caso las diferencias son escasas. Por ello las normas de calibre que aquí se expresan no tienen por qué ser de aplicación a todos los países, aunque sí son las más aceptadas en el comercio mundial.

En nuestro caso la comparación de los valores obtenidos se somete a la Norma aprobada por el Ministerio de Agricultura de España en el Boletín Oficial de Estado (BOE), correspondiente a la trasposición normativa europea para pimiento verde fresco de consumo humano REGLAMENTO CE Nº 1455/1999 de la COMISIÓN EUROPEA de 1 de Julio de 1999, por el que se establece la comercialización de los pimientos dulces. Esta normativa europea se refiere a pimientos dulces de las variedades (cultivares) obtenidas de *Capsicum annuum* L. var. *Annuum*, destinados al consumidor en estado fresco, con exclusión de los pimientos dulces destinados a la transformación industrial.

Por lo que respecta al calibre, dice la norma, vendrá dado por el diámetro máximo (anchura) perpendicular al eje. La tolerancia admitida en una partida, según la norma para la Categoría I (primera) es, para una partida, del 10% en número de frutos que difieran en menos de 5 mm, con una relación Longitud/Diámetro superior a 2.

Así pues según esta Norma se aplicará, al objeto de este estudio, de la siguiente manera:

Relación Longitud/diámetro ≥ 2 para todos los frutos. El que no cumpla será considerado destrío.

Calibre I: Todos los frutos de diámetro ≥ 30 mm.
Calibre II: Todos los frutos comprendidos entre 25 y 30 mm.
Calibre III: Todos los frutos inferiores a 25 mm.
Calibre destrío: Todos los frutos con diámetros inferiores 20 mm.

RESULTADOS

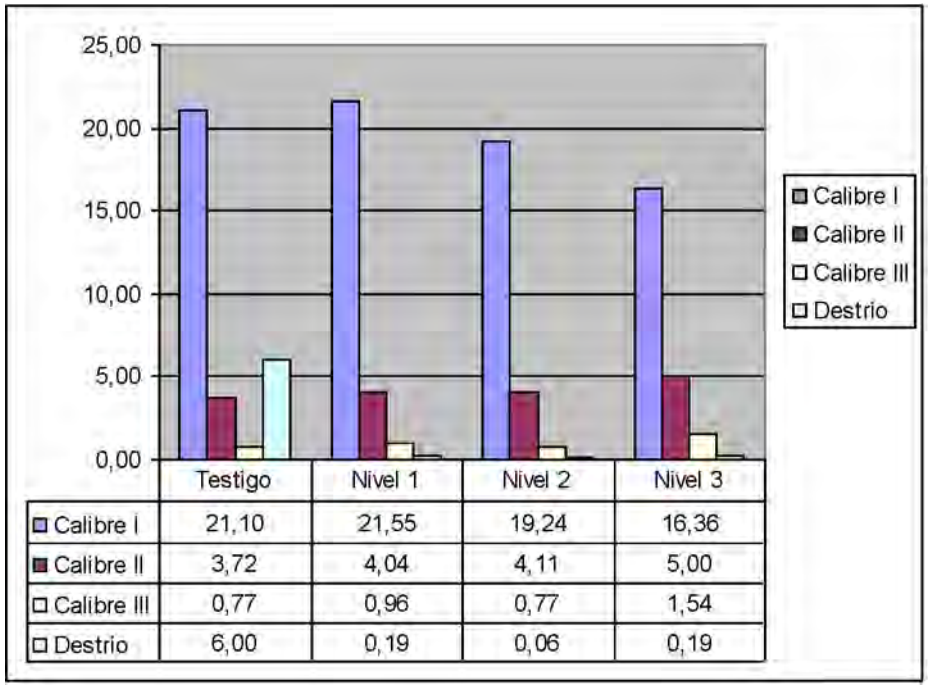
De los 1559 frutos estudiados se ha obtenido la siguiente Tabla de Contingencia (Tabla nº 1)

Tabla 1: Tabla de contingencia del número de pimientos según Calibre * Tratamiento

		Tratamientos				Total
		Testigo	Nivel 1: 0,75 mMol/l	Nivel 2: 1,5 mMol/l	Nivel 3: 3,0 mMol/l	
Calibre	Calibre I (C I)	329	336	300	255	1220
	Calibre II (C II)	58	63	64	78	263
	Calibre III (CIII)	12	15	12	24	63
	Destrío (D)	6	3	1	3	13
Total		405	417	377	360	1559

Tabla 2: Porcentajes de calibre según Nivel de H_2O_2

Datos	Testigo	Nivel 1	Nivel 2	Nivel 3	Total frutos
Calibre I	329	336	300	255	1220
% Primera	21,10	21,55	19,24	16,36	78,26
Calibre II	58	63	64	78	263
% Segunda	3,72	4,04	4,11	5,00	16,87
Calibre II	12	15	12	24	63
%Tercera	0,77	0,96	0,77	1,54	4,04
Total vendible	424	440	399	378	1641
% de Vendibles	27,19	28,20	25,62	24,27	105,27
Destrío	6	3	1	3	13
% de Destrío	0,38	0,19	0,06	0,19	0,83
Producción total	405	417	377	360	1559
% de Producción	25,98	26,75	24,18	23,09	100,00



	Testigo	Nivel 1	Nivel 2	Nivel 3
Calibre I	21,10	21,55	19,24	16,36
Calibre II	3,72	4,04	4,11	5,00
Calibre III	0,77	0,96	0,77	1,54
Destrio	6,00	0,19	0,06	0,19

Gráfico 1: Relaciones Calibres & Tratamientos

CONCLUSIONES

A la luz de los datos obtenidos se puede concluir que un exceso de agua oxigenada disminuye el calibre de los pimientos, siendo así que los Testigos y el Nivel 1 de H_2O_2 tienen el mismo C I, prácticamente pero disminuye de forma manifiesta a medida que se llega al Nivel III de agua oxigenada.

Todos los Tratamientos tienen prácticamente el mismo porcentaje de C II. El porcentaje de C III ya es el doble en el Nivel 3 que el Testigo. El porcentaje mayor de destrío lo dan los Testigos. Como conclusión final se puede considerar que el Niveles 1 (0,75 mMol/L) se comporta como el Testigo. El Nivel de 1,50 mMol/L tiene un efecto mínimo sobre los calibres. El Nivel 3,0 mMol/L disminuye el C I, aumentando notablemente C II y el D. Nuestra recomendación es que no se superen niveles de 1,50 mMol/L de H_2O_2 en las soluciones nutritivas.

REFERENCIAS

Beese, F., Horton, R., Wierenga, P.J., 1982. Growth and yield response of Chile pepper to trickle irrigation. *Agron. J.* 74, 556–561.

Bosland, P.W., Votava, E.J., 2000. Peppers: Vegetable and Spice Capsicum. CABI Publishing, USA.

Cason, T.N., Uhlaner, R.T., 1991. Agricultural production's impact on water and energy demand: a choice modeling approach. *Resour. Energy* 13, 307– 21.

Cuenca, R.H., 1989. Irrigation System Design: An Engineering Approach. Prentice Hall, Englewood Cliffs, USA.

Doorenbos, J., Kassam, A.H., 1979. Yield response to water. Irrigation and Drainage Paper No. 33, FAO, Rome. FAO, 2002. Deficit irrigation practices. Water Reports No. 22, FAO, Rome.

Green, G., Sunding, D., Zilberman, D., Parker, D., 1996. Explaining irrigation technology choices: a microparameter approach. *Am. J. Agric. Econ.* 78, 1064-1072.

Hood, S., 2002. Rural water use efficiency—real water use efficiency and the opportunities. In: Proceedings of the 11th Australian Cotton Conference, Brisbane, Queensland, Australia, pp. 285-295.

Kassam, A., Smith, M., 2001. FAO methodologies on crop water use and crop water productivity: expert meeting on crop water productivity. FAO Paper No. CWPM07, Rome.

Leskovar, D.I., David, T., Forbes, A., 2006. Subsurface Drip Irrigation to Conserve Water and Improve Quality of Specialty Vegetable and Forage Crops in the Edwards Aquifer Region. Texas A and M University, Texas A and M Research and Extension Center, Unvalde, TX 78801.

María S., Zapata, P.J., Castillo S., Guillén F., Martínez Romero, D., 2010. Antioxidant and nutritive constituents during sweet pepper development and ripening are enhaced by nitrophenolate treatments. *Food Chem*. 118, 497-503.

Marín A., Ferreres, F., Tomás-Barberán F.A., Gil M.I., 2004. Characterization and quantitation of antioxidante constituents of sweet pepper (*Capsicum annum* L.). *J. Agric. Food Chem*. 52 3861-3869.

Michael, A.M., 1997. Irrigation Theory and Practice (Revised). Vikas Publishing House Pvt. Ltd., New Delhi.

Ngouajio, M., Wang, G., Goldy, R.G., 2008. Timing of drip irrigation initiation affects IWUE and yields of bell pepper under plastic mulch. *Am. Soc. Hortic.* 18, 325- 544.

NORMAS DE CALIDAD PARA PIMIENTO FRESCO. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31988R0079:ES:HTML Norma del Ministerio de Agricultura en el BOE, REGLAMENTO CE Nº 1455/1999 de la COMISIÓN de 1 de Julio de 1999.

Orihuela, D.L., 2002. La calidad del agua en la agricultura. ISNB 84-607-4097-8. Depósito legal H-39-2002. Huelva . España. 295 pág.

REGLAMENTO (CE) Nº 1455/1999 de la COMISIÓN de 1 de Julio de 1999.

Sandra, P., 2001. Growing more food with less water. *Sci. Am.* 284, 46-49.

Singh, S.D., 1978. Effect of planting configuration on water use and economics of drip irrigation system. *Agron. J.* 70, 951-954.

Triantafilis, J., Ahmed, M.F., Odeh, I.O.A., Warr, B., 2002. Soil salinisation risk assessment using saline irrigation water in the lower Namoi valley. En: Proceedings of the 11th Australian Cotton Conference, Brisbane, Queensland,Australia, pp. 495-508.

Wu, I.P., Gitlin, H.M., 1975. Irrigation efficiencies of surface, sprinkler and drip irrigation. In: Proceedings of the 2ndWorld Congress on Water Resource, Water for Human Needs, New Delhi, India, pp. 191–199.

Xie, J., Cardenas, E.S., Sammis, T.W., Wall, M.M., Lindsey, D.L., Murray, L.W., 1999. Effects of irrigation method on Chile pepper yield and phytophthora root rot incidence. *Agric. Water Manage*. 42, 127-142.

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YIELD AND GROWTH OF TAHITI LIME, *CITRUS LATIFOLIA*, IN THE FIRST TWO YEARS AT TWO LOCALITIES IN PUERTO RICO

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ABSTRACT: An experiment of 'Tahiti lime' (*Citrus latifolia*), also called 'Persian lime', was established at the Agricultural Experiment Stations of Isabela and Corozal, Puerto Rico. The trees were grafted on the rootstocks 'Swingle citrumelo', 'Carrizo', 'HRS 812', 'Rough lemon', and 'Cleopatra mandarin'. A randomized complete plot design was used with four replications and two trees per plot. Although the citrus greening (HLB) disease was detected in some trees, these trees continued to produce fruits in the first two years of growth. In addition to their ground fertilization, the trees received a foliar supplement mixture for reducing the effect of the disease. Data for the first harvest (second year of growth) showed no significant difference in either mean fruit number or in total weight per tree for the overall rootstocks, between Isabela and Corozal (84.0 and 66.6 fruits, and 8.6 and 8.5 kg, respectively). Nevertheless, there was significant difference in yield among the rootstocks, the best yielders being the trees on rootstocks 'HRS 812', 'Swingle' and 'Rough lemon' (110.2, 92.3 and 88.3 fruits per tree, respectively). The greatest total weight of fruit per tree came from rootstocks 'HRS 812', 'Swingle' and 'Rough lemon' (12.7, 10.6 and 9.8 kg, respectively). In terms of growth traits, the rootstocks in Isabela showed the higher significant canopy volume (17.8 vs. 11.0 m^3). Among the rootstocks, 'Rough lemon' and 'HRS 812' showed the highest canopy volume. There was no significant difference in efficiency between the two rootstocks or localities.

Keywords: Rootstocks, disease, yield

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PRELIMINARY EVALUATION IN TAHITÍ LIME (*CITRUS LATIFOLIA*) OF SELECTED FERTILIZATION METHODS

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ABSTRACT: Citrus production in Puerto Rico has been increasing in recent years. The most common citrus trees planted are Valencia, Encore mandarin and lime Tahiti. Farmers have increased their interest in producing citrus although in 2010 Huangonbling disease was reported. Among management practices recommended to diminish the detrimental effect of the disease are vector control and use of adequate management and fertilization practices to keep trees producing longer. Puerto Rico Department of Agriculture (DAPR) is promoting the use of slow release fertilizers and soil applications of soluble fertilizer to increase citrus production. An experiment was established to validate DAPR recommendations in a private seven-year-old Tahiti lime orchard at Ciales (municipality located in central highlands of PR). Trees were planted at a distance of 4.2 x 5.8 m for a total of 622 trees per hectare. The following four fertilization methods were tested: 1. Granular fertilizers with a 10-5-20 analysis applied every four months (conventional fertilization); 2. Two applications of slow release fertilizers and four applications of soluble fertilizers, applied to the soil with a backpack sprayer (DAPR recommendation); 3. The same amount of fertilizers as in treatment 2, but applied with a motorized sprayer; 4. Two applications per year of slow release fertilizer at a rate of 1.36 kg N/tree. The experiment was arranged in a complete randomized design with four replications. The variables measured were canopy volume, fruit number, fruit weight, and N content in leaf tissue. Harvest was monthly. Statistical analysis indicated that treatment 1 (conventional fertilization) produced the lowest fruit number and weight per tree, whereas treatment 4 produced the highest. No fruit yield differences were detected between treatments 2 and 3. An economical analysis is needed to differentiate between treatments 2 and 3. Preliminary results indicate that granular fertilization is not recommended if compared with the other two fertilization methods promoted by DAPR and the application of slow release fertilizer twice a year. Response of Tahiti lime trees to fertilization treatments will be continued for another year to obtain a better data set in order to be able to make recommendations to farmers.

Keywords: Slow release fertilizer, Tahiti lime, fertilization, tissue analysis

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PRATIQUES TECHNIQUES ET STRATEGIES PRODUCTIVES EN SYSTEMES A BANANIERS PLANTAIN : DIAGNOSTIC AGRIENVIRONNEMENTAL D'UNE SPECULATION VIVRIERE D'IMPORTANCE POUR LA SECURITE ALIMENTAIRE NATIONALE

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RÉSUMÉ : La banane plantain dans la plupart des pays producteurs de la Caraïbe et d'ailleurs est commercialisée principalement au niveau local. En Haïti, où la production annuelle est estimée à 170 000 tonnes, la consommation s'élève à 22 kg /habitant /an. Cette spéculation constitue donc un aliment majeur dans l'approvisionnement vivrier de la population. Toutefois, le secteur de la banane plantain reste encore informel, caractérisé par : 1) des variétés traditionnelles (musqué, mateyenne, cochon, miss kitty,…) ; 2) des problèmes phytosanitaires affectant les rendements et les revenus des planteurs liés à la sensibilité des variétés cultivées à la maladie des raies noires, aux nématodes et aux charançons ; 3) des pratiques culturales extensives et/ou itinérantes ; 4) une production fortement influencée par les saisons. Ce secteur est également fragilisé par l'inorganisation du marché et l'absence de régulation de l'Etat dans les différentes régions pour ce qui concerne l'écoulement des produits agricoles. Cette communication porte sur une enquête agro-environnementale qui a été menée sur la région qui produit le plus de bananiers plantain en Haïti. Le document d'enquête comportait 8 grands thèmes d'informations (identification et caractérisation de l'exploitant, structure et description de l'exploitation, détails du parcellaire de l'exploitation, conduite technique de la banane plantain, caractérisation technico-économique de la production de plantain, affectation des ressources de l'exploitation, observations de l'enquêteur, questions ouvertes complémentaires) regroupant au total une centaine de questions. L'analyse statistique des données recueillies sur le terrain a permis de construire une typologie des exploitations productrices et des pratiques culturales mises en œuvre pour la production de plantain. L'objectif à terme est de pouvoir mettre en relation stratégies productives, pratiques techniques, dégradation du milieu et performances agronomiques, de façon à identifier les marges de progression des différents types de planteurs étudiés. La typologie permettra également de sélectionner les situations les plus représentatives de la diversité de la réalité agricole étudiée de façon à y entreprendre de façon raisonnée le diagnostic agroécologique nécessaire à l'évaluation fine de l'impact des pratiques agrotechniques sur les dynamiques des microorganismes et de la macrofaune du sol. Les enjeux d'un tel diagnostic sont économiques, mais également environnementaux et sanitaires car celui-ci doit permettre de déboucher sur des propositions agrotechniques innovantes favorisant l'émergence de systèmes de production de banane plantain plus performants sur le plan du développement durable. Le diagnostic agroécologique sera réalisé dans un second temps afin de confirmer les hypothèses qui seront émises au terme de l'interprétation des résultats actuels.

Mots-clés **:** banane plantain, agriculture, Haïti, pratiques agrotechniques, systèmes de production

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EXPRESIÓN UTERINA DE RECEPTORES PARA HORMONAS ESTEROIDEAS EN EL ÚTERO DE CERDAS GESTANTES

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RESUMEN: Cerdas en gestación se utilizaron para evaluar la tasa de ovulación, número de embriones vivos, y la expresión uterina de los genes para los receptores de estradiol, andrógeno y progesterona durante dos épocas del año (verano e invierno; n=15 por época). A los 30±2 días post-inseminación, las cerdas se sacrificaron para contar el número de cuerpos lúteos y el número de embriones vivos. Además, muestras del tejido uterino se colectaron e inmediatamente se almacenaron en nitrógeno líquido para posteriormente extraer ácido ribonucleico (ARN) total. El ARN total se utilizó conjuntamente con cebadores específicos y, utilizando las reacciones de transcriptasa reversa y polimerasa en cadena en tiempo real, se determinaron las cantidades relativas de ARN mensajero (ARNm) para los receptores de estradiol-17β, andrógenos y progesterona en el tejido uterino. La tasa de ovulación (número de cuerpos lúteos) fue similar entre las cerdas en gestación durante las diferentes épocas (13.5±0.8 y 13.1±0.7 para invierno y verano, respectivamente; P=0.7). Sin embargo, el número de embriones vivos fue mayor en cerdas gestando durante invierno (11.1±1.0 y 8.3±0.9 para invierno y verano, respectivamente; P=0.05). Las cantidades relativas de ARN mensajero (ARNm) del receptor para estradiol-17β fueron mayores en cerdas gestando durante el invierno versus verano (12.4±1.5 y 7.5±1.4 para invierno y verano, respectivamente; P=0.03). Contrariamente, las cantidades relativas de ARNm del receptor de andrógeno fueron menores en cerdas gestando durante el invierno en comparación con el verano (2.0±0.4 y 3.8±0.4 para el invierno y verano, respectivamente; P=0.004). Por otro lado, no hubo diferencias en la cantidad relativa de ARNm del receptor de progesterona (2.5±0.4 y 2.63±0.4 para el invierno y verano, respectivamente; P=0.8). Los resultados de esta investigación sugieren que diferencias en la expresión de los genes para los receptores de estradiol-17β y andrógenos podrían explicar las disminuciones en el tamaño de la lechigada observadas comúnmente durante la época de verano.

Palabras clave: receptores, esteroides, útero, cerdas, número de embriones

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INCLUSIÓN DE HENO DE LA ESPECIE INVASORA *HYPARRHENIA RUFA* EN DIETAS PARA GANADO CAPRINO

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RESUMEN: *Hyparrhenia rufa* representa actualmente un limitante para los productores pecuarios y de forraje en Puerto Rico debido a que su agresivo crecimiento invade especies mejoradas o nativas de pasturas tropicales. La producción de heno de esta especie invasora y su utilización como parte integral en dietas para pequeños rumiantes podría ser una alternativa para su control parcial durante algunas épocas del año. El objetivo de este experimento fue determinar el efecto de la inclusión de heno de *Hyparrhenia rufa* (HHR) sobre el consumo y la digestibilidad de la material seca (MS), proteína bruta (PB) y fibra detergente neutro (FDN) en dietas basadas en heno de gramíneas tropicales naturalizadas (HGT). El experimento se realizó en el proyecto de pequeño rumiantes de la Universidad de Puerto Rico utilizando ocho caprinos criollos según un diseño reversible con cuatro repeticiones por tratamiento. Los caprinos se alojaron en jaulas individuales provistas de comederos con doble compartimiento, bolsas recolectoras de heces y agua *ad libitum* y se asignaron a uno de dos tratamientos: 100% heno de GTN (mezclas de *Panicum maximum*, *Sorghum hapalense* y *Dichantium annulatum*; 87.12% MS, 4.70% PB, 67.81% FDN), o una dieta conteniendo 80% HGT y 20% HHR (89.78% MS, 4.21%PB, 80.50% FDN). El forraje se ofreció a 3% del peso vivo de los caprinos en base seca. El experimento consistió de dos periodos experimentales cada uno con siete días de adaptación a las dietas y cinco días de recolección de datos. Se determinó el consumo total de forraje y la digestibilidad aparente de la MS, PB y FDN. Se calculó además el consumo individual de HHR, el consumo de las dietas relativo al peso vivo de los animales y el porcentaje de consumo de HHR en relación al total de forraje o HHR ofrecido. El consumo total de forraje y el consumo en relación al peso vivo animal en base seca fue similar en caprinos alimentados con dietas conteniendo 100% HGT o con aquellas con 80% HGT y 20% HHR (1243 vs 1263 g/d, y 2.53 vs 2.44%, respectivamente). El consumo de HGT con relación a su ofrecimiento fue mayor ($P<0.05$) en caprinos alimentados con 100% HGT que con la proporción 80:20 HGT:HHR (88.26 vs 81.93%). El consumo de HHR con relación su ofrecimiento y con relación al consumo total de forraje fue de 42.16% y 10.63%, respectivamente. La digestibilidad aparente de la MS (56.70 vs 56.21%) PB (63.52 vs 58.57%) y FDN (55.48 vs 57.205) fue similar entre tratamientos experimentales. En resumen, la inclusión a 20% de HHR en dietas para caprinos basadas en HGT no afectó el consumo total de forraje ni la digestibilidad de MS, PB y FDN. Los caprinos consumieron 10% del HHR ofrecido, valor que podría representar el nivel de sustitución ideal en dietas para caprinos basadas en heno de gramíneas tropicales.

Palabras clave: *Hyparrhenia rufa*, heno, caprinos, consumo, digestibilidad

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EFFECTS OF SEX AND AGE ON TENDERNESS OF MEAT FROM COMMERCIAL CATTLE IN PUERTO RICO

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ABSTRACT: Longissimus muscle samples were collected from a total of 102 commercial animals to study the effect of sex and age [three categories arranged by the number of permanent incisors (PI); category A (0-2 PI), B (4-6 PI), and C (8 ≤ PI)] on beef quality traits, especially tenderness. Two aging periods were established, 24h and 14d post-mortem at 5° C for determination of Warner Braztler shear force (WBS), myofibril fragmentation index (MFI), muscle calcium concentration, pH and color (L*a*b*). No significant effect of sex and age were found for WBS (raw) and MFI at 14d. However, sex alone was a good indicator of tenderness based on results from both WBS (raw and cooked beef) and MFI determined at 24h ($P \leq 0.09$). In that sense, females presented lower WBS (raw and cooked) and higher MFI ($P \leq 0.05$) in that aging period. For age, category C resulted in lower WBS 24h (cooked, $P \leq 0.05$). Moreover, a positive correlation between muscle calcium concentration 24h and cooked WBS 24h was observed ($r = 0.52$, $P < 0.0001$). Within males, category C had less calcium concentration in muscle (39.59 μM) than A (65.60 μM) and B (57.91 μM) ($P \leq 0.10$). Also, higher pH (24h and 14d average = 6.11) and lower L* value 14d (29.18) resulted in males from category C. In that sense, WBS 24h was negatively correlated with pH in that aging period ($r = -0.74$, $P < 0.0001$) and positively correlated with L* value 14d ($r = 0.38$, $P < 0.05$). These results indicate that in commercially harvested cattle, females can present better tenderness profiles than males. Furthermore, even though sacrificed males with eight permanent incisors showed signs of dark, firm and dry meat (high pH and low L* values), they had lower WBS (C = 6.12 kg) than younger bulls (B = 10.89 kg, A = 8.99 kg), which ultimately could result in a more palatable beef product.

Keywords: Tenderness, sex, age, beef

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A COMPARATIVE EVALUATION OF EM ON SOIL QUALITY AND FRESH YIELD OF *BRASSICA OLERACEA* VAR. *ACEPHALA* GROWN ON ORANGEBURG LOAMY SAND SOIL

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ABSTRACT: Effective Microorganisms (EM) is a microbial inoculant used in agriculture to improve soil quality. It was designed to improve soil condition for healthy crops and increase production while reducing the use of chemicals and other synthetic compounds. A field study was conducted to comparatively examine the effects of EM and traditional nutrient sources on fresh leaf yield of collard greens (*Brassica oleracea* var. *acephala*) and post harvest soil quality factors. The study, a 4 x 4 RCBD was conducted on the Research and Extension Center farm of Florida A&M University, Quincy, Florida, during the fall of 2011. The treatments were 202 kg/hectare of N as ammonium nitrate fertilizer, mushroom compost, EM at 0.1 percent per hectare, and control. Seedlings were planted on raised beds 1.83 m center and 0.46 m within rows. The raised beds were covered with black plastic, and were drip irrigated. The crops were harvested approximately 12 weeks after planting. Data collected included plant height, plant weight, leaf length, leaf width, root length, and root weight. The fresh yield in kilograms per hectare was derived using aboveground plant weight. Approximately two weeks after harvesting, soil samples were obtained from each block. Soil cores were removed at 0-15.24 cm and 15.24- 30.5 cm and were processed and subjected to physical and chemical analyses. All data were statistically analyzed using SAS 9.1.3. Results showed that fresh yield was significantly higher in plots treated with ammonium-nitrate fertilizer and mushroom compost than in those treated with EM or the control. However, crop yield was significantly higher in plots treated with EM compared to the control. The average heights and average weights of plants were significantly higher in soils treated with ammonium-nitrate fertilizer and compost than in those treated with EM or the control. However, plant weights from EM plots were significantly higher compared with the control. While the average root lengths of plants were significantly longer in soils treated with EM than in those treated with ammonium-nitrate fertilizer and compost, there were no significant differences in root weights among the treatments. Preliminary analysis of soil chemistry showed no significant differences among the treatments in concentration of P, NO_3, TKN, pH, OM, or CEC. This study will be continued to obtain more accurate information.

Keywords: Microbial inoculant, crop yield, soil quality, synthetic compounds, compost

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PLASMID SCREENING AND ANTIBIOTIC RESISTANCE OF *ENTEROCOCCUS* SPP. ISOLATED FROM IRRIGATION WATERS IN PUERTO RICO'S FARM LANDS

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ABSTRACT: The bacteria are ubiquitous and can be isolated from plants, soil, and water. They have also been reported in raw and processed meats, as well as in fermented foods and dairy products. *E. faecium* and *E. faecalis* are the most common species among the *Enterococcus* genus and are often referred to as the major environmental and food contaminants. These two species are a common cause of community-acquired and food borne related illnesses. Recent reports identified *Enterococcus* spp. as a fecal contaminant of irrigation waters. Therefore, we decided to analyze the *Enterococcus* spp. diversity in irrigation waters in several plantain fields in Puerto Rico. In this work, we were able to identify 237 isolates by using Multiplex-PCR. The species identified were *E. faecalis*, *E. faecium*, *E. casseliflavus*, *E. avium*, *E. gallinarum* and *E. durans*. Antibiotic resistance studies were performed for all isolates, testing the MIC of each antibiotic using prepared microtiter plates for susceptibility. Results showed that there was a great variability in antibiotic resistance among the isolates. Plasmid DNA Extraction is currently being study to characterize the plasmid content for each isolate. Agarose Gel Electrophoresis analysis revealed that several *E. faecalis* and *E. faecium* isolates possess a pattern with plasmids ranging from 3 to 10 Kb. The identified plasmids have a high copy number and appear to be stable under non-selective pressure conditions. Several of the isolates also have larger low copy number plasmids ranging well above 20 kb. So far, we have not seen a plasmid pattern in any of the *E. casseliflavus*, *E. avium*, *E. gallinarum* or *E. durans* isolates. These preliminary results showed that some isolates contain plasmids that may be directly related to their antibiotic resistance. This work is in progress and we will explore the possibility that the variability in antibiotic resistance among the isolates is due extrinsically to the presence of a diverse antibiotic resistance plasmid content and not intrinsic chromosomal resistance.

Keywords: Multiplex-PCR, Antibiotic Resistance, *Enterococcus* spp.

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CHARACTERIZATION AND VIRULENCE OF SIX INDIGENOUS *BEAUVERIA BASSIANA* (DEUTEROMYCOTINA: HYPOMYCETES) ISOLATES FROM PUERTO RICO AGAINST THE COFFEE BERRY BORER, *HYPOTHENEMUS HAMPEI* FERRARI AND THEIR USE FOR FIELD APPLICATIONS

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ABSTRACT: Six isolates of *Beauveria bassiana* found infecting the coffee berry borer naturally in Puerto Rico were evaluated. All isolates were amplified with the first ITS1F and ITS4, amplified by a portion of the 18SrDNA region, the entire region of the 5.8S subunit, transcription regions ITS 1 and 2 ITS entire internal and a portion of the 28S rDNA region. Sequences were analyzed and compared with the BLAST database. All isolates were identified as *B. bassiana*. Based on several parameters including percentage insect mortality, average survival time, mortality distribution, percentage spore germination and spore production, the two best isolates, Bb-H09 and Bb-P09, were selected for further bioassays and field evaluations. The selection was carried out in two phases: In the first phase, isolates with mortality above 60% were selected, and in the second phase, for the preselected isolates, the LC_{50}, sporulation rate (confirmed mortality/total mortality) and conidia production on *H. hampei* cadavers were determined. The Bb-H09 isolate caused on average 90.0% mortality, conidia production 95.25 million/ml and LT_{50} 96 hrs; the Bb-P09 isolate caused in average 96% mortality, conidia production 68.1 million/ml and LT_{50} 96 hrs. The LC50s for Bb-H09 and bb-P09 was 478,910 and 271,134 conidia/ml, respectively. The Bb-P09 isolate was selected for field evaluations. Three field bioassays were established to evaluate the effect of soil and foliar sprays of *B. bassiana* (Bb-P09 isolate) on suppression of coffee berry borer population, emerging from fallen berries through time. Field experiments were established on a coffee plantation with no previous record of the fungus, and under favorable environmental conditions (27 to 29 °C; 82 to 91% RH). No significant difference ($P < 0.05$) in mortality was detected between foliar vs. soil applications. On average, the percentage mortality caused by the fungus was 46.53% and 42.62% in the foliar and soil treatments, respectively.

Keywords: *Beauveria bassiana, Hypothenemus hampei*, coffee, bio-control, Puerto Rico

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MANAGING INVASIVE ARTHROPOD SPECIES IN PUERTO RICO: IMPROVING RISK ASSESSMENT, INCREASING PROBABILITY OF DETECTION, AND TRIAGE METHODS

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ABSTRACT: The overall objective of our research was to use existing data to explain the establishment of invasive arthropods in Puerto Rico and predict, based on land use, past patterns of establishment, and interception data from agricultural inspectors. We have begun constructing a database of potential invasive arthropods based on pests of commodities grown in Puerto Rico, in other locations with moderate to high traffic with Puerto Rico. Island-wide vegetation and crop production maps have been obtained from the Puerto Rico Gap Analysis Project (Volume 1: Land cover, vertebrate species distributions and land stewardship) commissioned by the USDA. We have compiled a list of arthropods that are reported to have successfully invaded Puerto Rico in the last 10 years and we are currently researching these arthropods and the establishment histories, as far as they are known. We are assessing for most of these species whether different monitoring methods could have prevented their arrival. One unexpected finding is that a large number of invasive arthropods recently established in Puerto Rico were not even considered before. That is, they are species that we were not monitoring before their arrival. Other aspects of our project and the results will be discussed.

Keywords: Invasive species, Puerto Rico, arthropods, crops, risk

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COMPOSICIÓN QUÍMICA Y DEGRADABILIDAD IN VITRO DE LA MATERIA SECA Y PAREDES CELULARES DE LA ESPECIE INVASORA *HYPARRHENIA RUFA*

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RESUMEN: Posibles alternativas para el control de la especie invasora *Hyparrhenia rufa* (HR) incluyen la producción de heno durante determinadas épocas del año o pastoreo estratégico utilizando ganado caprino. Sin embargo, para la implementación de estas prácticas agronómico-pecuarias es imperativo conocer las variaciones anuales en el valor nutritivo reflejado por el contenido de nutrientes y la degradabilidad in vitro ruminal de la materia seca (DIVMS) y las paredes celulares (DIVFDN) de esta especie botánica. El objetivo de este experimento fue determinar dichas variaciones a través el año. El experimento se realizó en la Estación Experimental Agrícola de la Universidad de Puerto Rico en el municipio de Lajas. Se colectaron mensualmente cuatro plantas aleatoriamente seleccionadas de HR cortadas manualmente a dos pulgadas de altura sobre el suelo en uno de tres predios experimentales. Muestras compuestas de cada predio se analizaron en duplicado para determinar el contenido de materia seca (MS), proteína bruta (PB), PB-insoluble en detergente ácido (PBIDA) fibra detergente neutro (FDN) y fibra detergente ácida (FDA), hemicelulosa (HC), lignina (LIG), DIVMS y DIVFDN. Los datos experimentales se analizaron según un diseño completamente aleatorizado y la prueba de Tukey se utilizó para la separación de medias. Los valores mínimos y máximos en el contenido de MS de HR fueron de 22.23% en septiembre y 51.56% en febrero. El contenido de PB de HR fue mayor ($P<0.05$) durante agosto a septiembre que durante los restantes nueve meses del año, sin embargo, el contenido de PBIDA fue similar. Los contenidos de FDN, FDA y lignina de la especie invasora durante enero y febrero fueron mayores ($P<0.05$) que en el periodo desde marzo a diciembre, pero el contenido de hemicelulosa varió poco durante el año. La DIVMS y DIVFDN de HR durante el período de agosto a octubre fue mayor ($P<0.05$) que durante los otros meses del año. En resumen, se observaron variaciones marcadas en el contenido de nutrientes y degradabilidad ruminal in vitro de la MS y FDN de HR a través del año. Dado el mayor contenido de PB y mayor DIVMS y DIVFDN desde agosto a octubre, esta época del año podría ser la más apropiada para la producción de heno o el pastoreo de esta especie invasora.

Palabras clave: *Hyparrhenia rufa*, composición química, degradabilidad in vitro

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THE ROLE OF AN INVASIVE SPECIES, *CORBICULA FLUMINEA* (MÜLLER), ON THE PHYTOPLANKTON COMMUNITY STRUCTURE IN TWO PUERTO RICO RESERVOIRS

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ABSTRACT: Reservoirs in Puerto Rico are the main source of drinking water, thus water quality maintenance is of concern from both an ecological and public health perspective. Invasive bivalves such as the Asian clam, *Corbicula fluminea*, have been found to increase light penetration, increase nutrient availability, and decrease phytoplankton abundance. Two reservoirs in Puerto Rico, with differing trophic status were studied to explore the relationship between *C. fluminea*, nutrient concentrations and the phytoplankton community. Guajataca and La Plata reservoirs have been classified as having a mesotrophic and eutrophic status, respectively. The reservoirs were sampled during "wet" and "dry" seasons and characterized for nutrient concentration, physical parameters, chlorophyll-a, and phytoplankton community structure. Primary productivity (as indexed by chlorophyll-a) was highly correlated to reservoirs' total P and total N concentrations. There were weak relationships between the phytoplankton community structure and water quality parameters, but these could not be distinguished based on "wet" and "dry" seasons. This probably occurred due to the small number of observations gathered, phytoplankton blooms respond quickly to nutrient inputs, zooplankton grazing pressure, and ecological succession in the transition during salinity and nutrient inputs. La Plata reservoir tended to have a larger phytoplankton biovolume but a lower diversity than Guajataca. Although the trophic status of the reservoirs is different, it appears that there are similar factors influencing the phytoplankton community composition, and may not be nutrient related. This implies that while nutrients are important determinants for in-lake primary productivity and possibly for phytoplankton community structure, other factors are also important. Although the presence of *C. fluminea* was observed in both lakes, densities were much lower than expected and the surviving ones were in the juvenile state. This observation is in support of the r-selection ecological paradigm that population reductions of invasive species occur in unstable habitats. Experiments conducted under controlled conditions suggest that *C. fluminea* do not affect in-lake nutrient concentrations, but may influence the phytoplankton community structure.

Keywords: Invasive species, Asian clam, *Corbicula fluminea*, water quality, lake ecology

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LA COMMERCIALISATION DE L'IGNAME EN GUADELOUPE (FWI)

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RÉSUMÉ : L'igname est une culture alimentaire d'importance dans le monde tropical. En 2009, la FAO estimait la production d'igname à près de 50 millions de tonnes. En Guadeloupe, elle est la première culture vivrière et la quatrième culture après la canne à sucre, la banane et le melon (Chambre d'Agriculture, 2009) toutes trois développées en priorité pour le marché européen. Accompagner le développement des filières agricoles dans les Départements Français d'Amérique est aujourd'hui une priorité et l'un des objectifs de la recherche agronomique. A côté des grandes cultures dominantes et organisées que sont la canne à sucre et la banane, la production d'igname apparaît comme un secteur informel et encore mal connu. La présente étude a pour objectifs de caractériser les réseaux de distribution de l'igname en Guadeloupe. Pour cela, des enquêtes ont été réalisées auprès des producteurs d'ignames et des distributeurs. Les acteurs intervenant dans la commercialisation de l'igname sont nombreux et la diversité des circuits de commercialisation est importante. A côté des réseaux structurés au sein desquels l'igname d'importation est principalement écoulée, la plus grande partie de la production locale passe par des réseaux plus informels au sein desquels les règles de coordination entre acteurs reposent sur des relations de confiance et des contrats moraux. Différents types de débouchés coexistent mettant en œuvre des circuits très contrastés tels que la vente directe où l'igname passe directement du producteur au consommateur, ou alors la vente en GMS qui fait intervenir un nombre plus important d'intermédiaires. Les différents circuits de commercialisation présentent des niveaux d'exigence et des contraintes variés qui influent sur les choix de commercialisation des producteurs d'igname et ceux-ci sont révélateurs des stratégies poursuivies par les producteurs. Ainsi, certains producteurs tirent l'essentiel de leur revenu de l'igname et préfèrent maximiser leurs bénéfices en vendant leur production à la ferme ou sur le marché. Pour d'autres producteurs, l'igname ne représente qu'une production de diversification à côté d'une autre culture principale et ceux-ci préfèrent adopter un mode d'écoulement rapide en faisant appel à des intermédiaires. Nos résultats suggèrent qu'une voie de développement de la filière est de mieux articuler l'offre et la demande en igname. Il est donc nécessaire de mieux connaître les attentes des consommateurs et d'étudier les déterminants de leurs choix d'achat d'igname (garantie de l'origine et du mode de production, critères gustatifs, prix).

Mots-clés **:** igname, commercialisation, stratégies d'acteurs, freins au développement, leviers d'action

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COMPORTAMIENTO DE DOS CULTIVARES DE YAUTÍA (*XANTHOSOMA* SPP.) CON PULPA AMARILLA EN LA ZONA CENTRAL DE PUERTO RICO

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RESUMEN: Los cultivares de yautía Superkelly y Nazareno, ambos de pulpa amarilla, se evaluaron en la zona central de Puerto Rico, en 2008 y 2009, utilizando distintos tratamientos al material de propagación. En ambos cultivares, el material de propagación se trató con el fungicida biológico Companion y con cal agrícola. Los datos se analizaron usando un diseño para parcelas divididas repetidas en dos años. El factor año representa la parcela principal; los cultivares, la subparcela; y el tratamiento al material de propagación, la sub-sub-parcela. El factor año afectó significativamente el porcentaje de mal seco durante el segundo año (62%) comparado con el del primer año (28%). Este resultado parece estar relacionado con un exceso de precipitación en el segundo año (2,058 mm) comparado con la del primero (1,194 mm). Los rendimientos de yautía no se afectaron significativamente por los factores evaluados. El promedio de rendimiento a través de todos los tratamientos fue de 6,208 kg/ha de cormelos mercadeables. Ambos cultivares fueron afectados por enfermedades foliares ocasionadas por la bacteria *Xanthomonas campestris* y los hongos *Colletotrichum* spp. y *Alternaria* spp.

INTRODUCCIÓN

La yautía (*Xanthosoma* spp.) pertenece a la familia Araceae y es originaria de la parte norte de América del Sur. En el siglo 19 fue introducida a África del Sur, país que se ha convertido en el mayor productor mundial. Se considera que la yautía es el cultivo más antiguo en Puerto Rico, heredado de los aborígenes Arawak (Montaldo, 1991).

La producción de yautía en Puerto Rico para el año 2008 fue de 940 t, lo que equivale a aproximadamente el 10% del consumo local (Departamento de Agricultura de P.R., 2009). En la mayoría de los países de América Latina la yautía es bien apreciada por su sabor y textura. De las raíces y tubérculos producidos en Puerto Rico es la preferida de nuestros consumidores (Cortés y Gayol, 2006).

La enfermedad conocida como "mal seco" ha sido el factor que más ha afectado la producción mundial de este cultivo (Elango, 1998). En Puerto Rico, los siguientes hongos han sido asociados a esta enfermedad: *Rhizoctonia solani*, *Fusarium solani*, *Phythium* sp. y *Sclerotium rolfsii* (Bejarano et al., 1998).

No existe un método que controle eficientemente la enfermedad; sin embargo, se ha observado que en terreno de buen drenaje con un buen manejo del agua de riego se pueden obtener mayores rendimientos (Lugo et al., 1987). Aún en terrenos con pobre drenaje y nivel freático alto, se logró aumentar la producción en 70% con la preparación de bancos y manejo del riego (Snyder et al., 2010).

La yautía se considera principalmente como una fuente de carbohidratos, de los que puede contener de 15 a 30% (Montaldo, 1991). Además, contiene de 2 a 3% de proteína y 70 a 77% de agua. Su valor nutricional compara con el de la papa y probablemente sea más fácil de digerir. Las variedades de pulpa amarilla se consideran una excelente fuente de caroteno (Hernández, 1996). La importancia de los carotenos en la dieta es que son precursores de la provitamina A, que es convertida luego en vitamina A. Esta vitamina es esencial para el crecimiento y desarrollo normal, para el sistema inmunológico y la vista (Higdon, 2005).

El propósito de este estudio fue evaluar el comportamiento de dos híbridos de yautía de pulpa amarilla con distintos tratamientos al material de propagación en la zona central de Puerto Rico.

MATERIALES Y MÉTODOS

La investigación se realizó en la Estación Experimental Agrícola en Corozal, localizada en la zona climatológica de altura húmeda a una altitud de 195 metros sobre el nivel del mar. La serie de suelo predominante es Corozal arcilloso (Typic Hapludults) caracterizado por su acidez, baja fertilidad y desagüe lento.

Los cultivares de yautía evaluados fueron Superkelly y Nazareno, ambos de pulpa amarilla. Estos cultivares son el producto del programa de fitomejoramiento en yautía de la Estación Experimental Agrícola de la Universidad de Puerto Rico. Pedazos de cormo de 112 g de peso se utilizaron como material de propagación para ambos cultivares de yautía. El material de propagación se trató de dos maneras diferentes como parte de la investigación. Un grupo de pedazos de ambos cultivares fue tratado con el fungicida biológico *Bacillus subtilis* GB03 Companion.

El tratamiento consistió en sumergir el material de propagación durante 10 minutos en una solución del fungicida a razón de 200 ml/100 litros de agua. El otro tratamiento consistió en la aplicación de cal agrícola al material de propagación. Al día siguiente de los tratamientos los pedazos de cormo se sembraron en las parcelas experimentales. La preparación del terreno consistió en dos cortes de arado y rastrillado, rotocultivador y luego la preparación de bancos utilizando un sistema de gangas de tres discos a cada lado. Los ensayos se sembraron en dos años consecutivos (diciembre 2008 y octubre 2009). La precipitación durante el período experimental fue de 1,194 y 2,058 mm para los años 2008 y 2009, respectivamente. Se sembró a una distancia de 137 cm entre bancos y 30 cm entre plantas, utilizando cuatro hileras de 10 plantas por unidad experimental en un diseño de bloques completos al azar con cuatro repeticiones.

Para el manejo de malezas, se utilizaron los herbicidas Clomazone a razón de 3.5 litros/ha como preemergente y Paraquat como postemergente según recomendado en el Conjunto Tecnológico para la producción de Raíces y Tubérculos (1997). El fertilizante se aplicó a las seis y 20 semanas después de la siembra a razón de 56 g/planta por aplicación utilizando la formulación comercial con análisis 14-3-13-3.

La cosecha se realizó a los 270 días después de la siembra; los datos se tomaron de las dos hileras centrales de cada parcela experimental. Durante la cosecha se tomaron datos del número y peso de cormelos mercadeables, considerando mercadeables aquellos que pesaban más de 112 gramos. El porcentaje de mal seco (porcentaje del sistema radicular afectado por esta enfermedad) se determinó a los cinco meses de la siembra utilizando dos plantas por parcela experimental. El

porcentaje de plantas cosechadas se refiere al número de plantas que llega hasta la etapa de cosecha, sobreviviendo los nueve meses de la investigación. Los datos se analizaron usando un modelo para parcelas divididas repetidas en dos años. El factor año representa la parcela principal; los cultivares, la subparcela; y el tratamiento a la semilla, la sub-sub-parcela. Se hicieron pruebas de LSD para encontrar diferencias entre medias en los casos en que la prueba F del Anova era significativa.

RESULTADOS Y DISCUSIÓN

Los análisis estadísticos mostraron que el factor año afectó significativamente el porcentaje de brotación del material de propagación evaluado a los dos meses de la siembra y el porcentaje de mal seco (datos no presentados). El porcentaje de brotación durante el año 2009 (89%) fue superior comparado con el de 2008 (76%). Por otro lado, el porcentaje de mal seco durante el 2008 (28%) fue significativamente menor que el del 2009 (62%). Estos resultados pueden ser consecuencia de la mayor precipitación ocurrida en el transcurso del experimento durante el año 2009 (2,058 mm) comparado con la del año 2008 (1,194 mm). Una mayor cantidad de agua durante los primeros dos meses de la siembra acelera el proceso de brotación del material de propagación. Por otro lado, una alta precipitación durante los primeros cinco meses de la siembra en terrenos arcillosos afecta el desarrollo de la planta, especialmente su sistema radicular. Estos suelos pueden permanecer varios días saturados en agua después de eventos de alta precipitación, lo que contribuye a una mayor incidencia de mal seco. Los demás parámetros de este estudio no fueron afectados significativamente por el factor año.

El Cuadro 1 muestra que los rendimientos de yautía no se afectaron significativamente por los factores evaluados (cultivar y tratamiento del material de propagación) ni tampoco hubo interacciones. El promedio de rendimiento a través de todos los tratamientos fue de 6,208 kg/ha de cormelos mercadeables. Este rendimiento es más bajo que el rendimiento obtenido con el cultivar Estela de pulpa blanca en esta zona de producción (González, 2010; González, 2007). Sin embargo, esta baja en rendimiento puede ser compensada por el precio mayor que se paga por las variedades de pulpa amarilla comparado con el precio de las de pulpa blanca. También hay que reconocer que ambos cultivares fueron afectados severamente por enfermedades foliares, especialmente bacteriosis ocasionada por *Xanthomonas campestris* y los hongos *Colletotrichum* spp. y *Alternaria* spp. Estas enfermedades afectan el área fotosintética de la planta, lo que puede ocasionar una disminución en rendimiento.

El porcentaje de brotación fue significativamente superior (16%) en el cultivar Superkelly que en Nazareno. Esto indica que Superkelly se establece con mayor rapidez en el campo que Nazareno, lo que puede disminuir los costos del manejo de malezas. El porcentaje de plantas cosechadas fue significativamente afectado por ambos factores (cultivar y tratamiento al material de propagación). El cultivar Superkelly finalizó con mayor número de plantas al momento de la cosecha, al igual que las plantas cuyo material de propagación fue tratado con cal. El biofungicida Companion no fue efectivo en proteger las plantas hasta la fase de cosecha cuando es utilizado de la manera descrita en este experimento.

Ni el número ni el peso promedio de los cormelos se afectó significativamente por los dos factores evaluados. A través de los distintos tratamientos se obtuvo un promedio de 2.05 cormelos/planta con un peso promedio de 217 g.

En general los resultados indican que no hubo efecto de cultivar ni efecto de tratamiento a la semilla sobre los rendimientos de yautía en esta zona de producción. Ni los cultivares de yautía ni los tratamientos a la semilla afectaron significativamente el porcentaje de mal seco, el número promedio de cormelos/planta ni el peso promedio del cormelo. Los rendimientos obtenidos de estos cultivares de yautía quizás sean aceptables por ser de pulpa amarilla, ya que obtienen un precio superior al precio de los de pulpa blanca. Sin embargo, para aumentar la rentabilidad en esta zona de producción hay que realizar más investigación relacionada con manejo integrado para disminuir el daño ocasionado a la planta por el mal seco y por las enfermedades foliares reportadas en este estudio.

Cuadro 1. Rendimiento y otras características de la planta de dos cultivares de yautía con diferentes tratamientos al material de propagación[1].

Cultivares	Tratamiento material propagación	Rendimiento kg/ha	Brotación dos meses %	Mal seco %	Plantas cosechadas %	Cormelos merc./planta No	Peso promedio cormelo g
Superkelly	Companion	5,368	85	46	88	1.7	215
	Cal	6,221	90	48	96	1.8	236
Prueba de F (0.05)		N.S.[2]	N.S.	N.S.	N.S.	N.S.	N.S.
Nazareno	Companion	5,896	69	45	75	2.3	203
	Cal	7,348	79	40	89	2.4	218
Prueba de F (0.05)		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Cultivar		N.S.	*[3]	N.S.	*	N.S.	N.S.
Tratamiento Material de Propagación		N.S.	N.S.	N.S.	*	N.S.	N.S.

[1]Cada valor es el promedio obtenido durante los dos años de la investigación.
[2]No significativo al P< 0.05.
[3]Significativo al P< 0.05.

REFERENCIAS

Bejarano, C. A., M. Zapata, A. Bosques, E. Rivera Amador y L. J. Liu, 1998. *Sclerotium rolfsii* como componente del complejo patológico causante del mal seco de la yautía (*Xanthosoma sagittifolium*) en Puerto Rico. *J. Agric. Univ. P. R.* 82 (1-2):85-95.

Cortés, M. y L. Gayol, 2009. Análisis descriptivo de las preferencias de los consumidores de raíces y tubérculos en Puerto Rico. *J. Agric. Univ. P. R.* 93 (3-4):273-276.

Departamento de Agricultura, 2009. Ingreso Bruto Agrícola de Puerto Rico. Oficina de Estadísticas Agrícolas. Santurce, Puerto Rico.

Elango, F., 1998. Enfermedades en la producción de raíces y tubérculos. Seminario internacional sobre producción y mercadeo de raíces y tubérculos en regiones del trópico húmedo. Escuela de Agricultura de la Región Tropical Húmeda. San José, Costa Rica. 35 pp.

Estación Experimental Agrícola, 1997. Conjunto Tecnológico para la Producción de Raíces y Tubérculos. Universidad de Puerto Rico. Publicación 101.

Hernández, R., 1996. Cultivo de yautía. Guía Técnica No. 27. Fundación de Desarrollo Agropecuario, Inc. República Dominicana. 38 pp.

Higdon, J., 2005. Carotenoids. Linus Pauling Institute, Oregon State University (http://lpi.oregonstate.edu/infocenter/phytochemicals/carotenoids).

Lugo, W. I., H. Lugo Mercado, J. Badillo, A. Beale, M. Santiago y L. Rivera, 1987. Response of tanier to different water regimes. Proc. Caribbean Food Crops Society, 23:113-117. Saint John, Antigua.

Montaldo, A., 1991. Cultivo de Raíces y Tubérculos Tropicales. Instituto Interamericano de Cooperación para la Agricultura. San José, Costa Rica. 407 pp.

Snyder, V. A., A. González Vélez, A. J. Beale y M. A. Vázquez, 2010. Raised beds and aeration tubing for growing tannier (*Xanthosoma* spp.) in a poorly drained upland ultisol with perched water table. *J. Agric. Univ. P. R.* 94 (3-4):225-235.

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IMPROVED NUTRIENT MANAGEMENT FOR MAIZE INBREDS IN MOLLISOLS OF PUERTO RICO

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ABSTRACT: Commercial winter nurseries and agro-biotechnology firms have established in Puerto Rico, primarily on the southern semi-arid coast of Puerto Rico in fertile soils that have irrigation infrastructure, and in which field operations can be mechanized. The maize (*Zea mays* L.) production area is estimated at over 2,300 ha, distributed among seven major companies. Maize is grown for seed production, seed propagation, and hybrid selection, primarily from November to March in monoculture. When not under cultivation, the soils are kept weed-free by disking and other tillage operations. There is concern that current cropping practices may have a negative impact on soil quality and on agro-ecosystem sustainability. Inbred parental seed is the basic building block for the production of hybrids. Inbred lines typically are shorter, have less vigor, thinner stalks, smaller tassels, smaller ears, and lower seed yields compared to open-pollinated maize varieties or hybrids. A decreased rooting capacity makes inbreds more vulnerable to nutrient imbalances and deficiencies, drought stress, disease and insect vulnerability. In an effort to obtain higher seed yields, fields of inbred maize could be being over-fertilized. Fertilizer-N continues to be the most frequent limiting factor, and uncertainty exists regarding the optimum fertilizer-N application due to variations in soils, climatic factors, expected seed yields of genetic materials, and fertilizer recommendation philosophies. We performed a series of experiments aimed at improving the knowledge base to understand and improve nitrogen (N) management in these systems. We have determined that use of cover crops such as cowpea (*Vigna unguiculata*), is an important component of agroecosystem sustainability. Cowpea has rapid soil coverage, can be kept in vegetative state by mowing or herbicide application, requires little soil moisture or irrigation, has 60- to 70-day dry matter biomass near 2,600 kg/ha, and has N extraction of 95 kg N/ha, part of which originates from biological N fixation. Part of the N can be made available to subsequent maize crop via N mineralization. We have found that cover cropping can improve maize yields by 15% as compared to monoculture. Experiments evaluating crop response to fertilizer-N have shown that in inbreds with expected yields of less than 3,000 kg seed/ha, fertilizer-N rates could be maintained at or below 112 kg N/ha. Said amounts can be sufficient to account for grain N removal and to optimize yields. Careful attention should be paid to providing adequate irrigation, pest control, and providing N via fertigation in two to four applications to maximize fertilizer-N use efficiency. The fertilizer N use agronomic efficiency, as calculated by the difference method is typically lower than for hybrids, with maximum values of 9 kg DM/kg N. Experiments evaluating crop response to sources of fertilizer-N application applied pre-plant, in combination with sources of fertilizer-N application applied via fertigation at total rates of 150 kg N/ha, reveal no consistent source effects or mode of application on crop yields.

Keywords: fertilizer-nitrogen, maize fertilization, nutrient use efficiency

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COMPARISON OF PARENTS WITH F_1 AND F_2 GENERATIONS OF SORREL (*HIBISCUS SABDARIFFA*)

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ABSTRACT: Sorrel (*Hibiscus sabdariffa*), also known as Jamaican sorrel or Roselle, develops a bright calyx of petals with an acidic flavor. Sorrel is used to make juice, punch, wines or a variety of delicacies such as jams and chutney. It is harvested mostly during the Christmas season and is part of most of the islands' traditions. The purpose of this experiment is to evaluate characteristics of parental, F_1 and F_2 generations of sorrel from selected crosses. The developmental characteristics of F_1 and F_2 generations of sorrel were compared to their parents in regards to plant height, number of branches and floral induction on a bi-monthly basis. Three sorrel varieties were used in this experiment included a Day Neutral variety from St. Kitts (KDN), 268100 from Nigeria (100) and a local white variety from St. Croix (W). Three hybrids used in this experiment were KDN x 100, 100 x KDN and W x 100. A 100 x KDN also had an F_2 generation. This experiment has far reaching agricultural implications because it was found that all hybrids with the parental 100 and KDN grew faster. It was also found that the white variety took the longest to initiate floral buds. The F_1 generations kept the characteristics of the parents with regard to height, leaf shape and flowering time. However, the F_2 generation had characteristics of both parents. This research was funded through the VI Dept. of Agriculture Specialty Crops Block Grant and USDA-NIFA-Resident Instruction in Insular Areas (Grant #2008-34816-20016).

Keywords: Roselle, breeding

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DETECTING VIRUSES DURING PAPAYA PRODUCTION IN THE VIRGIN ISLANDS

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ABSTRACT: There are multiple viruses that can infect varieties of papaya. The plants can become infected at any time during growth and production. Nine papaya lines, grown in a double row system, were monitored for virus over a one year period. ELISA (Enzyme-Linked Immunosorbent Assay) was used on leaf tissue from the various trees over time to monitor for the presence of the viruses. Papaya Ring spot Virus (PRSV) was detected in plants within two months of field establishment. All papaya plants were infected with PRSV by the fifth month. Papaya Mosaic Virus and Cauliflower Mosaic Virus were also found in some papayas over time. Fruit set was monitored over time to determine viral influence on fruiting. Trees with multiple viruses declined most rapidly. All papaya lines with only PRSV were productive for six months following infection. Though the papayas remained productive when only infected by PRSV, the compounding of multiple viral infections was detrimental to these papaya lines. The research in this study was supported by a USDA-Hatch grant.

Keywords: ELISA, Papaya Ring Spot Virus, Papaya Mosaic Virus, Cauliflower Mosaic Virus

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EVALUATION OF SWEET POTATO IN THE US VIRGIN ISLANDS FOR PRODUCTION UNDER WEEVIL PRESSURE

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ABSTRACT: Sweet potato grown in the US Virgin Islands is plagued by the sweet potato weevil, *Cylas formicarius* (Fabricius). A trial was set up to monitor weevil populations during sweet potato production. Pheromone bait was used to attract weevils and monitor their population over time. At harvest, sweet potato storage roots were graded for marketability based on size and weevil damage. The weevil population increased during the first four weeks and stabilized through the thirteenth week. Weevil damage to the sweet potato leaves was visible by the third week. Of the ten varieties evaluated, only 'Beauregard-14' had jumble-size roots present. 'Beauregard-14' and 'Bonita' had the greatest total and marketable weight per plant and were two weeks earlier than the other varieties. 'Beauregard-14', 'Bonita', 'Evangeline' and 'Liberty' averaged over two marketable roots per plant. Though 'Qilin' averaged two roots per plant, it was the only variety with no marketable roots due to smaller size and weevil damage. From this initial trial, 'Beauregard-14', 'Bonita', 'Evangeline' and 'Liberty' have production potential for the US Virgin Islands. This research was funded by the USDA through the VI Department of Agriculture Specialty Crops Block Grant.

Keywords: Sweet Potato Weevil, *Cylas formicarius*, weevil damage

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EVALUATION OF THE CONDENSED TANNIN CONTAINING TROPICAL LEGUME *CALLIANDRA CALOTHYRUS* ON GASTROINTESTINAL NEMATODE CONTROL AND GROWTH PERFORMANCE IN ST. CROIX WHITE HAIR X DORPER LAMBS IN THE U.S. VIRGIN ISLANDS

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ABSTRACT: In the U.S.V.I., small ruminant production is a crucial component of the agricultural sector and makes up the majority of ruminant livestock production. Low-external-input small ruminant farmers are reliant upon tropical grasses that have low nutrient quality and must often supplement expensive imported grain to meet the nutritional requirements for their production needs. Internal parasitism, specifically the gastrointestinal nematode *Homonchus contortus*, accounts for the greatest amount of economic loss to the small ruminant farmer. Legume supplementation has been shown to increase animal performance and condensed tannin containing forages have exhibited anthelmintic qualities. The objective of this experiment is to evaluate the condensed tannin containing legume calliandra (*Calliandra calothyrus*) for its ability to successfully establish a perennial hedgerow for creep grazing and in cut-and-carry feeding systems on average daily gain and as a natural anthelmintic. Calliandra young plants were transplanted into an alley hedgerow at the Agriculture Experiment Station of the U.V.I. on St. Croix in April, 2009. The hedgerow was allowed to establish for approximately 18 months. The first creep grazing trial with St. Croix White Hair x Dorper (STXD) lambs began on 13 October 2010, but ended four weeks into the trial due to extreme internal parasite loads resulting in heavy animal attrition and the lambs de-barked the calliandra trunks which had detrimental effects upon the calliandra forage bank. On 15 June 2011 the second experiment began that consisted of two treatment groups: the control treatment consisted of lambs (n=18) grazed on native guinea grass (*Panicum maximum*) pasture and the experimental treatment consisted of lambs (n=18) grazed on native guinea grass that were supplemented three times per week with calliandra that was cut and carried to the lambs and fed in a quantity greater than lamb intake levels. Data was collected on individual animals over the course of the six month trial at 30-day intervals. To quantify internal parasite load, FAMACHA© scores, fecal egg count (FEC), and packed cell volume (PCV) was determined; animal performance was measured by total weight gain and average daily gain (ADG). Animal growth and performance was higher for lambs supplemented calliandra where lamb total weight gain resulted in 5.4 kg and an ADG of 44 g compared to the control lambs on native pasture without supplementation that gained a total of 3.1 kg and had an ADG of 26 g ($P<0.05$). Results from the FAMACHA scores, FEC, and PCV indicate that there were no significant differences in gastrointestinal parasite infections or anemia levels in lambs from either treatment at any point during the six month trial. However, the FAMACHA© eye score system did prove to be a reliable indicator of anemia, validated through PCV (negative correlation) and of *H. contortus* population, validated through FEC (positive correlation) in STXD lambs. Calliandra can increase animal growth and performance, but did not exhibit anthelmintic qualities when administered through a cut and carry supplemental feeding system.

Keywords: *Calliandra calothyrus*, *Homonchus contortus*, lambs, anthelmintic

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RESPONSE OF PLANTAIN TO INTERCROPPING AND SUPPLEMENTAL ORGANIC FERTILIZATION IN A SUSTAINABLE AGRICULTURAL SYSTEM

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ABSTRACT: Two experiments were established at the Agricultural Experiment Substation at Gurabo in eastern Puerto Rico to evaluate various intercropping systems with plantain, and the use of supplemental organic fertilization (chicken manure). Three intercrops were evaluated, sweet potato (*Ipomoea batatas*), coriander (*Coriandrum sativum*), and eggplant (*Solanum melongena*). It was intended for the results to benefit farmers who produce chicken manure as a waste from farm operations and farmers that can use the material as a supplement for inorganic fertilization. The results from the first experiment (2008-2009) showed no significant effect of chicken manure on the yield of coriander or sweet potato when used as intercrops with plantain. However, a significant decrease in eggplant yield was observed with the application of chicken manure. No significant effect on plantain yield was observed with the application of chicken manure, whereas the intercrop significantly affected plantain yield. A significant decrease in plantain yield was observed with sweet potato as the intercrop. Results from the second experiment (2009-2010) showed that chicken manure had no significant effect on the yield of any of the intercrops. However, plantain yield significantly decreased with the application of chicken manure.

Keywords: Chicken manure, *Ipomoea batatas*, *Coriandrum sativum*, *Solanum melongena*