CARIBBEAN FOOD CROPS SOCIETY

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CARIBBEAN FOOD CROPS SOCIETY

37

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15-20 July 2001

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Port of Spain, Trinidad & Tobago

Science, Technology, and Education – Empowering Caribbean Agriculture"

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by
Wilfredo Colón

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Caribbean Food Crops Society Meeting
37th Annual Meeting
15-20 July 2001

Port of Spain, Trinidad & Tobago

"Science, Technology, and Education – Empowering Caribbean Agriculture"

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Chairperson: *Mr. Winston Gibson,* CFCS President, 2001
Chief Technical Officer, Ministry of Food Production and Marine Resources

Honourable Tevor Sudama, Minister of Food Production and Marine Resources; Honourable Dr. Jennifer Jones-Kernahan, Minister in the Ministry of Food Production and Marine Resources; His Excellency Ambassador for France; His Excellency Dr. Jorge Luis Pérez Alvarado, Ambassador of the Dominican Republic; Mrs. Wendy Lee Yuen, President of the Agricultural Society of Trinidad and Tobago and Chairperson of the National Agricultural Marketing and Development Corporation; Mrs. Maureen Manchouk, President, National Institute of Higher Education (Research and Technology); Mr. Swallay Mohammed, Permanent Secretary, Ministry of Food Production and Marine Resources; Dr. Alberto Beale, Chairman, Board of Directors of the Caribbean Food Crop Society (CFCS), and other Directors of the Society; Professor Charles R. McDavid, Dean Faculty of Agriculture and Natural Sciences, of the University of the West Indies; Dr. Compton Paul, Executive Director, Caribbean Agricultural Research and Development Institute; Dr. Arlington Chesney, Inter-American Institute for Cooperation on Agriculture, Regional Director and country representative for Trinidad and Tobago; members of the diplomatic corps, distinguished guests, ladies and gentlemen.

It is with a sense of honour and a feeling of great humility, that I have the responsibility and the pleasure of warmly welcoming each and every one of you to the opening ceremony of this the 37th Annual Conference of the Caribbean Food Crop Society. I have not often had the honour of addressing such a distinguished gathering of luminaries as are assembled here this morning.

To the several visitors in our midst, I trust that your travel arrangements went smoothly; that transport from the airport was satisfactory and timely; and that you find your accommodation comfortable.

Ladies and gentlemen, I stand here before you in the capacity of President of the CFCS, 2001, and in that capacity, my primary responsibilities are for the organizing and management of all activities related to the successful mounting of this event.

This conference brings together farmers, scholars, researchers, policy makers, extensionists, growers, processors and several other stakeholders involved in or concerned about food production, distribution and policy, and aims to embrace members from the four main language groups of the Caribbean basin.

You would recall that the hugely successful 36th annual meeting and conference was held in Boca Chica, Dominican Republic in August last year. Now it is Trinidad and Tobago's turn, and we intend to do everything possible to make this year's meeting a successful and productive event.

As you know the theme of this year's conference is *"Science, Technology, and Education – Empowering Caribbean Agriculture"*. While this theme may appear to some to be broad, there is no gainsaying the fact that if Caribbean agriculture is to become competitive and sustainable, science, technology and education must be adopted and applied as strategic instruments to achieve that goal.

Consistent with the main theme, the conference will therefore focus on six sub-themes. These are:

~ Crop and Livestock Improvements – alternative production systems, biotechnology, non-traditional commodities, HACCP, etc.
~ Integrated Pest Management and Food Safety – pesticides and residue levels, contaminants, biocides, regulatory, and cultural practices
~ Post Harvest Technology – maturity and quality indicies, packaging and storage of produce, processing, and preservation.
~ Land and Water Resources – remediation techniques, soil amendments, application of GIS techniques, soils and environmental pollution.

~ Marketing, Economics and Policy issues – quality assurance, marketing intelligence, and international standards.
~ Agricultural Education and Extension – participatory research and development (the primary focus of the Farmers Forum on Tuesday), Farmer Field Schools, methodologies for technology transfer.

Distinguished ladies and gentlemen, the conference call for scientific papers related to the main theme, and to the six sub-themes just mentioned, yielded some sixty-odd submissions. Over the next week, these scientific papers will be the subject of intense scrutiny and discussions during the technical sessions.

On behalf of the Society, and the conference organizing Committee, I wish to express our profound appreciation to the scholars, researchers and other professionals who so resoundedly responded to the call for papers.

During the course of the conference, six technical sessions will be held to examine the scientific papers received and related to the six sub themes. A moderator and rapporteur have been selected for each technical session.

A poster display has been mounted, and you are invited to view the display during the breaks today and tomorrow.

As already stated the Farmers Forum tomorrow will address the issue of participatory research and development as a facet of our agriculture. The theme of the forum is Farmer Participation in Research and Development.

Wednesday has been reserved for field trips, and delegates are encouraged to indicate early which one of the two trips they prefer to attend. On the trip to north Trinidad, participants will visit a commercial horticulture enterprise, broiler production facility, the entomology section of the Research Division of the Ministry of Food Production and Marine Resources, a mixed vegetable – producing farm, and selected areas of the University of the West Indies.

The south trip will also visit the University of the West Indies, then move on to a commercial vegetable farm, the entomology section of the Research Division, Ministry of Food Production and Marine Resources, a large horticultural enterprise and Caroni (1975) Ltd, our largest single agricultural entity in the country.

A dinner and cultural evening is planned for tonight at the Hilton Poolside. On Wednesday night, the Awards Banquet will be held at the Savannah Terrace, Trinidad Hilton Hotel.

Distinguished ladies and gentlemen, this year's event is being sponsored by CARDI, IICA, UWI and the Ministry of Food Production and Marine Resources and each of these agencies is represented on the hard-working organizing committee. I wish to thank the organizing committee for the very professional and dedicated manner with which it approached its tasks.

Special thank you to Aurora Noguera-Devers, Joy Persad-Myers, Judith Ann Francis, Kathleen Gittens, Michelle Evelyn, and staff.

To NIHERST, a special thank you for its role in sourcing the human and other resources for interpretation at the conference.

To those corporate bodies which have agreed to sponsor some of the conference activities, another special thank you.

Greetings

Dr. Alberto Beale, Acting Chairman
Board of Directors, CFCS

Good Morning!

The Honorable Trevor Sudama, Minister of Food Production and Marine Resources of Trinidad and Tobago. Mr. Winston Gibson, Chief Technical Officer of the Ministry and President of the Caribbean Food Crops Society (CFCS) for the year 2000-2001. Dr. Guy Anais, Vice Chairman of the Board of Directors of the Society. Dr. Compton Paul, Executive Director of the Caribbean Agricultural Research and Development Institute (CARDI), Executive Secretary of PROCICARIBE, and President of the Organizing Committee of this meeting. Dr. Richard Brathwaite, Chairman of the Food Production Department of the St. Augustine Campus of the University of the West Indies (UWI) in representation of Dr. Charles McDavid, Dean of the Faculty of Agriculture and Natural Sciences, and co-host of this meeting. Dr. Arlington Chestney, Regional Director for the Caribbean of the Inter-American Institute for Cooperation on Agriculture (IICA). The Honorable Jorge Luis Pérez Alvarado, Ambassador Extraordinaire in representation of the Honorable Hipólito Mejía, President of the Dominican Republic. Dr. Rafael Ortiz Quezada, Under Secretary of Agriculture for Research in representation of the Honorable Eligio Jácquez, Secretary of Agriculture of the Dominican Republic. Distinguished Dr. Miguel A. Lugo López, Special Advisor to the Society's Chairman and the scientist to whom this meeting is dedicated. Ladies and Gentlemen.

We are truly delighted that after an absence of 16 years, the Caribbean Food Crops Society will hold its 37th Annual Meeting in Trinidad and Tobago. It gives me great pleasure to declare open this meeting. I wish to greet you all with a great sense of friendship and respect.

I would now like to initiate the meeting presenting the members of the Board of Directors. These are:

- Dr. Guy Anais, Vice Chairman of the Board, and Research Scientist at I.N.R.A. in Guadeloupe.
- Mr.Kofi Boateng, Secretary of the Board and Assistant Director of the University of the Virgin Island's Cooperative Extension Service.
- Mrs. Aurora Lugo López, Treasurer of the Board from Puerto Rico.
- Mr. Winston Gibson, CFCS President for the year 2000-2001 who serves as the Chief Technical Officer of the Ministry of Food Production and Marine Resources of Trinidad and Tobago.

The Board members from the French Speaking countries are:

- Dr. Guy Anais, from I.N.R.A in Guadeloupe.
- Mr. Xavier Merlini, President of AMADEPA, from Martinique.
- Mr. Marceau Farrant, Research Scientist from INRA in Guadeloupe.

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- Dr. Compton Paul, Executive Director of CARDI, Trinidad & Tobago.

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- Mr. Jerry Dupuy, Barceló Enterprises, Dominican Republic

- Dr. Alberto J. Beale, Agricultural Experiment Station of the University of Puerto Rico.

The position of Board Representative from the Dutch Speaking countries is currently vacant.

The members of the Advisory Board of the CFCS are:

- The Honorable Hipólito Mejía, President of the Dominican Republic.
- Dr. Altagracia Rivera de Castillo, Executive Director of the Centro para el Desarrollo Agropecuario y Forestal (CEDAF) of the Dominican Republic.
- Dr. Lawrence Lewis, Deputy Commissioner of Agriculture of the U.S. Virgin Islands.
- Dr. Charles McDavid, Dean of Agriculture and Natural Sciences at the St. Augustine Campus of the University of West Indies.
- Dr. Antonio Pinchinat recently retired from IICA, St Lucia.
- Dr. Fernando Gallardo, former Associate Dean and Deputy Director of the Agricultural Experiment Station of the University of Puerto Rico.

The two Special Advisors to the Chairman of the Board are:

- Dr. Darshan Padda, former Chairman of the Board of Directors of the CFCS and former Vice President of the University of the Virgin Islands.
- Dr. Miguel A. Lugo López, Emeritus Professor of the University of Puerto Rico and to whom we dedicate this 37th Annual CFCS Meeting.

The Caribbean Food Crops Society wishes to express its gratitude to the Ministry of Food Production and Marine Resources of Trinidad and Tobago, to the Caribbean Agricultural Research and Development Institute (CARDI), to the Faculty of Agriculture and Natural Sciences of the St Augustine Campus of the University of the West Indies (UWI) and to the Regional Office for the Caribbean of the Inter-American Institute for Cooperation of Agriculture (IICA) for inviting us to hold this 37th Annual Meeting in Port of Spain, Trinidad, and for agreeing to co-host the activity. We were eager to return to Trinidad, since the last time we met in this beautiful country was in 1985. This year marks the fourth time that the CFCS has held its annual meeting here.

The success of a Meeting depends on several factors. Two of these are the quality of the presentations and posters and 2) the diversity of its participants. This Society serves as the most effective mechanism for providing direct outreach from researchers, extensionists, Ministry of Agriculture personnel and members of the private sector to all the people of the islands and territories of the Caribbean. The greater the diversity and the number of persons attending the Meeting, the more widespread the results of last year's scientific breakthroughs and innovative projects will be.

Our Society promotes the integration of members of the agricultural sector of the Caribbean. We have also reached out to the environmental and natural resources sectors of our Region. The CFCS is the oldest and most effective regional agricultural society in the Caribbean. As I look around the audience, I am able to identify Society members from a great number of institutions.

The Society members that actively participate every year in our meetings come from: INRA from Guadeloupe and Martinique; AMADEPA or Association Martiniquaise pour le Developpment Productions Agricoles of Martinique; the General and Regional Councils of Martinique; the University of the West Indies; the Caribbean Agricultural Research and Development Institute (CARDI); the Inter-American Institute for Cooperation on Agriculture (IICA); the Cooperative Extension Service and Agricultural Experiment Station of the University of the Virgin Islands, and their Department of Agriculture; the United States Department of Agriculture; the Ministry of Agriculture of Jamaica; the Centro para el Desarrollo Agropecuario y Forestal (CEDAF), as well as from the State Department of Agriculture, from the private sector and from universities from the Dominican Republic such as the Universidad Nacional Pedro Henríquez Ureña (UNPHU).

Participants include members of the faculty of the University of Florida, The Ohio State University, Tuskegee University, Prairie View A & M University, Ana G. Méndez University System and other North American institutions. Members from the Agricultural Experiment Station and the Faculty of Agriculture of the University of Puerto Rico are also regular participants.

In the past, the summer meeting of the Caribbean Basin Administrative Group was held in conjunction with the annual CFCS meeting. We are hopeful that next year we will be able to double or triple presentations from scientists working on CBAG research projects.

We are delighted that this year we have a large participation from the Ministry of Food Production and Marine Resources of Trinidad and Tobago, from the University of the West Indies, from CARDI and from PROCICARIBE. We look forward to holding future CFCS Meetings jointly with PROCICARIBE. We hope that a large delegation from Trinidad is able to attend the 38th Annual CFCS Meeting, which will be held in Martinique in July 2002.

Although we do not have all of the data from the registration table yet, I believe that the largest delegation from outside of the host country is from Martinique. I wish to congratulate the CFCS members from Martinique for being so active every year in CFCS activities.

Our Society must strive to attract new members from other islands in the Region. Over the years, we have held our annual meetings in 14 different locations in the Caribbean. However, in some countries we have not met for over 30 years, and in others, we have not met at all. We would like to explore new possibilities for venue in the year 2003. Countries that come into mind are Grenada, Belize, Guyana and the Bahamas. We request your support to the Board of Directors in identifying venues for CFCS Meetings.

Our Society must strive to establish linkages with other national and international entities within the Region. The Association of Caribbean Universities and Research Institutes (UNICA) have a membership from over 35 universities and research institutes from the Caribbean Region. The Caribbean Council of Higher Education in Agriculture (CACHE) has as its member's approximately twenty universities that include agricultural programs in their curricula. I have invited the Secretary General of UNICA, Prof. Mervyn Alleyne, and a representative of CACHE to make presentations today on what their organizations are, as well as their priorities and projects.

The CFCS should also serve to promote a closer collaboration between the Ministries of Agriculture of the Caribbean. All our countries produce more or less the same crops and animal products, and all face similar production constraints. By working together, we shall be able to reduce duplicity and make a more effective use of our limited resources.

Today, as we initiate our Annual Meeting, I would like to recognize one of most faithful members of our Society. He is a scientist, a gentleman, a diplomat, a Caribbeanist and a true patriarch of this Society. To him we dedicate this 37th Annual Meeting of this Society. Dr. Miguel Lugo-López please stand up and be recognized.

Thank you!

Keynote Address

***Mrs. Wendy Lee Yuen*, President, Agricultural Society of Trinidad & Tobago; Chairperson, National Agricultural Management and Development Corporation (NAMDEVCO)**

Mr. President; Honourable Trevor Sudama, Minister of Food Production and Marine Resources of Trinidad and Tobago; Excellency, Dr. Jarge Lius Perez Alvarado, Chairman and Board of Directors of the Caribbean Food Crops Society, other distinguished members of the head table; especially guests, presenters, ladies and gentlemen: Welcome to Trinidad and Tobago on this auspicious occasion – the 37th Annual Meeting of the Caribbean Food Crops Society.

It is indeed a great honor and a pleasure for me to address you this morning at the start of this conference and having reviewed the diverse list of papers to be presented by our researchers and technologists and educators throw out the challenge to you all to carry out the mandate of your conference theme "Science, Technology and Education – Empowering Caribbean Agriculture". Now more than ever before we, farmers of the region need your assistance as globalisation forces us to become efficient producers in a fiercely competitive market place where the playing field is far from level.

Mr. President, Caribbean Agriculture needs to take a quantum leap forward in the application of science and technology to current production methods in food crop farming. The time has come for research to be carried out on the farm by both farmers and researchers. In this way, meaningful solutions can be found for current problems. We must empower farmers with the tools necessary to identify problems and seek solutions. Systems must be developed to effectively and efficiently deliver information. Given our lack of infrastructure and a food production sector characterized by smallholdings we need to review our current systems for transfer of technology.

Perhaps the time has come for our researchers and extentionists to re-tool and find new methodologies for the delivery of technology. How can we involve the farmer in this process? How can we make the best use of our limited resources to reach the widest possible audience? Can we adopt the participatory approach and use former field schools to affect a more rapid delivery of technology? These questions are just some food for thought as you discuss these and other issues over the coming week.

While our ability to compete internationally and I dare say our very ability to survive, depends to a great extent on our ability to apply science and technology to our production processes, this research and technology transfer is not without considerable financial constraints. Recognizing the disadvantage that this imposes on Caribbean farmers, there are numerous international agencies seemingly bent on correcting the imbalance that exists between farmers of the developed world and farmers of the developing world in terms of their ability to access technology and education.

Sadly, inspite of the large sums of many identified for this purpose, the difficulties in meeting loan conditionalities, the exorbitant consulting fees attendant on the loan package and other administrative nightmares, very little of this aid ever tends its way to the small farmer. Perhaps there is a greater role to be played by agricultural societies and co-operations directing Ministries and the most deserving beneficiaries.

Despite all of our apparent disadvantages in utilizing science and technology, I am happy to tell you that all is not "doom and gloom". Here in Trinidad and Tobago our food crop farmers have risen to the global challenge and are price competitive in number of fresh vegetables and fruits. Even as we fact total declining acreages under food production levels of key food crops, alluding to greater efficiencies possibly due to greater adoption of suitable technologies. This has enabled our farmers to supply a wide range of high quality fresh fruit and vegetables to both the domestic and export markets even in the face of competing imported products which have enjoyed a 0% CET for CARICOM region and 40% from outside of CARICOM. Another result of this increased productivity has been the marked upsurge of our intra-regional trade since 1988 and the significant increase in our extra-regional exports particularly in crops such as hot peppers.

Mr. President, while we recognize the benefits of science and its role in improving both quantity and quality of food crops produced, we must be ever vigilant not to compromise our consumers and our environment in terms of safety. Food safety implies the judicious application of pesticides in conformity with the manufacturer's specifications. Ladies and gentlemen it is no longer acceptable to leave the responsibility of food safety solely to the discretion of the farmer. We are all consumers of fresh produce, and as such deserve to be protected. We must call on all Governments of the region to not only enact safe food legislation but also to implement suitable systems which will enforce the minimum standards for food safety. WTO conditionalities demand traceability and accountability for safe food systems and these must be fully functional to facilitate the export of fresh produce.

Ministries of Agriculture and Food Production need to take the lead in this imitative to ensure good food quality. While the analytical capabilities of many small Caribbean countries may not be adequate, here is another opportunity for inter-regional co-operation by having member states contribute to the establishment of one central lab facility where appropriate testing for pesticide residues and other contaminants can be carried out. If we fail to provide our domestic consumers with assurances of good quality, safe produce, then we run the risk of driving our customers preferences to "so-called safer imports". Our deficiencies in pesticide residue analysis have caused us to accept the stated quality of imports without question but this may very well be an area for some concern.

Arising out of our concerns for safe food, as well as a concern for the safety of the environment and not least, the farmer and his workers, we need to explore more fully the practices of integrated pest management and encourage greater usage of botanicals and biologicals in preference to harsh chemical pesticides. Where possible farmers should be instructed in techniques to locate and identify beneficial insects rather than adopting the old approach of "if it moves – kill it". Cultural and biological rather than chemical solutions should be encouraged.

To translate this IPM strategy to a national perspective would require a great deal of support from policy makers, pesticide control boards and indeed from Ministers and governments. Mr. President, it is my personal view that we need to severely restrict the availability and usage of certain classes of pesticides which are hazardous to the environment the farmer and the consumer. This is one area deserving of further research as we all seek safer alternatives in the production of food crops.

Utilizing IPM as a production strategy can facilitate the attainment of international standards as specified in the Codex Alimentarius. Together with good agricultural practices, IPM can be significantly reduce the number of critical points in a HACCP production system and the resulting crops will be more wholesome and consumer friendly.

Mr. President, the food crop sector has an important role to play in the Caribbean region due to its direct impact on a number of key issues. The region has to look beyond the stated declining contributions of agriculture to the ADP. These figures are relative to growth in other sectors such as tourism or in the case of Trinidad and Tobago petroleum and should not be used as the sole indicator of agricultural performance. Indeed in absolute terms there has been significant growth in the sector. However statisticians/economists have found it convenient to attribute revenue from agro processing to the manufacturing sector to the detriment of the agricultural sector. For e.g. various reports would have your believe that the coconut industry is dead and waiting to be buried yet it supports a \$100M a year soaps and fats and oil industry with linkages to transport, packaging, advertising, employment generation and foreign exchange earnings.

Notwithstanding its seemingly small contributions to GDP, the food crop sector has a serious responsibility in terms of the provision of food security and contribution to the adequate nutrition of the population of the region. Mr. President, several benefits accrue fro the fulfillment of this role.

By continuing to produce our food crops we enhance our self-sufficiency and reduce the dependency on risky international suppliers who are facing threats from all manner of exotic pests and diseases from Foot and Mouth disease to Asian bird flu. We generate employment for our citizens particularly in the rural areas and this contributes significantly to overall social stability.

The FAO in its paper on "Issues at stake relating to Agricultural Developments, Trade and Food Security" has concluded" "significant progress in promoting economic growth, reducing poverty and enhancing food security cannot be achieved in most countries without developing more fully the potential capacity of the agriculture sector and its contribution to overall economic development".

Participants your interventions this week aimed at increasing agricultural production and productivity are indeed welcome and timely. Against a background of continuing export subsidies in developed countries which discourages domestic production in food importing countries the challenge for you this week is to guide us to the appropriate science and technology that will truly empower Caribbean Agriculture. Mr. President, Ladies and Gentleman, I wish you a fruitful conference.

Feature Address

Hon. Minister Trevor Sudama
Ministry of Food Production and Marine Resources

Mr. President; Ms. Wendy Lee Yuen, President of the Agricultural Society of Trinidad and Tobago; members of the Board of Directors of the Caribbean Food Crops Society; other distinguished members at the head table; participants, ladies and gentlemen, may I add my own welcome to each of you here this morning. A special welcome to the several visitors to Trinidad who come from other countries in the Caribbean and Latin America.

Mr. President, it is with interest that I took note of the theme of this the 37th Annual Caribbean Food Crops Society (CFCS) Conference, which is *Science, Technology and Education – Empowering Caribbean Agriculture.*

Considering the present state of Caribbean agriculture, the unfolding demands in the area of international trade in agricultural and food products and the challenges our countries face in closing the gap on producers from developed countries, I applaud the Society for its choice of this theme at this particular time.

I do so because I concur fully with the Society that fostering the application of science, the use of technology and the educating and training of stakeholders are indispensable to sustainably empowering Caribbean agriculture.

The status of agricultural development in Caribbean states is such that despite the continued reliance of these countries on agriculture for foreign exchange, food supply and employment, the contribution of the sector has declined in relative terms in varying degrees from country to country.

For example, in the case of Trinidad and Tobago, the relative contribution of agriculture to GDP had declined from 5.0 percent in 1985 to 2.2 percent in 2000, while the sector's labour force fell from 10.8 percent of the national labour force to 9.0 percent over the same period.

The decline in relative contribution of the agricultural sector to the economy of our states has been attributed to several factors including low productivity of the traditional export commodities, coupled with the failure of the non-traditional commodities to make-up the deficit. The technologies in use are neither the most productive nor the latest, and unit production costs are higher than those of competitors in developed and some developing countries.

Mindful of the potential role and contribution which agriculture can still play in the development of Caribbean states, and in attempting to address the reduction in market share of traditional export commodities, the governments of these states must adopt policies and strategies to diversify production and marketing, and to increase production, productivity and competitiveness.

Improvements in the development and use of technology will determine to a large measure, the success of these states in diversifying agricultural production, increasing productivity and meeting the challenges and demands of the export market.

Already science and technology are affecting access to export markets. The Codex Alimentarius (or food code) is fast becoming the seminal global reference point for consumers, food producers, national food control agencies and the international food trade.

In that context, giving effect to the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS) and the Agreement on Technical Barriers to Trade (TBT) pose daunting challenges to countries such as ours.

Indeed, a number of developing countries consider SPS requirements to be one of the greatest impediments to trade in agricultural and food products, particularly in the case of the European Union (E.U.).

The problems developing countries have in complying with SPS requirements reflect their wider resource and infrastructure constraints that limit their ability to comply with SPS standards.

A particularly acute problem is access to appropriate scientific and technical expertise and infrastructure.

Furthermore, in many circumstances SPS requirements are incompatible with existing systems of production and marketing in developing countries. In the case of Trinidad and Tobago, increased food safety standards in export markets have already affected some fish and fish products, and are a potential threat to other commodities such as milk, vegetables, fruits and poultry.

And then, we are faced with yet another scientific and technological challenge-genetically engineered foods. The Codex Alimentarius is coming under increasing pressure to publish draft standards for genetically modified organisms (GMOs), and we can be sure that scientific and technological requirements will dominate those standards when formulated.

We have taken note of the 1999 Codex Alimentarius guidelines for the production, processing, labelling and marketing of organically produced foods. In each case, we are alerted to the need for our countries and region to develop scientific, technological and educational capabilities to deal with the guidelines, which are soon to become standards.

And so the imperatives of accessing, developing and promoting the adoption of appropriate technology and scientific methodologies become obvious.

In that respect, Caribbean states must consider the benefits to be gained by adopting a regional approach to satisfying the ever-increasing demands of the markets in international trade for agricultural products.

It is equally obvious that if our states are to confront the challenges of increasing productivity and improving competitiveness, science and technology must be applied in the areas of research, extension, agro-processing and marketing.

In the case of research, a priority area of attention and effort must be on increasing the effectiveness, efficiency and responsiveness of the existing research and extension institutions in our countries and region.

Research and development should lead to technology transfer to farmers or to technology adaptation or innovation in biotechnology or agri-based industry.

Regional agriculture teaching and research institutions must ensure that syllabuses are appropriately modified to remain current and aligned to vital issues demanding response from our agricultural sectors.

On a related note, we should all be concerned with the dwindling enrolment in the agriculture disciplines at the University of the West Indies (UWI) and at the Eastern Caribbean Institute of Agriculture and Forestry (ECIAF).

In the case of the government of Trinidad and Tobago, we are considering a mechanism to stimulate increased competition among researchers and research organizations through the establishment and operation of a competitive research fund to finance projects that meet strategic national agricultural development objectives.

In addition, we are now undertaking a review of the operations and organisation of state-funded research an extension institutions and systems with the intent of making required adjustments.

In the areas of agro-processing and marketing, Trinidad and Tobago are considering the application of incentives as targeted and transitional instruments to help achieve the specific developmental objective of technology transfer.

Mr. President, in many places information and information technology are being viewed as factors of production. The availability, accessibility and flow of information to and among sector participants are fundamental requirements for encouraging the application of science and technology in our agricultural sectors, and for increasing the level of entrepreneurship.

Caribbean countries must enhance the information technology infrastructure servicing the agricultural sector to allow ready access of databases to stakeholders, particularly producers and marketers.

In that regard, we are encouraged by the progress made in the region with the development and installation of the Caribbean Agricultural Information Service (CAIS); the Caribbean Agricultural Marketing Intelligence and Development network (CAMID), and the several networks within the Agricultural Science and Technology Networking System of the Caribbean (PROCICARIBE).

In the case of PROCICARIBE, the objectives include:

~ assisting and facilitating the establishment of commodity-based and thematic networks, and
~ assisting in the design and establishment of a science and technology system for the development of sustainable agriculture in the Caribbean.

Mr. President, these efforts are critical if our states are to

~ provide access to information products and services in priority areas for development, and
~ build capacities in member's states to manage information, and for the collection, organization, dissemination and analysis in support of the needs of the sector.

Mr. President, while we note these advances, stalled initiatives such as the efforts of CEDAF (Centro Para Desarrollo Agropecuario y Forestal) and CCST (Caribbean Council for Science and Technology) to establish a Biotechnology Network must be reactivated and brought to fruition.

Mr. President, these is also a role for science, technology, education and training in our efforts to foster rural development. Our past attempts to realise acceptable levels of development in our rural communities have been disappointing and have led to a redefinition or repositioning of the concept of rural development. At the international level, the issue of the multi-functionality of agriculture has been raised and is receiving the attention of stakeholders.

In the revised dispensation, science and technology are being viewed as essential inputs for environmentally sustainable rural development and employment generation.

In our region, we must also address the development and provision of information and information services within the context of rural development. The analysis shows that in general, rural communities in our countries have not as yet benefited from the unfolding revolution in information technology.

We must therefore deal with the issue of providing information infrastructure and services for rural development, including the strengthening of information and communication capacities in our rural areas.

In so doing, quite apart from the provision of hardware, software, databases and Internet access, the matter of information literacy of the intended beneficiaries must be approached in the context of knowledge management.

Mr. President, most of the Caribbean countries have already completed their needs assessment over the short to medium term, of their agricultural sectors, and are aware of the deficiencies in education and training among their stakeholders.

I had previously mentioned deficiencies in our capacities to meet Codex Alimentarius standards, which are related to a shortage of scientific and technological know-how. These deficiencies are also evident when we attempt to deal with issues of genetically modified foods, biotechnology, informatics, biodiversity and sustainable resource management.

Comprehensive plans to satisfy those education and training needs among our farmers, researchers, marketers, rural communities, extensionists, policy makers, scientists, quarantine officers, and processors, among others, must now be drawn up, and resources secured to execute those plans over the next several years.

While some assistance in funding for education and training can be expected from international agencies, Caribbean states must themselves be prepared to adjust developmental priorities to provide resources to cater to those needs.

Mr. President, distinguished participants, I have attempted in a concise manner, to share with you my vision of the role of science, technology and education in Caribbean agriculture if it is to be empowered, competitive and sustainable over the medium to long term.

We are aware that considerable resources will be required to provide physical and other infrastructure; to adopt or change existing production processes; to establish new institutions; to change laws and regulations and to educate and train a range of sector stakeholders.

Given the limited availability of financial resources common to each of our economies, and the fierce intersectoral competition for those resources, you will agree that the challenge ahead is a formidable one.

Yet the stakes are high, and our failure to respond to the imperatives for making our agriculture competitive and sustainable will impact negatively and perhaps disastrously on our economies, and on the well being of our peoples.

Where feasible, we will need to plan and act as a region, but in many instances, the response must be at a national level.

We have configured and shared a vision for the future of Caribbean agriculture. The challenge now is to do everything possible to realize that vision.

Mr. President, distinguished participants, I wish you all success with your Conference, and thank you for your attention.

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THE POTENTIAL USE OF FARMER FIELD SCHOOLS WITHIN THE ENGLISH SPEAKING CARIBBEAN

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ABSTRACT: Farmer Field Schools (FFS) have become a useful institution in facilitating an integrated approach to Integrated Pest Management (IPM). It has been viewed as an impressive advance in IPM implementation over the last decade (Ter Wheel and Van Der Wulp, 1999). Its impact is well documented among the rice production systems of small farmers in The Philippines, Indonesia, Vietnam and India. For instance in Indonesia following the implementation of FFS, rice farmers were able to reduce pesticide use by 60% with an accompanying yield increase of 13% (Kairo, 2000). Similarly in the Philippines there was a recorded 80% decrease in the use of insecticide among vegetable growers. There have also been many success stories out of Central America. This presentation explores potential use of this methodology within the English Speaking Caribbean.

INTRODUCTION

Excessive Pesticide use among growers is a key concern to the global interest in Sustainability. Pesticides pose serious health hazards to women, men, girls and boys. They contaminate the environment. They exacerbate crop production problems by building pest resistance, eliminating natural enemies of pests and encouraging the use of allegedly safer but more expensive products. According to FAO, 520 species of insects and pests worldwide 150 plant diseases and 113 weeds are resistant to pesticides (FAO 2000). There is also the chance that farmers loose touch with more indigenous control methods to which they were accustom and which may not use much pesticide.

The region has fallen prey to excessive chemical pesticide use. There is an efficient and highly successful agribusiness which markets pesticides and which farmers customarily rely on, especially for routine guidance. Many farmers can easily obtain credit and subsidy support for chemical use which would not be available for non-chemical alternatives. Occasionally the region is the recipient of obsolete stock, which is outlawed in their countries of origin. Pesticide laws themselves are either obsolete, non existent or disobeyed.

Growers are still unable to interpret dosage requirements. They hold strongly to the philosophy of quick visible kills without respect to post harvest intervals. Storage facilities are poor, so is the disposal of used containers and the use of leak-free machinery. There is the often-reported use of "cocktails" which at times contain up to 4 or 5 pesticides in a daily routine and especially close to harvest in order to ensure a good-looking harvest for the consumer. There is minimal or non-existent pressure from the consumer who is either very ignorant of what is taking place or very helpless to demand improved standards.

Thus in keeping with the philosophy of IPM, this paper asks how can the farmer field school concept become a useful institutional mechanism within the English speaking Caribbean in order to minimize quantities of pesticides used while maximizing productivity?

CURRENT IMPORT- EXPORT TRENDS

The Tables 1 and 2 below indicates the current trends of Import and Exports into and out of Trinidad and Tobago.

Table 1. Agricultural Insecticide Exports and Imports (kg) to and from Trinidad and Tobago for the period January to September 2000. Source CSO, Port of Spain, Trinidad and Tobago.

Country	Imports	Exports
Anguilla	-	80
Antigua and Barbuda	-	960
Barbados	-	366
China	1,609	-
British Virgin Islands	-	40
Dominica	-	420
Germany	29,560	-
Grenada	-	1717
Guyana	-	5011
St Kitts Nevis	-	1122
St Lucia	-	139
St Vincent & the Grenadines	-	5
United States of America	43,910	-

Table 2. Imports of Agricultural Insecticides, Fungicides, and Herbicides (Mkg) into Trinidad and Tobago for the years, 1985, 1990, 1995-2000. Source CSO, Port of Spain, Trinidad and Tobago.

Year	Insecticides for Agricultural Use	Fungicides in Packets	Herbicides in Packets
2000	1.41	0.11	0.34
1999	0.43	0.15	0.56
1998	1.59	0.13	0.70
1997	0.39	0.16	1.44
1996	0.33	0.14	0.35
1995	0.33	0.08	1.21
1990	0.60	0.17	0.10
1985	0.67	0.33	0.10

Table 1 indicates that this country has imported the bulk of its needs from the larger countries in the business namely: China, The USA and Germany. In return this country has no export business to them. It also engages in " re-exporting" to many of the smaller territories within the region. The largest recipient of exports is Guyana followed by Grenada and St Kitts- Nevis. These countries therefore have a dependency which may not be appropriate in controlling what pesticides they purchase.

With respect to Table 2, the quantity of Insecticide imported for Agricultural use has doubled since 1985. There has been less Fungicide in packets since 1985. Generally Fungicide imports are lower than the other Pesticides. Also since 1995, there has been a tendency to import less Herbicide in packets. One speculation about Herbicide use is that previous users could be returning to manual weed control or the noticeably popular (throughout Trinidad and Tobago) method of using a "String Trimmer" device.

THE FARMER FIELD SCHOOL

The school operates as a network, which facilitates interaction between the decision-makers viz. The Extension workers, Technical Expertise of varying institutional origins, The Farmers, Researchers and other useful contributors. All become stakeholders in a quest to reduce pesticide use and costs, minimize health risks and contain environmental hazards. The idea is that farmers will be encouraged and trained to observe specific trends of pest infestations on a designated plot owned by one of them. They would be encouraged to understand the modes of life and habits of crop pests in relation to their surroundings. Different environments become targets of comparisons. So one major point of contrast becomes the plot with pesticide applications versus the one without. In so doing they would understand the real effect (if any) of chemical control on any yield increases and decide whether the cost of the pesticide applications could be minimized. To obtain maximum success there must be a high quality relationship among the stakeholders.

CURRENT SITUATIONS

Specialist crop protection technical and extension experts from Antigua (Gore, 2000), Belize (Magloire, 2000), Grenada (Phillip, 2000), Haiti (Donis, 2000), Jamaica (Chung, 2000), Saint Vincent and the Grenadines (Edwards, 2000) and Trinidad and Tobago (Ramroop et al., 2000) reflected on pest control practice and related issues within their respective Agrarian environments. A review of their reports reveals several current situations as follows:

- In most countries there is an understaffed crop protection unit unable to cope with all the possible pest control initiatives.
- There is an Extension link with farmers which is still "top down" in its approach despite more recent sensitivity to "bottom up" approaches. Accompanying research is lacking especially due to a shortage of funds.
- Agricultural input suppliers dominate the transfer of pesticide technology
- Farmers still prefer to use broad-spectrum pesticides, which are readily available but do not easily focus on specific pest targets. Despite this prevailing situation some farmers are becoming aware of newer target specific pesticides and biopesticides
- There is a lack of policy on Integrated Pest Management or any type of pesticide control. Where policies exist, much revision is needed.
- Biological control mechanisms have become popular since its successful use in the control of the Hibiscus Mealy bug.
- The experts define IMP more in the context of cultural practices, not necessarily thinking about a truly integrated concept.
- Some countries, which have poorer farmers, have a better record of limited pesticide use.

Given these circumstances the FFS will need much new support preferably organized from a new operation with linkages to existing units. Research and Development funds for the required networks will need to be sought. Given the dominance of pesticide importers, it may be useful to respect their stakeholder status and incorporate them in the process. Can such an entity employ IPM officers or share a state cost for this purpose? A likely outcome of their participation is that they may have to agree to lower volume of sales to maintain their business. Network decisions are expected to help this major decision.

Can consumers and middlemen be part of the funding process by being made to pay a tax to help fund the schools' activity? A strategy, which promotes the use of pesticide-free products, can help this process. Environmental and Ecotourism groups could also be persuaded to join IPM networks.

Any new operation will organize the growers and choose lead participants for their indigenous knowledge, keen observation skills and their influence of reasonable proportions of other growers. This mobilization would challenge existing patterns of selection where Extension Officers tend to be selective of clients on biases of class, income, ethnicity, age and gender. Even consumers can be made to be a part of the network observing trends among pest populations and in post harvest circumstances. It would also be important to assess the large proportion of partime farmers within the sector. They may need special incentives and persuasions to become part of any fulltime involvement within FFS networks.

Farmers can be credited with strategic and practical powers of observation, given the fact that their daily livelihoods depend on the agricultural products they produce. It is essential to understand that they have become industry driven in this era of postmodern development. No longer are Caribbean farmers food producers for an exclusive niche immediately surrounding their farms. Hence in observing how to increase output from the farm, they know that maximum yield and a blemish free product is an answer to survival. In so doing they excel in the use of unwarranted quantities of many products. A large number of them may still be unable to comprehend instructions on labels without misinterpretation and subsequent overkills and abuses to the environment. The quest of the Farmer Field School in the Caribbean is how to contain these approaches while helping farmers to sustain their livelihood and equity status within communities.

CASE STUDY

A case study of a recent farm visit further illustrates this dilemma.

On a visit to Farmer Dell he had three plots of vegetables namely Eggplant, Tomato and Corn. The former two were still in production and the corn crop had just been completed. There were two dead birds, apparently "freshly killed" by stomach poisoning. They were found among the corn stalks perhaps having mistaken pellet granules of a preemergent herbicide for grain. His eggplant plot looked healthy and he was harvesting the following day for the local market. However he chose to spray the previous day with a' cocktail' of pesticides with varying post harvest intervals. On being questioned about this practice, he said he had to do this so that when he harvested fruit, the parent plants would be ready to continue production for the following week. Still there were reasonable quantities of white flies and other pests, which seem completely adapted to the high levels of pesticides present in the plots.

Dell complained of a persistent symptom of unexplained joint pains, which he noticed has eased since he employs someone else to spray. He has had little formal education and don't think he can be employed in any other occupation but vegetable crop production.

Dell does not think that he would easily join a farmer's group as the executives of such organizations only look after themselves and he would not derive benefits from his participation. August 2000.

This is the typical small farmer from Trinidad and Tobago. He is part of a total population of approximately 6,000, which helps to feed the island's 1.2 million population and possibly the hotel, restaurant and other service industries. It would be difficult yet important to reorient his thinking to the FFS concept. He is not easily persuaded by neighbors, hence not readily inclined to adopt new group rules, which will pertain to information sharing among them. Given his dependence on the continuous cash flow for the standard of his livelihood, the FFS model may have to help the farmers find a diversified perspective for their small businesses.

An additional perspective pertains to a misunderstanding that the FFS is a panacea solution to all pesticide problems. Extension and other outreach agencies will need to inform personnel about the precise definition of the school. Currently it addresses specific needs in crop production.

Within the Caribbean region, it is possible to create networks among other types of practitioners such as the home gardeners, the livestock farmer and the homemaker who for instance may have a severe mosquito infestation, which cannot be controlled by regular aerosol spraying. These are new challenges for the FFS concept.

Pest management problems arise from two sets of use changes namely those of Human use, where human beings make new demands, acquire new taste and become victims of new marketing arrangements. Secondly those of changes in the natural system through pest introductions and pesticide resistance (Norton, 2000). This paradigm must influence the thinking of policy and decision makers. Can tariffs and other trade interventions curb unwarranted introductions to the region? Can the new mandates of the World Trade Organization influence policy and method in order to enhance IPM approaches? These are important research questions.

Consumers can be encouraged to understand their taste patterns and possibly realize the potential value of more local, fresher, minimally processed foods in their diets. Researchers may also need to monitor the introduction of new biological pests, biological pesticides and other such product interventions, which may eventually become an unsustainable entity within the natural system. What I conclude from these points is that there needs to be a new thrust in research, which refreshes options for crop production and other options pertaining to pesticide use in other occupational domains. Many researchers will need to retool their capacities to be successful interveners in the development process.

The typical Gender issue of the invisible female will need to be addressed in the new FFS paradigm. The distinct Gender Division of labor does exist in the region. Females still perform specialist agricultural assignments while carrying out their caring functions in the home. Many of these assignments are invisible to their spouses, other males, researchers and extension workers. Therefore women must not be obliterated from the FFS networks because of this invisibility. If so, there is the likelihood that their best roles in the process may be undermined much to the detriment of the change processes involved.

EXPERIENTIAL LEARNING

From the perspectives of Extension Teaching methods, the FFS School is an attempt at Experiential Learning. This is a learner-centered approach where the farmers will learn from experience. It is a paradigm recognized since the late twentieth century whereby learning provides opportunities for a person to engage in an activity, review it critically, draw some useful insight from an analysis and apply the result in a practical situation. The FFS will use Experiential learning in order to provide an effective IPM strategy. A graphic representation is illustrated in Figure 1 below

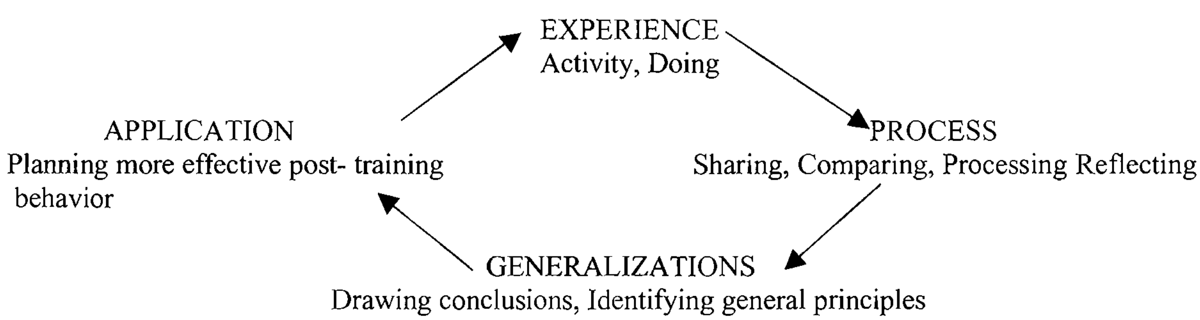

Figure 1. Experiential Learning. TC110: Instructional Methods and Course Requirements Page AE-18. University of Wisconsin, Madison 1989.

This challenges the linear model, which has a top-down relationship in which Research and Development resides at the upper end and the farmer at the lower. The model assumes that the farmer will be engaged only in the' lower order' thinking areas of Recall Remember and Recollect. Frequently they are regarded as too poorly educated to even do this very well. This model is illustrated in Figure 2

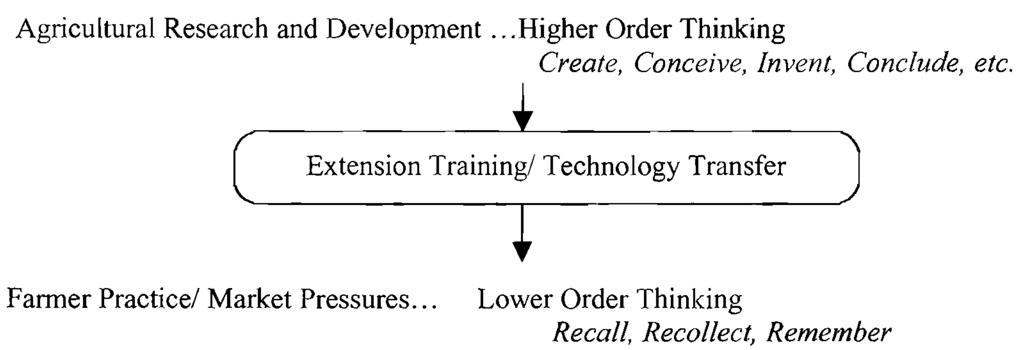

Figure 2. The Linear Model of Technology Transfer. Adapted from Norton 2000 and Grasha 1987.

The new approach of the FFS is to engage higher order thinking among the farmers. They are expected to reflect, consider, reason, invent and conceive. This newer change model where relationships are realigned is illustrated in Figure 3.

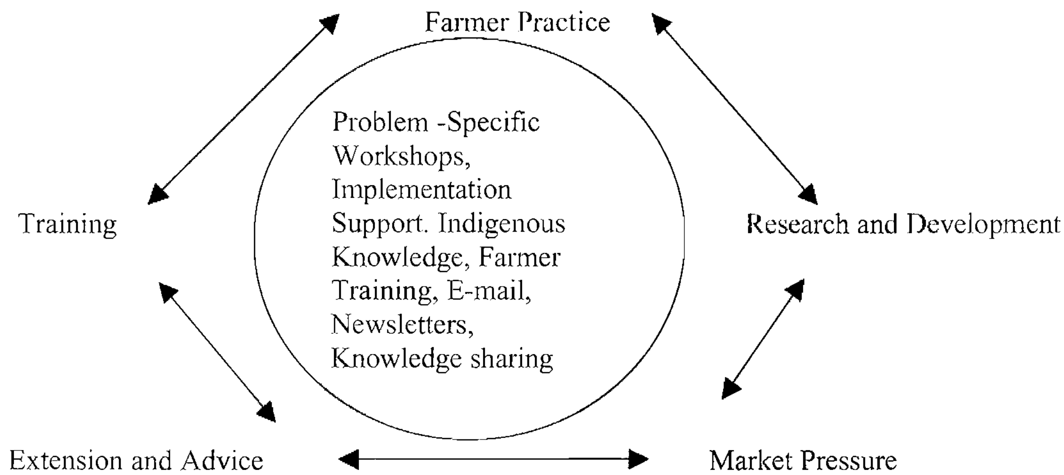

Figure 3. Model of realigned relationships required for The Farmer Field School. Adapted from Norton 2000.

This model challenges the Extension-Research linkages to become much more involved with clients. Within the region all the intended activities of such an integrated system are present. However the intensity of operation and interest is lacking especially with respect to involving the larger population of typical small farmers. They are constrained by many reasons previously mentioned. There is still much casual interest in Indigenous knowledge. Networks are weak and biased. Implementation support usually lacks funds for effective completion. Market pressure is mounting almost to the point of latent intimidation. So much work will be needed in order to reorient Extension- Research systems into the FFS paradigm.

CONCLUSIONS

It is firstly concluded the FFS idea is not currently implemented within the region. Many odds are against its proliferation. Farmers are using exorbitant quantities of pesticides and may not easily be inclined to change. Neither are they inclined to network discussions about pesticide use and attendant IPM. Some stakeholders are ignorant of the methodology and liken it to Cultural practice control and Biological control. Some of the stakeholders like the consumers, female farmers and the environmentalist are currently invisible. They must become visible.

FFS needs an Extension teaching methodology, which is well known but never easily practiced in the English speaking Caribbean. If it were to be implemented it would halt a thriving pesticide business and affect the income of both the farmer and the input supplier in unpredictable ways.

The use of FFS is therefore thwart with constraints, which must be challenged. It would be important to organize the stakeholders for learning. In so doing the region needs to understand the big difference between knowledge based on recall and deeper forms of understanding. All learning is rich, complex and occasionally unpredictable. (Ewell, 1997) Hence all stakeholders in IPM must be immediately identified and an attempt must be made to build an effective learning environment, which can foster collective knowledge and active discussion among the desired FFS networks.

Then learning about curbed pesticide use, pest behavior and plant host reaction must shift from the teacher–centered stage to the learner–centered stage. The networks are expected to facilitate learning in the context of compelling "presenting problems" with reflection, reworked patterns, reworked relationships and connections. The objective is to improve an understanding of the pest problem and identify the full range of opportunities for improving IPM.

Like all successful Extension work, stakeholders should use "bite-size" attacks on the problem. Given the proliferation of small farmers juxtaposed fewer but influential large producers, careful decisions need to be made about where to start the process and which networks should initiate the process. Authorities must start with few networks, which can focus on the specific problems and achieve results, which could serve to gain political mileage and enhance popularity within the Agricultural community.

Therefore much work needs to be done if the Farmer Field School concept is to be implemented in the English Speaking Caribbean. When doing so it would be important to be sensitive to sound "bottom up" Extension methodologies and ensure a realignment of relationships among carefully identified stakeholders. Eventually with key, appropriate activities in place the region will boast of similar successes as its Asian and Central American counterparts.

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THE PHILOSOPHY OF THE OPEN SCHOOL OF TROPICAL ANIMAL SCIENCE AND PRODUCTION

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ABSTRACT: The paper begins by attempting to acknowledge as many of those persons and organizations worldwide who or which contributed output and activities that helped in the distillation of ideas that helped to formulate this school of thought. The paper also outlines the four (4) assumptions underlying the philosophy of the "Open School of Tropical Animal Science and Production" (OSTASP), and the six (6) elements of the Philosophy. The Mission Statement of the OSTASP is "To contribute towards the continued production, utilization and conservation of Tropical Animal Resources for the benefit of humanity". The Membership of the OSTASP would consist of 1] The Founders [Garcia and Archibald], 2] Foundation Scholars, 3] Scholars, 4] Fellows, 5] Associates, 6] Student Members, 7] Cooperate Members, 8] Institutional Members, 9] Farmer Members, and 10] Ordinary Members. The Suggested Approach of the OSTASP will have the following elements:

(i) an increased dialogue between in situ and ex situ wildlife conservation efforts (the bringing together of the different human elements, the advancing of the humanizing project = the Trialectic);
(ii) the intensive production of species with the potential for domestication;
(iii) the utilization of animal biotechnology for the conservation of useful genes from within the existing wildlife gene-pool;
(iv) the expanded research into the anatomy (digestive and reproductive), health and husbandry of wildlife species;
(v) the development of an International Network on Wildlife [Non-domestic animal] research and development, which would include Zoos, Conservation Parks, Universities, Research Institutions, and Private Collections; and
(vi) the use of the CGIAR International Plant Genetic Resources Institute (IPGRI) Network Model could be used as the basis for setting up the Tropical Animal Science Integrated Network [TASIN].

In order to give the OSTASP life all members would be invited to belong to a Web Based Community. Within this community network members could then be of service to each other while we collectively attempt to advance the Mission of the OSTASP, which is "To contribute towards the continued production, utilization and conservation of Tropical Animal Resources for the benefit of humanity"

BACKGROUND

The purpose of this paper is to outline the philosophy behind the OSTASP. All philosophical introspection has always first begun with a question. The question that will now be posed would be: "Why is it necessary in the year 2001 to address the issue of Tropical Animal Science and Production from a philosophical perspective?" This could be the subject of a very scholarly debate but we do not have the luxury of time and space in which this could be done. One could, however, first choose to begin at the very beginning by attempting an answer for "What is Science?" This can be seen as the study of matter and things using the empirical method approach to arrive at universal truths. Modern man has further classified Science into Basic Sciences, Applied Sciences, and Social Sciences. Descriptions of these have now all become axiomatic, so there is no need to elaborate further. Agriculture is an Applied Science [which includes Animal Science as a discipline]. As an Applied Science it attempts to apply the knowledge of the Basic Sciences towards the production of food and utility for mankind from plants and animals, and for the maintenance of the environment in a sustainable manner. It, however, also has to draw very heavily on the knowledge generated from the Social Sciences as it has to do with the economics of the production process, religious attitudes towards the production and use of foods, and social policy formulation as it pertains to food production, human nutrition, poverty alleviation, and human well being. Therefore, one could and quite possibly have encountered "Agricultural Experts" who are Agricultural Economists or Sociologists, and Rural Development Specialists but who may have very little expertise in the production side of the Applied Science.

In other words they are "Social Scientists" who are being asked to make decisions and give advice about an "Applied Science" for which they have neither been trained nor were they equipped to deal with. It is critical that we address this at this junction in history, with the overtones and primeval emphasis of "Globalization". Thus the Assumptions and Philosophy of the St Augustine School of Tropical Animal Science and Production must be resonantly articulated. One has attempted to crystallize this school of thought that was the result of work done with, and discussions held by the authors with many people during the period 1975 to 2001. Some of these thinkers and doers are too numerous to mention and time and space does not permit. This, however, would be done in the expanded version of this paper.

THE ASSUMPTIONS OF THE OSTASP

The Assumptions are as follows:

I] the maintenance of Tropical Animal Biodiversity is essential for the well being of humankind on earth;

II] Tropical Animals have been selected by nature to be adapted to Tropical Environments;

III] there are five (5) factors governing the production of any species of animals or livestock and they are as follows:

1) Nutritional and Feeding Factors
2) Breeding, Genetics and Reproduction Factors
3) Health and Disease Factors
4) Environmental Factors
    a) The Physical Environment (Housing)
    b) The Social Environment (other animals) and
5) The Economic and Marketing Factors; and

IV] <u>all</u> animal species can be produced using a Systems of Production Modeling Approach [Figure 1].

THE PHILOSOPHY OF THE OSTASP

The elements of the Philosophy are as follows:

1] the concept of the intensification of production is necessary whether in situ or ex situ;

2] the use of the Systems of Production Modeling Approach has the features as described in Figure 1.

3] Animal Production should be based to the greatest possible extent on the use of the local and available feed resources;

4] seek to understand the factors affecting animal production for each species being studied; in the case of new species, first attempt an understanding of the anatomy and functioning of the Digestive and Reproductive Systems;

5] "Production Systems" should be intensive in approach and integrated in nature, seek to find complementary animals and plants; and

6] "Systems of Production" must encourage plant and animal diversity.

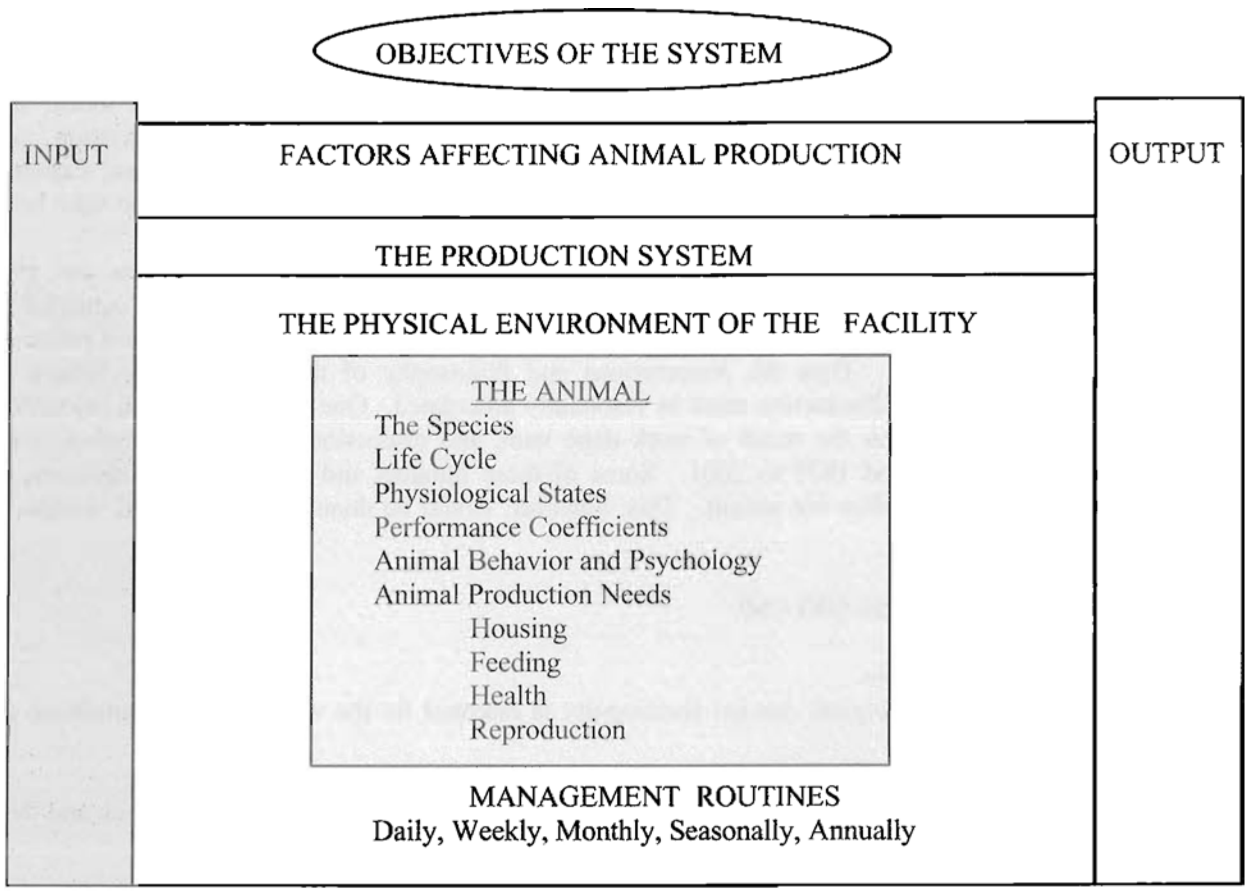

Figure 1. Concepts for developing an animal production system for any species.

THE WAY FORWARD BEYOUND THE YEAR 2001: HOW SHOULD PEOPLE WHO SUBSCRIBE TO THE OSTASP PROCEED

Intensification for the development of this school of thought:

This concept of intensification involves the bringing together of many animals into a single location, or within close proximity to each other with the problems attendant on increasing animal population densities. In the extreme situation of ex situ intensification implications of the above are that animals have to be fed and watered with timely waste removal; preventive techniques have to be instituted to avoid the introduction and rapid spread of diseases; animals' social behavior need to be considered; provisions have to be made for the animals' social needs to be met; and the design of the housing plays a key role in facilitating all of the above.

Approaches at Developing Intensive Animal Production Systems:

A philosophical approach that is being suggested for the developing and planning any system is based on two elements:

1] an understanding of the factors affecting animal production and

2] the physiological states of the animal species in question.

What must be noted is that there exist an interaction between the above two; and this interrelationship will determine the nature of the production system. The reason for this is that at each physiological state, the effect of each factor is different OR the needs of and the threats to the animals' survival will be different.

In developing an Intensive Production System its objectives must be clearly established from the start to identify which physiological states should be included in the model. The source of the animals for the production system to be established will also need to be identified as follows: wild caught captive breeders; wild caught juveniles for growth or the management of all physiological states. The modern day poultry industry reflects the success that this industry has had with this type of approach. In the North American Dairy Cattle Sector, over the last twenty years we have seen an evolution from all production units being contained on one farm to the development of large and very specialized farms made up of only one production unit, which manages therein only a very narrow range of physiological states. This has seen the decline of the Family Dairy Farm and the expansion of the specialized production units with cooperate structures of management in which thousands of cows are milked three times per day. It is not being suggested here that we emulate this in the Developing Tropical World, but what is being suggested is that lessons can be learnt from the production and business principles evolved and employed.

In the Developing Tropics it is the Dairy Goat that holds the greatest potential for expansion [Knights and Garcia, 1997]. Never the less there is an abundance of Tropical animal species which are on the verge of domestication and to which one should address attention. A short list is as follows:
Eland (*Taurotragus oryx*), Capybara (*Hydrochaeris hydrochaeris*), Agouti (*Dasyprocta leporina*), Collard Peccary (*Tayassu tajuca*), Paca (*Agouti paca*), Iguana (*Iguana iguana*).

The reality is, however, that the Tropical Animal Scientists working in the Tropical Developing Countries [wherein are the repositories of the abundant animal genetic material] do not have the resources, financial and otherwise, to accept the challenge. Globalization and its consequent decrease in research support from small states, has found them not looking after their own interest in exploiting their biodiversity. This is also helping to make this unfortunate situation even worse.

THE NEW HORIZONS

The complementary activity of the in situ and ex situ conservation techniques will pose the new challenges for Tropical Animal Science [TAS]. The major challenges will lie in the intensification of production activities in both the in situ and ex situ conservation situations. It is for this reason that a Tropical Animal Science Integrated Network (TASIN) is being suggested as a component of the OSTASP. It is envisioned that this network could be funded and function in a manner similar to the International Board for Plant Genetic Resources (IBPGR). The first task of the OSTASP would therefore be to get this network going by any means necessary. The nature of the network linkages and the general expected outputs are presented in Figure 2. This would afford a better opportunity for the two conservation camps to interface and have constructive dialogue with all the stakeholders in Tropical Animal Science, [Domestic Livestock (Food, Companion and Laboratory Animals/ animals at different points in the productivity and utility to humanity continuum); Animals on the verge of Domestication; and Wild Animals]. TASIN was first suggested by Garcia (1999).

The future horizons for Tropical Animal Science and Production lies:
[1] in getting a better understanding of this wide range of under-utilized non domesticated tropical animal resources and
[2] in creating synergisms from the efforts of the 2300 Zoos world wide [the ex situ conservation and research efforts] and the 4000 plus nature reserves worldwide [the in situ conservation efforts].

This work has already started through the initiatives of Darwin, and with the formation of societies such as the London Zoological Society in 1828 and the Smithsonian Institution. These institutions have laid the groundwork for Tropical Animal Science, which is still in its infancy as we know it today both in the Developed and Developing countries. This is because those persons who have been working in Animal Science in the Tropics have focused mainly on the exploitation of Dairy and Beef Cattle (*Bos tauru, B. indicus*) for beef and milk, sheep and Goat (*Ovia aries* and *Capra hircus*) for mutton, chevron, and milk; chickens (*Gallus domesticus*) for eggs and meat; turkeys (*Melagris gallapavo*) for meat and plumage; Ducks (*Anas platyrhynchos*) for meat; Horses (*Equus caballus*) for work and enjoyment, Dogs (*Canis familiaris*) and Cats (*Felis catus*) for companionship. Thus Animal Science has focused mainly on 10 species of animals.

In order for Tropical Animal Science to fully blossom, 'blinkers' would have to be removed, our Eurocentric approach to Animal Science would have to be changed and greater dialogue between the in situ and ex situ approaches to animal conservation, management and production must be engaged. Blaut (1997) has suggested that this "Eurocentric diffusionism" has contributed to the current lack of success and overall development of tropical agriculture and has contributed to the destruction of small holder agriculture in Puerto Rico and the United States Virgin Islands. One should take note of this and avoid it having a negative effect on the future of Tropical Animal Science that is still in its infancy. Hence those who subscribe to the thinking of the OSTASP would agree that there is a need to view Tropical Animal Science and Tropical Livestock Development from a different perspective, if the science is to be advanced. A move possibly from "Dialectical" thinking to "Trialectical thinking (critical thinking in the light of advancing the humanizing project)" as has been suggested by the late Dr Herb Addo in the last paper he wrote before he left this life (Addo, 1996).

THE SUGGESTED APPROACH OF THE OSTAS&P

This new approach should have the following elements:

(i) an increased dialogue between in situ and ex situ wildlife conservation efforts (the bringing together of the different human elements);

(ii) the intensive Production of Species with the potential for domestication;

(iii) the utilization of biotechnology for the conservation of useful genes from within the existing wildlife gene-pool;

(iv) the expanded Research into the anatomy (digestive and reproductive), health and husbandry of wildlife species;

(v) the development of an International Network on Wildlife [Non-domestic animal] research and development, which would include Zoos, Conservation Parks, Universities, Research Institutions, and Private Collections; and

(vi) the use of the CGIAR International Plant Genetic Resources Institute (IPGRI) Network Model could be used as the basis for setting up the TASIN as suggested in Figure 2.

MEMBERSHIP TO THE OPEN SCHOOL OF TROPICAL ANIMAL SCIENCE AND PRODUCTION

Membership to the OSTAS&P would be as follows:

1. Founders [Garcia and Archibald].
2. Foundation Scholars, those who have contributed to the teaching in the degree, M.Sc. in Tropical Animal Science and Production. UWI,
3. Scholars, persons who in the opinion of the Founders and Members of the School have made a significant contribution to Tropical Animal Science and to concepts in developing this school of thought.
4. Fellows, all graduates of the M.Sc. Programme in Tropical Animal Science and Production, and M.Phil in Livestock Science, UWI.
5. Associates, all graduates with a B.Sc. in Livestock Production, UWI.

6. Student Members, all students registered in the M.Sc. in Tropical Animal Science and Production, or M.Phil in Livestock Science or Ph.D. in Livestock Science, UWI.
7. Cooperate Members, Companies which would like to advance the mission of the OSTASP through their support in cash or in kind.
8. Institutional Members, Institutions which would like to advance the mission of the OSTASP through their support in cash or in kind.
9. Farmer Member, Farmers who in the opinion of the Founders and Members of the School support the Mission of the OSTASP through their active support and practices.
10. Ordinary Member, any persons who in the opinion of the Founders and Members of the School support and contribute towards the Mission of the OSTASP.

HOW THE OSTASP WILL FUNCTION

In order to give the OSTASP life all members would be invited to belong to a Web Based Community. Within this community network we could then be of service to each other while we collectively attempt to advance the Mission of the OSTASP.

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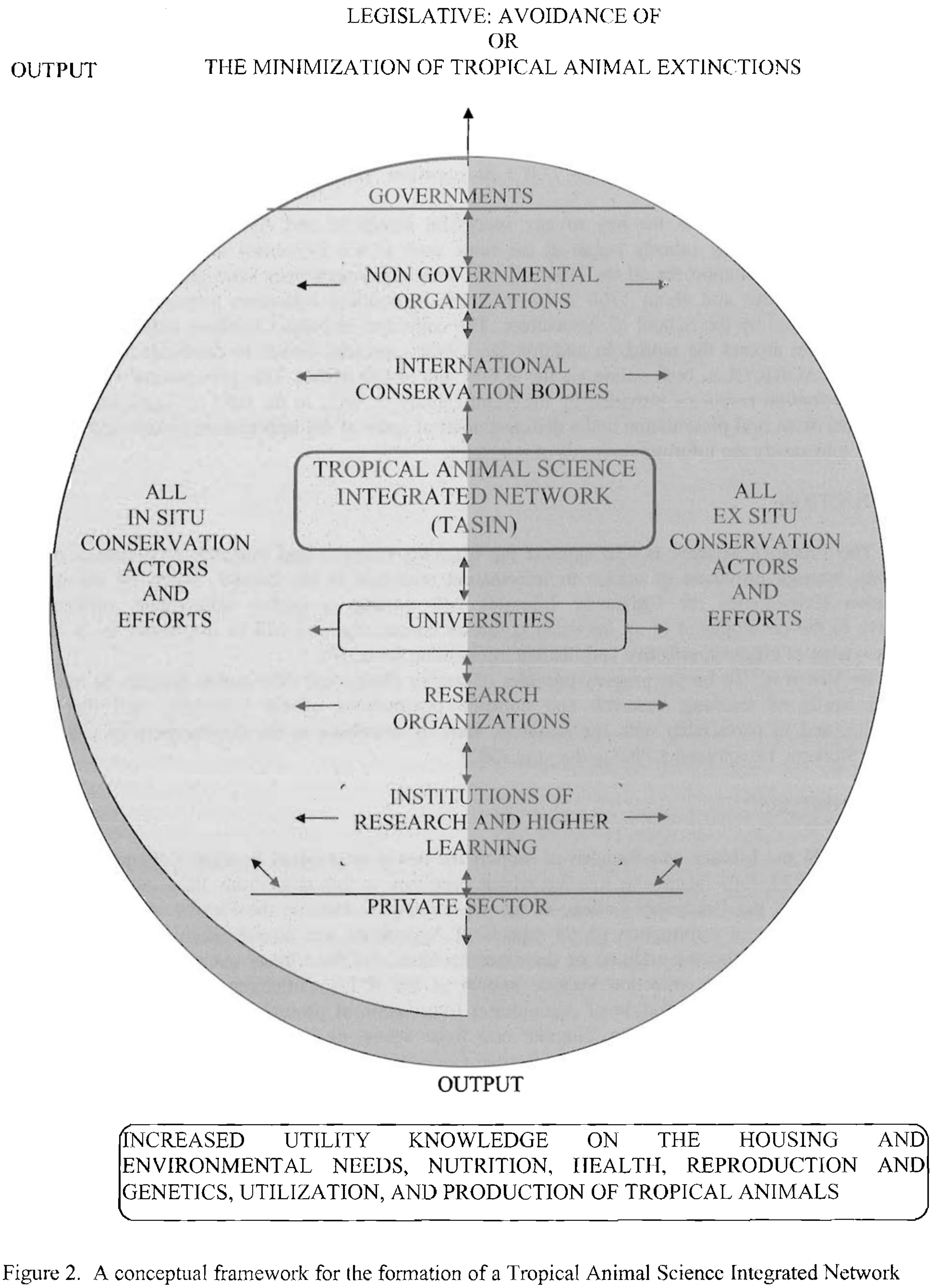

Figure 2. A conceptual framework for the formation of a Tropical Animal Science Integrated Network (TASIN).

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THE UNIVERSITY LIBRARIES: PROVIDING INFORMATION SUPPORT FOR SCIENCE, TECHNOLOGY AND EDUCATION IN AGRICULTURE

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ABSTRACT: Information is the key to any successful enterprise and Agricultural Education is no exception. The University Library began at the same time as the University and has been providing essential information support for all the Teaching and Research programmes since then. With over 6,000 book/monograph titles and about 1700 serial titles the Agriculture collection covers all the areas of Agriculture covered by the School of Agriculture. The collection includes Caribbean material as well as information from around the world. In addition the Library provides access to databases such as CAB Abstracts and AGRICOLA, both online via the WWW and as CD ROMs. This presentation will focus on the vast Information resources provided by the Main Library, U.W.I., in the field of Agriculture. It will take the form of an oral presentation and a demonstration of some of the information sources and retrieval tools we use to satisfy the information needs of our users.

INTRODUCTION

The Library's Mission is "To support the teaching, research and outreach programmes of the University through provision of access to information resources in all formats. Aided by the use of information technologies the University Libraries will develop a quality information environment conducive to the development of an information literate community, and will be responsive to its clients in the provision of efficient, effective and flexible information services".

Its Vision is "To be the primary provider of quality library and information services to meet the changing needs of teaching, research and outreach programmes of the University and the wider community, and in partnership with the academic staff to contribute to the development of Caribbean societies (Strategic Development Plan to the year 2002)".

A BIT OF HISTORY

In 1924 the Library was founded to support the newly established Imperial College of Tropical Agriculture (ICTA), thus began our mission which continues to this day. From 1924 until 1960 when ICTA merged with the University College of the West Indies to become the Faculty of Agriculture an impressive collection of information on all aspects of Agriculture was already acquired. After this the University developed with the addition of the other Faculties and the Library grew in tandem with this development. The original collection became known as the ICTA Collection of which a substantial portion still survives. The collection of Agricultural Information at present is very comprehensive and covers everything from avocados to Zingiber and from agouti to zandolee! There are items in the collection, especially in the West Indians and Special Collections Division that can be found nowhere else in the world. There are Serial Titles that exist in a continuous run from Volume 1 to the present volume, e.g. Advances in Agronomy (1949-); Annals of Botany (1887-); Journal of Agricultural and Food Chemistry (1953 -); Journal of Agricultural Engineering Research (1956 -); Journal of Animal Science (1942-); to name a few.

The Staff has naturally grown along with the size and complexity of the Library. In January 1928 the Registrar and Editor of the journal "Tropical Agriculture," Mr. G. Gianetti, was appointed to serve as librarian and it was not until 1945 that the first professional Librarian was appointed [1]. At present there are 25 professional Librarians employed at the University Libraries. The Librarians in charge of the subject Divisions all have the relevant subject specialisation which allows them to more effectively satisfy the information needs of their users.

THE COLLECTION

A rough count of print material in the Agriculture Collection done in July/August 2000 showed a total of 6175 monograph titles and 1644 serial titles. The following is a breakdown by subject areas.

Table 1. Monograph and Serial Titles in the Agriculture Collection as at August 2000.

Subject Area	Monographs	Serials
S (General Agriculture, Extension, Economics and Soils)	1587	828
SB (Plant Culture)	2987	544
SD (Forestry)	354	89
SF (Animal Culture)	679	132
SH (Aquaculture & Fisheries)	318	47
SK (Hunting sports and Wildlife Management)	17	4
Z (Bibliographies, Abstracts and Indexes)	233	218

Collection Development or How do we decide what to buy?

Funds from the Library's budget are allocated to each subject Division according to a formula developed from certain criteria. These include number of courses in the subject area, number of students/course and average cost of books in that subject area. Lecturers and Researchers in the Faculty recommend books, serial titles and non-print material for purchase. The Library provides them with information on new materials by sending out publishers' catalogues and other promotional materials from publishers and booksellers. From these they then make their recommendations. They are also welcome to recommend material from their own sources. The Divisional Librarian also makes selections for purchase but this is mainly for general reading in the subject area.

Periodically we do stocktaking of the Collection and the materials are reviewed in light of conditions existing at that time. We may decide to remove material from the open shelves if it is obsolete or in very bad condition and is beyond repair. Sometimes courses change or are dropped and the relevant items may no longer be needed, these are removed to allow space for more relevant items. Before anything is removed or discarded relevant Faculty members are consulted so that nothing that is important is lost. In this way we try to maintain a dynamic collection of materials that meets the changing needs of our users.

Non-print material

In addition to all the printed materials we also acquire information in many non-print formats. Such as traditional formats (microfiche and microfilm), some examples of which are back volumes of Chemical Abstracts and many newspapers, local and foreign. Among this category we also have computer diskettes, videotapes, CD-ROM and online resources available via the World Wide Web (WWW).

Finding Information in the Library

The library is organised along subject divisional lines corresponding roughly to the Faculty served. The Agriculture and Life Sciences Division occupies part of the second floor and houses the bulk of information on Agriculture but because of the broad based nature of the subject materials are distributed among other Divisions. Information on Agricultural Engineering and some aspects of Soils Science can be found in the Engineering and Physical Division, and Rural Sociology and Agricultural Economics in the Social Sciences Division.

The key to finding information in the Library is the catalogue. This started as a card catalogue arranged by Author/Title, Subject Index and Classified Index, a great portion of which still exists on the ground floor of the Library building. Since 1989 the catalogue has been automated and at present it is available online in the Library and via the WWW on our web site at http://www.mainlib.uwi.tt. Most of the material in the Library is captured by the OPAC (Online Public Access Catalogue) and can be retrieved using the user friendly search screens. There are a number of entry points to the OPAC, you can search by the Author, Title or Call Number of an item once you have this information. If you have a topic in mind and would like to see what exists on it in the Library then a Keyword or Subject Search will be most helpful. You can combine keywords using Boolean operators such as 'AND', 'OR' or 'NOT' to expand or narrow your search. Material in every format is contained in the catalogue and there is a field that indicates the format of the item you want as well as its location in the Library and its status.

The OPAC is very useful for finding monographs or books, serial titles and audio-visual materials but not for finding journal articles, conference papers and reviews. For this type of information you need to use Abstracts and Indexes in the particular subject areas. Traditionally the Library subscribed to the leading abstracting and indexing services in Agriculture, such as CAB Abstracts, Bibliography of Agriculture and Agrindex and also Biological Abstracts. As anyone who has ever used these tools in print would know, while they are very effective they also are time consuming. We now subscribe to the same tools in electronic form, on CD-ROM or online via the Internet which allows more flexibility in searching and is much faster.

List of databases for Agricultural Information

CARINDEX: includes the literature of agriculture and the related sciences. It collects bibliographic references to either conventional (journal articles, books) or non-conventional materials (sometimes called "grey literature" e.g. theses, reports, etc.), not available through ordinary commercial channels. Our records are sent to the FAO headquarters in Rome where they are incorporated into the AGRIS database. This means that our researchers and students get international exposure for their work.

TROPAG & RURAL: produced by the Information, Library and Documentation department of the Royal Tropical Institute, The Netherlands, are two databases containing full bibliographic references with abstracts to the worldwide literature on agriculture and economic and social development. RURAL: focuses on a wide range of topics including development strategies, international co-operation, health development, agriculture, income generation, education, women and development and environmental issues. TROPAG: covers literature on the cultivation of food crops and industrial crops, animal husbandry, forage and pastures, Aquaculture, forestry, agroforestry, postharvest operations, farming systems and environmental management in tropical and subtropical regions.

The AGRICOLA (Agricultural Online Access) database contains bibliographic records of materials acquired by the National Agricultural Library (NAL) and co-operating institutions in the agricultural and related sciences and provides worldwide coverage of the agricultural literature. In addition, AGRICOLA contains subfiles of related bibliographic citations that have been prepared by sources other than the National Agricultural Library, for example, the Food and Nutrition Information Centre (FNIC) and the American Agricultural Economics Documentation Centre (AAEDC). These and other information centres and co-operators contribute subfiles to AGRICOLA covering special subjects.

CAB ABSTRACTS: is a database that covers the subject of agriculture in the broadest sense. It includes: agronomy, biotechnology, crop protection, dairy science, economics, environmental degradation and remediation, forestry, genetics, herbicides, irrigation, leisure, recreation and tourism, microbiology, nutrition, parasitology, rural development, veterinary medicine, and much more. Journals, monographs, conferences, books, annual reports, and other sources from more than 100 countries are scanned regularly for inclusion in the CAB ABSTRACTS database, to produce approximately 150,000 new records per year and nearly all the records have informative English abstracts.

AGRIS: is the international information system for the agricultural sciences and technology, created by the Food and Agriculture Organisation of the United Nations (FAO) in 1974, to facilitate information exchange and to identify world literature dealing with all aspects of agriculture. It is a co-operative system in which participating countries input references to the literature produced within their boundaries and, in return, draw on the information provided by the other participants. 199 national, international and intergovernmental centres participate and submit about 14.000 items per month. The system collects bibliographic references (to date, about 3 million) to either conventional (journal articles, books) or non-conventional materials (sometimes called "grey literature" e.g. theses, reports, etc.), not available through ordinary commercial channels. One of the main reasons for AGRIS' existence is to encourage the exchange of information among developing countries, whose literature would not be covered by other international systems.

OCLC FirstSearch: is a comprehensive and complete reference service with a rich collection of databases and with links to the World Wide Web, over 5.9 million online full text articles, full-image articles from over 3,300 electronic journals, library holdings, and interlibrary loan. It supports research in a wide range of subject areas with well-known bibliographic and full-text databases in addition to ready-reference tools such as directories, almanacs and encyclopaedias.

EBSCO Host: is a multi-database system with several being useful for agricultural information, e.g. CSA Life Sciences Collection and Academic Search Elite. CSA Life Sciences Collection provides comprehensive access to life-sciences oriented disciplines from Cambridge Scientific Abstracts. This database ranges from 1982 to the present with areas such as: Agricultural & Environmental Biotechnology, Algology, Mycology & Protozoology, Ecology, Entomology, Genetics (Human & Animal), Immunology, Industrial & Applied Microbiology, Medical & Pharmaceutical Biotechnology, Neurosciences, Nucleic Acids, Oncogenes & Growth Factors, Risk Assessment, Toxicology, and Virology & AIDS. This database is updated monthly on EBSCOhost. Academic Search Elite provides full text for over 1,530 academic, social sciences, humanities, general science, education and multi-cultural journals. In addition to the full text, this database offers indexing and abstracts for nearly 2,720 journals. Over 1,700 journals are peer reviewed. Full text backfiles go as far back as January of 1990, while indexing and abstract backfiles go as far back as January of 1984. This database is updated daily on EBSCOhost.

Searching these databases is quick and easy. Most allow Basic and Advanced searches, depending on the searcher's skill, and lots of online help to facilitate effective searching. With subscription to these various databases the Library is able to offer our users almost complete coverage of the information available in all fields of Agriculture.

Services to Users

Loans: All members of the University community automatically become members of the Library but must register with us to have full access to all our services. All students and staff are allowed to borrow materials from the library but the loan privileges vary according to status. Academic staff and Postgraduate students are allowed to borrow serials but undergraduate students are not. Loan periods also vary for different categories of materials, e.g. Materials from the reserve collection have shorter loan periods than those from the open collection.

Reference: This is one of the most important services we provide for our users. The Library staff is trained in answering any reference enquiry a user might have. Users can access our reference service by any means, in person, by telephone, e-mail, fax and by post. We can also respond via any of these means as well. Once an enquiry is received it is channelled to the member of staff best able to deal with it and the user obtains feedback on the progress of the enquiry.

The Information Centre (TIC): TIC was set up in 2000 to give users access to electronic information databases and services. It is strategically located on Floor 1 at the northern end, opposite the library's entrance. Eight computers are currently available at this location and it is open for most of the time that the Library is open. Services available from TIC include research assistance, one-on-one tutorials, reference queries via e-mail, printing, downloading and e-mailing search results.

User Training

In our mission to produce an Information Literate community the Library provides training for all of its users. Users are given Library Instruction where they are trained to use the catalogues and all the other services provided by the library; Bibliographic Instruction where they are taught how to write up their references and bibliographies in accordance with existing standards in that area. In addition we try to teach our users critical thinking skills where we provide guidelines for evaluating information sources including web sites and also in deciding what information is most relevant for their present needs. To assist in making their information seeking more efficient and effective we teach how to develop search strategies and how to choose the information retrieval tool/s most relevant to their topics. We also provide training in the use of all the databases and other information resources available to our users.

In addition to these three we provide photocopying services at the library and Inter Library Loans and Document Delivery Services mainly from the British Library Lending Division.

Conclusion

In this paper I have attempted to highlight the products and services which we at the University Libraries provide for the benefit of our users, and to help us achieve our mission. There is a lot more that can be said on every topic that I have touched on but I hope that I have been able to give you an indication of the support that we can provide for whatever aspect of Agriculture you are engaged in. I hope you will contact us soon so that you can take advantage of all our services.

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INITIATING SELF-DISCOVERY EXTENSION IN TRINIDAD

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ABSTRACT: An alternative approach to extension education for Pineapple farmers in Tableland, Trinidad was initiated based on constructivist learning principles. Experiential learning and interactive techniques, which facilitated self-discovery, were used to address identified problems in fertilizer use and insufficient soil conservation practices. The objectives of this exercise were to pilot a participatory method and to encourage farmers to change the agronomic practices that they discovered reduced their optimum returns. Traditional technology transfer approaches were not considered appropriate as these farmers were operating profitable enterprises, albeit in an unsustainable manner. Group administered pre-evaluations, simulation exercises, walk-about on plots and structured discussions were used to guide farmers to identify problems in their production practices and to suggest workable solutions to which they could commit themselves to implement. Farmer involvement and feedback throughout the sessions were high and initial evaluation indicated improved contextual knowledge. This initiative also presented an opportunity to introduce participatory techniques to extension field staff, who would be the main facilitators of this approach and to challenge them to use creativity in designing participatory exercises, which simulate the concepts to be conveyed. The experience has wider application in other farm enterprises.

INTRODUCTION

Over the years, several approaches have been tried regionally to meet the education needs of farmers. The precursor to extension was the establishment of Botanical Gardens in the late 1800's by the Europeans for purposes of demonstration of new methods and techniques as well as experimentation. It was in the 1900's however that extension development in the Caribbean really began to take shape and programs were developed to meet various national agricultural goals. Most are the approaches used were top-down. They were based on the linear model of communication and its prescriptive approach to solving farmers' problems. Birmingham (1999) summarized several of the approaches used in developing countries. Approaches tried in Trinidad include: Commodity-based extension, provided by government or commodity producers or both depending on the nature of the product; Ministry-based general extension, in which extensionists were not used primarily for education purposes, but rather to serve a number of other functions of the Ministry, for example data collection, farmer registration, subsidies, incentives, and land regularization. On most occasions these functions were given priority over farmer education.

The Training and Visit (T&V) system was also tried in early 1990 in an effort to reach more farmers on a timely basis. However, successes were short lived as this system was constrained by the unavailability of resources in a timely manner and on a sustained basis to do demonstrations. Also, the working arrangements of pubic sector employees, which provided for "casual or occasional leave", which was incompatible with the fairly inflexible routine of the Training and Visit system. Farmer feedback was not part of this approach. The Farming System Research and Extension (FSRE) approach in the early 1990's tried to focus on farmer's needs and problems, and used an integrated approach to development. Researchers, extensionists, and socio-economists, met with farmers as a team to analyze and plan for them. While this approach was laudable for its interdisciplinary approach and first attempts to involve the clientele in some meaningful way, the resulting prescriptions were based on the top-down Transfer of Technology (TOT) model and farmers' active participation beyond providing information requested was minimal.

CONCERN

In spite of these worthy approaches tried over the years, the impact of extension is still being debated. Campbell (2001) summarized some of the difficulties public sector extension faces in the region. The most important of these is that farmers complain that extension is not reaching them. In the instances, and there are many, where extension does reach the community, farmers often say that the technology promoted is not fully sustainable on their farms (Van de Fliert and Braun, Circa 2000). Further, extension officers note that farmers often complain that extension has nothing new to offer them yet they always want extension to come and "teach them something new" (Personal Communication, R. Ramdass, MFPMR, 2001). It would appear that farmers value information from external sources much more than indigenous community-based knowledge, and have become dependent on this information overtime.

THEORETICAL PERSPECTIVES

Our beliefs about how adults learn guide our approach to extension education for our clientele. Most of the approaches traditionally used are constructed on the theory of behaviorism. The goal of such approaches is to communicate or transfer knowledge and skills to a learner. Learning is said to have occurred when a correct response or a desired behavior is demonstrated.

This type of approach based on programmed instruction does not require any mental processing by learners. They are passive recipients of information on technologies developed elsewhere, and are simply required to produce the response desired by the information provider. This approach provides a lot of new information, but does not teach learners how to learn, nor does it provide any motivation for inquiry, discovery and for learning new things on their own. Learners become information dependent and remain so. Their ability to process, analyze and synthesize information is restricted. They would always want to see the information provider and want to be informed about "something new to try out" on their farms.

It has long been recognized however, that relating instructional content to the specific context of learners' lives and interests increases motivation to learn (Dirkx and Prenger, 1997, p.2). This type of learning, frequently called contextual learning recognizes that learning is a complex process that involves much more than the behaviorist approaches that emphasize drill and practice, recall of facts, and automatic performance of specified procedures (Imel, 2000). This type of approach, based on the theory of constructivism holds that individuals learn by constructing meaning through interacting and interpreting their environments. Constructivist approaches are based on inquiry, discovery and situated learning. Mason (2000) stated that knowledge is embedded in the context in which it is used, and learners create novel and situation-specific understandings by "assembling" knowledge from diverse sources appropriate to the problem at hand. It emphasizes that learning is an active process of constructing rather than acquiring knowledge.

The characteristics of contextual learning are listed (Clifford and Wilson, 2000) as: emphasizing problem solving; assisting learners in learning how to self regulate their learning, anchoring teaching in the diverse life context of the learners, and encouraging students to learn from each others. Strategies based on this type of learning focus on the learner in the learning situation and utilize discussions among farmers, researchers, extensionists to determine what is appropriate for a given situation. Such strategies center on meaningful participation of all the stakeholders.

There are two fundamental problems however, that must be faced squarely if organizations are to implement Farmer Participatory Approaches (FPA) and strategies. These are (Engel, 1990):

i) The dominant bias in favour or research-based knowledge, frustrating the input of other types of knowledge which are necessary to develop sustainable solutions to farmers' real problems; and

ii) The internal difficulties institutions have to face as they attempt to pursue alternative strategies and develop solutions with farmers.

Administrative re-organisation, redefinition of roles and responsibilities, sharing of work domains or "turfs" and retraining of staff would be major challenges.

RESULTS OF PARTICIPATORY EXPERIENCES IN TRINIDAD

Two exercises that were intended to form part of a wider program of Farmer Participatory Approaches (FPA) to Ecological Crop Management (ECM) were conducted in July 2000 among Pineapple farmers in the Tableland region of South Trinidad.

First Session:

Problem: Farmers were cropping Pineapple on the same holding and applying only N in the form of Urea. Their crops were showing symptoms of nutrient deficiencies.

Aim: To show that the plant uses Nitrogen (N), Phosphorous (P) and Potassium (K). By adding only one of these, N, as Urea, the plant gets proportionately less of the other nutrients.

Exercise: A modified version of the Nuts Game, used to teach the concept of sustainability (Van veldhuizen et al., 1997), formed the basis for the discovery experience. Farmers were given containers with equal amounts of 3 evenly sized, but different coloured peas, which were thoroughly mixed. They removed fixed amounts and counted the number of each type of pea. An equal amount of one type of pea was added, thoroughly mixed and the above procedure was repeated twice. Farmers recorded their observations. Farmers observed that overtime two sets of beans were being depleted while one was steadily increasing. They were then told that the peas represented the 3 different major nutrients, and the one that was being replaced, represented nitrogen, applied in the form of urea. They were asked to discuss their observations and its relationship to their fertilising practices. They were able to deduce, some immediately and others after a short while, that since the plant was removing all these nutrients, and they were only replacing one, there would be a subsequent deficiency in the other two nutrients over time.

Recall: A year after the participatory activity, a sample of those who attended was interviewed. All farmers (n=8) recalled the demonstration and what was learnt about fertiliser deficiency in the practices used by pineapple farmers. This compared with 50 percent total recall, and 50 percent partial recall on the meaning and function of the N, P, and K in fertilisers, which was taught via traditional methods in other sessions.

Second Session:

Problem: Farmers were cropping Pineapple on steep slopes with minimal soil conservation measures on soils prone to erosion. Farmers were unaware of the consequences of this practice, and techniques to prevent erosion.

Activity 1: Farm Walkabout.
Aim: Farmers to observe the effects of erosion and discuss potential solutions to prevent soil loss.
Exercise: The extension officer led a structured walkabout to pre-selected areas of the field, which demonstrated a range of effects of soil erosion. Plants were of varying maturity. Farmers observed channelling, ground cover, silting of drains, exposure of roots and subsoil. Discussions centred on what the farmer did on observing the problem as well as possible indigenous remedies. Subsequently, in a newly established field, farmers discussed potential problems and a range of possible solutions appropriate to their conditions.

Activity 2: Simulation of erosion

Aim: To show the effects of water erosion on topsoil on steep slopes.

Exercise: Farmers were taken to a vertical drain at the side of a cultivated pineapple bed on a hillside. They were asked to pour a measured amount of water along the drain and to collect the run-off in a container at the end of the drain and time the activity. They had to observe and discuss what occurred. This was repeated along a drain on the same slope, which had some leaves in it from a nearby tree and natural grass barriers. They then compared and discussed their observations and the reasons for the differences. They observed that there was greater run-off in the bare drain compared with the leaf-covered drain. The water also ran down the slope faster and was more discoloured. They discussed measures that they could take to reduce the rate of run-off and topsoil erosion on their farms.

Recall: On evaluation all the persons recalled the demonstration and its purpose. All knew about prevention methods to be used.

Overall comments on the participatory Methods

All the respondents thought that they were different to the usual extension methods and they liked their experiences. They stated that farmers were allowed to take part in and contribute to the activities. All preferred field to classroom learning and wanted to attend further sessions although not necessarily in relation to pineapple production.

DISCUSSION

Improved contextual knowledge is increasingly being regarded (Erbaugh et al., 2001) as a key precursor to the adaptation and application of new technologies. The Ministry of Agriculture in Trinidad, as in several other countries in the region, is still locked into the technology transfer mode. The assumption is that the provision of "sacred" information from the generators of knowledge to those who have little knowledge would solve farmers' problems -the "full glass to empty glass" relationship. Training courses, seminars, demonstrations constitute the dominant techniques of program delivery.

Farmers in Tableland reported liking the Participatory experiences, especially, that they were allowed to take part in and contribute to the activities and share their thoughts. To facilitate experiential learning, a fundamental shift away from lecturing and talking to farmers, to an approach where we listen and discuss more is needed. Rather than prescribe scientific information to groups, we need to generate knowledge from groups in contextual situations and combine such knowledge with our own knowledge-set and then develop meaningful learning experiences that involve farmers in the process of inquiry, self-discovery and elaboration. Cognitive psychology tell us that learners bring an existing cognitive structure to the learning situation, and they must make sense out of the new learning relative to the old if true learning is to take place. It is in this regard that the knowledge set of researchers, farmers and extensionists must come together and generate a complete new knowledge-set for dissemination.

The notion that farmers have knowledge based on their long experience of farming in a particular situation is one that will have to be internalised by researchers and extensionists. This will require retraining of our researchers and extensionists. The institution itself will have to adapt and become more flexible to allow for greater interaction among researchers, extensionists and farmers. A seamless interface between research and extension is what is now needed. This is quite different from the top down approach with its clear-cut division of responsibilities. Such adaptations must start at policy level. Central to this change must be that policy makers themselves become sensitised to these modern approaches that actively promote farmers' meaningful participation in specifying their immediate problems, the technology development process, and in tapping their knowledge. Extension providers will require training in these approaches and methods. The Farmer Field School (FFS) approach used to teach Integrated Pest Management (IPM) is a tested method along these lines.

The challenge is for extension providers to engage clients in creative activities that bring to the fore their natural enquiring minds and learning abilities. This would serve to empower farmers, providing them with an enhanced capacity to solve their problems and determine appropriate actions for their farm situations and even the confidence to demand strategic information from providers when necessary.

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APPROACHES TOWARDS AGRICULTURAL AND ENVIRONMENTAL EDUCATION, TRAINING AND EMPOWERMENT FOR THE CARIBBEAN AND DEVELOPING TROPICAL COUNTRIES: 2001 TO 2050

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ABSTRACT: This paper examines the historical relationship between higher education in Agriculture and the economy in the English Speaking Caribbean [ESC] with special emphasis on the philosophy, content, structure and delivery of the degree offering. This is done within the context of the significant changes occurring in the agricultural sector, and in the economies of the region, the fragility of our ecosystems, as well as of globalization. The paper evaluates the current degree programmes and presents an emerging paradigm that focuses on strategies for enhancing Access to the University Education in Agriculture and the Environment in the Caribbean and the wider tropics.

BACKGROUND

The Historical Context between Higher Education in Agriculture and the Economy in the English Speaking Caribbean

The critical demand for food in the tropical world (wherein lies most of the less developed countries [LDCs]) is increasing and is likely to continue. To a large extent this is intrinsically associated with rapidly growing populations in a fundamentally traditional agrarian environment. In the Caribbean small-holder farming is widespread and so is the use of modern agrochemical inputs. In the context of food deficit three issues need to be observed:

(1) the availability of agricultural technologies is not a sufficient condition for increasing food supplies in the tropics,
(2) land degradation is severe and extensive, leading to reduced productivity under both traditional and modern agricultural technologies and
(3) an absence of concrete development planning and a lack of instruments for its implementation to initiate the socio-economic transformation of the rural people.

Declining access to food will severely curtail development and compromise the ability of countries in the tropics to lay a solid foundation for socio-economic progress. The traditional global food baskets are unlikely to achieve production growth to meet the increasing worldwide affordable demand for food. The demand for food globally is not only driven by increasing numbers of inhabitants but also as a result of increasing purchasing power of the growing middle class particularly in some regions of the developing countries. Thus effective demand for food is increasing which would lead to increases in food prices to the LDCs with all its consequences and ramifications.

Higher education [HE] will have to play critical strategic roles for future developments of the LDCs. The two issues in this regard are:

1. relevant training for empowerment and
2. relevant research for development.

Education can be conceived as all activities that aim to provide and obtain information, knowledge, skills, the ability to use them and the ability to generate or create them. Thus there is a need to create and maintain linkages between different levels of education primary, secondary, tertiary institutions for lifelong learning. HE has a role to play at all levels.

The English-speaking Caribbean evolved as an appendage to European Agrarian Economies over the last four hundred years. These economies were developed to produce primary tropical agricultural products to be given added value elsewhere, while on the other hand the Caribbean Economies became net importers of everything including food. Today the situation has changed slightly, but not in favor of the region since dependence on imported food has increased while the export of our primary products has declined significantly. Thus local economies which were primarily agrarian responded to colonial centres' needs and not to the needs of the Caribbean Peoples to improve their well-being.

Higher Education in Agriculture also reflected this philosophy. This is evidenced by the following statement made by Sir Francis Watts [Principal Emeritus], H. Martin Leake [Principal] and Major H. C. Corlette [Architect] of the Imperial College of Tropical Agriculture in Tropical Agriculture [ICTA], in Tropical Agriculture Volume 2, 1925:

"The object of establishing the Imperial College of Tropical Agriculture was to enable instruction of a nature somewhat similar to that which is now so widely given in Agricultural Colleges throughout the world in connection with the crops of temperate climates to be given to young men about to engage in agricultural work in the tropics. While there are abundant facilities for the former there are few relating to the latter, or tropical aspect of the case."

With the formation of the ICTA in 1921 higher education in Agriculture and the Environment was only accidentally afforded people of the English Speaking Caribbean [ESC] as ICTA from 1921 to 1960 was primarily engaged in the training of Europeans or Caribbean persons who were being tutored to service European interests and investments. But the ICTA was a colonial institution funded by both Caribbean and British investments.

In 1960 one saw the development of the Faculty of Agriculture, within the University of the West Indies [UWI] with a substantial HE and training mandate for developing the potential of the people of the English speaking Caribbean. The syllabus and training methodologies remained externally focused. The main objectives of the training were to produce the following cadres of professionals:

- extension officers
- agricultural researchers
- agricultural administrators and
- agricultural managers.

All of the above entailed "Training for Certification" and for "Employment". It is important to note that unlike the former ICTA era, within the UWI system Agriculture was no longer an independent institution but became a unit within a larger system, competing for everything from budget to space accompanied by the subsequent fragmentation of disciplines. In addition the academic and instructional directions became constrained by the new Social Sciences and Humanities outlook. Thereby restricting the development of the new pedagogical needs of HE in Agriculture and the Environment. Around this time as well one saw the further development of tertiary level Agricultural Colleges throughout the English speaking Caribbean. In fact many of these colleges preceded the Faculty of Agriculture UWI, but provided feeder students into ICTA. But the philosophy and objectives behind this training were still the same.

In addition, post 1960s, within the newly emerging independent nations more emphasis was placed on the Arts, Humanities and Social Sciences both at the Secondary and Tertiary levels, and less on the Sciences, especially on the applied sciences of Agriculture and the Environment. There were also fewer job opportunities [i.e. to seek "Employment or to be an Employee"] in these areas, a situation which remains today. This is no different to the employment trends that have taken place in the Developed Countries, but with one exception, Higher Education in Agriculture and the Environment was never neglected or compromised as has been done in the Caribbean in recent times.

The Changing Attitudes and Directions for Higher Education in Agriculture in the English Speaking Caribbean

The future direction of HE in the Caribbean countries should be determined by the following:

1. Caribbean countries are essentially agrarian, therefore development in such countries fundamentally apply to the development of the rural communities;
2. Globalization is knowledge driven;
3. Technology and its use is also knowledge driven;
4. Food security issues linked to environmental, cultural and geo-political;
5. Empowerment, training not specifically for certification, but to enable people to have increase capacity to create, acquire and use knowledge to achieve their goals and
6. Must promote sustainable resource use and production systems.

Our attitudes towards higher education should reflect the change in directions as dictated by the above.

Table 1. Event Line at the University of the West Indies

Year	Action taken
1921	ICTA Diplo. PG
1960	BSc. Programme Introduced
1974	Pre-agriculture Indroduced
1983	Agronomy Indroduced
1992	BSc. Programmes in LS, CS, and Agribusiness Introduced
1994	Human Ecology Introduced
1996	Merger

Table 1 presents an Events Line for HE in Agriculture at the UWI that has been the premiere Training Institution for the English Speaking Caribbean [the Caribbean Foods Crops Society started here]. This progression only demonstrated

- Programme diversification,
- changes in packaging from yearlong courses [1921 to 1974] to courses offered by the terms [from 1974] to course offered by semester [from early 1990s],
- more changes in packaging from 2001 a new change is being planned to be instituted, i.e. programmes of minors and majors, to achieve similarity in form with universities in the United States.

The latter change sounds similar to that suggested by Watts et al in 1925: "instruction of a nature somewhat similar to that which is now so widely given in Agricultural Colleges throughout the world".

Particularly the last point reflects a change in structure essentially for conformity in form with other institutions. It is not internally driven by a philosophy or vision of Agricultural and Environmental education as a strategy for regional development and transformation. Although in the past there was an effort to make the curriculum regionally relevant. The more things change the more they remain the same. All these changes over the years have had the same Educational and Philosophical Objectives as earlier stated, and in the main have just added or reduced courses or simply repackaged them.

Access, content, structure and the delivery of the degree offerings: Historically access to programmes has been via High Schools, Secondary Schools and Technical colleges. But the main constraint to access has been the need for the science based courses which are not offered at all the secondary schools. The programmes have been offered for three years (six semester packaging), with accommodation for attendance in either the full or part time mode. Some programmes are offered in distance mode partially or completely. Courses have been mostly classroom based with limited practical exposure. With an increase in secondary school enrollment in Trinidad and Tobago, the near future will also see an increase in demand for places in HE. HE institutions should therefore need to prepare to accommodate this expected increase in demand for access.

The Present Situation in Caribbean Economy and the Environment:

The Economies of the English Speaking Caribbean are driven by the following:

1. Agriculture, which is plagued with problems and is on the decline, but people must eat every day, and Agriculture is linked to good environmental management [and the Caribbean economies are net importers of food];
2. Tourism, which is a very fickle industry and is in the main dependent on a well managed environment [and the food and beverage which services the tourist sector are import based and its meaningful contribution to the economy can be improved through greater utilization cuisines based on locally produced foods]; and
3. Mineral Extraction Industries, [Oil and Natural Gas, Bauxite, Limestone], these are all non-renewable resources, and can lead to environmental degradation if not properly managed.

The situation ahead has become even more complicated due to:

1. Imminent Globalization;
2. Global Warming with potentially devastating impacts on agriculture in many parts of the Tropics;
3. Increases in the Volume and Value of Importation of food leading to decreased food security;
4. Decreased employment in Agriculture and increasing unemployment within our economies;
5. New Communication Technologies making information or misinformation more accessible to all;

Higher Education in Food, Agriculture, and Natural Resource Management- an Imperative for the LDCs.

In this regard the following points should be noted:

1. There is a positive relationship between access to higher education, economic growth and the reduction in poverty.
2. A community of well educated people is better able to adopt and make use of new and emerging technologies and better able to adapt to changing market environments, and taking advantage of the opportunities created.
3. A well educated society is better able to govern itself and to secure and keep abreast of information that will facilitate governance.

Critical Changes needed in Higher Education in Agriculture and the Environment for the Caribbean

Critical Changes are needed in Higher Education in Agriculture and the Environment for the Caribbean and these must be in the context of the following considerations listed.

1. Institutional arrangements are needed that promote growth and development of the disciplines of Agriculture, Food and the Environment within the UWI system.
2. The academic contents of the programmes should conform to the peculiar requirements of the sub-region. There is a clear need to form partnerships for life-long interaction. It is high time that students are accepted as equal partners and stakeholders in this process and see themselves as such.
3. Agriculture should establish strategic alliances and linkages with pertinent regional and extra regional institutions and organizations.
4. The existing funding of the UWI is enrollment dependent and as a result budgetary allocations are subject to fluctuations.

HE: Training and Empowerment Curriculum [HETEC]

The new educational paradigm is set within the context of an evolving Socio-Economic Matrix. This new and evolving framework has the following features:

1] Universal ACCESS to information;
2] Increasing demand for ACCESS to higher education per se, within an environment of rigid matriculation requirements;
3] Increasing demand for knowledge based services;
4] Changes in underlying attitudes for acquiring HE and these are:
   - a shift away from Education only for Certification for Employment to Education for Empowerment
5] Recognition of the need for continuous upgrade of skills;
   - training on a need to know basis for skills upgrade and acquisition

Suppose an HE institution is to take an entrepreneurial approach to agribusiness management training through the provision of new courses and curriculum to achieve it or, to offer new programmes for empowerment and training within this proactive situation. But the HE institution continues to use old teaching and delivery models. Then questions must now be raised about whether objectives of this new approach will be achieved.

Some of these questions are:

- Will these new courses, which have a corporate orientation lend themselves to teaching and information dissemination in the traditional didactic format?
- How does one successfully coordinate a field trip into the mind of an agro entrepreneur?

It is believed that the Case Study and Problem Based methods hold the answer to these questions. In fact schools of Business and Law have been using these methods for decades. The Faculty of Medical Sciences [UWI] and other Medical Schools have gone to the Problem Based Teaching modes over the last five years. Schools of Agriculture, the Environment and other Applied Sciences have not gone this rout as yet and are being left behind.

The Philosophy behind the Teaching and Delivery Strategies for the Alternative Approaches

1. Training should focus on the empowerment of the learner.
2. There should be linkages within the training or education for Agriculture and the Environment from the Primary to the Secondary to the Tertiary level.
3. Servicing the needs of the stakeholders must be of primary concern.
4. Training must not be in the abstract and must involve appropriate training methods and tools and should be locally entrenched.

Elements of New Degrees/ Higher Education Programmes in Higher Education for Agriculture and the Environment

1. Entry Routes
   Must accommodate the needs of all potential learners.
2. The Philosophy behind the Education Initiative
   The new philosophy must be derived from within the societies. [See Box]
3. The Finished Product Desired

[Begin with the End in Mind: Creating Problem Identification and Solving abilities]

$\Rightarrow$ Technical Competence
$\Rightarrow$ Technological Competence
$\Rightarrow$ Empowerment
$\Rightarrow$ Experience
$\Rightarrow$ The Skills

⇒ The Type of Human
⇒ Entrepeneurs
⇒ Creating Problem Identification and Solving abilities

4. The Pedagogical Needs and Approaches
   ⇒ Pedagogical Needs
      1. Old
      2. Added
      3. Different
   ⇒ Programme Delivery Modes
      1. Modes
      2. Access
5. Programme Participants
   ❖ The University/ Programme Management Unit
   ❖ The Stakeholders or Workplace sites
      ➢ Commercial Farms
      ➢ University and HE farms and facilities
      ➢ Commercial Processing Facilities
      ➢ Other Institutional Facilities
      ➢ The Food and Beverage Service Sector
      ➢ Other
   ❖ The Leaners
6. Programme Content
   This will now have to worked out after feedback from this paper is obtained an with the participation of all stakeholders.
7. Programme Delivery
   ⇒ Delivery Modes
   ⇒ Infrastructure Requirements
8. Learner Evaluation
   ⇒ Continuous Assessment
   ⇒ Final Evaluation
9. Programme Evaluation

A Radically New Approach towards the Delivery of Agricultural and Environmental Education
An outline of the Programme Framework

Pre-entry Profiling
and Characterizing:

1. Students given pre-entry questionnaires
2. The programme for the student to follow will be based on their background, needs, and goals.

Entry: Phase 1
Semester 1/
[3 Months Face to Face/
Six to 9 Months Distance]

Phase 2
Workplace Based Programme
[Two/ Three Calendar Years]
[Workplace Exposure plus

1. This period coluld be conducted either in the face to face or distance modes.
2. This would involve the student being exposed to
   - The method of programme execution
   - The expectations of the student
   - An approach at developing problem solving skills
   - The information kit
   - Knowledge based skills
3. Flexibility for the student to change routes

Distance Education Delivery

This could be disciplinary based [e.g Tropical Agronomy and Horticulture, Marketing Processing and Product Development, Tropical Animal Science and Production, Tropical Environmental Management] or could be rotational. This would depend on the areas of concentration required by the student and the type of disciplinary degree being pursued.

This period could involve the following:
1] courses delivered by distance to the students;
2] the students working on problems or projects within the workplace

Phase 3
Out of Workplace Based Programme
[One Calendar Year: Face to Face/
Two Calendar Years : Distance]

The student or learner could now leave the workplace and devote full time to study to finish the formal part of the education within the prescribed framework.
This could be done:
Via distance or through the formal classroom setting.

CONSTRAINTS

The constraints faced in attempting to develop a programme with the above features are as follows:
1] the university's slow response to the rapidly changing socio-economic matrix and some of the university's management staffs' attitude towards HE in Agriculture, in the recent past;
2] people within the ESC are being exposed to temperate based programmes which are are attractive but not necessarily relevant to the Caribbean and the wider Tropical world and the LDCs;
3] locally created programmes are not "sexy" and attractive to some outward looking university academic administrators.

CLOSING REMARKS

It is now clear that in order to initiate a proactive and empowering solution to HE in Agriculture and the Environment the following have to be addressed:

1. The institutional arrangements for Agriculture in the UWI must be addressed as a matter of urgency.
2. Prompt initiation of dialogue with all the stakeholders.
3. Immediate expanded use of Case Studies and the Problem Based Teaching Methods.
4. The expanded exposure of student exposure to the industry.
5. Planning of the New Programmes Development in consultation with the wider clientele and stakeholders.

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PLANT PROTECTION COOPERATION WITHIN THE CARIBBEAN PHYTOSANITARY CARTOGRAPHY, DATA BANK CREATION

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ABSTRACT: The similar agricultural development, of the Caribbean productions systems, makes it a solidar region taking in consideration the aggressions suffered by our crops. The geographical context, political characteristics and the linguistics differences, permitted the settlement of different insular plant protection regulations. The increase of exchanges and transportations within our societies, the lack of efficient control of tourist tours and information on phytosanitary problems of neiboring countries, carry every year new pests and parasites in the Caribbean. The procedures of their control, usually take in consideration the territory invaded, but does not stop new introductions and the spreading abroad. The purpose of this project is to favour the settlement of common information concerning the main harmful organisms with economical status, the creation of a warning network, able to prevent the risks and to follow the evolution of pests newly introduced. The exchanges of information on control measures and regulations of use of pesticides, in order to assess their efficiency and impact on our agro systems. The final objectives being the promotion of and the extension of technologies sorely tested with the dialogue and input of all involve in the process of crop production, the farmers being inserted in the centre of the reflex ion.

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CONTROLLING PASTURE MOLE CRICKETS WITH NEMATODES

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ABSTRACT: Several bahiagrass (*Paspalum notatum*) pastures in south Florida have been destroyed by non indigenous mole crickets (Orthopthera: Gryllotalpedae: *Scapteriscus* spp.). 'Pitfall' traps were installed on damaged pastures in July 1997 and weekly numbers of trapped mole crickets were recorded through December 2000 and used to develop mole cricket population histories. The mole cricket nematode (*Steinernema scapterisci)* was applied in strips to cover 1/8, 1/4, and ½ the area of different pastures in May and September 2000, and in March and April 2001 to determine the best procedures and times for using the nematode. An exponential curve (Gaussian, 3 Parameter) best described the weekly incidence of immature (nymphs and juveniles) mole crickets in bahiagrass pasture. Mole cricket eggs usually begin to hatch in May and the number of trapped nymphs reached a peak (average = 23 nymphs/week) in July and then dropped sharply. Preliminary data showed a reduction in peak incidence of immature mole crickets after applying the nematodes in experimental plots, regardless of strip treatment. Percentage of trapped mole crickets that were infected with nematodes ranged from 86% for the ½ area treatment to 41% for the control on 4 April 2001 sample date. These levels of infection clearly indicate that the nematode has become established across entire pasture and is reproducing and killing mole crickets.

INTRODUCTION

Non-indigenous mole crickets *Scapteriscus* spp. (Scudder) cause serious damage to pasture, lawn and crops in Florida. It is estimated from a survey by the South Florida Beef and Extension Program (1998) that nearly $45 million revenue is lost annually to cattle producers in south central Florida as result of reduction in hay and forage production by mole crickets damage and an extra $10 million/year spent on pasture renovation.

All three pest mole crickets found in Florida: 'Tawny', *S. vicinus* (Scudder), 'Southern', *S. borellii* (Giglio-Tos) and 'Short-winged', *S. abbreviatus* (Scudder); were inadvertently introduced into either ports of Georgia, South Carolina or Alabama from South America in ship's ballasts in the early 1900s (Walker, 1981). From these points of introduction, the Tawny and Southern mole crickets spread westwards and southwards and by 1960 had covered the entire state of Florida (Walker and Nickle, 1981).

Mole crickets spend nearly all their year-long life cycle underground (Walker, 1984), making population sampling in the field very difficult. Eggs are laid in clutches in underground chambers. Nymphs tunnel to the surface and feed in the upper soil and litter. Juveniles and adult make and occupy extensive tunnel systems. In south and central Florida, tawny mole cricket has one generation per year but the southern mole cricket has two generations annually (Walker 1984). It is only during their peak mating flights in early spring to late summer that pest mole crickets are conspicuous to the casual observer.

Mole cricket damage to pasture and turfgrass is principally due to feeding by tawny mole crickets (Hudson, 1984). At night, crickets usually leave their borrows to feed on above-ground plant parts, biting off stems and leaves, which are dragged into their burrows to be eaten, whereas roots may be eaten at any time. Mechanical damage to plants is caused by the tunneling activity of mole crickets and is the principal detrimental effect of southern mole crickets on pasture. Damaged pasture first appears as yellow in small or big patches which die and turn brown. In areas of high mole cricket population density, the surface 20 to 25 cm soil layer is honeycombed with numerous tunnels and ground feels spongy when stepped on. Heavily damaged pasture grass has virtually no root system and is easily pulled from the soil by cattle of foot traffic.

Three basic sampling techniques for monitoring mole crickets have been described (Hudson 1988) although none has overcome the basic obstacle of showing good correlation with true population density. These sampling techniques are sound traps for flying adults (Walker, 1982), linear pitfall traps for monitoring the activity of immature mole crickets (Lawrence, 1982) and soil flushing for both classes (Short and Koehler, 1979). More than 15-yr data has been collected around Gainesville and Bradenton urban areas on adult pest mole crickets flights with sound traps (Walker, 1994). However, adult mole crickets could fly over long distances and sound trap numbers may not reflect mole cricket seasonal distribution on specific ranches

This study was designed to 1) use permanently set pitfall traps to monitor the long-term seasonal abundance of immature mole crickets on pasture in relation to rainfall and pasture damage. 2) Use population histories developed as baseline to evaluate the efficacy of biological control with mole cricket nematodes.

MATERIALS AND METHODS

The study was conducted on selected ranches in south central Florida with severe initial mole cricket damage symptoms. In July 1997, six pitfall traps were installed on a 4-ha bahiagrass pasture at two heavily infested ranches in the Green Swamp area of Polk County and one each in Manatee and Pasco counties. The same number of traps were set on newly-established, healthy pastures in Desoto and Highlands counties and on .two pastures at the Range Cattle Research and Education Center (RCREC), Ona in Hardee county.

Traps at each site were labeled 1-6 in decreasing slope and were cleaned weekly from July 1997 through December 1999. At cleaning, trapped tawny and southern mole crickets in each trap were counted. Development of immature mole crickets was monitored at one site in the Green Swamp area by measuring the length of the pronotum of 20 trapped mole crickets monthly. Amount of weekly rainfall was recorded for the two Green Swamp sites in Polk County, the Manatee, and Pasco sites. Pasture on damaged sites was rated as to percentage yellow, dead brown, and bare ground/weeds, every spring using a divided m^2 quadrat. The quadrat had 100 divisions, each representing a percentage point, and was thrown randomly to twenty locations on the 4-ha field.

Nematodes (*Steinernema scapterisci (Ss))* were applied in September 2000 to one-acre centers of two-acre bahiagrass plots in strips to cover 0, 1/8, 1/4, and 1/2 of the plots. A modified sod-seeder was used to apply the nematodes to about one inch depth of the topsoil. The standard application rate of nematodes is one billion/A, but stripping allows for significant reduction in quantity applied/A. Following strip-application of nematodes in the field, weekly monitoring of trapped mole cricket number was continued through 2001. Additionally, every 28 d, samples of mole crickets were collected 24 hr after cleaning traps and taken to the laboratory and analyzed for nematode infection. This involved incubation of mole crickets that died in the laboratory at 28 °C for a period up to 14 d. The cadavers were then separately examined under the microscope at 50 X for the presence or absence of *Ss* nematodes.

Data on weekly trapped mole crickets were subjected to statistical analysis of variance (SAS 1989) with site as main plot and year and week as split and split-split plots in time, respectively, and traps as replicated blocks. Due to significant site x year interaction, weekly abundance of trapped mole crickets were fitted to week of the year, separately for each site, using SigmaPlot regression software (SPSS Inc 1997) that maximized regression coefficient of determination (R^2) and minimized standard error (SE). Comparisons of nematode strip-treatment effect on mole cricket abundance and of the level of nematode infection in mole crickets were made with analysis of variance and Fisher's LSD mean separation.

RESULTS AND DISCUSSION

Seasonal Dynamics of Juvenile Mole Crickets on Bahiagrass Pasture

Trapped mole cricket numbers varied depending on site of bahiagrass pasture ($P < 0.05$), year ($P < 0.001$) and week of the year (WOY) ($P < 0.0001$). The interaction between site and year also approached significance ($P < 0.10$). The 3-yr (1997-1999) mean weekly trapped mole crickets ranged from 10.1 to 12.4/trap for the two Green Swamp sites in Polk County, and the sites in Pasco and Manatee counties, but from 0.7 to 1.7/trap for the newly established bahiagrass pastures in Desoto and Hardee counties (Table 1). Sites that recorded annual mean weekly mole cricket numbers > 10 such as Combee, Clark, Nutts, and Harlee ranches also had pasture severe damage (yellow +dead/weeds) ranging from 49 to 72% (Table 2). Conversely, the lightly infested sites including Desoto and the RCREC stayed green in spring and showed little sward damage.

Weekly abundance of immature (nymphs and juveniles) pest mole crickets on damaged bahiagrass pastures over time within the year was best described by an exponential curve (Gaussian 3 Parameters) (Figs 1-4). Mole cricket eggs normally hatch in May-June (Walker, 1983), and the number of trapped nymphs on pasture reached a peak after the first major summer rainfall in June-July. The 3yr-mean peak trap counts ('a' value) were 23 on week (X_0) 30 for Combee ranch (Fig 1), 26 on week 25 for Clark ranch (Fig 2), and 40 on week 25 for Nutts ranch (Fig 3). On Harlee ranch (Fig 4), we experienced variable yearly patterns of weekly nymph abundance. A peak reaching over 100 nymphs/trap occurred in early July of 1997, a bimodal peak (June and September) averaging 45/trap in 1998, and a peak of only 20/trap in 1999. On these damaged fields also, at least one spike in mean weekly nymphs/trap exceeded 50 during the three year monitoring. Data on mole cricket numbers obtained during 2001 season will be compared to the previous 3-yr mean to evaluate the effectiveness of nematodes for biocontrol.

Preliminary data obtained in Spring 2001 from the Polk City trial indicate that mole crickets that were initially infected with the nematode have spread the nematode across the whole 24-acre pasture. Nematode infection level in trapped mole crickets was 80% or higher at ½ rate strip application, 60% at 1/4 rate, 50% at 1/8 rate and even 33% at 0 rate (Table 2). These results have persisted through June 2001(Table 3) which suggest that the targeted market price for *Ss* nematode on golf courses ($200/A) can be substantially reduced to $20-30/A using strip application on pasture. Field application cost would run similar to a bush-hog operation of $5-10/A. Grass recovery from previous damage has been slow because of weed infestation into damaged areas. Estimated basal grass cover changed from 43% in May 2000 to 50% in May 2001 and it may be necessary to reseed the damaged areas. However, recycling of nematodes in mole cricket population should result in long-term control of the pest and improve chances of grass recovery from re-seeding. For proper control, nematodes should be injected into the top inch of the soil, during the fall or spring adult mole cricket seasons, after a rainfall, at sundown, in areas where adult mole crickets are abundant.

SUMMARY

Pitfall traps were used to develop 3-yr population histories of pasture mole crickets in several south-central counties of Florida. The period June-July marked peak abundance of mole cricket nymphs on pasture. The efficacy of *Steinernema scepterisci* nematodes for controlling mole crickets was studied from strip filed inoculation of the nematode. Preliminary data showed a successful establishment of the nematode within the mole cricket population even with 1/8 area treatment. Classical biological control is a long-term, slow process and significant improvement in pasture condition is expected over time.

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Table 1. The effect of pasture site on 3-yr mean weekly mole cricket count/trap and corresponding pasture damage estimate.

County	Ranch	count/trap	Damage estimate, %		
			Green	Yellow	dead/weeds
Polk	A. D. Combee	10.1	45	4	51
Polk	George Clark	12.4			
Manatee	Harlee Farm	11.2	28	10	62
Pasco	Mary Nutts	11.0	51	37	12
Hardee	RCREC-71A	0.7	98	1.5	0.5
Hardee	RCREC-87	1.7	85	5	10
Desoto	Steven Houk	1.6	97	2	1.0
	LSD *P*=0.05	5.7	12	8	11

Table 2. Percentage of trapped mole crickets infected with Ss nematodes on 4/21/01 following application on 9/27/00.

Strip treatment	# trapped mole crickets	# mole crickets infected with Ss nematodes	% infection
½ area coverage	21	18	86
1/4 area coverage	19	16	84
1/8 area coverage	20	12	60
0 coverage	17	7	41

Table3. Percentage of trapped mole crickets infected with Ss nematodes on 5/18/01 following application on 9/27/00

Strip treatment	# trapped mole crickets	# mole crickets infected with Ss nematodes	% infection
½ area coverage	5	4	80
1/4 area coverage	7	3	43
1/8 area coverage	4	2	50
0 coverage	6	2	33

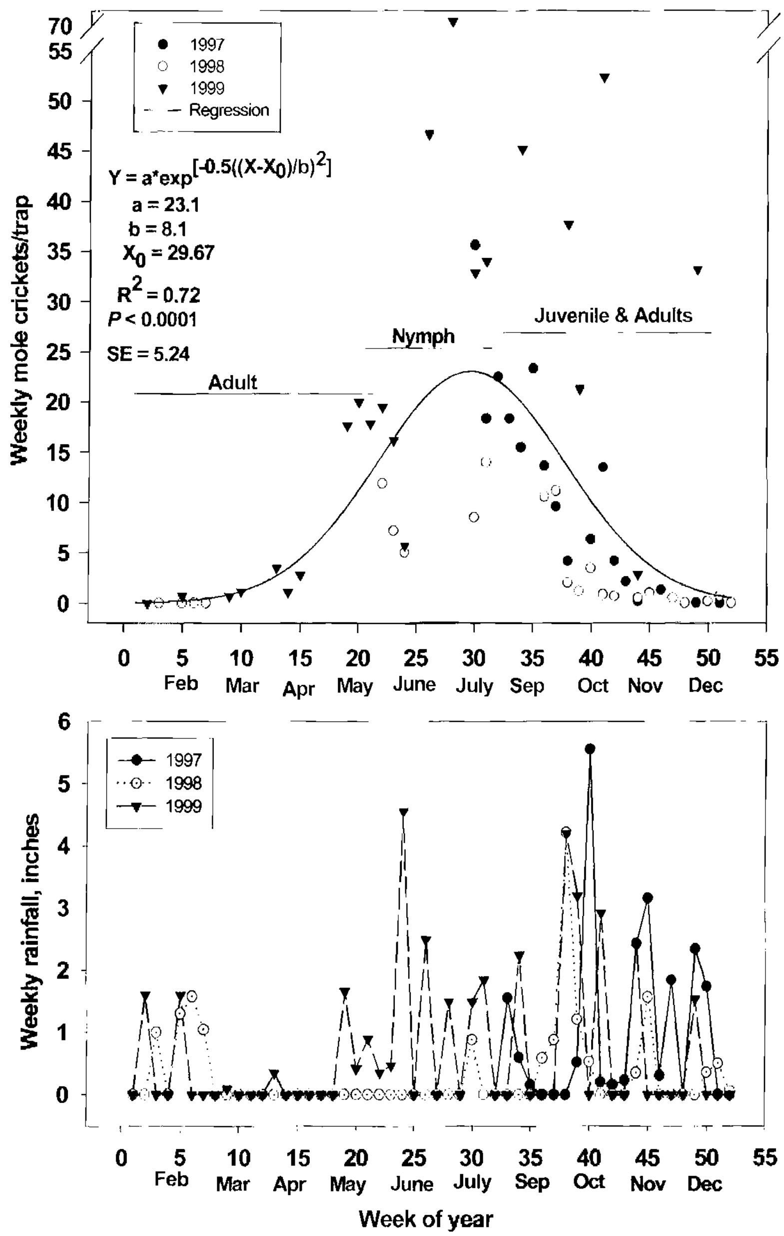

Figure 1. Mean weekly number of mole crickets trapped on A.D. Combee ranch in Polk county from 1997-1999 and weekly rainfall amount.

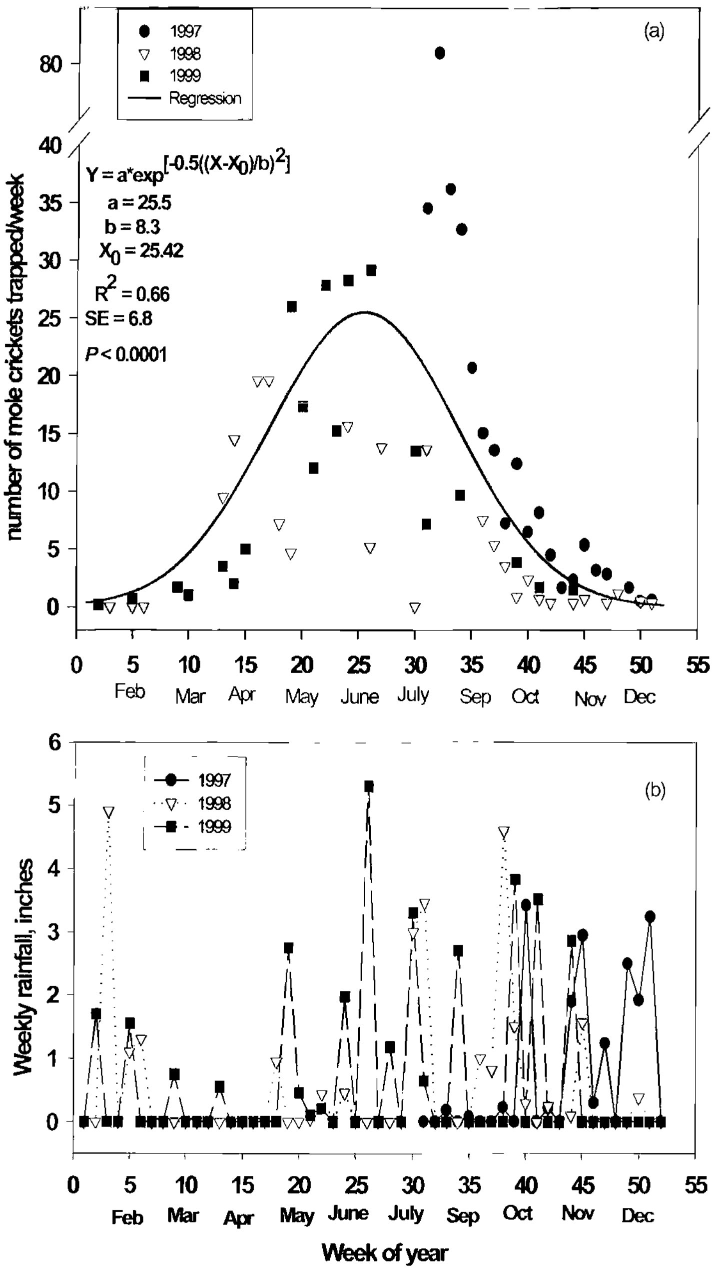

Figure 2. Mean weekly number of mole crickets trapped on Georg Clark's ranch in Polk county from 1997-999 and weekly rainfall amount.

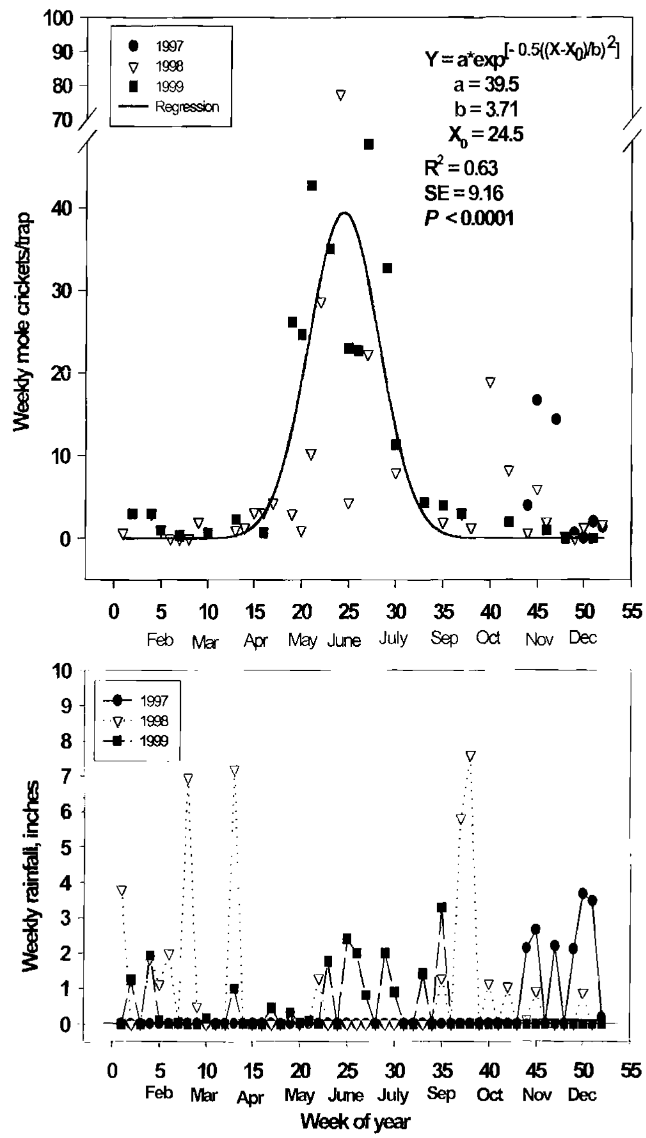

Figure 3. Mean weekly number of mole crickets trapped on Mary Nutt's ranch in Pasco county from 1997-999 and weekly rainfall amount.

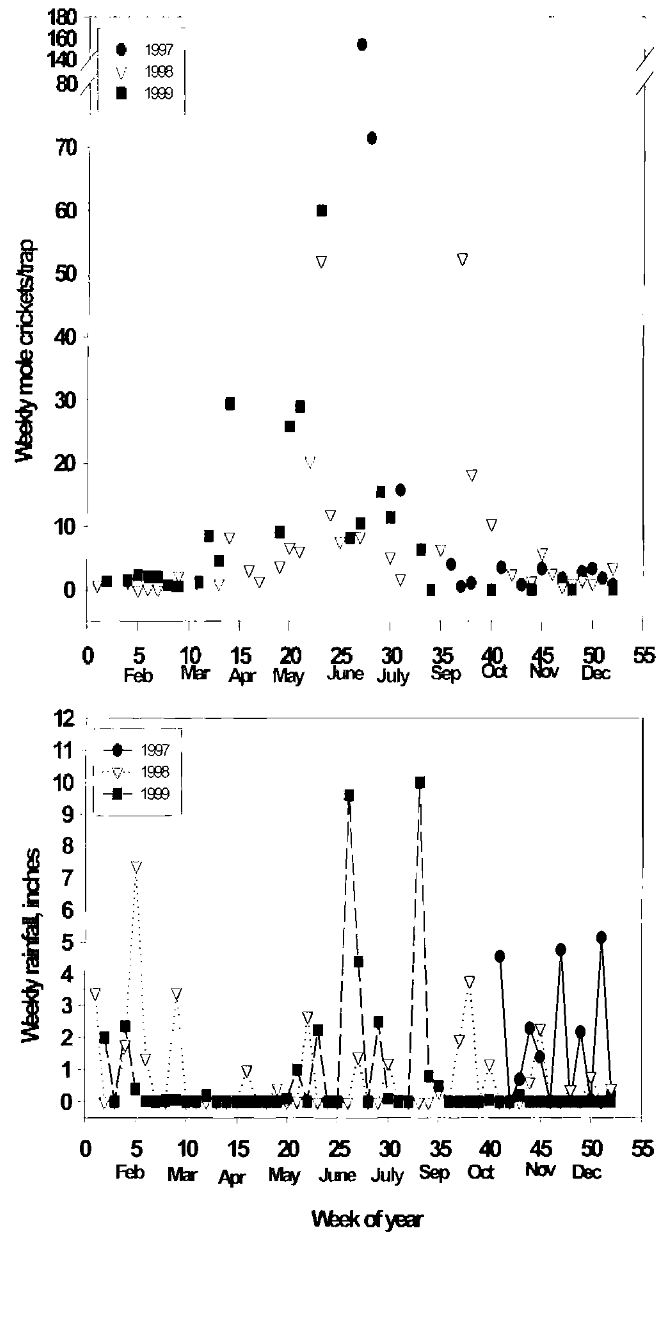

Figure 4. Mean weekly number of trapped mole crickets on Harlee farm in Manatee county from 1997-1999 and weekly amount of rainfall.

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STATUS OF THE HIBISCUS MEALYBUG (HMB) *MACONELLICOCCUS HIRSUTUS* AND THE EXOTIC NATURAL ENEMIES IN TRINIDAD

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ABSTRACT: The HMB was first reported in Trinidad in 1995. Following short term control strategies a classical biological control programme was initiated in 1996 as a long term sustainable control strategy. The exotic natural enemies released were *Cryptolaemus montrouzieri* (Cm), *Scymnus coccivora* (Sc) and *Anagyrus kamali* (Ak). Since 1996, six islandwide surveys were conducted to determine spatial distribution of HMB and the exotic natural enemies to assess the impact of the natural enemies, and to quantify plant damage. The methodology was developed by the FAO under the Technical Cooperation Project (TCP). The data from these surveys were compared to determine the impact of the natural enemies on HMB. Generally few Ak and Sc were recovered. However, Cm appears to be established in the environment. The HMB population after releases was also low for all counties. *Hibiscus spp.* continue to be the most susceptable host plants. Although crinkling and curling symptoms appeared in surveyed plants, damage was not critical. Data from these surveys also served to provide supportive information on the status of the HMB population and facilitated the resumption of regional trade.

INTRODUCTION

The Hibiscus Mealybug (HMB), *Maconellicoccus hirsutus* Green (Homoptera: Pseudococcidae), which is native to South–East Asia has a wide host range attacking over 125 plant species (Peterkin, et al , 1999). It was first reported in the Western Hemisphere in Grenada in 1994. In August, 1995 it was recorded in Trinidad (Mc Comie, 1995). The pest is now widespread in the region (FAO, 1999) (Table 1).

* Table 1: Current reported distribution on Pink Hibiscus Mealybug in the Caribbean Sub – Region

Country	Date of Reporting
Grenada and Carriacou	November 1994
Trinidad (and) Tobago	August 1995, November 1996, respectively
St. Kitts (and) Nevis	November 1995, December 1995, respectively
Netherlands Antilles:	
Aruba, Saint Maarten, St. Eustatius, Curacao	?, September 1996, May 1997, June 1997, respectively
St. Lucia	
Anguilla	October 1996
Guyana	1996 ? / February 1997
British Virigin Islands (Tortola)	April 1997
St. Vincent and the Grenadines	May 1997
United States Virgin Islands:	
St. Thomas, St. John, St. Croix	May 1997, May 1997, June 1997, respectively
Puerto Rico:	
Culebra, Vieques, PR Mainland (E. Farjado)	December 1997, June 1997, April 1998, respectively
Montserrat	January 1998
Guadeloupe	April 1998
Martinique	March 1999

* Source: FAO Circular Letter No. 1/99

Chemical and cultural practices were adopted as short-term control strategies which however were not effective (Mc Comie, 1996). Following these measures a classical biological control programme was initiated in 1996 as the main component of an IPM system for long-term control. Two (2) exotic ladybird beetles *Cryptolaemus montrouzieri* (Cm) and *Scymnus coccivora* (Sc) (Coleoptera: Coccinellidae) were introduced together with the parasitic wasp *Anagyrus kamali* (Ak) (Hymenoptera : Encyrtidae) were used for the control of the HMB. In 1999, another exotic parasitic wasp, *Gyranusoidae indica* (Gi) (Hymenoptera : Encyrtidae) was reported in Trinidad (CABI, 1999). This wasp was one of the complex of biogents used in controlling HMB in St. Kitts, and Grenada, however, it was never officially introduced in Trinidad.

Large scale surveys are necessary to demonstrate the impact of exotic natural enemies on pest populations (Neuenschwander, 1996). This requires large numbers of field units, randomly selected for sampling in order to obtain empirical data.

In 1997 as part of the FAO Technical Cooperation Project (FAO/TCP) on the Hibiscus Mealybug, a survey protocol was developed for implementation by individual countries. This survey was previously designed to capture data on the status of levels of HMB infestations, impact of natural enemies, data to determine establishment of natural enemies and to quantify plant damage. Collection of other mealybugs for identification was also sought. Data from these surveys also serve to determine future control programmes. In 1999 the FAO / TCP Protocol was slightly modified to include sites on secondary roads to capture farms with sorrel and ochro.

Since 1996, islandwide surveys have been conducted every year in Trinidad and in Tobago. Data from these surveys have provided supportive information on the status level of HMB and assisted with the resumption of regional trade.

METHODOLOGY

Grids

The island was divided into 50 km squared grids. Only grids that were accessible by main and/or secondary roads were surveyed. A total of 88 grids were accessible in all eight counties as follows:

Caroni	11	Nariva/ Mayaro	14
St. George West	14	St. Patrick East	7
St. George East	8	St. Patrick West	14
St. Andrew/ St. David	14	Victoria	6

Survey Routes

Survey routes were identified on the grid map before going out into the field. Three (3) sampling points were selected along the main road 2.0km apart and another three (3) along secondary roads 1.0km apart. Secondary roads were sampled to capture commercial crops like ochro and sorrel. The first sampling point was selected at random and predetermined at 0.0, 0.5, 1.0 and 1.5km from the edge of the grid.

Sites

Each sampling point was classified as Urban Homestead, Rural Homestead, Farm, Teak Forest, Roadway or Empty Lot. These sampling points were described as follows:-

Urban Homestead - a household in a developed area away from the city.
Rural Homestead - a household in the country.
Farm - an area cultivated with agricultural crops or ornamentals.
Teak Forest - an area intensively cultivated with teak.
Roadway - a site at the side of a main or secondary road.
Empty Lot - a vacant uncultivated area in urban or rural communities.

Indicator Plants

The list of indicator plants selected were those highly susceptible to the HMB. Eight plant species were selected as follows: *Annona spp* - soursop, *Sida spp.*- broomweed, *Hibiscus esculentus* - ochro, *Hibiscus spp.*- ornamental hibiscus, *Hibiscus sabdariffa*- sorrel, *Achrysanthes indica*- man–better-man, *Tectona grandis* - teak, *Malacra sp.*- wild ochro.

Sampling

Sampling units were used according to the parts of the plant that were attacked or available. These include branch / shoot, flowers / fruit or leaves.

Ten plants were sampled for each site and five units per plant were scored. A sample was taken from the first 15cm of the shoot selected within arms reach. For fruits, the first five encountered while walking around the tree were sampled.

The first of the five units per plant sampled was collected, placed in separate plastic bags and taken to the laboratory for further examination and scoring. Each plastic bag was labelled with grid number, site number, sample number, date and collector's name.

Additional samples were collected from sites with more than one indicator plant species.

Field Scoring and Recording

Shoots / Flowers: Mealybug population and plant damage was recorded on a scale of 1-5 as follows: - No Mealybugs, plants show no sign of damage; No Mealybugs, plants show signs of damage e.g. curling and crinkling of leaves; Small inconspicuous colonies of Mealybugs at terminal buds or inflorescences; Conspicuous infestations limited to terminal buds; High infestations, extending to stem, sooty molds may be present.

Fruits (Soursop): Mealybug population and other symptoms were also recorded on a scale of 1-5 as follows: -No Mealybugs, fruit(s) clean, no sooty molds; No Mealybugs, fruit(s) show(s) signs of previous infestation e.g. Sooty mold, Mealybug waxing coating; Small inconspicuous colonies of Mealybugs (<) less than 10% surface area; Conspicuous colonies limited to part of the Fruit 10-30% of surface area; High infestations over 30% of surface area.

Laboratory Scoring of Shoots / Flowers for HMB: In the laboratory the following observations were made from the samples: number of ovisacs; number of crawlers; number of juveniles; number of adult females.

Laboratory Scoring of *A. kamali* and *G. indica*: Actual counts of intact mummies, empty mummies and adult *Anagyrus kamali* and *Gyranusoidae indica* were recorded.

Laboratory Scoring – *C. montrouzieri* and *S. coccivora*: The following observation were made on Cm and Sc. Number of Larvae, pupae and adults and number of other natural enemies. All *C. montrouzieri* and other natural enemies which could feed on *A. kamali* were removed and the number of insects left in the plastic bag were recorded.

Percentage Parasitism: Following counts of *A. kamali*, *S. coccivora* and *C. montrouzieri* all samples from each site were placed in rearing jars for emergence of adult *A. kamali* and *G. indica*. These jars were monitored every 2-3 days for a period of three weeks and the number of emerged parasitoids were recorded.

The percentage of parasitism was calculated as follows:-

$$\text{Percentage Parasitism} = \frac{\text{No. of emerged parasitoids X 100}}{\text{Total no. of susceptible stages+intact mummies}}$$

The Statistical Package for Social Sciences (SPSS) was used for data processing.

RESULTS AND DISCUSSION

Average HMB Score by Plant Species: For most crops there were peaks and fluctuations in average scores for the six surveys. However, scores for most species was <2, indicating relatively clean plants. *Hibiscus spp.* maintained the highest score throughout the surveys while the average score peaked (2.0) in sorrel in the last survey.

It is evident that HMB is established in the environment but their populations have been suppressed. The early short term strategies of chemical use and cultural practices may have initially been efffective in controlling population growth. The long term biocontrol measures afterwards continued to suppress the pest.

Average HMB Score for Commercial Crops: Ornamental hibiscus, sorrel and ochro are preferred hosts of HMB. Although the scores were low (<2.00) for these crops heavy losses can be obtained especially on sorrel and ochro. Management of the pest therefore, should begin early in these species.

Percentage of Samples with HMB score of 2 and above by County: Generally there were peaks and fluctuations in the percentage of samples scoring 2 and above for all surveys. Survey 2 had the lowest percentage of samples scoring 2 and above for all counties. The highest (54.49) percentage was found in St. George East county in Survey 6 (Figure 1). Control strategies should therefore be intensified in this area. This occurred because sorrel was the most predominant plant species in that county. The crop was abandoned in the fields after the final harvest allowing for build up of the HMB population.

Overall the southern counties St. Patrick East, St. Patrick West, Nariva / Mayaro and Victoria had the highest percentage of samples scoring two (2) and above. These counties should be more closely monitored and augmentative releases be made if necessary, to suppress the pest population.

Survey 2 consistently had the lowest percentage of samples scoring 2 and above for all countries. The highest (17.2%) was found in St. Patrick West while the lowest (1.2%) was found in Caroni. At that time major control activities including public awareness were still being executed which resulted in the low pest populations.

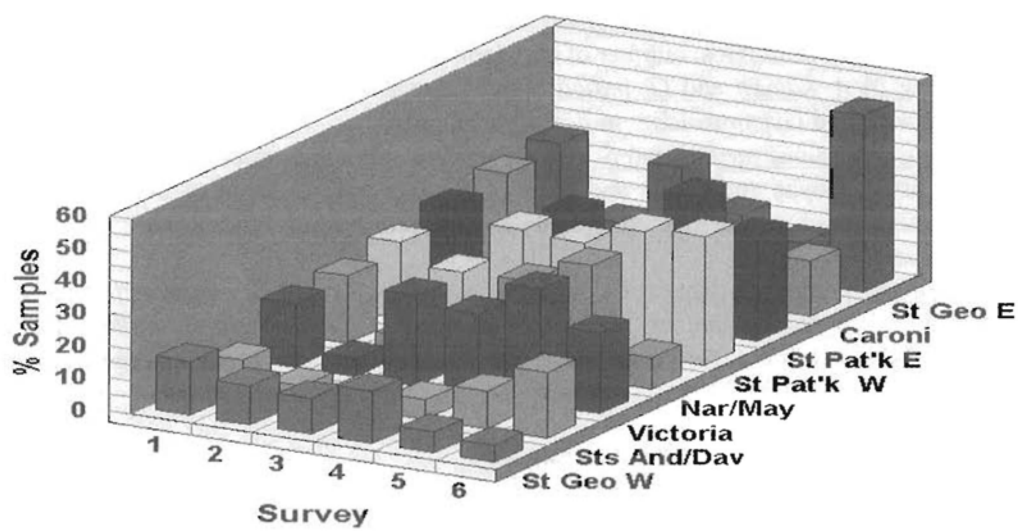

Figure 1. Samples with HMB Score of 2 and above by county.

Cm in the field by County: It is evident that wherever HMB was present, Cm was also present. Peaks in HMB populations, coincided with peaks in Cm populations (Figures 2 and 3). For Survey 6, the percentage of samples scoring 2 and above peaked at 54.49 while the percentage of Cm peaked at 16.33.

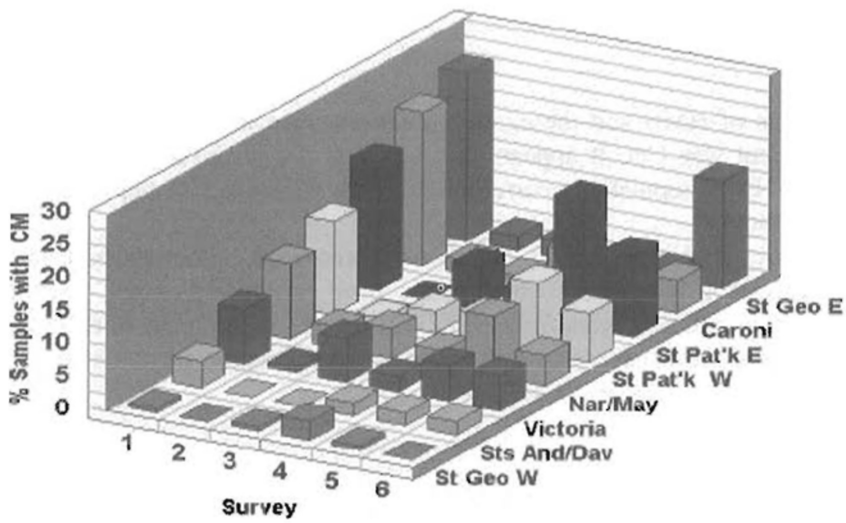

Figure 2. Cryptolaemus montrouzieri (Cm) in the field in relation to county.

HMB and Natural Enemies relative to Field Sites: HMB was most prevalent in Rural (40.34%) and Urban (37.99%) sites. These sites also had the highest percentage of samples with Cm for all six surveys. The percentage of Sc and Ak was quite low in those sites and almost not present in the other sites. At low pest populations it is possible that Cm may feed on Sc and Ak thus accounting for their low populations.

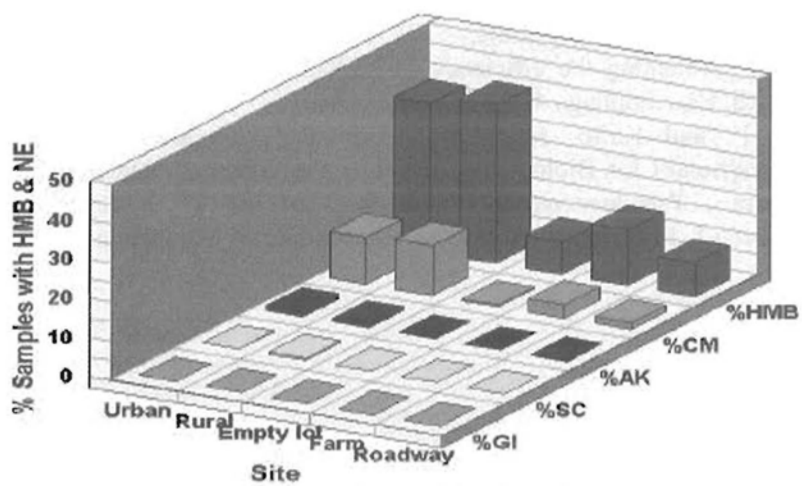

Figure 3. HMB and natural enemies relative to field sites.

The results were consistent for all surveys i.e. peaks and fluctuations in HMB population coincided with that of Cm. Nine months after initial releases of Cm the impact of this Natural enemy on HMB was quite visible and remained so (Mc Comie, 1996). Cm was also reported (Gautam et al., 1996) to be quickly established in the environment.

The peaks and fluctuations in pest and natural enemy populations are typical in classical biological control programmes in which natural enemies are released for controlling pest populations.

CONCLUSION

Generally counts of HMB and the exotic natural enemies were low. The most prevalent natural enemy in the environment was Cm. It appears that this was the preferred coccinellid for release. In all instances the peaks in HMB populations corresponded with peaks in Cm populations. Cm seems to be established in the environment.

Few *S. coccivora, A. kamali* and *G. indica* were recovered. Although these natural enemies were present in the environment, it is doubtful whether they have established or not. Exclusion studies in the short term and long term population dynamics studies will determine the status of these natural enemies.

Data from these surveys have provided supportive information on the status level of HMB and assisted with the resumption of regional trade.

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DETERIORATION OF YAM (*DIOSCOREA ALATA*) TUBER SEED-PIECES IN NATURAL SOIL AND COMPOSTS

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ABSTARCT: A survey of fungi on yam (*Dioscorea alata* cv. "Kabusah") tuber seed-pieces was conducted in order to appreciate those that can induce rotting in natural soil and composts. *Fusarium oxysporum* and *F. solani* seem to prevail on tubers after storage, as shown when the tuber pieces were incubated in autoclaved ferrallitic soil. In natural ferrallitic soil, *F. solani* dominated on the tuber pieces. This fungus was also easily trapped with pieces of tuber flesh incubated in both a ferrallitic and a vertisol soil. It was accompanied with a *Pythium* and *Geotrichum* species in the ferrallitic soil. When the tuber seed-pieces were incubated in a compost suppressive for *Pythium* and conducive for *F. solani*, they were severely decayed by this pathogen and did not germinate. In another "vegetable mud" substrate, 100 % of seed-pieces germinated and produced a good-starting plant. Our results indicate that *F. solani* can play an important role in tuber seed-pieces rotting in natural soil and some composts. Some indications on the management of this type of planting materials are discussed.

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PESTICIDE RESIDUES ON LOCAL FOOD CROPS: REALITIES AND RECOMMENDATIONS

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ABSTRACT: A recent market basket survey of organophosphate insecticides in Trinidad clearly indicated improper use of this class of insecticides on produce offered for sale to local consumers. In several cases, crops appeared to have been harvested without regard for recommended pre-harvest intervals, as well as being treated shortly before harvest. On many samples, recommended maximum residue levels were exceeded, particularly on celery, on which mixtures of insecticides were frequently and consistently detected. Supervised field trials of five of the most commonly detected organophosphates showed that recommended pre-harvest intervals of each pesticide were often not in accordance with actual field degradation rates. In some cases, residue levels of pesticides declined faster than expected, raising the possibility of re-infestation of crops by pests within the recommended pre-harvest intervals. Our results indicate a pressing need for supervised efficacy and pesticide residue trials, of all pesticides used on food crops under local growing and storage conditions, and offered for sale locally or exported. The recent acceptance of HACCP for food production systems also mandates regular monitoring of edible crops for contaminants, including pesticide residues, to ensure the safety of consumers.

INTRODUCTION

The effective application of pesticides is a necessity in modern crop protection. For many local farmers, it often represents the only means of guaranteeing their harvests and their livelihood. Unfortunately, pesticide overuse often leads to the development of pest resistance, which in turn results in pesticides becoming ineffective at recommended rates of application, or being ineffective altogether. Consequently, increased rates of application may become necessary for pest control, or by the use of other pesticides or control strategies. However, the development of genetically modified pest-resistant crops, which may reduce the use of pesticides, is not without problems, particularly in Europe (1).

The application of combinations of pesticides is a well-established practice in pest control, and is commonly done by local farmers (2). In addition, the "more is better" principle is often adopted in application rates, leading to problems of pesticide residues on harvested crops. Such residue problems are exacerbated by praedial larceny of freshly sprayed crops (3), as well as the non-observance of recommended pre-harvest intervals (PHI), following the final pesticide application. However, pre-harvest intervals are often developed under conditions which may differ significantly from local growing conditions and may thus be considered inappropriate by local farmers.

Nevertheless, pesticide residues on crops are cause for concern for consumers, and maximum permissible levels in edible crops have been set for each pesticide (4). Not surprisingly, pesticide residues have occasionally been found on crops exported to the US from the Caribbean (5). Once maximum permissible levels are exceeded, such produce is rejected, and enhanced monitoring of subsequent shipments is implemented. In the face of strong competition from other regions, such action may result in permanent loss of markets for local and regional farmers.

In this study, a survey of pesticide application practices by local farmers was undertaken to determine pesticide usage patterns, followed by a market-basket study on the levels of organophosphate pesticides on produce offered for sale to consumers. Supervised field trials on selected organophosphate pesticides were carried out, to determine their persistence patterns and PHI under field conditions, as well as to help explain the results of the market basket study. Summary findings are presented and recommendations made, for the benefit of both the farmer and the consumer.

MATERIALS AND METHODS

(a) Farmers' survey

Farmers (N = 69) in north, central and south Trinidad were interviewed, using a questionnaire. Information obtained on pesticide application practices, including the use of mixtures of pesticides, types of pesticides used on various crops, and the observance of recommended pre-harvest intervals were collated. Results of this survey are presented in Tables 1 and 2.

(b) Market basket study

A total of 200 samples representing 17 crops, was purchased in local markets and supermarkets, for analysis of organophosphate pesticide residues, from September 1996 to May 1997. This number was calculated to represent all produce containing pesticide levels above the Codex Alimentarius (4) Maximum Residue Levels (MRL), determined within 0.05 units at the 95% confidence level (6). Codex protocols on minimum sample size and items per sample were closely followed in sample collection. Summary results are shown in Table 3.

(c) Supervised field trials

Five organophosphate (OP) insecticides were applied individually to Pak Choi Brassisca sinensis L), using a randomized block design and 200 plants per treatment. Eight spray applications were made at recommended rates of application for each pesticide during the dry season. In comparison, five applications were made during the wet season, since applications were made only during periods of little or no rainfall, until close to crop maturation.

The method of analysis used (7) was validated prior to sampling, and quality control measures implemented during the entire programme.

Calculated values of pr-harvest intervals required for each pesticide to fall below its MRL are summarized in Table 4.

RESULTS AND DISCUSSION

(a) Farmers' survey

Table 1 shows the summary data on use patterns of pesticides, excluding herbicides, by local farmers. A wide range of different chemical classes are used in crop protection, with the most used pesticides being profenofos, used as two different formulations, and cypermethrin.

In addition, the same formulation of a pesticides could be used on a range of crops to control different pests. For example, for OP pesticides, up to 34 different formulations, containing 27 OP pesticides, were used on tomatoes, while 27 different formulations with 16 OP were used on cabbages (Table 2).

Likewise, mixtures of pesticides were applied simultaneously, often using the "more is better" principle. Spreaders and stickers were also used to enhance pesticide persistence, mainly during the wet season, but appear to be increasingly used in the dry season as well. Pesticides were normally applied to cash crops at 4-5 day intervals in the dry season, and even more frequently during the wet season. Recommended pre-harvest intervals were often not strictly adhered to, this practice being encouraged by consumers preferring unblemished produce, as well as incidents of praedial larceny.

(b) Market basket study

Of the 200 samples analyzed, 22% contained detectable OP pesticides, of which 10% exceeded Codex Alimentarius MRL (4). The worst affected crop was locally grown celery, with 15 of 18 samples containing detectable OP residues, 13 above the MRL.

The most commonly detected OP was methamidophos, followed by triazophos, profenofos, diazinon, ethion, pirimiphos methyl and dimethoate.

These results in Table 3 were consistent with our farmers' survey data, with respect to pesticide use patterns and practices, including the observance of pre-harvest intervals. For example, the 40.20mg/kg triazophos and 15.74mg/kg methamidophos levels on celery are well above the MRL and pose a significant threat to the health of the consumer. Similarly, the 8.52mg/kg profenofos level, also on celery, strongly implies that harvesting was carried out soon after spray application, since this pesticide decays rapidly once applied in the field (8).

Our market basket data strongly suggest the need for increased monitoring of produce offered for sale to consumers. Continued education of farmers on the observance of safe pre-harvest intervals is also required.

(c) Supervised field trials

For each pesticide, the residue (Y) at time (t) fitted and exponential decay model of the following form, representing the pesticide decay rate:

$$Y = a + b\,e^{-ct}$$

where Y is the fitted pesticide concentration; t is the time (days) after spray application; a, b, and c (c>0) are the estimated parameters; (a + b) denotes the initial pesticide level.

The time taken for each pesticide to decay to below the MRL was calculated for both wet and dry seasons. Results are shown in Table 4.

Of the five OP pesticides investigated, triazophos was highly persistent in both wet and dry seasons, while methamidiphos was more persistent under dry than wet conditions. In comparison, phenthoate, profenofos and pirimiphos methyl disappeared rapidly under wet or dry conditions.

Our pre-harvest intervals, calculated for pesticide levels to fall below the Codex MRL, compared well with those recommended by the pesticide manufacturers for pirimiphos. However, for phenthoate and profenofos, our rates were about half those recommended by the manufacturers; while this provides added safety for the consumer, it could lead to pest re-infestation, if the pesticide levels become too low to maintain control. For methamidophos, the experimental and manufacturer's values agreed for the dry but not the wet season. In comparison, triazophos required about a week more than recommended, to fall below its MRL, and can result in produce being harvested before the MRL is achieved. These findings may explain the detection of methamidophos and triazophos on several samples of our market basket survey.

CONCLUSIONS AND RECOMMENDATIONS

The results of our studies clearly illustrate the realities that must be faced, if the many problems facing the farmer and the consumer are to resolved. Obviously much more needs to be done to maximize the benefits of pesticide applications, as well as to protect the health of consumers.

Since our studies involved only OP pesticides, the other classes of pesticides, particularly the carbamates, many of which are even more toxic to humans than the OP (Table 1), require similar attention. Efficacy trials are urgently required, to optimize the effectiveness of pesticide applications, using multidisciplinary teams of pesticide application and residue scientists, entomologists, plant geneticists and statisticians. Such trials can allow pre-harvest intervals following final pesticide applications, appropriate to local growing conditions, to be developed with the required degree of confidence. The identification of less persistent but effective pesticides closer to harvest can also result from such studies, for the benefit of both farmer and the consumer.

Since effective implementation of HACCP systems is likely to become a requirement for the continued export of fresh produce to other countries, regular monitoring of pesticide residues should be carried out, as evidence of such implementation. To this end, revised legislation to control the quality of local foods with respect to pesticide residues has already been implemented (9) and should be used to good effect.

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Table 1. Farmers' Survey on Use of Pesticides in Trinidad.

Chemical name	Frequency of Use (%)	Type / LD 50(mg/kg)	Function
Profenofos	15.68	Organophosphate / 358	Insecticide
Cypermethrin	15.52	Pyrethroid / >4920	Insecticide
Copper salts	11.11	Copper / > 2000	Fungicide
Mancozeb	9.64	Dithiocarbamate / >5000	Fungicide
Chlorothalonil	6.05	Chlorothalonitril / >10000	Fungicide
Methamidophos	5.72	Organophosphate / 20	Insecticide
Oxamyl	5.07	Carbamate / 5.4	Insecticide/Acaricide
Cartap	4.74	Thiocarbamate / 335	Insecticide
Bacillus thuringiensis	4.58	Biological / ND	Insecticide
Phenthoate	2.61	Organophosphate / 410	Insecticide/Acaricide
Triazophos	2.45	Organophosphate / 58	Insecticide
Benomyl	1.96	Carbamate / >5000	Fungicide
Methomyl	1.8	Carbamate / 20	Insecticide/Acaricide
Teflubenzuron	1.63	Substituted urea / >5000	Insect growth regulator
Pirimiphos methyl	1.63	Organophosphate / 2050	Insecticide/Acaricide
Fenbutatin oxide	1.47	Organotin / 2631	Acaricide
Formetanate	1.31	Carbamate / 20	Insecticide/Acaricide
Fenvalerate	1.31	Pyrethroid / 451	Insecticide/Acaricide
Ethion	1.14	Organophosphate / 208	Insecticide/Acaricide
Dicofol	1.14	Chlorinated alcohol / 578	Acaricide
Malathion	0.98	Organophosphate / 2000	Insecticide
Dimethoate	0.82	Organophosphate / 387	Insecticide
Diazinon	0.82	Organophosphate / 1250	Insecticide
Carbosulfan	0.82	Carbamate / 250	Insecticide

Table 2. Use of Organophosphate Pesticides on Selected Produce in Trinidad.

Crop	No. of different formulations used	No. of active ingredients in formulations
Tomato	34	27
Cabbage	27	16
Eggplant	22	20
Cauliflower	16	13
Sweet pepper	23	19
Okra	16	16
Cucumber	13	14

Table 3. The time taken for each pesticide to decay to below the MRL calculated for both wet and dry seasons.

No. positive	No. Exceeding MRL	Organophosphates, Exceeding MRL	Organophosphates Not Exceeding MRL
1	0	none	Ethion, dimethoate
1	0	none	Ethion, pirimiphos
15	13	Diazinon, profenofos, pirimiphos, methamidophos, triazophos	Malathion, pirimiphos, diazinon, methamidophos
4	1	Triazophos, methamidophos	Profenofos, pirimiphos
6	0	none	Methamidophos
5	2	Triazophos, ethion	Profenofos, triazophos, ethion, dimethoate
1	0	none	Diazinon
6	3	Methamidophos	Diazinon, methamidophos
0	0	none	none
1	0	none	Diazinon
0	0	none	none
3	1	Methamidophos	Diazinon
0	0	none	none
0	0	none	none
0	0	none	none
1	0	none	Ethion
0	0	none	none
44	20		

Table 3. Calculated Pre-Harvest Intervals from Field Trials Compared to Manufacturers' Recommended Values.

Pesticide	Season	Calculated PHI (days)	Manufacturers' PHI (days)
Pirimiphos	Dry	<1	3-7
	Wet	2	
Phenthoate	Dry	3	14-21
	Wet	2	
Profenofos	Dry	>7	15
	Wet	6	
Triazophos	Dry	28	21
	Wet	>21	
Methamidophos	Dry	>14	14-21
	Wet	6	

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OCCURRENCE OF *RADOPHOLUS SIMILIS* AND OTHER PLANT-PARASITIC NEMATODES IN ANTHURIUM SHADE-HOUSES IN TRINIDAD

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ABSTRACT: A systematic zig-zag design was implemented at three anthurium shade-houses during 1992 – 1993 for monthly sampling of plant – parasitic nematodes. *Radopholus similis* was shown to be the predominant nematode associated with the crop. *Paratylenclus minutus* was the only other potential plant – parasitic nematode identified. Population densities of *R. similis* exhibited annual fluctuations with maximum levels observed between August and September at the three locations. The population densities of nematodes varied widely with locations but the composition of females, males, and juveniles within the populations was similar. Various fungi were isolated from root lesions. Stunting, chlorosis, and root rotting were commonly associated with nematode infested plants.

INTRODUCTION

Anthuriums are popular for their leaves and flowers and are grown commercially for the North American and European markets. The crop can succumb to range of fungal and bacterial diseases (Dilbar, 1992). Surveys conducted for nematodes in Trinidad (Bala and Hosein, 1990b and 1996), Hawaii (Goo *et al.*, 1994), Madeira (Faria, 1992) and Jamaica (Hutton *et al.*, 1982) indicated that anthurium cultivars were hosts to a number of plant-parasitic nematodes including the burrowing nematode, *Radopholus similis* which appeared to be the one most deleterious to the crop. *Radopholus similis* is generally associated with the disease known as anthurium decline and the nematode may also interact synergistically with soilborne fungi. The association of *R. similis* and *Pythium* sp. has been reported in anthurium decline in Jamaica (Hutton, 1987) and Hawaii (Aragaki *et al.*, 1984). Anthurium decline is generally associated with leaf senescence, stunting, reduced yield, root rotting, sparse sucker production, decline and death of plants. Losses of up to 60 percent reduction in yield and poor quality blooms have been reported for Jamaica and Hawaii (Hutton, 1987 and Aragaki *et al.*, 1984)

In Trinidad, commercially produced anthuriums are generally grown in raised beds using crushed or chopped coconut husk. The growing beds are generally supplemented with "fibre bast" which is a by-product obtained from the crushed coconut husk when the fibre is removed. It is made-up mainly of coir dust and residual fibre. The management practices in the shade-houses include the use of very toxic pesticides. In most situations the application of nematicides is based primarily on the appearance of foliar symptoms but this may not necessarily be associated with nematodes as the presence of other soilborne organisms (Bala and Hosein, 1990a) can confound the problem of anthurium decline.

The study was initiated because of the problems anthurium decline and reduction in yield that were common in shade-houses. The use of proper diagnostic procedures and the monitoring of nematode populations were also needed to improve management strategies. The aim of the study is to identify and determine the population densities of plant-parasitic nematodes associated with the crop over time and to further investigate management strategies that may reduce the dependency on nematicides. The first of these two objectives is reported in this paper.

MATERIALS AND METHODS

Selection and location of sampling sites

Three farms were sampled to determine the distribution and density of plant- parasitic nematodes affecting local anthurium production between 1992 and 1993. These farms were selected based on the differences in the locality. In addition, these shade-houses had been established for at least three years using imported planting material. One farm was located in south Trinidad in the undulating hills at Oropouche, about 6 km south-west of San Fernando. The second was situated in noth Trinidad on top of the mountains of Maracas in the northern range, about 5 km northeast of The University of the West Indies. The climatic conditions at this location were much cooler with heavier rainfall than the other two locations. Also its location on the leeward side of the mountains provided good drainage and humid condition for the growth of the crop. The third farm at Arima, in northeast Trinidad, was located about 5 km miles south of the northern range and about 2 km east of the Piarco International Airport

The description of the three shade-houses and the agronomic and practices at each of the sites were recorded. The anthuriums cultivars Fla Success, Tropical, and Lydia grown at Oropouche, Maracas, and Arima, respectively, were obtained from the Netherlands as tissue-cultured plants. At the three locations, plant beds were usually topped-up with coconut husk to keep the plant upright. In July 1993 plants at Oropouche and Maracas were partially "lifted" and then tilted to about 45 degree. The tilting of plants was adopted to reduce plant height and it was claimed by the growers that it stimulated side shoots and encouraged root growth.

Design for taking samples of nematodes in anthurium shade-houses

Sampling of nematodes in growing medium and roots on beds was done monthly for one year along plant rows according to a systematic zigzag design.

Five beds each consisting of four rows of 60, 160 and 180 plants were selected for sampling at Oropouche, Maracas, and Arima respectively. Plots were divided into two sections running parallel to each other, so that each section had two rows of plants. Each section was further sub-divided into 0.65 x 0.65m micro-plots (0.42m quadrants) consisting of four plants each to facilitate the systematic zig-zag sampling design. The sub-samples, which consisted of roots and growing medium from single plants, were taken from every other plant in a systematic zig-zag pattern along rows. When one plant was sampled it was not sampled again until all other plants in that micro-plot was sampled. The shade-houses at the three locations were sampled identically.

In a sampling plot, monthly sub-samples were not taken from both sections simultaneously. Instead samples were taken from each section alternately on a monthly basis. The length of the sampling plots for the three locations varied. Therefore, each sampling section of a plot at Oropouche, Maracas, and Arima consisted of 6, 16, and 18 micro-plots respectively.

Composite samples consisting of 6, 16 and 18 monthly sub-samples were collected from Oropouche, Maracas, and Arima respectively. Samples were taken 5-12 cm from the stem and 10-20 cm deep in the root rhizosphere. For each sub-sample, approximately 100 cm^3 of growing medium with roots were collected and bulked. The samples of roots and growing medium were packaged separately in plastic bags. These were transported in styrofoam containers to the laboratory and nematode extraction was conducted within 24 hours (Hooper, 1986 a,b). The sampling method described helped to limit the movement between plants and minimised the spread of bacterial diseases, chemical exposure, and plant damage in the shade-houses.

Distribution of *R. similis* and other nematodes in anthurium shade-houses

Data analyses for the spatial distribution of nematodes in anthurium were compared at the three shade-houses. The population of nematodes was $\ln(x+1)$ transformed before analysis. Mean, standard deviation, standard error of the means, and the coefficient of variation (CV) were calculated for each location.

The percentages of females, males, and juveniles in the population were arc sine transformed (Gomez and Gomez, 1976).

Isolation of fungi from roots

Rootborne fungi associated with *R. similis* in anthurium roots were isolated on water agar and potato dextrose agar according to Booth (1971). Identification of fungi was done to genus level with assistance of personnel from the Plant Pathology Section, Central Experiment Station, Centeno.

RESULTS

Detection and density distribution of *R. similis* and other plant-parasitic nematodes

Radopholus similis was the major plant parasitic nematode found in the anthurium roots and growing medium at Oropouche, Maracas, and Arima during 1992 to 1993 (Table 1). *Paratylenchus minutus*, detected at Maracas was the only other plant-parasitic nematode identified during the study.

The maximum density of *R. similis* in the population range was generally similiar for the three locations. The population means of root and medium at Arima were lower than the other two locations, but the standard deviation and standard error of the mean showed similiar trend for all locations. However, there was a common trend in the variation of the number of nematodes among the five monthly samples for the three locations. The range for CV was also large among samples within the shade-houses for *R.similis*. The overall CV for Oropouche, Maracas, and Arima were 0.71, 0.74, and 1.28 for roots and 0.65, 0.54, and 1.0 for growing media respectively.

Root and growing media populations of *R. similis* were significantly different (P = 0.01) among the three shade-houses with the highest population levels at Oropouche followed by Maracas and Arima (Table 2). There were highly significant differences (P = 0.01) in the populations of *R. similis* females, males, and juveniles in roots and growing medium at the three locations.

Fluctuations of *R. similis* populations in roots and growing media

Low populations were observed at Oropouche in December and during March to June, while the highest levels were observed in August to November and January to February. At Oropouche the lowest and highest mean populations recorded for 10g roots were 178 in July and 1417 nematodes in September respectively. The populations in the growing medium varied from 23 to 249/100 cm^3 in April and February respectively.

At Maracas, there were little differences in the population levels during the period September to May. The lowest populations occurred in May and the highest was in August. At Maracas, lowest and highest root population levels were 41 and 344 nematodes/10g in March and June respectively. The mean populations for growing medium varied from 20 to 76/100 cm^3 for May and October respectively.

Three distinct peaks were observed at Arima in September, February and July. Means of root populations for the lowest and highest at Arima were 1 and 105 nematodes per 10g roots for June and September respectively. Growing medium mean population varied from 0 to 39 in September and February respectively.

Paratylenchus minutus was found only at Maracas and showed similar population fluctuations as *R. similis*. Two distinct peaks were observed, one in September to November and the other from April to June. A lower peak was observed in January to February (Figure 1).

Distribution of *R. similis* in roots and growing media at three locations

The mean percentages of females, males, and juveniles of *R. similis* in roots and growing media were compared at the three locations. The percentages of females and juveniles of *R. similis* in roots were significantly ($P=0.05$) higher than males in root at the three locations. However, there were no significant differences ($P > 0.05$) between the percentages of females and juveniles in roots at the three locations. Also there were no significant differences ($P > 0.05$) between percentages of males in roots at Oropouche and Maracas, but these were significantly ($P = 0.01$) higher than at Arima.

The percentages of females in the growing medium were significantly ($P = 0.01$) higher than the juveniles and males at the three locations. The percentage of juveniles in growing medium at Arima was significantly lower ($P = 0.001$) than for Oropouche and Maracas. There was no significant difference ($P > 0.05$) between juveniles and males in the growing medium at the three locations.

Fungi associated with *R. similis* infested roots

Fusarium sp., *Rhizoctonia* sp., *Pythium* sp., *Phytophthora* sp. and *Penicillium* sp. were isolated from roots lesions but *Fusarium* and *Penicillium* spp. were common at all locations. *Rhizoctonia* sp. was the main fungal species inhabiting anthurium roots at Arima. In addition, there was more severe root rotting of declining plants at Oropouche and Maracas compared to Arima. This observation was not investigated.

DISCUSSION

Radopholus similis was the predominant nematode associated with anthurium at the three locations. At Maracas the application of a foliar fertilizer and the use of nematicides may have contributed to the longevity of the plants. The application of aldicarb every six months may have held *R. similis* in check thus maintaining population levels lower than 200 nematodes /10g roots compared to the higher populations observed at Oropouche. The management strategy adopted at Oropouche was possibly not as effective compared to the two other locations and may have contributed to the higher population levels at this location. The lower means observed at Arima were possibly due to the use of more potent nematicides such as aldicarb and phenamiphos. The use of phenamiphos in Jamaica (Hutton, 1987) and aldicarb and phenamiphos in Hawaii (Aragaki *et al.*, 1984) were also effective in reducing population levels of *R. similis* on anthurium.

Paratylenchus minutus occurred only at Maracas and was not as commonly distributed as the burrowing nematode on the crop. It appeared that the low numbers of this nematode observed in July and March were related to nematicide treatments.

The coefficient of variation (CV) appeared to show a similar trend for the three locations. The higher values at Arima were due to the low means and do not indicate greater variability in population means compared to the other two locations. However, the population cycle is responsible for the lower CV that occurred periodically at the three locations. The use of nematicides along with the other management practices in the shade-houses may have also affected the spatial distribution of the nematodes.

Despite the extreme differences in *R. similis* population densities, a defined pattern of fluctuation was discernible for all three locations. The cultivation of anthurium as a monocrop, nature of growing medium, the differences in site management with respect to the frequency in use and types of nematicides, location of site, age of plants and cultivars are factors that may have affected the population densities and fluctuation at the three locations. Goo *et al.* (1994) reported *R. similis* populations in anthurium cultivars varied from 3.4 to 110.8 nematodes/g roots in Hawaii. Bala and Hosein (1996) found that *R. similis* populations could exceed 1,000 /10g fresh root, and varied with site and cultivars. In perennial crops, variation in population peaks for *R. similis* was observed during the year and over years for different countries (Mohandas and Ramana, 1988; Koshy and Sosamma, 1978; Ducharme and Suit, 1967).

The comparable proportion of *R. similis* females, males and juveniles for the three locations may indicate that the population density did not influence the composition of the nematode in anthurium. There were always more females in anthurium roots and growing medium and this was also observed in bananas (Mateille, 1992).

Radopholus similis damage to the root system could have induced secondary attacks by parasitic and saprophytic fungi. This may contribute to root rotting and lower population levels of the nematode. The association of *R. similis* with *Pythium splendens* has been reported as part of a disease complex contributing to anthurium decline (Hutton, 1987). The association of *R. similis* / fungi disease complex in a range of other agricultural crops has been reviewed by Koshy, 1986. Nematodes are of tremendous importance as components of disease complexes with other pathogen. Their importance cannot be overlooked, as some of the damage normally ascribed to nematodes alone can be part of a complex to which nematodes contribute. Further investigation is required in this area.

The ecological environment created by the drier conditions as a result of the bed being constructed with a convex base and lined with polyethlylene at Arima may have favoured the more frequent occurrence of *Rhizoctonia* spp., compared to the other shade-houses. *Fusarium* spp were also the most common fungi isolated from roots at all sites. Bateman (1961) reported that *Rhizoctonia* stem and root rot were favoured by relatively high temperature and dry soil conditions compared to lower temperature and wet soil conditions for *Pythium* sp. In the shade-houses *R. similis* always appeared to be the major pathogen associated with anthurium root rot even though fungal organisms may be present.

With respect to control methods certification of disease free material must be emphasised as part of an integrated control strategy for *R. similis* in anthurium. The need for more frequent sampling or monitoring will assist in identifying the critical times before nematode populations can buildup to damaging levels. There will always be the dependency on the use of synthetics for high cash crop such as anthurium. However, the timely application of nematicides such as aldicarb and phenemiphos will decrease plant protection cost and lower the volume of pesticides released into the environment. Alterative control strategies such as hot water treatment and the use of organic amendment have proven to be effective managements methods. Their integration with other management strategies should be investigated so as to complement the use of pesticides.

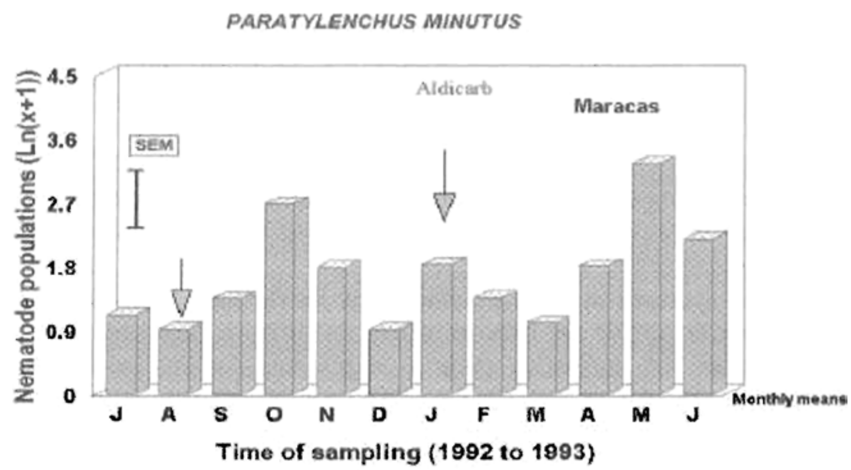

Figure 1. The population fluctuation of *Paratylenchus minutes* in anthurium roots at Maracas. Plants were treated with aldicarb at $10 g/m^2$ every six months.

Table 1. Statistical parameters on the distribution of *Radopholus similis* populations [ln(x+1)], occurring in anthurium roots and growing media at Oropouche, Maracas, and Arima in Trinidad.

Location (Oropouche)										
	Roots (10 g)					Growing medium (100 cm3)				
Time of sampling	Mean	SEM	Stdev	Range Min.-Max.	CV	Mean	SEM	Stdev	Range Min.-Max.	CV
July	4.75	0.26	0.75	4.03-5.50	0.16	4.42	0.09	0.20	4.19-4.65	0.05
August	6.56	0.44	0.98	4.95-7.95	0.15	3.91	0.39	0.87	2.57-4.62	0.22
September	6.86	0.55	1.24	4.77-7.89	0.18	4.89	0.18	0.39	4.29-5.25	0.08
October	6.26	0.41	0.92	5.07-7.35	0.15	5.34	0.22	0.49	5.02-6.03	0.09
November	6.71	0.21	0.48	6.20-7.23	0.07	5.09	0.40	0.89	4.03-6.10	0.17
December	4.98	0.05	1.12	3.43-5.86	0.22	4.10	0.33	0.73	3.93-5.71	0.18
January	6.42	0.49	1.08	4.51-7.03	0.17	1.79	0.04	0.08	4.26-5.49	0.04
February	6.58	6.55	0.23	5.94-7.22	0.03	5.44	0.19	0.43	4.97-6.10	0.08
March	4.10	1.11	2.45	0-6.02	0.60	4.72	0.12	0.26	4.51-5.14	0.06
Abril	5.54	0.34	0.77	4.93-6.65	0.14	3.44	0.35	0.79	0-4.04	0.23
May	5.48	0.16	0.36	4.86-5.72	0.07	3.44	0.35	0.79	2.40-4.51	0.23
June	5.19	0.45	1.01	3.66-6.52	0.19	2.62	0.85	1.89	0-4.71	0.72
Mean	6.10	0.23	0.79	4.89-7.26	0.13	4.59	0.23	0.78	3.18-5.52	0.17
Location (Maracas)										
	Roots (10 g)					Growing medium (100 cm3)				
Time of sampling	Mean	SEM	Stdev	Range Min.-Max.	CV	Mean	SEM	Stdev	Range Min.-Max.	CV
July	3.38	0.53	1.18	2.08-4.72	0.35	2.51	0.69	1.55	0-3.99	0.62
August	4.28	1.04	2.31	1.10-7.22	0.53	1.72	0.72	1.62	0.-3.33	0.94
September	3.80	0.69	1.54	2.20-6.03	0.41	3.20	0.23	0.51	2.56-3.95	0.16
October	3.65	0.43	0.97	2.64-5.20	0.27	4.16	0.37	0.82	3.22-4.99	0.19
November	4.67	0.57	1.26	2.77-5.99	0.27	3.19	0.43	0.97	2.30-4.66	0.30
December	4.05	0.50	1.11	2.77-5.40	0.30	2.71	0.68	1.53	0-3.58	0.56
January	3.13	1.07	2.40	0-5.20	0.52	3.89	0.15	0.34	3.50-4.23	0.09
February	3.54	1.06	2.37	0.5.55	0.65	3.99	0.52	1.17	1.95-4.84	0.29
March	3.51	0.22	0.48	2.94-3.97	0.10	2.86	0.77	1.82	0-4.89	0.64
Abril	4.66	0.29	0.64	3.71-5.52	0.18	3.65	0.30	0.68	2.94-4.44	0.19
May	3.51	0.54	1.22	1.61-4.75	0.26	2.33	0.69	1.55	0-3.78	0.67
June	5.19	0.24	0.54	4.43-5.77	0.15	3.93	0.17	0.37	3.61-4.51	0.09
Mean	4.58	0.18	0.64	3.74-5.84	0.14	3.56	0.56	0.56	2.49-4.34	0.16
Location (Arima))										
	Roots(10 g)					Growing medium (100 cm3)				
Time of sampling	Mean	SEM	Stdev	Range Min.-Max.	CV	Mean	SEM	Stdev	Range Min.-Max.	CV
July	2.15	1.33	2.98	0-6.03	1.39	0	0	0	0-0	0
August	1.14	0.74	1.66	0-3.64	1.49	1.19	0.73	1.63	0-2.99	1.37
September	1.15	0.70	1.58	0-3.05	1.37	1.41	0.88	1.97	0-4.03	1.60
October	1.23	0.70	1.78	0-3.61	1.45	0.51	0.51	1.15	0-2.57	2.24
November	0.28	0.79	0.62	0-1.39	2.21	1.40	0.86	1.93	0-3.85	1.50
December	2.32	0.28	2.42	0-5.61	1.04	0	0	0	0-0	0
January	1.65	1.08	2.28	0-4.24	1.37	1.45	0.70	1.56	0-3.22	1.29
February	2.10	1.02	2.26	0-4.62	1.08	1.13	0.72	1.60	0-3.37	1.64
March	1.13	0.76	1.70	0-3.85	1.50	0	0	0	0-0	0
Abril	0.23	0.28	0.62	0-1.38	2.21	1.49	0.66	1.47	0-0	1.24
May	3.21	0.37	0.83	2.2-3.87	0.26	2.20	0.90	2.00	0-3.95	0.97
June	0.32	0.32	0.72	0-1.61	2.25	0.89	2.50	1.25	0-2.64	1.58
Mean	2.49	0.41	1.43	0.47-4.67	0.57	2.08	0.29	1.00	0-3.68	0.48

SEM = standard error of means; CV= coefficient of variation (Cv=s/x), Means (x) are based on 5 monthly samples; S= standard deviation; N = 12 monthly means: each monthly means comprised of five samples.

Table 2. Population densities [ln(x+1)] of *Radopholus similis* females, males, and juveniles in anthurium shade-houses at three locations in Trinidad.

		(A) Roots (10g)		
Locations	Females Mean	Males Mean	Juveniles Mean	Total Population
Oropouche	7.86 (2592)	6.61 (742)	7.75 (2322)	8.65 (5710)
Maracas	6.07 (433)	4.77 (118)	5.90 (365)	6.82 (916)
Arima	3.99 (54)	2.59 (13)	3.57 (36)	4.51 (90)
SEM	0.63**	0.53**	0.57**	0.69**
		(B) Growing media (100 cm3)		
Locations	Females Mean	Males Mean	Juveniles Mean	Total Population
Oropouche				
Maracas				
Arima				
SEM				

Nematode populations of (A) Roots and (B) growing media ln(x+1) transformed; Figures in paranthesis were backtransformed ln(x+1) nematode populations; ** is significant at (P=0.01); SEM is standard error of mean.

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EFFET DE L'ELIMINATION DU VIRUS DE LA MOSAIQUE CHEZ *DIOSCOREA TRIFIDA* CV INRA 5-20 SUR LA PRODUCTION DE TUBERCULES AU CHAMP.

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RESUME: L'espèce *D. trifida* est entièrement virosée et sa culture est menacée de disparition dans la zone caraïbe. Les travaux de l'équipe de Degras (Saleil et al.1990) au Centre INRA des Antilles et de la Guyane, ont permis d'obtenir à partir du cultivar INRA 5-20, un clone CT 10 indemne du virus de la mosaïque (YMV). Ce papier donne les premiers résultats d'évaluation des potentialités de production de ce clone en vue de redynamiser la culture de l'espèce. Des vitroplants plantés en 1999 ont produit des semences dites de première génération. En 2000, des cultures comparées issues de ces semences et de vitroplants ont donné un rendement moyen de plus de 2 kg par plante, équivalent à plus de 40 t pour 20 000 pieds à l'hectare. De plus, le nombre de tubercules utilisables comme semences (25–100 g) représente 2.5 à 10 fois la quantité nécessaire à la replantation. Des essais d'évaluation des rendements obtenus dans les conditions de l'agriculteur sont en cours.

ABSTRACT: Most of *D. trifida* cultivars (cush cush yam) available are infected by viruses mainly yam mosaic virus (YMV). The species is threatened with disappearance in the Caribbean zone. In 1990, Degras and his team (Saleil et al.,1990), at the Centre INRA des Antilles et de la Guyane, have succeeded to obtain a clone CT 10 free from YMV from the cultivar INRA 5-20. This paper reports the preliminary results of the evaluation of potential production of that clone. The goal is to encourage the re-introduction of cush cush yam in the farms. In 1999, the planted vitroplants produced seed yam (called first generation). In 2000, tuber harvest from crop obtained from seed yam and vitroplants gave an average yield of more than 2 kg per plant, equivalent to more than 40 metric tons for 20 000 plants per hectare. Moreover, the number of seed yam (25-100g) represents 2.5 to 10 times the amount needed for the next planting. Tuber yield assessment in farming conditions is under way since the beginning of this year.

INTRODUCTION

Les tubercules de l'igname américaine *Dioscorea trifida* (Igname cousse couche) sont très appréciés dans les caraïbes pour leurs qualités organoleptiques et nutritionnelles. Leur valeur alimentaire est un peu supérieure à celle de la pomme de terre dont ils émulent tous les modes de préparation (Degras et al., 1977).

Parmi les Dioscoreae cultivées D. trifida fleurit et produit des graines, ce qui a conduit à un programme de sélection et d'amélioration génétique à l'INRA pendant de longues années. Le premier cycle a conduit à plusieurs hybrides. Le plus performant, dénommé INRA 5-20, a donné en station expérimentale 39 t/ha et dans un réseau d'essais en Guadeloupe et en Martinique près de 19 t/ha, supérieurs de 30 à 50 % aux rendements des cultivars traditionnels (Arnolin, 1973; Degras, 1986). Un deuxième cycle d'hybridation et de sélection a conduit à la variété INRA 5-20, donnant des tubercules de meilleure qualité. Degras et al. (1993) rapportent que la variété INRA 5-20 promettait des rendements pouvant atteindre 55t/ha.

Malheureusement D. trifida est très sensible aux viroses et en quelques années tous les efforts de la recherche ont été anéantis par une attaque massive du virus de la Mosaïque de l'igname (YMV) avec une réduction drastique des rendements. Les tubercules-semences, indemnes du virus, sont devenus rares et une désaffection progressive pour la culture de cette espèce s'est installée. Des tentatives de guérison entreprises depuis quelques années sur la variété INRA 5-20, ont conduit à un clone CT10, grâce à la combinaison de la culture in vitro et de la thermothérapie, et M7.2 par culture de méristème, tous deux issus du cultivar INRA 5-20 (Balagne, 1985; Saleil et al. 1990). L'observation du comportement de ces deux clones in vitro et au champ a montré que seul CT10, après contrôle sérologique, est indemne de potyvirus (YMV, YMMV,..).

Ce travail montre qu'il est désormais possible de produire du matériel de plantation sain (vitroplants et/ou tubercules-semences indemnes de YMV) à partir de CT 10, ouvrant ainsi la voie au redémarrage de la culture de l'igname cousse-couche qui redevient une spéculation rentable pour l'agriculteur. Nous rapportons les premiers résultats d'évaluation comparative de cultures issues de vitroplants et de tubercules-semences (première génération) comme matériels de plantation.

MATERIEL ET METHODES

Les vitroplants utilisés dans cette expérimentation proviennent d'une tissuthèque de plants de D. trifida cv INRA 5-20 clone CT10, indemnes de potyvirus et en particulier du virus de la mosaïque d'igname (Yam Mosaic virus). La multiplication est obtenue en salle de culture sur milieu de Murashige et Skoog additionné des vitamines Morel et Martin. Au bout de 45 à 60 jours, les plants sont repiqués sur des pastilles de tourbe (jiffy pots) et sont transférés en salle d'acclimatation où ils passent encore 3 semaines. La dernière étape consiste à les adapter progressivement aux conditions extérieures avant leur plantation au champ.

Les tubercules-semences (dits de première génération) sont obtenus à partir de culture de vitroplants plantés l'année précédente. Ils ont été testés à l'aide d'un sérum monoclonal anti-potyvirus (AGDIA, Inc Elkhart, USA) et sont exempts de la mosaïque de l'igname.

Pour mettre la culture dans les meilleures conditions d'estimation des potentialités de chaque matériel de plantation, les ignames ont été plantées sur un sol utilisé l'année précédente pour la culture maraîchère. Au moment de la préparation il a reçu un amendement organique similaire à celui utilisé pour les cultures maraîchères.

L'expérimentation vise à comparer trois cultures constituées chacunes de 50 plantes. Le matériel de plantation est constitué de vitroplants et de tubercules-semences de deux classes de poids (25-35 g) et (55-65 g). Les cultures sont menées en conditions irriguées et non irriguées. La plantation est effectuée en avril 2000 sur des billons espacés de 1 mètre. Chaque plant sur le billon est distant de 40 cm, ce qui correspond à 25 000 pieds à l'hectare. Pour une meilleure utilisation de la lumière, les plantes ont poussé sur des tuteurs hauts de 1.50m. Pendant les 2 premiers mois toutes les plantes ont été irriguées. Seuls les lots considérés comme irrigués ont continué à bénéficier d'un arrosage tous les deux jours par aspersion correspondant à un apport d'eau journalier de 7 mm. Malheureusement le stress hydrique sur les lots dits non irrigués n'a duré qu'un mois à cause de l'arrivée précoce des pluies avec une répartition uniforme sur tout le cycle de la plante. L'effet du stress hydrique, bien que n'ayant duré qu'un temps court, semble avoir suffi pour moduler les résultats que nous rapportons

Chaque plante reçoit au pied, 3 mois après plantation, 40 g d'un engrais complet. A la fin du cycle les mesures ont été faites sur l'ensemble des plantes correspondant à un traitement.

RESULTATS ET DISCUSSION

Malgré les réserves faites sur l'effet de l'eau sur les traitements nous continuerons à parler de plante irriguée et non irriguée pour la clarté de l'exposé.

Initialement dans l'esprit des chercheurs, l'utilisation des vitroplants comme matériels de plantation serait destinée à fournir des tubercules-semences (1ère génération). Une technologie de production en masse de vitroplants indemnes de virose, livrables pour plantation directe au champ a été mise au point. Elle est semblable à la technologie de production de tubercules-semences à partir des minisetts, en usage au Nigeria (Orkwoor, 1997). C'est ce que nous avons fait en 1999 pour obtenir des tubercules-semences de première génération à partir de vitroplants après assainissement des plants. Nous avons eu la surprise de constater que les vitroplants (sur une culture de 100 plantes entièrement récoltées et analysées) avaient un rendement moyen de plus de 2 kg de tubercules par plante, répartis en tubercules commercialisables (poids >100 g) et en tubercules-semences. Une analyse plus complète a donc porté sur les cultures de l'année suivante que nous rapportons dans ce travail.

Production de tubercules

Que ce soit avec les vitroplants ou avec les tubercules-semences de classe 25-35 g ou 55-65 g, le nombre de tubercules par plante est stable quel que soit le traitement. Il se situe entre 19 et 25. Sur la base des intervalles de confiance avec α-0.01, les nombres de tubercules rencontrés dans les différents traitements ne sont pas significativement différents. Cependant une tendance à l'augmentation du nombre de tubercules est observée en condition non irriguée.

Le rendement moyen de tubercules par plante irriguée et non irriguée est respectivement (2.2 $\pm$ 0.4) kg et (2.4 $\pm$ 0.4) kg pour les vitroplants; (2.5 $\pm$ 0.5) kg et (3.7 $\pm$ 0.7) kg pour les semences de 25-35 g; (2.6 $\pm$ 0.7) kg et (3.4 $\pm$ 0.9) kg pour les semences de 55-65 g. Les rendements ne sont pas significativement différents en conditions irriguées, quel que soit le matériel utilisé (vitroplants ou tubercules). Le traitement « non irrigué » provoque une augmentation significative des rendements avec les tubercules-semences. puisqu'ils dépassent 3 kg. L'utilisation de tubercules de 55-65g au lieu de 25-35g ne se justifie pas car le rendement n'est pas amélioré.

Les poids moyens des tubercules ont été déterminés sur la totalité des tubercules produits par la culture puis sur la classe de tubercules commercialisables. En condition irriguée ou non irriguée le poids moyen de tubercules est de l'ordre de 100 g (Tableau) pour les vitroplants, et respectivement 116 g et 149 g pour les semences 25-35g, 137 g et 169 g pour les semences de 55-65 g. L'augmentation du rendement en condition non irriguée se traduit aussi par un poids moyen de tubercules plus élevé.

En ce qui concerne les tubercules commercialisables (poids>100 g), le poids moyen de tubercules est de l'ordre de 200 g pour les vitroplants, 230 g pour les semences de 25-35 g et supérieur à 245 g pour les semences de 55-65 g. La proportion de tubercules commercialisables représente 73.6% à 78.8% de la récolte totale pour les vitroplants alors qu'elle se situe entre 80% et 89% pour les tubercules-semences tout poids confondu.

Production de semences

L'une des particularités intéressantes de D. trifida est son aptitude à produire à la fois des tubercules commercialisables et des tubercules-semences (poids compris entre 25 et 100g) grâce à la multi-tubérisation. Si le coefficient de multiplication définit le nombre de semences de poids 25-100 g produites par plante, nous obtenons respectivement 2.1 et 9.6 pour les vitroplants irrigués et non irrigués. Il est respectivement, en condition irriguée et non irriguée, de 7.5 et 8.3 pour les tubercules-semences de 25-35 g, 6.6 et 5.6 pour les tubercules semences de 55-65g. Lorsqu'on part de plants sains, la culture génère des semences pour la plantation suivante et pour une éventuelle commercialisation des semences non utilisées, susceptible de produire un revenu non négligeable à l'agriculteur.

Le rendement en tubercules par plante obtenu à partir de vitroplants est très supérieur à celui qui était attendu et confirme nos résultats antérieurs. Sachant que les vitroplants, lors de la plantation, ne disposent d'aucune réserve glucidique, les résultats nous conduisent à relativiser l'importance de l'effet du tubercule-mère sur le rendement final lorsque (1) l'eau n'est pas facteur limitant, (2) qu'une fertilisation appropriée est assurée aux plantes et enfin (3) que le cycle est suffisamment long chez D. trifida pour un développement optimal de son appareil végétatif. L'irrigation tout au long du cycle ne semble pas être nécessaire puisqu'un stress hydrique, bien positionné au cours du cycle peut avoir un effet bénéfique sur le rendement. Ceci ouvre la voie à l'étude des phases critiques du cycle pour une optimisation de l'apport de l'eau.

En ce qui concerne les tubercules-semences, l'utilisation des poids 55-65 g au lieu de 25-35 g n'améliore pas de manière significative le rendement en tubercules commercialisables et en semences. En plus des semences de poids 25-100g, chaque plante produit un grand nombre de tubercules de poids compris entre 10-25g, qui peuvent être utilisés pour produire, après germination, des plants. A cause de leur fragilité, ils poseront les mêmes exigences que les vitroplants dont la prise en charge pourra être assurée par une filière de production de plants.

Les résultats rapportés sont des moyennes sur des cultures comportant au minimum 50 plantes. Un pied de vitroplant dans la culture a donné jusqu'à 63 tubercules totalisant un poids de 6.30 kg. Un pied issu d'un tubercule-semence a produit 47 tubercules totalisant 6.7 kg. Nous en déduisons que les performances potentielles de production de tubercules à partir de vitroplants ne sont pas très éloignées de celles des tubercules-semences. Les recherches sur les facteurs de l'élaboration du rendement sur cette variété INRA 5-20, indemne de virose vont se poursuivre. Sur le plan pratique des essais multi-locaux sont en cours depuis cette année, chez les agriculteurs pour déterminer les rendements en conditions réelles, et suivre la vitesse de recontamination virale au champ. L'objectif affiché est la re-introduction de cette igname dans les exploitations pour y trouver la place qu'elle devrait avoir.

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Tableau : Production de tubercules de consommation et de tubercules-selmences à partir de *D.trifida*, variété INRA 5-20, clone CT 10 assaini.

Matériels de plantation	Vitroplants		Semences 25-35g		Semences 55-65g	
Traitement	**Irrigué**	Non irrigué	Irrigué	Non irrigué	Irrigué	Non irrigué
Nombre moyen de tubercules/plante	21,4 ± 2,5	24,4 ± 2,5	21,6 ± 2,9	24,5 ± 3,3	19,0 ± 3,1	20,1 ± 2,6
Rendement moyen / plante (kg)	2,2 ± 0,4	2,4 ± 0,4	2,5 ± 0,5	3,7 ± 0,7	2,6 ± 0,7	3,4 ± 0,9
Poids moyen de tubercules (g)	103	96	116	149	137	169
Poids moyen de tub. com.* (g)	209	197	230	234	250	281
Rendement total T/ha (20000 pieds)	44	47,4	50	73,5	51,5	67,9
Rendement en tub. com.*, T/ ha (20000 pieds)	34,7	34,9	40	63	43,1	60,3
% de la récolte totale	78,8	73,6	80,1	85,8	83,8	88,7
Nombre de semences 25-100g /plante	2,1	9,6	7,5	8,3	6,6	5,6

*Tub. com. = tubercules commercialisable

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PRELIMINARY INVESTIGATIONS INTO THE TAXONOMY OF THE GALL MIDGES (DIPTERA: CECIDOMYIIDAE) AFFECTING *CAPSICUM* SP IN JAMAICA

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ABSTRACT: Persistent interception of a Dipteran larva in shipments of hot pepper (Capsicum chinense) from Jamaica to the United States of America (USA) in recent years, has led to the imposition of mandatory fumigation of the commodity prior to export. The insect has been identified both as Contarinia lycopersici, a tomato pest of quarantine importance to the USA and Prodiplosis longifilia a citrus pest restricted in that country to Florida. The present study compares the pepper midges in Jamaica with C. lycopersici and P. longifilia based on morphological characteristics and host infestation. Preliminary results derived from comparative morphological examination of adult males, suggest that the pepper gall midges of Jamaica are distinguishable from C. lycopersici and P. longifilia. There is an urgent need to identify and or describe the species present in order to develop a management strategy for the pest.

INTRODUCTION

In February 1997, USDA-APHIS reported the interception of a Dipteran larva in shipments of hot pepper from Jamaica to the United States of America (USA). The insect was declared of Quarantine importance, as the USA has a zero tolerance for dipterans. Persistent interception of the pest led to a mandate, effective October 1998, that all hot peppers for export from Jamaica to the USA be fumigated with Methyl Bromide.

The insect has been variously identified as *Contarinia* spp, *Contarinia lycopersici and Prodiplosis longifilia.* It was unclear to the Jamaican authorities whether one or both species were present. Thus the gall midge problem in Jamaica became known as the gall midge complex (Prodiplosis *longifilia* and *Contarinia lycopersici).*

The *Contarinia* and *Prodiplosis* genera both belong to the tribe Cecidomyiini, a diverse group made up entirely of plant feeders (Gagne 1989). They are reportedly close relatives, being separable only by the males. The male terminalia of *Prodiplosis* is distinguishable from Contarinia by the long aedeagus relative to the length of the hypoproct and gonopods and the dorsoventral rather than mesolateral articulation of the gonopods (Gagne 1986).

Approximately 300 species have been assigned to the *Contarinia* genus, while there are 10 described *Prodiplosis* species. Member species of both genera attack flowers and buds of a wide range of hosts (Gagne 1994, 1986).

Contarinia lycopersici (Felt) has been reported from the West Indies (but not from Jamaica) from as early as 1932, where it was found to attack tomatoes. No alternate host was found. The larvae infested and caused injury to tomato flowers, which may wither and absciss or the ovary is damaged, resulting in malformation of fruits (Callan 1941).

Prodiplosis longifilia (Gagne) is reported feeding on limes in Florida and from Columbia and Peru where it attacks tomatoes, potatoes, alfalfa and other crops (Pena and Mead 1988). The larvae completely destroy the ovaries of the flowers causing premature flower abscission.

In Jamaica, gall midge larvae are found feeding within the pedicel of mature hot pepper fruits as well as in the flower buds of hot and bell peppers. A recent survey of infested farms across the island revealed that 66% of farms had larvae in both fruit pedicel and flower buds, 28% had only the fruit pedicel infested and 6% had larvae only in the flower buds (Goldsmith 2000,). Larval feeding within the fruit pedicel results in a brown to black scar that is often secondarily invaded by fungi (e.g. *Alternaria sp.*). The result is rotting of the fruit, which may fall from the plant or is otherwise unmarketable. Infested flower buds whither and may fall from the tree.

The present study compares the pepper midges in Jamaica with *C. lycopersici* and *P. longifilia* based on morphological characteristics and host infestation.

MATERIALS AND METHODS

Adult and larval mounts were prepared of gall midges found infesting hot pepper pedicel separate from those found within pepper flower buds. To obtain adults, larvae were placed in petri dishes or glass jars containing loose, damp soil. Emerged adults were collected from the top and sides of the container 10 to 12 days after incubation.

Some larvae and reared adults were killed and placed in 70% ethyl alcohol. Specimens were mounted for microscopic study in Canada balsam, using the method outlined by Gagne (1989, 1994). All specimens were examined using a phase-contrast, compound microscope. Drawings were made of morphological characters including male genitalia, male and female antennae, ovipositor, legs and wings.

The lengths of the female first and second antennae flagellomeres of 20 pepper 'bud' midges and 20 pepper 'stem' midges were measured. The ratio of the length of the first to the length of the second was calculated for both groups. Data were analyzed using the analysis of variance.

Attempts were made to identify the genera and the species using taxonomic keys developed by Raymond Gagne (Gagne 1994).

Tomato and citrus flowers from plants inter-cropped with or planted close to infested pepper fields were examined for gall midge infestation. Two pepper plots, each planted at Bodles Research Station and next to pepper plots infested with pepper 'bud' midge, were monitored for gall midge infestation. Each week, four flower buds were removed from each of ten plants and dissected using a dissecting microscope. A third plot, planted in Spring Village, St. Catherine (5 km east of previous site), where tomatoes were inter-cropped with "stem" midge infested hot peppers, was similarly monitored over a two- month period (March to May 2000).

Two separate hot pepper plots planted at Bodles Research Station, March–August 2000 and October 2000 –June 2001, and infested with pepper 'bud' midge, were monitored for pepper 'stem' midge infestation. Three mature fruits were removed weekly from each of ten plants and dissected using a dissecting microscope.

Tomato and citrus buds from plants isolated from infested fields were also examined.

RESULTS AND DISCUSSION

Gagne's taxonomic keys classify the Jamaican gall midges as: Subfamily: Cecidomyiinae, Super tribe: Cecidomyiidi, Tribe: Cecidomyiini, Genus: *Prodiplosis* and *Contarinia*.

The larval specimens examined were similar morphologically. They possessed a clove shaped spatula, one pair enlarged and asetose terminal papillae and three pairs of terminal papillae with short setae (Figure 1). The structure of the terminal papillae is characteristic of the Cecidomyiini tribe and is similar for both the *Contarinia* and *Prodiplosis* genera. According to Gagne (1995) larvae of the two genera are indistinguishable.

All adult specimens examined during the study exhibited the following combinations of generic characters: palpus four segmented, antennae 2+12 segmented, male flagellomeres all bimodal and bifilar; female flagellomeres elongate with relatively short necks; tarsal claws simple, curved beyond mid-length, empodium as long as claws; ovipositor long and finely tapered; male terminalia with short simple tapered aedeagus, bilobed hypoproct; short, simple gonocoxite and tapered gonostylus.

The species of gall midge found infesting pepper flower buds differ morphologically from those found in the pepper pedicel with regards to the relative size of the female first and second antennal flagellomere. Results revealed significant differences in the length of the first antennal flagellomere of the pepper 'stem' midge when compared with those of the pepper "bud" midge. The first flagellomere of the 'pedicel' midge averaged 17.0im in length and was 1.5 times that of the second, which averaged 11.1im. The mean length of the female first flagellomere of the 'bud' midge was 12.0im in length, 1.3 times as long as the second which measured 9.2im in length (Figure 2).

Differences in the lengths of the female first and second flagellomeres have been used by Gagne to distinguish between two similar *Contarinia* species: *Contarinia lycopersici* and *Contarinia maculipennis*. He reported that in *C. maculipennis* the female first flagellomere was 1.8 to 1.9 times that of the second while in *C. lycopersici* the difference was 1.4.

The pepper 'bud' midge does not appear to infest the pepper pedicel. No midge was found affecting pepper stems at Bodles Research Station after five and eight months of monitoring plots infested with the 'bud' midge.

The Jamaican gall midges differ from *Prodiplosis longifilia* with regards to the male terminalia, the male antennae and host preferences. The terminalia of male *P. longifilia* has a long aedeagus relative to the hypoproct while in the Jamaican midges the aedeagus is approximately the same length as the hypoproct (Figure 3). The long aedeagus is a character of the *Prodiplosis* genus and is used to separate it from *Contarinia* (Gagne1986, 1989). In this regard the Jamaican gall midge is more like *Contarinia*.

The flagellomeres of the male Jamaican gall midges are bifilar while those of P. longifilia are trifilar (Figure 4). Males in most of the Cecidomyiini genera, including the *Contarinia* genus, have two circumfila (bifilar) instead of three (trifilar) (Gagne 1989,1994). The male flagellomeres of *Prodiplosis* species, however, are variable and may have two or three circumfila (Gagne 1994).

Examination of citrus flower buds removed from orange trees intercropped with infested pepper plants revealed no gall midge infestation.

Morphologically, the Jamaican gall midges are quite similar to *C. lycopersici*. Preliminary investigations have revealed only one difference: the articulation of the male gonopods. All known species of *Contarinia*, including *C. lycopersici*, have mesolateral articulation of the gonopods (Gagne1986). The Jamaican gall midges, however, have dorsoventral articulation of the gonopods (Harris, Personal communications 2001).

Importantly, the Jamaican midges have not been found to infest tomato flowers.

CONCLUSION

There are two species of gall midges affecting hot peppers in Jamaica. One is strictly a flower bud pest while the other affects the pedicel of hot peppers. It is not yet known whether this species will affect other parts of the pepper plant. Gagne et al. 1999, reported on a *Clinodiplosis* species (Diptera: Cecidomyiidae) from Costa Rica, which affects the flowers and leaves and stems of cultivated peppers.

The pepper 'pedicel' midge appears to be the more economical, infesting more fields island-wide and resulting in scarred, unmarketable fruits. As it is present within the fruits, it is also the one more likely to be found in export boxes.

Both species differ from *P. longifilia* and *C. lycopersici* morphologically and in terms of host preference. They also differ from other species of *Contarinia* known to attack *Solanum* (Gagne 1995) as well as the three groups of *Prodiplosis* described by Gagne 1986. Importantly, they possess some characters that are used to separate *Contarina* from *Prodiplosis* species. Gagne reported that the *Contarinia* is distinguishable from *Prodiplosis* by the short aedeagus relative to the hypoproct and mesolateral rather than dorsoventral articulation of the gonopods. The Jamaican gall midges have a short aedeagus relative to the hypoproct (*Contarinia*) but a dorsoventral articulation of the gonopods (*Prodiplosis*).

It is possible then, that the Jamaican gall midge is an undescribed species of *Contarinia*, *Prodiplosis* or different genus altogether. Correspondence from Dr. Gagne through Dr. Harris suggested that the midges might be an undescribed species of *Prodiplosis*. Further work is needed to describe the species, determine life cycle and ecology so as to effect a management strategy for the pest.

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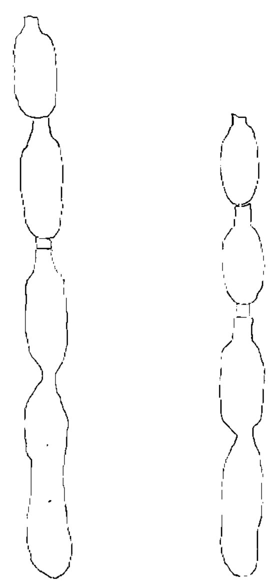
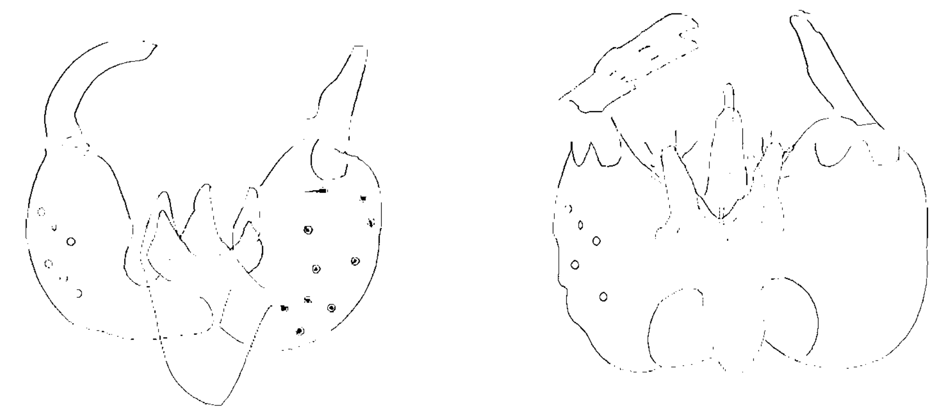
a b

FIG 1. Jamaica gall midge : a, larval spatula; b, larval posterior segment.



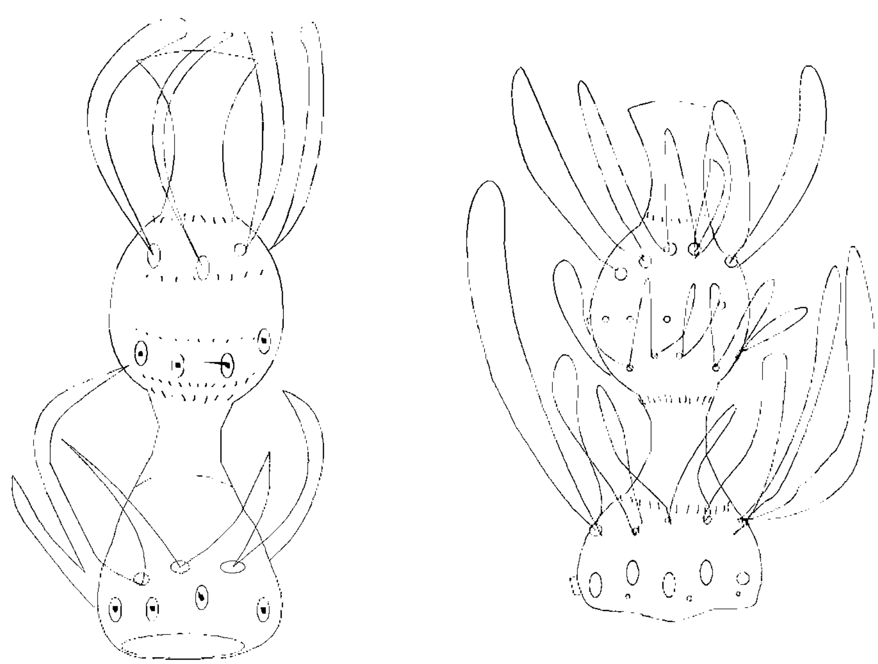
a b

FIG2 Female first through fourth antennal flagellomere
a, Jamaican 'ste'm midge; b, Jamaican 'bud' midge



a b

FIG 3 Male terminalia: a, Jamaican gall midge; b, *P. longifila* (Gagne1986)



a b

FIG 4. Male third antennal flagellomere:
a, Jamaican gall midge b, *P. longifilia*

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COMPLEJO MOSCA BLANCA-BEGOMOVIRUS EN EL CULTIVO DEL TOMATE Y GENERALIZACIÓN DE UN PROGRAMA PARA SU MANEJO

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RESUMEN: A partir del año 1989 y ante la presencia de altas poblaciones de moscas blancas y de severas afectaciones por begomovirus en el cultivo del tomate, se realizaron investigaciones para el diagnóstico de las virosis y de especies de moscas blancas, aspectos bioecológicos y epidemiológicos, consideraciones en el monitoreo de la plaga en hidropónicos y campo, así como ensayos de métodos de control. Los resultados obtenidos permitieron elaborar un sistema de manejo integrado, el que fue comprobado en diferentes áreas de tomate, donde se valoró el comportamiento de la plaga, la efectividad de las medidas de lucha y la colaboración con los productores en las decisiones a tomar y en la aplicación de la estrategia de control. La transferencia de la tecnología se basó en la limitación de la diseminación de las virosis, la reducción de los niveles poblacionales del complejo mosca blanca-begomovirus y la recuperación y mantenimiento de un nivel de saneamiento en las zonas dedicadas al cultivo del tomate, con la valoración de su impacto económico, ecológico y social. Este programa se ha generalizado desde los años 1992-1993 y en la actualidad se aplica en unas 15 mil hectáreas en todo el país, que representan el 64,7% del área cultivada. Es significativo que unas 7 mil hectáreas son protegidas con el bioplaguicida (V. lecanii), lo que ha contribuido a reducir la utilización de insecticidas químicos, alcanzando sólo un 10% y 3,3% de áreas afectadas por mosca blanca y por begomovirus respectivamente.

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IMPORTATION AND LABORATORY PRODUCTION OF TWO SPECIES OF PARASITIC WASPS FOR BIOLOGICAL CONTROL OF THE CITRUS BLACKFLY (*ALEUROCANTHUS WOGLUMI* ASHBY) (HOMOPTERA: ALEYRODIDAE) IN TRINIDAD

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ABSTRACT: Two exotic parasitic wasps, *Amitus hesperidum* Silvestri and *Encarsia perplexa* Huang & Polaszek, were introduced from Florida into Trinidad during 2000 and 2001, respectively, for the biological control of the citrus blackfly (CBF), *Aleurocanthus woglumi* Ashby. The importation was carried out following guidelines under the FAO Code of Conduct (1996) and the two species were reared in the laboratory for at least one generation to eliminate contaminants prior to being released in the field. Procedures followed during the importation are described. Details are provided of the protocols developed for the laboratory rearing of the CBF and the two natural enemy species.

INTRODUCTION

The citrus blackfly, *Aleurocanthus woglumi* Ashby (Homoptera: Aleyrodidae), a native of Asia, was first reported in the Caribbean from Jamaica in 1913. It subsequently spread to many other countries in the region (IIE, 1995) and was first reported from the Port of Spain area of Trinidad in 1998. Over the next two years, the pest spread rapidly, initially on citrus and other plants in backyard gardens, and later moved to areas of commercial citrus production. This rapid spread was attributable to a lack of effective, host specific natural enemies. The citrus blackfly (CBF) has the potential to cause severe losses in fruit production, ranging from 25% to almost complete crop failure (Smith *et al.*, 1964; Watts and Alam, 1973). This has serious implications for Trinidad, where citrus is an important commercial crop.

CBF is an excellent candidate for classical biological control since a number of successful biological control programmes have been launched against this pest in the Caribbean (Caltagirone, 1981; Browning, 1992; Martin, 1999). In January 2000, the Ministry of Food Production and Marine Resources (MFPMR), Trinidad & Tobago embarked upon a project aimed at the implementation of biological control for CBF. Two parasitic wasps selected for introduction were *Amitus hesperidum* Silvestri (Hymenoptera: Platygasteridae) and *Encarsia perplexa* (=*E. opulenta* (Silvestri) of authors, misidentified) (Hymenoptera: Aphelinidae). This was based on the fact that in all the countries where CBF was introduced, biological control using one or both natural enemies was found to be the most economical, long-term and sustainable method of control (Browning, 1992). In Florida, for example, *A. hesperidum* and *E. perplexa* successfully kept the pest under good control for more than 10 years, resulting in millions of dollars in savings and engendering an increased credibility in biological control of alien pests (Tefertiller *et al.*, 1991).

MFPMR funded the importation programme and contracted CABI Bioscience's Caribbean and Latin American Regional Centre (CLARC) to undertake the importation on its behalf. CABI was also required to assist with capacity building within MFPMR through the provision of training in laboratory production of CBF and the introduced natural enemies and in the identification of the two natural enemy species. Other partners in the importation programme were Caroni (1975) Ltd and the Cooperative Citrus Growers' Association (CCGA). The introduction was carried out following guidelines outlined in the Code of Conduct for the Import and Release of Exotic Biological Control Agents (FAO, 1996). The parasitoids were reared in the laboratory at CLARC for at least one generation prior to being released in the field. This paper outlines procedures followed during the introduction, and protocols developed at CLARC for the laboratory rearing of CBF and the two natural enemies.

IMPORTATION OF NATURAL ENEMIES

The natural enemies were obtained through collaboration with Entomologists in a laboratory in Florida, USA. The parasitoids were collected in the field in Florida and reared under laboratory conditions for 2-3 generations to eliminate any contaminants before being shipped to Trinidad.

One of the requirements of the Code of Conduct is the preparation of dossiers on the potential natural enemies being considered for introduction. Thus, prior to the importation, dossiers were prepared on *A. hesperidum* and *E. perplexa* and submitted to MFPMR for appraisal (Lopez *et al.*, 2000a, b). Each dossier consisted of three sections:

1. summarized information on CBF and its control, including biological control
2. summarized information on the potential natural enemy and
3. potential risks and their minimization, and procedures for elimination of contaminants

Relevant authorities within MFPMR reviewed the dossiers. Following this, the introduction of the two natural enemies was approved and the Plant Quarantine Division of MFPMR issued the necessary import permits.

One shipment of *A. hesperidum* and two shipments of *E. perplexa* were imported from Florida. Procedures followed during the importation were similar for all three shipments. Entomologists from CLARC and MFPMR and the Plant Quarantine Officer received each shipment at the airport. The shipment was then transported to CLARC's laboratories in Curepe and opened in the quarantine area in the presence of the Entomologist from MFPMR. All the insects in the shipment were carefully examined under the microscope and compared with voucher specimens to confirm their identity prior to being released on CBF-infested citrus plants under cages in the laboratory.

The first shipment, which arrived on the 5th of April 2000, was hand-carried by Dr. A. Polaszek, CABI Bioscience's expert taxonomist. It contained 240 adults of *A. hesperidum* and 200 mummies (pupae of CBF containing pupal stages of the parasitoid). After the shipment was opened, Dr. Polaszek prepared the voucher specimens by collecting some male and female *A. hesperidum* from the shipment vials and placing them in alcohol in small glass vials after confirming their identity under a microscope. The vouchers were deposited with MFPMR. The 200 mummies received in the shipment were carefully transferred into clear glass vials, covered with a mesh cap and placed on moistened paper towels in a clear plastic container. This prevented desiccation of the mummies and facilitated the emergence of a further 232 adults.

The first shipment of *E. perplexa*, containing 125 adults, arrived on the 5th of January 2001. The second shipment, which was received on 24th January, consisted of 200 adults. Of these, only 3 and 4 adults were males in first and second shipments, respectively, and the remaining were females. The Entomologists in Florida sent a glass vial containing about 6 specimens in alcohol with the shipments. This material was deposited with MFPMR as vouchers for the shipments.

Throughout the duration of the project, a total of six persons, including staff members from the Research Division of MFPMR, Caroni (1975) Ltd and CCGA, were attached to CABI Bioscience and received hands-on training in the production of CBF and the two natural enemies. They were thus exposed to the day-to-day problems encountered during the rearing process and the methods used to solve the problems.

During his stay in Trinidad, Dr. Polaszek conducted a one-day training on the taxonomic identification of parasitic Hymenoptera for all persons involved in the rearing and field release programmes. He elucidated the main characteristics used for distinguishing various parasitic genera that attack Aleyrodidae. The participants then examined alcohol-preserved specimens of *A. hesperidum* and female *Encarsia perplexa* (obtained by Dr. Polaszek during his visit to Florida) to familiarize themselves with various morphological features of each species. They also examined prepared slides of *E. perplexa* and other *Encarsia* spp.

IDENTIFICATION OF NATURAL ENEMIES

The morphological features used to diagnose *A. hesperidum* included the entirely dark (black) body, lack of wing venation (except for a short vein along the margin) and long, transparent wings, which extended beyond the length of the adult. Males were generally larger than females. All the antennal segments in males were almost similar in size and shape, and loosely attached to each other so that they were bead-like in appearance. The antennal segments in the female were more tightly packed and ended in a club-shaped clava.

Variations in the size, shape of abdomen and colour were among the main features that distinguished the two sexes of *E. perplexa*. Females were almost entirely yellow in colour, except for some dark markings on the thorax and the sides of the abdomen. The tip of the abdomen was black and pointed due to presence of a short, sharp ovipositor. The males were much smaller than females with body almost entirely black with occasionally lighter patches and the tip of the abdomen was not pointed but slightly rounded. There was a distinct fringe of hairs along the margin of the wings in both sexes.

LABORATORY PRODUCTION

Host plants: Citrus plants with 5-6 expanded new flush leaves were used for culturing CBF. The plants were potted in 15-cm diameter plastic bags in a 2:1 topsoil, manure mixture. They were maintained under caged conditions outdoors to prevent them from becoming infested with various pests. The plants were watered three times a week and a foliar fertilizer (Nutrex® N, P, K 20:20:20) was applied once a month.

Rearing conditions: Plants destined for use in laboratory production of CBF and the parasitoids were brought into the Controlled-temperature laboratories (CT Rooms) 1-2 days prior to being used in order to acclimatize them. All rearing rooms were fitted with a double door entrance and an ultra-violet light (uv light or insecutor) to prevent contaminants from getting in or out of these areas.

CT rooms: CT Rooms were used to obtain oviposition by CBF as well as for CBF and parasitoid rearing. Temperatures of 28±2° C and relative humidity (RH) 70±10% were maintained in the laboratory in which citrus plants were placed for oviposition. This room did not have any lights because better oviposition was obtained under dark conditions. In the other CT rooms used for rearing CBF and the parasitoids, the temperature and RH were 26°C and 60±10%, respectively. Artificial lighting was provided in the form of banks of 4-6 fluorescent lights and 2-4 incandescent bulbs, suspended 10-20 cm above the cages. The lighting regime used was 12 h light : 12 h dark.

Greenhouse conditions: The greenhouse was maintained under ambient conditions, with a wall-mounted fan for air circulation. Several steps were taken to prevent contaminants from getting into the rearing room. Along with the double door entrance and uv light, the room was sealed with on all sides with a nylon mesh. Additionally, a 20-cm wide moat around the greenhouse prevented ants and other contaminants from getting in.

Cages: Metal frame cages, 52 cm x 52 cm x 90 cm or 1 m^3, covered with thin, white nylon mesh and open at one end, were used for rearing both the CBF and the parasitoids.

Culture establishment and maintenance: Plants with new flush growth were examined for the presence of pests and diseases. They were washed with a very dilute soap solution, then with water and allowed to dry before being used for culturing CBF. Once the plants had developed 4-6 generations of CBF or 2-3 generation of parasitoids, they were completely depleted of nutrients. They were clipped back and moved out. The plants were placed under outdoor cages, fertilized and allowed to reshoot.

CBF

Five to nine potted plants were placed in each cage, depending on the size of the plants and the cage. Large numbers (400-1000) of field-collected CBF adults were released in each cage. A few days later, the plants were examined for oviposition, and for the presence of contaminants such as pests like mealybugs as well as natural enemies like coccinellids, parasitoids and spiders, which were promptly removed. Plants were labeled with date(s) of infestation and moved into cages in the outdoor rearing facility. When the allocated space in the outdoor facility became insufficient, they were placed in CT Rooms. CBF took about 7-8 weeks to complete one cycle outdoors and an additional 1-2 weeks in the CT Room. A total of 25-40 plants were infested each week until about 400-500 plants with moderate to heavy infestations were obtained.

For culture maintenance, emerging adults were allowed to continue to develop on the same plant(s) for another generation if new flush growth is present on the plant at this time. If new flush was not present, the adults were collected and released on clean plants with new flush placed in cages in the dark room for oviposition. Plants that harboured mainly 1st / 2nd instars were used for parasitoid rearing and the remaining plants were used for culture maintenance.

Amitus hesperidum

A total of 20 citrus plants harbouring mostly 1st instars of *Aleurocanthus woglumi* Ashby were set up in four small cages. All the adults received in the shipment as well as those emerging from the mummies were released in the various cages. Development of the parasitoid from egg to adult stage took 60-75 days. When the adult parasitoids began to emerge, the date(s) of emergence were recorded. The parasitoids were collected, sexed and allowed to mate. From an initial population of 472 adults, a total of 1983 parasitoids were produced in the first generation during June and July. The number of males produced was 606 and females 1492, with a male to female ratio of 1:2.3. A total of 491 adults (112 males, 379 females) were used for culture maintenance. The remaining 1492 adults (494 males, 998 females) were used for field releases.

Subsequently, routine culture maintenance was carried out by releasing about 50-100 mated females per cage containing 4-5 moderate- to heavily-infested plants. At least two generations of parasitoids could often be reared on most plants. This is because CBF adults usually emerged from unparasitized pupae about 2-3 weeks before parasitoids emergence occurred. Once the plants in the cage had new flush growth, the adults moved to these points and oviposited. Two-three weeks later, the eggs had hatched and mostly 1st / 2nd instars were present on the plants. The emerging parasitoids thus found these stages and oviposited on them. The parasitoids were subsequently collected using a brush or an aspirator and allowed to mate before being released in a new cage or in the field.

Amitus hesperidum was very prolific and a total of over 2000 parasitoids were produced at CLARC between August and November despite lower scales of production. More than half of these insects was used for augmenting field populations. Transfer of *A. hesperidum* cultures to MFPMR's Central Experimental Station, Centeno (CES) which began with the first laboratory generation in June/July, was completed in December 2000.

Encarsia perplexa

For the two shipments, a total of 18 and 15 citrus plants harbouring all stages, but predominantly 2nd/3rd instar of *Aleurocanthus woglumi* Ashby were set up in a total of 8 cages, 4 cages per shipment. Adults from the shipments were released on the plants within a few minutes after opening the shipment and examining the vials with parasitoids for contaminants.

Development from egg to adult stage of the parasitoids took 25–30 days. Production of first generation *E. perplexa* occurred in only one cage from the first shipment and two cages from the second shipment. A total of 237 female *E. perplexa* were collected for about six weeks during February and March 2001. A total of 176 females were sent for field releases between 6th February and 13th March. On the remaining, 32 unmated females were rclcased in second shipment cages @8 females per cage. This was done to ensure male production in these cages. The remaining insects, together with those emerging after the 13th of March, were used for maintenance of laboratory cultures as follows: Plants on which production of parasitoids occurred were placed in two 1m x 1m x 1m cages together with 5-10 new plants harbouring mixed stages of CBF. Adult *E. perplexa* that were already present or emerged later thus had additional CBF to parasitize. The cages were observed twice a month but were otherwise left undisturbed to provide near-natural conditions for the developing parasitoids.

During the 1st week of May, at least one male and fairly large numbers of females were seen in the cages. This meant that production of males and a new generation of parasitoids had occurred in the cages. From nearly 150 parasitoids that were found in the two cages, 110 females were collected and sent for field releases on the 8th of May. On the 16th of May, two *E. perplexa* females emerged from mummies collected at the site of the 1st release, confirming its establishment in the field. Culture maintenance in the large cages has continued. Transfer of cultures to CES has already begun and is expected to be completed in a few weeks.

Procedures for eliminating contaminants

Constant vigilance was of utmost importance to maintain clean, contaminant-free cultures. To deal with specific problems of contamination, the following routine practices were carried out:

- only healthy, contaminant-free plants were used in culturing CBF and parasitoids
- after CBF oviposition and before the introduction of parasitoids, plants were thoroughly examined for contaminants, which were promptly removed
- all infested plants were examined regularly and dead insects and other debris was removed
- when necessary, leaves with older infestations were wiped with a clean moist cloth to remove honeydew deposits and minimize the development of sooty mold
- cage meshes were changed regularly and dead insects and other debris removed
- the introduction process was overseen by experienced Entomologists at CABI Bioscience who had conducted extensive work on classical biological control of Aleyrodidae and other Homoptera

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FIELD REARING OF *AMITUS HESPERIDUM* SILVESTRI (HYMENOPTERA: PLATYGASTERIDAE) FOR CONTROL OF CITRUS BLACKFLY *ALEUROCANTHUS WOGLUMI* ASHBY (HOMOPTERA: ALEYRODIDAE) IN TRINIDAD W.I.

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ABSTRACT: *Amitus hesperidum* Silvestri (Hymenoptera: Platygasteridae) was introduced to Trinidad in 2000 in an attempt at classical biological control of the Citrus Blackfly *Aleurocanthus woglumi* Ashby (Homoptera: Aleyrodidae). Following quarantine, *A. hesperidum* were reared in the field in sleeve cages for multiplication and subsequent distribution. Fifty-three sleeve cages were established at six locations in Trinidad, however efforts were concentrated at the Todd's Road Citrus Estate of Caroni (1975) Limited. These sleeves resulted in a yield of 372 insects/sleeve with peak emergence at 56-66 days after the initial release of parasitoids. These results were used to guide the establishment of a further 35 sleeve cages for the production of parasitoids. One hundred participating farmers were trained in the biological control of Citrus Blackfly and provided with batches of 100 parasitoids for release on their farms.

INTRODUCTION

Amitus hesperidum Silvestri (Hymenoptera: Platygasteridae) was introduced to Trinidad in 2000 in an attempt at classical biological control of the Citrus Blackfly *Aleurocanthus woglumi* Ashby (Homoptera: Aleyrodidae). This introduction formed part of an Integrated Pest Management (IPM) approach to managing the pest (Anon, 2000). The release programme involved a period of laboratory rearing in quarantine, followed by field rearing in sleeve cages, open releases and island-wide distribution (White *et al.*, 2001).

The productivity and emergence period of the initial sleeve cages were evaluated, in order to facilitate and streamline later field rearing of *A. hesperidum* for island-wide distribution by citrus farmers.

METHODOLOGY

Six sites, distributed in major citrus growing areas in Trinidad, were selected for field rearing of *A. hesperidum*. Sites were located in Moruga, Caparo Valley, Tableland, Freeport, Penal and Cumuto. Releases were made in June and July 2000.

Orchards that were known to have high populations of Citrus Blackfly were selected. Individual branches were targeted for sleeve cages which had at least 30 hatched egg spirals (1^{st} or 2^{nd} instars), with spirals distributed over several young leaves. Sleeves were prepared of Organza, 40cm x 60 cm and fitted around branches in the field one week before releases were made. On the day of setting up the sleeve, and again two days prior to releasing parasitoids, all leaves were examined and any predators, mites, aphids or insects were removed with a soft brush. Petroleum jelly was applied to the branch below the sleeve as a barrier to ants. A roof/shade of opaque polythene was erected over the sleeve to deflect rain and direct sunshine.

Care was taken to ensure that there was at least 30cm between the sleeve and the polythene to prevent overheating of the sleeve. Releases were made at approximately 5pm. Both male and female parasitoids (10 of each where possible) were placed in each sleeve. The parasitoids used had emerged on the day before the release. At Todd's Road 17 sleeve cages were used. At the other sites cages were established as follows: Cumuto 4, Penal 12, Freeport 8, Tableland 7 and Moruga 5.

Subsequent to the release of parasitoids the sleeves were examined weekly and all contaminants removed as described above. When it was observed that parasitoids had begun to emerge sleeves were visited every 2-3 days and parasitoids collected using aspirators.

Monitoring of field rearing was conducted during the period June – August 2000 at the Todd's Road estate of Caroni (1975) Limited, (Caparo Valley) with 17 sleeve cages, in three fields of Valencia Orange. As the monitoring process proceeded it became apparent that the sleeve cages from Todd's Road would satisfy the initial requirements for *A. hesperidum*. As a result, less effort was placed on gathering parasitoids from the other sites. The sleeves at Tableland and Moruga were removed before emergence, so that the parasitoids would disperse naturally.

Following the initial releases, a further 35 sleeve cages were set up at the Todd's Road Estate to produce parasitoids for distribution by farmers. The sleeve cages were established as described above and regular inspections were made to remove contaminants. Fifty-five days after the inoculation, the branches on which the sleeves were placed were removed and housed in an insectary in a large mesh cage. Parasitoids were collected at 2-3 day intervals from these shoots. Parasitoids collected were placed in vials within insulated cups and fed with a drop of dilute honey. The number of parasitoids recovered was recorded.

The parasitoids collected were supplied to farmers for release on their citrus estates. Each farmer received an insulated vial containing 100 parasitoids. To facilitate the transfer of both the insects and techniques, four seminars were held by staff of Central Experimental Station, Ministry of Agriculture, Lands and Food Production. Participants were exposed to the value of the biological control, the parasitoid, and shown how to make the releases. The sessions were planned to coincide with the emergence of parasitoids, and 100 farmers were targeted.

RESULTS

At the Todd's Road site the mean recovery of *A. hesperidum* was 372 ± 133 (2SE) per sleeve cage. There were high fluctuations between cages the highest yielding 1162 and the lowest 15 parasitoids.

The temporal distribution of emergence is illustrated below (Figure 1). The modal emergence time for each sleeve cage appeared to fall into two periods, roughly days 56-59 and days 64-66. This suggestion of a bimodal distribution is mirrored in Figure 1. Ten percent of the parasitoids emerged by day 54, 25% by day 58, 75% by day 66 and 90% by day 79.

At the other sites the yields were much less (Table 1). The main objective of sleeve rearing at the six sites was to gather parasitoids for redistribution to a further 20 sites. Since the sleeves at Todd's Road satisfied the need for parasitoids at this stage, less effort was placed on the other sites and the sleeves were removed to allow any remaining *A. hesperidum* to disperse naturally. In the case of Tableland and Moruga the sleeves were removed before any emergence occurred.

The 35 sleeve cages for mass production of *A. hesperidum* yielded 8420 parasitoids (mean = 240) over a 25 day period. Excised branches were not housed individually so the variability between sleeve cages was not determined. The yield was 15% short of what was targeted, but the numbers were supplemented with parasitoids from a laboratory colony and all participating farmers were satisfied.

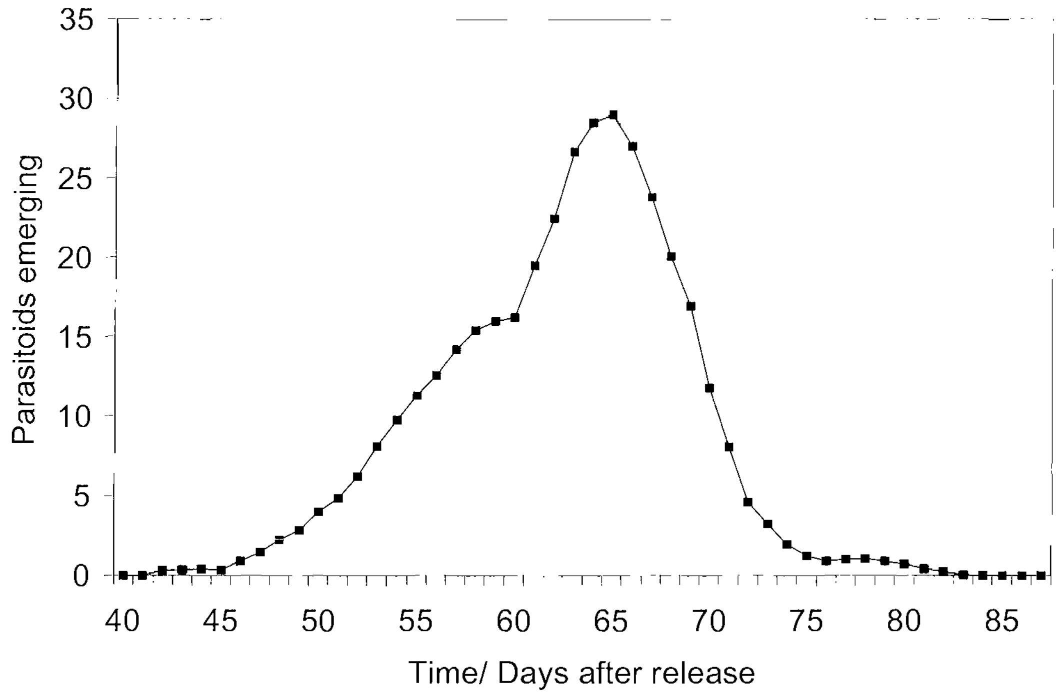

Figure 1. Temporal distribution of *A. hesperidum* from sleeve cages in citrus fields, Todd's Road, June-August 2000.

Table 1. Sleeve cage recovery of *A. hesperidum* from six sites in Trinidad, July- August 2000.

Site	Number of Sleeves	Mean Yield	SEM	Remarks
Todds Road	17	372	66.5	Effort Concentrated here
Cumuto	4	142.8	58.6	Collected on 4 occasions
Penal	12	19.0	6.8	Collected on 4 occasions
Freeport	8	10.9	5.3	Collected on 2 occasions
Tableland	7			Sleeves removed before parasitoid emergence
Moruga	5			

DISCUSSION

Field rearing of *A. hesperidum* within sleeve cages was highly successful. The roofs/shades appeared to be important to the success of the sleeve cage not only as shade but to prevent wetting of the sleeve during rainfall. Sleeves poorly sheltered from rain developed high levels of sooty mould and produced fewer parasitoids. Collection of parasitoids was not possible from wet sleeves as the insects got stuck to the mesh. As such, collections were made after dew had dried off.

Regular cleaning of contaminants was also very important. During initial cleaning it was usual to remove larvae of Coccinellids, Neuropterans, ants, mites and fungi. Some eggs or small larvae were invariably missed and at subsequent inspections had to be removed.

When collecting *A. hesperidum*, the disturbance appeared to stimulate further immediate emergence. This was beneficial as *A. hesperidum* adults live for a few days only, and a delay of even one day is a significant portion of their longevity. Upon entering the field all sleeves were shaken before beginning collection, so as to avoid having to await emergence.

The yield of each cage is dependent on several factors unrelated to the fecundity of the parasitoid. These factors include, the number of available blackfly at the appropriate stage for parasitism, the stress that the parasitoids were exposed to during transfer, the microclimate within the sleeve (whether shaded or un-shaded), any parasitoids escaping during inoculation, and level of sanitation within the sleeve. For these reasons no attempt has been made to present the sleeve cage yield per female introduced.

A. hesperidum parasitises first and second instar nymphs. The developing parasitoid remains dormant while the blackfly completed its development up to the pupal stage. At this time the parasitoid development continues, eventually killing the blackfly. As a result, the period of peak parasitoid emergence in the sleeves is probably more dependent on the age structure of the blackfly population than on the development rate of the *A. hesperidum*. In the case of the initial 17 sleeves the hint of a bimodal distribution is probably due to parasitism of different instars of blackfly.

The 35 sleeves for farmer participatory releases yielded less than expected. The yield may have been influenced by the transfer of the branches into the insectary. Collection of the entire sleeve however was useful as delays in collection due to transport or weather can be avoided and the parasitoids can be delivered in a shorter period. Despite the drying of the excised branch, parasitoids were able to emerge for at least over three weeks.

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DISTRIBUTION OF *AMITUS HESPERIDUM*, RELEASED FOR THE CONTROL OF THE CITRUS BLACKFLY (*ALEUROCANTHUS WOGLUMI* ASHBY) IN TRINIDAD

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ABSTRACT: *Amitus hesperidum*- a natural enemy of citrus blackfly (CBF) was imported into Trinidad in April 2000 and releases began in June 2000 in commercial citrus fields. An island wide survey was conducted in February 2001 to determine the distribution of *Amitus*, 8 months after initial releases. Leaf samples were collected from 100 farms across six counties. Counts of pupae with parasite exit holes, pupae with CBF exit holes and unhatched pupae were recorded. Leaves were also incubated in an insectary for emergence of adult *Amitus*. On a county basis average parasitism of 34%, 31%, 27%, 25%, 16% and 9% occurred in counties St. Patrick, Caroni, St. George, Victoria, St. Andrew/St.David and Nariva/Mayaro respectively. On a farm basis parasitism levels of 87 %(Penal) and 100% (Flanagin Town, Tableland) were observed at release and non-release sites respectively. *Amitus* adults were recovered at 32 farms of which, 14 were *Amitus* release sites, while 18 farms were non-release sites. Ratios of unhatched pupae to emerged *Amitus* adults as high as 1:3 were observed at both release and non-release sites in counties St. George and St. Patrick respectively. The average distance between non-release sites and the closest release site was 4.4km.

INTRODUCTION

Citrus blackfly (CBF), *Aleurocanthus woglumi* Ashby, was first reported in 1997 and subsequently identified in 1998 in Trinidad. In an island wide survey conducted in February-March, 2000, CBF was found in five of six counties and later in August 2000 it was found in all six counties. One indigenous insect-pathogen, *Aschersonia aleyrodis*, was observed, but this seemed to be ineffective in reducing CBF levels. However, no other natural enemies of citrus blackfly were observed. The management strategy for CBF involved a long-term, sustainable and integrated approach to pest management or IPM, where biological and cultural control measures and to a limited extent chemical control measures were utilized. The predominant feature in the IPM program for CBF was biological control. Two control biological agents; *Amitus hesperidum* and *Encarsia perplexa* were therefore utilized. In April 2000 *Amitus hesperidum* was imported into Trinidad from Florida and field releases initiated in June 2000. Table 1 shows the number of sites and number of *Amitus* released by county for June-December, 2000. The second biogent, *Encarsia perplexa*, was imported in January 2001 and releases initiated in February 2001. This paper however only deals with the distribution of *Amitus hesperidum,* 8 months after field releases.

MATERIALS AND METHODS

The survey was conducted during February-March 2001. A list of 300 citrus farms was used to select 100 (33%) farms. Farms were divided into three strata via a stratified sampling procedure, based on farm size and county (Table 2). In the first stratum, two farms managed by the state enterprise, Caroni (1975) Ltd. were placed in a separate stratum because of their size, 438ha and 750ha, relative to other farms. Both farms in this stratum were surveyed. In the next stratum, which consisted of 51 farms with more than 3 ha, 70% (36 farms) were randomly selected and surveyed. In the remaining stratum, which consisted of 247 farms with less than 3 ha, a 25% sample (62 farms) was taken using a systematic random sampling procedure. Of the 100 farms surveyed 47 were release sites, while 53 were non-releases sites.

At each farm site 5 citrus trees per ha (up to 20 trees per farm) were randomly selected. From these trees, 6 sample leaves per tree were selected, removed and carried to the laboratory.

Samples were examined under a binocular microscope (40x). Counts of the number of pupae with parasite exit holes and the number of pupae with CBF exits holes were recorded. Percent parasitism was calculated using the following equation:

$$\left\{ \frac{\text{number of pupae with parasite holes}}{\text{total number of pupae with exit holes (CBF + parasite)}} \right\} \text{x } 100$$

From each site, 3 leaves with unhatched citrus blackfly pupae were selected and the number of unhatched pupae recorded. The leaves were placed in glass jars, covered with black cloth and left for 15 days to allow for emergence of *Amitus*. The ratio of unhatched pupae to emerged adult *Amitus* was recorded after 15 days.

Dispersal distances between release and non-release sites were determined by estimating the distance between sites where *Amitus* was recovered but not released, and the closest release site.

RESULTS AND DISCUSSION

Table 3 shows the average parasitism based on the number of pupal cases with parasite exit holes/ total number of pupal cases (CBF + parasite) with exit holes. On a county basis average parasitisms of 34%, 31%, 27%, 25%, 16% and 9% occurred in counties St. Patrick, Caroni, St. George, Victoria, St. Andrew/St.David and Nariva/Mayaro respectively. In Florida 25%-35% parasitism has been recorded (Cherry and Pastor, 1980) between 1978 and 1979. The percent parasitism in Trinidad is consistent with these findings. The lower percent parasitism of 16% and 9% in St. Andrew/St. David and Nariva/Mayaro can be attributed to initially low CBF population levels in these counties. In addition for these counties, releases were made at fewer sites as well as fewer wasps were released.

On a farm basis for release sites, 87% parasitism of CBF was recorded in Penal. *A. hesperidum* has also spread to non-release sites where 100% parasitism was recorded in farms at Flanagin Town and Tableland, county Caroni. At the Todd's Road, (Caroni 1975 Ltd.) orchard in Trinidad, a release site, parasitism of >75% and in many fields approaching 100% has been observed (Graham White, Pers. Comm. 2001). Hart et al. (1978) also reported 100% parasitism at some release sites in Florida.

Differences in parasitism at both county and farm levels, can be attributed to a number of factors including CBF population levels, number of *Amitus* released, date (timing) of release and abiotic factors such as temperature and rainfall.

Amitus hesperidum was recovered in 32 of the 100 farms of which 16 were release sites and 18 non-release sites (Tables 4-5, Figure 1). The highest number of adult *Amitus hesperidum* recovered at a release site was 134 in Penal located in county St. Patrick, while at a non-release sites, the highest number of adult *Amitus hesperidum* recovered was 90 in the Fyzabad area county Victoria.

Tables 4-5 shows the number of unhatched pupae, number of *Amitus* recovered and ratios of unhatched pupae to emerged Amitus. Ratios of unhatched pupae to emerged *Amitus hesperidum* adults as high as 1:3 were observed at both release and non-release sites in counties St. George and St. Patrick respectively. Experimenters (Flanders, 1969) have found that 60% of CBF pupae yield two *Amitus* adults. However, it is not unusual for the emergence of three adults (V. Lopez, Pers. Comm. 2001).

Table 5 shows the average distance for *Amitus* recovered between non-release sites and release sites. The average dispersal distance between release and non-release sites was 4.4 km within 4 months of releases, allowing for emergence of 3 generations. These findings are consistent with Selhime et al., (1982) who reported dispersal distance of 3.7 km in 3 generations of *Amitus*.

The greatest distance of dispersal between a non-release site and the closest release site was 16.25 km within 4 months of releases, allowing for emergence of 3 generations. This unusual occurrence was in the county Nariva/Mayaro. It is thought that human intervention may be responsible, since grower-to-grower transfer of *Amitus* was encouraged. In addition, growers were shown the techniques for releases.

Consistent recoveries of *A. hesperidum* at release and non-release sites demonstrate that the bioagent has survived, multiplied and dispersed in citrus orchards throughout Trinidad, 8 months of initial field releases.

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Table 1. Number of sites and number of *A. hesperidum* wasps released in Trinidad, April-December 2000.

County	# of Sites	# of Wasps
Caroni	36	3955
St. George	52	3202
Victoria	31	2901
St. Patrick	24	2342
Nariva/Mayaro	16	1623
St.Andrew/St.David	13	1243

Table 2. Stratified sample of citrus farms surveyed for *A. hesperidum* in Trinidad, 2001.

County	Farm Size			
	Caroni (1975) Ltd.	> 3ha	< 3ha	Total
Caroni	1	9	10	20
St.George	-	4	8	12
St.Andrew/St.David	-	6	6	12
St. Patrick	1	6	24	30
Victoria	-	6	5	12
Nariva/Mayaro		5	9	14
Total	2	36	62	100

Table 3. Average parasitism of citrus blackfly pupae found in counties in Trinidad.

COUNTY	LOCATION	AVERAGE PARASITISM
St. Andrew/St.David (12)*	Cumuto (6)**	24
	Sangre Grande (1)	49
St. Andrew/St. David		16
St. George (12)	Wallerfield (1)	33
	Talparo (4)	39
	Santa Cruz (1)	58
	Mundo Nuevo (4)	10
St. George		27
Caroni (20)	Freeport (3)	25
	St. Helena (2)	53
	Gran Couva (2)	12
	Caparo (1)	73
	Flanagin Town (5)	68
	Tabaquite (2)	14
	Brasso (1)	21
Caroni		31
St. Patrick	Penal (16)	17
	Siparia (2)	71
	Fyzabad (4)	54
	Chatham (1)	52
	Erin (5)	50
	Palo Seco (7)	18
St. Patrick		34
Victoria (12)	Moruga (3)	29
	Williamsville (2)	32
	Princess Town (1)	47
	Tableland (2)	50
	Piparo (3)	2
	New Grant (1)	2
Victoria		25
Nariva/Mayaro (14)	Poole (4)	18
	Rio Claro (3)	18
Nariva/Mayro		9

*, ** -Numbers in parentheses indicate the number of farms sampled in each county and each location.

Table 4. Ratios of unhatched CBF pupae to recovered *Amitus* adults at farms where Amitus releases were carried out in Trinidad.

COUNTY	LOCATION	# PUPAE PLACED IN JAR	# AMITUS RECOVERED	RATIO PUPAE:AMITUS
St. Andrew/St. David	Cunaripo	10	12	1:1
	Cumuto	9	5	2:1
	Cumuto	16	4	4:1
St. George	Wallerfield	25	5	5:1
	Talparo	6	20	1:3
	Talparo	51	16	3:1
	Santa Cruz	19	11	2:1
	St. Helena	8	14	1:2
	Gran Couva	22	15	1:1
	Carapichaima	10	1	10:1
St. Patrick	Penal	31	17	2:1
	Penal	465	71	7:1
	Penal	608	134	5:1
	Erin	229	20	14:1

Table 5. Ratios of unhatched CBF pupae to recovered *Amitus* adults at non-release farms in Trinidad.

COUNTY	LOCATION	# PUPAE PLACED IN JAR	# AMITUS RECOVERED	RATIO PUPAE:AMITUS	DIST. FROM CLOSEST RELEASE (KM)	NO. MONTHS RECOVERED AFTER RELEASE/ GENERATIONS
St. Andrew/ St. David	Plum Mitan	55	12	5:1	5.6	2 months/1generation
	Freeport	6	1	6:1	1.5	8 months/5 generations
	Freeport	19	2	10:1	0.4	7months/4generations
	Mundo Nuevo	40	2	20:1	5.1	4 months/3 generations
St. Patrick	Fyzabad	0	12		3.2	7 months/4 generations
	Fyzabad	1729	90	19:1	3.2	7 months/4 generations
	Palo Seco	168	20	8:1	3.8	4 months/3generations
	Penal	395	42	9:1	3.3	4 months/3 generations
	Penal	201	47	4:1	4.2	4 months/3 generations
	Penal	12	40	1:3	3.9	4 months/3 generations
	Penal	283	25	11:1	4.2	4 months/3 generations
	Penal	151	19	8:1	1.5	5 months/4 generations
	Penal	238	32	7:1	4.5	5 months/4 generations
	Siparia	20	4	5:1	3.8	4 months/3 generations
	Rancho Quemado	78	8	10:1	0.4	4 months/3 generations
Victoria	Piparo	234	53	4:1	0.6	7 months/4 generations
Nariva/Mayaro	Mayaro	119	15	8:1	16.3	4 months/3 generations
	Rio Claro	69	25	3:1	2.9	4 months/3 generations

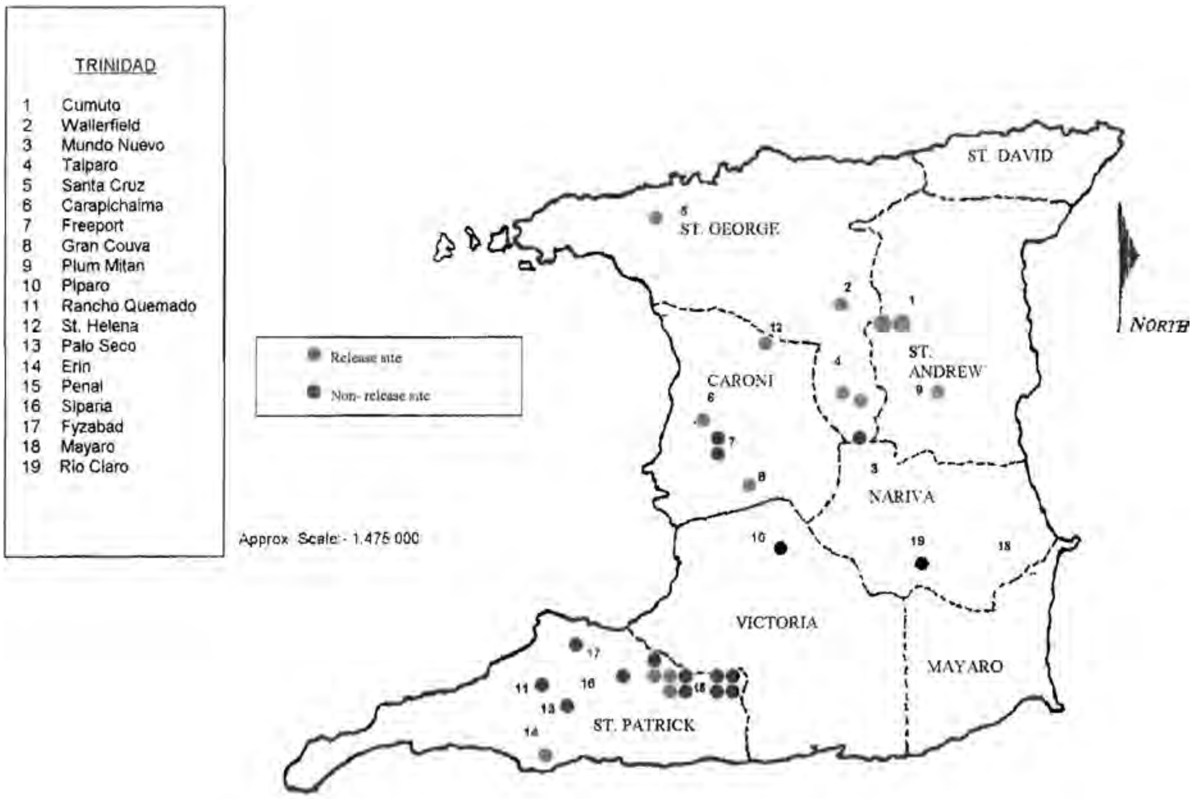

Figure 1. Distribution of *Amitus hesperidum* recovered in Trinidad, February-March 2001.

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AMARANTHUS DUBIUS INTERFERENCE IN SWEET POTATO: EFFECT ON MINERAL UPTAKE

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ABSTRACT: Sweet potato is considered a successful competitor against some weeds. *Amaranthus dubius* is a common weed that adversely affects sweet potato production throughout the Caribbean Basin. Limited research has been performed on weed interference in sweet potato under tropical conditions. In this scenario, understanding weed-crop relationships is fundamental for developing economical weed control strategies. A study was conducted to determine the effect of *A. dubius* interference on sweet potato mineral uptake under tropical conditions. Treatments included sweet potato without *A. dubius*, interspecific sweet potato with *A. dubius*, and *A. dubius* alone. At 5, 7, 9, 11 and 13 weeks after planting, two plants per plot and per species were cut at the soil level, washed and divided in leaf lamina, petiole and stem for nutrient concentration analyses. Interference by *A. dubius* significantly reduced sweet potato's uptake of N, K and Mg at 11 weeks after planting and later. Uptake of P and Ca was reduced at 13 weeks after planting.

INTRODUCTION

Sweet potato (*Ipomoea batatas*) is considered successful competitor against some weeds (Onwueme, 1978). Because of the vining nature of sweet potato, mechanical cultivation as a weed control can be used only during the first four weeks after transplanting without undue mechanical injury to the crop (Glaze et al., 1981). Annual grasses are not a major problem in sweet potato plantations because they may be controlled by grass herbicides in this broadleaf crop. On the contrary, broadleaf weeds, such as *Amaranthus dubius*, may escape from early control and their postemergence control becomes difficult. In this scenario, understanding weed-crop relationship is fundamental for developing economical weed control strategies.

As crops, weeds greatly differ in their ability to extract nutrients from the soil. Previous research has shown a definite effect of weeds on the total nutrient uptake by crops. For example, in sugar beets the leaf content of P, K and Fe was significantly reduced when redroot pigweed was allowed to grow for four or more weeks (Miller and Meggit, 1962). Bhowmik and Reddy (1988) reported that in tomato leaves the concentration of N and K decreased, whereas the concentration of P increased, as the density of barnyardgrass increased.

Limited research has been performed on weed-crop nutrient uptake under tropical conditions. *A. dubius* is a common troublesome weed in sweet potato production throughout the Caribbean Basin. The effect of *A. dubius* on sweet potato yield was assessed by Semidey et al. (1987). Yield reduction of 91% occurred at 91 *A. dubius* plants/m^2. Lugo et al. (2000) hypothesized that the rapid growth and development of *A. dubius*, along with its difference in plant architecture compared to that of sweet potato, enable this weed to interfere seriously, thus causing the dramatic decrease in sweet potato yield in the tropics. This study reports the effect of *A. dubius* interference on sweet potato mineral uptake under tropical conditions.

MATERIALS AND METHODS

The experiment was conducted in 1998 on the Juana Díaz Agricultural Experiment Station farm of the University of Puerto Rico. This location is 12 m above sea level. The soil was from the San Antón Series (Cumulic Haplustolls) with a pH of 7.4 and 1.2% organic matter. Cultivar Mina was used. Plots were four 6.1 m long rows spaced at 0.90 m. Distance between plants within the row was 30 cm. After planting, standard management practices, including drip irrigation, were used (Univ. of PR - Estación Experimental Agrícola, 1997). One application of fluazifop-p-butyl at 0.59 kg ai/ha was made two weeks after weed emergence, and broadleaf weeds were removed by hand. Treatments included 1) sweet potato without *A. dubius*, 2) interspecific sweet potato with *15 A. dubius* plants/m of row, and 3) 15 *A. dubius* plants/m of row. *A. dubius* density was established two weeks after emergence. The weed was allowed to interfere season-long. A randomized complete block design with four replications was used. At 5, 7, 9, 11 and 13 weeks after planting, two plants per plot and per species were cut at the ground level. The plants were washed and divided into leaf lamina, petiole and stem. For nutrient concentration analyses, plant parts were oven-dried at 54°C to a constant weight and then ground. The determination of N and P concentration was made colorimetrically. Concentrations of K, Ca and Mg were determined by spectrophotometry. All chemical analyses followed the reference procedures for the Southern Region of the United States (Univ. of Georgia, 1992; Virginia Agric. Exp. Stn., 1992). Nutrient concentrations were expressed as a percentage of the tissue dry weight. Estimates of nutrient uptake were calculated by considering average concentration in tissue and tissue dry weight. Sweet potato yield was determined 22 weeks after planting.

RESULTS AND DISCUSSION

Sweet potato yield in weed free plots was equivalent to 9,232 kg/ha. Season-long interference by 15 *plants of A. dubius* per meter of row reduced this yield by 96%. Average nutrient concentrations for 11 and 13 weeks after planting have been summarized in Table 1. Across plant parts, the concentration of nutrients obtained in this study followed the general pattern reported for other tuber crops. Concentration of K in tissues tended to be higher than that of N, whereas Mg was the least concentrated nutrient (Table 1). Interestingly, and except for Ca at 13 WAP, at 11 and at 13 WAP the concentration of nutrients in sweet potato alone was not statistically different from that of sweet potato interfered with *A. dubius* (Table 1).

As expected, dry weight accumulation of sweet potato and *A. dubius* increased throughout the season (Figure 1). In contrast to the general pattern for nutrient concentration, sweet potato's dry weight was reduced when grown with *A. dubius* (Figure 1). Significant differences were observed at 11 WAP, where reduction in sweet potato dry weight was 62%, as a consequence of being grown with *A. dubius*. Previous reports confirm that *A. dubius* interference in sweet potato is practically limited to the first part of the crop cycle because the weed completes its growing cycle about eight weeks before sweet potato crop does (Lugo et al., 2000).

In this study, interference by *A. dubius* reduced nutrient uptake by sweet potato (Figures 2 to 6). This reduction was more accentuated by the end of the cropping cycle. As for dry weight, significant differences for mineral uptake between sweet potato alone and interspecific sweet potato were detected at 11 and at 13 WAP. Interference by *A. dubius* reduced significantly sweet potato's uptake of N, K and Mg at 11 weeks after planting and later (Figures 2, 4 and 6). Uptake of P and Ca was reduced at 13 weeks after planting. Because differences in mineral concentration in tissues between sweet potato alone and interspecific sweet potato were minimal, reduction in uptake for interspecific sweet potato appears as a result of the reduction in dry weight.

Uptake of N by *A. dubius* alone was less than for sweet potato alone (Figure 2); conversely P uptake was higher (Figure 3). Potassium and Mg uptake by *A. dubius* was similar to that of sweet potato alone (Figures 4 and 6). Thus, total nutrient uptake by the crop and by the weed may be compared by considering both the concentration in the tissue and the dry weight, because these characteristics were dissimilar (Table 1 and Figure 1). Careful attention must be paid to the above results because they are limited to nutrient accumulation in the plant parts above ground. The overall results indicated that differences in nutrient uptake between sweet potato alone and interspecific sweet potato interfered by *A. dubius* (plant parts above ground) appear more related to reduction in dry weight than to changes in the mineral concentration of the tissues.

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Table 1. Average mineral concentration in plant part above ground in sweet potato alone, sweet potato growing interspecificaly with *A. dubius* and *A. dubius* growing alone.

	AVERAGE MINERAL CONCENTRATION				
	N	P	K	Ca	Mg
11 weeks after planting			%		
Sweet potato alone	2.29	0.41	6.47	2.03	0.47
Sweet potato + A.dubius	2.20	0.44	6.30	1.81	0.34
A. dubius alone	1.69	1.10	6.06	2.41	0.72
LSD $_{0.05}$	NS	0.10	NS	0.30	0.15
13 weeks after planting					
Sweet potato alone	2.21	0.46	4.85	2.35	0.46
Sweet potato + A. dubius	1.92	0.43	5.80	1.97	0.38
A. dubius alone	1.63	1.19	5.36	2.65	0.84
LSD $_{0.05}$	0.56	0.19	NS	0.23	0.10

Figure 1 - Effect of *Amaranthus dubius* interference on sweet potato dry weight

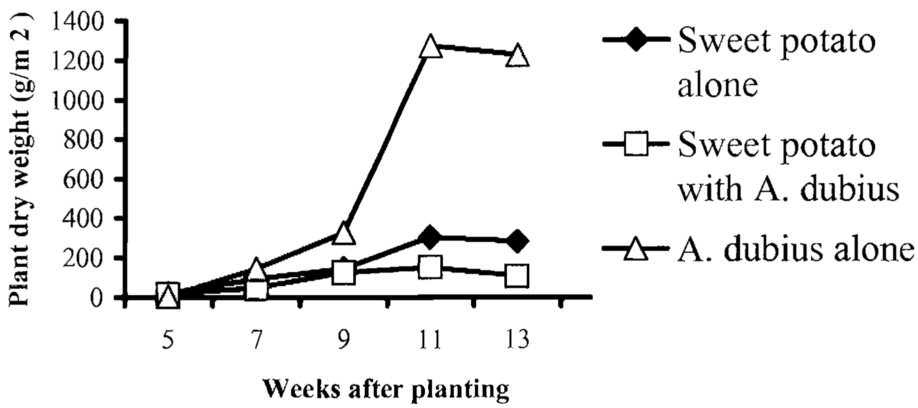


Figure 2 - Effect of *Amaranthus dubius* interference on sweet potato N uptake

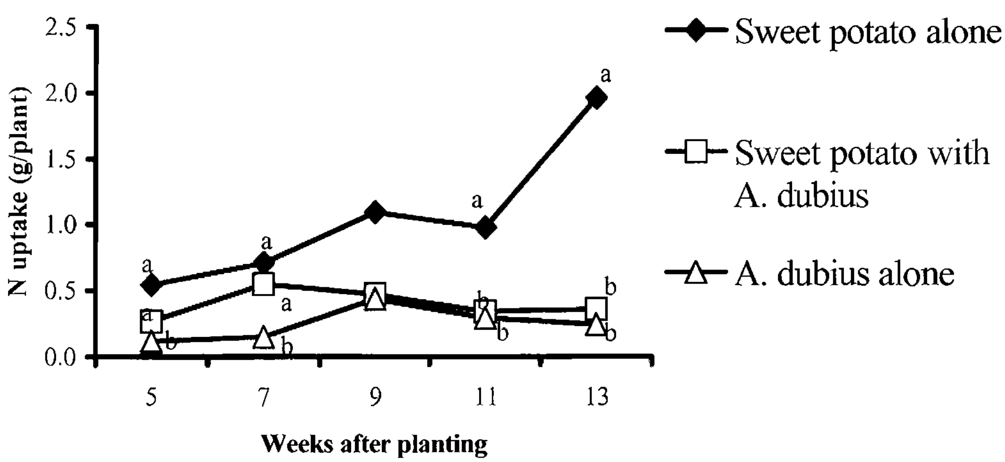


Figure 3 - Effect of *Amaranthus dubius* interference on sweet potato P uptake

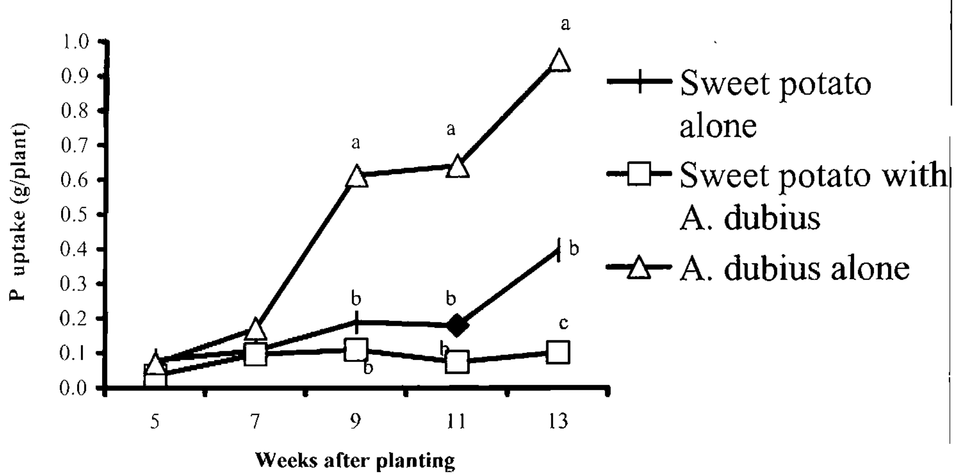


Figure 4 - Effect of *Amaranthus dubius* interference on sweet potato K uptake

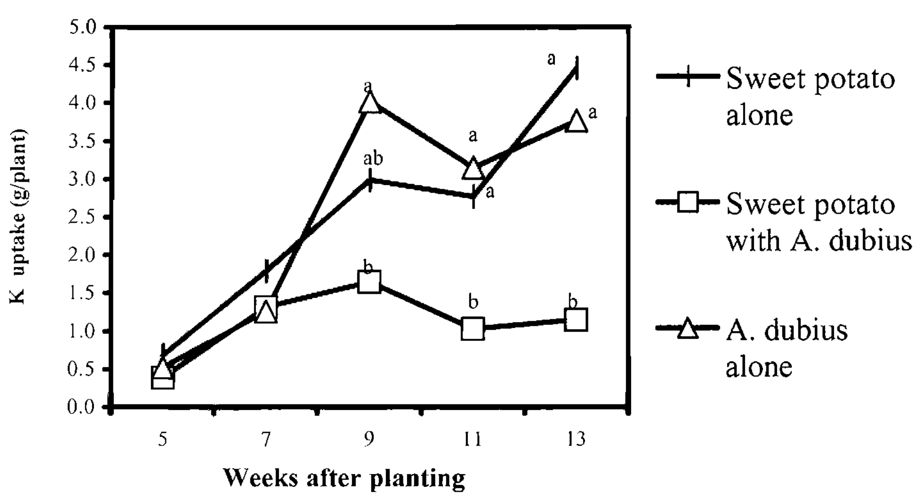


Figure 5 - Effect of *Amaranthus dubius* interference on sweet potato Ca uptake

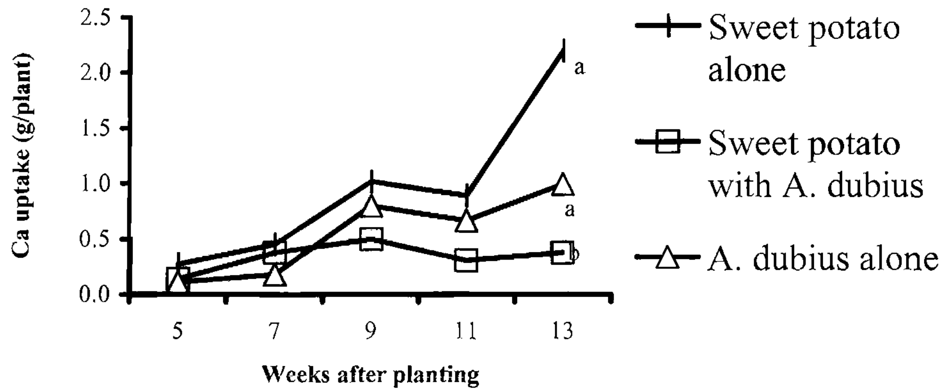
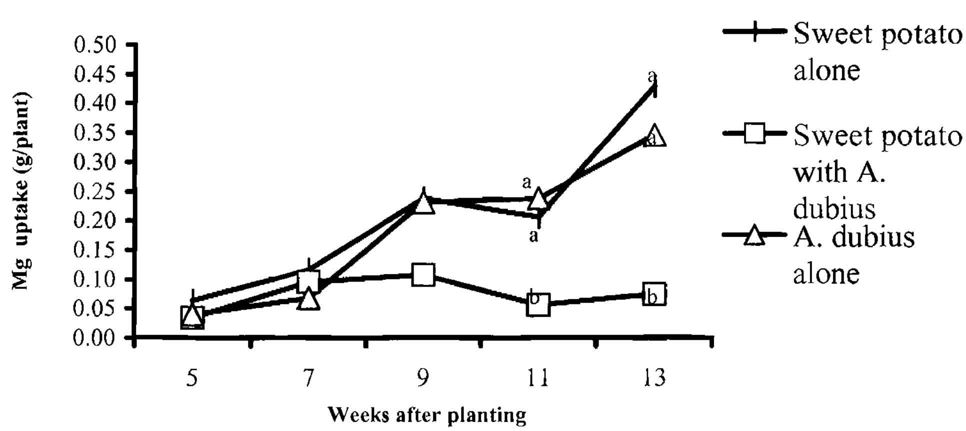


Figure 6 - Effect of *Amaranthus dubius* interference on sweet potato Mg uptake



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ETUDE DE LA PRODUCTION DE BULBILLES CHEZ *D. ALATA* CV BELEP – CONSEQUENCES SUR LE RENDEMENT EN TUBERCULES

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RESUME: Les bulbilles sont des tubercules aériens qui ont contribué naturellement à la dispersion des espèces ayant l'aptitude à en produire, mais souvent de manière sporadique. L'intérêt porté à la maîtrise de la production des bulbilles vient du fait qu'elle peut constituer pour certaines espèces, une voie alternative originale à la production de semences d'igname. Les travaux rapportés dans ce papier reposent sur les observations conduites sur les facteurs de promotion de la bulbification chez *D. alata* cv Belep. Depuis 2 ans nous obtenons une production régulière de bulbilles sur cette variété à partir de tubercules entiers ou fragmentés. Le nombre moyen total de bulbilles récoltées par plante se situe entre 20 et 30 et le nombre moyen de bulbilles utilisables comme semences pour la culture suivante est compris entre 6 et 10. La formation des bulbilles (phénomène terminal du cycle) ne semble pas être en compétition avec la production des tubercules car les rendements en tubercules observés donnent des valeurs comprises entre 2.3 et 3.8 kg par plante selon le poids des tubercules utilisés comme matériel de plantation.

ABSTRACT: The bulbils are aerial tubers that have contributed naturally to the dispersion of species having the aptitude to produce some, but often in sporadic manner. If we succeed to master bulbil production it could constitute for some species, an original alternative way to produce seed yam. Work reported in this paper comes from observations conducted on factors of promotion of the bulbification in D. alata cv Belep. Since 2 years we have obtained a regular production of bulbils on this variety from whole tubers or setts. The total average number of bulbils harvested per plant ranged from 20 to 30 and the average number of bulbils usable as seeds for the next planting was between 6 and 10. The production of bulbils (terminal phenomenon of the cycle) did not seem to affect tuber formation since tuber weight harvested gave values between 2.3 and 3.8 kg per plant according to the size of the planting material.

INTRODUCTION

Dans les conditions normales de culture, les espèces d'igname les plus cultivées sont celles qui sont réticentes à la production de graines susceptibles de constituer des semences. De ce fait, la création variétale est un processus long qui commence à livrer petit à petit les réponses aux problèmes posés par l'amélioration des rendements et la résistance aux maladies. Les semences d'igname sont en fait de petits tubercules ou des fragments de tubercules. En conséquence, une quantité non négligeable de tubercules destinés à la consommation est réservée pour la plantation de l'année suivante. En cas d'achat, le coût des tubercules nécessaires à la plantation d'un hectare peut représenter 35 à 40 % de celui de la production (Orkwor, 1997). L'un des facteurs importants qui limitent la production de tubercules d'igname est donc la disponibilité en matériels de plantation sains.

Les méthodes traditionnelles ne permettent pas de répondre à la demande élevée en matériels de plantation. Pour améliorer la situation et réduire le prélèvement opéré sur une récolte, plusieurs voies de production de matériels de plantation ont été explorées. Ferguson (1972), Vander Zaag et Fox (1981), ont utilisé sans grand succès au champ des boutures de tiges. Okoli et al (1982) ont mis au point, au Nigeria, une technique rapide de production de semenceaux (minisetts) pour approvisionner les agriculteurs. Cette dernière technique a été améliorée et utilisée à l'intérieur et à l'extérieur du Nigeria pour produire, à partir de minisetts, des tubercules-semences entiers (Orkwoor, 1997). La multiplication clonale comporte l'inconvénient de perpétuer toute l'histoire pathologique d'une variété malade. Dès que des clones sains ont été obtenus, souvent par combinaison de culture de méristème et de thermothérapie, les vitroplants sont devenus des matériels intéressants pour la production de tubercules-semences. Il est même envisagé, malgré leur fragilité, de les utiliser au champ pour la production de tubercules commercialisables ; cependant peu d'études à ce jour ont été menées dans ce sens.

Un autre matériel intéressant, constitué par les bulbilles, a été laissé de côté jusqu'ici. Ce sont des tubercules aériens (Wickam et al. 1982). Chez *D. bulbifera* (Igname à bulbilles), la bulbille est le lieu préférentiel de stockage des glucides et, sous forme entière ou fragmentée, reste le principal, sinon l'unique, matériel de plantation (Degras et al. 1977). Chez les autres espèces cultivées comme *D. alata, D. opposita, D. dumetorum, D. pentaphylla,* (Degras, 1986) qui en forment, souvent de façon sporadique, on sait que les bulbilles, produites sur les ignames le long des rivières, ont été les principaux artisans de leur dispersion hors de leur zone d'origine.

D. alata cv Belep, cultivée en Guadeloupe et tolérante à l'anthracnose, produit de grandes quantités de bulbilles, les années où les pluies ont été précoces et la pluviométrie abondante le long du cycle. Nous avons identifié l'eau comme l'un des facteurs de promotion et de régularisation de la bulbification. La maîtrise de la production annuelle de bulbilles chez les espèces capables d'en produire, avec comme objectif de combiner production de tubercules commercialisables et de tubercules-semences (non prélevés sur la récolte) pourrait constituer une voie alternative intéressante. Ce papier rapporte les premiers résultats sur la tentative de maîtrise de la production des bulbilles chez *D. alata,* cv Belep.

MATERIELS ET METHODES

Le matériel végétal est *D. alata* cv Belep, retenu pour sa précocité et sa tolérance à l'anthracnose.

Essai 1999. Les matériels de plantation sont constitués par des semenceaux (fragments de tubercules) de 100g, 50g et 25g et des bulbilles de 15-20g. Après germination deux lots ont été formés pour les 100g et 50g, tous les semenceaux de l'un des deux lots sont ébourgeonnés avant plantation. Cette technique nous avait permis, il y a quelques années, d'induire la multi-tubérisation dans la même espèce mais chez la variété Lupias (Clairon et Zinsou). En supprimant la dominance apicale l'apparition de multiples bourgeons et de tiges a conduit à un nombre élevé de tubercules avec réduction de leur taille et de leur poids.

Essai 2000 : L'objectif est de confirmer les résultats de l'année précédente en particulier l'effet de l'eau et du poids des tubercules-semences sur la production de bulbilles. Les matériels de plantation sont représentés par des vitroplants et des tubercules–semences (de première génération), obtenus à partir des vitroplants. Trois classes de poids ont été utilisées : 40-60 g, 80-120 g et 180-200 g. Chaque traitement contient 50 individus.

Les expérimentations ont été conduites au domaine Duclos au Centre INRA des Antilles et de la Guyane en Guadeloupe. La plantation est mise en place en avril sur un sol qui a reçu un amendement organique similaire à celui utilisé pour les cultures maraîchères. Les billons sont espacés de 1 mètre, les plantes sur le billon sont distantes de 40 cm (ce qui équivaut à 25 000 pieds/ha). Pour une meilleure utilisation de la lumière, les plantes ont poussé sur des tuteurs hauts de 1.50 m.

En 1999, toutes les plantes sont irriguées. En 2000, toutes les plantes sont irriguées pendant les 2 premiers mois pour permettre leur démarrage. Seuls les lots considérés comme irrigués ont continué à bénéficier d'un arrosage tous les deux jours par aspersion, correspondant à un apport d'eau journalier de 7 mm. Chaque plante reçoit au pied, 3 mois après plantation, 40 g d'un engrais complet. A la fin du cycle les mesures ont été faites sur l'ensemble des plantes correspondant à un traitement.

RESULTATS

Essai de 1999

Production de bulbilles

Nous avons obtenu une importante production de bulbilles. Les semenceaux de 100g et de 50g non égermés donnent le même nombre de bulbilles qui se situe entre 8 et 10 par plante. Dans le même essai les semenceaux de 25g et les bulbilles de 15-20g n'ont pratiquement pas produit de bulbilles. L'égermage avant plantation des semenceaux de 100g et 50g augmente significativement le nombre moyen de bulbilles. En ce qui concerne les semenceaux de 100g, celui-ci est égal à 22 par plante, pour les semenceaux égermés. Le doublement du nombre de bulbilles sur les plantes issues des semenceaux égermés est essentiellement dû à l'apparition d'un plus grand nombre de tiges résultant de la suppression de la dominance apicale.

Le poids moyen des bulbilles se situe entre 9.9 et 10.5g quel que soit le poids ou les traitements subis par les semenceaux. Une analyse plus poussée sur les bulbilles sera effectuée sur les essais de l'année suivante.

Production de tubercules

Contrairement aux résultats obtenus sur la variété Lupias, l'ébourgeonnement ne provoque pas une multi-tubérisation chez la variété Belep.

Le nombre moyen de tubercules par plante est de 1.4 ± 0.2 pour les semenceaux de 100g et de 50g avec ou sans bourgeon. L'égermage n'a donc aucun effet sur le nombre de tubercules produits. Quel que soit le traitement, le rendement moyen de tubercules par plante varie peu. Il est respectivement de (2.4 ± 0.3) kg et (2.0 ± 0.2) kg pour les semenceaux de 100 g avec ou sans bourgeon ; et de (2.2 ± 0.3) kg et (2.0± 0.3) kg pour les semenceaux de 50 g avec ou sans germe. Le poids moyen de tubercules est respectivement de (1.7 ± 0.3) kg et de (1.4 ± 0.3) kg pour les semenceaux de 100 g avec ou sans bourgeons ; et de (1.6± 0.3) kg et (1.4 ± 0.3) kg respectivement pour les semenceaux de 50 g avec ou sans bourgeons. Les tubercules obtenus sont tous commercialisables et on n'obtient pas de tubercules utilisables directement comme matériels de plantation.

De l'essai 1999 nous concluons que :

- l'eau favorise la production de bulbilles. Ceci confirme les observations faites sur Belep au cours de ces dernières années, montrant une relation entre la formation des bulbilles et l'arrivée précoce des pluies et leur abondance au cours du cycle de la plante.
- même sous irrigation, les plantes provenant de matériel de plantation de poids inférieurs à 25 g ne produisent pratiquement pas de bulbilles. Le même constat a été fait sur des cultures issues de bulbilles et des vitroplants menées parallèlement (résultats rapportés dans un autre papier)
- la production de bulbilles n'affecte significativement ni la taille des tubercules ni le rendement.

Essai 2000: Dans cet essai nous avons voulu tester les conclusions de l'année précédente

Production de bulbilles

Dans tous les cas le nombre de bulbilles produites par plante est supérieur sous irrigation quelle que soit la taille du tubercule-semence utilisé. Il se situe entre 30 et 32 sous irrigation et entre 19 et 25 pour les plantes non irriguées (Tableau 1). Seule l'irrigation et non le poids des tubercules-semences a une incidence significative sur ce nombre.

Le poids moyen d'une bulbille est plus faible sur les plantes irriguées (14-18g) que sur les plantes non irriguées (entre 20.5 et 30g). Plus le nombre de bulbilles produites est grand, plus le poids moyen des bulbilles est faible.

En considérant les bulbilles de poids>20 g comme semences, nous avons déterminé le nombre de bulbilles de ce poids fourni par plante. Ce nombre est d'autant plus grand que le poids des tubercules-semences est élevé puisqu'on passe de 6 à 10. Grâce à la formation des bulbilles, la plante produit des quantités de semences suffisantes pour assurer la plantation de l'année suivante sans aucun prélèvement sur la récolte des tubercules destinés à la consommation.

Production de tubercules consommables

Pour les trois tailles de tubercules-semences, avec ou sans irrigation, le nombre de tubercules produits par plante est toujours de l'ordre de 1 confirmant tous les résultats obtenus jusqu'ici à partir de Belep que l'on parte de fragments ou de tubercules entiers (Tableau 2).

Un meilleur rendement en tubercules par plante est observé en l'absence d'irrigation. Dans nos conditions, l'utilisation de gros tubercules-semences avec comme objectif d'augmenter le rendement, n'est pas justifié. Quel que soit le traitement, les plantes produisent un rendement moyen en tubercule égal ou supérieur à 2.8 kg. Si on ajoute le poids de bulbilles produites le rendement moyen par plante est égal ou supérieur à 3.2 kg, dans nos conditions de culture.

DISCUSSION

Au cours de nos observations sur la physiologie de *D. alata* cv Belep, nous avons constaté que cette variété, possédant l'aptitude à produire facilement des bulbilles, ne l'exprimait que les années où l'arrivée précoce des pluies (dès juillet), favorise la mise en place d'un appareil végétatif important. L'eau est donc un facteur limitant important. Ce problème est résolu par l'irrigation dont l'utilisation doit être optimisée.

Un bon développement de l'appareil végétatif favorable aussi bien à la production de bulbilles que de tubercules est assuré dans notre étude par la culture sur tuteurs. Ils permettent une meilleure utilisation de la lumière par les plantes. La présence de tuteurs a l'avantage d'isoler les bulbilles du sol. Dans ces conditions de production, les bulbilles destinées à être utilisées comme des semences sont préservées des parasites et des maladies telluriques.

La mise en place d'un appareil aérien suffisant, est aussi sous la dépendance du type de matériel de plantation. Parallèlement à ce travail et dans les mêmes conditions d'irrigation et de fertilisation, les cultures issues de semenceaux et de bulbilles de petit poids et de vitroplants (ne possédant aucune réserve au départ) produisent peu ou pas de bulbilles. Sur ces mêmes plantes, le rendement moyen en tubercules par plante est inférieur à ce que nous avons obtenu avec des tubercules semences de poids>40g utilisées dans ce travail. L'utilisation d'un matériel de plantation, contenant suffisamment de réserves pour mettre précocement en place une plante vigoureuse crée les conditions d'une bonne bulbification. L'appareil végétatif au cours du cycle est alors capable de remplir le puits souterrain (tubercules), d'induire la formation et le remplissage des bulbilles.

Nous avons confirmé que l'irrigation favorise la formation des bulbilles mais le nombre de bulbilles formé en l'absence d'irrigation n'est pas négligeable. Nous pouvons expliquer ce résultat inattendu par une année 2000 exceptionnellement pluvieuse qui semble avoir pratiquement annulé l'effet de manque d'eau sur les cultures non irriguées. L'effet de manque d'eau n'a duré qu'un mois mais il semble avoir suffi pour diminuer le nombre moyen de bulbilles produites par plante. En revanche corrélativement on assiste à une augmentation du rendement moyen de tubercules. Nos résultats permettent de soupçonner une compétition entre la bulbification et le remplissage des tubercules chez cette variété. Dans les conditions favorables à la bulbification qui est un processus terminal du cycle, l'apparition d'un puits aérien (bulbilles) entraîne une distribution différente des assimilats. Il serait intéressant d'étudier la portée de ce phénomène et son influence sur la formation des bulbilles et sur l'élaboration du rendement en tubercules.

Sous irrigation, en pratiquant une culture sur tuteurs et en choisissant le matériel de plantation approprié, la production annuelle de bulbilles peut être maîtrisée chez *D. alata* cv Belep et constituer une voie alternative de production de semences pour cette variété.

La quantité de bulbilles formées excède les besoins en semences pour la replantation. Il s'offre alors à l'agriculteur la possibilité de combiner la production de tubercules commercialisables avec celle de bulbilles-semences. L'excédent de bulbilles non utilisées pourrait alors être vendu comme semences.

Les facteurs dont nous avons parlé affectent sûrement la production de bulbilles dans toutes les régions. Nous soupçonnons cependant aussi l'effet de la photopériode qui permet d'induire la formation de bulbilles en chambre de culture où il y a possibilité de moduler la durée d'éclairement (recherches en cours).

Remerciements : Les auteurs expriment leur sincère gratitude à Monsieur Camille Constant dont le dévouement, la disponibilité et la compétence ont permis la réalisation de ce travail. Nous le remercions pour la préparation des plants en culture in vitro et les soins attentifs apportés aux plantes depuis leur acclimatation au champ jusqu'à la collecte des données. Nous remercions également Monsieur VenthouDumaine pour l'aide apportée au moment de la récolte et de la collecte des données

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Tableau 1: Effet de l'irrigation et du poids de tubercule-semence sur la production de bulbilles (Essai 2000)

Poids des semences	40-60 g		80-120 g		180 – 200 g	
Traitement	Irrigué	Non irrigué	Irrigué	Non irrigué	Irrigué	Non irrigué
Nombre moyen de bulbilles /plante:	31,4	22,6	30,4	25,4	31,9	18,8
Nombre de bulbilles de P>20g /plante	6,7	6,4	7,6	10,4	10	6,8
Nombre de bulbilles de P<20g /plante	24,7	16,2	22,8	15,0	21,9	12,0
Poids moyen des bulbilles (en g)	14,4	20,3	17,0	29,7	17,9	27,8
Rendement moyen de bulbilles/plante (g)	451	459	516	754	570	523

Tableau 2: Production de tubercules sur les pieds ayant produit des bulbilles (Essai 2000)

Poids des semences	40-60 g		80-120 g		180-200 g	
Traitement	Irrigué	Non irrigué	Irrigué	Non irrigué	Irrigué	Non irrigué
Nombre moyen de tubercules /plante	1,2±0,2	1,0±0,1	1,2±0,2	1,2±0,2	1,4±0,3	1,0±0,1
Rendement moyen en tubercules/plante	2,8±0,6	3,5±0,6	2,8±0,6	3,8±0,6	3,2±0,7	3,1±0,7
Poids moyen des tubercules (kg)	2,4±0,5	3,3±0,5	2,4±0,5	3,2±0,6	2,3±0,5	3,0±0,6
Poids moyen de bulbilles /plante (kg):	0,45	0,46	0,52	0,75	0,57	0,52
Rendement moyen en tubercules + bulbilles par plante (kg)	3,3	3,8	3,3	4,6	3,8	3,6

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THE ROLE OF CARINET IN REGIONAL PHYTOSANITARY DEVELOPMENT

Ronald Barrow, *CARINET Coordinator, Trinidad*

ABSTRACT: As signatories to the Convention of Biological Diversity, the Caribbean countries were charged with the responsibility to develop national biodiversity strategy and action plans. One of the activities required to implement the plan has to do with the establishment of a biodiversity database and a capacity building programme to offer identification and characterisation services – a key element in regional phytosanitary development undertaken by CARINET- The taxonomic network of the Caribbean Information is provided on the taxonomic capability of the Caribbean region and the CARINET programme of work including: (i) Capacity building; (ii) Rehabilitation of resources, (iii) establishment of information and communication services and (iv) The adaptation and development of user-friendly technology, which has been so designed to provide the taxonomic services required. Mention is made of the activities undertaken by CARINET that positively impact on regional phytosanitary development e.g. identification of insects, microorganisms, nematodes and weeds of plants quarantine importance e.g. Pink Hibiscus Mealybug, papaya mealybug, citrus blackfly, black sigatoka, diseases of bananas

INTRODUCTION

Awareness of the earth's dwindling biotic wealth spread far and wide during the years leading up to the 1992 Earth summit in Rio de Janeiro. Once governments everywhere began recognising how invaluable and endangered biodiversity is, they embraced the idea that something had to be done to improve the ways in which we use biological resources to benefit the generations now living and those to come. This shared sense of urgency led 156 nations and the European Union to sign the legally binding Convention on Biological Diversity (CBD) during the Earth Summit.

Most of the Caribbean countries are signatory to the 1992 Convention on Biological Diversity and as such are required to develop National Biodiversity strategy and Action Plans. This exercise has already been completed and one of the main problems identified in the wise use of biodiversity and natural resources was paucity of biodiversity information and inaccessibility to biodiversity information that has been collected. In this regard several strategies and specific actions have been recommended to counteract these deficiencies. One such activity to be undertaken provides for the establishment of a database and a capacity building programme to offer identification and characterisation services. It is within the ambit of this activity that CARINET, The Caribbean Biosystematic network continues to play an important role and in so doing support regional phytosanitary development.

Before embarking on CARINET's role in this exercise, I consider it useful to provide you with some background information on the network.

What is CARINET?

It is the taxonomic capacity building network of the Caribbean established under the aegis of the SCMA in December 1993 in Barbados and became operational in March 1996, with membership of all CARIFORUM countries. As the taxonomic network of the Caribbean and in support of sustainable development in agriculture, forestry and the wise use of our natural resources the goal of the network is-

To ensure that a cadre of trained scientists exists in the Caribbean who are able to advise about, work with identification of insects, mites, nematodes, micro-organisms and non vascular plants and who have experience in handling and assessing data associated with those organisms.

What is Taxonomy?

Taxonomy is the branch of science dedicated to identifying and classifying different forms (species) of organisms.

THE NEED FOR TAXONOMY AND HOW IT SUPPORTS REGIONAL PHYTOSANITARY DEVELOPMENT

Taxonomy is the most vital ingredient in any proposal for sustainable agricultural development, wise use of biodiversity and the environment. Recently, environment awareness has led to the reduced use of chemicals and adoption of more environment-friendly methods of combating pests and diseases e.g. biological control IPM. The use of these methods hinges on the accurate identification of pests and diseases and their natural enemies. The importance was borne out in the incidence of the Pink (Hibiscus) mealybug (HMB). HMB was identified at least two years after its appearance as the destructive pest it is. Accurate and timely identification could have avoided the attendant destruction and costs related to control and curtailed trade. It is considered that upgrading the taxonomic capability of the region would improve the Caribbean's ability to respond to the challenges of globalisation of trade in agriculture and the threat of environmental degradation.

TAXONOMIC CAPABILITY OF THE REGION

A survey conducted in 1996 revealed that the taxonomic resources- manpower and collections were grossly inadequate to meet the taxonomic needs of the Caribbean sub- region. In addressing these concerns CARINET implemented the following programme of work:

- Capacity building- manpower and infrastructural upgrade
- Establishment of Information and Communications services
- Rehabilitation / establishment of reference collections and records
- Development and adaptation of user friendly technology

CAPACITY BUILDING

Training for Technicians; Professionals- Applied Biologists, Specialists (taxonomists)

Objectives of training programme
- To provide training in key systematic groups at all levels as indicated above.
- To develop joint training programmes for the sub-region with support from regional institutions as part of the South- South, North- South, Co-operation.

It is intended that the training will provide a nucleus of 12 taxonomists for the network that would function mainly at the 5 (five) Centres of Excellences (Belize, Guyana, Jamaica, Suriname and Trinidad and Tobago), other National Co-ordinating Institutes and National Institutes.

Training programmes undertaken

1997 Identification of Mealybugs of the Caribbean.

1998 Taxonomy and identification of plant pathologic fungi and bacteria of agricultural importance.

1999 Identification of whiteflies of agricultural importance in the Caribbean.
Joint programme with MIZA Venezuela- One week training workshop on the taxonomy: *Alticidae; Chrysomelidae.*

2000 Insect Curation and Collection Management.Three Caribbean scientists were awarded BioNET fellowships that were undertaken at CABI BIOCIENCE, UK.

1996 Doreen Jodhan (T&T) – Taxonomy of Macrofungi (Basidiomycetes) of T&T.
1997 Lennox Chandler (B'dos) – Taxonomy of Mealybugs and Whiteflies.
1998 Pearl Wharton-Gill (Guyana) - Characterisation and identification of *Ralstonia spp.*

INFORMATION AND COMMUNICATION TECHNOLOGY

CARINET is in the process of designing and developing a database and webpage.
Using Linnaeus II as an interface database comprises four (4) data groupings each a database itself:

- i Taxonomic Database- species.
- ii Directory of Experts
- iii Institutions - Plant Health Laboratories
- iv Support Tables.

The first three databases will be presented to the end-user as facets of the stored information; the fourth is a collection of supporting information common to all, but associated in different ways. The CARINET database will provide reliable information on experts/ scientists working in specific areas in the Caribbean, and also up-to-date information (bionomics, taxonomy) on insects and microorganisms of economic importance.

WebPage

An interactive web page is being designed that would provide a user-friendly web site to be hosted by ECOPORT. ECOPORT is a database not just a web site, designed and devoted entirely to inter disciplinary integration of information to manage biodiversity. ECOPORT is sponsored by FAO, the University of Florida and the Smithsonian National Museum of Natural History.

REHABILITATION/ ESTABLISHMENT OF RESOURCES

The upgrade of insect collections has already started in several of the MCs. The Ministry of Agriculture (MoA) of T&T; Pest Management Unit of Grenada; The Institute of Jamaica and Belize where the Agriculture Health Authority (BAHA) has been established. An attempt is being made in Barbados to merge the insect collections now housed at MoA, CARDI and Barbados Museum and Historical Society (BMHS).

CONCLUSION

How the activities of CARINET impact (positively) on regional phytosanitary development: The Swiss based world Conservation Union – IUCN reported in a recent article that 'alien' species cause considerable damage to the economy through reduction of crop and livestock yield and degradation of freshwater and marine ecosystems. Among such pests mentioned- The Asian longhorn beetle on timber in Canada, the Asian tiger mosquito, the erect prickly pear, the yellow Himalayan raspberry. We could add to this list- Mealybugs - HMB and Papaya; citrus canker; coffee berryborer and coffee rust, black sigatoka on bananas, lethal yellowing on coconuts, striga and since we are not only concerned with plants mention must be made of foot and mouth disease and the spread of the Amblyomma tick.

If we are to strengthen our plant and animal quarantine services and have effective IPM programmes, it is imperative that those operations be supported by capable taxanomic services to reliably identify pests, diseases, weeds and their natural enemies. This can only be achieved via trained manpower, access to reference collections and relevant databases. In developing our database and web site CARINET is intending to put technology in the hands of inspectors and extension officers so that the phytosanitary needs of the Caribbean sub-region could be met.

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POTENTIALITES DE PRODUCTION DE TUBERCULES A PARTIR DE BULBILLES ET DE VITROPLANTS CHEZ *D. ALATA* CV BELEP

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RESUME: Nous avons réalisé une étude comparative de la production expérimentale de tubercules en utilisant comme semences des bulbilles, des tubercules entiers de même classe de poids (15-25g) et des vitroplants. Nous obtenons en moyenne 1 tubercule par plante issue de bulbille ou de tubercule comparé à 7 tubercules pour les vitroplants. Le poids moyen des tubercules se situe entre 1.4 et 1.7 kg pour les bulbilles ou les semenceaux, et est seulement de 0.2 kg pour les vitroplants. Le rendement moyen en tubercules par plante est de 1.7, 1.8 et 1.4 kg respectivement pour les bulbilles, tubercules et vitroplants. Le rendement en tubercules commercialisables (poids supérieur à 400g) est de 16.5 T pour les vitroplants, entre 32.5 et 34 T pour les bulbilles ou les semenceaux, sur la base de 20 000 plants à l'hectare. De plus, seuls les vitroplants génèrent plus de 25 000 tubercules utilisables directement comme semences (25-100g) et plus de 20 000 tubercules (10-25g) potentiellement utilisables moyennant quelques précautions.

ABSTRACT: We carried out a comparative study of tuber production by using as planting materials, bulbils, minisetts of same range of size (15-25g) and vitroplants. We obtained per plant an average number of 1 tuber for the bulbils or minisetts and 7 tubers for the vitroplants. The average weight of tubers harvested was between 1.4 and 1.7 kg for the bulbils or minisetts, and only 0.2 kg for the vitroplants. The average tuber yield per plant was 1.7, 1.8 and 1.4 kg respectively for bulbils, minisetts and vitroplants. The yield in marketable tubers (weight higher than 400g) was 16.5 metric tons for vitroplants, between 32.5 and 34 metric tons for bulbils or minisetts, based on 20 000 plants per hectare. Moreover, only the vitroplants generated more than 25 000 seed yam (25-100g) usable directly and more than 20 000 seed yam (10-25g) potentially usable after sprouting in adequate conditions.

INTRODUCTION

La production, en abondance, de semences saines et de qualité, exemptes de parasites et indemnes de viroses doit répondre à plusieurs objectifs : (1) satisfaire les besoins des agriculteurs, (2) améliorer le rendement de l'igname, (3) relancer la culture de certaines espèces dans les régions où elles sont en voie de disparition, (4) éviter ou réduire le prélèvement opéré sur la récolte de tubercules destinés à la consommation. Plusieurs voies de production de matériels de plantation ont été explorées. Ferguson (1972), Vander Zaag et Fox, (1981) ont utilisé sans grand succès au champ des boutures de tiges. Okoli *et al.*, (1982) ont mis au point, au Nigeria, une technique rapide de production de semenceaux (minisetts) pour approvisionner les agriculteurs en matériels de plantation. Cette dernière technique a été améliorée et utilisée à l'intérieur et à l'extérieur du Nigeria pour produire, à partir de minisetts, des tubercules-semences entiers (Orkwoor, 1997). La multiplication clonale comporte l'inconvénient de perpétuer toute l'histoire pathologique d'une variété malade.

Dès que des clones sains ont été obtenus souvent par combinaison de culture de méristème et de thermothérapie, les vitroplants sont devenus des matériels intéressants pour la production de tubercules-semences. Il est même envisagé, bien que leur manipulation soit délicate, de les utiliser au champ pour la production de tubercules commercialisables mais peu d'études à ce jour ont été faites dans ce sens.

Les bulbilles n'ont pas retenu jusqu'ici l'attention des chercheurs. Ce sont des tubercules aériens (Wickham *et al.*, 1982). Chez *D. bulbifera* (igname à bulbilles), la bulbille est le lieu préférentiel de stockage des glucides et, sous forme entière ou fragmentée, constitue le principal sinon l'unique matériel de plantation (Degras *et al.* 1977).

Chez *D. alata* cv Belep, nous étudions les facteurs de régulation de la formation des bulbilles. La maîtrise de la promotion des bulbilles chez les espèces à tubercules qui peuvent en produire peut constituer une voie alternative de production de matériel de plantation. Les premiers résultats de production de bulbilles sont rapportés dans ce séminaire (Zinsou *et al.*, 2001). Dans ce papier nous rapportons les résultats d'une étude comparative de la production expérimentale de tubercules commercialisables (poids > 400 g) à partir de bulbilles et de semenceaux de même classe de poids (15-25g) et de vitroplants. Nous avons voulu répondre à la question : les bulbilles et les vitroplants peuvent-ils servir de matériels de plantation pour produire directement de gros tubercules (de consommation) ?

MATERIEL ET METHODES

Le matériel végétal utilisé dans cette étude est constitué d'une part, par des bulbilles et des semenceaux de même classe de poids (15-25g) et d'autre part, par des vitroplants de *D. alata* cv Belep. Les bulbilles sont obtenues sur des plantes issues de fragments de tubercules de poids supérieurs à 50g. Les vitroplants sont produits par multiplication *in vitro*, sur milieu de Murashige et Skoog additionné des vitamines Morel et Martin, de bouture de tiges. Au bout de 45 à 60 jours, les plants sont repiqués sur des pastilles de tourbe (jiffy pots) et sont transférés en salle d'acclimatation où elles passent environ 3 semaines. La dernière étape consiste à les adapter progressivement aux conditions de champ avant plantation. Les bulbilles et les tubercules récoltés en même temps ont la même durée de dormance et germent à la même période.

La plantation des différents matériels a été effectuée en avril sur un sol qui a reçu un amendement organique similaire à celui utilisé pour les cultures maraîchères. Chaque traitement comporte 100 bulbilles, 100 vitroplants et 40 semenceaux. Les billons sont espacés de 1 mètre et les plantes sur le billon sont distantes de 40 cm (ce qui équivaut à 25 000 pieds/ha). Pour une meilleure utilisation de la lumière, les plantes ont poussé sur des tuteurs hauts de 1.50m. L'expérimentation a été entièrement conduite sous irrigation par aspersion correspondant à un apport d'eau journalier de 7 mm. Trois mois après plantation chaque plante reçoit au pied 40 g d'un engrais complet. A la fin du cycle les mesures de rendement ont été effectuées sur l'ensemble des plantes correspondant à un traitement.

RESULTATS ET DISCUSSION

1 - Production de tubercules

Le nombre moyen de tubercules produits par plante est respectivement de 1.1 ± 0.1 pour les bulbilles, 1.3 ± 0.3 pour les semenceaux et 6.9 ± 0.8 pour les vitroplants. Une plante issue d'une bulbille de Belep donne un tubercule, ce qui est le cas général lorsqu'on part d'un tubercule entier ou fragmenté chez cette variété. En revanche les vitroplants ont la capacité de produire de multiples tubercules de taille différente.

Le rendement moyen de tubercules par plante est de 1.7 ± 0.3 kg pour les bulbilles, 1.8 ± 0.4 kg pour les tubercules et 1.4 ± 0.1 kg pour les vitroplants. Pour α=0.01, les valeurs ne sont pas significativement différentes pour les bulbilles et les semenceaux de même classe de poids. Le rendement obtenu à partir de vitroplants semblent cependant plus faible. Ce phénomène est souvent observé lorsque la répartition des assimilats se fait sur un plus grand nombre de tubercules.

Les résultats intéressants se situent au niveau du poids moyen des tubercules récoltés dans chaque traitement. Le poids moyen des tubercules est de 1.5 ± 0.3 kg pour les bulbilles, 1.4 ± 0.3 kg pour les semenceaux mais 0.20 ± 0.03 kg, pour les vitroplants. Alors que le poids moyen par tubercule est comparable pour les bulbilles et les semenceaux, il est significativement inférieur pour ceux provenant des vitroplants.

Si l'on considére les tubercules commercialisables (poids supérieur à 400g), leur poids moyen est de 1.7 kg pour les bulbilles et les semenceaux et de 0.8 kg pour les vitroplants. Sur la base de 20 000 plantes à l'hectare le rendement est estimé respectivement à 32.6 t (97 %) pour les bulbilles, 34.6 t (91.2%) pour les semenceaux et seulement 16.75 t (62 %) pour les vitroplants. Les valeurs entre parenthèses représentent le pourcentage des tubercules commercialisables par rapport à la récolte totale.

2 Production de bulbilles et ou de tubercules semences.

Sur les plantes issues de bulbilles et de semenceaux de petits poids et celles issues de vitroplants aucune production de bulbilles n'est constatée, ce qui confirme d'autres observations faisant prévaloir le rôle du tubercule-mère qui doit disposer d'une quantité minimale de réserves glucidiques initiales. Ceci semble ne pas être le cas pour les bulbilles et les semenceaux et encore moins chez les vitroplants. Contrairement aux bulbilles et aux semenceaux qui génèrent peu de tubercules de petit poids, 38 % de la récolte issue des vitroplants sont constitués de tubercules de poids inférieur à 400g. Ceux de poids compris entre 25 et 100 g, sont susceptibles d'être utilisés directement comme semences. Ils représentent environ 1.4 tubercules-semences par vitroplant. Un grand nombre de tubercules de poids < 25 g subsiste. Leur utilisation est possible et nécessite au préalable leur prise en charge par une filière d'élevage des plants.

Les bulbilles et les vitroplants peuvent constituer des matériels de plantation intéressants pour la production de tubercules commercialisables. Les rendements sont plus faibles mais non négligeables par rapport à ceux obtenus à partir des semenceaux ou des tubercules-semences de poids plus élevé. Les tubercules récoltés sont homogènes et de taille relativement modérée, ce qui facilite la récolte qui peut être mécanisée, et réduit les dommages au moment de la récolte. Nous constatons une régularité de la forme des tubercules, ce qui rejoint un souci de calibration. Cette exigence doit de plus en plus être prise en compte car aux Antilles françaises l'igname n'est plus l'aliment de base comme dans d'autres sociétés. Il entre désormais comme une composante d'un régime dit varié. Le client achète juste la quantité qu'il lui faut pour un repas et si la taille du tubercule excède ses besoins, il délaisse celui-ci pour un autre tubercule, la pomme de terre par exemple. L'exigence de la calibration ira en s'affirmant car les supermarchés prennent une part de plus en plus importance dans la distribution des produits agricoles.

Les bulbilles peuvent être utilisées pour la production de tubercules commercialisables, calibrés et de forme homogène. Les vitroplants semblent avoir une double vocation, en générant en plus des tubercules-semences.

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TABLEAU 1: Etude comparée de la production de tubercules à partir de différents matériels de plantation chez *D. alata* cv Belep

Matériels de plantation	Bulbilles 15-25 g	Semenceaux 15-25 g	Vitroplants
Nombre moyen de tubercules par plant	1.1 ±0.1	1.3 ± 0.3	6.9 ±0.8
Rendement moyen de tubercules/plante (en kg)	1.7 ± 0.3	1.8 ± 0.4	1.4 ± 0.1
Poids moyen des tubercules (en kg)	1.5 ± 0.3	1.3 ± 0.3	0.20 ± 0.03
Poids moyen tub commercial (>400g) en kg	1.7	1.7	0.8
Rendement en T/ha (20 000 pieds /ha)	33.6	35.6	27.2
Rendement en T/ha de tub commercial	32.6	34.6	16.7
Nombre de tub-semences de poids 25-100g /ha	1 410	1 500	28 100
Nombre de tub-semences de poids 10-25g /ha	0	0	19 800
Total	1 410	1 500	47 900

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INTEGRATED MANAGEMENT OF THE RED FIRE ANT (*SOLENOPSIS INVICTA*): A NEW PEST IN ANTIGUA

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ABSTRACT: The red fire ant was imported into Antigua several years ago and has now become a serious pest. The ants are very aggressive and will invade houses and other structures. They sting without provocation. Multiple stings have occasionally required hospitalization. Young livestock and small pets have also been attacked. The presence of fire ants in crop fields interferes with field operations and the ants are implicated in the spread of pink and papaya mealy bugs. The Ministry of Agriculture has begun a programme to assist communities in managing the ant with a minimum of risk to human health and the environment. A survey of all parishes in Antigua has established the extent of the problem and the target areas for management programmes. Testing of control measures, including bio-agents and other organic methods has been carried out. Tests have included commercial baits and spot treatments. The results of these tests and consideration of fire ant behaviour have formed the basis for a number of integrated management recommendations, which have been communicated to the public through brochures, community meetings and the media.

INTRODUCTION

The tremendous rains which Antigua and Barbuda experienced in November 1999, when Hurricane Lenny delivered over 20 inches of rain in a 24 hour period, caused widespread flooding, serious erosion and landslides over most of the country. The flooded soils and floodwaters also brought another problem to light. This was the fact that Antigua was now host to a particularly aggressive reddish-brown ant, which made large, dome shaped nests in the soil and that were now very obvious in pastures, gardens and waste ground around most of Antigua.

The Ministry of Agriculture began getting calls from concerned citizens, who had been stung or who had had these ants invade their homes. There were numerous reports of ants attacking pets, or getting into their food, inflicting severe injury to young animals and in some cases to children and older adults. It was clear that the country had a serious new pest problem to deal with.

Initial observations of nesting behaviour, variable ant size and feeding preferences, as well as structure of the ant itself, suggested that the new pest was none other than the red imported fire ant that has caused so much misery and controversy in the Southern United States of America, since its importation from Brazil in the late 1920's or early 1930's.

The Plant Protection Unit collected individual ants and specimens sent for identification to various centres. Confirmation was received from the USDA-APHIS and CARINET that the new ant species was, in fact, *Solenopsis invicta*, a species not previously recorded for Antigua and Barbuda.

Biology and Life History of the Red Fire Ant

Solenopsis invicta (Buren) (S. wagneri) (Hymenoptera, Formicidae, Myrmicinae) is native to Brazil and was introduced into Alabama in the southern United States around 1930, probably carried in soil used as ship's ballast. Since then it has spread throughout the southern states and reached Puerto Rico sometime between 1975-1984. The ant lives in large colonies of between 100,000 to 500,000 individuals. The colonies live in dome shaped nests in the soil. The domes are typically 20 to 30 cms high and up to 40 cms in diameter. In favourable soil and in dry conditions, the nest may extend to 1 metre below ground and the queen usually occupies the lower regions of the nest. During dry weather, the above ground structures are vacated and may be hard to detect.

The sterile female workers are of different sizes, ranging from 2-5 mm. Some tend the queen and the brood, tasting her food before she eats. Other workers forage for considerable distances on the surface and in underground tunnels, which may stretch for 10 metres or more. Food is very varied and in Antigua has been seen to include other insects, or parts of larger arthropods such as dead cockroaches or ground spiders. Plant seeds, including discarded mango seeds as well as honeydew excreted from plant-sucking insects such as aphids and mealy bugs are consumed. Fire ants have a particular preference for fatty or oily foods and are often attracted to pet food. This preference is used to our advantage in the formulation of baits.

Nests may have only one queen who lays all the eggs (monogyne colonies) or there may be colonies with multiple queens (polygyne colonies) (Greenberg et al 1985). Winged females and males are also produced, which swarm after wet weather and mate during flight. The white or pale yellow eggs hatch in about 7-10 days and the larvae take a further 6-10 days before pupation. Adult workers emerge 9-15 days after this. A mature queen fed by workers can lay up to 800 eggs per day (Texas A&M website).

Disturbed nests are frequently abandoned, the colony moving to another site. Where there are multiple queens, the colony may split up and form several new colonies. A queen and a few workers can start a new colony. Ant populations tend to be larger where colonies are polygynous and can reach 40 to 150 mounds per acre, with as many as 40 million ants per acre.

Development of Management Strategy for Antigua and Barbuda

It was quickly evident that a serious problem existed in Antigua following the extensive flooding during Hurricane Lenny. It is not known when the fire ant was first introduced into Antigua. However, the scale of the problem and the distribution of fire ants around the country revealed by the survey, to be reported on later, suggest that it had been here for some while prior to 1999, but in much lower numbers. Many persons believe that it may have entered Antigua as far back as 1995 after Hurricane Luis on relief supplies.

A review of management experiences in the United States indicated that eradication was an unrealistic objective and that management of the ant to reduce invasion of homes and attacks on pets and livestock were a high priority. The focus on domestic environments also dictated that considerable care should be given to the safety aspects of any management system recommended that involved the use of chemical pesticides.

The Integrated Pest Management National Network Committee which was formed in June 1999 under the umbrella of PROCICARIBE and the Caribbean IPM Network set up a Fire Ant Sub-committee in February 2000 to determine a management strategy. The committee was broad based and comprised members of the Ministry of Agriculture (Plant Protection, Communications, Extension, Lands); Ministry of Health (Central Board of Health); Ministry of Tourism and Environment (Environment Division); CARDI; IICA and UWI. It was decided that the following activities were required to tackle the problem:

1. Conduct survey to determine the extent of the infestation and community needs
   - Obtain positive identification of the ant.
   - Validate available methods for management of the ant.
   - Develop a long-term management plan
   - Provide the public with practical and accurate information about how to deal with their ant infestation problems.

The initial focus was on the domestic situation as this was the most pressing problem.
Three work groups were established to deal with: Public awareness; Strategy for management and control; Survey and identification.

Various organisations, including FAO, WHO and CARDI were contacted to seek technical and financial assistance.

Execution of Management Programme

Survey of Ant Distribution

The survey was necessary to provide an accurate assessment of the distribution of the fire ant in Antigua and Barbuda. It was hoped that this might provide some indication of the area of initial introduction and also suggest areas more favourable to its establishment.

METHODOLOGY

The Survey and Identification work group developed a survey questionnaire with the assistance of CARDI's biometrician and entomologist. It was decided to visit 1600 households in 40 communities in Antigua. Five teams consisting of 5 persons (1 plant protection, 1 Extension, 3 Health workers) were established and visits were made in the afternoon between 3 p.m. to 6 p.m. Each team was responsible for visiting 8 communities. Team members were provided with identification cards. Transportation was provided by both the Agriculture and Health Departments. Conducting trial interviews at schools and recreational areas, prior to the main survey, validated the questionnaire.

The questionnaire contained questions regarding number of ant mounds in person's yards and incidence, symptoms and severity of ant stings or injury to household members. Information was also sought on whether treatment of the ants had been carried out and what treatments had been used. Respondents were also asked to indicate what they thought should be done about the problem.

The survey was carried out during August/September 2000, after some delays in obtaining the necessary resources due to financial constraints.

RESULTS

The survey completed 1596 interviews in forty communities widely spread over Antigua. Barbuda was not included in the initial survey. The average number of mounds reported per household was 2.66, but this number varied widely among different communities. Distribution: Table 1 shows the distribution of mounds reported by each community. Highest average mound populations were found in the central areas of Lightfoots (17.6), Clarke's Hill (8.2) All Saints (8.1). Golden Grove, located to the south of St. John's was also high with a mound density of 7.6/household. Low levels of infestation were reported in several eastern and southern coast communities as well as in the city of St John's and some surrounding areas. Highly urbanised areas would likely be unfavourable to the establishment of nests and the high water table in St. John's would also deter establishment. As would be expected, there was a highly significant correlation between mound incidence and (a) injury incidence and (b) treatment of infestations. Attitudes to what should be done were highly variable and, rather surprisingly, did not correlate significantly with levels of incidence or injury.

Treatment:

Some form of treatment was being used in all communities surveyed. Diesel oil, Sevin (Carbaryl), hot water and fireant granules were the more popular treatments and were reported to be effective at least 80% of the time. A partial list of treatments and perceived success rates are provided in Table 2.

Injuries:

At least 5% and, in some communities, as high as 68% of persons reported being stung by the fireant. Ant stings were reported to result in pus filled inflamed spots or blisters that sometimes left black marks on the skin after healing. Some persons reported itching, swelling and occasionally an allergic reaction that required hospitalisation. In most cases, stings were treated with commercially available insect bite preparations or alcohol-based products. Some doctor-prescribed, topical or oral medication was also used.

Response:

The majority of respondents (72%) thought something should be done about the ant problem and many suggested that the government should mount a programme to effect control. Many also thought that it should also provide any chemicals to be used to treat the ants. Some persons suggested the need for some kind of co-operation between government and the affected communities.

Additional survey of impact of fireants on agriculture

Subsequent to the distribution survey in late August/September 2000, a series of telephone interviews was carried out in order to determine the effect of fireants on livestock. The information is also based on reports of Livestock Officers. Quantitative information was not available for analysis. Livestock officers reported seeing injury to kids and lambs since 1997 in the Bendals area and at Olivers beginning in 1999. In other areas, such as Parham, Greencastle, Potters and Lindsay, injured kids lambs and some cattle have been observed in 2000. Animals attacked by ants develop vesicles on their skin and animals show reduced weight gains and become weaker.

The telephone interviews with livestock owners provided additional evidence of injury to livestock in other areas. Details are provided in Table 3.

Evaluation of Alternative Strategies for Integrated Management

As indicated previously, the primary focus in the initial stages was to control the domestic problem and there was considerable concern about the safety aspects and cost of any chemical used around the home.

Consideration of the ant's feeding habits and ability to move considerable distances in search of food, as well as the frequency with which the ant forms new colonies, indicated that management on a community basis would be necessary to achieve any degree of long term population control. Nevertheless, the government was not in a financial position to mount a major countrywide programme.

The committee decided that the major components of a management programme should include the following elements:

- Restrict spread of ants in soil or plant containers by careful inspection and treatment/fumigation. Target: Nurseries
- Reduce food sources close to homes, schools and playgrounds. Garbage with food remains, uneaten pet food and discarded containers with food residues are all attractants for fireants. Careful attention to garbage and sanitation will reduce potential food sources that attract ants to houses and school grounds. Target: Householders, Schools and Sports Clubs
- Spot application of safe insecticides to control ants inside the home and nests close to domestic buildings.
- Treatment of individual mounds or broadcasting of bait in yards, lawns and pastures depending on numbers and visibility of nests.
- Selection of optimum time for identification of nests and their treatment

The Fireant Committee undertook to make an assessment of information gathered primarily over the Internet, regarding organic pesticide treatments, which might be suitable for treatment of ants in sensitive areas. The committee also approached the agricultural supply stores in an effort to obtain samples of the newer commercial baits and drenches specifically labelled for fireant control and to encourage them to import these alternatives to the conventional organo-phosphates and carbamates, such as chlorpyriphos, diazinon and carbaryl.

Table 1. National Fire Ant Survey 2000- Average Number of Fire Ant Mounds per Household in Communities Surveyed.

No.	Location	No. of Mounds	No.	Location	No. of Mounds
South Coast					
1	Old Road	0.7			
2	Urlings	1.7			
3	Johnsons Point	1.2	Central		
	West Coast		26	Potters	2.4
4	Bolans	1.6	13	Bellevue Hts.	4.0
5	Jennings	2.2	24	Gunthorpes	2.2
6	Bendals	1.8	25	Lightfoots	16.7
7	Golden Grove	7.8	27	Clarkes Hill	8.2
St. John's & Surrounding Communities			30	All Saints	8.1
8	Cooks Hill	1.9	South Central		
9	Green Bay	1.1	29	Liberta	4.5
10	Hatton	2.4	28	John's Hughes	2.7
11	Perry Bay	0.8	31	English Harbour & Cobbs Cross	1.1
12	Brown's Ave.	1.7	33	Christian Hill	3.7
14	St. John's City	0.5	South East		
15	Point	0.8	32	Bethesda	1.2
17	Villa	3.0	40	Newfield	0.7
18	Dry Hill & Old Runaway	3.4	35	Mill Reef & St. Phillips	0.3
16	Mc Kinnons	0.7	34	Freetown	0.9
22	High Point	0.4	North East		
23	Skerrits Pasture	0.8	38	Pares	2.1
North West			37	Seatons & Glanvilles	4.1
19	Cedar Valley	1.8	36	Willikies	1.6
20	Longfords	4.1			
21	Barnes Hill	0.6			

Table 2. Summary of most frequently used treatments as reported in the survey

	Frequency		No. times successful	
Treatment Mentioned	Number	Percent	No.	Percent
Diesel Oil	449	44.5	382	85.1
Sevin (Carbaryl)	173	17.2	150	86.7
Hot Water	106	10.5	85	80.2
Fireant Killer/Granules	45	4.5	43	95.6
Household Insecticides	41	4.1	33	80.5
Gasoline	29	2.9	25	86.2
Diazinon	22	2.2	13	59.1
Kerosene	20	2.0	13	65.0
Gasoline & Kerosene	20	2.0	20	100.0
Used Lubricating oil	19	1.9	15	78.9
Pest Control Agency	16	1.6	13	81.3
Malathion	15	1.5	15	100.0
Soap Water	12	1.2	11	91.7
Household Bleach	9	0.9	8	88.9
Boric acid powder	7	0.7	6	85.7

Table 3. Impact of Fireant on livestock in Antigua as reported by farmers in telephone interview.

Location	Mounds/acre (Approx.)	Animals farmed	Animals attacked	No. Animals lost	Comments
North Sound	Not assessed	Sheep /goats	Yes	10	All young animals lost
English Harbour	>25	Goats	Yes	6 (3%)	Young animals lost
Bethesda	> 20	Sheep, goats	No	0	Puppy killed
Bellevedere	8 in paddock 4 in paved pen	Goats	No	0	Pen paved
Vernons New Extension	>40 in untreated areas 6 in pen area	Poultry	Yes	2 adult birds & 4 broilers (2-3 weeks old)	Adults overwhelmed while laying
Jolly Hill	20-30 (pen) 40 (area with dung heap)	Sheep	Yes	1 (3%)	Affected lamb rejected by mother
Lavington Estate	16	Cattle	No	0	Ants not a problem

Trial 1. Laboratory Test: Treatments were applied to 10 ants in glass jars using 3 replicates of each treatment. Water alone was used as a control. A hot water extract of citrus peel was made and allowed to steep for several days according to Drees. An additional treatment comprising the citrus extract plus garlic and hot pepper (cv. West Indies Red) was also prepared. Treatments were sprayed on the ants in the bottom of the container. The ants used were collected from several nests in different locations.

Table 4. Effect of in vitro spraying on survival of live ants

Elapsed Time (Hrs)	Live ants observed (Percent of initial population)		
	Water alone	Citrus peel extract	Citrus peel+garlic+ pepper extract
0	100	100	100
1	100	100	0
2	100	93	0
3	100	83	0
24	73	20	0

Trial 2. Evaluation of treatments to ant mounds: This trial evaluated the effect of 4 treatments applied directly to the ant mounds in the field. Treatments comprised Water alone (Control), Boiling Water (approximately 100°C), Citrus peel solution and Boric acid/sugar solution bait. Approximately two litres (0.5 gallons) of drench was applied to a nest. The boric acid bait was placed in a jar laid on its side near the nest, with a small hole in its lid to allow ant access. Solution was changed every 7 days. Tests were carried out at several locations in various parts of the country. Not all treatments were included in at each location.

Ant activity was observed around the undisturbed nest up to 28 hours after application and scored visually to determine ant survival. The results obtained are presented in Table 5 below.

Table 5. Effect of direct mound treatments on live ant population observed

Elapsed Time (Hrs)	Treatment Water (Control)	Hot Water	Citrus peel solution	Boric acid/Sugar bait
0	+	+	+	+
1	+	-	+	+
2	+	+	+	+
4	+	+	+	+
7	+	+	+	+ (20)
14	+	+	+	+ (19)
21	+	+	+	+ (13)
28	+	+	+	+ (9)

Note: (+s) indicate numbers of ants present; (-) = absence of ants

Trial 3. Chemical Treatments: A number of chemical treatments are recommended by universities and state extension services in the southern United States where fireants have been researched for many years. In recent years a number of new chemicals have been developed and labelled specifically for fire ant treatment.

Table 6. Effect of chemical mound treatment on ant activity.

Day	Treatment Ascend (Abamectin)	Demon TC (Cypermethrin)	Fireant Killer (chlorpyriphos)
0	+++	+++	+++
1	+++	+	++
2	++	-	-
3	+	-	-
4	-	-	-

Note: (+s) indicate numbers of ants present; (-) = absence of ants

Conclusions from product testing

Citrus peel treatments were generally ineffective unless combined with garlic and hot pepper (*in vitro* test only). Hot water did reduce ant numbers temporarily but the reappearance of ants after 2 hours suggests that the 2 litres of water used was insufficient to penetrate the nest adequately. Most recommendations for boiling water treatment require 4 to 6 times this volume for full penetration of sufficient hot water. Boric acid as with most baits took some time to reduce ant populations and was not successful in obtaining complete removal of ants even after 28 days. However the bait had evidently not caused the colony to vacate the site, which is a requirement for a successful bait.

The chemical treatments were all effective and reduced ant numbers to zero. Cypermethrin and chlopyrifos acted quickly reducing numbers to zero in 24 hours. The abamectin bait acted more slowly, as expected, and zero ant population was achieved in 4 days.

General Recommendations: Experience in Antigua so far suggests the following steps will reduce the fireant problem to manageable proportions.

- Keep area clean and as free as possible of potential food items and spilt pet food should all be checked regularly
- Regularly inspect for ant nests, particularly after heavy rains. Garbage cans and compost heaps are particularly prone to attract fireants. If a few ants are seen foraging, but no trails are evident, some dry dog food can be placed as bait and ant trails will usually be evident within a few hours. These can then be followed to the nest, which can be spot treated.

- For general treatment of an infested area, broadcast bait in dry conditions at the label recommended rate. Nests near to domestic buildings or electrical installations can be spot treated immediately.
- In neighbourhoods heavily infested with fireants, repeat bait applications as soon as any re-infestation is observed, taking special care to bait border areas. Where possible assist in organising community management of fireant populations as this will greatly reduce re-invasions.
- Pesticide selection should be guided by human use of the area to be treated and threats to pets or livestock. Baits used according to directions are usually safer than spot treatments as amount and concentration of active ingredient is much lower. Table 7 lists some of the pesticides currently labelled for fireant control in the United States with notes on recommended use.

Additional testing of other pesticides for ant control in different situations is needed. Baits offer the best approach to reducing populations in school and sports grounds and in home yards or where ant populations are large and spot treatment is impractical or nest location is difficult to determine. The cost of baits is high but the amount used is small and much longer-term protection is afforded if applied properly. Also where there is a problem with invasion from neighbouring properties, bait can help extend control to nests of ants foraging from the adjacent property. Environmental contamination is much reduced, as amounts of active ingredient per hectare are very small. Spot treatments can be used where the nest population is less than five per 0.1 ha lot or to treat rogue nests that escape the baiting. The best time for spot treatment is after heavy rains when nests are active near the surface and easily visible. Organic treatments such as boric acid baits can be used with care in the home as a preventive treatment.

Public Awareness: Since the inception of the sub-committee, considerable emphasis has been placed on providing information for the public. Activities included interviews with Ministry of Agriculture professional staff on national television and evening community meetings to explain the management options and promote sound community action to manage the fireant. A factsheet was produced and distributed at these meetings. Also a video was obtained from Texas A & M University and used to illustrate management options. Meetings were attended by members of the Central Board of Health and by some agrochemicals suppliers who had made efforts to obtain some of the recommended pesticides. Opportunity as taken to discuss proper use of pesticides and the dangers they present if not properly stored and handled.

Current Situation and Future Needs: Currently, the fire ant situation is at a relatively low level, due to the prolonged drought, which has weakened many colonies and driven them deep under ground. Foraging is now largely at night. However, as soon as the rains return, a new upsurge in house invasions and attacks on animals and people is expected. The work done by the sub-committee has been very valuable in assessing the situation and raising awareness, and providing information on safe fireant management. However, there is still much that is not known about the situation. What has happened to the native ant population? What are the best ways to manage the ant without damaging native species or the rest of the environment? Are there indigenous materials that can be used to formulate local baits? Many of these questions cannot be answered without financial support, which is very limited in the country right now. The ant is present in Puerto Rico. Is it or will it become a regional problem? Should there be a regional approach to this highly aggressive insect?

Lessons Learned: The approach to managing the fireant situation has proved to be quite successful, in that the broad based approach right from the start, enabled the co-ordination of and access to a range of resources that would not have otherwise been available and facilitated activity despite very limited funding. The community approach was taken from the start and although there has not been significant development of co-ordinated community action to manage the fireant, there is a much greater appreciation of what to do to manage it safely. The involvement of agrochemicals suppliers has also been helpful in encouraging their participation and support, though it would have been good to see a much wider rage of materials made available for testing and public evaluation. The crisis in late 1999/early

2000 showed that responding quickly to such biological crises was very difficult in the absence of any financial resources budgeted for emergency response measures. The lessons learned in handling the fireant situation have helped to generate a swifter response to the arrival of other exotic pests {the Pink Mealybug (*Maconellicoccus hirsutus*) in 2001}.

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EVALUATION OF THE EFFICACY OF NEW CHEMISTRIES FOR CONTROLLING MAJOR LEPIDOPTERA PESTS ON VEGETABLE AMARANTH IN JAMAICA

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ABSTRACT: Vegetable amaranth (callaloo), *Amaranthus viridis*, a popular vegetable in Jamaica with increasing economic importance for export is attacked by numerous phytophagous pests. Among the major species are Lepidoptera: Pyralidae. (*Spoladea recurvalis* and *Herpetogramma bipunctalis*) and Noctuidae (*Spodoptera exigua, S. frugiperda* and *S. eridania*). Growers currently rely on insecticides applied usually every 8 days, which results in indiscriminate use of insecticides, and field failures of insecticide applications have been observed. Initial investigative data suggest pyrethroid resistance. Block trials were conducted over two growing seasons to compare the efficacy of four lepidoptera specific biorational pesticides Proclaim® 5SG (emamectin benzoate), Confirm® 2F (tebufenozide), Spintor® 2SC (spinosad) and Ecozin® (azadirachtin) with the farmer standard, Karate® (lambda cyhalothrin) in control of major lepidoptera species. The modes of action and efficacy are discussed. Results indicate that spinosad gave the best protection against the lepidoptera complex, reducing insect damaged losses by (77.66% and 95.83%) over season I and II respectively. Tebufenozide and emamectin benzoate also gave superior control compared to the farmer standard.

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DISEASE PREVALENCE AND PESTICIDE USAGE ON SELECTED CROPS IN TRINIDAD AND TOBAGO – A REVIEW OF THE PLANT DISEASE DIAGNOSTIC RECORDS (1990-2000) OF THE PLANT PATHOLOGY DEPARTMENT, MINISTRY OF FOOD PRODUCTION AND MARINE RESOURCES.

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ABSTRACT: As a consequence of the diagnostic function of the Plant Pathology Department, Ministry of Food Production and Marine Resources, a database of the important diseases of crops grown in Trinidad and Tobago has been developed over the years. This database is compiled from records of plant samples collected from surveys, field visits and plant clinics conducted by the staff of the department, and specimen submissions from farmers, extension officers and home gardeners. In this paper, 1967 diagnostic entries, representing 27 selected crop species from six families for the period 1990 to 2000, were reviewed. Data were analyzed to determine the prevalence and distribution of diseases, causal agents and crop species affected. Seasonal and annual variations of disease incidence are discussed. Results indicated that 28.8% of recorded health problems were associated with fungi while bacteria, viruses and nematodes accounted for 23.2%, 13.9% and 1.2% respectively. Health problems with undetermined aetiology accounted for 8.2% of reports. The Solanaceae was the family most prone to disease. The records revealed a high use of pesticides, emphasizing the need for an Integrated Crop Management (ICM) approach to plant health.

INTRODUCTION

Disease is defined as 'harmful deviation from normal functioning of physiological processes.' (Johnston and Booth, 1968). Diseases in plants are caused by a number of agents, including living agents (nematodes, fungi, bacteria, viruses, mycoplasma, protozoa) and non-living agents (poor agronomic practices, physical damage, chemical damage, inbreeding, unknown factors). It is estimated that there are 80,000 – 100,000 plant diseases, some of which have caused severe economic and human loss throughout history (Fortune, 1994). In the period 1845-1851, for example, the potato famine in Ireland caused by the fungus *Phytophthora infestans* resulted in the loss of one million lives and mass migration from Ireland. Early and accurate diagnosis of plant disease can help prevent crop losses and reduce expenditure on crop protection measures by providing the most appropriate and cost effective management procedures in a timely manner. A plant disease diagnostic facility is therefore an important component in any successful agricultural sector.

The Plant Pathology Department of the Research Division, Ministry of Food Production and Marine Resources, Trinidad and Tobago, has for many years offered a plant disease diagnostic service to its clients (farmers, extension officers, home gardeners, researchers and the public at large). This service is supplied free of charge and is the only one of its kind in the country. With a high demand for this service, the department has developed into a major diagnostic center for plant diseases. In managing the information generated, an extensive database of diseases found on agricultural, horticultural and forestry plants in the country has been developed.

This database is compiled from information obtained from samples collected from field visits, surveys and plant clinics by staff of the department and specimen submissions from clients. In this paper, data on 27 selected food crops belonging to the families Compositae, Umbelliferae, Leguminosae, Cruciferae, Cucurbitaceae and Solanaceae were examined. The objectives of this paper were to determine (a) the frequencies of host and pathogen reports and the effects of rainfall, acreage planted and distance from the diagnostic center on these frequencies and (b) trends in pesticide use on the various hosts. The data were extracted from records over the last 11 years (1990-2000). Because of the critical and monopolistic role this department plays in the diagnosis of plant disease, it was assumed that the database reflects the major pathogenic problems experienced in Trinidad and Tobago on these selected crops.

MATERIALS AND METHODS

Information on diseased specimens is collected on Plant Disease Identification Record forms (Appendix 1). Apart from general information on grower's name, address, host plant and symptoms, information on cropping patterns and agronomic practices, including pesticide usage, is also recorded.

The food crops selected for this study were as follows:

Family	Common Name	Botanical Name
Compositae	Lettuce	Lactuca sativa
"	Cabbage	*Brassica oleracea* var. *capitata*
"	Cauliflower	*Brassica oleracea* var. *botrytis*
"	Broccoli	*Brassica oleracea* var. *italica*
"	Pak-choi	*Brassica chinensis*
Cucurbitaceae	Cantaloupe, Musk melon	*Cucumis melo*
"	Carillie	*Momordica charantia*
"	Christophine	*Sechium edule*
"	Cucumber	*Cucumis sativus*
"	Loukie, Gourd	*Lagenaria siceraria*
"	Pumpkin	*Cucurbita moschata*
"	Squash	*Cucurbita pepo* var. *melopepo*
"	Watermelon	*Citrullus lanatus*
"	Zucchini	*Cucurbita pepo* var. *medullosa*
Leguminosae	Bodi	*Vigna unguiculata*
"	Salad bean, Beans, Contender bean, Red bean, String bean, Harvester bean	*Phaseolus vulgaris*
"	Jack bean	*Canavalia ensiformis*
"	Pigeon pea	*Cajanus cajan*
"	Seim	*Lablab niger*
Solanaceae	Cherry pepper	*Capsicum annuum* var. *cerasiforme*
"	Bird pepper	*Capsicum frutescens*
"	Hot pepper	*Capsicum annuum* var. *abbreviatum*
"	Melongene	*Solanum melongena*
"	Pimento	*Capsicum annuum* var. *longum*
"	Sweet pepper	*Capsicum annuum* var. *grossum*
"	Tomato	*Lycopersicon esculentum*
Umbelliferac	Celery	*Apium graveolens* var. *dulce*

Botanical names taken from Purseglove, J.W. Tropical Crops Dicotyledons. Publs. Longman, UK, 1968

Diagnostic records on these forms are also stored electronically using Microsoft Excel. Data for the period 1990-2000 were analyzed using SPSS statistical program to produce frequency and cross tabulation information with respect to host plant, pathogen, location, year, month and pesticide usage. Graphpad Instat 3.05 statistical package was used for correlation analyses and t-tests.

The Central Statistical Office (CSO) of Trinidad and Tobago supplied data on annual crop acreage planted in the country for the period 1991 to 1998. For an analysis of the relationship between disease incidence and rainfall, precipitation records (1990-2000) for Piarco from the Meteorological Office of Trinidad and Tobago were used. The months during the period 1990-2000 were divided into dry (less than 100 mm) and wet (100 mm or more). There was a total of 53 dry and 79 wet months. Unpaired t-tests (with Welch corrections) were performed on frequency data in these two categories for fungi, bacteria and viruses. For nematodes, the Mann-Whitney test was used instead because the data did not follow a Gaussian distribution.

Causal agents were classed as follows: fungus, bacterium, virus, nematode, unknown and other. The class 'Other' included agronomic, physiological, phytotoxic and entomological problems as well as incomplete diagnoses because of poor specimen material.

A comparison of report frequencies by county was done by measuring distances as a straight line from the geographic center of the various counties to the diagnostic center in Centeno and these figures were correlated with reports received.

RESULTS AND DISCUSSION

1. Host plant.

The frequencies of specimen submissions and causal agents in the various host families and species are presented in Table 1. With a total of 1967 specimen submissions, 2380 causal agents were diagnosed, as individual samples frequently suffer from more than one health problem. The Solanaceae, with 62.8% of the total number of causal agents diagnosed, was the family recorded most often followed by Cucurbitaceae (14.2%), Leguminosae and Cruciferae (8.7% each) with Umbelliferae and Compositae being recorded 3.3% and 2.3% of the total respectively. The three most susceptible crops, tomato (717 health problems), hot pepper (380) and sweet pepper (223) were solanaceous crops. Cabbage, watermelon and bodi each had over 100 records of causal agents and were the leading crops for health problems in their respective families. Cabbage was recorded more often than the other crucifers (cauliflower, broccoli and pak-choi) combined. A similar situation existed with bodi, which was recorded more than the other legumes (salad bean, jack bean, pigeon pea and seim) combined. Watermelon, with 131 health problems, accounted for 38.8% of the cucurbit records while pumpkin was the second most recorded host in this family with 63 (18.6%) causal agent entries.

It was not possible to determine whether host frequency was related to the number of farmers/home gardeners cultivating the crops, as data on individual farmer activity are lacking. However, data on total acreage planted on a national level, obtained from the CSO, showed no significant correlation to frequency of health problems (r = -0.0037, p = 0.9817, Figure 1). Tomato problems, for example, were consistently recorded six times more often than pumpkin although pumpkin was planted on acreages two or more times greater than tomato. These results suggest health problem frequency may depend on crop susceptibility more than crop popularity. It is plausible to assume, for instance, that the Solanaceae showed the highest incidence of disease because the family is most prone to health problems. Data on farmer numbers would still be needed, however, to confirm this hypothesis as many small farmers may have a greater demand (with different frequency profile) on a diagnostic facility than few large farmers.

2. Causal agent.

Fungi were associated with more plant health problems than any other causal agent with 686 diagnostic entries (Table 1). Fungi were also the most widespread pathogens, affecting every family significantly with Compositae having 33, Cruciferae 52, Cucurbitaceae 193, Leguminosae 83, Solanaceae 285 and Umbelliferae 40 entries. Of the 27 host species considered, only four had no fungal record (cauliflower, loukie, cherry pepper and bird pepper). Loukie, cherry pepper and bird pepper each had just 2 specimen submissions for the 11-year period under study.

The major fungal genera encountered are recorded in Table 2, where genera with a frequency of five percent or more of total fungal entries are shown. *Corynespora* had the highest frequency (16.1%), limited to eight hosts while *Colletotrichum* had the second highest frequency (15.1%) spread over 16 host species. *Colletotrichum* was considered the most problematic fungus of the food crops, affecting more hosts than *Corynespora*. Other major fungal genera were *Cercospora* (13.5%, 11 host sp.), *Rhizoctonia* (9.7%, 14 host sp.) and *Sclerotium* (8.2%, 12 host sp.).

Corynespora and *Cercospora* cause foliar diseases in a range of food crops. *Colletotrichum* is responsible for many anthracnose diseases causing lesions on aboveground organs (including leaves, flowers, fruits, stems). *Rhizoctonia* and *Sclerotium* are associated with diseases of underground organs and ground level stem areas, resulting in wilt symptoms, though they both can also occur on aboveground organs.

Bacteria were also recorded frequently (551 reports, Table 1). They were not as widespread as fungi with respect to host families or species. There were no records among the Compositae or Leguminosae while only six were found among the Cucurbitaceae. Bacteria mainly affected two families, the Solanaceae (464 records) and Cruciferae (69 records). Umbelliferae had 12 records. Fourteen host species had no bacterial problems.

The major bacterial genus encountered was *Ralstonia*, with 47.8% of bacterial entries but this genus was found exclusively on the Solanaceae. *Xanthomonas,* associated with three families, accounted for 37.8% of bacterial entries while *Pseudomonas* (on three families) and *Erwinia* (on 2 families) accounted for 9.4% and 4.9% respectively (Table 2).

Ralstonia is the causal agent for bacterial wilt disease of the Solanaceae. *Xanthomonas* causes foliage lesions, chiefly on crucifers (black rot) and solanaceous crops (bacterial spot). *Pseudomonas* spp. also causes leaf spotting on crucifers (peppery leaf spot), celery (bacterial blight) and tomato. *Erwinia* is often associated with rotting symptoms of plants.

The viruses were recorded 331 times but were confined to three families, Cucurbitaceae (11 records), Leguminosae (49) and Solanaceae (271). Cucumber mosaic, potato virus Y, tobacco mosaic and unidentified viruses belonging to the potyvirus group were detected in tomato and hot pepper samples. Cowpea severe mosaic virus was detected in samples of bodi.

There were just 28 entries for nematodes. They occurred on 5 families making them more widespread in this regard than bacteria or viruses.

Fungi, therefore, seem to cause more health problems as a whole to food crops than other pathogens because of the large numbers of records and the widespread nature of the problems among the various host species.

There were 194 entries of unknown aetiology spread through all six families. The category 'Other' includes entomological and agronomic problems. This category does not reflect total level of entomological or agronomic problems on crops in Trinidad and Tobago as other departments in the Research Division handle these problems and possess their own diagnostic records. However, the frequency of problems under this heading (24.8% of total health problems, Table 1) brought to the Plant Pathology Department reflects the ease at which farmers and other clients can erroneously diagnose plant health problems and emphasizes the need for an adequate diagnostic facility.

3. Annual and geographic variation.

Annual variation in frequency of reports (Figure 2) showed a marked increase from 1997 to 2000 compared with the period 1990-1996 and may be due, in part, to a number of factors, including increased disease incidence, increased awareness of farmers of the services offered by the Plant Pathology Department and increased vigilance of staff of the Research and Extension divisions.

There was a very significant correlation between county distance and frequency of reports (Figure 3) with the correlation coefficient $r = -0.81$ and $p = 0.0081$. St George East, the county in which the Plant Pathology Department is located, had the highest number of reports (598) followed by Caroni (508) and St. George West (375), the two other counties in close proximity to the department. The counties furthest from the department, St. Patrick, Mayaro and Victoria had 7, 88 and 126 reports respectively (Figure 4). There were 17 samples from the island of Tobago. Travel distance, therefore, has a significant and negative effect on the reporting of plant health problems to the department.

Distance plant disease diagnosis via the Internet can reduce the time required for getting data from the field to diagnostic centers and removes the impediment of travel distance. This data transfer is accomplished by the use of digital cameras to take photographs of field problems, and stereoscopes and microscopes with attached digital cameras to capture and send detailed images of disease symptoms. Though this system of diagnosis will not be as accurate as the examination of actual specimens by pathologists, it reduces the time and the human resources required to bring samples to centers and can supplement sample submissions from remote areas. An improved and upgraded system like this will also allow for more flexible communication between the agricultural extension officer, the grower and the staff at the Plant Pathology Department. This improved communication will facilitate the dissemination of information on control measures and Integrated Crop Management (ICM) strategies, another function of the Plant Pathology Department related to its diagnostic service. An improved and upgraded system will result, therefore, in reduced time for diagnosis and control of plant disease problems and a more detailed and complete database of the plant health situation in the country.

4. Rainfall.

Table 3 shows the results of the comparison of diagnostic records during wet and dry months. There was an extremely significant difference with bacteria (3.15 and 4.86 mean records in the dry and wet months respectively), and a significant difference with nematodes (0.40 and 0.09 respectively). Fungi and viruses showed no significant difference in incidence with rainfall.

Many plant pathogenic fungi are hydrophilic. Fortune (1998) demonstrated that a minimum of five hours of surface moisture was required for germination of *Colletotrichum* spores, the most pervasive fungus recorded. The lack of a significant difference in fungal records between wet and dry months may be explained by the use of irrigation systems, which, while providing adequate water for plant growth, also provide adequate moisture for fungal germination, penetration and establishment during the dry months.

Nematodes, though showing a significant preference for the dry season, were recorded in too small numbers (28 records for the 11 year period) to reach any definite conclusions. However, it is expected that during periods of drought, nematode problems will be exacerbated.

The positive response of bacteria to rainfall is indicative of the fact that the most common genera reported (*Ralstonia*, *Xanthomonas* and *Pseudomonas*) are almost completely dependent on rain splash and free movement of ground water for their dispersal. Moisture is also necessary for their multiplication.

5. Pesticide Usage.

Pesticide usage is widespread among the farming population in Trinidad and Tobago (Lopez *et al.* 1995; Lopez *et al.* 1996). Of the 1967 specimens received 1447 (73.6%) were reported to have been treated with at least one pesticide (Table 4). Four hundred and eighty three specimens (24.6% total) were treated with three or more pesticides. Of these, 281 had three or more insecticides and 304 had three or more fungicides applied to them. Specimens subjected to at least 6 pesticides, including 3 types of both insecticide and fungicide numbered 102 (5.2% total specimens). A total of 2345 fungicide and 2329 insecticide entries were recorded during 1900-2000.

The level of human health problems caused by pesticides depends on a number of factors, including the types and quantity of pesticide applied, timing of application with respect to harvest date and plant organs consumed. Table 5 compares the mean number of pesticides used on various crops. Pigeon pea and salad bean were subjected to the smallest range of pesticides having means of 0.8 (maximum 3) and 1.1 (maximum 4) pesticides per submission respectively. The plant organ consumed with pigeon pea (the seed) is protected from the external environment by a pod. The crop cycle ranges from four months for some varieties of pigeon pea to over one year. Chemicals applied, therefore, may leave little or no residue on the organ for consumption. Celery and cabbage, on the other hand, were subjected to the largest number of pesticides, 2.7 (maximum 8) and 2.9 (maximum 9) per submission, respectively. The organ consumed in both cases is the foliage, which is exposed to the external environment, and the crop cycles of both are relatively short, from 1.5 to 3 months depending on variety. The results on Table 5, therefore, raise some concern about the number of chemicals used, especially on these two leafy vegetables.

With respect to pesticide type, the most commonly used insecticide was Tambo®, a mixture of profenofos and cypermethrin (10% of total insecticide records with LD_{50} of 358 mg/kg and 251-4123 mg/kg respectively) (Tomlin, 1994). (Table 6). The insecticide/nematicide/acaricide oxamyl (9%), which has an extremely low LD_{50} of 5.4 mg/kg was second in frequency of use. Other commonly used insecticides were alpha-cypermethrin (8.2%; LD_{50} 79-400 mg/kg), methomyl (5%; LD_{50} 17 mg/kg), diafenthurion (5%; LD_{50} 2068 mg/kg) and diazinon (4.6%; LD_{50} 300-400 mg/kg.

Several fungicides have been used in disease management (Table 6). Copper fungicides (31.9% of total fungicide records) were the most frequently used. Other common fungicides included chlorothalonil (17.6%), benomyl (10.7%), mancozeb (10.1%) and etridiazole (4.9%). Fungicides were generally less toxic than the insecticides, having LD_{50} ratings of 700 mg/kg and over.

The category 'Other' included 34 fungicides and 56 insecticides, each with a record frequency of less than 3% of its group total.

Because of the type of information recorded on the diagnostic forms with respect to pesticides, it was not possible to ascertain whether the appropriate chemicals were used on the crops or whether they were used in the correct manner. However, with 73.6% of specimens being treated with pesticides, some of which are extremely toxic, the use of at least six pesticides on 5.2% of submissions and with the frequent use of pesticides on some short-term, leafy vegetables, training in ICM methods should be provided to all involved with food crop production to avoid the risk of environmental pollution and human health problems.

The development of pesticide testing facilities within the Ministry of Food Production and Marine Resources will also assist in reducing the problem of pesticide abuse. Acceptable pesticide residue levels on agricultural products are now mandatory for international trade. Routine checking of growers' produce by a pesticide testing facility will not only safeguard local consumers and the environment, but will also help growers in their efforts to produce acceptable products for export and so increase their competitiveness on the international market.

CONCLUSIONS

The Solanaceae was most prone to disease problems, with tomato, hot pepper and sweet pepper being the species submitted most often to the Plant Pathology Department for diagnosis. Cabbage, watermelon and bodi were the most susceptible species in the Cruciferae, Cucurbitaceae and Leguminosae respectively.

Fungi were the most common pathogen reported among food crops both in terms of number of records and diversity of hosts. Bacterial diseases affected the Solanaceae and Cruciferae and, to a lesser extent, Umbelliferae. Bacterial disease incidence was significantly enhanced by wet environmental conditions, while fungal and viral frequencies were not.

Although there has been a greater demand for the diagnostic services of the department in the last four years, travel distance acts as a deterrent to the submission of specimens to the department. This problem can be relieved to some extent by the introduction of improved communication systems in the department and Extension Division using up-to-date information technology.

Pesticide usage on food crops has signaled the need for education among growers on the safe use of pesticides and ICM methods. Some leafy vegetables, especially celery and cabbage, were subjected to the greatest incidence of pesticide use among the food crops, which suggests some level of abuse, with the attendant human and environmental problems. The development of pesticide testing facilities for routine testing of pesticide residues on agricultural products will also assist in reducing the overuse of chemicals and increase the size of the market of local produce by making agricultural products more acceptable internationally.

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Table 1. Frequency of specimen submissions and causal agents (health problems) recorded at the Plant Pathology Department on 27 food crops during the period 1990-2000.

Family	Crop	Specim submitted	Causal agent (Health problems) Bact	Fun	Vir	Nem	Unk	Oth	Total causal agent	% Grand Total of causal agent
Compositae	Lettuce	53	0	33	0	1	4	17	55	2.3
Cruciferae	Cabbage	118	45	30	0	0	26	30	131	5.5
"	Cauliflower	15	9	0	0	0	4	5	18	0.8
"	Broccoli	13	10	3	0	0	1	3	17	0.7
"	Pak-choi	36	5	19	0	0	3	13	40	1.7
Cruciferae Sub-Total		182	69	52	0	0	34	51	206	8.7
Cucurbitaceae	Cantaloupe	9	0	7	0	0	0	4	11	0.5
"	Carillie	31	0	30	0	2	3	6	41	1.7
"	Christophine	10	0	14	0	0	1	2	17	0.7
"	Cucumber	41	2	42	0	2	2	7	55	2.3
"	Loukie	2	0	0	0	0	0	2	2	0.1
"	Pumpkin	53	3	25	3	0	5	27	63	2.6
"	Squash	8	1	6	1	1	1	3	13	0.5
"	Water melon	106	0	68	6	2	7	48	131	5.5
"	Zucchini	5	0	1	1	0	1	2	5	0.2
Cucurbitaceae Sub-Total		265	6	193	11	7	20	101	338	14.2
Leguminosae	Bodi	94	0	46	44	1	7	18	116	4.9
"	Salad bean	46	0	23	4	0	10	17	54	2.3
"	Jack bean	1	0	2	0	0	0	1	3	0.1
"	Pigeon pea	17	0	5	0	0	3	13	21	0.9
"	Seim	12	0	7	1	1	2	3	14	0.6
Leguminosae Sub-Total		170	0	83	49	2	22	52	208	8.7
Solanaceae	Cherry pepper	2	0	0	1	0	0	1	2	0.1
"	Bird pepper	2	0	0	1	0	0	1	2	0.1
"	Hot pepper	287	69	88	112	4	18	89	380	16.0
"	Pimento	62	17	20	17	0	2	16	72	3.0
"	Sweet pepper	186	91	33	12	3	16	68	223	9.4
"	Melongene	94	41	14	0	1	5	37	98	4.1
"	Tomato	595	246	130	128	6	59	148	717	30.1
Solanaceae Sub-Total		1228	464	285	271	14	100	360	1494	62.8
Umbelliferae	Celery	69	12	40	0	4	14	9	79	3.3
Total		1967	551	686	331	28	194	590	2380	
% Grand Total			23.2	28.8	13.9	1.2	8.2	24.8		

Key: Bact=Bacterium, Fun=Fungus, Nem=Nematode, Oth=Other, Specim=Specimen, Unk=Unknown, Vir=Virus

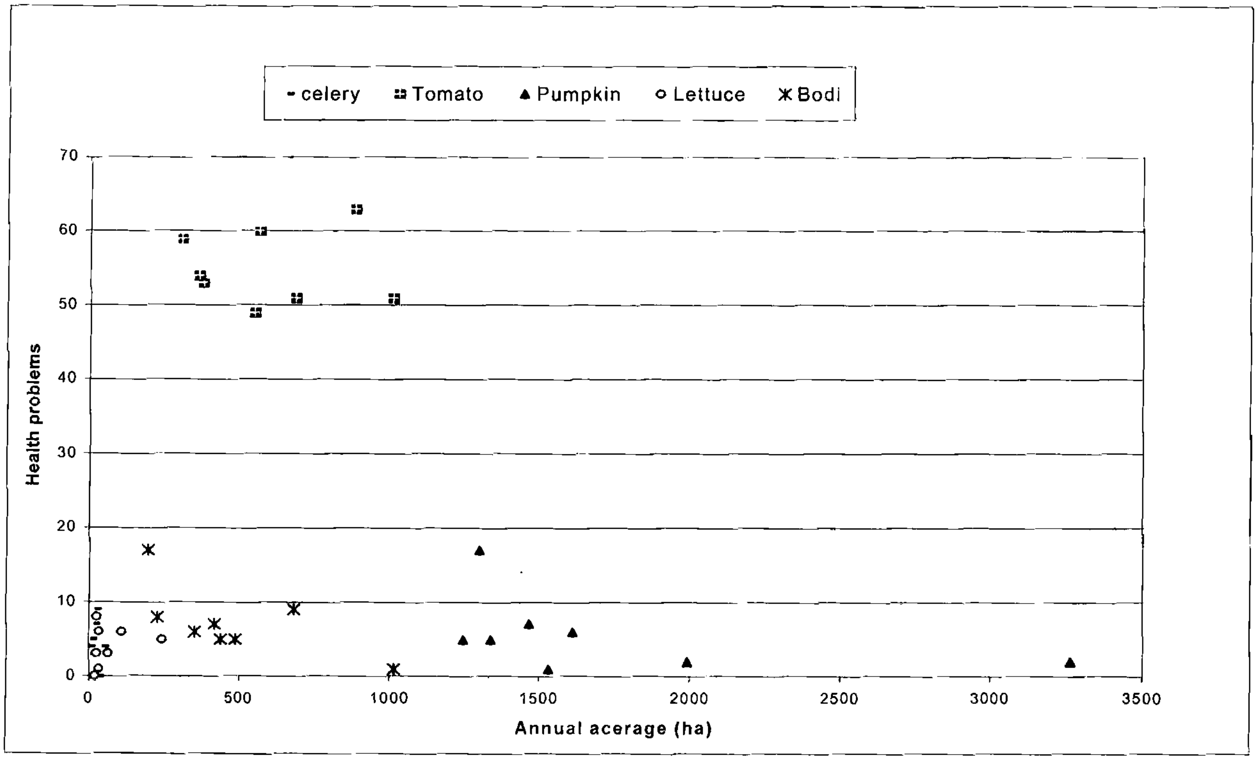

Figure 1. Correlation between annual acerage of five crops planted in Trinidad during 1991-1998 and number of health problems diagnosed by the Plant Pathology Department. The linear correlation r=-0.0037. p=0.9817 (not significant).

Table 2. Major genera of fungi and bacteria recorded at the Plant Pathology Department on six host families (27 food crop species) during the period 1990-2000 and the number of host families and species affected by each genus.

Class	Genera	% Class total	# Host families affected	# Host species affected
Fungi	Corynespora	16.1	4	8
"	*Colletotrichum*	15.1	5	16
"	*Cercospora*	13.5	6	11
"	*Rhizoctonia*	9.7	5	14
"	*Sclerotium*	8.2	3	12
"	*Phytophthora*	7.9	2	6
"	*Pseudoperonospora*	6.9	1	8
"	*Alternaria*	5.1	4	6
"	*Didymella*	5.0	1	7
Bacteria	*Ralstonia*	47.8	1	5
"	*Xanthomonas*	37.8	3	8
"	*Pseudomonas*	9.4	3	6
"	*Erwinia*	4.9	2	6

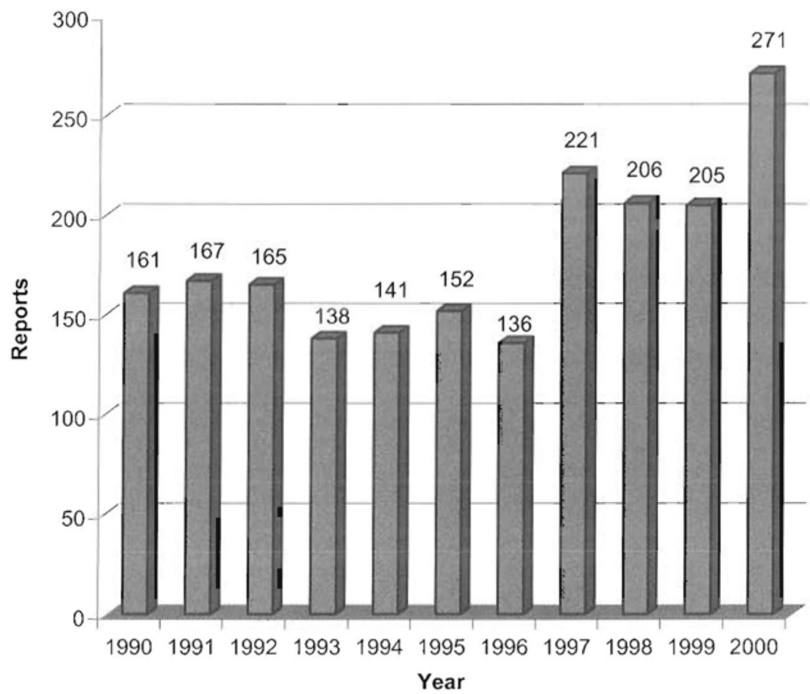

Figure 2. Frequency of specimen submissions (reports) received by the Plant Pathology Department for 1990-2000.

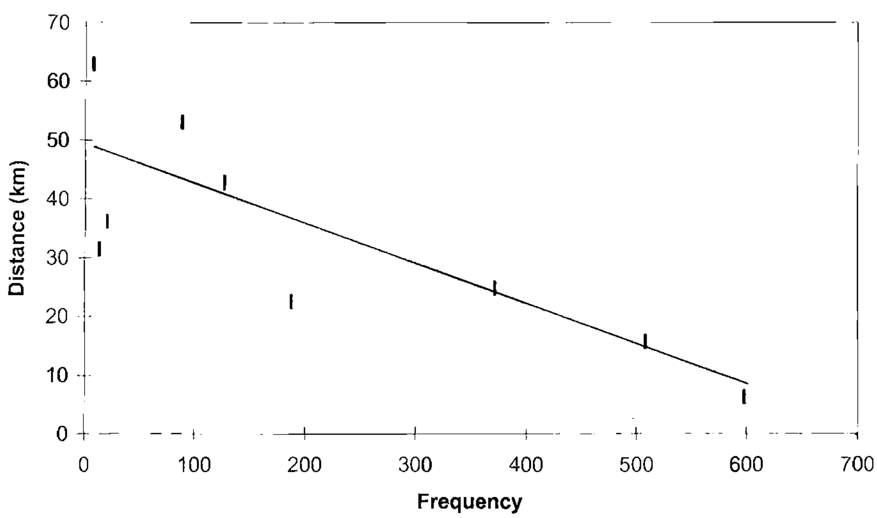

Figure 3. Frequency of specimen submissions versus distance (km) from the Plant Pathology Department, Centeno during the period 1990-2000. $r = -0.81$, $p = 0.0081$(very significant), slope = -0.065.

Table 3. Mean frequency of records for fungi, bacteria, viruses and nematodes during wet (100 mm or more rainfall) and dry (< 100 mm rainfall) months 1990-2000. Rainfall data taken from Piarco.

Pathogen	Dry months	Wet months	Unpaired t (df)	p value	Remarks
Fungus	5.64	4.77	1.527 (95)	0.1301	Not significant
Bacterium	3.15	4.86	3.985 (129)	0.0001	Extremely significant
Virus	2.85	2.28	0.997 (73)	0.3220	Not significant
Nematode	0.40	0.09	3.078 (64)	0.0256	Significant

Table 4. Frequency data on pesticide usage on 1967 food crop specimens recorded at the Plant Pathology Department, Centeno (1990-2000).

Item	Number	Percentage of total specimen submissions
Specimens treated with pesticide	1447	73.6
Specimens treated with 3 or more pesticides	483	24.6
Specimens treated with 3 or more fungicides	304	15.5
Specimens treated with 3 or more insecticides	281	14.3
Specimens treated with 3 or more of both fungicides and insecticides	102	5.2

Table 5. Mean number of pesticides applied to various food crops at the time of submission to the Plant Pathology Department at Centeno during the period 1990-2000. SEM = Standard Error of Mean. Minimum number of pesticides applied was zero for all crops.

Crop	Submissions	Mean # of pesticides per submission (SEM)	Maximum # applied
Pigeon pea	17	0.8 (0.25)	3
Salad bean	46	1.1 (0.17)	4
Lettuce	53	1.9 (0.26)	6
Pak-choi	36	1.9 (0.26)	6
Pumpkin	53	1.9 (0.23)	6
Carillie	31	2.0 (0.41)	7
Cucumber	41	2.0 (0.28)	6
Pimento	62	2.0 (0.25)	8
Bodi	94	2.2 (0.23)	10
Melongene	94	2.3 (0.23)	9
Hot pepper	287	2.4 (0.13)	11
Sweet pepper	186	2.4 (0.15)	11
Cauliflower	15	2.5 (0.38)	5
Water melon	106	2.6 (0.23)	10
Tomato	595	2.6 (0.10)	10
Celery	69	2.7 (0.25)	8
Cabbage	118	2.9 (0.23)	9

Table 6. Frequency of use and toxicity of fungicides and insecticides recorded on 27 root crops at the time of submission to the Plant Pathology Department, Centeno during the period 1990-2000. Percentages are from 2345 fungicide records and 2329 insecticide records.

Pesticide group	Common name	% Total group record	Acute oral LD_{50} mg/kg (rats)
Insecticide	Profenofos/cypermethrin mixture	10.0	358/251-4123
"	Oxamyl	9.0	5.4
"	Alpha-cypermethrin	8.2	79-400
"	Methomyl	5.0	17
"	Diafenthurion	5.0	2068
"	Diazinon	4.6	300-400
"	Other (56 insecticides)	58.2	
Fungicide	Copper	31.9	700-800
"	Chlorothalonil	17.6	> 10 000
"	Benomyl	10.7	>10 000
"	Mancozeb	10.1	> 5 000
"	Etridiazole	4.9	> 1 028
"	Other (34 fungicides)	24.8	

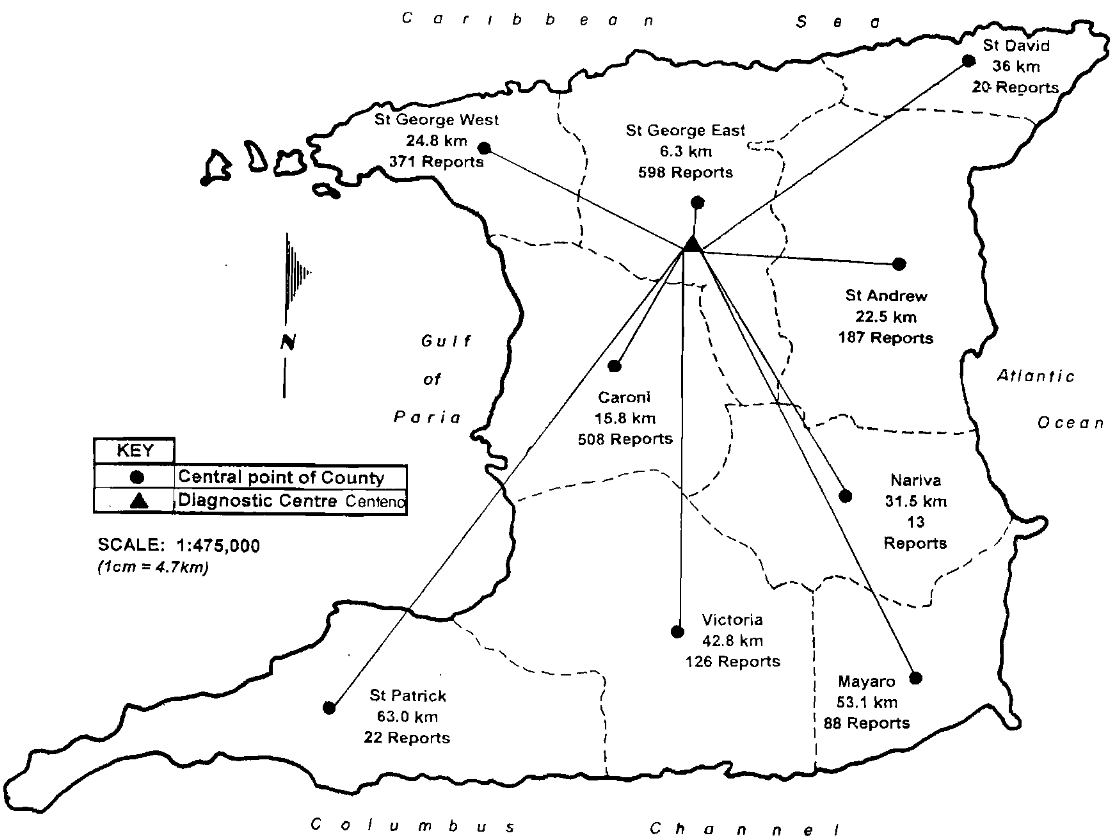

Figure 4. Counties in Trinidad showing distance (km) from the diagnostic center of the plant Pathology Department at Centeno and number of specimens received (reports) over the period 1990-2000.

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NEMATODOS FITOPARÁSITOS ASOCIADOS A MALEZAS EN DIFERENTES LOCALIDADES DE LA REGIÓN SUR DE LA REPÚBLICA DOMINICANA

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ABSTRACT: Tomando como referencia los cultivos más importantes de varias zonas agrícolas, se estudió la relación existente entre los nematodos y las malezas que se presentan; para tales fines consideramos los parámetros, frecuencia e incidencia. En todas las provincias consideradas se tomaron muestras en las zonas agrícolas más importantes. Las observaciones se realizaron sobre las malezas: *Acanthospermun hispidium, Amaranthus dubius, Amaranthus spinosus, Argemone mexicana, Borreria laevis, Boerhavia erecta, Commelina diffusa, Cenchrus echinatus, Cleome viscosa, Cyperus rotundus, Digitaria sanguinalis, Echinocloa colonum, Euphorbia heterophilla, Euphorbia hirta, Euphorbia glomifera, Eleusine indica, Lepidium virginicum, Oxalis violaceae, Pseudoelephatopus spicatus, Rottboellia exaltata, Sida acuta, Sida rombifolia, Sorgum halepense, Solanum americanum, Trinfetta rhomboidea, Jatropha gossypifolia, Parthenium hysterophorus, Croton lobulado, Portulaca oleracea, Panicum maximum*. Estas fueron listadas por su densidad e identificadas previamente, luego se colectaron muestras de suelo y raíces totalmente al azar dentro del cultivo. Para la identificación y estudio de los nematodos procesamos el suelo con el método de "Tamizado - Embudo de Baermann" y las raíces con "Licuadora - Embudo de Baermann". Los resultados obtenidos mostraron la presencia de los géneros de nematodos más importantes para los cultivos como son: *Meloidogyne sp, Pratylenchus sp, Helicotylenchus sp, Rotylenchus reniformis, Aphelenchoides sp, Ditylenchus sp* y *Trichodorus sp*. Las malezas que demostraron mayor presencia de nematodos fueron: *Euphorbia heterophilla* (85%), *Digitaria sanguinalis* (69%), *Echinocloa colonum* (69%), *Eleusine indica* (77%), *Portulaca oleracea* (69%) y *Commelina diffusa* (54%) para la zona de San Cristóbal; en la provincia Peravia: *Amaranthus dubius* y *Euphorbia heterophilla* (76.92%), *Commelina diffusa* y *Cyperus rotundus* (69.22%), *Parthenium hysterophorus* (64.54%) y *Eleusine indica* (61.54%); en la zona de Azua: *Cyperus rotundus* (38.9%), *Echinocloa colonum* (74.5%) y *Parthenium hysterophorus* (21.1%).

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SCREENING COWPEA ACCESSIONS FOR THE SEASONALLY DRY HEAVY CLAY SOILS OF THE US VIRGIN ISLANDS

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ABSTRACT: Cowpea [*Vigna unguiculata* (L) Walp] is adapted to well-drained soils and is also drought tolerant. It is primarily used as a pulse crop. It is such a versatile crop with multiple uses [i.e., vegetable crop (both for the green young leaves, shoots and the green peas)], cover crop, and also as forage. Little information is available on its adaptation to heavy clay soils. The objective of this research was to characterize 25 cowpea pure lines for seedling vigor (i.e., plant height), dry pod yield, forage dry matter (DM) and tolerance to high pH soils (pH>7.5). Replicated field studies were conducted on a mildly alkaline Fredensborg clay (fine carbonatic, isohyperthermic, Typic Rendolls, Mollisol) in 2000. Average plant height ranged from 24 to 62-cm at 56-d after planting. Days to floral initiation ranged from 36 to 62-d after planting, indicating a high variability among lines. Pod yield differed ($P<0.05$) among lines, with highest pod yield for line IT97K-437-8 (450 kg ha^{-1}). Forage yield also differed among lines ($P<0.05$) with DM yields exceeding 3,500 kg ha^{-1} for line IT90K-277-2. Twelve lines exhibited high seedling vigor, excellent forage and seed yield, and low symptoms of iron deficiency. These were selected for further evaluation.

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp] is a valuable, multiple-use legume, that thrives in dry environments (300 mm rainfall). It is cultivated primarily for use as a pulse. In fresh form, the young leaves, immature pods and peas are used as vegetable. This plant also has potential for use as a cover crop, and for forage (Quinn, 1999).

The International Institute of Tropical Agriculture (IITA) maintains a collection of more than 15,000 lines of cultivated cowpea and 1,500 accessions of wild cowpea relatives in their gene bank (IITA, 1997). They are the main distributers of cowpea germplasm lines.

Annual global production of cowpea is estimated to be over 3 million tons (Food Agriculture Organization; FAO, 1999). Area planted surpass 12.5 million hectares, 8 million of which are planted in Central and West Africa. Brazil and the West Indies have the most significant production of cowpea in Latin America.

Several cowpea breeding lines have been developed and tested by IITA (2000). They reported major differences between varieties for grain and fodder yields under poor soil fertility. The performance of cowpea lines on heavy clay, and high pH soils is unknown. Twenty five cowpea lines originating from IITA were established to determine seedling vigor (i.e., plant height), pod yield, and forage yield.

MATERIALS AND METHODS

Twenty-five cowpea lines (Table 1) were evaluated at the Agriculture Experiment Station, University of the Virgin Islands, St. Croix. Soil type was a mildly alkaline Fredensborg clay (fine carbonatic, isohyperthermic, Typic Rendolls, Mollisol) with pH of 8.3.

Replicated plots (complete block) were used for this study. Plot size was 2.5 X 5-m and distance between plots was 1-m and 2-m between blocks. Three rows of each line (0.5-m between rows and 0.25 within row/plants) were planted on 1 June 2000. Plots were irrigated for 3-d to ensure a uniform germination. Rainfall was sufficient thereafter, so no irrigation was needed.

Experimental variables included (i) stand germination (number seedlings m^{-1} of row; on a % basis) 5-d after planting; (ii) bi-weekly seedling height 2-wk after emergence up to 8-wk; (iii) days to floral initiation; and (iv) pod and forage yield in 1 m^2. Forage from 1-m^2 sections of the center rows of each plot was clipped to determine fresh weight. Subsamples (500 g) were obtained and dried in a 60 F forced air oven for 72 hrs. These samples were used for calculating DM concentration and DM yield.

Data were analyzed using analysis of variance in the General Linear Model of SAS (1989). Seedling vigor was determined using repeated measure analysis of variance to show time trend interactions (Littel, 1986). All effects with probability levels >0.05 were considered not different. Mean comparison was made with F-protected LSD.

RESULTS

Field germination (%) of cowpea accessions ranged from 20 to 100% (Table 1). A uniform germination occurred 5-d after planting. Rainfall (21 mm) in June 2000 did not affect growth of cowpea lines and no moisture stress was observed on the plants during the study (E. Valencia, visual observations).

Table 1. Field germination (%) of cowpea line accessions evaluated at St. Croix, US Virgin Islands in 2000.

	IITA cowpea lines	Germination (%)
1	IT81D-994	80
2	IT82D-716	20
3	IT86D-719	80
4	IT87D-914	90
5	IT89KD-288	40
6	IT97K461-4	100
7	IT82E-16	40
8	IT89KD-391	80
9	IT86D-715	80
10	IT90K-76	40
11	IT94K-437-1	93
12	IT96D-733	80
13	IT97K-1042-8	90
14	IT81D-985	35
15	IT90K-82-2	30
16	IT86D-721	35
17	IT89KD-374-57	60
18	IT95K-627-34	60
19	IT95K-1491	40
20	IT90K-277-2	50
21	IT86D-716	35
22	IT93K-452-1	60
23	IT95K-222-5	60
24	IT96D-724	90
25	IT97K-1129-51	60

There was significant difference ($P<0.05$) on seedling vigor. Plant height ranged from 12.7 cm (IT82E-16) to 20.6 cm (IT87D-914) 2-wk after planting (Table 2). At 8-wk the tallest plant was line IT95K-627-34 (62 cm). Days to floral initiation varied. Line IT93K-452-1 flowered 37 d after planting. Some cowpea lines flowered as late as 62-d after planting, indicating a wide variability among lines. Crauford et al. (1996) noted that in latitudes where photo-periods ranged from 10 to 16 h d^{-1} and temperature range of 19 to 30C, the mean days to flowering were from 32 to 140 d for 17 photo-period sensitive cowpea genotypes. Dry pod yield of cowpea lines was significantly different ($P<0.05$). The most productive cowpea line was IT97K-1042-8 (433.7 kg ha^{-1}), followed by IT86D-719 (226 kg ha^{-1}). Forage yield also varied (Table 3). Dry matter yield of IT90K-277-2 (3560 kg ha^{-1}) was superior to all other lines. Pod yield of this line, however, was very low (46.8 kg ha^{-1}).

Table 2. Seedling vigor and days to floral initiation of 25 cowpea lines evaluated in St. Croix US Virgin Islands in 2000.

	IITA cowpea lines	Plant Height (cm)				Inflorescence
		2-wk	4-wk	6-wk	8-wk	d
1	IT81D-994	18.0	22.9	27.6	45.2	--
2	IT82D-716	13.1	20.6	26.4	39.0	42.0
3	IT86D-719	16.1	24.3	31.0	38.6	43.5
4	IT87D-914	20.6	29.5	41.5	51.6	53.0
5	IT89KD-288	18.2	27.4	44.8	58.3	--
6	IT97K461-4	18.0	23.5	33.8	39.2	43.5
7	IT82E-16	12.7	23.2	37.2	46.0	47.0
8	IT89KD-391	15.2	25.7	38.2	46.0	--
9	IT86D-715	14.4	20.3	26.0	31.1	47.0
10	IT90K-76	15.7	27.1	32.9	43.4	43.0
11	IT94K-437-1	16.4	20.2	20.3	24.8	40.0
12	IT96D-733	18.0	26.5	36.6	45.5	--
13	IT97K-1042-8	14.5	23.9	33.7	42.4	57.5
14	IT81D-985	13.1	24.3	37.6	49.7	--
15	IT90K-82-2	12.8	24.5	37.2	47.5	62.5
16	IT86D-721	14.5	21.0	34.2	44.1	53.0
17	IT89KD-374-57	17.5	22.5	28.6	35.4	--
18	IT95K-627-34	14.7	23.6	45.2	62.6	43.0
19	IT95K-1491	15.2	24.0	36.8	53.0	40.0
20	IT90K-277-2	14.1	24.3	36.6	44.8	43.5
21	IT86D-716	14.9	23.6	34.8	42.3	55.5
22	IT93K-452-1	14.9	23.7	35.8	46.1	36.0
23	IT95K-222-5	16.1	28.3	42.0	52.7	62.0
24	IT96D-724	15.6	26.7	38.9	53.2	--
25	IT97K-1129-51	15.4	24.3	34.1	46.4	40.0
LSD		3.5	4.7	13.5	14.7	11.4

CONCLUSIONS

Twelve lines exhibited high seedling vigor, excellent forage and seed yield, and low symptoms of iron deficiency. These lines were selected for further evaluation. Cowpea lines also exhibited high drought tolerance, as evidenced by the low amount of rainfall received in June (21 mm). The selected cowpea lines can serve for a dual purpose in the US Virgin Islands. It can be an excellent forage for small ruminant livestock and the grains can be used for human consumption. Its potential for use as a cover crop and inter-cropping with cereal grains and root crops should be assessed.

Table 3. Pod and forage yield of 25 cowpea accessions evaluated at St. Croix US Virgin Islands in 2000.

	IITA cowpea lines	Pod yield	Forage yield
		----kg ha^{-1}----	
1	IT81D-994	--	1094
2	IT82D-716	138.5	1122
3	IT86D-719	226.0	1325
4	IT87D-914	50.2	3047
5	IT89KD-288	--	--
6	IT97K461-4	150.6	1075
7	IT82E-16	134.1	1847
8	IT89KD-391	--	--
9	IT86D-715	28.7	2020
10	IT90K-76	95.8	2246
11	IT94K-437-1	23.2	571
12	IT96D-733	--	--
13	IT97K-1042-8	433.7	1860
14	IT81D-985	--	--
15	IT90K-82-2	--	--
16	IT86D-721	17.4	2091
17	IT89KD-374-57	--	--
18	IT95K-627-34	154.6	3206
19	IT95K-1491	197.2	1700
20	IT90K-277-2	46.8	3561
21	IT86D-716	115.1	2273
22	IT93K-452-1	209.4	1498
23	IT95K-222-5	--	--
24	IT96D-724	--	--
25	IT97K-1129-51	252.8	268
SE†		113	1122
LSD		381	1220

†SE=Standard error

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DEVELOPMENT OF BREEDING LINES FROM THE HOT PEPPER CULTIVAR, WEST INDIES RED

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ABSTRACT: The hot pepper cultivar, "West Indies Red," was described. Three breeding lines were extracted from this popular cultivar in order to develop lines with more uniform berry shape, size and colour. These lines were compared to the parental population and described showing differences only in berry quality upon which selection pressure was applied. The next round of the Single Seed Descent selection procedure will be applied to ensure further homozygosity for berry colour, shape and size.

INTRODUCTION

The hot pepper cultivar, "West Indies Red" (*Capsicum chinense* Jacquin) was selected by CARDI-Antigua (Cooper1989) who distributed quality seed to producers in several Caribbean countries and also exported to Africa. Both the domestic and foreign markets prefer the berry quality that is reminiscent of the cv. Scotch Bonnet for which premium prices are paid. The West Indies Red displays comparatively the highest level of general adaptability to the agro-ecological conditions of the Caribbean where it is found to be tolerant to viral diseases (Geminiviruses, TEV and PVY) and insect pests.

However, the exporters of fresh berries, in particular, find that the berries of the West Indies Red are too heterogeneous in shape, size and colour. The task, therefore, is to improve this cultivar by making the berries more uniform in these characters.

MATERIALS AND METHODS

In 1996, breeder's seed of the selection, West Indies Red, was obtained from CARDI-Antigua. An observation plot of 7,000 individuals was planted on one half hectare in Barbados. The Capsicum Descriptors (IPGRI et al 1995) were applied to describe the cultivar. About 10% of the plants in the plot was sampled at random and described.

In 1997, an isolated plot of one hectare was planted and simple recurrent mass selection was applied for berry shape, colour and size just before full maturity. Three different lines based on these three characters selected.

In 1998, the three different lines were planted into three separate plots and selection was continued for the same three characters.

In 1999, the lines were again planted and the most robust, prolific and typical plants were selected. Single flower isolations were made to ensure selfing and berries were harvested singly. This was in preparation for the next round of the Single Seed Descent (SSD) selection procedure (Allard 1960).

Simultaneously with the above, a comparative trial was carried out on the three lines and their parent population. The design used was a randomized 4x4 Latin square replicated twice. The treatments were therefore replicated eight times. All field operations were evenly applied over the experimental plots. The last harvest was completed on 15 September 1999. The data were subjected to the analysis of variance using the MINITAB statistical software (MINITAB 1996).

RESULTS AND DISCUSSION

The cultivar, West Indies Red, was described. The Capsicum Descriptors are presented in Table 1. This cultivar in Barbados exhibited very high levels of general adaptability, tolerance to pest and diseases, possessed high pungency and unique organoleptic qualities. The mean dimensions of the berries were 3.8 cm long x 3.21 cm wide and 84 - 100 berries weighed a kilogram. There was a mixture of shapes of berries; about 10 - 15% had the equatorial fold of the Scotch Bonnet, and the rest were elongate, lantern shaped, some were blocky while others were oblong. There were many colours and hues on the berries at full development just before full maturity. Some were very pale green to cream, very dark green, some with a purple blush or splash on the shoulders and others light green. This wide variability in berry shapes and colours lent itself to the extraction of breeding lines based on these characters. Three lines were differentiated and named 'Caribbean Green,' 'Caribbean Red' and 'Caribbean Purple.' Some of the more important Capsicum Descriptors of the three lines, are presented in Table 2. The main visual difference between the lines was in the colour of the berries just before full maturity. They were as follows: 'Caribbean Red' – cream; 'Caribbean Purple' - purple splash on light green; 'Caribbean green' - deep, dark green.

The berries of all the lines turned red upon full maturity. The berries within each breeding line were of more uniform shape, size and colours than the parent population, 'West Indies Red.' The three breeding lines did not differ significantly from 'West Indies Red' in the characters of total number of berries per plant, mean plant height, mean canopy width and mean berry weight. Significant differences were observed in mean length and mean width of berries (Table 3). The longest berry (4.07 cm) was borne by the 'Caribbean Purple' and the shortest (3.77 cm) by the 'Caribbean Red.' The blockiest berry where the width was almost the same as the length was observed on the 'Caribbean Red': the mean berry length was 3.77 cm and the mean width was 3.14 cm. The 'Caribbean Purple' and cv. West Indies Red were equal in berry width which was significantly narrower than that of the 'Caribbean Red' and the 'Caribbean Green.'

It was very important to confirm that the three breeding lines were the same as the 'West Indies Red' in plant ideotypic and yield characters. This meant that selection gains were made in the desired directions of berry colour, shape and size.

Work will continue along the SSD procedure in order to fix berry colour, size and shape in the breeding lines until maximum homozygosity, hence uniformity, is reached. Selection between and within progeny rows from selected berry types should lead to the desired uniformity and stability by the S_4-S_6 generations. An effort will be made to accelerate cultivar development by producing 2-3 generations per year.

CONCLUSIONS

The extraction of three breeding lines from the hot pepper cultivar, West Indies Red, progressed up to the point of single fruit selection after three cycles of simple recurrent mass selection. The lines differed from the parental population only in the desired characters of berry colour, size and shape. The next step is SSD to attain the highest level of homozygosity and uniformity in berry colour and shape.

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Table 1. A description of the cultivar West Indies Red (*Capsicum chinense* Jacq.) according to some main descriptors.

Plant descriptor	**State**
Stem colour	Biennial
Nodal anthocyanin	Green
Stem shape	Green
Stem pubescence	Cylindrical
Plant height	Sparse
Plant growth habit	66-100 cm
Plant canopy width	Intermediate between prostate and erect
Branching habit	85 cm
Leaf colour	Dense
Leaf shape	Green
Lamina margin	Ovate to lanceolate
Leaf pubescence	Entire
	Sparse
Infloresence descriptor	**State**
Days to flowering	65 days
Number of flowers per axil	Range 1-5; mode 2; mean 2-3
Flower position	Intermediate between pendant and erect
Corolla colour	Greenish white
Corolla spot colour	None
Corolla shape	Rotate
Corolla length (mm)	1-5
Another colour	Bluish
Another length (mm)	1-1.2
Filament colour	White
Filament length (mm)	1
Stigma exsertion	Slightly exserted
Infloresence descriptor	**State**
Male sterility	Absent
Calyx pigmentation	Absent
Calyx margin	Intermediate
Calyx annular constriction	Present
Fruit descriptor	**State**
Fruit colour at intermediate stage	Light green; dark green, purple blush and cream
Fruit set	High
Fruit bearing (number of days from first fruit set to last fruit formation)	240-360
Fruit colour at mature stage	Red and dark red
Fruit shape	A mix of campanulate and blocky shapes with a small percentage carrying the equatorial fold of the Scotch Bonnet parent
Fruit length (cm)	3.8
Fruit width (cm)	3.21
Fruit weight (g)	10.80
Fruit pedicel length (cm)	1.9
Fruit wall thickness (mm)	1.5-2.5
Fruit shape at pedicel attachment	Truncate, cordate and lobate
Neck at base of fruit	Absent
Fruit shape at blossom end	Blunt, sunken, sunken and pointed types
Fruits cross-sectional corrugation	Intermediate
Plant descriptor	**State**
Number of locules	3-4
Fruit shape	A mix of campanulate and blocky shapes with a small percentage carrying the equatorial fold of the Scotch Bonnet parent
Fruit surface	Smooth
Ripe fruit persistence	
Pedicel with stem	Intermediate
Pedicel with fruit	Intermediate
Placenta length	¼-½ fruit length
Seed description	**State**
Seed colour	Straw
Seed surface	Smooth
Seed size	Intermediate
Seed diameter (mm)	3
1000 seed weight (g)	4.5
Number of seeds per fruit	20-50

Table 2. Description of the 3 breeding lines extracted from cv West Indies Red in 1999 at Graeme Hall, Barbados.

Descriptors	Caribbean Green	Caribbean Red	Caribbean Purple
Shape of berry	Blocky	Cylindrical	Blocky
Length of berry (cm)	3.76	4.2	4.6
Width of berry (cm)	3.32	2.8	3.9
Weight of berry (g)	12	13	8.8
Berries/kg	85	89	100
Berries/lb	38	40	45
Colour of unripe berries	Deep dark green	Pale light green	Green with a purple blush
Colour of ripe berries	Deep dark red	Light red	Dark red
Berries/node	2	2	2
Berries/plant/picking	32	33	33
Fruit stalk length (cm)	2.7	2.2	2.8
Stalk persistence on plant	Intermediate	Intermediate	Intermediate
Stalk persistence on berry	Persistent	Persistent	Persistent
Fruit wall thickness (mm)	2.6	1.2	2
Locules/berry	4	4	4
Exocarp smoothness	Very smooth	Smooth	Smooth
Corrugation of berry	Corrugated	Corrugated	Corrugated
Calyx margin	Intermediate	Intermediate	Intermediate
Calyx annular ring	Present	Present	Present
Plant height (cm)	80.66	79.52	77.27
Plant width (cm)	97.6	97.38	95.27
Leaf shape	Ovate	Ovate	Ovate
Leaf length (cm)	9.55	11.60	10.10
Leaf width (cm)	4.1	4.9	4.1
Leaf pubescence (abaxial)	Sparse	Sparse	Sparse
Leaf pubescence (adaxial)	Sparse	Sparse	Sparse
Leaf pubescence pattern	Uniform	Uniform	Uniform
Leaf pigmentation	Green	Green	Green
Stem shape	Cylindrical	Cylindrical	Cylindrical
Stem pigmentation	Green	Light Green	Green
Stem pubescence pattern	Sparse	Sparse	Sparse
Stem pubescence pattern	Sparse	Sparse	Sparse
Nodal pigmentation	Green	Green	Green
Growth habit	Intermediate	Intermediate	Intermediate
Days to emergence	Seven	Seven	Seven
Days to transplanting	Thirty-five	Thirty-five	Thirty-five
Plants/ha/ac (000)	30-40/12-16	30-40/12-17	30-40/12-18
Days to flowering	39	39	39
Days to harvest	80	80	80
Harvest duration (months)	>6	>6	>6

Table 3. A comparison between West Indies Red and three breeding lines in a varietal test grown in 1999 in Barbados

Treatment	Total No. fruits/plant	Mean height of plant (cm)	Mean width of plant (cm)	Mean weight of fruit (g)	Mean length of fruit (cm)	Mean width of fruit (cm)
Caribbean Purple	227.40	77.27	95.27	10.4	4.07	3.05
West Indies	236.20	76.68	96.79	10.26	3.91	3.05
Caribbean Red	228.90	79.51	97.38	10.59	3.77	3.14
Caribbean Green	222.67	80.24	97.58	12.36	3.97	3.12
SEM (df=18)	11.09	1.46	1.42	0.69	0.06	0.04
P	0.857NS	0.280NS	0.662 NS	0.146 NS	0.018**	0.293NS

NS = not significant, ** = significant

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YIELD PERFORMANCE OF TOMATO CULTIVARS GROWN UNDER ORGANIC MANAGEMENT SYSTEM

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ABSTRACT: On-farm trials were conducted during the spring season of 1999 and 2000 to evaluate the yield performance of tomato (*Lycopersicon esculentum* Mill.) cultivars grown under an organic management system. In 1999, twelve cultivars: 'Bonita', 'Celebrity', 'Colonial', 'Empire', 'Floramerica', 'Joker', 'Liberty', 'Merced', 'Mountain Pride', 'Olympic', 'Pilgrim' and 'Sunmaster' were grown under an organic management system consisting of mulching with grass straw, fertilizing with cow manure and using organic pesticides for insect control. Similar cultivars were evaluated in spring 2000, but due to lack of seed, 'Bonita' and 'Liberty' were replaced with cultivars 'Keepsake' and 'Mountain Fresh'. In 1999, significant differences ($P<0.05$) in tomato fruit yield were observed among cultivars. Marketable yield ranged from 28.5 t ha^{-1} for cultivar 'Pilgrim' to 43.8 t ha^{-1} for 'Sunmaster'. The top three cultivars with yields of over 40 t ha^{-1} were 'Sunmaster', 'Bonita', and 'Empire'. 'Sunmaster' also produced the highest total number of tomato fruits (233,000 ha^{-1}). Significant yield differences were also observed in 2000. Marketable fruit yield in 2000 ranged from 20.0 t ha^{-1} for cultivar 'Olympic' to 38.6 t ha^{-1} for 'Merced'. The top four cultivars were 'Merced', 'Mountain Pride', 'Sunmaster' and 'Keepsake'. Tomato fruit worm was the major insect pest affecting most cultivars. The organic pesticides used were not very effective in controlling fruit worms. This study indicates that cultivars 'Bonita', 'Empire', 'Keepsake', 'Merced', 'Mountain Pride' and 'Sunmaster' are suitable for tomato production under an organic management system.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a very popular crop among small-scale growers in the U.S. Virgin Islands (USVI). Although tomato ranks first in importance, about 90 percent is imported from the U.S. mainland. Local production is not sufficient to meet increasing demands. The 1992 Census of Agriculture (U.S. Dept. of Commerce, 1995) reported a total production of 45,003 kg (99,006 lbs) harvested from 37 farms with a combined area of 14.98 ha (37 acres). In 1998, production dropped to 11,283 kg (24,823 lbs) harvested from 54 farms with a combined area of 10 acres (U.S. Dept. of Commerce, 2000). This represents a 75 percent decrease in production over previous years. The USVI imports most of the tomatoes from the U.S. mainland and neighboring Caribbean islands (Pearrow, 1992).

Tomato is a high management crop because it is very susceptible to damage by insect pests and diseases. Growing tomato in the USVI with minimum pest control usually results in reduced yields. Although the climate of the Virgin Islands is favorable for year-round tomato production, growers are confronted by a number of production constraints associated with crop management practices. The major constraints are high cost of production (labor and production inputs such as fertilizers and pesticides), limited water resources for irrigation and an inefficient marketing system. The cost of inputs constitutes a major expenditure in vegetable production. Reducing the use of these inputs would cut production cost and increase economic returns to vegetable growers. In addition, the environmental impact of toxic pesticides can be minimized if growers would use other options, such as organic methods, to produce vegetables. Sustainable crop management systems encourage efficient use of local resources, thereby reducing dependency on external and imported inputs.

Sustainable vegetable production can be achieved in the USVI by adopting a combination of sound crop management strategies including the use of cultivars adapted to low production and management inputs. These cultivars have high tolerance to pests and diseases as well as efficient in utilizing soil nutrients. To develop a sustainable and profitable vegetable production enterprise, growers must be able to meet market demands in terms of vegetable cultivar preferences, volume, quality and seasonal requirements. There is little information on sustainable crop management practices and cultivars for USVI vegetable growers. Palada et al., (2000) reported that eggplant can be grown successfully without the use of chemical fertilizers and pesticides. Information on new and improved vegetable cultivars adapted to low-input sustainable crop management practices is lacking. There is a need for continuous screening of new vegetable varieties developed and released by seed companies and research institutions to provide growers with information on promising varieties. Most of these new varieties are grown under high management inputs and may not perform well under low-input systems of limited-resource growers.

Tomato cultivar evaluation has been a continuous and on-going activity under the vegetable variety evaluation project at the Agricultural Experiment Station, University of the Virgin Islands. Results of tomato variety evaluation trials have been summarized in several reports (Collingwood et al., 1992; Navarro, 1982; Ramcharan, 1981; Petersen, 1987; Palada et al., 1993; 2001). These trials were all conducted using high-input crop management practices. The objectives of the studies presented in this paper were to: 1) evaluate the performance and adaptability of tomato cultivars under low-input/sustainable production systems; and 2) select superior cultivars in terms of yield stability, pest and disease tolerance and quality for commercial production and home gardening.

MATERIALS AND METHODS

The trials were located on farmer=s field in Estate Glynn, St. Croix, USVI (lat. 17°42'N, long. 64°48'W). The soil is a Glynn gravelly loam (clayey, skeletal, mixed, superactive, isohyperthermic, typic argiustoll) as described by Lugo-Lopez, et al. (1998). Average rainfall is 1015 mm per year. The field trials were planted on 9 February 1999 (first season) and 26 January 2000 (second season).
Twelve cultivars were evaluated for each season. All cultivars were hybrid with determinate plant type and are recommended for spring season production except cultivar Sunmaster, a heat-tolerant tomato recommended for summer planting. Seeds of all cultivars were obtained from Otis S. Twilley Seed Co., Inc., South Carolina.

The cultivars were planted in plots consisting of three rows 7.3 m long and spaced 1.2 m apart. Each plot measured 3.6 m x 7.3 m or 26 m^2. Plants were spaced 0.61 m within rows. All plots were drip irrigated to maintain soil moisture tension at -20 kPa. The experiment was established using a randomized complete block design with three replications. The organic management system consisted of application of dehydrated cow manure (2-1-2), applying organic and botanical sprays such as Dipel, M-Pede, Rotenone, and Bioneem. Cow manure was applied at the rate of 26 kg/plot (10 $t.ha^{-1}$). All plots had dry guinea grass (*Panicum maximum*) straw mulch applied in a 15 cm thick layer.

Data on plant height, number of fruits, fruit size, and fruit yield (total and marketable) were taken at each harvest. In 1999, samples were harvested seven times on April 20, 23, 26, and 28 and on May 3, 7, and 10. Only six harvests were taken in 2000 (April 5, 11, 19, 26, and May 3 and 8). All data were taken from a harvest sample of 10 plants in the middle row. Fruit quality attributes such as percent soluble solids (brix) and pH were determined at harvest, from random samples. Visual field observations were performed on the incidence of pests and diseases during the early plant establishment, active vegetative growth and bloom stage. Plant height and stem diameter were measured only during the first harvest. Data were analyzed for statistical significance using the SAS program.

RESULTS AND DISCUSSION

Plant Height and Stem Diameter

Average plant height and stem diameter are presented in Table 1 for the 1999 and 2000 trials. In 1999, significant differences ($P<0.05$) among cultivars were observed in both plant height and stem diameter (Table 1). Tallest plants were observed in cultivars 'Joker' (83.6 cm), 'Floramerica' (82.4 cm), 'Empire' (81.8 cm) and 'Mountain Pride' (80.5 cm). Shortest plants were found in cultivars 'Sunmaster' (63.3 cm) and 'Merced' (64.9 cm). There was no evidence of lodging in taller cultivars since all cultivars were supported with steel rods (stakes) and tied with plastic string. Cultivars 'Colonial', 'Celebrity' and 'Mountain Pride' developed larger stem diameter compared to other cultivars (Table 1). These cultivars had an average stem diameter of 10 mm or higher. Stem diameter is an important character that determines the tendency of plants to lodge. Also, a larger stem diameter is ideal for supporting larger and heavier fruits than a smaller stem diameter.

Significant differences in plant height and stem diameter were also observed in 2000 (Table 1). Cultivar 'Mountain Fresh' produced the tallest plants (90 cm). Most cultivars attained average plant height greater than 80 cm. Cultivars 'Sunmaster' and 'Keepsake' produced the shortest plants. Average stem diameter for all cultivars was relatively higher than in the 1999 trial. Cultivars 'Empire' and 'Mountain Pride' developed the largest stem diameter (15.4 mm and 14.9 mm, respectively). Cultivars 'Joker' and 'Sunmaster' produced the smallest stem diameter with average of 11.0 and 12.0 mm, respectively.

Number of Fruits and Yield

The number of fruits (total and marketable) and fruit yield (total and marketable) are shown in Tables 2 and 3 for the 1999 and 2000 trials, respectively. All cultivars matured in 70 days (first harvest) after transplanting. Significant differences in fruit number and yield were found in both years. In 1999, total number of fruits ranged from 183,000 ha^{-1} for cultivar 'Olympic' to 332,000 ha^{-1} for 'Sunmaster' (Table 2). 'Sunmaster' produced the largest total number of fruits which was significantly ($P<0.05$) higher that all cultivars except 'Bonita'. Cultivars 'Olympic' and 'Merced' produced the lowest total number of fruits averaging less than 200,000 ha^{-1}. Although 'Merced' produced the lowest total number of fruits, this cultivar produced the highest percentage (79%) of marketable fruits (Table 2). Only 70 percent of fruits from cultivar 'Sunmaster' was marketable. Other cultivars, which produced marketable fruits of 70 percent or greater were 'Celebrity', 'Floramerica', 'Liberty', 'Mountain Pride' and 'Olympic'.

'Sunmaster' produced the highest total fruit yield (56.9 t ha^{-1}) however, this yield was not significantly different from any other cultivar except 'Olympic' (Table 2). 'Sunmaster' also produced the highest marketable fruit yield (43.8 t ha^{-1}) followed by cultivars 'Bonita' (42.9 t ha^{-1}), and 'Empire' (42.7 t ha^{-1}). Most of the cultivars, which produced high percentage of marketable fruits, did not differ significantly in marketable fruit yield. The three top yielding cultivars in terms of marketable fruit yield (>40 t ha^{-1}) were 'Sunmaster', 'Bonita' and 'Empire'. Most cultivars produced marketable fruit yield greater than 30 t ha^{-1}.

Results from the second season (2000) trial also showed significant differences ($P<0.05$) among cultivars in terms of number of fruits and yield (Table 3). Total number of fruits ranged from 140,000 ha^{-1} for cultivar 'Joker' to 245,000 t ha^{-1} for 'Sunmaster'. In general, the number of fruits (total and marketable) from the 2000 trial was relatively lower compared to the first season (1999). Only six harvests were made due to the incidence of foliar diseases (bacterial spot and mosaic) later in the season. The top four cultivars with high marketable fruit yield (>30 t ha^{-1}) were 'Merced' (38.6 t ha^{-1}), 'Mountain Pride' (35.2 t ha^{-1}), 'Sunmaster' (31.0 t ha^{-1}) and 'Keepsake' (30.8 t ha^{-1}). All other cultivars produced marketable fruits in the range of 20 to 27 t ha^{-1} (Table 3).

Fruit Weight, Soluble Solids and pH

Significant differences ($P<0.05$) in fruit size and soluble solids were found among cultivars in 1999 (Table 4). Average fruit weight ranged from 160 g for cultivar 'Liberty' to 318 g for 'Empire'. Fruit weight of cultivar 'Empire' was superior to all other cultivars. Cultivars 'Liberty', 'Mountain Pride', 'Pilgrim' and 'Sunmaster' produced fruits with an average weight of less than 200 g. Soluble solids of all cultivars were ranged from 4.03 to 4.58%. Fruits of cultivar 'Empire' contained the highest (4.58%) soluble solids, whereas fruits of 'Sunmaster' contained the lowest (Table 4). Although 'Sunmaster' produced the highest number of fruits as well as fruit yield, fruit quality (weight and soluble solids) was inferior to the other cultivars. No significant differences in juice pH were observed among cultivars. Juice pH ranged from 3.73 ('Bonita') to 3.96 ('Sunmaster').

Results of the evaluation trial in 2000 indicated significant differences ($P<0.05$) in fruit weight and pH but not in soluble solids as shown in Table 4. All cultivars except 'Mountain Pride' produced fruits with an average weight greater than 200 g. Cultivars 'Floramerica', 'Merced' and 'Olympic' had an average fruit weight greater than 250 g and were significantly superior to 'Mountain Pride' (Table 4). Soluble solids and pH were relatively higher in 2000 than those obtained in 1999. Soluble solids ranged from 4.70% for cultivar 'Floramerica' to 5.44% for 'Empire', while juice pH ranged from 4.17 ('Mountain Fresh') to 4.37 ('Olympic'). Results from two seasons evaluation trial indicate that cultivar 'Empire' has ideal fruit quality attributes for fresh market organic tomatoes as shown by its larger fruit size and higher soluble solids. It is also one of the cultivars with high marketable fruit yield. Thus, organic vegetable growers in the Virgin Islands should consider growing this cultivar for fresh market tomatoes.

Cultivar Response to Insect and Disease Pests

The incidence of insect and disease pests was monitored by visual observation throughout the growing season. In 1999, the incidence of pests and disease was low. Damage due to insect pests was not serious since the pest population was low. However, tomato fruit worms, caterpillars and spider mites affected all cultivars. The most common leaf disease was the tomato mosaic virus which appeared later in the season. All cultivars seemed to be affected but the degree of infection varied among cultivars. In 2000, high insect and disease incidence was observed and this accounted for the relatively lower yield compared with yield in 1999. Several insect pests were observed during the growing season and among them were ants, caterpillars, mealy bugs, whiteflies, stinkbugs and fruit worms. Incidence of bacterial leaf spot and tomato mosaic virus was also common among cultivars. Despite the high incidence of insect pests and diseases, some cultivars produced high fruit yield. Regular applications of organic pesticides were quite effective in reducing pest damage. These observations suggest that organic pesticides can be as effective as conventional pesticides in minimizing insect pest populations in tomato production. Tomato growers have the option of using organic sprays and still maintain economical yields.

SUMMARY AND CONCLUSIONS

This study has shown that tomato can be grown successfully under an organic management system without the use of chemical fertilizers and pesticides. Marketable yield levels were comparable to or better than those obtained in previous tomato germplasm evaluation trials conducted using a conventional crop management system. The cultivars differed in their yield performance when grown under sustainable crop management practices. Outstanding cultivars for organic tomato production in terms of marketable yield and fruit quality are 'Bonita', 'Empire', 'Keepsake', 'Merced', 'Mountain Pride' and 'Sunmaster'. These cultivars performed well and appeared to be adapted to the growing environment of the Virgin Islands under low-input sustainable crop management practices. Vegetable growers should consider selecting these cultivars for spring production season using minimum inputs.

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Table 1. Plant height and stem diameter of tomato cultivars grown under organic management system. Agricultural Experiment Station, University of the Virgin Islands, St. Croix.

	Plant height (cm)		Stem diameter (mm)	
Cultivar	1999	2000	1999	2000
Bonita	76.6 abc	-	8.34 b	-
Celebrity	77.5 ab	80.2 abcde	10.25 ab	13.3 ab
Colonial	73.7 abc	85.2 abc	11.22 a	13.5 ab
Empire	81.8 a	85.6 abc	9.91 ab	15.4 a
Floramerica	82.4 a	84.7 abc	8.11 b	12.8 ab
Joker	83.6 a	89.4 ab	9.54 ab	11.0 b
Keepsake	-	72.4 c	-	12.3 ab
Liberty	72.2 abc	-	9.60 ab	-
Merced	64.9 bc	79.7 bcde	9.37 ab	12.7 ab
Mountain Fresh	-	90.9 a	-	13.2 ab
Mountain Pride	80.5 a	82.7 abcd	10.02 ab	14.9 a
Olympic	74.4 abc	84.1 abcd	8.00 ab	14.2 ab
Pilgrim	75.1 abc	77.6 cde	8.33 b	13.5 ab
Sunmaster	63.3 c	74.7 de	9.70 ab	12.9 b

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

Table 2. Yield of tomato cultivars grown under organic management system, Spring, 1999, Agricultural Experiment Station, University of the Virgin Islands, St.Croix, USVI.

	Number of fruits/ha		Fruit yield		Marketable
Cultivar	Total (x1000)	Marketable (x1000)	Total (t/ha)	Marketable (t/ha)	fruits (%)
Bonita	298 ab	199 abc	56.0 a	42.9 ab	67
Celebrity	246 bcde	175 bcd	49.6 ab	39.2 abc	71
Colonial	243 bcde	165 bcd	47.6 ab	33.6 abcd	68
Empire	207 de	140 d	49.9 ab	42.7 ab	68
FlorAmerica	211 de	151 cd	44.5 ab	33.3 bcd	72
Joker	224 cde	153 cd	56.0 a	33.7 abcd	68
Liberty	265 bcd	199 abc	42.1 ab	31.9 cd	75
Merced	192 e	152 cd	43.5 ab	37.1 abcd	79
Mountain Pride	281 abc	211 ab	50.8 ab	39.8 abc	75
Olympic	183 e	130 d	39.9 b	31.3 cd	71
Pilgrim	247 bcde	160 cd	43.1 ab	28.5 d	65
Sunmaster	332 a	233 a	56.9 a	43.8 a	70

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

Table 3. Yield of tomato cultivars grown under organic management system, Spring, 2000. Agricultural Experiment Station, University of the Virgin Islands, St. Croix, USVI.

Cultivar	Number of fruits/ha		Fruit yield		Marketable
	Total (x1000)	Marketable (x1000)	Total (t/ha)	Marketable (t/ha)	fruits (%)
Celebrity	198 abc	136 abc	39.0 bc	27.4 bcd	69
Colonial	191 abc	104 bcd	38.7 bc	22.8 cd	54
Empire	211 abc	129 abcd	41.8 abc	28.6 bcd	61
Floramerica	171 bc	89 cd	39.6 bc	22.4 cd	52
Joker	140 c	95 cd	32.5 c	22.3 cd	68
Keepsake	203 abc	144 abc	40.6 bc	30.8 abc	71
Merced	195 abc	152 ab	47.6 ab	38.6 a	78
Mountain Fresh	164 bc	105 bcd	33.2 c	23.9 cd	64
Mountain Pride	230 ab	180 a	43.7 abc	35.2 ab	78
Olympic	151 c	79 d	35.6 bc	20.0 d	52
Pilgrim	198 abc	116 bcd	38.8 bc	24.3 cd	59
Sunmaster	245 a	155 ab	53.5 a	31.0 abc	63

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

Table 4. Fruit weight, soluble solids and pH of tomato cultivars grown under organic management system. Agricultural Experiment Station, University of the Virgin Islands, St. Croix, USVI.

Cultivar	Fruit weight (g)		Soluble solids (%)	pH
	1999	2000	1999	2000
Bonita	216 bcde	-	4.36 ab	-
Celebrity	229 bcd	205 ab	4.22 bc	4.22 ab
Colonial	201 bcde	242 ab	4.19 bc	4.34 a
Empire	318 a	222 ab	4.58 a	4.29 ab
Floramerica	222 bcd	253 a	4.17 bc	4.34 a
Joker	221 bcd	235 ab	4.42 ab	4.34 a
Keepsake	-	216 ab	-	4.34 a
Liberty	160 e	-	4.42 ab	-
Merced	242 bc	255 a	4.22 bc	4.27 ab
Mountain Fresh	-	227 ab	-	4.17 b
Mountain Pride	189 bcde	195 b	4.44 ab	4.32 ab
Olympic	246 b	253 a	4.42 ab	4.37 a
Pilgrim	177 de	214 ab	4.37 ab	4.34 a
Sunmaster	187 cde	201 ab	4.03 c	4.26 ab

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

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THE EFFECT OF FRUIT AND INFLORESCENCE PRUNING ON FRUIT SIZE AND YIELD OF DWARF GOLDEN APPLE (*SPONDIAS CYTHEREA* SONN.)

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ABSTRACT: An experiment was conducted from Sep 1998 to Dec 1999 to determine the effects of 8 combinations of fruit and inflorescence pruning on fruit size and yield of dwarf golden apple (*Spondias cytherea* Sonn) grown in Belvidere, Grenada, W. I. Pruning treatments were 1: 0% fruit + 50% inflorescence 2: 25% fruit + 50% inflorescence 3: 50% fruit + 50% inflorescence 4: 75% fruit + 50% 5: 0% fruit + 0% inflorescence 6: 25% fruit + 0% inflorescence 7: 50% fruit + 0% inflorescence 8: 75% fruit + 0% inflorescence. Fruit pruning increased fruit size. At 75% it was highly significantly different (P=0.000) from the 25% and 0% levels but was not significantly different from pruning at 50%. Inflorescence pruning reduced fruit size. The interaction between fruit pruning and inflorescence pruning tended to reduce fruit size. Fruit and inflorescence pruning reduced fruit yield in terms of weight and number. Fruit pruning at 0% and 25% had a highly significant difference (P=0.000) from 75% on total number of fruits. Pruning treatmeats of 0%, 25%, and 50% had a highly significant difference (P=0.001) from 75% on total weight of fruits.

INTRODUCTION

The golden apple (*Spondias cytherea* Sonn.) is native to the Society Islands of the South Pacific (Weir et al., 1982). From there it has been widely distributed around the tropics. It was first introduced into the Caribbean in the 18th century (Morton, 1961) where it has adapted well to local conditions and have become a natural part of the agricultural landscape. It is grown on a small scale in many tropical and subtropical areas like Indonesia, Florida Keys, Hawaii, the Caribbean, Venezuela and Suriname (Popenoe 1979; Weir et al., 1982, Morton 1987). In other countries the golden apple is also referred to as June Plum, Pomme-Cythere, Ambarella, Mokak, Coe, Hevi, among others (Morton, 1987; Geurts et al., 1986).

Even though the golden apple is distributed worldwide and has become a popular fruit for West Indian consumers it has received little recognition from the scientific community of the region (Bauer et al., 1993). This may be attributed to the fact that historically it was a fruit of insignificant commercial importance. In Grenada, the importance of golden apple as a commercial export crop has been realized since 1985 when extra-regional export to the USA began. Formerly small quantities of the crop was exported by hucksters to the neighbouring island of Trinidad. After 1985, the golden apple quickly rose to prominence as one of the major non-traditional export crops. In 1996, in terms of volume, it was the second most important non-traditional export crop after mango. In that year 368 tonnes were exported.
Despite the increased importance of golden apple, the crop still continues to be grown mainly in a haphazard manner as scattered trees among the more important tree crops like cocoa and banana. The Grenada Agricultural Census of 1995 estimated pure stand national cultivation at 10.9 hectares.

In the present system of golden apple cultivation, no agronomic attention is paid to the trees by farmers. As a result, trees are very tall and therefore difficult and dangerous to harvest, therefore many fruits are damaged during harvesting (Daulmerie, 1994). In 1993, the Inter-American Institute for Co-operation on Agriculture (IICA) introduced a dwarf type of golden apple which bears relatively small fruits on a short tree. This introduction was viewed as a means to obtain a larger proportion of undamaged fruits since the dwarf trees are easily harvested at the ground level. One disadvantage though of the dwarf type is that the fruits are smaller than the traditional type and therefore its fruits are not readily accepted on the local and export markets.

This experiment was aimed at increasing fruit size of the dwarf golden apple through fruit and inflorescence pruning so that larger fruits can be obtained from the dwarf trees to facilitate easier marketing of the fruits.

MATERIALS AND METHODS:

The trial was superimposed on two year old dwarf golden apple trees growing on a private farm in the Belvidere, St. John's region of Grenada. Soil type was of the Capitol clay loam series.

The trial consisted of eight treatments in a 4 x 2 factorial arrangement. The factors are four levels of fruit pruning and two levels of inflorescence pruning. Treatments were set out as follows:

TREATMENT NO.	DESCRIPTION
1	0% fruit pruning, 50% inflorescence pruning.
2	25% fruit pruning, 50% inflorescence pruning.
3	50% fruit pruning, 50% inflorescence pruning.
4	75% fruit pruning, 50% inflorescence pruning.
5	0% fruit pruning, no inflorescence pruning.
6	25% fruit pruning, no inflorescence pruning.
7	50% fruit pruning, no inflorescence pruning.
8	75% fruit pruning, no inflorescence pruning.

The trial was laid out in a randomized block design. There were 13 blocks of eight trees. Each block received each of the experimental treatments. The trees were grown on a slope at the side of a ravine therefore each block was selected based on geographical proximity along the contours and relative uniformity of size.

The experiment began in November 1998 and ended in December of 1999. At the beginning, the mature fruits from each tree were harvested, weighed and counted. The following week the treatments were applied. Further applications of the treatments were applied every two weeks while further harvesting of mature fruit was done as necessary. One application of 12.8.24 fertilizer at the rate of 190 kg/ha was made in March 1999. Manual and chemical weed control with paraquat and glyphosate were practised.

At each harvest the fruits were weighed and counted. Harvesting was performed on nine occasions. Analyses of variance using Minitab statistical software were performed on average fruit weight, total fruit weight and total number of fruits.

RESULTS AND DISCUSSION:

Analyses of variance for the main and interaction effects were conducted on average fruit weight, total fruit weight and total number of fruits over the whole period.

Fruit Size:

For ease of measurement average fruit weight was used as an indicator of fruit size. Analysis of the effect of fruit pruning regime revealed that fruit pruning tended to increase fruit size. Fruit pruning at 75% gave the largest fruit size of 58g followed by fruit pruning at 50%, with 54g, Table 1. The fruit size obtained by the former pruning regime was 11g greater than the no pruning regime. Fruit pruning at 75% and 50% levels were highly significantly different (P=0.000) from the 25% and 0% levels. There was no significant difference between the 75% and 50% fruit pruning levels.

Inflorescence pruning at 50% tended to reduce fruit size (Table 1) but the effect was not significant. The interaction effect between fruit pruning and inflorescence pruning on fruit size, was inconsistent. At the fruit pruning level of 25% there was an increase in fruit size, the 50% level had no effect while the 75% level reduced fruit size, Table 1. Fruit pruning at 75% together with no inflorescence pruning was significantly different (P=0.035) from fruit and inflorescence pruning combinations at 25% and 0% fruit pruning levels.

Total Fruit Weight:

No fruit pruning (0%) gave the best yield, Table 2, however it was not significantly different from pruning at 25% and 50%. Fruit pruning regimes of 0%, 25% and 50% were highly significantly different (P=0.001) from 75%, the latter producing the poorest yield. Inflorescence pruning had a negative effect on yield. The best yield was obtained with no inflorescence pruning, Table 2.

The effect on yield by pruning of inflorescences at 50% was highly significantly different (P=0.007) to no inflorescence pruning. Fruit and inflorescence pruning had a negative interaction effect on yield (Table 2), however the reduction in yield was not statistically significant. The greatest negative interaction effect was obtained from the combination of fruit pruning at 75% with inflorescence pruning at 50%.

Total Number of Fruits:

Analysis of the effect of fruit pruning on total number of fruits harvested showed that 0% and 25% fruit pruning were highly significantly different (P=0.000) from 75% fruit pruning. The highest mean total yield of 326 fruits came from 0% fruit pruning while 75% fruit pruning resulted in the lowest mean total yield of 165 fruits, Table 3.

Fruit pruning therefore tended to reduce total number of fruits harvested. As severity of fruit pruning increased total number of fruits harvested decreased. For the inflorescence pruning effect, 50% pruning was significantly different (P=0.01) from 0% pruning and the former had a negative effect on yield. No pruning produced the higher number of fruits, Table 3. In the case of interaction effects between fruit pruning and inflorescence pruning, the analysis revealed no significant differences. Generally inflorescence pruning increased the negative effect of fruit pruning on total number of fruits harvested with the exception of fruit pruning at the 25% level, Table 3.

As we have seen the fruit size of dwarf golden apple was successfully increased through the influence of fruit pruning while yield was reduced. The increased fruit size was expected since the removal of some fruits allowed the plant to distribute the available nutrients to fewer number of fruits hence increasing individual fruit size.

Although no record of pruning work on dwarf golden apple was discovered in the literature, this result is similar to that obtained by Pawar et al (1994) on pomegranate, where fruit size improved with increasing severity of pruning and total yield was reduced by pruning.

CONCLUSIONS:

The best pruning regime to increase fruit size of dwarf golden apple was 75% fruit pruning. Increased fruit size through this practice is however obtained at the expense of a reduction in yield both in terms of weight and number of fruits harvested. Therefore the recommendation of the practice of pruning would depend on whether cost/benefit analyses indicate that marketing of the increased fruit size would compensate for the reduced yield experienced. This is unlikely as the largest increase in fruit size obtained was only 11g which would not be significant in the market place. The development of the dwarf golden apple industry therefore depends on finding market niches which uses the fruit in its normal size.

Fruit and inflorescence pruning both reduced fruit yield while the latter reduced fruit size. Inflorescence pruning therefore is not a worthwhile practice.

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Table 1: Effect of fruit and inflorescence pruning on average fruit weight of dwarf golden apple

	Average Fruit Weight (AFW) (g) Inflorescence Pruning		
Fruit Pruning (%)	0%	50%	Mean AFW (g)
0	49	49	49
25	49	51	50
50	54	54	54
75	58	53	55
Mean AFW (g)	53	52	

SEM Overall fruit pruning = 0.87, (84 d.f.) Overall Inflorescence pruning = 0.62, Body of table = 1.23

Table 2: Effect of fruit and inflorescence pruning on total fruit weight of dwarf golden apple

	Total Fruit Weight (kg) (TFW) Inflorescence Pruning		
Fruit Pruning (%)	0%	50%	Mean TFW (kg)
0	17.57	14.12	15.85
25	13.44	13.38	13.41
50	14.74	12.34	13.54
75	12.31	5.94	9.13
Mean TFW (kg)	14.51	11.45	

SEM Overall Fruit Pruning = 1.11, (84 df) Overall Inflorescence Pruning = 0.79, Body of table = 1.57

Table 3: Effect of fruit and inflorescence pruning on total number of fruits of dwarf golden apple

	Total No. of Fruits (TNF) Inflorescence Pruning		
Fruit Pruning (%)	0%	50%	Mean TNF
0	358	293	326
25	271	270	271
50	278	227	253
75	217	112	165
Mean TNF	281	226	

SEM Overall Fruit Pruning = 21.70, (84 df) Overall Inflorescence Pruning = 15.34, Body of table = 30.69

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EVALUATION AND SELECTION OF IMPORTED AND LOCALLY COLLECTED TROPICAL TYPE SWEET POTATO ACCESSIONS

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ABSTRACT: Sweet potato [*Ipomoea batata* (L.) Lam.] is an important root crop in the Caribbean. In 1998 a selection program was established to evaluate landraces and accessions from the USDA Plant Germplasm System, for horticultural traits and adaptability to conditions in the Caribbean. Tuber number fluctuated from 49,056 to 97,170 /ha and yields ranged from 28,577 to 57,798 kg/ha. Analysis of variance showed significant differences for accession and time of harvest but not for the interaction between accession and harvest time. Accession 98-023 produced the highest yield, but root deformation may limit its commercial acceptance. Accession 98-022 and 97-031 produced 43,173 and 43,500 kg/ha, respectively, and have good tuber shape, high quality flesh appearance and good flavor. All of the accessions evaluated in this experiment are susceptible to the sweet potato weevil.

INTRODUCTION

Sweet potato [*Ipomoea batata* (L.) Lam.] is an important root crop in the Caribbean. In Puerto Rico sweet potato production is estimated at 3,013 t with value of $1.9 million. In 1999, imports of sweet potato for fresh market were estimated at 9,510 t with most of the imported sweet potato coming from Dominican Republic. In 1950, the University of Puerto Rico initiated a program to improve local sweet potato varieties (Moscoso, 1955). Cultivars Miguela and Mina were recommended for commercial use after intensive testing (Badillo-Feliciano et al., 1976). In addition, the USDA Tropical Agriculture Research Station at Mayagüez established a program to develop a staple type sweet potato to replace the Irish potato in Puerto Rico (Martin, 1987). Cultivars Papota, Viola, and Ivory were released from that program. Also, nine sweet potato clones (local landraces) have been evaluated by the University of Puerto Rico at the Corozal Experiment Substation in low fertility soils, and for damage by the sweet potato weevil (*Cylas formicarius elegantulus*). More recently, a formal program for the improvement of tropical vegetables was financed by the local Agricultural Experiment Station and by the USDA. This program includes sweet potato breeding. The objective of this work is to introduce and evaluate sweet potato clones for horticultural traits and adaptability to conditions in the Caribbean.

MATERIALS AND METHODS

The experiments were conducted at the Agricultural Experiment Substation in Isabela, in northwestern Puerto Rico. The soil is an Oxisol (Typic Hapludox, very-fine kaolinitic isohyperthermic) with a pH of 6.0 and 15,230, 1400 and 80 mg/kg of P, K, Ca and Mg, respectively. The average rainfall is 1630 mm, with a maximum temperature of 29 C and a minimum of 19 C. The accessions evaluated in this project came from the USDA Plant Germplasm System (NPGS); landraces were from different places of Puerto Rico. Cultivars were propagated from vine cuttings of approximately 45 cm long and were planted in a raised bed. From 1998 to 2001, 120 accessions were evaluated in different sites. Low yielding, off-shaped and disease infected cultivars were discarded. After the preliminary screening seven accessions and two check varieties were selected for the final test. Experimental plots were 5.3 m wide by 6.0 m in long with 4 rows and 1.1 m apart. The experimental design was a Randomized Complete Block with a split plot arrangement and four replicates. Accessions were the main plots and times of harvest the subplots. Fertilizer 6-6-12 at a rate of 1121 kg/ha was banded two weeks after planting. All plots were hand weeded twice. Overhead irrigation rate of 25 mm per week was applied as needed. Other evaluations such as sugar content, number of tubers, yield, and damage by the sweet potato weevil were conducted in the field and in the laboratory. Analysis of variance and Fisher's Least Significant Difference Test (LSD) were conducted for number of tubers and yield.

RESULTS AND DISCUSSION

After preliminary screening and selection based on skin and flesh color, tuber size and shape, disease tolerance, and desirable agronomic characteristics, seven accessions and two varieties were selected for final evaluation. Skin and flesh color are very important characteristics in sweet potato. Table 1 shows origin and skin and flesh color for the seven accessions and two varieties evaluated in this experiment. All of the accessions, except 97-031, have reddish skin. Flesh color varied from light yellow to yellow. Cultivar 98-022 is the only accession with a white flesh color. Acceptable tuber shape is another trait that has commercial value. Accessions 98-022 and 97-031 had the most commercial root shape and tubers were soft and without any undesirable characteristics. Cultivar 98-023 produced big tubers with some degree of deformation. Venus, Martina and other accessions evaluated had some deformation after 135 days. Accession 98-039 produced a high number of tuberous roots, but most of them were small at harvest time suggesting that this accession is late in maturity compared to the other lines.

Table 1. Origin, skin and flesh color of nine accessions of sweet potatoes evaluated at the Isabela Experiment Substation in 2001.

Local ID (PI)	Origin	Skin Color	Flesh Color
98-022	PR	Purple	White
98-023	PR	Pink	Light-yellow
97-031 (564118)	Taiwan	Cream	Light-yellow
97-033 (564120)	Taiwan	Purple	Yellow
98-039	PR	Pink	Yellow
98-040	PR	Purple	Yellow
97-045 (564770)	Papua	Purple	Light-yellow
Martina	USDA-TARS	Purple	Yellow
Venus	USDA-TARS	Purple	Yellow

Table 2 shows the analysis of variance for number of tubers and yield (at 119 and 149 days after planting). There were significant differences, among varieties and harvesting time at P 0.05. The effect of block and the interaction between accessions and time were not significant. Since there were no significant differences for interaction, Table 3 only shows accessions means for tuberous root number and yield. Root number fluctuated from 156 to 309 in a 31.8 m^2 (Table 3). Venus had the lowest number of tuberous roots in the experiment. Number of tuberous roots is one of the most important components of sweet potato yield. Total number of tuberous roots may be determined as early as 30 days after planting (Togary, 1950).

Table 2. Analysis of variance for number of tubers and yield at 119 and 149 days after planting.

		P-value	
Source	df	Tubers	yield
Block	3	0.0634	0.5716
Accessions	8	0.0001	0.0001
Error (a)	24		
Time	1	0.0062	0.0001
Accession by time	8	0.6031	0.1826
Error (b)	27		
Total	71		
c.v.		13.7598	16.3505

Yield fluctuated from 28,577 to 57,798 hg/ha (Table 3). The analysis of variance shows no significant differences for block and interaction between time and accession (Table 2). The analysis did show significant differences for accession and time of harvest. Accession 98-023 produced the greatest tuber yield and accession 97-045 the lowest yield (Table 3). No significant differences at the five percent level were found between accession 98-040 and Martina.

Table 3. Number of tuberous roots and estimated yield of nine accession of sweet potatoes evaluated at Isabela Experiment Substation in 2001.

Accession	Tuberous Roots Number	Yield kg/ha
98-023	193*	57,798
98-040	165	46,999
98-039	309	43,951
Venus	156	43,769
97-033	218	43,740
97-031	247	43,500
98-022	242	43,173
Martina	175	39,500
97-045	167	28,577
LSD (0.05)	44	12,069

* Numbers of tubers in 31.8 m^2.

The yield reported here are in accordance with yield levels reported by Badillo-Feliciano (1976). Evaluation of damage by sweet potato weevil (*Cylas formicarius elegantulus*) was also made in the field and in the laboratory (data not show). All of the accessions evaluated were susceptible to damage by this insect.

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FRUIT CHARACTERISTICS OF PROMISING QUENEPA (*MELICOCCUS BIJUGATUS* JACK.) CLONAL SELECTIONS FROM PUERTO RICO

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ABSTRACT: The quenepa is becoming an increasingly important fruit crop in Puerto Rico both for local consumption and export. Production comes mostly from spontaneous trees, but some farmers are beginning to plant organized orchards. As a result, some research interest is beginning to emerge particularly in the area of germplasm evaluation. Studies at the Agricultural Experiment Station of the University of Puerto Rico have resulted in the selection of several promising clones obtained from a partial evaluation of the extensive number of seedling trees growing throughout the island. The present work relates to the most recent findings regarding selection of superior plant material based on the evaluation of fruit and production characteristics of the trees. The illustrated results were obtained from 5- to 10-year-old grafted trees planted at the University farm in Juana Díaz. Selected clones had individual fruits ranging in size from 10 to 20 grams of fresh weight and from 45 to 64% in pulp content. Data of other important fruit characteristics evaluated are illustrated.

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BEARING CHARACTERISTICS AND YIELD IN YOUNG TREES OF SELECTED CARIBBEAN BREADFRUIT [*ARTOCARPUS ALTILIS* (PARK.) FOSBERG] CULTIVARS

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ABSTRACT: The most widely recognised breadfruit cultivars in the Caribbean are the 'Yellow' and the 'White'. However, yield data are not available for these cultivars or for those that are less known. Four-year old trees of 12 cultivars, five from Jamaica, five from St. Vincent and two from Trinidad and Tobago growing in a germplasm collection at the University Field Station of the University of the West Indies in Trinidad, were evaluated. The results indicated that the cultivars differed in their time of bearing, yield, fruit number and fruit size. 'Yellow' was earlier, less seasonal and higher yielding than most of the other cultivars during early growth.

INTRODUCTION

The first major introduction breadfruit to the Caribbean was made by William Bligh who landed 6 trees in St. Vincent and in Jamaica in December, 1793 and February, 1794, respectively. Most of the plants were of seedless varieties and had been obtained from Tahiti, but he also collected one seedless and one seeded type from Timor (Powell, 1977). He recorded having five "kinds" (Powell, 1977, p. 396) of breadfruit, not including the seeded variety, therefore, four of the seedless varieties appear to have originated from Tahiti. The curator of the botanical garden in St. Vincent, to whom the plants had been delivered also reported having six varieties growing there, with differing seasons of production and levels of yield (Howard, 1950).

Today, the most widely known breadfruit cultivars, are the 'Yellow' and the 'White' and where these distinctions are not made, the cultivar is designated as 'Common' or 'Creole'. The recognition of other cultivars is greatest in St. Vincent, where Roberts-Nkrumah (1997) reported the existence some 22 cultivar names, and in Jamaica where more than one dozen types have been named (Roberts-Nkrumah, unpubl.). Prior to these listings, Leakey (1977) and Andrews (1991) reported four varieties in the English-speaking Caribbean, and six in St. Vincent, respectively. The author is currently undertaking descriptions of some of these varieties.

For more than two decades, the Caribbean has been the major exporter of breadfruit to North America and to the United Kingdom. Currently, commercial breadfruit production is very limited, and one major area in which information is needed to encourage this and in particular, year-round supply, is cultivar differences in bearing characteristics and yield. During the survey of the Vincentian germplasm, differences were identified but could not be confirmed due to intervening factors such as location, age and production systems (Roberts-Nkrumah, 1997). This study was undertaken to evaluate selected breadfruit germplasm existing in the Caribbean, for these characteristics when grown under the same environmental conditions.

MATERIALS AND METHODS

In 1992, a breadfruit germplasm collection was established at the University Field Station, Valsayn, Trinidad. The soil type is River Estate Loam and the site receives approximately 1500 mm of rain annually with 85 - 90 %, occurring between May and December.

The cultivars, 'Yellow' and 'White' obtained from eastern Trinidad, were established in the collection and were represented by five and four trees, respectively. In 1996, one tree of each of five cultivars from St. Vincent and Jamaica cultivars were added to the collection as follows:

Vincentian accessions	Jamaican accessions
Kashee	Macca
Hog Pen	Common/Yellow Heart
Hope Marble	Timor/St. Kitts
Cocobread	Cassava
Creole	Yellow Heart

The management of the trees included mulching and irrigation during the dry season, fertiliser and Nematicides applications twice yearly, fungicidal applications especially during the rainy season, and regular mechanical weed control.

Data were recorded on harvesting periods for 'Yellow' and 'White' in four-year old trees in 1996, and for eight-year old trees in 2000 to compare the effect of age on bearing pattern. Harvested yield as total fruit mass/tree and the yield components, fruit number and mean fruit size were also recorded for four-year old trees of these cultivars and, in 2000, for the Vincentian and Jamaican germplasm. Statistical analyses were not attempted because most of the accessions were single tree specimens.

RESULTS AND DISCUSSION

Bearing characteristics

Four-year old trees of both 'Yellow' and 'White' had a minor season in the early part of the year extending from January to February for 'White' and from February to March for 'Yellow'. The major production period, extended from May to August for 'White' and to mid September for 'Yellow' which also had another minor season in mid-November (Fig 1). Fruit were available for 20 weeks of the year. Eight-year old trees of both cultivars showed peak production during the July to August period with ' Yellow' having a more pronounced small early season lasting five weeks weeks in March to April, while there were a few single fruit harvests from 'White' between April and June. Both cultivars also had a minor season in October (Fig. 2). Fruits were available for 12 and 19 weeks in 'White' and in 'Yellow', respectively.

In contrast, the Vincentian cultivars were later bearing. The early minor season for 'Hope Marble' and 'Creole' occurred in July, for 'Kashee' in July to August and for 'Hog Pen' in August. The peak production period for these cultivars was from September to October, 'Hope Marble', 'Hog Pen' and 'Cocobread' peaking earlier than 'Kashee' and 'Creole' (Fig. 3). These peak periods extended only for three to four weeks.

Most of the Jamaican cultivars, except 'Cassava', were also later bearing than the 'Yellow' and 'White' and had an early minor season followed by a peak production period. The minor season extended for three to five weeks from July to early August and the peak season being August to September for 'Kashee' and October for the other cultivars. 'Cassava' had its major peak in July followed by a minor season in October.

While, the precise time of bearing differs annually, largely due to environmental variations, there are two important consequences of these cultivar differences in bearing pattern. Firstly, is that there is a spread in the peak production period for another two months into September and October. Barrau (1959) and Fownes and Raynor (1993) reported similar extension of breadfruit production through the differing bearing seasons. Secondly, the overlapping of major seasons of some cultivars with the minor seasons of others ensures the availability of a greater diversity of cultivars. This will facilitate a wider range of uses of the fruits but may not necessarily confer price advantages. Higher prices are possible during the November to May period, when only "Yellow' and 'White produce small harvests.

Total Fruit Yield/Tree

At four years old, the highest yielders were 'Yellow', 'Macca', and 'Kashee' with annual production of 140 to 89 kg /tree (Table 1). At an estimated plant population of 70 trees/ha, the estimated yield potential is 9.8 MT/ha for young trees of the 'Yellow' breadfruit. 'Cocobread', 'Creole', 'Cassava', 'Timor' and 'Yellow Heart' were much lower yielding with only 50 to 30% of the production of the high yielders.

One factor that would have contributed to this difference was the duration of their availability. While differences in the relationship between yield and the yield components would most likely be another important contributor, the author suggests that differences in tree vigour and specifically branch production might limit the number of bearing sites available on a tree. At four years, 'Yellow' had more branches than the other cultivars. Fownes and Raynor (1993) found a closely correlation between tree size and canopy volume and yield in breadfruit. Another factor would be fruit number per branch. Given that by eight years, 'Yellow' was able to achieve over 300 kg/tree/year, it is important to determine how much of the yield differences identified in the study is attributable to random differences between individual trees, to genuine differences in cultivar yield potential and to adaptability to the environment. Yield potential would definitely influence choice of cultivar for commercial production.

Fruit number/tree

Cultivars 'Yellow', 'Macca' and 'Hope Marble' (101 to 71) produced the most fruits while the fewest fruits (17 to 35) were produced by 'Cocobread', 'Common', 'Timor' and 'Yellow Heart' (Table 1), most of which were low yielders. Fruit number obviously contributed to high yield in 'Yellow' and 'Macca'. The relationship between fruit number and yield needs to be further investigated for each cultivar individually and would require a larger sample of trees. Apart from the possible factors identified above that might affect yield, another consideration that determines the number of fruits harvested would be the extent of pre-harvest drop.

Mean Fruit Mass

The heaviest and largest fruits were those of 'Cocobread', 'Common' and 'Kashee' (2 – 1.78kg), in comparison with the small fruits of 'Cassava', 'Yellow Heart', 'Creole' and 'White' (1.17 to 1.29 kg). The other cultivars were approximately 1.4 to 1.6 kg (Table 1).

Fruit mass at harvest is influenced by the duration of the fruit growth period, the suitability of growing conditions, including the presence of disease. Since all fruit were harvested at maturity, environment and disease were the major factors that could have affected size. It is well known that breadfruit grown in high rainfall areas tend to be larger than those grown in drier areas. Roberts-Nkrumah (1997) also reported larger fruit mass for cultivars such as 'Hog Pen'(2.7 kg) and 'Creole' (2.3 kg) in St. Vincent than those obtained in this study. A high incidence of fruit rot was also observed in the field in 2000.

Again, there is need to establish the relationship between fruit mass and yield. Large mass did not compensate for low fruit number in 'Cocobread' and 'Common' but it contributed along with fruit number to high yield in 'Kashee'.

CONCLUSIONS

At four years old, 'Yellow' from Trinidad was superior to the other breadfruit cultivars under the conditions at the University Field Station. It was not only earlier-bearing and gave three harvest seasons, two minor and one major, as did 'White', but it gave the highest yields because it produced a large number of medium-sized fruits over a longer period. The season of breadfruit availabilty could be extended by two months by planting a mixture of the Trinidadian, Jamaican, and Vincentian cultivars.

The relationships between yield and fruit number and fruit mass should be investigated for each cultivar although from this study, high fruit number was more commonly associated with high yield than large fruit mass. Since environment influences bearing pattern, tree vigour and the yield components, a multi-locational with larger tree samples per cultivar is required to obtain a more conclusive evaluation of the commercial potential of the less known cultivars in Trinidad.

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Table 1. Total fruit yield/tree, number of fruits, and mean mass of harvested fruit of four-year old trees of selected Caribbean breadfruit cultivars

CULTIVAR	YIELD (kg)	FRUIT NO.	MEAN MASS (kg)
Yellow (TT)	140.39	105	1.44
White (TT)	70.14	67	1.29
Kashee (SV)	88.5	55	1.78
Hog Pen (SV)	79.8	48	1.58
Hope Marble (SV)	74.85	71	1.42
Cocobread (SV)	35.45	17	2
Creole (SV)	52.4	44	1.25
Macca (J)	101.9	82	1.45
Common (J)	62.4	27	1.84
Timor/St. Kitts (J)	34.13	28	1.41
Cassava (J)	50.6	47	1.17
Yellow Heart (J)	42.25	35	1.25

J = Jamaica, TT = Trinidad and Tobago, SV = Saint Vicent.

Fig. 1 Pattern of Fruit Production in Breadfruit Cultivars Yellow and White in 1996

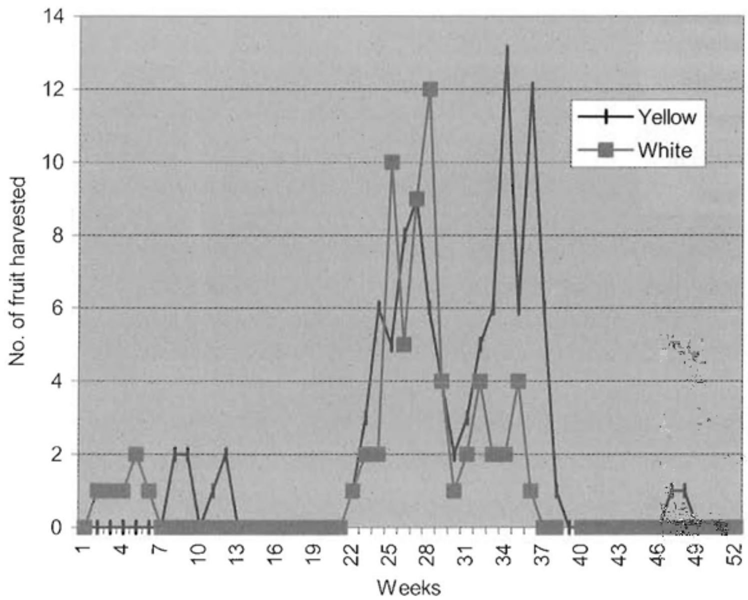


Fig. 2 Pattern of Fruit Production in cv Yellow and cv White in 2000

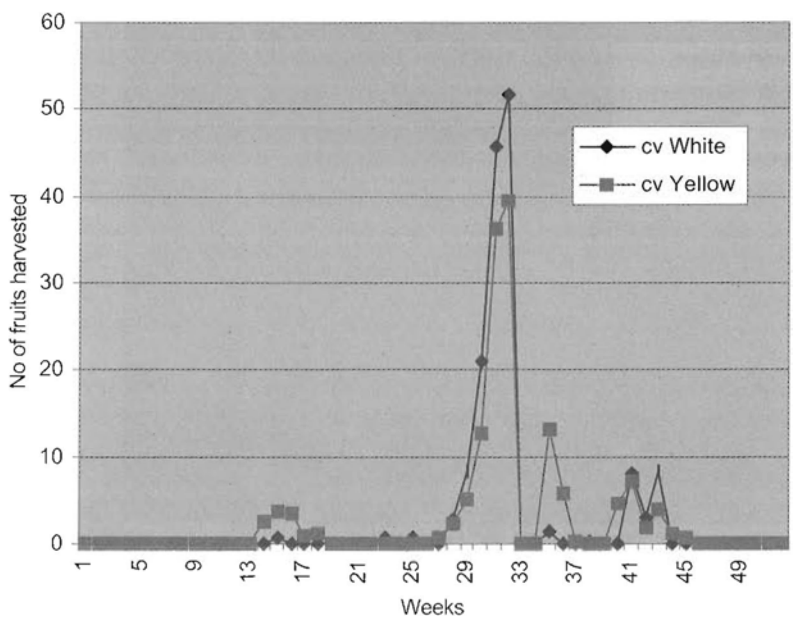


Fig. 3 Pattern of Fruit Production in Vincentian Breadfruit Cultivars in 2000

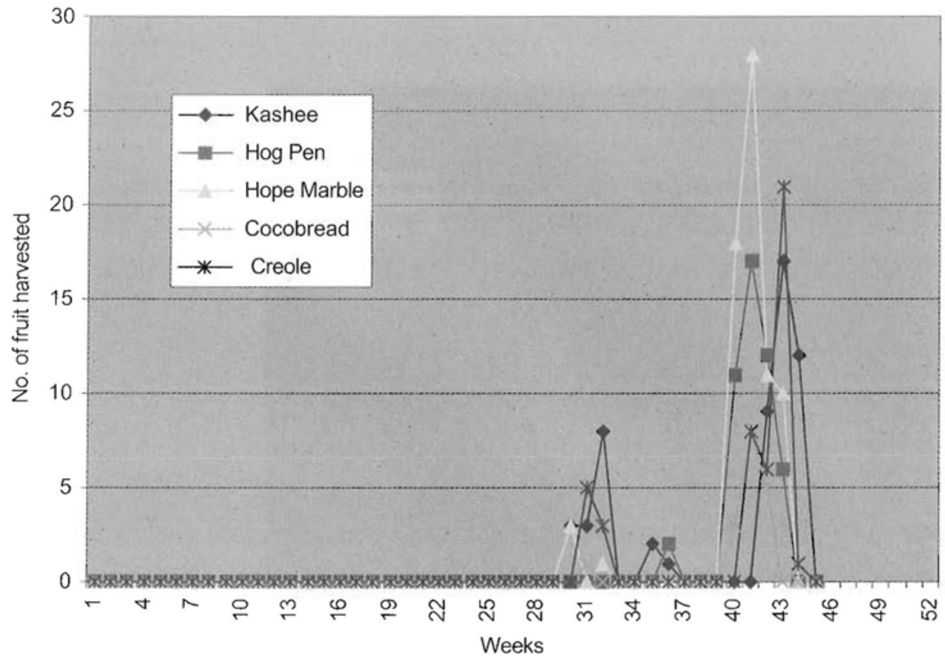
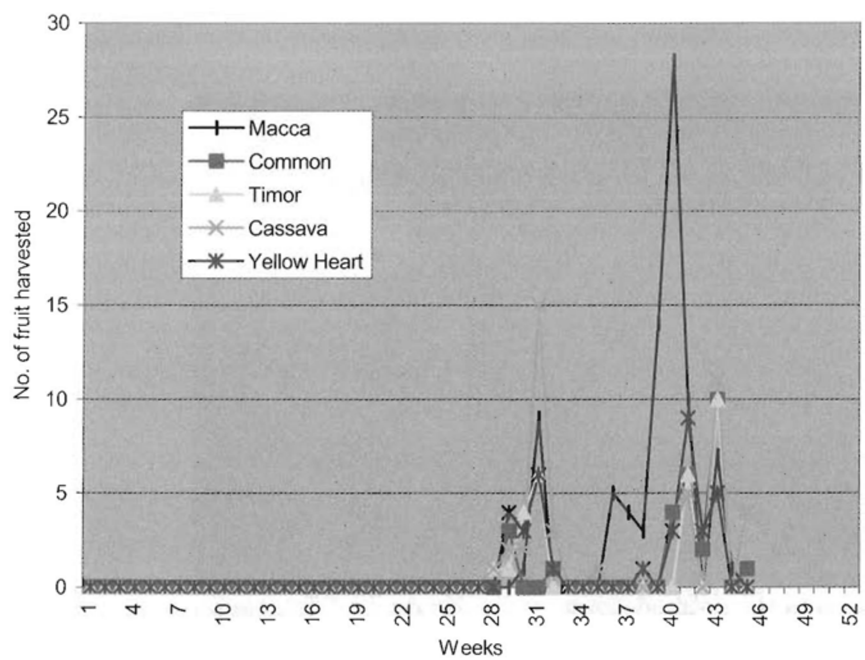


Fig. 4 Pattern of Fruit Production of Jamaican Breadfruit Cultivars in 2000



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EFFECT OF ORGANIC AND SYNTHETIC MULCH (REFLECTIVE AND NON REFLECTIVE) ON YIELD OF SCOTCH BONNET HOT PEPPER

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ABSTRACT: Field studies were conducted at the Famu research farm at Quincy, Florida, during the 1999 and 2000 growing seasons to examine the effect of organic and synthetic mulches on the yield potential of Scotch Bonnet hot peppers *Capsicum chinense*. For the 1999 study, only 2 mulches, one organic (Bahia grass) and one synthetic (black plastic) and a control (bare ground) were used. The 2000 study extended the synthetic mulches to white plastic and silver plastic (both reflective) and the organic mulches to perennial peanut and mushroom compost. For both years, the experimental design was a Randomized Complete Block Design with 3 replications. A drip irrigation system was installed to supply the moisture requirements of the crop. Weekly harvests were conducted to obtain data on yield parameters such as fruit size, fruits plant^{-1} and marketable fruits ha^{-1}. For the first year of the study, fruits from plots mulched with Bahia grass, were significantly larger ($P < 0.05$) than fruits from plots mulched with black and white plastic. However, none of the plots showed any significant differences in fruits plant^{-1} and marketable fruits ha^{-1}. In the second year of the study, With the exception of plots mulched with bahia grass, yield from plots mulched with organic mulches were significantly higher, $P < 0.05$ than plots mulched with black and white synthetic mulches and the control plots. However, marketable fruit yield from plots mulched with silver plastic was not statistically different ($P < 0.05$) to yield from organic mulch plots. Highest yield (2629 kg ha^{-1}) was obtained from plots mulched with mushroom compost. These plots also produced significantly higher yield ha^{-1} and fruits plant^{-1} compared to all plots with the exception of those mulched with perennial peanut and silver plastic. Plots mulched with black plastic produced significantly smaller fruits compared to all other plots.

INTRODUCTION

In the Southeastern United States, Florida ranks second to Texas, in terms of total acreage devoted to hot pepper production. While chemicals, including herbicides and inorganic fertilizers have been used with success to enhance yields, alternative cultural practices that are safe to human health and the environment, while at the same time maintaining high levels of crop productivity are needed (Relf, 1998). The useful effects of mulches in agricultural production are well documented. Benefits cited from the use of mulches include higher yields and better weed control (Hutchinson and McGiffen, 2000; Dale, 2000; Sanders et al., 1999) earlier maturity and fruit set (Tarara, 2000) reduced nutrient leaching and moisture loss, and improved fruit quality (Waterer, 2000).

More specific studies have focused on the influence of mulches on yield of horticultural crops. (Csizinszky et al., 1999) used a randomized complete-block design to evaluate the effect of ultraviolet-reflective mulches on tomato yields. They concluded that spring tomatoes grown on reflective mulches were larger and produced greater marketable yields, than those grown on non-reflective (black) polythene mulch. Using a randomized complete-block design, Hutchinson and McGiffen, 2000, investigated the effect of cowpea cover crop mulch on desert pepper production. They concluded that cowpea mulch provided greater fruit weight and promoted plant growth and fruit production

The objective of this study was to evaluate the yield potential of Scotch Bonnet hot peppers grown on synthetic mulches (reflective and non reflective) and organic mulches.

MATERIALS AND METHODS

Studies were conducted in Spring 1999 and 2000 on a Bonifay Sandy Loam soil at the FAMU research farm at Quincy Florida. In each study, treatments were arranged as a randomized complete-block design with three replications. Each treatment consisted of a 20-foot (approx. 1.0 m) strip within three 150-foot long raised beds spaced 3 feet apart. Twenty-foot strips of both white and silver plastic were laid over the existing black plastic while 20-foot strips of black plastic were removed for the purpose of laying the organic mulches. Mushroom compost treatments were composed of a mixture of approximately 3 parts soil to 1 part mushroom compost spread approximately 2.5 cm (1") to 5 cm (2") over the ground and mixed to a depth of approximately 12 cm (5") with the use of a spade and rake.

About 1.5 cm (1/2") to 2.5 cm (1") of the compost was allowed to cover the surface of the bed to complete the mulch. For the 1999 study, only 2 mulches: one organic (Bahia grass) and one synthetic (black plastic) and a control (bare ground) were used. The 2000 study extended the synthetic mulches to silver plastic and white plastic (reflective) and the organic mulches to perennial peanut and mushroom compost. For both years, the experimental design was a Randomized Complete Block Design with 3 replications. The soil was fumigated with Terr-O-Gas (66.6 % methylbromide and 33.3 % chloropicrin) at 224 kg ha^{-1} and a drip irrigation system was installed to supply the moisture requirements of the crop.

Two weeks after fumigation, 12-week old Scotch Bonnet seedlings that were grown in the greenhouse during the winter months were transplanted into the field. For Mature yellow fruits were harvested from a 36 square feet area of the center row of each treatment on a weekly basis, over a 17-week period, starting on August 15, and ending on November 15. Fruits were separated into marketable and cull, then marketable fruits were size graded on a weight basis by determining the number of fruits it took to weigh one pound (0.45 kg). The data were analyzed by analysis of variance (ANOVA) (SAS institute, 1988, version 8.0) General Linear Models Procedure. When significant F-values were found, differences between means were determined by using Duncan's multiple range test.

RESULTS

For the 1999 study, Bahia grass treatments produced significantly larger fruits with an average of 42 fruits to the pound, compared to black plastic with an average of 46 fruits per pound ($P < 0.05$). However, despite being numerically higher, yield ha^{-1} and $plant^{-1}$ were not significantly different compared to yield from black plastic treatments and the control (Table 1).

Table 1. Scotch Bonnet yield as affected by polyethylene and organic mulch in 1999

Treatment	Fruits/plant	fruit size	Yield (kg ha^{-1})
Bahia grass	50 a	42 b	3036 a
Black plastic	42 a	46 a	2441 a
Control	49 a	44 ab	2858 a

Means followed by the same letter are not significantly different, $P < 0.05$

For the 2000 study, all yield parameters (yield ha^{-1}, fruits $plant^{-1}$ and fruit size) were better for mushroom compost treatments. Fruits $plant^{-1}$ and yield ha^{-1} obtained from mushroom compost treatments were significantly higher than those obtained from all treatments with the exception of perennial peanut and silver plastic treatments. Except for black plastic treatments that produced significantly smaller fruits compared to all other treatments, fruit size was similar for both organic and synthetic mulch treatments (Table 2).

Table 2. Scotch Bonnet yield as affected by polyethylene and organic mulch in 2000

Treatment	Fruits/plant	fruit size	Yield (kg ha^{-1})
Mushroom compost	38 a	40 b	2629 a
Perennial peanut	33 ab	46 b	2150 a
Bahia grass	23 bc	42 b	1450 bc
Black plastic	10 d	64 a	504 d
White plastic	15 cd	46 b	905 cd
Silver plastic	32 ab	46 b	1974 ab
Control	16 cd	46 b	934 cd

Means followed by the same letter are not significantly different, $P < 0.05$

DISCUSSION

With the exception of silver plastic treatments, plants grown on organic mulches performed significantly better than those grown on synthetic mulches. Although preliminary, the findings of this study suggests that growing Scotch Bonnet hot peppers on organic mulch produces higher yields compared to synthetic mulches and bare ground treatments. Considering the great deal of emphasis being placed on environmentally friendly agricultural practices, the findings of this study provide a need to widen the scope of future studies, to determine how the use of mulches could optimize crop production in sustainable agriculture. Although the relative costs of using organic versus synthetic mulches were not covered in this study, the documented benefits of using organic substances as mulch may outweigh those obtained from the use of synthetic mulches. This issue poses another challenge for future research on the use of organic and synthetic mulches, not only for hot pepper production but also for other horticultural crops.

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PRE-BREEDING FOR RESISTANCE TO BLACK POD DISEASE OF CACAO

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ABSTRACT: A pre-breeding programme was initiated at CRU in 1997 to accumulate genes for resistance to black pod disease (*Phytophthora* pod rot) of cacao. Promising accessions were selected from the International Cocoa Genebank, Trinidad (ICG,T), intercrossed and their progenies screened for resistance to *Phytophthora* using a leaf disc inoculation method. From 36 crosses established in 1998, 1010 seedlings were tested in three rounds of leaf inoculations for resistance to *P. palmivora*. Results showed significant differences in resistance to *P. palmivora* among progenies from the 36 crosses. Progeny distributions for most crosses showed the occurrence of useful transgressive segregates with higher levels of resistance than the parental clones. Narrow sense ($h_{n.s.}$) and broad sense ($h_{b.s.}$) heritabilities were estimated at 0.33 and 0.51, respectively. Genetic gain (G_s) was estimated at 0.98 on the 0-5 resistance rating scale (selection intensity, 10% = 1.755, standard deviation = 1.092 and $h_{(b.s.)} = 0.51$). The selected seedling population would therefore have an average genetic resistance level of 2.42 (mean of all progenies, 3.4 - 0.98 expected genetic gain) which is higher than the resistance level of SCA 6 (2.64), a resistant control in the experiments. Based on the result of the leaf test for resistance to *Phytophthora*, 101 resistant seedlings were selected and planted in the field for further observations. The enhanced population derived from this programme should provide a source of useful resistance genes to black pod disease of cacao.

INTRODUCTION

A pre-breeding programme has become necessary in cacao due to the relatively narrow genetic base of most commercial varieties and their vulnerability to black pod disease (BP). Furthermore, experience acquired by plant breeders over the past century has demonstrated that plant germplasm collections such as the International Cocoa Genebank (ICG,T) are rich sources of resistance to pests and pathogens (Iwaro et al., 2000). The lineage of many important resistant cultivars can be traced back to germplasm collections (Peterson, 1975), yet most collections including the ICG,T remain largely unexplored for their potential as reservoirs of resistance genes (Harlan, 1977). The susceptibility of most commercial varieties to BP poses a challenge to cocoa farmers as the cost of chemical control continues to rise. The ultimate solution is to breed resistant varieties and to use them for commercial cultivation. Under these circumstances, it is imperative that a pre-breeding programme be initiated to provide new genes for resistance to black pod disease, high yield and to broaden the relatively narrow genetic base of commercial cocoa cultivars.

In response to the above challenge, a pre-breeding programme was initiated at CRU in 1997. The main objective of the programme is to develop populations with high levels of resistance to BP in view of the difficulties in enhancing resistance to a satisfactory level in previous breeding programmes. Since the ICG,T contains diverse germplasm, the pre-breeding programme is intended to capture as much of this diversity as is consistent with the major objective of enhanced disease resistance. This paper reviews the progress achieved within the first two years of the pre-breeding programme.

MATERIALS AND METHODS

The sequence of activities for the pre-breeding programme is outlined below:

Select parents from the germplasm collection (ICG,T)
Establish bi-parental crosses
Evaluate seedling progenies for resistance to *Phytophthora*.

Establish promising resistant seedlings and susceptible control seedlings in the field
Observe seedlings for early flowering, vigour and disease resistance in the field
Identify and transfer promising genotypes/populations to user countries, applying the accepted standard phytosanitary and quarantine measures

Selection of parental genotypes and establishment of bi-parental crosses.

Based on the accumulated information in CRU and the International Cocoa Germplasm Database (ICGD) on resistance to BP, WB and yield characteristics (bean number, bean weight and pod index), 32 promising parental genotypes were selected in 1997 from the Forastero, Refractario and Trinitario genetic groups. Subsequently, bi-parental crosses were conducted among the selected genotypes and 36 crosses were established (Table 1). Thirty seedlings were raised per cross and maintained in the greenhouse. In addition, 10 replicates of each parental genotype and two control clones (SCA 6 and ICS 1) were established by top grafting and maintained in the same greenhouse.

Selection of *Phytophthora* isolate for screening

At least five species of *Phytophthora* (*P. palmivora, P. megakarya, P. capsici, P. citrophthora,* and *P. megasperma*) have been identified as causal agents of black pod disease at different locations (Griffin, 1977; Brasier, Griffin and Maddison, 1981 and Zentmyer, 1988). Two of these species (*P. palmivora* and *P. capsici)* are present in Trinidad and Tobago (Iwaro, Sreenivasan and Umaharan, 1998). With restrictions on the transfer of pathogen from one country to another, only *P. palmivora* and *P. capsici* can be used for screening in Trinidad. So far, the ranking of resistance appears to be constant for different isolates and even species of *Phytophthora*. Van der Vossen (1997) reported that the ranking order for resistance to black pod caused by *P. megakarya* in Cameroon or Togo was very similar to that for black pod caused by *P. palmivora* in Côte d'Ivoire. Iwaro *et al*., (1998) also observed a similarity in the ranking of clones inoculated with *P. palmivora* and *P. capsici*. These observations suggest that the results of screening for resistance to *Phytophthora* at one location would be relevant to breeding programmes for black pod resistance at other locations. We selected an aggressive isolate of *P. palmivora* for the screening of progenies.

Evaluation of progenies for resistance to *P. palmivora*

The progeny population (1010 seedlings) and the parental clones including two control genotypes (32 accessions) were evaluated by the leaf disc inoculation method (Nyassé, Cilas, Herail and Blaha, 1995) from the age six months. Two leaves (interflush-2 as described by Greathouse, Laetsch and Phinney, 1971) were collected from each seedling and each grafted plant. Two leaf discs were obtained from each leaf and randomised in trays lined with moist paper towel. Each leaf disc (1.5 cm in diameter) was inoculated with 10 µl of zoospore suspension (200,000 zoospore mL^{-1}) of *P. palmivora* and incubated at 25°C and high relative humidity for six days. After incubation, the levels of resistance of the inoculated leaf discs were assessed using a disease rating scale indicated below:

Disease rating	Symptoms	Disease rating	Symptoms
0	No symptom	3	Coalescence of brown spots
1	Small localised penetration points	4	Expanding lesions
2	Small expanding lesions	5	Large dark brown lesions

Inoculation was conducted in six series of five plants per progeny for each series, and were repeated three times.

Data collected from the three replicates were subjected to covariance analysis to adjust for differences between test series. The control clones were used as covariates. Analysis of variance was performed to assess the differences among progeny seedlings, both within and between genetic groups. A parent-offspring regression was carried out to estimate the narrow sense heritability ($h^2_{(n.s)}$) for resistance. Genetic advance (G_s) was estimated based on a selection intensity (I) of 10%, standard deviation of the resistance scores (SD) and the broad sense heritability ($h^2_{(b.s)}$).

RESULTS AND DISCUSSION

Significant differences ($P<0.05$) were observed among the 36 progenies evaluated for *Phytophthora* resistance (Table 1). Figure 1 shows the distribution of disease resistance scores on a 0-5 rating scale for the 1010 seedlings evaluated. The development of symptoms on leaves obtained from the 1010 seedlings indicated that none of the seedlings was immune to the isolate of *P. palmivora* used in the experiment. However, varying levels of resistance were observed among seedlings, in agreement with previous findings on cacao resistance to *Phytophthora* (Spence and Bartley, 1966; Soria, 1974; Sreenivasan, 1980 and Iwaro, Sreenivasan, Umaharan, 1997a & b). The distributions of some families show the occurrence of useful transgressive segregates with higher levels of resistance than the parental genotypes, particularly in crosses with two highly resistant parents, such as IMC 47 × ICS 41 (Figure 2). This suggests that resistance genes could be accumulated with a careful selection of resistant parental genotypes, inter-crossing and selecting among their progenies. More variation was observed among progenies derived from crosses between genetic groups (c.v. = 0.24) than among those obtained from parents in the same genetic group (c.v. = 0.20).

Assessment of heritability and genetic gain

Narrow sense and broad sense heritabilities were estimated at 0.33 and 0.51, respectively. Genetic gain (G_s) was estimated at 0.98 based on the broad sense heritability (0.51), standard deviation of scores (1.092) and selection intensity of 10% (1.755). This suggests that genetic gain of 0.98 points is possible on the 0-5 resistance rating scale. The selected seedling population would therefore have an average genetic resistance level of 2.42 (mean of all progenies, 3.4 - 0.98 expected genetic gain) which is higher than the resistance level of SCA 6 (2.64), a resistant control clone in the experiment.

Current and future activities (Establishment of promising seedlings in the field)

Following the screening exercise for *Phytophthora* resistance, the 101 most resistant seedlings were selected for replication and planting at two field sites. Three types of controls will be established at each site:

- Fifty seedlings that showed intermediate levels of resistance in the leaf disc test.
- Fifty seedlings that showed high susceptibility in the leaf disc test.
- Four control clones (two resistant and two susceptible ones, represented by five plants of each).

After their establishment in the field, these plants will be assessed for such characteristics as vigour, early flowering and field resistance to BP and WB. Confirmatory laboratory tests for black pod resistance will also be performed on detached pods. It is hoped that an opportunity will be created in the future to achieve a second cycle, made up of intercrossing between the most resistant plants selected during the first cycle.

Additional crosses. An additional 34 crosses have been established among other selected promising genotypes. Seedlings arising from these crosses are being evaluated for resistance to *Phytophthora* following the above procedures. The outcome of this activity will add to the number of promising genotypes in the different genetic groups (Forastero, Refractario, Trinitario and Mixed) available for distribution at the end of the pre-breeding programme.

Identification and transfer of promising genotypes/populations to user countries. Promising genotypes/populations possessing usable levels of resistance to *Phytophthora* infection showing good yield potential from the pre-breeding programme will be transferred to user countries following accepted standard phytosanitary and quarantine measures.

CONCLUSION

It is expected that by the end of the programme, populations showing genetic diversity and increased resistance to black pod will have been developed. These populations will provide cocoa breeders with a new array of resistance genes for the development of new varieties that combine high yield potential with an acceptable level of resistance to black pod disease.

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Table 1. Evaluation of seedling progenies and parental clones for leaf resistance to *P. palmivora*

							Parental Mean Value	
No.	Family	No. of plants	Mean value	Min.	Max.	S.D.	Female	Male
1	IMC 47 x ICS 41	30	2.92	1.23	4.86	1.34	2.63	3.43
2	B 5/3 x ICS 41	30	2.98	1.63	4.38	1.27	3.33	3.43
3	NA 399 x SCA 6	30	3.03	1.99	4.34	1.02	2.89	2.64
4	ICS 53 x NA 672	30	3.11	1.79	4.39	1.10	2.90	3.57
5	CL 19/10 x ICS 40	30	3.18	1.99	4.59	1.31	3.07	3.07
6	ICS 53 x SCA 6	30	3.18	1.31	4.61	1.27	2.90	2.64
7	NA 26 x NA 286	30	3.19	1.65	4.35	1.21	2.67	2.78
8	CL 19/10 x CL 19/49	30	3.24	1.83	4.51	1.19	3.07	2.92
9	M 33 x CL 19/10	30	3.25	2.23	4.44	0.99	2.44	3.07
10	ICS 70 x CL 19/10	30	3.25	1.58	4.39	1.32	3.67	3.07
11	NA 399 x LP 3/5	30	3.27	1.75	4.33	1.08	2.89	2.25
12	B 5/7 x SCA 6	30	3.28	1.85	4.57	1.11	3.29	2.64
13	NA 399 x PA 46	30	3.29	1.92	4.19	0.91	2.89	2.99
14	PA 125 x NA 672	30	3.34	1.78	4.46	1.20	2.63	3.57
15	M 33 x IMC 2	30	3.34	1.90	4.44	1.29	2.44	2.71
16	NA 399 x ICS 1	30	3.37	1.94	4.13	0.95	2.89	4.24
17	JA 5/34 x ICS 1	30	3.38	2.60	4.48	0.97	3.04	4.24
18	ICS 53 x ICS 1	30	3.43	2.15	4.18	1.05	2.90	4.24
19	PA 150 x CL 19/10	30	3.44	2.14	4.95	1.24	2.81	3.07
20	B 5/3 x EET 59	30	3.46	2.54	4.72	1.00	3.33	3.93
21	PA 125 x SCA 6	30	3.49	1.98	5.00	1.16	2.63	2.64
22	PA 125 x PA 46	30	3.49	2.17	4.16	0.87	2.63	2.99
23	PA 125 x ICS 29	30	3.51	2.69	4.91	1.06	2.63	3.71
24	NA 715 x ICS 40	30	3.57	2.15	4.52	1.14	3.29	3.07
25	JA 5/34 x NA 672	30	3.59	2.80	4.38	0.84	3.04	3.57
26	NA 715 x NA 534	30	3.68	2.48	4.78	0.86	3.29	2.78
27	ICS 70 x ICS 72	30	3.69	2.68	4.66	0.88	3.67	3.56
28	B 5/7 x NA 672	30	3.71	2.69	4.63	1.08	3.29	3.57
29	LX 47 x SLC 18	30	3.79	2.09	4.57	1.03	4.04	4.56
30	NA 26 x SLC 18	30	3.84	2.13	4.54	0.91	2.67	4.56
31	ICS 10 x ICS 29	30	3.88	1.98	4.78	1.11	2.65	3.71
32	ICS 46 x SLC 18	30	3.96	3.01	4.56	0.79	2.90	4.56
33	B 5/7 x ICS 1	18	3.57	2.60	4.37	0.88	3.29	4.24
34	ICS 75 x NA 534	15	3.28	1.43	4.33	1.44	3.03	2.78
35	NA 399 x NA 672	14	3.04	2.14	3.98	0.92	2.89	3.57
36	ICS 75 x ICS 40	3	3.15	2.58	4.17	1.22	3.03	3.07

Leaf disc inoculation. Inoculum concentration - 200,000 zoospores/ml

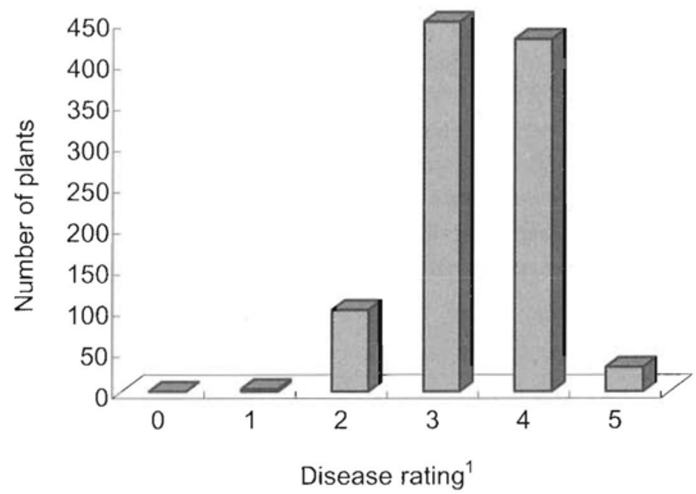

Figure 1. The distribution of scores for resistance to *P. palmivora* for progenies from crosses in year one of the germplasm enhancement programme. Rating 0 - no symptom 1 - small localised penetration 2 - small expanding lesions 3 - coalescence of brown spots 4 - expanding lesion points 5 - large dark brown lesion.

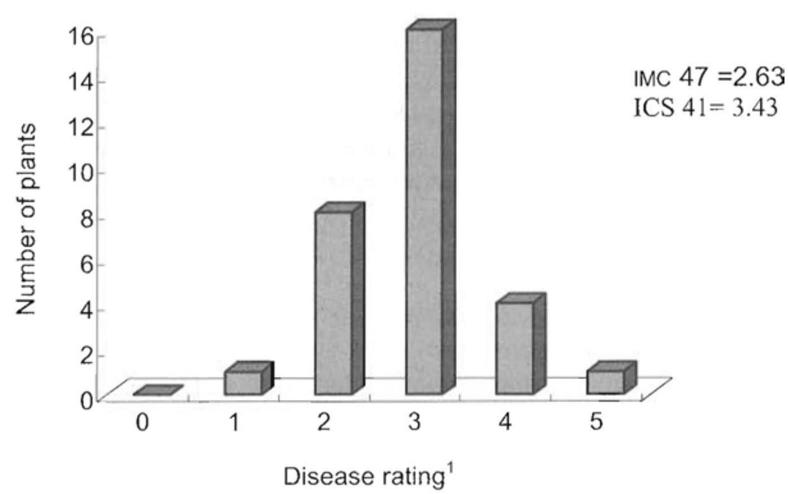

Figure 2. Disease rating distribution for individuals in IMC 47 × ICS 41. Rating 0 - no symptom 1 - small localised penetration 2 - small expanding lesions 3 - coalescence of brown spots 4 - expanding lesion points 5 - large dark brown lesion.

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SURVEY OF SUGARCANE RATOON STUNTING DISEASE IN BARBADOS

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ABSTRACT: Sugarcane yields have declined dramatically since 1968 in Barbados, and there is an urgent need for determination of the cause. Ratoon Stunting Disease (RSD) is seen as one possible cause. In order to determine the incidence of RSD in the fields in Barbados, 3,100 plant samples were taken from the fields across the island and were tested using Evaporative Binding-Enzyme Linked Immuno Assay (EB-EIA). This survey showed the widespread occurrence of the disease in the commercial fields. Five of the commercial varieties showed more than 10% positive samples. In addition, significant differences were observed between ratoons for the five major commercial varieties. Some of the new varieties under selection also tested positive for RSD.

INTRODUCTION

In Barbados, sugarcane was planted on about 8,000 hectares from which approximately 55,000 tonnes of sugar was produced, 1999-2000 crop. Yields of cane have declined dramatically since 1968 (Figure 1), and there is an urgent need for determination of its causes. RSD is thought to be one of the possible causes, and this study attempted to verify this. RSD is caused by the bacterium *Clavibacter xyli* pv. *xyli* (Cxx), and is known to be an economically important disease of sugarcane in most countries where the crop is grown. The bacteria survives on plant debris. RSD is difficult to diagnose in the field because of the absence of visible symptoms, and its presence could only be positively determined by laboratory analysis of sap samples. Field experiments in South Africa have shown an average 20-40% yield reduction due to RSD (Bailey and McFarlane, 1998). Studies on the ultrastructure of the RSD infected plants have reported the bacterium to be in the xylem vessels frequently adjacent to the vessel wall (Kao and Damann, 1980). Discoloration within the vascular bundles associated with RSD occurs in fully differentiated nodes of relatively matured stalks, or, less commonly, in young stalks (Gillaspie and Teakle, 1989). RSD is mainly transmitted through cutting tools and harvesters. Currently, about 80% of the sugarcane plants in Barbados are harvested by machine. Mechanical harvesting increases the chance of the disease spread within a field as well as between the fields.

Davis (1986) conducted a survey of RSD in Barbados and confirmed the presence of RSD. Thus a survey of the current incidence of the disease in Barbados as well as information on the susceptibility of the different varieties to the disease is important for the future development of the sugar industry.

MATERIALS AND METHODS

Collecting samples

Ten stalks per field at random were sampled. The field name, sugar cane variety, date of sampling, plantation name, crop (plant cane or ratoon), acres and rainfall zone were recorded for each sample. Equipment was sterilised between each sampling. Short lengths of cane were cut from the lower nodal region of the stalk, one node and internode length. One end of the sugarcane was cut at right angle and the other at a 45^{o} angle. The samples were collected in the field with a small 12 Volt air pressure pump. Air was forced through the cane and xylem fluid was collected in small tubes and sealed and placed in a cooler with ice.

The samples were brought to the laboratory where the Evaporative Binding-Enzyme linked Immuno Assay (EB-EIA) procedure was carried out. Australian and South African sugar researchers used this procedure routinely (Bailey and McFarlane, 1998 and Croft et al., 1994).

Testing samples (EB-EIA procedure)

Xylem extracts were brought to the laboratory and centrifuged at 3000 rpm for 30 minutes and the supernatant discarded. The pellet was resuspended in 200 µl of coating buffer. A quantity of 100 µl/well sample was then added to the 96 well micotitre plates and placed in an incubator at 37 °C overnight. For each sample three wells were used. The plate was then blocked with 200 µl per well of 5% skim milk in Phosphate Buffered Saline Tween (PBST) for 30 minutes followed by one wash with PBST-ween and incubated for one hour. RSD specific antiserum, 100 µl of 1/1000 dilution was added to each well and incubated for one hour, the plate was then washed once with PBST. The second antibody, goat anti-rabbit alkaline phosphatase conjugate 1/1000 dilution was added to each well and incubated for one hour, followed by five washes of PBST. Finally 100 µl of substrate 0.1% 4-nitophenyl phosphate in 10% diethanolamine buffer pH.9.8 was added and the absorbance at 405 nm was measured at 60 minutes with microplate reader (Unikan II). Chi-square analysis was done using only plantations where 30 or more samples were taken.

RESULTS

A sample was considered positive when the EB-EIA absorbance value was greater than the average absorbance value of negative control plus three standard deviations.

There is widespread occurrence of RSD in the commercial fields in Barbados (Table1). The following plantations are free of RSD infestation: Fisherpond, Cottage, Spring Hall, Mount Pleasant, Constant, Foursquare and Grove. Commercial fields across the island were sampled for the presence of bacteria. Percentage positive samples based on commercial varieties planted in Barbados are presented in Table2.

The percentage of infestation levels at different crop stages for five of the major commercial varieties planted in Barbados is presented in Table 3. The table shows a significant difference between the ratoon crops in the major commercial varieties ($P \leq 0.001$). Also there is a significant difference between the varieties ($P \leq 0.01$). But there is no interaction between variety and crop ($P > 0.05$). Percentage infestation of new varieties (stage 4 trial plots) is presented in Table 4. These varieties are still under selection. Only the promising varieties were selected and further trials will be conducted

DISCUSSION

The study confirmed the reports by Davis (1986) and Daugrois (1999) with respect to the presence of the disease in Barbados. This survey showed the widespread occurrence of the disease in the commercial fields in Barbados. Out of the 22 plantations sampled 19 had RSD positive fields above 25% with the highest being 80%. The data shows that out of the 11 commercial varieties five had percentage positive samples of more than 10%. For the five major commercial varieties there were significant differences between the ratoons as well as between varieties. The new varieties on trial (stage 4), which are being currently evaluated by the Agronomy Research and Variety Testing Unit are also infected with the RSD bacteria.

CONCLUSIONS AND RECOMMENDATIONS

It was recommended that trials to assess the yields be conducted on the major commercial varieties. Screen the new varieties for the presence of RSD before they are released is worth considering.

The new varieties on trial should be screened for RSD susceptibility before the promising varieties reach the final stages of evaluation. Clean planting material, (seedcane) programme will help to reduce further spread of the disease. Specific information such as seedcane sources and the extent of the disease in the fields will aid growers to make practical management decisions. A disease free nucleus seedcane programme is also recommended.

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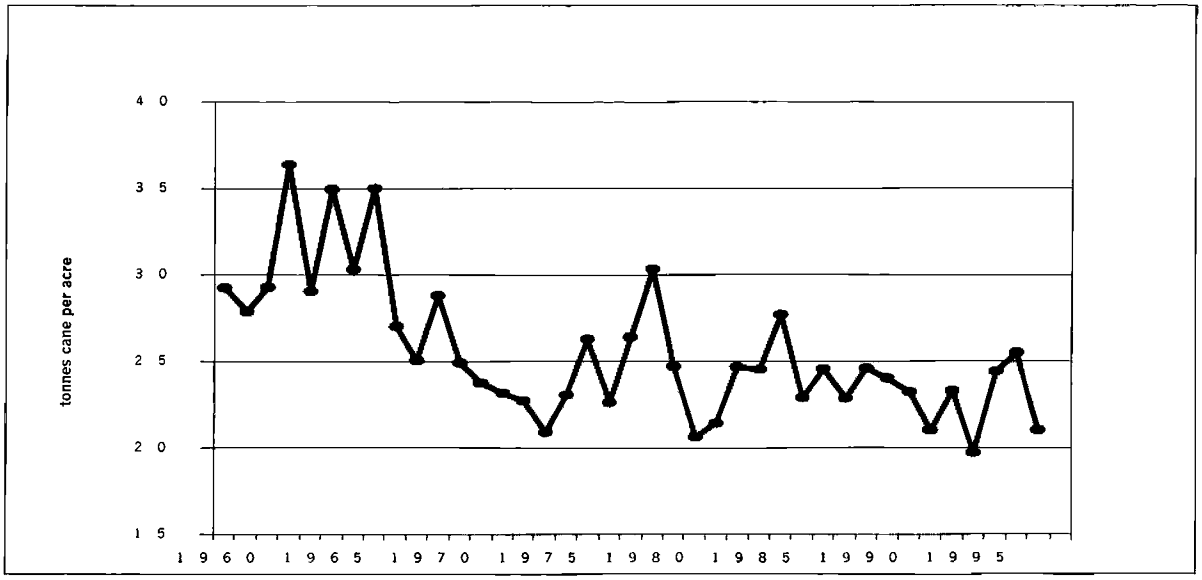

Figure1. Sugarcane yields in Barbados between 1960-1996

Table 1. Percentage positive fields and percentage positive samples of commercial fields for ratoon stunting disease in Barbados in 1999-2000 crop

Plantation	Total No of fields Sampled	Percentage of positive fields	Total no. samples	Percentage of positive samples
Lancaster	5	80.0	50	22.0
Sunbury	5	60.0	50	16.0
Redland	9	45.0	90	20.0
Kendal	4	50.0	40	12.5
Edgecombe	26	46.0	260	11.0
Three Houses	9	44.4	90	12.2
Malvern	7	42.8	70	12.8
Clifton	5	40.0	50	10.0
Warleigh	5	40.0	50	12.0
Dukes	3	33.3	30	6.6
Valley	3	33.3	30	6.6
Todds	3	33.3	30	10.0
Brighton	3	33.3	30	10.0
Lears	6	33.3	60	8.3
Staple Grove	6	33.3	60	10.0
Vineyard	9	33.3	90	5.5
Broomsfield	9	25.0	90	2.5
Hannys	4	25.0	40	5.0
Vaucluse	8	25.0	80	5.0
Spencers	6	16.6	60	3.3
Pleasant Hall	6	16.6	60	3.3
Rock Hall	8	12.5	80	3.8

Chi-squared = 42.082 (df=15) P=0.0002 (Very highly significant)

Table 2. Percentage positive number of samples of major commercial varieties at different crop stages for ratoon stunting disease in Barbados in 1999 – 2000 crop.

Variety	Total number of fields per variety	Percentage of positive fields	Total number of samples	Percentage of positive samples
B85764	3	66.6	30	16.6
B80251	17	52.9	170	16.4
B71383	4	50.0	40	17.5
B84930	7	42.8	70	11.4
B82238	37	37.8	370	10.5
B74541	28	35.7	280	9.2
B80689	21	33.3	210	8.5
B77602	36	25.0	360	5.0
B62163	10	20.0	100	4.0
B78436	5	20.0	50	4.0
B85266	6	16.6	60	5.0

Chi-square = 31.607 df=10 P=0.0005 (Very highly significant)

Table 3. Percentage infestation of major commercial varieties crop stages to ratoon stunting disease in Barbados

Variey	Percentage infestation			
	1st ratoon	2nd ratoon	3rd ratoon	4th ratoon
B74541	41.6	20.0	50.0	*
B77602	2.7	1.6	7.1	15.0
B80251	16.3	18.3	20.0	*
B80689	8.6	2.5	23.3	10.0
B82238	9.1	10.5	15.7	*

* data not available

Ratoon. ($P \leq 0.001$), Variety ($P \leq 0.01$)

Table 4. *Percentatge positive samples of stage 4 varieties from Agronomy Research and Variety testing Unit variety trials

Variety	No of fields sampled	Total no.of samples	Percentage positive samples
B 85747	2	20	20.0
B 86699	1	10	30.0
B 87163	1	10	60.0
B 881104	2	20	25.0
B 881602	2	20	5.0
B 881607	2	20	10.0
B 881911	2	20	25.0
B 88812	2	20	35.0
B 901027	1	10	50.0
B 901227	1	10	20.0
B 90666	1	10	50.0
B 92534	2	20	10.0
B 93141	3	30	10.0
B 93143	3	30	16.6
B 93216	2	20	10.0
B 93220	2	20	25.0
B 93261	2	20	10.0
B 93310	2	20	35.0
B 93334	3	30	10.0
B 93440	3	30	6.6
B 93528	2	30	20.0
B 9356	3	30	23.3
B 93638	3	30	23.3
B 93775	3	30	13.3
B 93796	3	30	10.0
B 9380	3	30	20.0
B 9387	3	30	20.0
B 93873	2	20	15.0
B 93902	3	30	10.0
BR8230	2	20	25.0
D8415	2	20	3.3
DB75159	2	20	35.0

*No analysis was done on this table.

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RESPONSE OF HOT PEPPER CULTIVARS TO LEVELS OF DRIP IRRIGATION IN THE VIRGIN ISLANDS

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ABSTRACT: In the Virgin Islands hot peppers (*Capsicum chinense* L.) are a high value crop of which there is great demand for both fresh pepper and processed products. Previous studies have identified cultivars with high yields and good market potential. A field trial was established during the summer season of 2000 to determine the response of hot pepper cultivars to levels of drip irrigation. Four cultivars ('Habanero', 'Red Scotch Bonnet', 'Yellow Scotch Bonnet', and 'West Indies Red') were drip irrigated at soil moisture levels maintained at -20, -40 and -60 kPa based on soil tensiometer. The trial was designed using a split-plot in randomized block design. The drip irrigation levels were the main plots and the cultivars were the subplots. Data on irrigation water use, plant height, and number and weight of fruits were collected. Results indicated no significant ($P>0.05$) response to levels of drip irrigation. The cultivars also did not differ significantly ($P>0.05$) in yield at each irrigation level. Significant differences ($P<0.05$) in mean plant height, fruit size and number of fruits across irrigation levels were observed among cultivars. Cultivars 'Habanero' and 'West Indies Red' produced higher number of fruits than 'Red' and 'Yellow Scotch Bonnet'. Cultivars 'Red Scotch Bonnet' and 'West Indies Red' produced larger fruits than 'Habanero' and 'Yellow Scotch Bonnet.' Total water use was highest at irrigation level of -40 kPa and lowest at -60 kPa soil moisture. Water use efficiency was highest at irrigation rate of -60 kPa and lowest at -20 kPa. This study indicates that increasing irrigation rate has no effect on hot pepper yield and therefore hot peppers can be produced with minimum irrigation.

INTRODUCTION

In the U.S. Virgin Islands (USVI) as well as the rest of the Caribbean islands, hot pepper (*Capsicum chinense* L.) is one of the most popular cash crops. It is commonly grown as a specialty crop by small-scale farmers for local markets (Crossman et al., 1999). A number of countries in the Caribbean basin are exploiting the excellent market opportunity and tremendous export potential of hot pepper. West Indian hot peppers are considered to be elite among hot peppers and command premium prices in export markets (Cooper et al., 1993). West Indian hot peppers imported to the U.S. sell for an average of $0.25 per fruit or $33.00/kg in specialty markets (Marsh, 1988; 1991).

Small-scale farmers with limited resources can improve their income by growing hot peppers. Production can be increased by growing improved cultivars combined with application of fertilizers, drip irrigation and other improved crop management practices. Research information on improved cultural practices for hot pepper production in the Caribbean is limited. Studies on the effect of plant density and row spacing have been reported (Anon, 1988; Cooper et al., 1993; Marsh and Rhoden, 1990; McGlashan, 1988). Few studies have been conducted, concerning the influence of drip irrigation on hot pepper production particularly in the semi-arid region of the Caribbean.

Drip irrigation is a highly efficient means of applying water and nutrients for the production of high value vegetables such as hot peppers. Sweet peppers and chile type peppers have been widely researched and there are numerous references in the literature regarding these crops. In contrast, there is very little documented research on drip irrigation for West Indian hot peppers. Although some work on Jalapeno peppers with respect to microirrigation management is available (Leskovar and Heineman, 1994), most recent information on microirrigation has been generated from experiments on the more commonly grown bell pepper (Hemphill, 1990; Madramootoo and Rigby, 1991; Smittle et al., 1994; Van Derwerken and Wilcox-Lee, 1988).

There are a number of publications by various Caribbean ministries of agriculture and the Caribbean Agricultural Research and Development Institute (CARDI) which makes reference to production guidelines and profiles on the West Indian hot pepper (Cooper et al., 1993). None of these research publications dealt specifically with irrigation or crop water use.

Although hot pepper has a long history of cultivation in many different ecological environments, the crop has not attracted much attention for research (Yoon et al., 1989). Microirrigation research conducted in the U.S. Virgin Islands with vegetables indicated that the practice is beneficial to production (Locascio et al., 1992; Navarro, 1987; Navarro and Newman, 1989; Palada et al., 1995). Microirrigation improved water use efficiency and increased yield and economic returns for vegetable crops. Sweet corn, tomato and cucumber had yield increases of 26, 24 and 23%, respectively (Palada et al., 1995). Microirrigation has also been found to improve the production of culinary herbs in the Virgin Islands (Palada et al., 1993a; 1993b).

Hot pepper is very sensitive to the effect of moisture stress. Studies in Brazil indicated that during the dry season, both fruit yield and weight were sharply reduced (Cheng, 1989). Flower and young fruit drop also occurred when plants encountered water stress. In Ethiopia, hot pepper is a crop of significant economic value but the full potential of the crop has not been fully exploited, due primarily to factors including the lack of irrigation (Haile and Zewdie, 1989). Some reports stated that the crop is generally believed to be tolerant to drought conditions because of its deep well developed root system. Ganpat (1973) reported that in Trinidad irrigation is necessary for crop production, particularly during the dry season. Moisture stress was reported to result in severe fruit drop. Cooper and Gordon (1992) reported reduced yields and decreased fruit size depending on the severity of the moisture stress. They stated that optimum production can only be obtained with adequate water and nutrients. Byer et al. (1992) reported that in Barbados, marketable yields in excess of 33,600 kg/ha can be achieved with the use of drip irrigation.

Research done on hot peppers in other tropical regions can provide some general indications regarding the water requirement of West Indian hot peppers, but specific research is necessary to provide definitive answers. For example, studies on drip irrigation levels would provide answers to questions like what is the minimum water requirement that will result in optimum yield and high fruit quality including pungency in hot peppers? The objectives of the study presented in this paper were to: 1) determine growth and yield response of four hot pepper cultivars to levels of drip irrigation; and 2) determine optimum and minimum irrigation requirments of hot peppers.

MATERIALS AND METHODS

The experiment was conducted at the Agricultural Experiment Station, University of the Virgin Islands, St. Croix, USVI (lat. 17°42'N, long. 64°48'W). The soil is a Fredensborg loamy, fine carbonatic, isohyperthermic, shallow typic calciustolls. Average annual precipitation is 1015 mm and rainfall distribution is not uniform throughout the year. The experiment was conducted from May 4 to October 10, 2000. Four cultivars; 'Habanero', ' Red Scotch Bonnet', ' West Indies Red', and 'Yellow Scotch Bonnet,' were grown at three levels of drip irrigation based on soil moisture tension (-20 kPa, -40 kPa and -60 kPa) as determined by soil tensiometers. The experiment was laid out using a split plot in randomized block design with three replications. The main plots were assigned to three drip irrigation levels while the cultivars were randomly assigned as subplots within the main plots.

The drip irrigation system consisted of main and submain lines made of 15-mm black polyethylene hose. The laterals were made of 15-mm T-tape (Hardie Irrigation, Sanford, FL) with laser-drilled orifices (emitters) 41 cm apart. Tensiometers (Irrometer, Riverside, CA) were installed at 15 cm depth near the base of a plant to monitor soil moisture levels. The soil tensiometer was placed on the middle row for each cultivar. Separate flow meters (water meter) were installed for each soil moisture treatment.

Transplants of cultivars were planted in plots consisting of three rows 5 m long. Rows were spaced at 0.91 m. Each plot measured 2.73 m x 5.0 m or 13.65 m^2. Plants were spaced 0.41 m within rows. Initial fertilizer was applied via fertigation with soluble fertilizer (20-20-20) at the rate of 100-100-100 NPK in kg/ ha. This was followed by side dressing of 15-15-15 in three splits at 30-day intervals at rates of 50-50-50 NPK in kg/ha resulting in total fertilizer application rate of 250-250-250 NPK in kg/ha.

The crop was harvested six times during the growing season. Yield samples were harvested from10 plants of the middle plot rows, on July 21, August 18, September 1, 13, 27 and October 10. Plant height was measured during the first harvest. Data on number of fruits, fruit size, and fruit yield (total and marketable) were collected for each harvest. The volume of irrigation water applied per treatment was recorded weekly and total water usage calculated at the end of the trial. Total water use was determined by subtracting the initial flow meter reading from the final reading taken at the at the last harvest. Water use calculations were based on total water use from total plot size of three replications for each irrigation level (Table 2). Data on plant height and fruit yield were analyzed for statistical significance using the General Linear Model (GLM) by SAS. Differences in cultivar means were compared using the Duncan's Multiple Range Test at 5% significance level. Data on total and mean water use for each irrigation level were summarized but not statistically analyzed.

RESULTS AND DISCUSSION

Plant Height

The effect of drip irrigation level (main plot) was not significant ($P>0.05$), however, cultivars (subplots) differed significantly ($P<0.01$) in mean plant height across drip irrigation levels. There was no significant ($P>0.05$) interaction between drip irrigation level and cultivar (Table 1). Cultivars 'Red Scotch Bonnet' (110.4 cm) and 'West Indies Red' (101.8 cm) were significantly taller in plant height than 'Habanero' (82.0 cm) and 'Yellow Scotch Bonnet'(72.0 cm). The plant height for all cultivars obtained from this trial are relatively higher than those reported by Crossman et al. (1999). However, 'Red Scotch Bonnet' was taller than other cultivars in all the trials conducted on-farm and on-station.

Number of Fruits, Fruit Yield and Fruit Size

The effect of drip irrigation levels on the number of fruits produced was not significant ($P>.05$). There was not a significant interaction between drip irrigation and cultivar (Table 1). Significant differences ($P<0.05$) in the total number of fruits were found among cultivars. Cultivars 'West Indies Red' and 'Habanero' produced the greatest number of fruits, significantly higher than cultivar 'Red Scotch Bonnet' (Table 1). These cultivars produced marketable fruits which were 40 to 50 percent higher than 'Red Scotch Bonnet.' This result seems to be consistent with those reported by Crossman et al. (1999) where cultivar 'West Indies Red' produced relatively higher number of fruits than other cultivars and 'Red Scotch Bonnet' produced lower yields. Although the effect of drip irrigation level was not significant, there was a tendency for the number of fruits to increase with decreasing irrigation rate for cultivars 'Red Scotch Bonnet' and 'West Indies Red.' This indicates that these cultivars may respond negatively to increasing levels of irrigation level.

Due to high variability in yield data both between replications (blocks) and drip irrigation levels, differences in fruit yield were not significant (Table 1). Also, yield levels were generally lower compared to previous trials (Crossman et al., 1999). Fruit yield therefore was not influenced by drip irrigation level. However, despite of no significant effect, cultivar 'West Indies Red' produced a relatively higher mean fruit yield (4121 kg ha^{-1}) than other cultivars. The lowest fruit yield (1990 kg ha^{-1}) was produced by cultivar 'Red Scotch Bonnet.' As with number of fruits, there was a tendency for fruit yield to increase with decreasing soil moisture levels, of the cultivars 'Red Scotch Bonnet' and 'West Indies Red' (Table 1). This suggests that these cultivars may actually benefit from reduced irrigation rate. There was no evidence of moisture stress in all cultivars even at the soil moisture level of -60 kPa.

Fruit weight was not influenced by drip irrigation level but differed significantly ($P<0.05$)among cultivars (Table 1). Largest fruits were produced by cultivars 'Red Scotch Bonnet' (7.53 g) and 'West

Indies Red' (7.14 g) and these were significantly larger than cultivar 'Yellow Scotch Bonnet'. Cultivar 'West Indies Red' is promising since it produced both higher number of fruits and fruit yield as well as larger fruit size compared to other cultivars.

Irrigation Water Use

Data on the estimated irrigation water use and efficiency are shown in Tables 2 and 3. The highest total irrigation water use was recorded on plots drip irrigated at soil moisture tension of -40 kPa and lowest at -60 kPa (Table 2). The higher irrigation water use at -40 kPa compared to irrigation water use at -20 kPa cannot be explained. It was possible that there was some leaks in the drip lines on treatment at -40 kPa when drip irrigation water was applied unattended. However, the data show that water use efficiency was highest at drip irrigation regime of -60 kPa. At this level, water use and cost were minimum. Also, the economic returns to irrigation water was highest at this level. Therefore, hot peppers can be grown under minimum irrigation water.

Table 3 show differences in water use efficiency and economic returns among cultivars. Gross returns were highest for cultivars 'West Indies Red' and 'Habanero.' Growing these cultivars resulted in average gross returns of $27,199 and $20,737 per hectare, respectively. In addition, these cultivars were most cost efficient in using drip irrigation water. Producing these cultivars resulted in higher economic returns to irrigation water.

SUMMARY AND CONCLUSIONS

This study has shown that drip irrigation levels did not affect growth and yield of hot pepper cultivars, but the effect of cultivar was significant on plant height, number of fruits and fruit weight. Cultivars 'West Indies Red' and 'Habanero' produced the highest total number of fruits, but 'West Indies Red' was superior in fruit weight than 'Habanero.' Both cultivars resulted in higher gross returns and water use efficiency than other cultivars. The study also indicates that hot peppers can be produced with minimum irrigation. Further studies on differential response of cultivars to minimum irrigation are needed to verify results obtained from this study.

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Table 1. Growth and yield response of hot pepper cultivars to levels of drip irrigation, UVI/AES, 2000.

Cultivar	Drip irrigation. regime (kPa)	Plant ht (cm)	No. fruits (ha^{-1} x1000)	Fruit yield (kg ha^{-1})	Fruit wgt (g)
Habanero	-20	79.4	543.4	4097	7.27
	-40	88.4	388.7	2186	5.28
	-60	78.1	531.7	3143	6.07
	Mean	82.0 b	487.9 a	3142	6.21 ab
Red Scotch Bonnet	-20	100.0	173.4	1340	6.46
	-40	127.2	238.1	1849	7.52
	-60	104.1	323.5	2781	8.62
	Mean	110.4 a	245.0 b	1990	7.53 a
West Indies Red	-20	119.9	437.9	3185	6.97
	-40	80.4	565.7	4072	6.95
	-60	105.2	693.5	5106	7.50
	Mean	101.8 a	565.7 a	4121	7.14 a
Yellow Scotch Bonnet	-20	70.6	533.5	3116	5.88
	-40	65.7	97.5	2678	5.68
	-60	79.6	512.1	2981	5.80
	Mean	72.0 b	381.0 ab	2925	5.79 b
Pr>F					
Drip irrigation regime		0.9650NS	0.0915NS	0.4675NS	0.4938NS
Cultivar		0.0014**	0.0176*	0.0754NS	0.0324*
Drip irrigation regime x cultivar		0.1460NS	0.3142NS	0.0680NS	0.3868NS

For each column, means followed by the common letter/s are not significantly different by Duncan's Multiple Range Test (P=0.05). NS=not significant; *P<0.05; **P<0.01.

Table 2. Estimated irrigation water use and efficiency by hot peppers grown under three drip irrigation regimes, UVI/AES, 2000.

Irrigation regime (kPa)	Total water use (liters plt^{-1})	Total water use (m^3 ha^{-1})	Total water cost[1] (\$ ha^{-1})	WUE[2] (liters kg^{-1})	WCE[3] (\$ kg^{-1})	Returns to irrig. water[4] (\$/\$)
-20	19.94	535	2261	2.94	2.83	2.34
-40	21.17	567	2400	3.39	2.57	2.56
-60	17.74	476	2011	2.19	1.78	3.70

[1]Estimates based on irrigation water cost of \$4.23/m^3.
[2]Water use efficiency (WUE = liters of water used to produce a kg of fresh hot peppers.
[3]Water cost efficiency (WCE) = cost of irrigation water to produce a kg of fresh hot peppers.
[4]Calculated from gross returns divided by irrigation water cost using \$6.60/kg local market price.

Table 3. Water use efficiency of hot pepper cultivars at various drip irrigation levels, UVI/AES, 2000.

Cultivar	Drip Irr. regime (kPa)	Gross returns[1] ($ ha^{-1})	WCE[2] ($ kg^{-1})	Returns to irrig.[3] ($/$)
Habanero	-20	27040	0.55	11.96
	-40	14428	1.09	6.01
	-60	20744	0.64	10.32
	Mean	20737	0.76	9.43
Red Scotch Bonnet	-20	8844	1.69	3.91
	-40	12203	1.30	5.08
	-60	18355	0.72	9.13
	Mean	13134	1.24	6.04
West Indies Red	-20	21021	0.71	9.30
	-40	26875	0.59	11.20
	-60	33700	0.39	16.76
	Mean	27199	0.56	12.42
Yellow Scotch Bonnet	-20	20566	0.73	9.10
	-40	17675	0.89	7.36
	-60	19675	0.67	9.78
	Mean	19305	0.76	8.72

[1]Gross returns are based on $6.60/kg market price of hot peppers.

[2]Water cost efficiency (WCE) = cost of irrigation water to produce a kg of fresh hot peppers.

[3]Calculated from gross returns divided by irrigation water cost using $6.60/kg local market price.

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EFFECTS OF HIGH PLANT POPULATION DENSITIES ON YIELDS, PLANT AND FRUIT CHARACTERS OF THE HOT PEPPER CULTIVAR, WEST INDIES RED

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ABSTRACT: Seven different plant population densities were tried on the hot pepper cultivar, 'West Indies Red', in two important trials, one was done in 1998 and the other in 1999 in Barbados. The population densities ranged from 5,744 plants up to 40,000 plants per hectare. The results showed a linear increase in yields as the plant population density increased. However, the yield from 30,000 plants per hectare did not differ significantly from that obtained from 40,000 plants per hectare. The yield per hectare from the highest plant population density of 40,000 plants was 123% higher than the yield from the farmer practice (9,570 plants/ha). The changes in treatments did not affect berry shapes and sizes. However, the plants grew taller and narrower as the population density increased.

INTRODUCTION

The hot pepper crop is growing in importance as exports and regional acreage have increased over the recent past. All the indicators are that the hot pepper industry is a growth economic activity. The demands of the market in United States of America alone far outstrip the total production of the Caribbean which represents less than 1% of that demand. During 1998 the CARICOM countries exported 4,667 tons fresh and processed hot pepper valued at US$10 million (Paul et al., 2000).

The popular hot pepper cultivar in the Caribbean over the past decade has been the "West Indies Red" selected by CARDI (Cooper and Gordon., 1992). The export and domestic markets show a preference for this cultivar whilst the farmers find that it gives the highest yields.

BACKGROUND AND JUSTIFICATION

Yields from the West Indies Red grown on farmers' fields, are far below hot pepper yields obtained in other countries. National yields of fresh berries in Barbados, for example, are around 8,000-10,000 kg/ha whereas those obtained from trials have surpassed 25,000 kg/ha. Comparatively, farmers' yields from other countries are, as follows: China, 22,500 kg/ha; Turkey, 20,400 kg/ha and Thailand, 13,300 kg/ha (Berke and Shieh, 2000).

One of the main reasons for low yields of hot pepper on farms in Barbados is the low plant population densities which are adjusted mostly to facilitate the work of the ridger and tractor which can make raised beds 168 cm apart. This bed width also facilitates mechanical weed control during early crop growth. It is reasoned that an increase in the number of plants per unit area, to approach the high plant population densities of 65,000 to 85,000 plants per hectare as practiced in Mexico, although on the slightly smaller plants of jalapeno and serrano cultivars of chilli pepper (Pozo, 1995), can contribute to increases in yields. It is also felt that closer spacings where the canopy completely covers the soil soon after transplanting will obviate the need for mechanical weed control on the standing crop. Therefore a study was undertaken to investigate the possibilities of planting at higher population densities in Barbados.

MATERIALS AND METHODS

Two trials were conducted in 1998 and 1999 in Barbados. Both trials were irrigated through drip lines which kept available soil moisture around 40-60%.

Trial #1: Six plant population densities including the farmers' practice (control) were tested, as follows.:

5,744	plants/hectare	-	93 cm x 187 cm
9,570	" "	-	93 cm x 112 cm (control)
11,488	" "	-	93 cm x 93 cm
13,398	" "	-	93 cm x 80 cm
17,232	" "	-	93 cm x 62 cm
19,140	" "	-	93 cm x 56 cm

A 6 x 6 Latin square design was chosen and the net plots at the widest spacing contained 14 plants. The plots measured 4.48 x 4.48 m and all plots were separated by metre wide paths. The data recorded and analysed were as follows: Days from transplanting to 50% flowering in a plot; Average width (cm) of plant canopy from five random plants per plot at 50% flowering; Average plant height (cm) from five random plants per plot at 50% flowering; Yield (kg) of fruits per plot at each picking; Average number of mature fruits per plant harvested from five random plants per plot at each picking; Plant height (cm) of five random plants per plot at each picking; Canopy width (cm) of five random plants per plot at each picking; Average weight (g) of fruit from 10 random fruits per plot at each picking; Average length (cm) of fruit from 10 random fruits per plot at each picking; Average width (cm) of fruit from 10 random fruits per plot at each picking.

The effects due to treatments were determined by the analyses of variance using the MINITAB statistical software (MINITAB, 1996).

Transplanting was done on 10 February 1998 and the first picking took place on 4 May 1998.

Trial #2: The second trial was conducted in the same field as the first. All the field and crop care operations were similar. Based on the results of the first trial, where yield increased linearly from the lowest population density to the highest, it was decided to test still higher densities. The treatments, therefore, were 3 different plant population densities as follows:

10,000 plants/hectare (control)
30,000 " "
40,000 " "

The control was taken as 10,000 plants/ha since it was closest to the farmer practice of 9,570 plants/ha in the first trial.

The three treatments were laid out in a 3x3 Latin square design replicated four times. The size of the experimental plots was 4.20 m x 4.76 m in order to accommodate a minimum of 20 plants in the net plot with the treatment containing the lowest plant population density.

The same set of data as in trial #1, were recorded and analysed using the same methods.

Transplanting was done on 6 May 1999, the first picking on 27 July 1999 and the last and seventh picking on 11 November 1999.

RESULTS AND DISCUSSIONS

Trial #1 (Table 1)

Average plant height and canopy width

These two plant developmental characters were very significantly affected by the treatments. The plants grew taller (P=0.011) and wider (P=0.000) when given more space. Wider spacings produced bigger plants with longer and a larger number of branches.

Yields

The yields from the plots with the higher plant population densities were very significantly higher (P=0.000) than the control (farmer practice). The general clear trend was a linear increase from lower to the higher densities. The widest spacing yielded 19.98 kg/plot and the closest 44.63 kg/plot of fresh pepper, an increase of 123%.

Average number of fruits per plant

The wider spacings yielded more fruits per plant (P=0.021). The clear trend was a linear decrease in the number of fruits per plant from the lowest to the highest plant population densities. This was due to the larger number of longer branches on bigger plants.

Average fruit weight

The general trend was a very gradual reduction in average fruit weight from the control towards the highest plant population density, 11.73g - 11.07g. Despite the significance of these differences (P=0.007), they were too small for practical purposes.

Average fruit width and length

The treatments did not affect these two dimensions of fruit. Coupled with the small differences in average fruit weight, it was clear that higher plant population densities up to 19,140 plants/ha did not affect fruit shape nor size.

Table 1. Comparison between five plant population densities and the control (9,570 plants/ha). Yield components and plant development characters were measured over six pickings on the trial conducted in Barbados in 1998.

Treatment Planst/ha	Yield per plot (kg)	Average number of fruits per plant	Average fruit weight (g)	Average Fruit width (cm)	Average Fruit length (cm)	Average Plant height (cm)	Average width of canopy (cm)
5,744	19.98	38.56	12.28	3.67	4.19	79.68	105.86
9,570 (Control)	33.77	39.02	11.73	3.66	4.10	76.79	99.96
11,488	37.98	33.83	11.98	3.58	4.11	74.30	91.29
13,398	40.54	32.62	11.59	3.61	4.11	73.93	90.46
17,232	41.18	31.61	11.38	3.57	4.08	70.93	84.51
19,140	44.63	30.35	11.07	3.53	3.96	71.37	83.47
SEM (df=23)	2.46	1.97	0.20	0.04	0.07	1.66	1.51
P	0.0***	0.021**	0.007**	NS 0.136	NS 0.313	0.011**	0.000***

NS = non – significance at 5%, *** = significance at 0.1%, ** = significance at 1%

Trial #2 (Table 2)

Yields and yield components

Yield per plant was very significantly affected by the treatments. The lowest plant population density produced 2.73 kg/plant whilst the highest yielded 0.85 kg/plant (P=0.000). This same trend was observed in the previous trial. However, the total yield per net plot and consequently the yield equivalent per hectare increased almost linearly with the increase in plant population density (P=0.000 and P=0.000, respectively). Also the number of fruits per plant decreased with the increase in the plant population density; the control produced 97 more fruits per plant than the closest spacing. However, despite the reduction in yield per plant as the population density increased, the total yield per plot was greatest at the highest plant population density since the larger number of plants per unit area more than compensated for the loss of yield per plant. Conclusively, 40,000 plants per hectare outyielded 10,000 plants per hectare (the control) by 123% (P=0.000).

Average weight of fruit, average length of fruit and average width of fruit were not affected by the treatments. All the three dimensions of fruit size did not change with the increase in plant population density. This was very important to fruit quality and meant that closer spacing of the plants of the cultivar, West Indies Red, presented an opportunity for increasing yields without any decrease in quality of fruits.

Plant development characters

The wider spaced plants grew laterally to fill up the space; canopy width of the control was 121.24 cm whilst that of the closest spacing (40,000 plants/ha) was 103.91 cm (P=0.000). Conversely, the plants grew taller the closer they were planted; the average plant height of the control was 87.97 cm whilst that of the densest plant population was 96.45 cm (P=0.000).

All the trends described above were also observed in population density trials with the cultivar, 'Scotch Bonnet' in Jamaica (McGlashan, 2000).

Table 2. Comparison between a low plant population density (the control, 10,000 plants/ha) and two other densities, three and four times higher. Yield components and plant development characters were combined over seven harvests on the trial with the hot pepper cultivar, West Indies Red, conducted in Barbados in 1999.

Treat. (Plants/ha)	Total yield/ plant (kg)	Total yield/ net plot (kg)	Yield equivalent (kg/ha)	Total no. of fruits/ plant	Mean weight of fruit (g)	Mean length of fruit (cm)	Mean width of fruit (cm)	Mean plant height (cm)	Mean canopy width (cm)
10,000 (Control)	2.73	15.88	15,125	215.04	10.84	3.85	3.11	87.97	121.34
30,000	1.14	34.27	32,641	136.64	11.17	3.84	3.32	93.06	103.75
40,000	0.85	35.46	33,775	117.78	10.90	3.83	3.19	96.45	103.91
SEM (df=23)	0.22	2.42	2,307	12.09	0.24	0.05	0.059	1.21	1.75
P	0.000***	0.000 ***	0.000 ***	0.000 ***	NS 0.598	NS 0.977	NS 0.055	0.000***	0.000 ***

NS = non-significance at 5%, *** = significance at 0.1%

CONCLUSIONS

From the two separate trials conducted on seven different plant population densities (range 5,744 to 40,000 plants/ha) with popular hot pepper cultivar, West Indies Red, the following conclusions are drawn: higher plant population densities produced highest yields of mature berries. Increase of yield from lowest to highest plant population density was linear. Despite the fact that closely spaced plants produced a smaller number of berries per plant than widely spaced plants, the larger number of plants per unit area at the closer spacings more than compensated, hence the higher yields at the higher plant population densities. Closer spaced plants grew taller and narrower than those at wider spacings (low plant population densities). Berry size, shape and weight were not affected by the higher plant population densities. Fruit qualities remained the same at wide or close spacings.

The economic impact of higher plant population densities should be measured and closer plant spacings should be considered for inclusion in production systems for high yields

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PUMPKIN RESPONSE TO FOUR EVAPOTRANSPIRATION REPLENISHMENT TREATMENTS

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ABSTRACT: The response of pumpkin, *Cucurbita moschata* (Duchesne) Poir, to four evapotranspiration replenishment treatments (25, 50, 75, and 100%) was studied at Lajas and Juana Díaz experiment station of the University of Puerto Rico. Pumpkin was planted on 1 March and 17 March, 2000 at Lajas and Juana Díaz, respectively. The experiment was arranged on a split plot, where the whole plot consisted of the evapotranspiration replenishment treatments (ERT) and subplots of drymatter and leaf area determination. Theoretical potential evapotranspiration (ET_0) was estimated using the Pan A evaporation method. The average Kp values used were 0.63 and 0.66 for Juana Díaz and Lajas respectively. Pumpkin (var. Soler) average Kc value was 0.78. ERT did not affect significantly crop leaf area, drymatter, and yield at both locations. The lack of response to treatments was due to the high amount of off-season rainfall that occurred during the trial.

INTRODUCTION

Pumpkin is one of the most important vegetable crops in Puerto Rico. Although Soler is the most widely planted pumpkin selection, little information is available or published on its water requirements, growth and yield. The Pan A evaporation method was used to estimate pumpkin ET and replenish it through irrigation. The Pan A evaporation method is a simple and inexpensive method that provides a measurement of the integrated effect of radiation, wind, temperature, and humidity on the evaporation from an open surface (FAO, 1990). This method has been widely investigated, representing valuables contributions to agricultural production in the tropics. The data presented herein is an ongoing research project and its goal is to determine the effect of irrigation on pumpkin growth and phenology to increase crop yields, improve quality and reduce production cost in Puerto Rico.

MATERIALS AND METHODS

The ongoing research was continued during the 2000 season at the Lajas and Juana Díaz Experiment Substations, of the University of Puerto Rico. The experiments were established on 1 March and 17 March at Lajas and Juana Díaz, respectively. During the 2000 season just one pumpkin cultivar (*Cucurbita moschata*) was included in the trial (Soler). Whole plot consisted of four evapotranspiration replenishment treatments (25, 50, 75, and 100%). Whole plots consisting of two beds per plot were arranged in a randomized complete block design with four replications. Each plot was divided into five subplots. Subplots corresponded to sampling dates: 3, 5, 7, 9, and 15 weeks (close to harvest) after planting. Data acquisition, overall crop and experiment managements were done as described by Rossy et al. (2000).

RESULTS AND DISCUSSION

Data gathered during this trial was transformed using the log function because it did not meet ANOVA assumptions. The ANOVA showed that evapotranspiration replenishment treatments (ERT) did not affect significantly pumpkin leaf area, dry matter and yield at both locations.

Observed dry matter accumulation (Figure 1) for both locations was greater than drymatter reported in 1999 experiment (Rossy et al., 2000). The statistical analysis showed no significant differences among ERT for drymatter. Drymatter accumulation at Lajas was much higher than at Juana Díaz despite the ERT. Drymatter accumulated at harvest was taken at 114 and 128 days after planting for Juana Díaz and Lajas, respectively. Pumpkin leaf area development was similar for both locations (Figure 2). These results contrast with leaf area data taken during 1999 season. Leaf area tended to be linear during 1999 while 2000 data tended to be quadratic at Lajas. Leaf area reduced drastically, at harvest, due to a severe attack of *Diaphania hyalinata*. At Lajas, pumpkin growth during 2000 was greater than 1999. No evident differences were observed between years for Juana Díaz.
ERT did not affect pumpkin yield.

Yield registered at Lajas varied between 29,000 and 36,000 kg ha^{-1} (Figure 3). Soler yield obtained at Juana Díaz was way below the average registered for the zone. An off-season rainfall that occurred during the trial caused lack of response to ERT, reduced the irrigation applied. Although the data set obtained during the current year was important, no inference could be done to the irrigation needed, because of the above-mentioned factors.

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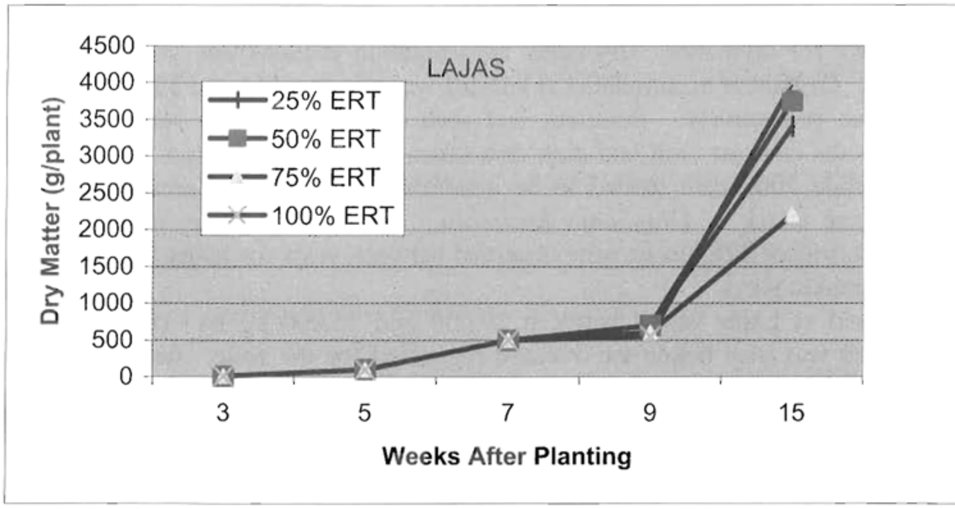

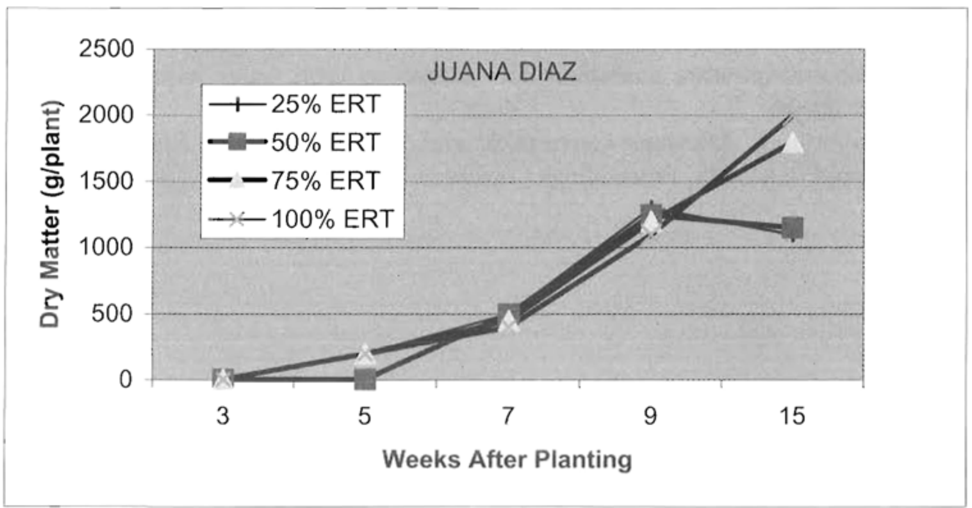

Figure 1. Pumpkin dry matter accumulation response to evapotrnspiration replenishment treatments (ERT) at Lajas and Juana Diaz, Puerto Rico.

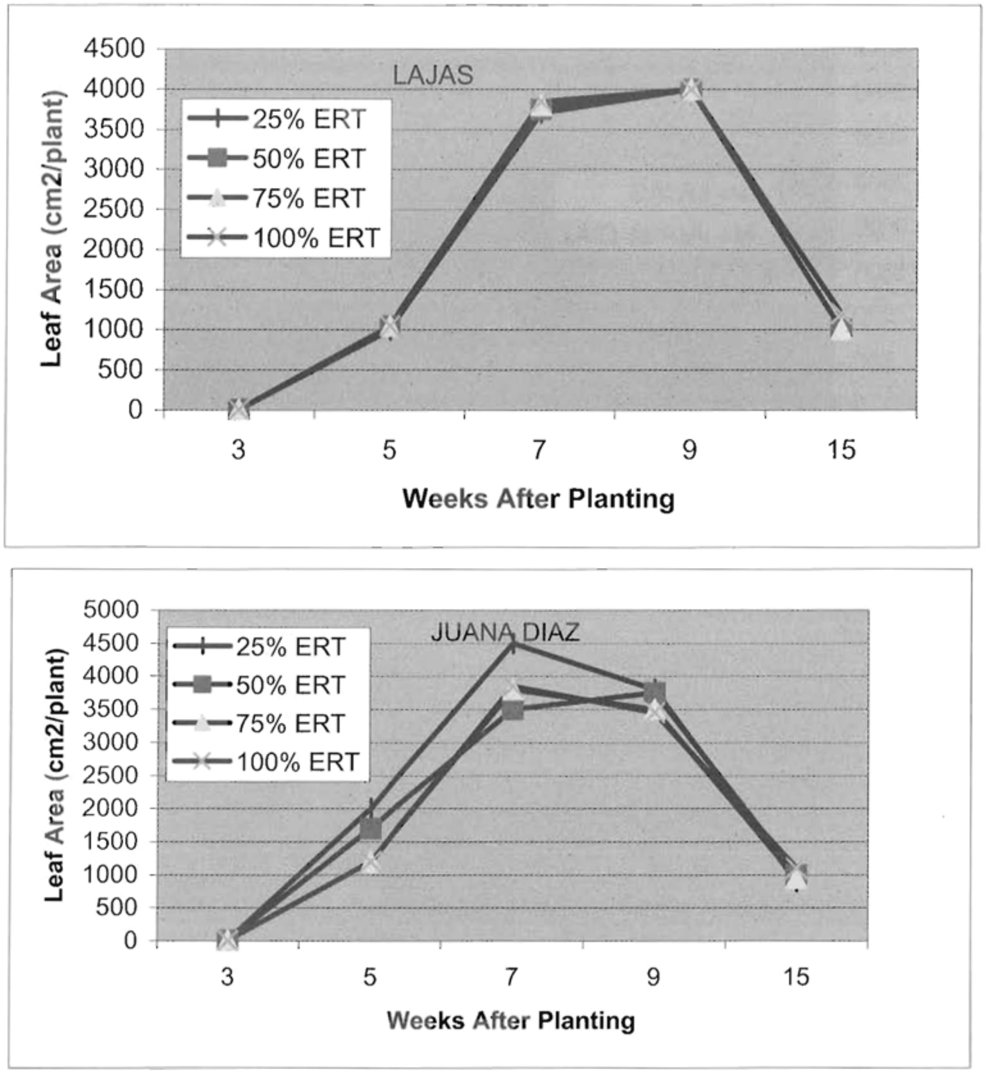

Figure 2. Pumpkin leaf area response to evapotranspiration replenishment treatments (ERT) at Lajas and Juana Diaz, Puerto Rico.

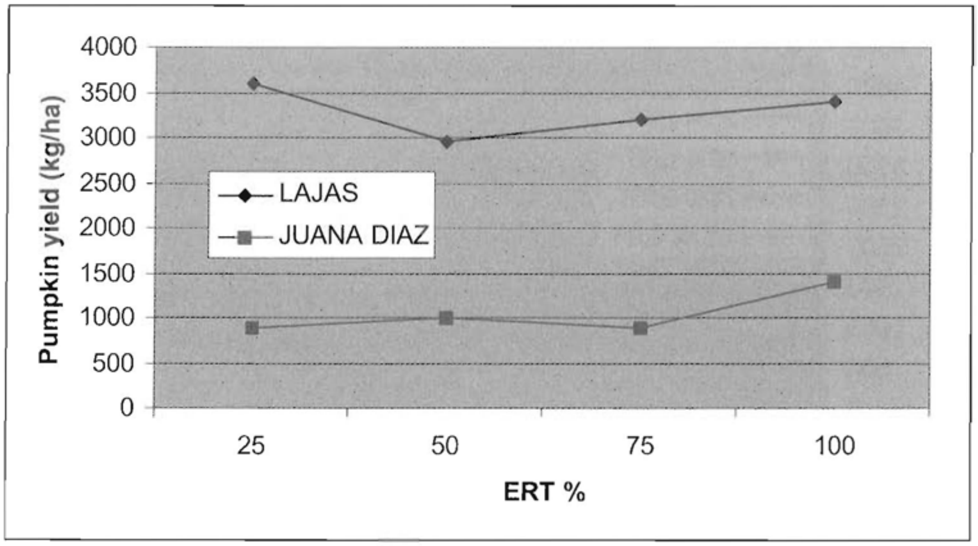

Figure 3. Pumpkin yield response to evapotranspiration replenishment treatments (ERT) at Lajas and Juana Diaz, Puerto Rico.

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THE COMBINED EFFECTS OF AFLATOXICOSIS AND COCCIDIOSIS ON THE PERFORMANCE OF BROILER CHICKS

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ABSTRACT: Three separate experiments were conducted to examine the combined effects of aflatoxicosis and coccidiosis on male broiler chicks. The experimental design was a 4 x 2 factorial, consisting of three different strains of coccidia (*Emeria tenella* 50,000 oocyts; *Emeria maxima* 50,000 oocyts; and *Emeria acervulina* 500,000 oocyts/chick) and two levels of aflatoxin (0; 3 mg/kg). Chicks were fed an aflatoxin-treated or non-aflatoxin-treated diet (control) from 1 d of age through 28 d of age. At 14 d of age, the chicks were infected with the coccidia. At 14 d post-infection the effects of treatments were assessed on weight gains, relative organs (liver, pancreas, gizzard, heart, and ceca) weights and gross lesion scores. Blood was collected for serum chemistry values and enzyme activities. Weight gains in chicks fed aflatoxin-treated feed were further lowered significantly when infected with the coccidia. Compared to the chicks that were infected with the other two coccidial strains, chicks fed aflatoxin and then infected with *E. tenella* were least affected. The combined effects of aflatoxicosis and coccidiosis significantly increased the relative weight of the liver, gizzard, pancreas and proventriculus. The severity of aflatoxicosis and coccidiosis was expressed also through decreased serum concentration of uric acid, albumin, total protein, cholesterol and the activity of alanine aminotransferase. Significant increase in relative cecal weight was observed mainly in the *E. tenella*-infected chicks. Intestinal lesion scores were observed in all groups, but were more severe in the *E. maximum* and *E. acervulina* infected chicks. It was concluded that coccidial infection was intensified by the presence of aflatoxin in the feed.

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VARIABILITY FOR ROOT FRESH WEIGHT AMONG TROPICAL TYPE VARIETIES OF SWEETPOTATO

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ABSTRACT: Frequently, farmers in Puerto Rico complain that the tuberous roots from the recommended varieties differ in size, shape and weight, a situation that increases difficulties for marketing. Baseline information on the magnitude of losses related to inappropriate root size is not available. The objective was to assess roots' fresh weight distribution among varieties of sweetpotato of common use in Puerto Rico. Four varieties were grown in a location on the southern coastal valley. For this study roots harvested at 162 days were selected. Roots were weighed individually. Distribution of the individual root fresh weight for each variety was compared to theoretical distributions by using the Kolmogorov-Smirnov Test. There was a high frequency of light-weighted roots. The Normal Distribution does not describe adequately the data for root fresh weight distribution from any of the varieties. Because of a high frequency of roots having lightweight, Lognormal and Weibull Distributions appear more adequate than the Normal Distribution to describe the actual root weight distribution. Roots end to be too small for the market, thus for commercial purposes, results stress that a relatively high percentage of photosynthates accumulated in the roots are lost. More emphasis on the selection for this characteristic is needed.

INTRODUCTION

Throughout the Caribbean Basin, and certainly in Puerto Rico, sweetpotato production is dependent upon tropical-type varieties. Tropical-type varieties are characterized by the intermediate sweetness of their flesh after boiling (Martin and Deshpande, 1985). Along with this sweetness this type usually has light-colored flesh, either white, cream or crystalline yellow. These characteristics are of preference in the American Tropics and the Caribbean Basin (Martin and Rhodes, 1984; Collins and Walter Jr., 1985).

In Puerto Rico sweetpotato is not a typical small farm crop. It is produced on a relatively large scale in the southern coastal valley of the main island. Field management is partially mechanized and includes drip irrigation, fertigation and mechanical harvest. Frequently, local farmers complain that the tuberous roots from the recommended varieties differ widely in size, shape and weight, a situation that increases difficulties for marketing. The result is that a relatively high percentage of roots (about 20%) have to be discarded because they do not possess the physical characteristics established for marketability. Along with this constraint, farmers face low yield stability and susceptibility to the sweetpotato weevil. Baseline information on the magnitude of losses related to inappropriate root size is not available. This information is needed for the development of a quantitative basis for the selection of new clones. The objective of this study was, therefore, to assess roots' fresh weight distribution among tropical-type varieties of sweetpotato of common use in Puerto Rico.

MATERIALS AND METHODS

Cultivars Mina, Miguela, Viola and Dominicana were selected for this study. Tropical-type Mina and Miguela were selected during the 1960s and 70s among local landraces (Badillo-Feliciano et al., 1976). Viola, named after its skin color (purple in Spanish), came out of Dr. Frank Martin's sweetpotato breeding program at the Tropical Agriculture Research Station of the USDA in Mayaguez, Puerto Rico.

This variety is semi-sweet and has been classified as a sub staple-type. Dominicana is cream-fleshed and the standard variety used in Puerto Rico.

The experiment was conducted in 1999 at the Juana Díaz Agricultural Experiment Station farm of the University of Puerto Rico. This location, in the southern coastal valley, has a semiarid climate and elevation of 12 m above sea level. The soil was from the San Antón Series (fine-loamy, mixed, isohyperthermic, Cumulic Haplustolls) with a pH of 7.4 and 1.2% organic matter. The experiment was laid out as a Randomized Complete Block Design with four replications. Plots were seven 10.67 m long rows spaced at 0.91 m. Distance between plants within the row was 30 cm. After planting, standard management practices were followed (UPR - EEA, 1997). Fertilization was at a rate of 922.7 kg/ha with a 6-6-12 fertilizer. Weeds were controlled busing glyphosate at establishment and mechanically thereafter. Drip irrigation was used. Harvests were made at 121, 141 and 162 days after planting. Results of the 162-day harvest are reported herein. Before harvest, above ground parts were removed and tuberous roots were obtained by plowing deep, moving them to the soil surface. Roots were weighed individually.

Data on roots' weight were used to estimate yield. Distribution of the individual root fresh weight for each variety was compared to theoretical distributions by using the Kolmogorov-Smirnov Test. Theoretical distributions evaluated included Normal or Bell-shaped Distribution and the Lognormal, Exponential and Weibull Distributions.

RESULTS AND DISCUSSION

Average weights for individual roots for varieties Mina and Miguela were similar and tended to be lower than those of Viola and Dominicana (Table 1). Range from minimum to maximum weight was considerable for all varieties. Overall there was a high frequency of light-weighted roots. When a graphic representation of a Normal Distribution was over imposed over an actual distribution visual inspection revealed that individual fresh weight for the root was not normally distributed. This result was corroborated by the Kolmogorov-Smirnov test (Table 2).

The Kolmogorov-Smirnov test evaluates the discrepancy between the actual distribution and a selected theoretical distribution. When using this test the null hypothesis is that there is not a statistically significant discrepancy between the theoretical distribution and the actual distribution. For the Normal Distribution, all Kolmogorov-Smirnov estimators (D) were significant at the 1% level. Therefore, the Normal Distribution does not describe adequately the data for root fresh weight distribution from any of the varieties (Table 2). Studying the distribution among root weights in orange-fleshed varieties, Lowe and Wilson (1975) determined that variances for this characteristic were not homogeneous among varieties. Along with genotype effects, variability for this characteristic was attributed to differences in the quality of the propagation material, planting season and in the rate of development of the tuberous root. None of the theoretical distribution evaluated in this study adjusted to the response of Mina or Miguela (Table 2). For Dominicana, however, Lognormal Distribution adequately adjusts to the results. Whereas for Viola the Weibull Distribution was adequate. Results were consistent in indicating high frequency light-weighted roots.

In Puerto Rico, the market for fresh sweetpotato has established a standard root weight from 226 to 681 g. This standard was used to calculate the percentage of commercial roots for each variety (Table 3). Overall results indicate that less than 60% of roots harvested in this study conformed to the marketable weight (Table 3). If this parameter were applied to all roots harvested in this study, more than 40% of them would be discards. For Miguela, for example, only 46% of the roots had the weight that is commercially acceptable. Conversely, for Dominicana 44% of the roots had weight above the accepted. The latter result, however, is indicative of a late harvest. In a practical situation, Dominicana should be harvest earlier than at 162 days after planting.

Overall results indicate that root fresh weight for traditional varieties of sweetpotato used in Puerto Rico is not normally distributed. Because of a high frequency of roots having lightweight, Lognormal and Weibull Distributions appear more adequate than the Normal Distribution to describe the actual root weight distribution. For commercial purposes, results stress that a relatively high percentage of photosynthates accumulated in the roots are lost. Roots are usually too small, and sometimes too large, for the market. The goal should be to select varieties that accumulate photosynthates in commercially marketable roots. In our project selection is for genotypes having high frequency of roots weighing from 340 to 681 g. New clones have increased percentage of commercial roots compared to that of the traditional varieties Mina and Miguela. However, more emphasis on the selection for this characteristic is needed.

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Table 1. Number of tuberous roots weighted, average root weight and maximum and minimum weight for individual root for four varieties of sweet potato harvested 162 days after planting.

Variety	Roots weighed	Average weight	Weight Range minimum	Weight Range maximum
	- no. -	- g -	- g -	- g -
Dominicana	296	380	17	2,553
Miguela	665	298	15	1,955
Mina	870	270	11	1,584
Viola	355	389	23	1,948

Table 2. Kolmogorov-Smirnov values (D) and probability level for the adjustment of theoretical distribution on the actual distribution of root fresh weight of tuberous roots harvested at 162 days after planting.

Theoretical Distribution	Variety	D	P value
Normal	Dominicana	0.18	<0.01
	Miguela	0.17	<0.01
	Mina	0.16	<0.01
	Viola	0.12	<0.01
Lognormal	Dominicana	0.06	NS
	Miguela	0.05	<0.01
	Mina	0.06	<0.01
	Viola	0.06	<0.01
Exponential	Dominicana	0.07	0.04
	Miguela	0.07	<0.01
	Mina	0.06	<0.01
	Viola	0.12	<0.01
Weibull	Dominicana	0.06	0.02
	Miguela	0.05	<0.01
	Mina	0.04	<0.01
	Viola	0.04	NS

NS=Non-significant, indicates that actual distribution does not significantly differ from the theoretical distribution.

Table 3. Yield at 162 days after planting and percentage of yield accumulated in commercial and non-commercial roots based on a market preference for weight between 226 to 681 g per root.

Variety	Yield*	Below < 226 g/root	Above 226 to 681 g/ root	Commercial >681 g/root
	kg/ha	%		
Mina	5,082	20	54	26
Miguela	7,307	19	46	35
Viola	5,082	11	52	37
Dominicana	4,138	14	42	44

*There were no statistical differences for yield among varieties. Yield includes both commercial and non-commercial roots.

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THE SMALL RUMINANT INDUSTRY IN THE CARIBBEAN – PRESENT STATUS AND STRATEGY FOR CONTINUED DEVELOPMENT

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ABSTRACT: An analysis of the status of the Caribbean small ruminant industry has shown that the industry has come a long way from the time of sheep and goats introduction in the 15^{th} and 16^{th} centuries and the realisation in the 1970s and 1980s of their economic potential. It is endowed with quality genetic resources some of which are exported, contributes to about 20% of mutton and chevon demands and benefits from some support and incentives. However, it is still a relatively young and unsophisticated industry, the continued development of which is mitigated by lack of or inconsistent policy on land availability and tenure, water use, praedial larceny, dog predation, and post harvest controls, lack of marketing and other pertinent databases, insufficient numbers of appropriate germplasm, lack of diversity in production systems, enterprises and value added products, inadequate technology and information and communication delivery and the need for continuous human resources development. R&D strategies have been identified to deal with these factors and together with the collaboration and cooperation of stakeholders, and particularly the empowerment of producers to take active part in product development, processing and marketing alongside traditional processers and marketers it is posited that the industry will be on the path to accelerated development.

INTRODUCTION

It is believed that the Spaniards introduced small ruminants, especially goats into the islands in the Caribbean Sea from or via the Canary Islands in the 15^{th} and 16^{th} centuries during the slave trade (Fielding and Reid, 1994). Up to the end of slavery, and subsequently of colonisation sheep and goat production in the independent states, as well as in the French and Dutch overseas territories remained a small-, low-resource farmer and hobbyist activity and therefore for a very long time the commodity's role was mainly in social and cultural events and it played only a minor role in economic development (Devendra and Burns, 1970; Devendra and Rankine, 1972; CARDI 1994). In the 1970s and 1980s the economic potential of small ruminants was recognised in many territories of the region and programmes were began to develop a small ruminant industry as a catalyst for food security, poverty alleviation, rural development and the diversification of the export-crop agriculture.

During the last decade regional governments, private individuals and organisations and international donor agencies, including the Arab Gulf Fund, Canadian International Development Agency (CIDA), European Development Fund (EDF) of the European Union (EU), International Fund for Agricultural Development (IFAD) and United States Agency for International Development (USAID) have provided resources to facilitate research and development (R&D) activities in support of the growth of the industry. Most of the efforts concentrated on component technology development, rather than total farm or production systems strategy, and mainly in the areas of nutrition and feeding, management and breed improvement (Table 1) with emphasis on biological efficiency as the determinant parameter. Some good technologies have been developed and where savings or increased income have been demonstrated (Table 2) or where there has been sustained technology transfer producers have responded positively and shown improved productivity (Table 3).

The continued and accelerated development of the industry in the coming years will depend mostly on the amount of investments and commitments made by stakeholders at all levels of the industry, especially in areas such as post harvest and market development where there is a clear lack of sufficient involvement at present.

Therefore we have analysed the industry and ascertained the current status and determined the critical factors that need to be addressed in order to achieve the desired accelerated development. This paper reports on the findings of the industry analysis.

METHODOLOGY

Commodity system analyses were conducted in Barbados, Jamaica and Trinidad and Tobago in the latter part of 2000, using samples of about 25 producers, processers and marketers. This information was supplemented or complemented with status data from Antigua and Barbuda, the Cayman Islands, French West Indies, Grenada, Netherlands Antilles, St Kitts/Nevis, and St Lucia. A report on the status of the industry was prepared, and using that as background document an eleven-member working group performed a SWOT analysis from which the key factors were identified. Strategies were then proposed to deal with the factors identified.

RESULTS

Overview of the current status of the industry

Production environment

Of the ten territories surveyed sheep are produced principally in Barbados, Trinidad and Tobago and the Windward Islands but Jamaica, the Leeward Islands and the Cayman Islands produce goats. The others tend to place equal emphasis on both species. Meat is the main focus and the product is useful primarily for food security. One-half of producers surveyed is commercially motivated and includes well-educated producers (Table 4). The majority are small producers and occupy small parcels of land. Family members are the main source of labour. The all-in-one system is the dominant production enterprise in the industry. Semi-intensive and intensive management systems are employed in 40-70% of cases. Improved pastures and fodder banks used for these systems include *Brachiaria* sp., *Cynodon* sp., *Digitaria decumbens*, *Panicum maximum*, *Pennisetum* sp., *Sorghum* sp., *Gliricidia sepium*, and *Leucaena leucocephala*. Free ranging and tethering are done on native pastures. Local production is estimated, at best, at 20% (2,511 MT) of the total demand (13,711 MT). Estimates of cost of production are available for models but there is not much reliable data on production costs for commercial operations. Competitiveness and profitability, therefore, are uncertain. Generally there are insufficient industry databases.

Genetic resources

There is availability of quality breeds of sheep (Barbados Blackbelly, West African, Virgin Island White, Blackheaded Persian, Katahdin and Dorper), and goats (Nubian, Saanen, Toggenburg, Alpine and the Boer). However, there are insufficient numbers of females to be used for foundation stock.

Agri-business/entrepreneurship

The all-in-one production system is the predominant enterprise. The industry lacks diversification in either production or processing and hence suffers from equitable income distribution.

Agro-processing

Very few producers also engage in post harvest operations. Most of the post harvest handling and processing are done at supermarkets. The CARDI Master Butcher Programme sensitised many producers and processers of small ruminants to the potential of value added products.

Marketing

At present there is virtually no marketing of by-products but there are marketing arrangements for meat and breeding stock (overseas), particularly Barbados Blackbelly sheep. For meat, traffickers and itinerant butchers dominate the marketing channels and producers do not maximise income. There is very little value adding. There is preference of the local market for local fresh mutton and chevon notwithstanding the relatively high prices compared with imported mutton and chevon. Local primary products and value added products have low penetration of supermarkets and the tourism sector because of a lack of consistency of supply and quality of products. There is insufficient information on local market intelligence, supply and demand, price elasticity, standards, etc.

Policy, support systems and incentives

There are policies available to support genetic improvement, research and to some extent post harvest systems and incentives. Several territories have duty free concessions or preferential duties on farm machinery and equipment and relief from income tax. A common external tariff on small ruminant products, currently at 20-40% is in place. There are farm roads, training and extension/technology transfer and information delivery systems. There is assistance for veterinary and public health inspection. Inputs supplies are generally available at farm stores. Specific support services such as project feasibility studies, appraisals for breed quality assurance and credit may be available on request.

Strategic alliance

The industry benefits from strategic alliances fostered primarily through CASRUNET under the PROCICARIBE mechanism. The members of the alliance include: MoAs, CARDI, UWI, IICA, SFC, THA, BAS, BSFI, JAS, RADA, GBSJ, ALPART, KAISER, SLREP, ART, feed manufacturers and suppliers of other agricultural goods and services.

Critical factors affecting future development

The key issues of the industry identified from the SWOT analysis of the status report were:

1. *Policy*: There is need for cohesive policies on land availability and tenure, water use, praedial larceny, dog predation, fair trade and pricing and post harvest controls
2. *Industry databases – production and marketing*: Reliable databases on true animal populations, producers, marketing systems and markets, especially of potential value added products are unavailable
3. *Foundation stock for commercial production*: There are insufficient females to be used for foundation stock by new entrants to the industry or for expansion by old producers
4. *Cost effectiveness and diversification of production enterprise*: There is a need to develop and validate in commercial environment low-cost production systems for a diversity of enterprises (breeder stock, weaner stock, feedlot and dairy enterprises)
5. *Value added products*: There is a total lack of special meat cuts for differentiated markets, as well as milk and milk products and by-products
6. *Quality assurance of products and by-products*: There is not much product differentiation at this time and therefore there are no standards

7. *Information and communication*: There is a need to ensure availability of information on all aspects of the industry to producers and processers
8. *Human resource development*: Both the technical personnel and the practitioners (producers, processers and marketers) need to be well trained and properly informed

Strategies for continued development

The overall underlying strategy for the continued development of the industry is the empowerment of producer associations to take active part in product development, processing and marketing alongside the traditional processers and marketers in order to ensure equitable income distribution. R&D institutions will work as facilitators with such producer groups. Seven R&D areas were identified from the analysis to address the key issues as follows:

Policy

Participate in or initiate, if possible, the development of new policies to address critical areas such as land availability and tenure, water usage, praedial larceny, dog predation, post harvest controls on health and safety and regional trade/distribution of germplasm
Use existing farmers' groups or form new groups to lobby political directorates to implement policies

Industry databases

Establish databases on current population of small ruminants, number of producers and associations, production practices, marketing systems and financial sources. Market studies to be undertaken to gather information on the market channels, prices, demand, price elasticity, potential for value-added products, by-products and demand for breeding stock.

Enhancing the availability of quality stock for commercial production

Introduce and evaluate new breeds and multiply the appropriate breeds and breed types for distribution to producers

Development of cost effective and sustainable production systems

Develop and test forage-based production systems for breeder, weaner, fattener/feedlot stock and dairy production enterprises. Transfer improved production technologies and monitor and evaluate improved production systems under commercial setting.

Post harvest systems for existing products and new value added products

Identify and/or develop post harvest infrastructure. Explore opportunities to create and develop new and value added products to fit the market and develop safety and quality standards and certification systems.

Development of information and communication systems

Information deriving from the databases and other *ex post* data to be stored, analysed, synthesised, packaged and distributed to stakeholders using appropriate technologies. Provide feedback on relevance of information to be collected from users. The Caribbean Small Ruminant Network (CASRUNET) as umbrella network, through its national nodes to be used to achieve the above listed strategies

Development of sustainable human resource base for the industry

Develop and expand linkages and foster alliances with other national. Regional and international institutions, including NGOs. Encourage professional development through workshops and seminars, and publication of R&D outputs and assist with the formation and strengthening of producer groups. Provide training for stakeholders in new production and processing technologies. Promote the participation in the industry of young and technology-receptive ("new farmers") producers.

The successful execution of the development plan will require the involvement of various stakeholders and collaborators/partners with different areas of expertise and levels of resources. Therefore roles were proposed for various stakeholders as follows:

Governments and Government agencies: Policy, enactment of legislations and development of standards and infrastructure, particularly those for post harvest and marketing, and financial support for R&D.

- CARDI and NARS: Spearhead R&D in collaboration with producers and other partners. Develop pilot enterprises and post harvest and marketing systems to produce investment profiles. Facilitate and coordinate development of the industry
- Producer groups and other stakeholders: Ownership of industry. Participate in R&D. Undertake commercialisation of the production, value adding and marketing.
- CASRUNET: policy analysis support and linkages, coordination of information flow and collation, synthesis, packaging and distribution of relevant information on the industry

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Table 1. A count of small ruminant research and development work in the Caribbean

R&D focus	1970-mid 1980	Mid 1980-1990/91	1990/91-2000	Total
Breed improvement	8	5	21	34
Management and production systems	12	13	41	66
Nutrition and feeding	17	15	44	76
Animal health	4	7	5	16
Technology transfer	0	0	4	4
Post harvest	0	1	3	4
Marketing	0	0	11	11
Socio-economics and gender	1	2	8	11
Total	42	43	137	222

Table 2. Pre and post intervention changes in feed costs and mortality at Marilissa Farms, Trinidad and Tobago

Production parameters	Pre intervention October 1994	Post intervention October 1997
Average monthly feed cost (TT$*)	9,000	3,500
Lamb mortality (%)	65	20
Ewe mortality due to pregnancy toxaemia	36	0.7

*6 TT$ = 1 US$

Table 3. Comparative mean productivity of sample Jamaican goat farmers.

	1992/93*	1999**	% Improvement
Herd size	38	91	139.5
No. breeding does	20	49	145.0
Litter size	1.52	1.69	11.2
Pre-weaning mortality (%)	18.7	11.3	39.6
Birth weight (kg)	2.35	2.94	25.1
Weaning weight (kg)	11.1	15.4	38.7
Weight 9 month old (kg)	21.2	30.0	41.5
Total stock sold/year	33.2	79.0	138.2

*1992/93 data from 29 producers; **1999 data from 78 producers

Table 4. Key production parameters of small ruminant producers in selected countries in the Caribbean.

	Barbados	Jamaica	Trinidad & Tobago	Average
Commitment (%):				
Full time		50.0	30.8	40.4
Part time		50.0	69.2	59.6
Reasons (%):				
Business/income	41.0	55.0	54.0	50.0
Other	59.0	45.0	46.0	50.0
Age (%):				
Under 40 yr	13.0	20.0	15.0	16.0
40 or more yr	87.0	80.0	85.0	84.0
Education (%):				
None/primary	6.0	20.0	61.5	29.2
Secondary and above	94.0	80.0	38.5	70.8
Farm size (%):				
<1.0 ha	73.0	25.0	38.5	45.5
1-2 ha	27.0	20.0	23.0	23.3
2.5-6 ha	0.0	30.0	23.0	17.7
>6 ha	0.0	45.0	15.5	20.2
Land tenure (%):				
Own and/or lease	82.0	85.0	76.9	81.3
Other arrangements	18.0	15.0	23.1	18.7
Labour (%):				
Farm family	65.0	70.0	77.0	70.7
Hired	35.0	30.0	23.0	29.3

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PROCESSING AND QUALITY EVALUATION OF A CARAMBOLA DRINK (*AVERRHOA CARAMBOLA*)

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ABSTRACT: The objective of the study was to utilise carambola fruits in drinks and to investigate the quality changes on storage at 10 °C and 25 °C for 5 weeks. A survey was conducted by 125 questionnaires to guide the objectives of the research. Carambola drinks of 4 treatments (9 % and 12% sucrose with or without 3% orange juice) were processed with 0.2% xanthum gum, 0.125% citric acid, 0.1% sodium benzoate and 0.125% ascorbic acid and pasteurised at 90 °C for 5min. From survey, 86.4% of respondents have eaten carambola fruits, while 26.9% have consumed carambola drinks. Some respondents (51.9%) disliked the acid taste and short shelf-life of the fruits. A carambola/orange drink (12 °Brix) was most preferred (66.4%) by un-trained panelists and was liked moderately to like very much. On storage, there were no changes (P>0.05) in °Brix of drinks but products darken more at 25 °C than at 10 °C as indicated by 'L' values.

INTRODUCTION

Carambola is an attractive tropical fruit belonging to the Oxalidaceae family (Morton, 1987). There are two species of Averrhoa belonging to the family Oxalidaceae : *Averrhoa carambola* and *Averrhoa bilimbi*. In Trinidad, there are no named varieties (Andrews and Ragoonath, 1990), but are classified as being 'sour' /tart or 'sweet.' Morton (1987) reported that there are two main classes – the smaller, very sour type, richly flavoured with more oxalic acid and the larger so-called 'sweet' type, mild flavoured with less oxalic acid. Tropical carambola is golden yellow with a touch of brown along the edges when ripe. Fruits are acutely five-angled and distinctly star shaped when cut across. The skin is thin, tender, translucent, crisp and very juicy (Morton 1987). The fruit is waxy in skin texture and deeply ribbed, containing 5-7 ribs. It may range from sour to semi-sweet to sweet in taste. In Trinidad, W.I. Carambola trees are non-seasonal plants, which generally begin production within first 12 to 18 months of planting. It can yield three to five crops per year (Campbell and Marte 1990). Fruit development can take form 61-70 days, depending on the variety type and the weather conditions.The largest crops of fruits mature during May-June, September-October and December-January (Andrews and Ragoonath, 1990), albeit local citizens indicate that their trees bear continuously throughout the year, or with three or four crops per year.

The carambola fruits are easily damaged and thus proper harvesting techniques are critical to the successful storage and marketing of the fruits (Campbell and Marte, 1990). The fruit has a short shelf life and is rapidly oxidised as the slices become brown on exposure to air. This browning effect is related to the oxidation of phenolic compounds by enzymes, particularly the poly-phenoloxidase (PPO) enzyme (Weller *et al.*, 1997). At 10 °C, fruits harvested at the first signs of yellowing can be stored for a maximum of 7 weeks without decay or qualitative losses (Balkissoon 1990). Andrews and Ragoonath (1990) indicated that carambola can be stored at 5 °C for at least 3 weeks or at 7.2 °C for 6 weeks.

Approximately, 25% of the carambola fruit due to its size, shape and appearance do not meet the desired market standards. Hence, they are utilised for process products to decrease waste and improve returns to farmers and growers (Lamberts and Schaffer, 1990). When the fruit is sliced, the pieces are star-shaped, sweet, crisp and juicy, simultaneously making them a tasty garnish on salads and desserts. Carambola provides flavour to stir-fried entrees, puddings, tarts, stews and curries. The fruit can also be cut in cross – sections and dried as sometimes is done in Jamaica with the ripe fruits (Morton, 1987). Our objective was to utilise carambola fruits to produce acceptable drinks. Various levels of xanthum gum and were added to the drinks and the quality changes on storage at 10 °C or 25 °C for 5 weeks were investigated. A questionnaire was conducted prior to practical investigation to identify the specific objectives of the research.

METHODS

Questionnaire

A questionnaire was conducted prior to the practical investigation on the production of an acceptable carambola drink. The questionnaire was conducted via personal interview/communication with 125 individuals to gain an insight as to the likes and dislikes for carambola, different uses of the fruit among the population and to guide the objective of the research. Only those students at the University of the West Indies, St. Augustine campus were interviewed.

Processing

Carambola, *Averrhoa carambola* of the Chinaseng variety was obtained form Citrus Grower's Limited, Laventille and from Ambrosia farms, Arima. The mature, yellow fruits (13 cm x 6 cm) were stored at 10 °C. The average weight of the fruit was 192.0 g. Fruits were selected to be free of bruises and blemishes and washed in 10 % chlorinated water (sodium hypochlorite). Fruits were peeled length-wise to separate the ribs and the seeds, slimy membranes and the center of the ribs were removed and juiced in an electrical juice processor and filtered. Xanthum gum at varying levels was mixed with the sugar and incorporated into diluted carambola juice. The formulation consisted of the following ing: carambola juice (35 %) and water (65 %) with additions of ascorbic acid (0.125 %), citric acid ().5 %), sodium benzoate (0.1 %) and sugar (9 % or 11 %).The drink was pasteurised at 90 °C for 5 min. After the first minute, citric acid, ascorbic acid, sodum benzoate and orange juice were added and stirred. The carambola drink was hot – filled in 300 ml bottles.

Experimental Design

The first stage of the study was to investigate the effects of adding different levels of xanthum gum (0.02 %, 0.05 %, 0.2 %, 0.3 %, 0.4 %, 0.5 %, 0.6 %) to the carambola drink of formulation: carambola juice (35 %), water (65 %), ascorbic acid (0.125 %), citric acid (0.5 %), sodium benzoate (0.1 %) and sugar (12 %). The products were stored at 20 °C for 1 month and observed for settling of sediments, and the level of consistency. In the second stage of experimental work, the carambola juice with 0.2 % xanthum gum was selected from the first stage of the experiment as having the least separation of sediments. To the base formulation, sugar was added at 9 % and 11 %, mixed with 3 % orange juice or without added orange juice. Bottles were stored at 10 °C or 25 °C for 5 weeks.. Analyses on the products were done at weekly intervals for sedimentation settling, colour analysis, pH, and ° Brix.

Statistical analysis

Data from questionnaire, physico-chemical analyses (colour, pH, total soluble solids as ° Brix) due to treatments (second stage of processing) storage, and sensory evaluation at 5 % level of significance were analysed using the Statistical Package for Social Sciences (SPSS) version 9.0 for Windows.

Physico-chemical analyses

Colour of the carambola drink was measured as 'L' 'a' 'b' using a Minolta Chroma meter. The pH of the carambola fruit and drink was measured on a pH meter at weekly intervals for 5 weeks, by immersing the pH probe into the carambola drink. The total soluble solids (TSS) as ° Brix was measured using a refractometer.

Microbiologica

Microbial examination of carambola drinks (second stage of processing) for the presence of lactobacilli (Tomato Juice Agar), yeasts and molds (Potato Dextrose Agar) and was performed on week 3 at 10 °C and 25 °C. Tomato juice agar plates were incubated at 37 °C except Potato Dextrose agar at 25 °C for 48 hours and the number of microorganisms reported as cfu ml^{-1}.

Sensory Evaluation

Sensory evaluation was performed on week 3 after processing on carambola drinks form the second stage of processing. Forty – nine (49) un-trained panelists of ages 20-24 chosen from the student population of the University of the West Indies, Trinidad, W.I. and members of the public participated in the sensory evaluation of the 4 treatments (9 % and 11 % sucrose/ with or without added 3 % orange juice). Sensory evaluation was conducted in the Sensory Evaluation laboratory. Samples were chilled at 5 °C prior to being served. The sensory attributes of the carambola drinks which were evaluated: colour, taste, sweetness, and overall acceptability using a hedonic scale of 9- like extremely; 8-like very much; 7-like moderately; 6-like slightly; 5- neither like nor dislike; 4-dislike slightly; 3-dislike moderately; 2-dislike very much; 1-dislke extremely.

RESULTS AND DISCUSSION

Questionnaire. Most of the respondents (86.4 %) to the questionnaire have eaten carambola as a fruit, 63 % ate only one fruit in a single occasion and 65 % consume the fruit only when available during the season. Some respondents (32. 8 %) were aware of the two types of carambola, (the larger, sweet type for processing and the smaller sour type which is eaten as a fruit) which are available locally. When respondents were asked to select the most desirable quality attributes, 29.6 % indicated taste, 26.9 % selected shape, 23.1 % odour and 8.3 % texture. Some respondents (51. 9 %) indicated that there were several attributes they disliked about the fruit: the acid taste, not being sweet, and the short shelf life of the fruit. Carambola is used to make a variety of products: as wines (27.8%); beverages (26.9 %); jams (16.7%); pepper sauce (15.7%); candied product (13.0%); pickle (11.0%); in baked products (2.8 %); cordial (0.9%). When respondent were asked about the acceptability of using carambola for food products, 31.2 % neither liked nor disliked; 27.2% liked very much; 25.6 % liked a little; 9.6 % liked extremely; 3.2 % disliked a little and 2.4 % disliked extremely the suggestion. Based on the responses of the participants, 27.2 % indicated that the fruit was most suitable to be used as a juice, while 22.4 % indicated as a drink. Most participants (66.4 %) preferred a blended carambola drink with orange juice while 59.2 % favoured a mixed fruit drink.

Effects of xanthum gum on sedimentation. Table 1 shows the effect of adding xanthum (%) on sedimentation (cm) of juices on storage after 4 weeks (first stage of processing). The least amount of settling of sediments was in carambola treatment with 0.2 % addition of xanthum gum (0.9 cm) and the most sedimentation in carambola juice with 0.02 % xanthum gum (2.1 cm). On storage of carambola juices with 0.2 % xanthum gum from the second stage of processing (9% sugar; 12 % sugar with or without 3 % orange juice) at 25 °C for 5 weeks, there was still some sedimentation (0.8 –1.2 cm). Carambola treatments, which were stored at 5 °C for 5 weeks had negligible sedimentation (< 0.3 cm).

Physico-chemical analysis. Colour differences ($P<0.05$) between different carambola drinks are were shown (Table 2). Carambola drinks darken on storage, as indicated by the lower 'L' values of Table 2 when compared to Table 3, with more darkening on storage at 25 °C than at 10 °C storage after 5 weeks. Comparing the 'a' and 'b' values of Table 2 (day 1 after processing) to Table 3 (after 5 weeks of storage), the products became more red and and more yellow. There was some browning in drinks.The enzyme, polyphenoloxidase (PPO) in the carambola causes oxidation, particularly if the tissues were scarred or bruised, thus resulting in browning of drinks (Weller *et al.* 1987). Browning susceptibility of fruit tissue has been reported to be related to ascorbic acid concentrations, PPO activity and phenolic content (Bauernfeind, 1958; Ponting and Joslyn, 1948). Changes in colour can result in decrease consumer appeal and therefore colour is an important determinant of shelf-life (Nagy and Rouseff, 1986).

Total soluble solids. Carambola drinks with 9 % sugarhad 13.2 °Brix; 9% sugar with 3 % orange juice – 12 °Brix; 11 % sugar – 14 °Brix; 11 % sugar with 3 % orange juice – 20.2 °Brix. The ° Brix content of raw carambola juice was 6.12 °Brix. There were no significant ($P>0.05$) in the total soluble solids on storage at 25 °C and 10 °C.

pH. The pH of the raw fruit juice was 2.88-3.01. Table 4 shows that the pH of the carambola drink decreased ($P<0.05$) on storage time. The increase in acidity could be related to the growth of lactobacilli which as determined after 3 week of storage. Oxalic acid is the principal acid found in the carambola fuit. Ripe carambola contains 9.6 mg/g pf oxalic acid while the green fruit contains about 5.0 mg/g (Lamberts and Schaffer, 1989). Other acids found include fumaric, malic, ketoglutaric, succinic and tartaric acid.

Microorganisms. No yeasts and molds were detected on microbial analysis after week 3 of processing. The decline in pH in carambola drinks on storage (Table 4) can be related to the presence of lactobacilli in the drinks ($9.9 \times 10^3 - 1.1 \times 10^5$ lactobacilli per ml).

Sensory evaluation. Thirty-three (70.2 %) of the panelists were within the age group of 20-24 years and 24 or 51.1% of panelists were males. Forty-six (97.9 %) of the participants were aware of carambola fruits, while 23 panelists or 48.9 % have consumed carambola drinks. Table 5 shows the sensory attribute scores assigned to carambola drinks. Carambola drinks were liked slightly to moderately for colour and taste. Sweetness was the least acceptable of all attributes, particularly for carambola drink of 11 % sugar/ 3 % orange juice, which was given a score of 4.76 indicating that it was disliked slightly to neither like nor dislike. This drink was not acceptable due to its high ° Brix content of 20.2. Similarly a carambola drink with 11 % sugar, which had 14 ° Brix content was disliked very much to disliked moderately (2.49). The overall acceptance of all treatments were liked moderately to liked very much (7.04-7.21) except the carambola with 11 % sugar with 3 % orange juice which was disliked slightly to neither liked nor disliked (4.23). Carambola drinks with 11 % sugar/ 3 % orange juice were considered 'too sweet' by panelists. When asked to choose the most preferred carambola drink treatment, 36.2 % of panelists preferred the 9 % sugar with 3 % orange juice, because of its odour and consistency and 36 % of panelists indicated that they would purchase.

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Table 1. Effects of Xanthum Gum (%) Addition on Sedimentation of Carambola juices* after 4 week Storage.

Xanthum gum, %	Sedimentation, cm
0.02	2.1
0.05	2.0
0.20	0.9
0.30	1.0
0.40	1.3
0.50	1.5
0.60	1.5

* first stage of processing

Table 2. Colour of Carambola Drinks (first stage of processing).

Treatments	'L'	'a'	'b'
9 % sugar	32.63	-0.96	-0.26
11 % sugar	30.10	0.00	0.60
9 % sugar + 3 % orange juice	33.33	-0.56	0.93
11 % sugar + 3 % orange juice	30.65	-0.16	0.00

Colour measurement taken after day 1 of processing

Table 3. Colour of Carambola Drinks on storage at 25 °C and 10 °C (second stage of processing)

Colour	9 % sugar	11 % sugar	9 % sugar/ 3 % orange juice	11 % sugar /3% orange juice
Storage, 25 °C				
'L'	28.05	27.95	28.37	28.23
'a"	0.19	0.26	0.17	0.19
'b'	0.86	0.78	0.93	1.10
		Storage, 10 °C		
'L'	29.02	28.08	28.95	29.15
'a'	1.21	0.58	0.31	0.19
'b'	1.21	0.94	0.70	0.77

Colour readings taken after 5 weeks

Table 4. pH of Carambola drink* on Storage.

	Carambola treatments			
Storage, wks	9 % sugar	11 % sugar	9 % sugar / 3 % orange juice	11 % sugar / 3 % orange juice
1st	4.00±0.01	4.02±0.01	3.98±0.01	4.02±0.01
2nd	3.99±0.01	3.89±0.01	3.92±0.01	3.94±0.02
3rd	3.94±0.01	3.77±0.01	3.88±0.02	3.87±0.01
4th	3.78±0.01	3.79±0.01	3.72±0.01	3.81±0.02
5th	3.76±0.02	2.98±0.01	3.66±0.02	3.74±0.01

* carambola drink from the second stage of processing

±SD

Table 5. Sensory Attributes of Carambola Drinks

Attributes	9 % sugar	11 % sugar	9 % sugar + 3 % orange juice	11 % sugar + 3 % orange juice
Colour	6.83±2.26	6.74±15.67	6.83±0.26	6.77±0.18
Taste	6.72±0.63	6.63±1.21	6.57±0.18	6.26±2.03
Sweetness	4.99±2.95	2.49±14.30	5.98±9.88	4.76±1.47
Overall acceptance	7.04±4.28	7.21±5.46	7.21±4.28	4.23±15.18

±SD

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L'ASSURANCE QUALITÉ ET LA DIVERSIFICATION VARIÉTALE ÉLÉMENTS DE LA RESTRUCTURATION DE LA FILIÈRE ANANAS DE LA MARTINIQUE

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RESUMEN: Ce programme prévoit aussi l'utilisation de nouvelles variétés hybrides avec des caractéristiques physiques plus adaptés à la transformation, et répondant aux normes de souhaitées par les clients en terme de goût, de coloration de la chair... Ces variétés ont été obtenues par Le CIRAD-FLHOR, qui pour faire face à une importante demande de matériel végétal à mis en place un programme d'amplification horticole combinant des méthodes de multiplication traditionnelle et celle plus moderne de la culture in-vitro.

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QUALITY CHANGES AND SHELF LIFE STUDIES OF TAMARIND CHEESE

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ABSTRACT: Studies were conducted to determine optimum setting conditions and storage temperature of tamarind cheese. Optimum setting conditions were identified at pH 2.5-2.8, with corn syrup, with or without preservatives at 70^0Brix and an end point temperature of 105^0C. Treatments with corn syrup were identified as more acidic than treatments without corn syrup but the texture of the latter was firmer than the former. Treatments stored at 30^0C decreased in firmness, with the opposite effect taking place at 10^0C. No microbial growth was observed throughout the 28 day storage period.

INTRODUCTION

Tamarind (*Tamarindus indica*) is a member of the leguminosae family (Nagy and Shaw, 1980; Shankaracharya 1998). It is considered as a minor fruit crop, native to Tropical Africa and cultivated in the Tropics and Subtropics (Shankaracharya, 1998; Morton, 1987; http://www.safari.net/~lychee/tamarind.htm). Among the many names for the fruit, the most common ones are: Tamarin, Tamarindies, Tamarindo and Imli (Morton, 1987).

Currently, the utilization of tamarind pulp is limited to the production of tamarind balls, tamarind sauce and tamarind juice. Less than 100 tonnes of tamarind is utilized in Trinidad and Tobago as opposed to 500 tonnes of citrus and 300 tonnes pineapple and guavas (Francis, 1995). These statistics emphasize the need to diversify the utilization of the tamarind fruit into other value added products.

Fruit cheese is a jam like product, with or without spices, and is served as an appetizer or a dessert (Jethro 1988). A major drawback in the production of fruit cheeses is determining the correct matrix with respect to temperature, pectin content, soluble solids content and pH (Kratz, 1993; Lashley, 1994; Marshall, 1986; Vandergarde et al., 1994). Manipulation of these factors optimize setting conditions for fruit cheeses.

While the tamarind pulp has been utilized in the production of jams, jellies, sherberts, drinks and fruit powders, there is no published information on the production of fruit cheese.

The objective of this investigation is to determine the effect of end point temperature, pH, concentration of pectin and percent soluble solids to optimize the setting point and shelf life of tamarind cheese.

MATERIALS AND METHODS

Ninety (90) kg of tamarind fruit (*Tamarindus indica)* was obtained locally in North Trinidad. The fruits were washed and shelled manually, by breaking the shell from the pulp and removing the fibers from the fruit. The tamarind was boiled in a 2:1 ratio of water to tamarind for 20 minutes and left at ambient temperature (30^0C), followed by agitation and pulping using a 2×2 mm wire- mesh sieve. The tamarind pulp was then stored in polyethylene bags at -18^0C and used for further investigations.

Pectin was mixed with 80g sugar and slowly added to 320 ml distilled water while blending on speed 2 of a Waring commercial blender, model 34BL97 (7012). The preservative potassium sorbate (0.1%) was mixed with the sugar and pectin. The quantity of pectin added to the solution varied depending on the percentage of the pectin solution required. Soluble solids of the pectin solution were standardized to 20^0 Brix by the addition of water or sugar if the percent soluble solids was too high or low.

Tamarind cheese was prepared by adding 160g sugar, 80 ml fructose corn syrup (55 HFS) and 5 ml soya oil to 500 g tamarind puree (15^0 Brix) and concentrated to 75^0 Brix (Figure 1). Pectin solution was rapidly incorporated into the mixture and allowed to set in a stainless steel tray over water at 10^0 C. The cheese was then cut into cubes 3 cm^3 and dusted in corn flour.

The pH, soluble solids, % pectin and type of pectin were varied to determine the optimum setting point of the tamarind cheese. Tamarind cheese was divided into four groups, with four replications in each group. Group A: 2.0 pH; Group B: 2.5 pH; Group C: 3.0 pH; Group D 3.5 pH. Trials for each group were conducted at concentrations of 1,2,3 and 4% pectin solution (Medium rapid set pectin 8611 and Low- methoxyl pectin) and 50, 60, 70, and 80% soluble solids. Each trial was repeated replacing 20% sucrose with fructose corn syrup (55 HFS). pH lower than 2.0 was obtained by the addition of potassium citrate prior to the addition of sucrose.

The experiment consisted of the following 8 treatments: 2.5 pH with corn syrup and preservative; 2.5 pH with corn syrup with out preservative; 2.5pH without corn syrup with preservative; 2.5 pH without corn syrup without preservative; 3.0 pH with corn syrup and preservative; 3.0 pH with corn syrup with out preservative; 3.0 pH without corn syrup with preservative; 3.0 pH without corn syrup without preservative

The samples were stored in plastic containers at 10^0C and at ambient temperature (30^0C) for 28 days. The samples were analyised for colour, texture, pH, organoleptic quality attributes, bacteria, yeast and molds on the initial day of processing and on a weekly basis thereafter, until the 28^{th} day of processing. Sensory data was provided for the initial and the 28^{th} day since no difference was reported on the other days between this period.

Colorimetric values L, a, b were recorded for each sample using a Minolta Colorimeter CR 200b model 75043073 and texture analyised using a Koehler texture analyzer model K 19550. Total soluble solids was measured using a Cole Parmer Ins. Co. hand held refractometer of 58-90^0 Brix FA 2000 model 02940-25. A standard volume of cheese (10 ml) was diluted with distilled water (30 ml) and used for measurement of pH and titratable acidity (TA) against 0.1N NaOH to an end point of pH 8.1 using an Orion pH meter 520A with a glass electrode.

Microbiological procedures were used to analyse the samples for general microbial growth in plate count agar and yeast/ molds in potato dextrose agar by the pour plate method. Four replicates of each sample was produced and sterile water blanks were used as a quality control measure. All samples were analysed for reducing sugars and total sugars (Miller, 1959).

Sensory evaluation was conducted on a 50-member panel that consisted of males and females from the age of 8 years and above. Each panelist received a single sample of the cheese sequentially for evaluation. The pieces of cheese were coded for identification and the order of presentation was counterbalanced across the subjects to avoid bias. The panelists were required to evaluate the samples for preference to the following end point descriptors: texture, colour, flavour and overall acceptability. The panelists were also required to rank the samples in order of acidity, with 1 dislike extremely to 9 like extremely. A triangle test was conducted to determine if a sensory difference could be detected in the samples with preservative and without preservative and in samples with corn syrup and without corn syrup.

Statistical analysis was performed using MINITAB software, version 12.12. The General Linear Model (GLM) procedure was employed. All significant differences were reported at the 95% confidence level. The experimental design was completely randomized and all groups and measurements were performed in quadruplicate.

RESULTS AND DISCUSSION

Optimum texture and flavour of tamarind cheese were achieved at pH 2.5 with corn syrup. Similar results were achieved in treatments with corn syrup, but without preservative. Increased firmness in treatments was more acceptable by the taste panelist with the exception of treatments at pH 2.5 with and without corn syrup (Table 1). A significant difference was observed in the taste of samples with corn syrup and the samples without corn syrup. Firmer textures were preferred, as softer textures had an inferior mouthfeel and were disliked by adolescence and adults (Mac Fie and Meiselman, 1996).

Treatments at pH 2.5 with corn syrup were less firm but more preferable than treatments at pH 2.5 without corn syrup (Table 1). The Wundt curve, relating sensory intensity to hedonic responses, could be used to explain these textural preferences (Mac Fie and Meiselman, 1996). This curve implies that the sensory intensity of a given stimulus increases to a maximum level then becomes unpleasant at the highest sensory intensity (Mac Fie and Meiselman, 1996). Treatments at pH 2.5 with corn syrup could be described as the maximum level, which decreases in acceptability as the product increases in firmness indicating that texture is a critical factor in the determination of the hedonic tone.

An r^2 value of 0.50 indicated a correlation between pH and texture. This correlation is mainly due to hydrogen bonding and the optimum pH necessary to optimize this bonding. When water was added to the fruit pulp, the negative charges associated with the pectin molecules repelled each other and prevented the hydrogen bonding necessary for gel formation (Marshall, 1986; Vangarde et al., 1994). As indicated previously, gels are formed when polymer molecules interact over a portion of their length to form a network that entraps solvent and solute molecules, resulting in the formation of junction zones (Vangarde et al., 1994). The presence of acid neutralized the negative charges resulting in hydrogen bonding and the formation of junction zones, hence, treatments at pH 2.5, resulted in the firmest gel (Figure 2).

Too much acid caused excessive bonding of pectin molecules due to decreased repulsion. This bonding apparently squeezed out the water that should be held in the spaces between the molecules, resulting in synersis and the formation of a weak gel, hence the gel formed in treatments at pH 2.0 were weak (Figure 2).

Treatments at pH 2.5 were firm in texture due to the greater number of non- ionized carboxyl groups, which enhanced the non- covalent attraction among the methoxyl, alchol and carboxyl groups. At higher pH values, repulsion was increased and hydrogen bonding decreased, resulting in a weaker set, which was observed in treatments at pH 3.0 and 4.0.

Although, the texture of treatments at pH 2.5 without corn syrup, was preferred to pH 2.5 with corn syrup, the flavour of the latter was more acceptable. This may be attributed to the increased acidity of the samples with corn syrup, as the flavour of the more acid samples were generally preferred.

The sweetness of fructose was perceived on the tongue by panelists more quickly than sucrose, due to the greater diffusion rate and the lower viscosity of fructose (Schenck and Aebeda 1992). This perceived sweetness of fructose reaches a peak and dissipates more quickly than sucrose, allowing the acid flavour to be perceived more clearly, hence, treatments with corn syrup were perceived as more acidic than treatments without corn syrup.

Fructose has a unique sweetness response compared to other sweeteners and is reported to improve the flavour of products. Due to its early detection and dissipation, fructose enhances flavours that develop later in the response cycle and is compatible with fruit and spice flavours (Schenck and Aebeda, 1992).

A set of stimuli and mechanisms of molecular interaction with the taste receptor cell has been proposed for each taste. The sour taste has been known to be proton- donating molecules, thus, sourness of foods are directly attributable to the presence of hydrogen ions (Schenck and Aebeda, 1992).

Acidity is a critical factor in the acceptance of tamarind cheese, and is correlated with texture. In preliminary investigations, treatments at pH 2.0, were softer than pH 3.0 and as previously indicated, treatments with a softer texture, were generally disliked.

Preference for treatments at pH 2.5 may have been influenced by increased firmness of treatments at this pH. Individuals generally have an innate preference for sweet, however, as described by the Wundt curve, the preference for sweetness decreases as it passes the maximum threshold (Mac Fie and Meiselman, 1996). Acidity suppresses the perceived sweetness of foods and beverages, shifting its acceptance higher or lower, therefore, an optimum balance of sour and sweet may have been obtained at pH 2.5.

The texture of tamarind cheese also influenced brix, end point temperature and to a lesser degree, % pectin solution. As the water leaves its binding sites on the pectin molecules and binds to the co solute, the pectin molecules are left with free sites, which can participate in pectin- pectin bonding. This greater contact between the pectin chains, results in the formation of junction zones and a network of polymer chains that entraps water and solute molecules (Marshall, 1986 and Vangarde et al., 1994).

Treatment at 50% soluble solids resulted in a soft set (Figure 3), due to the low concentration of soluble solids, which was insufficient to dehydrate the pectin molecules (Figure 3). Treatments greater than 70% soluble solids resulted in the increased size, increased dehydration and number of junction zones, which resulted in precipitate formation.

Concentrations of 1% pectin solution resulted in a softer set than 2 and 3% pectin solution, due to the decreased concentration of pectinic acid and number of junction zones. The inverse reaction resulted in a firmer texture of trials at 3% pectin solution. The number of junction zones was increased by the utilization of 3% pectin, resulting in a product of firm texture. For this reason, 3% pectin solution was identified as the optimum treatment (Figure 4).

Treatments at 4% pectin solution resulted in a soft set. This was due to an increase in the concentration of hydrated pectinic acid and insufficient concentrations of co solutes to dehydrate the pectinic acids.

The soluble properties of pectin must also be considered. Pectins are insoluble in aqueous solutions, however, they are soluble in pure water, hence, pectin was added as a solution not a solid. Dissolved pectins undergo deesterification and depolymerization in aqueous systems at rates below and above pH 4.0 (Marshall, 1986).

The texture of tamarind cheese was not only influenced by processing, but by storage as well. There was an increase in the firmness of treatments at 10^0C due to water loss from evaporation (Table 2). This may be due to temperature fluctuations in the environment, causing the relative humidity in the package to be higher than that of the environment (Earle 1983 and Stringer 1992). In order to achieve an equilibrium relative humidity, the product would loose moisture to the environment, resulting in a product with a firmer texture.

An optimum temperature of 105^0C was identified, as this resulted in a firm gel (Figure 5). Temperatures of 110^0C and 115^0C resulted in the formation of a weak gel due to the formation of invert sugar. During this inversion, sucrose (1 molecule) becomes invert sugar (2 molecules), resulting in an increase in the boiling point, however, the dehydration effect on pectin does not double, causing insufficient water to be evaporated (Marshall, 1986). An end point temperature of 105^0C resulted in sufficient evaporation of water and the formation of a firm gel.

Condensation was observed in samples at 10^0C. At 10^0C, the temperature on the inside of the container was higher than the external temperature. During refrigerated storage, cold air circulated over the product, resulting in the removal of heat. On cooling, heat formed inside the package, was transferred to the external environment causing the hot air to condense on the surface of the package at its dew point (Earle, 1983 and Stringer, 1992). Large headspaces resulted in more hot air circulation, resulting in a greater amount of heat transfer and condensation which could increase the probability of microbial spoilage and shorten the shelf life of the product.

The hygroscopic nature of fructose facilitated greater water absorption as the humidity increased (Schenck and Hebeda, 1992). This absorption of water in the product resulted in a softer texture, hence, treatments with corn syrup was softer than treatments without corn syrup throughout the storage period.
Sucrose is also hydroscopic, but to a lesser extent than fructose, therefore treatments with corn syrup were softer than those with out corn syrup throughout storage at 30^0C.

No microorganisms were observed at pH 2.5 and pH 3.0. Most bacterial organisms cannot grow at pH values of 2.5 and 3.0, although these are favorable conditions for the growth of yeasts and molds even with the addition of preservatives.

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Wash, shell and sort tamarind

↓

Boil in a 2:1 water to tamarind ratio for 20 minutes, cool, agitate and pulp

↓

Decrease pH to 2.5-3.0 by the addition of potassium citrate

↓

Add sugar, corn syrup (optional) and oil to tamarind pulp and concentrate to 75 % total soluble solids

↓

Pectin solution→ Add pectin solution

Mix sugar and pectin

↓

Allow to set in heat proof dish over water 10^0 C

Slowly add to water while blending on a low speed

Standardize to 20% total soluble solids

Figure 1. Flow chart of the production of tamarind cheese

Table 1. Effect of pH on sensory quality attributes of Tamarind cheese after 1 and 28 days of storage at 30^0C.

Treatments	Texture[W]		Flavour[X]		Overall acceptance[Y]		Acidity[Z]	
	1 day	28 days	1 day	28 days	1 day	28 days	1 day	28 days
Samples with corn syrup								
2.5 pH + preservative	7.8 [a]	6.8 [a]	8.1 [a]	8.2 [a]	7.2 [a]	7.2 [a]	8.8 [a]	8.1 [a]
2.5 pH – preservative	7.8 [a]	6.8 [a]	8.0 [a]	8.0 [a]	7.2 [a]	7.3 [a]	8.5 [a]	8.5 [a]
3.0 pH + preservative	5.9 [c]	4.4 [c]	5.1 [c]	5.2 [c]	4.0 [c]	4.1 [c]	5.1 [c]	5.1 [c]
3.0 pH – preservative	5.9 [c]	3.4 [d]	5.2 [c]	5.2 [c]	4.1 [c]	4.1 [c]	5.2 [c]	5.2 [c]
Samples without corn syrup								
2.5 pH + preservative	7.1 [b]	6.1 [b]	6.5 [b]	6.6 [b]	6.0 [b]	6.0 [b]	6.9 [b]	6.5 [b]
2.5 pH – preservative	7.1 [b]	6.2 [b]	6.9 [b]	7.0 [b]	5.7 [b]	5.9 [b]	6.8 [b]	6.9 [b]
3.0 pH + preservative	4.3 [d]	3.4 [d]	3.2 [d]	3.3 [d]	3.0 [d]	3.0 [d]	3.3 [d]	3.5 [d]
3.0 pH – preservative	4.3 [d]	4.5 [c]	3.2 [d]	3.3 [d]	2.8 [d]	2.9 [d]	3.2 [d]	3.2 [d]

$LSD_{0.05}$: [w] Texture = 0.51 [x] Flavour = 1.19 [y] Overall acceptance = 1.12 [z] Acidity = 1.17

Table 2. Effect of pH on textural properties of Tamarind cheese during storage.

Treatment	Texture of Tamarind Cheese (mm / 2.5 seconds)									
	Day 1		Day 7		Day 14		Day 21		Day 28	
	20C	30C	20C	30C	20C	30C	20C	30C	20C	30C
	All with corn syrup and preservative									
2.5 pH	46	46	43	49	39	50	35	51	29	53
2.5 pH	47	48	44	50	40	53	37	54	34	53
2.5 pH	49	50	46	51	41	51	38	53	36	50
2.5 pH	50	51	47	52	42	52	39	54	37	51
3.0 pH	62	62	55	65	52	50	65	47	65	50
3.0 pH	64	64	60	65	55	65	52	64	46	50
3.0 pH	69	69	66	70	59	70	54	70	50	70
3.0 pH	71	71	70	73	62	72	56	73	53	73
$LSD_{0.05}$	2.99		2.42		1.56		2.02		3.85	

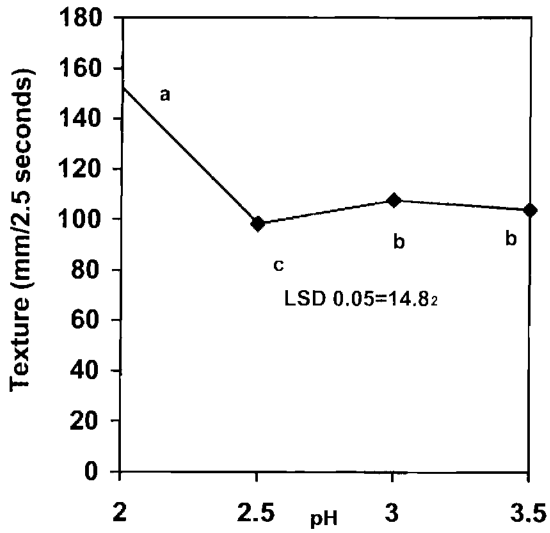

Figure 2. The effect of pH on the texture of tamarind cheese

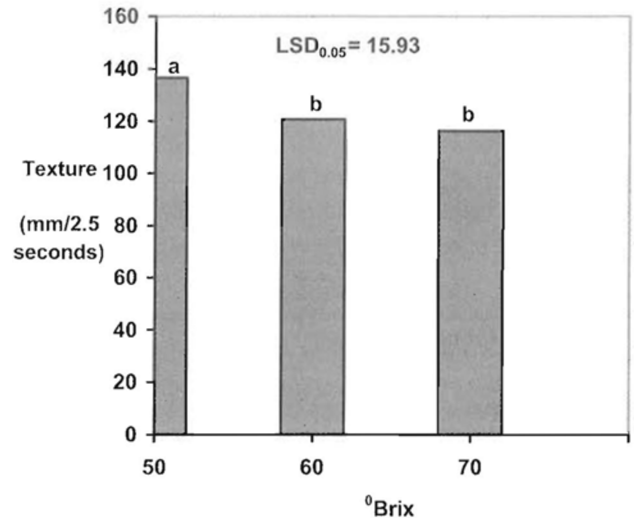

Figure 3. The effect of brix on the texture of tamarind cheese

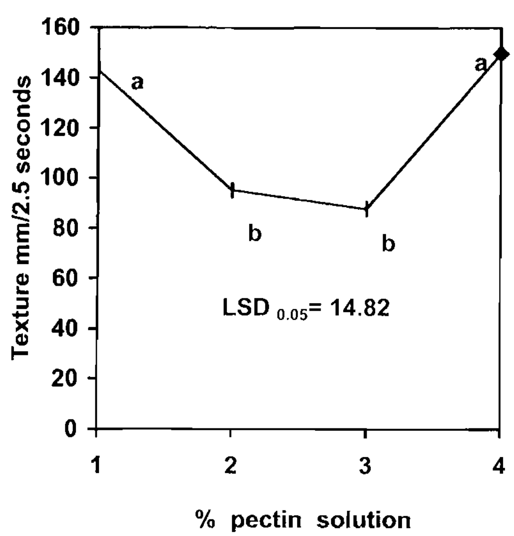

Figure 4. The effect of % pectin solution on the texture of tamarind cheese

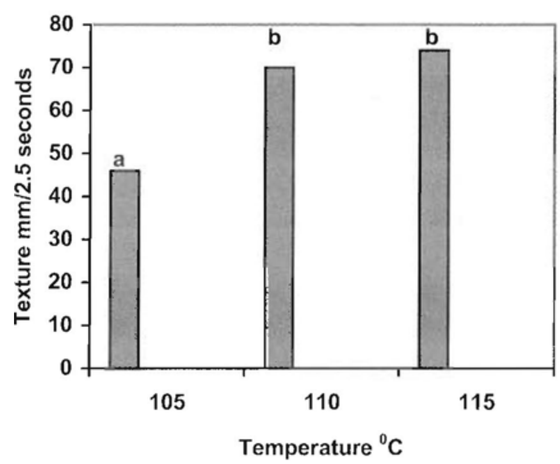

Figure 5. The effect of temperature on the texture of tamarind cheese

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OCCURRENCE OF THE CLIMACTERIC PATTERN OF RESPIRATION IN MINIATURE GOLDEN APPLE (*SPONDIAS CYTHEREA*) FRUIT

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ABSTRACT: Miniature golden apple fruit (*Spondias cytherea*) were harvested at three stages of maturity (immature, mature-green and breaker stages) and stored at 9°C, 21°C and 31°C for up to 14 days. Throughout storage, fruit were evaluated for carbon dioxide (CO_2) and ethylene (C_2H_4) production rates. For fruit at all three maturity stages stored at 9°C, respiration rates remained very low throughout storage increasing rapidly beyond 12 days at which time both senescence and chilling injury symptoms were well established. For fruit stored at 21°C and 31°C, respiration rates increased over time with senescence occurring in immature fruit and ripening occurring in mature-green and turning fruit. Ethylene was only detected at 21°C and 31°C and increased over time in fruit at all maturity stages. The respiratory pattern of the miniature golden apple was typical of a climacteric fruit. In immature fruit the rise in the rate of ethylene production occurred beyond 4 days and coincided with the climacteric rise of respiration and external evidence of senescence. In mature-green and turning fruit the rise in the rate of ethylene production occurred beyond days 5 and 4 respectively and also coincided with increased respiration rates.

INTRODUCTION

The golden apple *Spondias cytherea* is a member of the Anacardiaceae family and is native to the Society Islands of the South Pacific, Melanesia and Polynesia. Common names include the golden apple, jew plum, june plum, pommecythere and ambarella (Winsborrow, 1994). Golden apples are found as the common large fruit type where the tree attains a height of 9-25 m, and the miniature fruit type, where trees attain 1.5 - 3 m in height. Fruit of both types are oval, round or pear-shaped. Fruit size varies from about 5 to 6 cm in diameter and 9 to 10 cm in length with an average weight of 200 grams for the large fruit while miniature fruit are about 3 to 4 cm in diameter and 5 to 6 cm in length with an average weight of 65 grams (Persad, 1996; Winsborrow, 1994).

Early bearing, year round availability, ease of harvesting and the reduced likelihood of mechanical damage when harvesting is done at a more advanced stage are some of the characteristics of the miniature golden apple that give it a distinct advantage over the large type. Both fruit types have potential for increased utilization in fresh and processed forms. However, while the large fruit is well utilized locally and even exported by Grenada and to a lesser extent St. Vincent, the miniature fruit remain underexploited. As is the case with many tropical fruits, the availability of fresh miniature golden apple fruits is limited by a short post-harvest shelf-life. In the tropics fruits generally ripen and decay very quickly under ambient conditions, hence miniature golden apples ripen fully under ambient conditions however, deterioration in quality proceeds quickly due to its own innate physiological processes.

Symptoms of quality deterioration include excessive softening and fresh weight loss, the development of external and internal discolourations as well as unacceptable organoleptic attributes, and the onset of pathological decay.

Harvested fruits are living organs and as such they continue to respire and lose water just as before they were harvested. However, such losses are not replaced in a postharvest environment. Internal changes occur in stored fruits which directly affects postharvest quality and these include biochemical changes, as well as changes in texture and in respiration rates among others. It is not possible to improve the quality of produce after harvest but it is possible to reduce the rate of the development of undesirable changes such as loss of cellular integrity, excessive softening, the development of off-flavours and odours which results from senescence and decay. Temperature is the most important environmental factor influencing the deterioration of harvested fruits (Kader, 1992). Most perishable horticultural commodities store longer at temperatures just above 10^0C while at temperatures above the optimum, the rate of deterioration increases twofold to fourfold for every 10^0C rise in temperature (Kader, 1992).

Understanding some of the major physiological processes within harvested fruits, that affect quality, is essential if fruits are to be stored successfully for extended periods. The maintenance of optimum postharvest quality in fruits is dependent on the extent to which shelf-life can be extended by controlling the rates of respiration and ripening, the effects of moisture loss and ethylene production.

Published studies on the large golden apple fruit include those reported by Dualmerie (1994) and Mohammed and Wickham (1996), but there are no published data for the miniature fruit. Accordingly, this study was undertaken to determine respiration and ethylene production rates, chilling sensitivity and organoleptic changes in miniature golden apples during storage.

MATERIALS AND METHODS

Miniature golden apple fruit were hand-harvested from a small orchard in East Trinidad during 1997. Fruit were graded into immature (M1), mature-green (M2) and slightly turning or breaker (M3) according to size and colour. Fruit were placed in single-ply cardboard boxes and transported to the laboratory in the Department of Food Production at the University of the West Indies, St. Augustine within one hour of harvest. Fruit were washed in tap water, then dipped for 3 minutes in 300μg/ml, sodium hypochlorite solution to control surface pathogens and left for 25 minutes in a holding room (21^0C, 73% R.H.) until surface moisture had evaporated. Fruit of all maturity stages were then stored at 9^0C, 21^0C and 31^0C.

Chilling injury, respiratory measurements and ethylene production rates were taken at harvest, then daily while sensory evaluations were done at harvest followed by 2 day storage intervals up to 14 days. Bioelectrical resistance and electrolyte leakage measurements were taken at harvest, followed by 3 day storage intervals up to 12 days.

Fruit respiration was determined by the use of a Finnigan gas chromatograph Model # 9001; (Austin, Texas) which was used to measure simultaneous carbon dioxide (CO_2) and ethylene (C_2H_4) production rates daily. Ethylene was measured using a Flame ionization detector (FID) while carbon dioxide was measured using a Thermal conductivity detector (TCD). Fruit were weighed and incubated in 1-litre air-tight jars for 2 hours. Approximately 0.3 ml of the atmosphere in the jars was withdrawn with a 1.0 ml syringe and injected through a rubber septum in the gas chromatograph with helium as the carrier gas with a flow rate of 25 ml/min. The flow rates of hydrogen and air were 15 ml/min and 175 ml/min respectively. A megabore column of 0.53 mm and 30 m in length were used. The levels of both CO_2 and C_2H_4 were measured and calculated against standard gas mixtures. The lowest concentration or rate of carbon dioxide production that could be detected was 0.01% whereas that of ethylene was 1μg/ml.

Chilling injury (CI) based on external damage was scored on each fruit using a subjective scale: 1 = no damage, 2 = slight damage, 3 = medium damage, 4 = severe damage, 5 = very severe damage. The CI index was calculated according to the formula used by Pesis *et al.,* (1994).

$$\text{CI Index} = \frac{\sum_{0}^{5} (\text{injury level}) \times (\text{number of fruit at this level})}{\text{total number of fruit}}$$

Bioelectrical resistance (BER) was determined with an Osmose resistance meter (OZ-86 Shigometer) (Lougheed *et al*., 1981). Electrolyte leakage (EL) was measured using a Fisher Conductivity Meter (Model 152, Pittsburg, N.J.) and was determined using three 4 mm x 9 mm width disks weighing a total of 1 gram which were first washed in 20 ml of de-ionized water then shaken at 200 cycles per minute in 30 ml of 0.3M mannitol, as described by Cabrera and Saltveit (1990) using a Lab-line Orbit environ-shaker (Model 3528-5, Melrose Park, IL.) and was expressed as a percentage of the total conductivity after boiling.

Marketable quality was rated for each fruit using the following subjective scale 1= very poor quality, 2= poor quality, 3= moderate quality, 4= good quality and 5= excellent. The number of fruit with a rating of 3 and above were used to calculate percentage marketable fruit.

Comparative sensory evaluations for texture, aroma and flavour were performed using a 20 member semi-trained panel. Panelists used a modified hedonic scale of 1-5 with 1 representing unacceptable, 2-slightly acceptable, 3-acceptable (limit), 4-very acceptable and 5 extremely acceptable (Ranganna, 1986).

Severity of decay was rated on each fruit using the following subjective scale 1=no decay, 2=slight, 3=moderate, 4=severe and 5=complete breakdown. The incidence was reported as the percentage of fruit exhibiting a severity rating >1. To determine the major pathogen responsible for decay, samples from the advancing edge of the lesion were removed and cultured in a sterile environment on potato dextrose (PDA) agar plates. Subculturing was done on cornmeal agar until a pure culture with three isolated colonies were obtained. Pathogens associated with decayed fruit were identified by examination of the fruiting bodies under the light microscope (Brathwaite, 1981).

This experiment consisted of a completely randomized design with a factorial arrangement of variables. Each treatment was replicated three times with each replicate consisting of 10 fruit. Data were subjected to Analysis of Variance, using GENSTAT (Genstat 5.0, 1995) and the levels of significance determined by the F-test. Comparison of the means using the least significant difference (LSD) method was done at the 5% level, where applicable, in addition to the determination of correlation coefficients using MINITAB (Minitab Inc.,1991).

RESULTS AND DISCUSSION

Percentage marketable fruit

The quality of miniature golden apple fruit deteriorated over time ($P<0.001$) irrespective of storage temperature, resulting in declines in percentage marketable fruit (Figures 1A-C). Quality deterioration in fruit was generally evidenced by increased respiration and ethylene production rates as well as decay, tissue browning and degreening. Deterioration was more rapid in less mature fruit during storage at 9°C and 21°C but there was no influence of maturity on shelf life for fruit stored at 31°C as deterioration was extremely rapid for all stages of maturity (Figure 1C). At 21°C mature green and turning fruit storing relatively well for up to 8 days whereas at 9°C, fruit marketability was limited by the development of chilling injury with time (Figure 1A).

Respiration (CO_2) and ethylene (C_2H_4) production rates

Respiration rates remained very low in fruit of all maturity stages stored at 9°C for 12 days, beyond which major increases occurred. By this time both senescence and chilling injury symptoms were well established (Figure 1D). At 21°C and 31°C, respiration rates increased over time, typical of a climacteric fruit, with ripening occurring in mature-green and turning fruit and the attainment of climacteric peaks within 3-6 days (Figures 1E-F). Increases in respiration rates in immature fruit were attributed to senescence.

Ethylene was only detected at 21°C and 31°C and increased over time in fruit at all maturity stages (Figures 2A-B & Table 1). In immature fruit the rise in the rate of ethylene production occurred beyond 4 days and coincided with an elevated respiration rate and external evidence of senescence. In mature-green and turning fruit the rise in the rate of ethylene production occurred beyond days 5 and 4 respectively and coincided with increased respiration rates (Figures 1E-F and 2A-B).

Chilling injury index, bioelectrical resistance and electrolyte leakage

Fruit stored at 9°C developed chilling injury over time, but, while immature fruit had very severe injury beyond 10 days and mature-green fruit had moderate injury, turning fruit had only slight chilling injury (Figure 3). Chilling injury was evidenced by skin pitting (CI index), elevated respiration rates and electrolyte leakage (EL), as well as reduced bioelectrical resistance (BER). Immature fruit stored at 9°C had evidence of slight chilling injury from day 4 and symptoms became very severe one week later. Severe chilling injury damage was evidenced by extensive skin pitting accompanied by fruit showing the highest respiration rates beyond day 12 and the highest EL during storage and generally lower BER compared to turning fruit throughout (Tables 1 & 2). Both objective measurements BER and EL are commonly used as indicators of losses in membrane integrity in chilled-stressed tissues in many fruit.

Lougheed *et al.* (1981) and Mohammed and Wickham (1996) reported a similar inverse relationship between EL and BER, with the latter observing the same in golden apple fruit of the large type. An inverse relationship ($P<0.05$) was found to exist between BER and EL in immature fruit with $r = -0.469$. The equation which best described the relationship was $y = 4.44 + 1.29x$. Pitting of the skin in miniature golden apples was similar to that described by Abe *et al.* (1974) in eggplant which was attributed to the collapse of cells located several layers beneath the fruit surface.

Sensory evaluation (flavour, aroma and texture)

The production of aroma volatiles was greater in turning fruit than mature-green fruit at the two higher temperatures (Tables 2 & 3). At all three storage temperatures, turning fruit received the highest texture ratings throughout this study. Mature-green fruit received higher ratings than immature fruit up to 4 days at 21°C and 31°C and beyond 6 days at 9°C. Acceptable ratings for flavour were only given to mature-green and turning fruit (Tables 2 & 3). Mature-green and turning fruit at 21°C and 31°C were given acceptable organoleptic ratings for flavourdue to occurrence of ripening and accompanying changes those fruit ripening. At 9°C mature-green and turning fruit also received acceptable flavour ratings and this could be attributed to their advanced stage of maturation.

Decay

Decay only occurred in fruit stored at 21°C and 31°C after about 7 days resulting in termination of storage after 8 days (Table 4). The major fungus responsible for fruit decay was of the *Asteromella* spp.

CONCLUSION

Based on this study, it was concluded that the miniature golden apple is a climacteric fruit with simultaneous increases in CO_2 and C_2H_4 production rates occurring during storage at 21°C and 31°C. Also as is quite common for many tropical fruit, this fruit was found to be highly susceptible to chilling injury during storage at 9°C, however, injury was less severe in fruit of greater maturity.

ACKNOWLEDGEMENTS

The authors are grateful to the Campus Committee for Graduate Studies and Research of the University of the West Indies (St. Augustine) for providing the funding for this study. Special mention must also be made of several individuals whose assistance made this study possible namely Mr. Bruce Lauckner, Statistician at CARDI U.W.I. Campus St. Augustine, and Mr. K. John and S. Ali, Laboratory Technicians, for their invaluable assistance.

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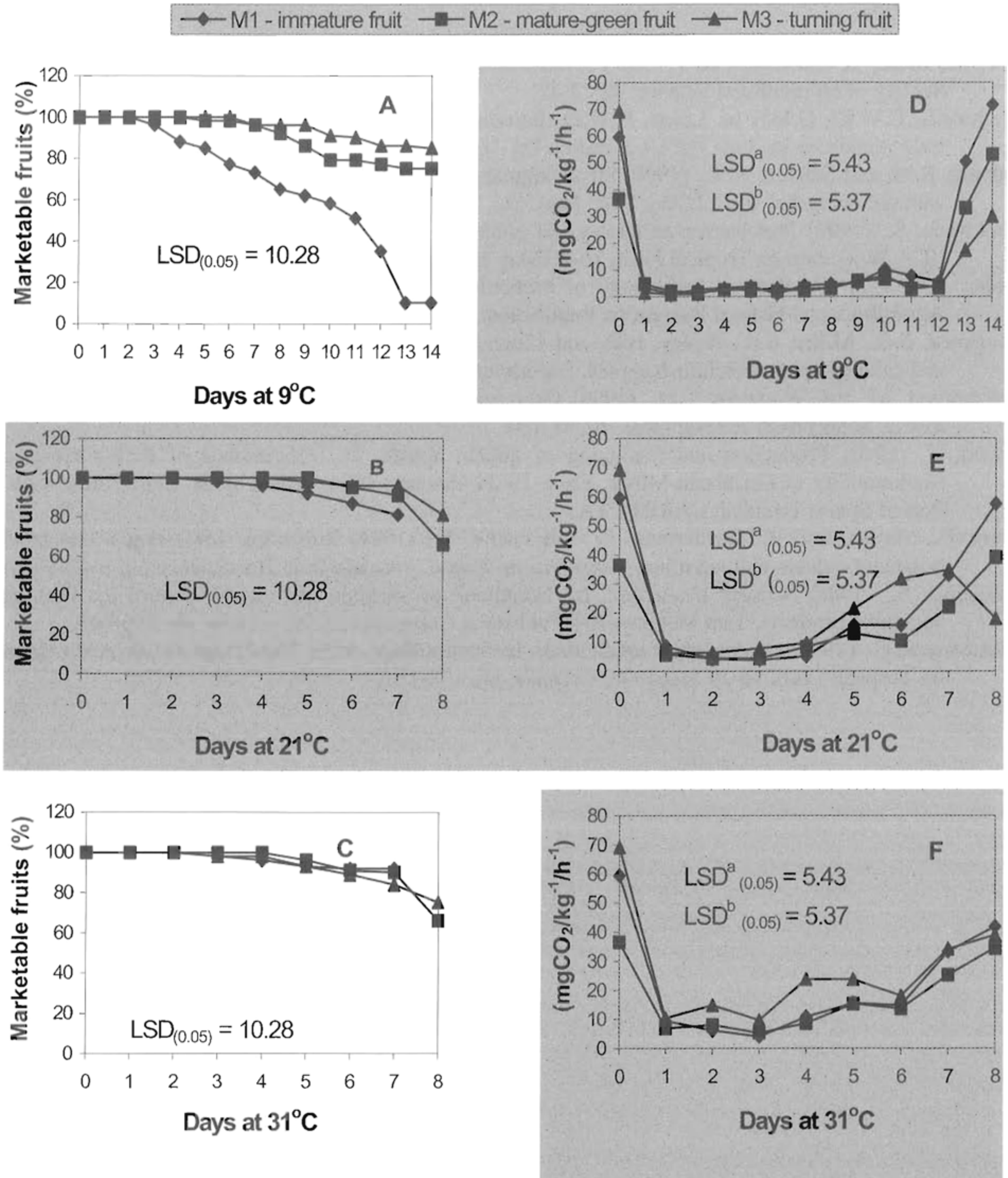

Figure. 1. Changes in percentage marketable fruit and respiration rates of miniature golden apple fruit at different storage temperatures and durations LSD: over time[a] while across maturity stages and temperature on the same day[b]. Level of significance (P<0.001).

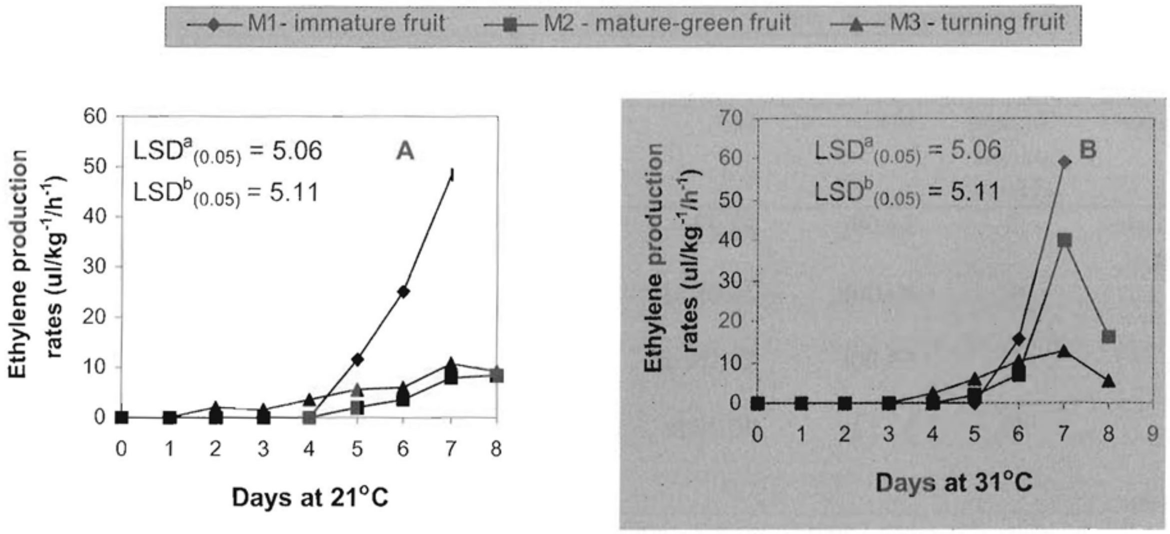

Figure 2. Changes in ethylene production rates in miniature golden apple fruit after 8 days of storage at 21°C and 31°C. LSD:over time[a] while across maturity stages and temperatures on the same day [b]. Level of significance (P<0.001).

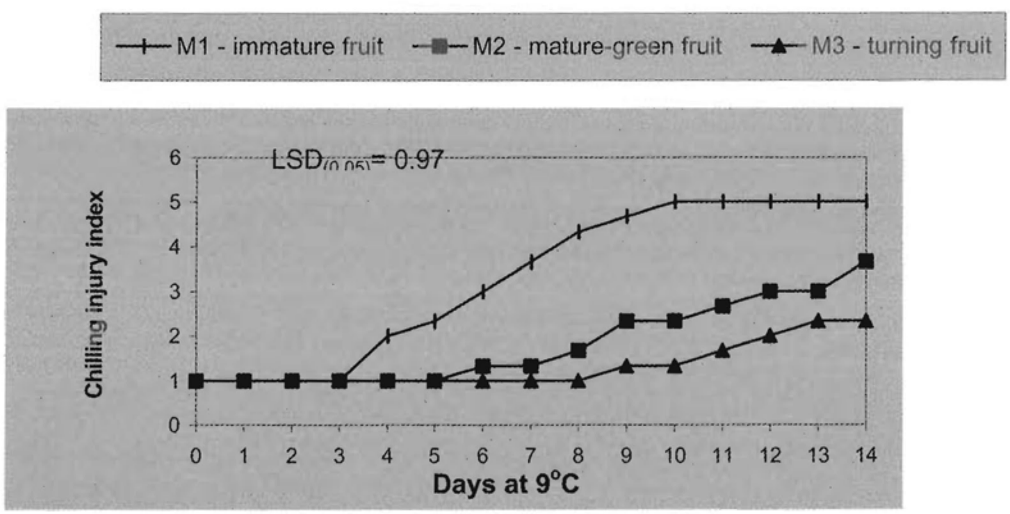

Figure. 3. Interaction effects of storage duration x temperature x maturity on the chilling injury index of miniature golden apple fruit stored for 14 days. Level of significance was (P<0.001).

Table 1. Interaction effects of storage period x temperature x maturity on electrolyte leakage in miniture golden apples during storage at 9C and 21C for 12 days.

		Temperature					
		9C			21C		
Parameter	Storage period (Days)	M1	M2	M3	M1	M2	M3
Electrolyte leakage)	3	34.00g [y]	22.32c	17.28b	10.00a	23.92cd	29.76ef
	6	48.00h	24.08cd	17.60b	10.08a	74.08k	90.88l
	9	55.00i	26.16cde	27.84de	ND [x]	ND	ND
	12	67.12j	27.28de	33.00fg	ND	ND	ND
LSD $_{(0.05)}$				4.17			

[y] Means followed by the same letter(s) are not significantly different ($P<0.05$), [x] ND=no data, due to fruit decay. Prestorage electrolyte leakage M1=11.47, M2=20.67, M3=17.03. M1 (immature fruit, M2 (mature-green fruit), M3 (turning fruit).

Table 2. Main effects of storage duration, temperature, and fruit maturity on the bioelectrical resistance and flavour of stored minitature golden apple fruit.

Treatments	Bioelectrical resistance (kilohms)[x]	Flavour
Days (D)		
0	58.08b[y]	1.00a
1		
2		1.96b
3	63.92b	
4		2.00b
5		
6	58.00b	2.33b
7		
8		2.81b
9	45.25a	
10		2.33b
11		
12	39.00a	2.11b
13		
14		2.11b
15		
$LSD_{(0.05)}$	10.56	0.49
Temperature C (T)		
8-10 T1	55.50a[y]	2.08a
20-22 T2	58.72a	2.42a
30-32 T3	-	2.28a
$LSD_{(0.05)}$	4.02	0.39
Maturity (M)		
Immature M1	47.03a[y]	1.02a
Mature-green M2	48.57a	1.81b
Turning M3	58.75b	3.46c
$LSD_{(0.05)}$	5.98	0.58
Statistical significance		
Day (D)	*	*
Temperature (T)	NS	NS
Maturity (M)	*	**
D x T	NS	*
D x M	NS	**
T x M	NS	NS
D x T x M	NS	*

[y] Means followed by the same letter(s) are not significantly different (P<0.05), [x]ND no data due to fruit decay. Prestorage electrolyte leakage M1=11.47, M2=20.67, M3=17.03. M1 (immature fruit, M2 (mature-green fruit), M3 (turning fruit). [x] Measurements only taken on days 0, 3, 6, 9, and 12.

Table 3. Interaction effects of storage duration x temperature x maturity on the texture and aroma of miniature golden apples stored for 14 days.

		9C			21C			31C		
Parameters	Storage Duration (Days)	M1	M2	M3	M1	M2	M3	M1	M2	M3
Texture	2	1.00a [y]	2.33d	3.33ef	1.33ab	2.33c	3.00de	1.00a	2.33c	3.67fg
	4	1.00a	1.33ab	3.33ef	1.33ab	2.33c	3.67fg	1.00a	1.33ab	4.00gh
	6	1.00a	1.00a	4.00gh	1.00a	3.00de	3.33ef	1.00a	3.33ef	4.33h
	8	1.00a	1.67b	4.33h	ND [x]	3.00de	4.00i	ND	3.00de	3.33ef
	10	1.00a	2.67ed	4.33h	ND	ND	ND	ND	ND	ND
	12	1.00a	3.33ef	4.00gh	ND	ND	ND	ND	ND	ND
	14	1.00a	3.00de	3.67fg	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$						0.48				
Aroma	2	1.00a	1.00a	2.00b	1.00a	1.00a	2.33c	1.00a	1.00a	2.67d
	4	1.00a	1.00a	2.00b	1.00a	1.00a	3.00d	1.00a	1.00a	2.00b
	6	1.00a	1.00a	2.00b	1.00a	3.33f	3.67g	1.00a	2.00b	3.00e
	8	1.00a	1.00a	2.00b	ND	3.00d	3.67g	ND	3.00e	4.00h
	10	1.00a	1.00a	2.00b	ND	ND	ND	ND	ND	ND
	12	1.00a	1.00a	2.00b	ND	ND	ND	ND	ND	ND
	14	1.00a	1.00a	2.00b	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$						0.25				

[y] Means followed by the same letter(s) are not significantly different ($P<0.05$), [x]ND no data due to fruit decay.

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RESPIRATION AND ETHYLENE PRODUCTION RATES OF CHILI PLUMS (*SPONDIAS PURPUREA* L) DURING STORAGE

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ABSTRACT: The chili plum is found throughout the Caribbean and Central American regions and is consumed in the fresh and processed states. Respiration and ethylene production rates were determined in fruit harvested at three different stages of maturation (immature, mature-green and turning) when stored up to 14 days at 4-5°C, 9-10°C, 20-21°C and 30-31°C. In a second experiment (experiment two), respiration and ethylene production rates were again determined however in fruit harvested at six different stages of maturity (very immature, immature, mature-green, turning, half-ripe and full-ripe) when stored up to 9 days at 9-10°C and 20-21°C. At 9-10°C, respiration rates declined in all fruit within 2 days with half-ripe fruit having the highest respiration rates by day 3. From days 3-5, while respiration rates declined for half-ripe and turning fruit, it increased for very immature, immature and mature-green fruit, then declined. At 20-21°C, half-ripe fruit exhibited more pronounced climacteric peaks than mature-green and turning fruit. Half-ripe and turning fruit exhibited climacteric peaks of respiration after 3 days while mature-green fruit did so one day later. Fruit underwent the post-climacteric respiratory phase within 24 hours after attaining their climacteric peaks. Ethylene was only detected at 20-21°C with peak production rates coinciding with the post-climacteric phase for full-ripe and turning fruit. Respiration and ethylene production rates of the chili plum were typical of a climacteric fruit.

INTRODUCTION

The chili plum (*Spondias purpurea* L) is a popular fruit in the Caribbean and Central and South America regions. Common names include 'Moyo', 'Sta Roseno', and 'Jismoyo' among others (Barbeau, 1994). A member of the Anacardiaceae family, the tree normally grows to about 3-10 meters in height. The leaves are usually 2.5 - 6.5 cm long with 5 - 23 leaflets.

In the Caribbean, fruiting occurs between the months of September to November (Adams, 1972). This smooth and shiny ellipsoid drupe measures 2.5 – 4.0 cm in length and 1.5 - 2.5 cm in diameter and ripens rapidly (2-3 days under ambient conditions) from the mature-green stage (Barbeau, 1994).

Although this fruit is widely consumed in both the fresh and processed states, there is an increasing demand for the fruit at both the immature and mature stages for use in processed forms that have great potential for the export market. There is generally a lack of published information on the postharvest behaviour of this fruit. While studies have been reported on freshly harvested chili plums pertaining to total soluble solids and total titratable acids content (Pilgrim, 1994) there are no published data on important physiological features such as respiratory behaviour and ethylene production rates during the storage of the fruit. Such information is essential if effective postharvest handling and storage techniques are to be established for this fruit. Although it is not possible to improve the quality of produce after harvest, effective postharvest handling and storage techniques can be used to reduce the rate of the onset of undesirable changes such as loss of cellular integrity, excessive softening, the development of off-flavours and odours which result from senescence and fruit decay.

Accordingly a study was conducted to examine the respiratory behaviour, ethylene production rates, chilling sensitivity and organoleptic changes in chili plums during storage at refrigerated and non-refrigerated temperatures.

MATERIALS AND METHODS

Chili plums were hand-harvested and graded into immature (M1), mature-green (M2) and slightly turning or breaker (M3) according to size, colour and apparent maturity. Fruit were placed in single-ply cardboard boxes and transported to the laboratory in the Department of Food Production at the University of the West Indies, St. Augustine within three (3) hours of harvest. Fruit were washed in tap water then dipped for 2 minutes in 200 ppm, sodium hypochlorite solution to control surface pathogens. Fruit were spread in a single layer and left for 20 minutes in an air-conditioned room (20-21^{0}C, 70-75 % relative humidity) until surface moisture had evaporated.

In the first study (experiment one) blemish-free fruit were stored at 4–5^{0}C (T1), 9–10^{0}C (T2), 20–21^{0}C (T3) and 30–31^{0}C (T4). Respiratory measurements, ethylene production rates, percentage marketable fruit, sensory quality, chilling injury and decay were assessed at harvest, and followed by daily assessments for up to 15 days.

Fruit respiration was determined by the use of a Finnigan gas chromatograph Model # 9001; (Austin, Texas) which was used to measure simultaneous carbon dioxide (CO_2) and ethylene (C_2H_4) production rates daily. Ethylene was measured using a Flame ionization detector (FID) while carbon dioxide was measured using a Thermal conductivity detector (TCD). Fruit were weighed and incubated in 1-litre air-tight high density jars for 2 hours. Approximately 0.3 ml of the atmosphere in the jars was withdrawn with a 1.0 ml syringe and injected through a rubber septum in the gas chromatograph with helium as the carrier gas with a flow rate of 25 ml/min. The flow rates of hydrogen and air were 15 ml/min and 175 ml/min respectively. A megabore column of 0.53 mm and 30 m in length were used. The levels of both CO_2 and C_2H_4 were measured and calculated against standard gas mixtures. The lowest concentration or rate of carbon dioxide production that could be detected was 0.01% whereas that of ethylene was 1µg/ml.

Comparative sensory evaluations for flavour were performed using a 20 member semi-trained panel. Panelists used a modified hedonic scale of 1-5 with 1 representing unacceptable, 2-slightly acceptable, 3-acceptable (limit), 4-very acceptable and 5 extremely acceptable (Ranganna, 1986).

Chilling injury (CI) based on external damage was scored on each fruit using a subjective scale: 1 = no damage, 2 = slight damage, 3 = medium damage, 4 = severe damage, 5 = very severe damage. The CI index was calculated according to the formula used by Pesis *et al.,* (1994).

$$\text{CI Index} = \sum_{0}^{5} \frac{(\text{injury level}) \times (\text{number of fruit at this level})}{\text{total number of fruit}}$$

Severity of decay was rated on each fruit using the following subjective scale 1=no decay, 2=slight, 3=moderate, 4=severe and 5=complete breakdown. The incidence was reported as the percentage of fruit exhibiting a severity rating >1. Marketable quality was rated for each fruit using the following subjective scale 1= very poor quality, 2= poor quality, 3= moderate quality, 4= good quality and 5= excellent. The number of fruit with a rating of 3 and above were used to calculate percentage marketable fruit.

During a second study (experiment two) fruit were harvested, graded, transported to the laboratory and washed as described previously. However, based on observations of very severe chilling injury during storage at 4-5^{0}C and extensive decay at 30-31^{0}C during the first study, fruit were stored at intermediate temperatures, (9-10^{0}C and 20-21^{0}C). Additionally during this study six maturity stages were used. Fruit were classified as (M1) very immature, (M2) immature, (M3) mature-green, (M4) slightly turning or breaker, (M5) half-ripe and (M6) full-ripe, according to size, colour and apparent maturity.

Respiratory measurements, ethylene production rates, sensory evaluation and decay were assessed again at harvest (day 0) and subsequently at 1 day intervals up to 8 days by the methods previously described.

Both experiments were of a completely randomized design with a factorial arrangement of variables. Each treatment was replicated three times with each replicate consisting of 10 fruit. Data were subjected to Analysis of Variance, using GENSTAT (Genstat 5.0, 1995) and the levels of significance determined by the F-test. Comparison of the means using the least significant difference (LSD) method was done at the 5% level, where applicable.

RESULTS

Percentage marketable fruit

Irrespective of storage temperature, the quality of chili plum fruit declined over time ($P<0.001$) resulting in comparative reductions in percentage marketable fruit. Increased softening and respiration rates as well as external discolourations paralleled reductions in quality and percentage marketable fruit. Less mature fruit generally had higher rates of quality deterioration, while storage of fruit at 20-21°C, 9-10°C and 4-5°C delayed quality deterioration compared to fruit stored at ambient temperature (Figures 1A-D). There were no marketable turning fruit beyond 9 and 11 days at 4-5°C and 9-10°C respectively due to excessive fruit softening. After 15 days at 9-10°C, 85% of mature-green fruit appeared marketable whereas only 42% of immature fruit appeared marketable (Figures 1A-B). However, despite this, all fruit stored for 15 days at this temperature developed chilling injury. Upon transfer to 20-21°C for 2 days chilling injury was manifested in mature-green fruit as tiny pits that coalesced into larger depressed areas with a definite brown discolouration.

Respiration (CO_2) and ethylene (C_2H_4) production rates

In experiment one, the respiration rates for fruit at all three maturity stages stored at 4-5°C and 9-10°C, remained very low throughout storage (Figures 2A-B). Generally CO_2 production rates increased ($P<0.001$) over time in fruit stored at 20-21°C and 30-31°C (Figures 2C-D). At these temperatures, ripening occurred in mature-green and turning fruit where as senescence was observed in immature fruit.
In experiment two, CO_2 production rates declined ($P<0.001$) in all fruit after 2 days at 9-10°C with full-ripe fruit having higher CO_2 production rates thereafter than immature, mature-green, turning and half-ripe fruit (Figure 3A). Between days 3-5, CO_2 production rates increased for immature and mature-green fruit, but declined for turning and half-ripe fruit (Figure 3A). At 20-21°C, immature fruit and half-ripe fruit exhibited a more pronounced climacteric peak than mature-green (M3) and turning fruit (Figure 3B). The respiratory climacteric observed in very immature to half-ripe fruit was notably absent in full-ripe as there were ($P>0.001$) reductions in CO_2 production rates for full-ripe fruit throughout this study (Figure 3B). In experiment two, C_2H_4 production rates also increased ($P<0.001$) for immature, mature-green and turning fruit, peaking between 3-5 days of storage at 20-21°C followed by a rapid decline (Figure 3C). Peak C_2H_4 production rates preceded peak CO_2 production rates for immature and turning fruit (Figures 3B-C).

Flavour

Organoleptic evaluations indicated that only mature-green and ripened fruit were acceptable in terms of flavour throughout, during both experiments (Figures 4A-D).

Chilling injury (CI)

Chilling injury (pitting) developed in all fruit stored at 4-5°C and 9-10°C after 4 days (experiment one). Symptoms were most evident in immature fruit and least in turning fruit (Figures 4E-F). Mature-green fruit stored at 9-10°C for 15 days followed by 2 days at 20-21°C developed moderate chilling injury (Figure 4E). Immature fruit, on the other hand, showed symptoms of severe chilling injury (Figures 1B and 4F). Mature-green fruit stored continuously for 15 days at 4-5°C, then transferred to 20-21°C for 1 day, exhibited severe chilling injury symptoms with tiny pits that coalesced into larger depressed areas and had a definite brown discolouration. The same occurred in mature-green fruit stored at 9-10°C for 15 days upon transfer at 20-21°C for 2 days.

Decay

Storage of fruit at 9-10°C greatly reduced pathological decay (Tables 1 & 2). All fruit stored at 20-21°C and 30-31°C were decayed by day 8 and decay was generally more prevalent and rapid in mature than immature fruit (Tables 1 & 2).

DISCUSSION

During this study, storage of chili plum fruit at reduced temperatures (4-5°C and 9-10°C) resulted in the development of chilling injury and loss of marketability. While mature-green fruit stored at 9–10°C for 15 days followed by 2 days at 20-21°C had symptoms of moderate chilling injury, immature fruit had symptoms of severe chilling injury and there were no marketable turning fruit beyond 9 and 11 days at 4-5°C and 9-10°C respectively because of excessive softening. Mature-green fruit stored continuously for 15 days at 4-5°C upon transfer at 20-21°C for 1 day developed severe chilling injury symptoms such as extensive brown discolourations.

Storage of fruit at 4-5°C and 9-10°C inhibited ripening and associated changes, thereby reducing the rates of respiration and C_2H_4 production and also pathological decay. However, during storage at 20-21°C and 30-31°C fruit ripening occurred with CO_2 production rates increasing two to three-fold over time in mature fruit, identifying the chili plum as a climacteric fruit. The respiratory pattern of the chili plum was typical of a climacteric fruit. Half-ripe fruit exhibited a more pronounced climacteric peak than mature-green and turning fruit. Similar reports were made by Roux (1940) with temperate plums (*Prunus* spp). A similar trend to that of CO_2 production rates was observed with C_2H_4 production rates in the chili plums stored at 20-21°C and 30-31°C as C_2H_4 production rates also increased over time due to the onset of ripening in mature fruit and senescence in immature fruit.

Organoleptic evaluations generally indicated that only mature-green and ripened fruit were acceptable in terms of flavour. There were no marketable fruit after 8 days for all 3 maturity stages stored at 20-21°C and 30-31°C as a result of extensive decay. Decay was generally more prevalent and rapid in mature plums than immature. A reduction of natural resistance of tissues to pathogen attack with increasing maturity has been previously reported by Ingham (1973).

Based on the findings of this study, it was concluded that the chili plum is a climacteric fruit and that it is highly susceptible to chilling injury.

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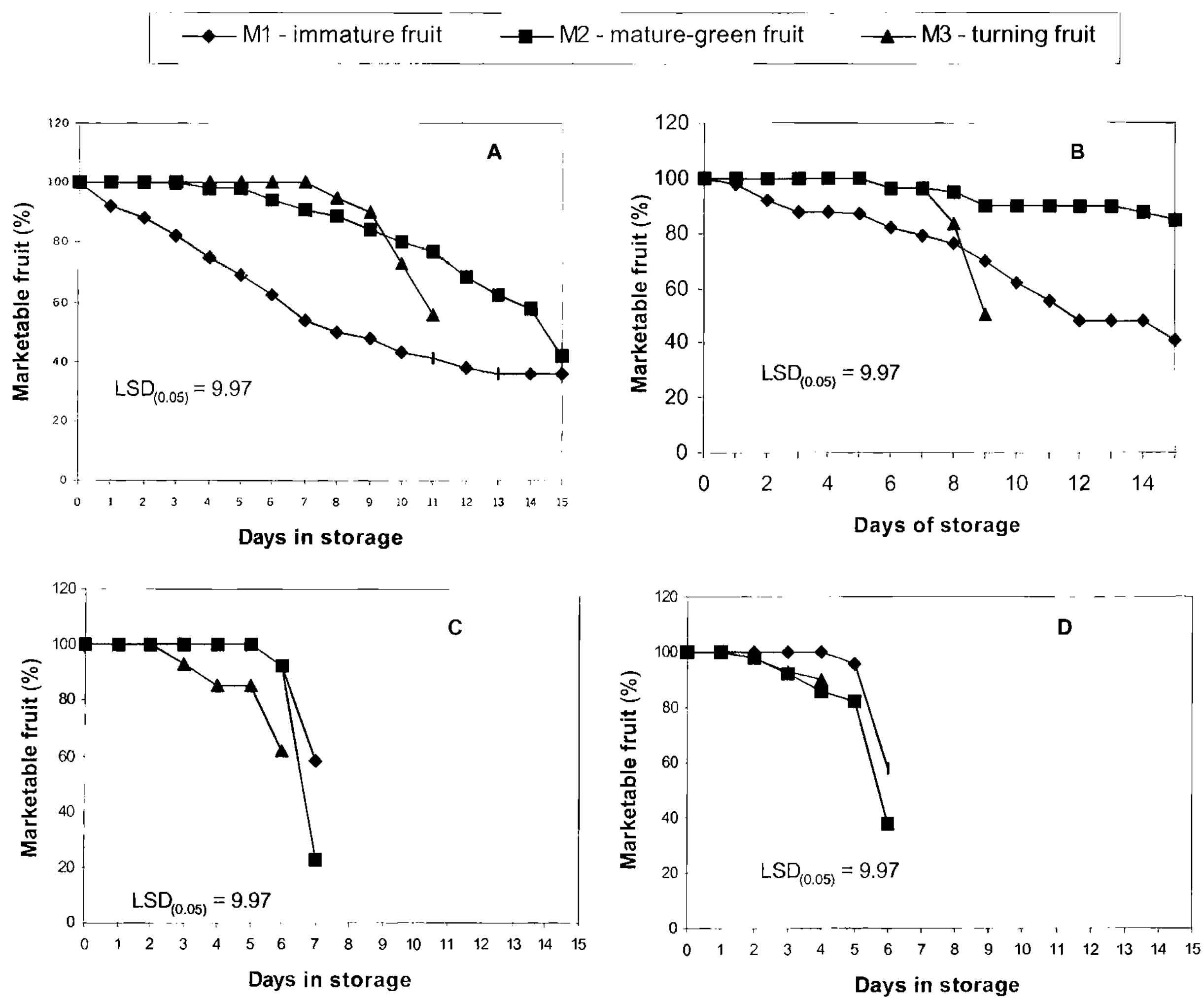

Figure 1. Percentage marketable chili plum fruit during storage for 15 days.
(A) Fruit stored at 4-5°C, (B) fruit stored at 9-10°C, (C.) fruit stored at 20-21°C and (D) fruit stored at 30-31°C. Level of significance (P<0.001).

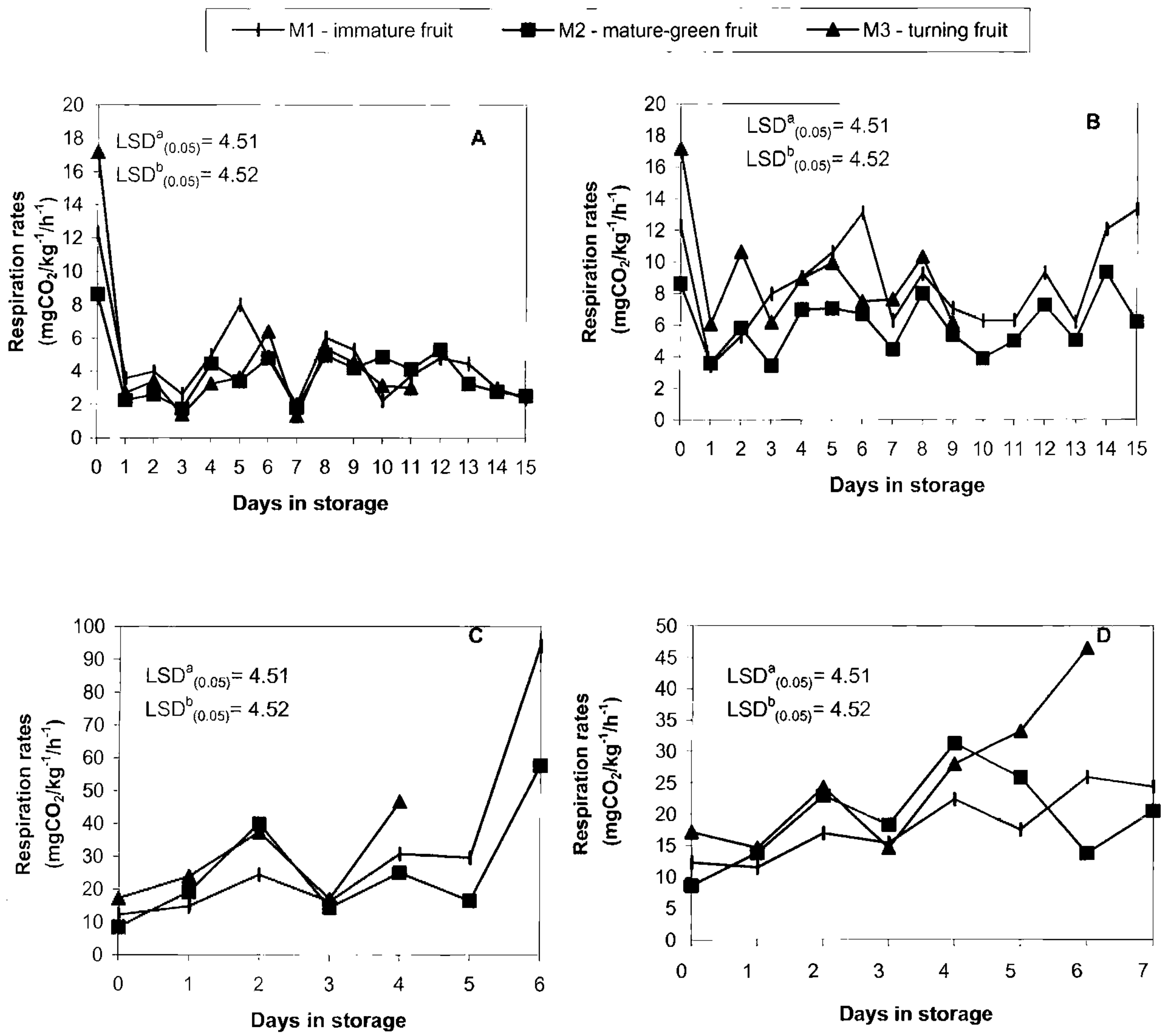

Figure 2. Changes in the respiration rates of chili plums during storage at different temperatures. (A) Fruit stored at 4-5°C, (B) fruit stored at 9-10°C, (C.) fruit stored at 20-21°C and (D) fruit stored at 30-31°C. LSD: over time[a] while across maturity stages and temperatures on the same day[b]. Level of significance ($P<0.001$).

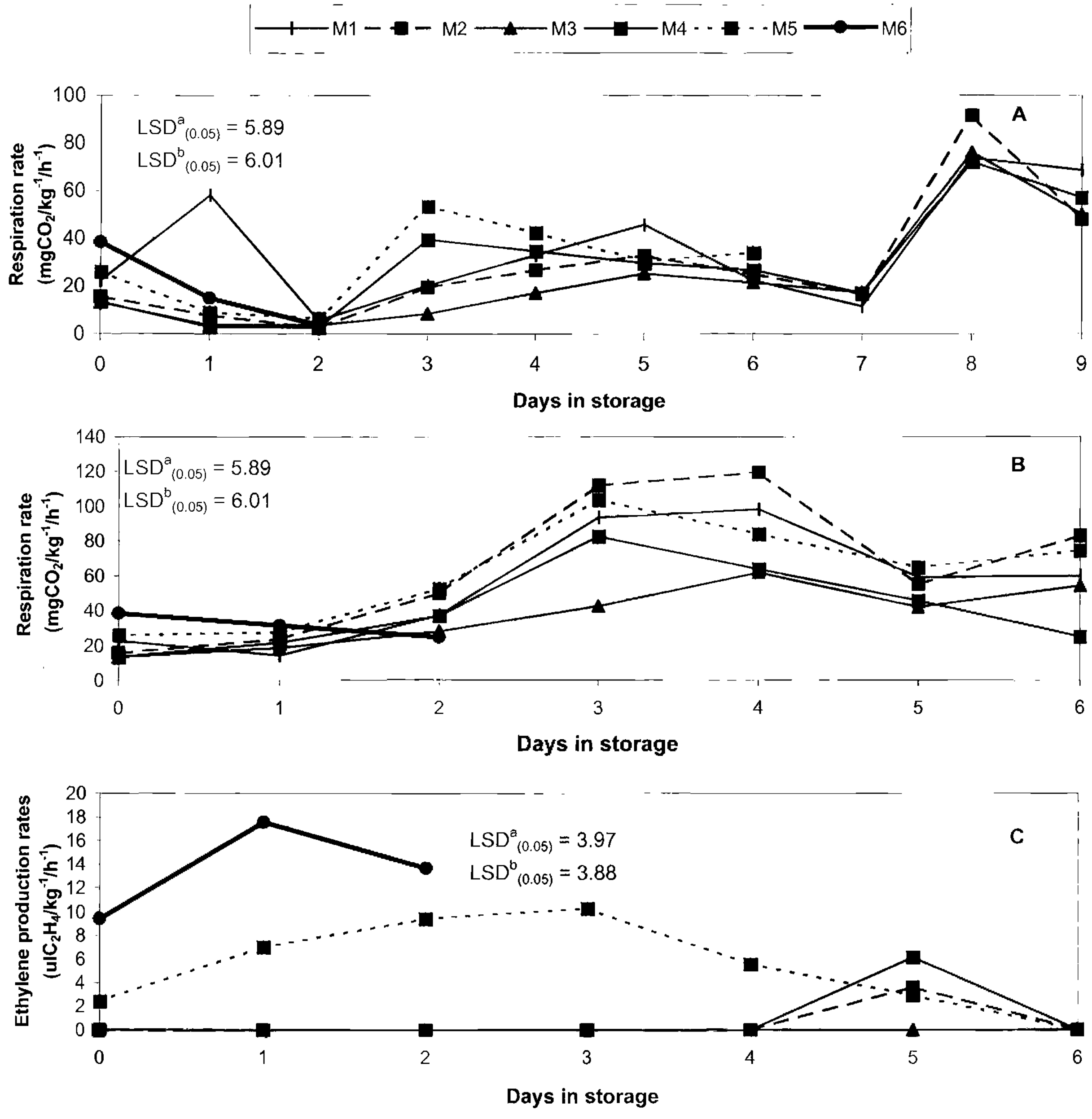

Figure 3. Changes in the respiration and ethylene production rates of chili plum fruit during storage. (A) Fruit stored at 9-10°C, (B) fruit stored at 20-21°C and (C.) fruit stored at 20-21°C. LSD: over time[a] while across maturity stages and temperatures on the same day[b]. M1= very immature fruit, M2= immature fruit, M3= mature-green fruit, M4= turning fruit, M5 = half-ripe fruit and M6 = full-ripe fruit. Levels of significance were ($P<0.001$) for respiration and ethylene production rates respectively.

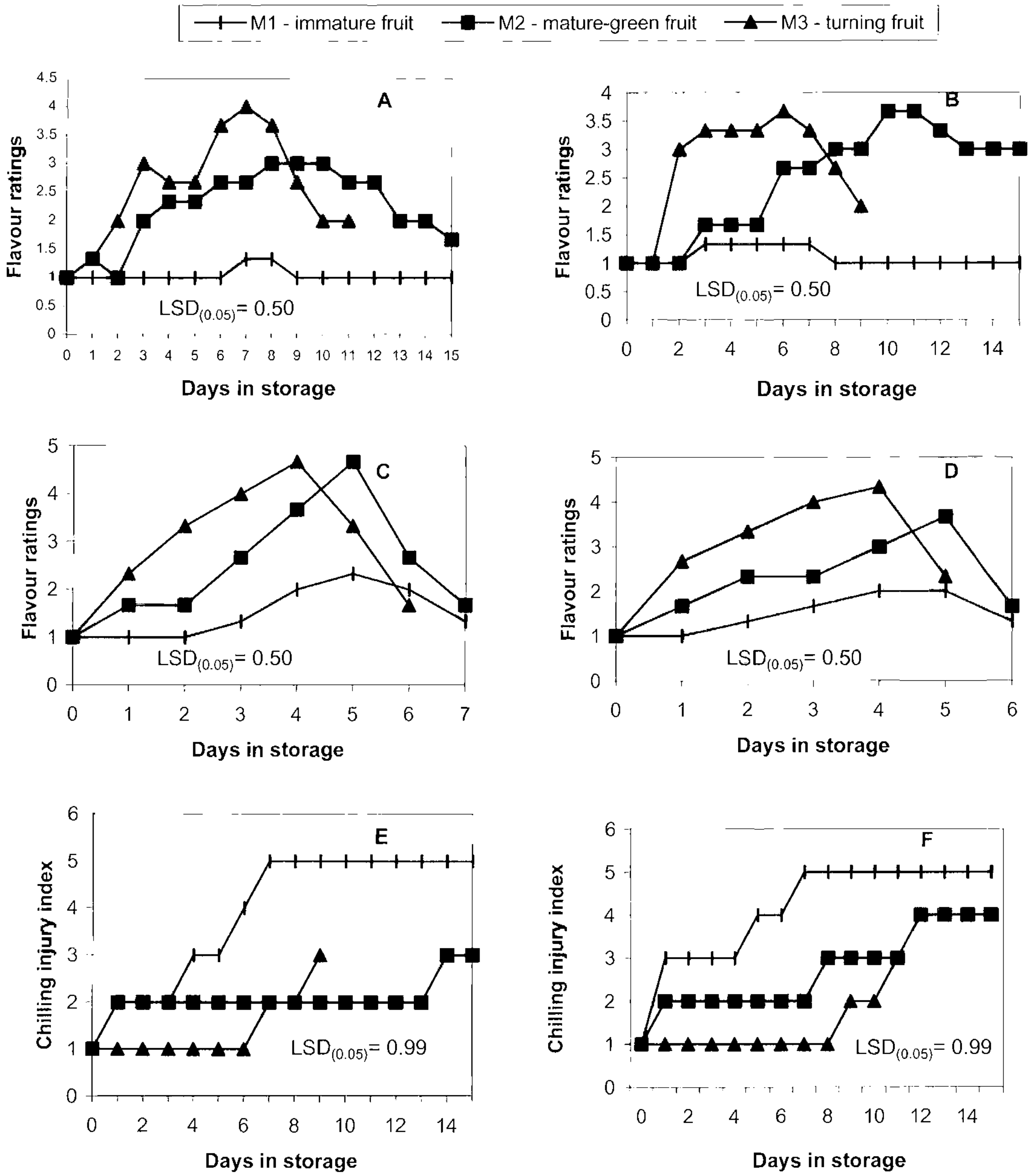

Figure 4. Changes in the flavour ratings and chilling injury index of chili plums during storage. (A) Fruit stored at 4-5°C, (B) fruit stored at 9-10°C, (C.) fruit stored at 20-21°C, (D) fruit stored at 30-31°C, (E) fruit stored at 4-5°C and (F) fruit stored at 9-10°C. Levels of significance were ($P<0.05$) and ($P<0.001$) for flavour and chilling injury respectively.

Table 1. Interaction effects of storage duration x temperature x maturity on decay incidence in chili plums stored at 20-21°C and 30-31°C for 8 days.

Parameter	Storage period Days)	Temperature (°C)					
		20 – 21			30 – 31		
		M1	M2	M3	M1	M2	M3
Decay (%)	4	0	0	13.33ab	0	20.00bc	13.33ab
	5	0	0	13.33ab	6.70a	20.00bc	26.70c
	6	13.33ab	13.33ab	40.00d	53.30e	73.30f	86.70g
	7	46.70de	73.30f	86.70g	100h	100h	100h
	8	100h	100h	100h	100h	100h	100h
$LSD_{(0.05)}$				11.37			

[Y] Means followed by the same letter(s) are not significantly different ($P<0.05$).
M1 = immature fruit, M2 = mature-green fruit and M3 = turning fruit.

Table 2. Interaction effects of storage duration x temperature x maturity on decay incidence in chili plum fruits stored at 9-10°C and 20-21°C, respectively.

Parameter	Storage period (Days)	Temperature (°C)							
		9 - 10		20 - 21					
		M5	M6	M1	M2	M3	M4	M5	M6
Decay (%)	2	0	0	0	0	0	0	0	16.67a
	3	16.67a	100f	0	0	0	0	33.33b	100f
	4	16.67a	100f	0	0	0	0	33.33b	100f
	5	16.67a	100f	0	0	0	0	60.00d	100f
	6	62.33d	100f	0	46.67c	26.67ab	46.67c	86.67e	100f
	7	100f	100f	100f	100f	100f	100 f	100 f	100f
$LSD_{(0.05)}$					13.17				

[Y] Means followed by the same letter(s) are not significantly different ($P<0.05$).
M1 = very immature fruit, M2 = immature fruit, M3 = mature-green fruit
M4 = turning fruit, M5 = half-ripe fruit and M6 = full-ripe fruit.

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ELEVAGE MARTINIQUAIS : LA DEMARCHE QUALITE: EXEMPLE DE L'ÉLEVAGE DU LAPIN DE CHAIR

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RESUMEN: Le consommateur est de plus en plus soucieux de la qualité des produits qu'il achète. Ses interrogations aujourd'hui concernent surtout tout ce qui de près ou de loin a un rapport avec la sécurité alimentaire. Il réclame donc des garanties sur l'origine et surtout sur les conditions de production de ce qu'il consomme. La démarche qualité peut répondre à cette préoccupation. Concernant la filière viande martiniquaise, les éleveurs de bovins, d'ovins caprins, de porcins de volailles et de lapins ont adopté une démarche commune. Cette démarche est soutenue par une interprofession qui rassemble différents acteurs. Il s'agit des producteurs, des distributeurs des importateurs et des transformateurs qui s'engagent à respecter la réglementation en vigueur et un cahier des charges rigoureux. Les principaux critères du cahier des charges sont pour la production : l'origine des animaux, la conduite sanitaire et d'élevage, l'alimentation , les condition d'abattage et celles du transport de la viande. L'éleveur est le premier maillon de la démarche qualité qui se poursuit jusqu'à la commercialisation de viande. Ainsi pour les filière d'élevage des engagements respectifs entre éleveurs, coopératives et groupements d'élevage, distributeurs, sont présentés au sein d'une charte interprofessionnelle. Ce document à pour objectif de proposer au consommateur une production régulière et de qualité. Un autre de ses buts est de dynamiser le secteur de l'élevage en assurant le maintien du cheptel local. Enfin, autre finalité recherché l'amélioration du revenu de l'éleveur. Des fonds nationaux et européens viennent consolider la démarche. L'exemple de la filière cunicole, montre un gain de productivité de 18 kg de viande par lapines entre 1995 et 1999, grâce à des investissements adaptés et surtout à une professionnalisation des éleveurs. Pour le secteur de l'élevage du lapin de chair, l'objectif au terme de 6 années de programme d'action est de passer de 9% à environ 30% de couverture de la consommation locale.

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HANDLING PRACTICES, CONSUMER PERCEPTION, AND QUALITY EVALUATION OF FRESH CARITE (*SCOMBEROMORUS BRASILIENSIS*) IN TRINIDAD, WEST INDIES

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ABSTRACT: This investigation provided an overview of the handling practices by individuals involved in the fish trade, consumer perception and quality of fresh carite offered for sale. Landing sites, wholesale and retail markets were visited and face-to-face interviews were conducted with fishermen, wholesalers, retailers and consumers. Microbiological and sensory analyses were performed on whole and gutted fish. All the facilities for handling and trading of fish were grossly under-equipped and in poor hygienic condition. Most consumers viewed whole fish as being 'fresh' and of superior quality compared to eviscerated fish. Fish was of best sensory quality when landed and of worse quality at the retail vendors' stalls. Several recommendations were provided for improvement of quality.

INTRODUCTION

The marine fisheries of Trinidad and Tobago, West Indies (W.I.) are characterised by high diversity in fish species, variety of harvested gear types and fishing fleet. The fishing industry has traditionally been inshore and artisanal. Major pelagic species harvested are carite, kingfish, cavalli, shark, and tuna as well as demersal stocks (Henry, 1997). Carite and king fish are of highest demand for export market and it is estimated that 70% of all carite landings are from the South and Southwestern coast of Trinidad, W.I. namely Moruga and Guayaguayare (Clarke, 1992). Locally, most fish are sold at major landing sites, local markets, roadside stalls or via bicycles and vans (Simon, 1993).

According to Adam (1989), most literature and research on Caribbean fisheries deal with the production and supply of fish, the potential marine resources and their fishing technology. Appropriate methodologies for identifying and addressing post-harvest losses in fisheries have been recognised as a key research priority (Dillon *et al.*, 1997). Freshness is one of the important parameters of quality of fish in most markets and fresh products often achieve a higher price, with the attitude among consumers that 'fresh fish is better' (Sorensen *et al.*, 1997). Assuming that safety is assured, consumers expect fish to be wholesome, and of good overall quality. This study identified the handling practices employed for fresh carite throughout the entire food chain from the fishing vessels, through onshore handling by fishermen, to distribution of fresh fish to the consumers. Consumers' perceptions and quality of fish offered were assessed at sale points.

METHODS

Study area*:* The landing site studied was at Grand Chemin Beach, Moruga (Southern coast of Trinidad, West Indies). It was estimated that 60% of carite and 30% of kingfish are harvested at this site in Trinidad, W.I. (Amarali, 2000). The site was visited many times at 5.30 a.m (boats return on shore) during the period of September 1999 to March 2000. The biggest wholesale market for retailers was visited at Sea lots, Port-of-Spain (North) at 5.00 a.m. (the market operates between a 2.00-6.00 a.m.). Interviews were conducted with retail vendors who were identified by the wholesalers. An observational approach was taken as to the infrastructure, general organisation of the fishing industry and handling practices at landing sites and vendors' stalls along highways (most of these stalls were located 2-3 metres along the major highways of (Churchill Roosevelt and Uriah Butler).

Data collection. Data were collected directly from fishermen at landing sites, wholesalers, vendors and consumers through face-to-face structured interviews by questionnaire and by informal interviews with several persons in the fishing trade of Trinidad and Tobago. There were 60 operational pirogue owners at the Gran Chemin landing site and 50% (30) were randomly interviewed. All the wholesalers' (6) as identified by the fishermen were interviewed. Ten (10) vendors who were identified by wholesalers as having purchased all their fish (100%) at this landing site were randomly chosen and interviewed at their roadside stalls. A convenience sampling was done for consumers at the vendor's stalls and the first 10 consumers at each vendor (100 consumers) were interviewed, using a questionnaire.

Participants were asked what they looked for when purchasing fresh fish and what features they took into consideration.

Analyses

Samples of Spanish mackerel or carite (*Scomberomorus brasiliensis*) of the family *Scombridae* were taken just behind the gill, transverse in the lateral body of each fish The treatment groups were (1) whole (non-gutted; NG) fish which were allowed to undergo all the normal practices employed until they arrived on shore; (2) eviscerated (gutted; G) carite as soon as they were harvested and brought on shore and (3) or carite obtained from vendor (vendor; V), which had been tagged (a red string attached to the tail) as soon as they arrived on shore and allowed to go through the normal handling procedures until they arrived at the vendor's stall. These tagged samples were purchased on the morning and the vendors were instructed to fillet the fish. The same representative portions (400-500 g) were taken as for other treatments (NG and G) and immediately iced and microbial analyses were performed within 1 hr of purchase. Fish were cleaned, filleted and wrapped in polyethylene wrap and aluminum foil and stored in a freezer at 0-4^{0}C for compositional analyses.

Total volatile bases: This test determined the extent of proteolytic degradation and formation of other nitrogenous compounds such as trimethylamines. Tests were conducted using the macro-distillation method as reported by Pearson (1976).

Microbial evaluation

Microorganisms were enumerated according to the method outlined by Dawood *et al.,* (1986). From each fish, 10 g sample was taken and serial dilutions prepared with Ringer's solution using the pour plate method with Plate Count Agar (PCA) and incubated at 20^{0}C for 72 hrs and 37^{0}C for 48hrs and the results reported as cfu $^{-g}$.

Sensory quality

Using a modified quality –rating scheme as described by Dawood *et al.*, (1986), six trained judges were asked to evaluate the fish treatments (NG; G; V) on characteristics of appearance of eyes and gills, odours, flesh colour and texture according to Table 1. These judges were a wholesaler vendor, a retail vendor, a boat captain, a boat owner, and two trained panelists (members who are accustomed evaluating the quality of fish in the fishing industry). At the retailer's stall, 100 consumers were interviewed at three sites. Twenty (20) consumers were interviewed at landing sites at Sea Lots and Moruga, 20 consumers at large retail markets of Port-of-Spain and Orange Valley and 60 consumers at roadside stalls at Valsayn, San Juan, Sangre Grande, Diego Martin, and Arima. These consumers purchased fish on a regular basis. The effects of treatments (NG, G and V) on the sensory scores for appearance of eyes and gills, odor, flesh color and texture. The means were separated by Duncan's Multiple Range test at the 5% level of significance.

RESULTS AND DISCUSSION

Observational approach at sites: The infrastructure at the landing site consisted of a concrete building containing cubicles for storage of gas and fishing tackle and an open area for the repair of boats and nets. There were no toilet and bathroom facilities, nor provision of water. The open-decked boats were 9m pirogues would only accommodate one fish box. This box was made of insulated fibre-glass coated plastic with a drainage hole and had a capacity to hold 228 kg of fish. The fish was then transported from boxes into smaller bins (50 kg capacity), then weighed and transferred into the fish boxes on the wholesalers vehicles. These vehicles which were either three ton open tray trucks or pickup (open tray) vans. Cool or cold storage facilities at ports were not available. Sorting of the fish was done on the bare ground.

Wholesale market. At Sea Lots, Port-of-Spain, the fish were separated by species and placed on the tables or in bins without ice. Inside the covered market building, fish were placed on stainless steel tables without ice. The vendors would manually transfer fish individually or as bulk transfer into boxes to be transported in their vehicles (not refrigerated), often in an unhygienic and haphazard manner. Some vendors brought ice in their boxes whilst others would use the melted ice from wholesalers' boxes to keep the fish cool. Some vendors brought large crocus feed bags for storage of fish. Often these bags were packed tightly with whole fish, without ice and stored on the floor. Faucets supplied water and a long hose facilitated washing. In all cases, retail vendors did not wear protective clothing, nor gloves except for rubber boots. Bulk of the fish was stored in bins at the back open-tray vehicles.

Responses from fishermen at landing sites: All fishermen interviewed at landing sites reported that they would fish for a 12-hr period, either during the day or night. Pirogues were designed to accommodate 250 kg icebox, but they generally transport between 25-38 kg of block ice. Ice would be crushed and mixed with water to produce a slurry. The quantity of ice applied to fish, varied according to the different species. Generally, there was the poor practice of overfilling fish in boxes.

The fishermen (50%) who used the gill netting method, 50% would allow their nets to drift in the water for 4 hrs while other reported a time period of 6 hrs. Fishermen stated it was difficult to state a specific period as the estimated time was dependent on the force of the sea current and weather condition. For fishermen who practiced live bait fishing, they kill the fish by stunning with a blow to the head of the fish, often resulting in open gashes. Some fishermen (33%) indicated that they place the fish immediately on capture in ice- boxes. The rest (67%) of the fish was left on the floor of the vessel until they had undergone rigor mortis which were then placed into ice boxes. It was a regular practice by all fishermen to store the excess fish which, could not have been accommodated in ice-boxes on the floor of the vessel. On shore, the fish were removed manually from ice boxes stored on board and transferred to open bins without ice to obtain weights. The fish were sold to exporters, wholesalers for retail trade or consumers on the landing sites. It was a routine practice for all fishermen to wash their fishing vessels and ice boxes with seawater (no disinfectant or sanitiser) within 1-2 hrs on arrival at shore. When the fishermen were asked for their opinions in respect to handling of fish, all responded that they were satisfied and indicated of no need for improvement.

Responses from wholesalers: On purchase of fish, the wholesalers (5 out of 6 interviewed) layered the fish with crushed ice, which were stored in fish boxes and loaded into vans. Only one wholesaler had large freezers for storage of fish. All wholesalers reported that they sold the fish at the wholesale market at Sea Lots, Port-of-Spain (North Trinidad, W.I.) because of better facilities and more competitive prices as compared to the wholesale market located in San Fernando (South Trinidad, W.I.). If all the fish were not sold at wholesale sites, they were stored and later sold at a cheaper price. Fish were weighed, and then displayed on tables (without ice) for purchase by retailers. The time from arrival of the fish at the port to being displayed on for wholesale vending was estimated to be 6-8 hrs.

Responses from retail vendors: Retail vendors usually purchase fish at the wholesale markets between 3.00-5.00 a.m. Iceboxes were transported in vehicles to store the fish. The length of time for this activity was between 4-6 hrs. Two (10%) of the vendors interviewed reported that the use old deep freezers as substitute iceboxes. None of the retail vendors bought ice ahead of purchase of fish as they were unable to anticipate the quantity of the catch that would be landed (often ice was inadequate) and found it risky economically. They all admitted to the reuse of melted ice from the wholesalers' boxes to keep the fish cool. Retail vendors (70 %) stored different species of fish separately while 30% did not. Most retailers began selling of fish to consumers between 9.00-10.00 a.m. At retail stalls, at Beetham and

Orange Valley, there were potable running water and toilet facilities were available. All roadside vendors brought supply of water in containers, often in limited supply. There was no provision of toilets for roadside vendors. Generally, fish were displayed uncovered and without ice on tables. Only whole fish were displayed until a customer requested the service to de-gut. All retail vendors mentioned that consumers preferred whole fish, as they would relate the presence of blood on the flesh to freshness. All retailers perceived that their handling of fish was satisfactory, having received no complaints from customers and therefore felt no need for improvement in their handling practice. It was a common practice to wrap the fish (whole, slice of fillet) in newsprint and then packaged in polyethylene bags to be sold to customers.

Responses from consumers: At landing sites, consumers (80%) would purchase fish as often as they could, generally twice per week. Even though some consumers (50%) had to travel a considerable distance to the landing sites, they viewed fish sold at this point, as being cheaper, superior in quality, and fishermen were more honest compared to fishermen at other retail outlets. However, most respondents (60%) relied on specific trusted retailers to judge the quality of the fish purchased. All buyers at Sea Lots landing site requested services from fishermen of gutting, cleaning, scaling and sometimes slicing or filleting from the retail fishermen whereas all consumers at the Moruga Fishing Centre perform these tasks at home. At the Moruga Fishing Centre, there was no supply of water for cleaning and dressingof the fish to be supplied to consumers. All consumers would purchase whole, ungutted fish but requested the removal of entrails on purchase. Consumers (40%) reported that they consume the fish on the same day of purchase, while the others refrigerated the fish for not more than 2 days.

At large retail markets. All consumers (20) who were interviewed at two of the largest retail markets at Port-of-Spain and Orange Valley preferred to purchase fish at these locations because of close proximity to their homes, place of employment or were not satisfied with the level of sanitation at roadside retail vendor stalls. Consumers (50%) stated that even though the fish were presented in the same manner as in roadside retail vendor stalls, at least there was a supply of running water and that the fish were not subjected to the direct rays of the sun, dust and exhaust fumes from vehicular traffic as in roadside stalls. As at other retail sites, consumers (90%) preferred to purchase whole fish and then requested services such as gutting, scaling, cleaning or filleting of the fish. In selection of fish, consumers (70 %) indicated that they would examine the gills, eyes and texture and smell for offensive odour. Consumers (85%) consumed fish on the same day of purchase while others consume within two days. Of those who stored fish, it was customary practice to wash, eviscerate, and store in polyethylene bags in freezers.

At roadside vendor stalls. Of the 60 consumers who were interviewed, 80% stated that the purchase fish at roadside stalls, mainly due to convenience, lack of time, limited or no choice and lower prices as compared to the supermarkets. Consumers (75%) expressed dissatisfaction with the presentation and quality of fish offered for sale at vendors stalls. Some recommendations provided by consumers, were that: the fish should be sold in an enclosed building rather than in open stalls; should be stored in ice and displayed in chillers; a supply of running water should be provided, and vendors should wear gloves in the handling of fish. As with other retail outlets, consumers usually ask for whole fish and then ask for the dressing services. Most customers reported having been sold spoilt fish and fooled into purchase of particular species of fish for another species. All individuals were of the view that eviscerated fish was synonymous with 'fresh' fish. Only thirty percent (30%) of the consumers requested to purchase fish stored in ice boxes rather than those displayed on tables without ice. Most participants (80%) reported of no awareness of the effect of temperature on the length of storage. Most consumers were familiar with the basic characteristics of fresh fish quality by examination of the skin, eyes and gills, however 55% of the consumers indicated that they did judge turgidity of the fish by touching. Consumers (50%) use the fish on the same day, 40% within two days of purchase and 10% within four days of purchase. At homes, the general practice was to wash the fish and then freeze in polyethylene bags. All consumers expressed satisfaction as to the quality of the fish and recommended no improvement in the handling practices by retailers.

Sensory evaluation: Table 2 shows the sensory scores assigned to carite for skin appearance, odour, flesh colour and texture. The gutted carite samples (G) scored the highest and thus had the best quality rating when compared to the other samples, G and V. Quality of fish was reduced ($P < 0.05$) at the retail vendor stalls.

Analyses: The total number of mesophilic aerobic microorganisms (CFU/g) was highest in carite samples sold by retail vendors (V; $3.7 \times 10^5 - 7.80 \times 10^5$), followed by the gutted sample (G; $3.8\text{-}13.0 \times 10^4$), with least microbial load for whole non-gutted carite sample (NG; $2.6\text{-}4.2 \times 10^4$), which did not relate to chill spoilage. The higher total bacterial viable load in the gutted fish (77 %; G) as compared to non-gutted sample (NG) was evident of poor evisceration. Microbiological testing of fish is often concerned with poor freshness quality rather than health hazards (Horner and Dillon, 1997). According to the International Commission on Microbiological Specifications for Foods (ICMSF, 1974) has indicated the lower limits (M) for acceptable fresh fish using these criteria at 25 °C was 1.0×10^6 cfu $^{-g}$. All the fish samples were within acceptable microbial limits.

Trimethylamine and total volatile bases have been used in the fish industry as indicators of spoilage for fish and fish products (Olafsdottir *et al.*, 1997). As reported by Pearson (1976), the fish is considered fresh, if the total volatile bases (TVB) is less than 20 mg N $100g^{-1}$ and stale if the values exceed 30 mg N $100g^{-1}$ (Pearson, 1976). The total volatile bases values for fish samples analysed after 24 hrs and 96 hrs of storage revealed that the gutted fish sample (G) had the lowest TVB values (27.8 mg N $100g^{-1}$ and 33.6 mg N $100g^{-1}$ respectively) as compared to samples NG and V (36.4 mg N $100g^{-}$ and 39.2 mg N $100g^{-1}$). All values except sample G stored at 24 hrs were higher than the limit of 30 mg N $100g^{-1}$.

Recommendations. The term 'fresh' fish as used in this investigation was fish that had not undergone any particular process of preservation after the death of the animal, except where practicable, chilling is used to reduce its temperature to near that of melting ice. Consumers reported that freshness was used as a criterion and indicator of quality Results from sensory, microbial and total volatile bases implied deterioration in the quality of fish sold by retail vendors (V) as compared to NG (fish not subjected to normal handling practices). An integrated quality assurance system is needed where the unit operations in handling and holding and distribution of fish are linked together so that process control is possible. In Trinidad, W.I., the ownership of fish can change several times between harvest by fishermen to delivery to wholesalers and retailers and finally the consumer. The operations were not closely coordinated thus resulting in delays between 5-8 hrs.

To be assured of good quality, the catch should be handled quickly and carefully and must be stored at slightly below 0°C at all stages of catchment to distribution so as to minimise loss in quality.

We recommend the use of boxes with holes in the bottom to allow melting water to run through so as to ensure effective chilling of the catch, and stable storage temperature.

There was lack of adequate physical infrastructure for the efficient fish handling system. Fish exports from Trinidad and Tobago have been banned from entering the European Union, because of landing sites, marketing facilities, processing and packaging facilities do not meet approved international standards (Ministry of Agriculture, Land and Marine Resources, 2000).

There should be a mandatory seafood inspection program such as a Hazard Analysis Critical Control System (HACCP) as an effective system to control public safety hazards in food is through the use of HACCP programs. In order to be effective, the HACCP system should be established throughout the production line, from catch to retail sale. In the case of fresh fish, the situation is most often that the fish change owner at the time of landing. Hence the new owner (exporter, wholesaler, processor, retailer, consumer) must also apply the HACCP principles.

All consumers reported that they do not purchase gutted fish, which is a contrary practice to the principles of good fish handling. Fish must be gutted, bled and washed quickly and carefully. The knowledgeable consumers judged the quality of fish by looking at the eyes, gills and turgidity of the flesh, however most consumers relied mainly on visual appearance. Many interviewees remarked that the fish was desirable quality, if the skin glistens. However, it was a usual practice for retailers to periodically throw water on the fish thus giving an illusion of 'freshness' with resultant deception. Consumers were not aware of the possible hazards, mal-practices and mistakes that can arise from poor handling of fresh fish. Most (90%) consumer viewed fish as being nutritious and tasty and judged freshness on purchase In a study of the consumer motives for buying fresh or frozen plaice in Denmark, the health factor was a greater determinant for the more experienced consumers as compared to less experienced consumers (Nielsen *et al.,* 1997).

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Table 1. Quality Rating Scheme for Carite

Sensory Attributes	Score
Appearance	
Eyes fresh, black pupil, bright red gills	5
Eyes flat, very slight greyness in pupil, slight loss of colour of gills	4
Eyes slightly sunken, greyed pupil, some discolouration of gills	3
Eyes sunken, milky white pupil	2
Eyes completely sunken, gills showing bleaching, covered with bacterial mucus	0
Odours	
Fresh seaweedy odours	5
Loss of fresh seaweediness	4
Lack of odours or neutral odours	3
Slight off odours, slight rancidity odours present	2
Definite off odours and rancid	0
Flesh appearance and colour	
No loss of fresh flesh colour, no reddening along backbone	5
Slight loss of fresh colour, no reddening along backbone	3
Some opacity, reddening along backbone	2
Opaque flesh, brown discolouration along backbone	1
Texture	
Rigid	5
Firm, elastic to the finger touch	4
Softening of the flesh	3
Softer flesh, dried appearance	2
Flesh soft and flabby, retains finger indentations	1

Table 2. Sensory Scores for Fish Quality.

Samples	Skin	Odour	Flesh Appearance	Texture
NG	4.71±0.18a	3.57±0.48b	3.58±0.37b	3.71± 0.18b
G	4.71±0.18a	4.71±0.18a	4.43±0.37a	4.29±0.18a
V	4.04±0.17b	1.88±0.26c	2.65±0.14c	3.11±0.08c

Means ± SE, followed by different letters are different ($P<0.05$)
NG-not gutted; G-gutted; V-sample from retail vendors
See quality rating scheme (Table 1).

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EGGPLANT CULTURE AND POTENTIAL AS A COMMERCIAL SPECIALTY CROP

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ABSTRACT: Eggplant *Solanum melongena* L. is a member of the Solanaceae family. The plant will grow as a perennial in warm regions of the world but is cultured as an annual in cooler regions. Eggplant is thought to be native to India and China and is currently grown on a very limited commercial scale in the USA. Field testing on the culture, insect control, and yield of the Black Beauty variety of eggplant was conducted under Ohio growing conditions during the summer of 2000. Early season insect control was most critical. Several synthetic and botanical insecticides were utilized. Yields harvested from nine test plots were equivalent to approximately 12.25 tons/acre. This suggests there is great potential for producing eggplant on a commercial scale in Ohio during the summer growing season. Eggplant has been imported to the USA from Mexico and the Dominican Republic in the past. As changes occur in the size and composition of the human population in the USA, there may be increasing opportunities for Caribbean countries to produce eggplant for export to the USA, especially for the winter and spring season markets.

INTRODUCTION

Some commonly cultivated crops in the family Solanaceae are potatoes, tomatoes, eggplants, peppers, and tobacco. Other non-cultivated plants in the family include Eastern black nightshade and horse nettle.

The focus of this research is on the culture of eggplants *Solanum melongena* L. This follows field investigations conducted on potatoes for a number of years. Eggplant is thought to be native to India, and perhaps also China. Reportedly, one of the earliest references to eggplant is from a Chinese book in the fifth century. It is thought eggplant was taken from Arabia to Spain, and eventually to North America. Eggplant has subsequently been grown in many regions of the world as a home garden plant, and to a lesser extent as a commercial crop. Caribbean countries that grow, and in some cases have exported eggplant to the UK, Holland, or the USA, include Trinidad, Barbados, Antigua, Grenada, and the Dominican Republic (Lamberts, 1990).

In the USA, eggplants are grown on a limited commercial scale, although they may be found in home gardens in virtually every state. States where some commercial production occurs are: Florida with 2300 acres and New Jersey with 1000 acres in 1999 (Schwap and Petrone, 2000). California reportedly produced eggplant on 840 acres in 1995 (Aguiar, Molinar and Valencia, 1998). Other states include Georgia with 717 acres, North Carolina with 267 acres, and Texas with 256 acres, all in 1992. Florida produces over 30 percent of the eggplant crop grown in the USA, and is able to produce all year except for August and September. The second largest producer is New Jersey, which produces eggplant from July through October. California harvests from April through December. During the winter months from January to March, Mexico exports eggplant to the USA (Aguiar, Molinar, and Valencia, 1998).

Eggplant is not widely eaten in the USA; however, it is a food commonly consumed by certain ethnic groups such as Italian and Asian Americans. In Japan, eggplant is reported to be the third or fourth most popular vegetable.

There are many different varieties of eggplants such as Black Beauty, Suriname Long Purple, Ichiban, Dusky, Little Fingers, Casper, Neon, etc. They also come in many different colors, from white to purple, and in shapes from round to long and narrow.

Eggplant is called by different names including Aubergine, Guinea squash, Brinjal, Melanzana, Patlican and Garden egg. The nutritive value of eggplant is quite low. In 100 grams of cooked eggplant, there are approximately 19 calories, 150 mg of potassium and minimal amounts of some other nutrients. It is an excellent food to also mix with other foods (Grijalva, 1998).

The soil type most conducive for high yields are sandy loams; however, eggplants will grow on most soil types. Optimum soil PH is reported to be in the range of 5.5 to 6.5. In Mississippi expected yields are 6 to 10 tons per acre (Nagel, 2001).

Ohio is not considered a commercial producer of eggplant. Therefore, this investigation was designed to explore the potential of eggplant as an alternative specialty crop in Ohio.

METHODS AND MATERIALS

Field testing on the culture, insect control, and yield of the Black Beauty variety of eggplant was investigated under Ohio growing conditions during the summer of 2000. The plot design consisted of 9 plots, each 50 feet long and 9 feet wide, with 3 rows per plot. A randomized block design was used with 3 replications. Unplanted alleys between plots were 12 feet wide.

Prior to planting, triple 15 NPK ertilizer was applied to the soil, and Devronal 50 DF plus Roundup were applied for weed control. Eggplant transplants were placed in raised beds covered with black plastic, on June 3-9, 2000. All plots received treatments of esfenvalerate, endosulfan, and carbaryl beginning a few days after transplanting. This was necessary due to early feeding damage by the Colorado potato beetle *Leptinotarsa decemlineata* Say and flea beetles *Epitrix_* sp., and to thereby allow the young transplants to become established.

Copper and Ridomil fungicides were also applied during the growing season. Some transplants that died early in the season were replaced. Later in the season slight feeding damage by Colorado potato beetle and Japanese beetle *Popillia japonica* was also observed. Insecticide treatments applied later in the season were Hot Pepper Wax on three plots, Neem extract on three plots, and no insecticide on three plots.

RESULTS AND DISCUSSION

At the end of the growing season, fruit was harvested and yield data collected. Overall, plot yields were high, and differences between treatments of Hot Pepper Wax, Neem, and untreated plots did not appear conclusive. Late season insect populations did not develop to economically important levels, and therefore results of these treatments would not be expected to have a conclusive effect on yield.

Approximately 2450 pounds of fruit were harvested from about one tenth of an acre. This yield would be equivalent to 12.25 tons per acre. The largest fruit weighed over 6 pounds. The eggplant crop was all harvested at the end of the growing season. It is recommended that in order to obtain the highest yields, the crop should be harvested at 7 to 10 day intervals, and at least 5 or 6 times during the production season (Granberry, 1990). Therefore, yields in this study could have potentially been even higher.

In this field investigation, eggplants were transplanted into raised beds covered with a black plastic mulch. It has been reported by some investigators that plastic mulch can cause a significant increase in eggplant yields (Gastier, 1995). Mulching eggplants with dried Guinea grass *Panicum maximum* L. in Antigua has also been reported to increase yield of eggplants (Daisley et al., 1988).

Certain insect pest species, such as flea beetles or aphids, may feed on more than one member of the family Solanaceae. Eggplant, however, may be fed upon by some different insect species in different regions of the world. For example, *Thrips palmi* Karny is reported to feed on eggplant in Caribbean countries such as Martinique (Denoges et al., 1987) and in Guadeloupe (Guyot, 1988). Likewise, whitefly *Bemisia argentifolii* reportedly feeds on eggplant in the Dominican Republic (Tappertzhoefen, 1996). Neither of these two insect species mentioned above would be pests of eggplant in all other regions of the world where eggplant is grown. In spite of some differences in culturing eggplant around the world, it is amazing how adaptable the plant is to different growing environments.

Fresh eggplant is quite perishable and may be preserved in good condition for only 7-10 days in cool storage following harvest. Mohammed Sealy (1986), reported that in Trinidad seal packaging of eggplants in high-density polyethylene films, in addition to refrigeration, caused their shelf life to be extended to at least 17 days.

There is indication that Ohio has potential for producing eggplant as a commercial specialty crop. Furthermore, as ethnic populations in the USA continue to increase, there may be increased opportunities for Caribbean Countries to export eggplant to markets in the USA, especially in winter and spring.

CONCLUSIONS

Early season insect and disease control is critical for maintaining high yields. Late season insect populations were very low and botanical insecticide treatments (Hot Pepper Wax and Neem) appeared to have no positive effect on yields. Yields of the Black Beauty variety of eggplants were remarkably high even under Ohio growing conditions.

Eggplant could be a significant cash crop for Ohio considering that approximately 2450 pounds of fruit were harvested from approximately one tenth of an acre. This would be equivalent to 12.25 tons per acre. With increasing ethnic populations in the USA, there may be increasing opportunities for Caribbean countries to export eggplant to the USA market, especially during the winter and spring seasons.

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DEVELOPMENT OF AN OSMOTICALLY DEHYDRATED CHRISTOPHENE CANDIED PRODUCT

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ABSTRACT: Christophene (*Sechium edule*) was osmotically dehydrated to produce a candied product. The christophene was blanched in hot water for 5 min followed by steam blanching for 5 min and then subjected to osmotic dehydration in various sugar solutions prepared to 30°Brix and increased daily for 3 days to 45°Brix, 60°Brix and 70°Brix. Final drying was at 68°C for 4 hours. Preliminary results indicated that products from 100% sucrose had a dull appearance with a coat of sugar while products in 100% glucose/fructose were sticky. In further work, peeled and un-peeled christophene cubes were soaked in 75% sucrose with 25% glucose/ fructose and un-peeled christophene to 50% sucrose with 50% glucose/fructose and 25% sucrose with 75% glucose/fructose. A product from 75% sucrose with 25% glucose/fructose had the best overall acceptability (liked slightly to moderately), lowest moisture content (10.5-15.2%) and had low microbial count (< 10 cfu g -1) after 21 days of storage at 19±1°C.

INTRODUCTION

Christophene or chayote *(Sechium edule*, Swartz) is a highly perishable and seasonal vegetable (Littman, 1981). The vegetable contains about 98% water, which limits its shelf-life. Osmotic dehydration partially removes water from fruits or vegetables immersed in a hypertonic solution (Rastogi et al., 1999). Water loss is accompanied by simultaneous diffusion of solute into the food. Osmosis is the molecular movement of certain components in a solution through a semi-permeable membrane to another solution that has a lesser concentration of the particular molecules (Raoult-Wack *et al.*, 1989). Drying is one of the oldest methods of food preservation (Desrosier and Desrosier, 1977). Candying is a method of preserving fruits and vegetables, thus making them available during the off season. Candied christophene can be used as fruit substitutes in the baking industry and as an alternative to the otherwise bland and unpopular vegetable. Our objectives were to reduce the moisture level of christophene and to create value-added products by employing the principles of osmotic dehydration. The effects of varying sucrose/glucose-fructose combination with and without peel on the physico-chemical and sensory attributes of the candied product were investigated.

MATERIALS AND METHODS

Processing

Christophene (*Sechium edule*) Swartz of the dark green type were purchased from the wholesale market, Port-of-Spain. Each experimental batch consisted of 15 kg. Over-mature christophene were not selected, due to the tough texture which required longer blanching time in the production of the candied product. Fig. 1 outlines the steps in the candying of christophene. Christophene were washed in water, cut into halves and the cores removed. The vegetable, either peeled or un-peeled was sliced (2 cm x 2 cm). The vegetable was blanched in hot water for 5 min and steamed for 5 min. Blanching was done to increase the permeability of cell membranes. The weight of the vegetable was taken before and after blanching.

In the first stage of experimental work, using peeled christophene, 3 types of syrups for osmotic dehydration of the vegetable were used: 100% sucrose (PT_1); 50% sucrose with 50% glucose/fructose (PT_2) and 100% fructose (PT_3). On day 1, the blanched christophene cubes were added to each type of syrup at 30°Brix and the total soluble solids as °Brix was increased on day 2 to 45°Brix, day 3 to 60°Brix and day 4 to 70°Brix. To the syrups, 0.01% citric acid was added with 0.04% green colouring and 5 g of liquid lemon flavouring.

In the second stage of the investigation, using both peeled and un-peeled christophene, 4 types of syrups were prepared as follows: 75% sucrose with 25% glucose/fructose (without peel); 75% sucrose with 25% glucose/fructose (with peel); 50% sucrose with 50% glucose/fructose (with peel); and 25% sucrose with 75% glucose/fructose (with peel). On day 1, the blanched christophene was added to each syrup at 30°Brix, and the total soluble solids as °Brix increased on day 2 to 45°Brix, day 3 to 60°Brix and day 4 to 70°Brix. Pearson Square method was used to calculate the required amount of sucrose and glucose/fructose required to attain the required ratio and Brix level. A 1:1 ratio of vegetable to syrup was used with 0.01% citric acid. On day 5, samples were drained of syrup and rinsed quickly with sterile water to remove excess surface sugar and allowed to drain for 3 minutes. Each treatment was weighed and dried in a dehydrator at 68°C for 4 hours. Moisture loss, % was monitored every hour. The candied products were cooled quickly and packaged in polyethylene bags (2 cm x 6 cm) and sealed and stored at 19±1°C. During storage, the products were analysed for pH, texture, colour, microbial and sensory quality.

Physico-chemical analyses

Moisture (%) of fresh christophene, osmotically dehydrated christophene before and after mechanical dehydration was determined by AOAC (1980). Colour was measured on the fresh christophene, osmotically dehydrated christophene and the dehydrated product on a Minolta Chroma Meter and expressed as L, a, b values. An average of three readings was taken for each sample and the average determined. Texture measurements of three samples in triplicate were measured on a Koehler Digital Penetrometer (Koehler Instruments Company Ltd, Bohemia, USA). The depth of penetration of the product by a 2.5 g needle after 5 sec was recorded as 0.01 mm. pH was recorded for the fresh christophene, blanched christophene, dehydrated christophene and stored products from 4 treatments of the second stage of experimental work. pH ws measured on an Orion model 520 A pH meter.

Sensory evaluation. In the first stage of experimental work, untrained panelists (28) in each session ranked the products from the 3 syrup treatments (100% sucrose; 50 % sucrose with 50% glucose/fructose and 100% fructose) on a scale from 1-3 (1- most preferred; 2- moderately preferred; 3-least preferred) for colour, texture, taste and overall acceptability. The sensory evaluation was conducted in 2 sessions. In the second stage of processing, the products from the four treatments (75% sucrose with 25% glucose/fructose (without peel): 75% sucrose with 25% glucose/fructose (with peel); 50% sucrose with 50% glucose/fructose (with peel); and 25% sucrose with 75% glucose/fructose (with peel) were given scores for colour, taste, texture and overall acceptability on a 9 –point Hedonic scale (9-liked extremely; 8-like very much; 7-like moderately; 6-like slightly; 5-neither liked nor disliked; 4-dislike slightly; 3-dislike moderately; 2-dislike very much; 1-disliked extremely) as described by Watts et al. (1970). Panelists were asked to suggest a desirable colour and flavour to be added in the second stage of processing. Sensory evaluation was performed by a 50 member of untrained panelists comprising of staff and students of the University of the West Indies.

Microbial evaluation. On storage, the candied products from the four treatments in the second stage of processing were examined for microbial quality. Microbial analysis was conducted on day 8, day 13, and day 20 after processing of the candied dehydrated product. Serial dilutions (10^{-1} –10-^{5}) of each treatment were prepared and total plate count enumerated on Plate Count Agar (PCA) and yeast and moulds on Potato Dextrose Agar (PDA). The PCA plates were incubated at 35°C and PDA plates at 25°C for 48 hours. The number of microorganisms was enumerated as cfu $^{g-1}$.

Statistical analysis. SPSS Statistical Packages for Social Sciences, Version 8 (Stanford University) was used to analyse the data using analysis of variance (ANOVA) to determine the effects of treatments on sensory parameters of taste, texture, pH and overall acceptability. Friedman's test was used for ranking of colour, texture, taste and overall acceptabilty of treatments from the first stage of experimental work. Analysis of variance at 5% level of significance investigated the effects of the four (4) treatments in the second stage of experimental work on moisture, physico-chemical and sensory quality of the products.

RESULTS AND DISCUSSION

First stage of Processing

There were no ($P>0.05$) differences in 'L' 'a' 'b' values based on syrup treatments (PT_1 - 'L' 43.6, 'a' - 1.6, 'b' 8.4 ; PT_2 - 'L' 42.8, 'a' -1.5, 'b' - 8.7; PT_3 -'L' 43.4, 'a'- 1.5, 'b' - 9.0), however there were changes ($P<0.01$) in 'a' values of the products on storage (Table 1)

Sensory. No differences ($P>0.05$) in preference for colour, appearance and taste of candied products due to syrup treatments but differences ($P<0.05$) in texture and overall acceptability (Table 2). Although, there were no differences in texture and overall acceptability between candied products PT_2 and PT_3, based on the overall mean attribute scores (colour, appearance, taste, texture and overall acceptability) for candied products, PT_2 was ranked first (Table 3) from the first stage of the experiment and thus, was selected for further study. The product in 100% sucrose had a dull appearance. Responses (out of 36) by panelists indicated the following recommendation for colour : green (14) yellow (8), natural (7), red (6) and other (1). Lime was the most desired flavour (12), followed by cinnamon (8), orange and ginger (7). Based on the highest response, the colour green and lime flavour were introduced in formulations in the 2nd stage of processing.

Second Stage of Processing

Fresh christophene had a high moisture content of 93.8%. The moisture was reduced in the osmotically dehydrated product (Table 4). The total moisture losses (%) on osmotic dehydration of fresh christophene to final candied products were: T_1- 83.3; T_2-76.6;T_3-65.70; T_4-63.10.The effect of syrup treatments on moisture loss of the product was significant ($P<0.05$). The presence of the peel in T_2 acted as a barrier to % moisture loss as compared to T_1. Treatments T_3 and T_4 had less moisture loss during osmotic dehydration than treatments T_1 and T_2, thus indicating that a higher percentage of sucrose to glucose/fructose was necessary to remove a higher % of moisture, which is the underlying principle of osmotic dehydration. Table 4 shows that in the final products T_1 and T_2 had the lowest moisture content of 10.4 and 15.2 % respectively with the low microbial count of <10 cfu g^{-1} on storage at 20°C for 21 days.

Physico-chemical analysis

There were no changes ($P>0.05$) in colour, texture and pH due to syrup treatments and storage. The average tristimulus values for the candied product were: "L' – 30.32±SD 2.6, 'a' - 10.83±SD 4.7, 'b' – 12.9±SD 4.2. Texture ranged from 15.1- 48.1 mm / 5 sec (SD 8.5-28.2). The pH of the fresh christophene was 6.01, blanchedchristophene 5.30 and candied product of 3.72-4.40 (SD: 0.03-0.28).

Microbial

Treatment T_1 with 75% sucrose with 25% glucose/fructose had the lowest microbial count which decreased on storage at 18-20°C for 20 days. T_2 , which was left un-peeled had a higher microbial load than T_1 even though the syrup treatment was the same. The peel of T_2 may have harboured microoraganisms, and acted as a barrier to water loss and sugar absorption. The higher microbial numbers of T_3 and T_4 and which increased on storage could be linked to the lower % sucrose syrup and higher moisture content of the product. Microbial spoilage does not occur in dried fruits which contain less than 18-25 % moisture (Somogyi and Luh, 1986).

Sensory evaluation

There were differences ($P<0.05$) in colour and texture of candied product, but no differences ($P>0.05$) in taste and overall acceptability due to syrup treatments (Table 5). Treatment T_1 was the most liked candied product for its colour (6.86), texture (7.08) with an overall acceptability of being liked slightly to liked moderately (6.6).

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Harvest christophene

↓

Store

↓

Wash

↓

Peel/do not peel

↓

Slice

↓

Weigh

↓

Blanch and Steam

1 st stage	2nd stage
100% sucrose	75% sucrose with 25% glucose/fructose
50% sucrose with 50% glucose/fructose	50% sucrose with 50% glucose/fructose
100% glucose/fructose	25% sucrose with 75% glucose/fructose

↓

Add citric acid, flavouring and colour

↓

Day 1, Boil syrup for 10 min: Submerge in 30°Brix

↓

Day 2, Measure °Brix and increase to 45°Brix

↓

Day3, Measure °Brix and increase to 60°Brix

↓

Day4, Measure °Brix, and increase to 70°Brix

↓

Drain and rinse excess surface sugar

↓

Dry at 68°C for 4 hrs

↓

Package

↓

Store, 19±1°C

Figure 1. Production of an osmotically dehydrated candied christophene

Table 1. Effect of Storage on Colour of Candied Product (first stage of processing)

Treatments	Colour					
	'L'		'a'		'b'	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
PT_1	43.6	5.90	-1.60	0.53	8.40	1.00
PT_2	42.8	0.07	-1.50	0.75	8.70	2.40
PT_3	43.4	0.56	-1.50	0.56	9.00	1.10
Not significant, P>0.05						
Storage						
Day 1	42.0	2.30	-2.00	0.10	8.16	1.40
Day 13	44.5	2.80	-1.14	0.14	9.36	1.10
Significance	P>0.05, n.s.		P<0.01, significant		P>0.05, n.s.	

n.s.- not significant: S.D. standard deviation

PT_1-100% sucrose (without peel); PT_2- 50% sucrose with 50% glucose/fructose (without peel); PT_3-100% fructose (without peel)

Table 2. Effect of Syrup Treatment on Texture and Overall Acceptability of Candied Product.

Treatment	Texture		Overall Acceptability	
	Mean	S.D.	Mean	S.D.
PT_1	2.46a	0.74	2.46a	0.79
PT_2	1.85b	0.70	1.75b	0.64
PT_3	1.71b	0.80	1.78b	0.83

PT_1-100% sucrose (without peel); PT_2- 50% sucrose with 50% glucose/fructose (without peel); PT_3-100% fructose (without peel)

1- most preferred; 3- least preferred

Table 3. Sensory Score and Rank of Candied Product (First stage of processing).

Treatment	Total Mean Score	Rank
PT1	2.31	3
PT2	1.50	1
PT3	1.79	2

PT_1-100% sucrose (without peel); PT_2- 50% sucrose with 50% glucose/fructose (without peel); PT_3-100% fructose (without peel)

Total mean score – average of scores of colour, appearance, taste, tecture and overall acceptability

most preferred; 3- least preferred

Table 4. Changes in Moisture Content (%) on Osmotic Dehydration of Christophene.

Treatment	% Moisture loss	% Moisture
Fresh christophene	-	93.8
Candied before dehydration, % loss from fresh christophene		
T_1	70.1	23.7
T_2	70.3	23.5
T_3	53.7	39.9
T_4	55.9	37.9
Final product, % loss on dehydration of candied product		
T_1	13.3	10.4
T_2	8.3	15.2
T_3	11.9	28.0
T_4	7.2	30.7

T_1-75% sucrose with 25% glucose / fructose (without peel)
T_2- 75% sucrose with 25% glucose / fructose (with peel)
T_3- 50% sucrose with 50 % glucose/fructose (with peel)
T_4-25% sucrose with 75% glucose/fructose (with peel)

Table 5. Effects of Syrup Treatments on Sensory Attributes of Products (second stage of processing)

Treatments	Sensory attributes							
	Colour		Texture		Taste		Overall acceptability	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
T_1	6.86	1.42	7.08	1.35	6.66	1.93	6.60	1.86
T_2	6.06	1.79	6.26	1.73	6.04	1.62	6.00	1.44
T_3	6.28	1.75	6.18	1.40	5.94	1.82	5.70	1.60
T_4	5.80	1.90	6.04	1.67	6.18	1.80	5.90	1.78
Average mean	6.24	1.79	6.39	1.55	6.18	1.80	6.11	1.68
Significance	$P<0.05$.		$P<0.05$		$P>0.05$		$P>0.05$	

Hedonic score- 9-like extremely; 8-like very much; 7-like moderately; 6-like slightly; 5-neither like nor dislike; 4-dislike slightly; 3-dislike moderatley; 2-dislike very much; 1- dislike extremely
T_1-75% sucrose with 25% glucose / fructose (without peel)
T_2- 75% sucrose with 25% glucose / fructose (with peel)
T_3- 50% sucrose with 50 % glucose/fructose (with peel)
T_4-25% sucrose with 75% glucose/fructose (with peel)

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MANAGEMENT INTERVENTIONS FOR IMPROVED YIELD IN MANGO CV JULIE

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ABSTRACT: Management protocols to enhance flowering and fruit-set of Julie Mango were investigated at two locations in Trinidad over two seasons. The protocols tested represented the positive results of previous studies on flowering or yield of Julie mango conducted within the region over the past ten years. Treatments included Potassium Nitrate for flower induction, and the use of microelements, fungicide and insecticide for improved fruit set and post fruit-set protection. Potassium Nitrate application increased flowering in both years but the effect was only significant in the second trial. In the first trial, a combination of all treatments resulted in increased yield, as assessed at 14 weeks. In the second trial increased yield was due to fungicide treatment only. Despite the applications, yield in the second trial was very poor. This leads to the conclusion that there were limitations other than nutrition, pests or disease that affected final yield.

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EVALUATING EGYPTIAN PEANUT CULTIVARS FOR USE IN THE SPACE PROGRAM

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ABSTRACT: As part of the National Aeronautics and Space Administration's Advanced Life Support program, several crops are being studied for possible use in bioregenerative life support to provide a source of nutritious food for planetary human space exploration. Peanut (*Arachis hypogea L.*) is among the list of crops selected for space missions and is an excellent source of oil and protein. Tuskegee University is currently studying peanut growth, nutrition and physiology in controlled environments. For this research, plants were grown hydroponically using nutrient film technique (NFT). Peanuts are grown in a soil-less culture in narrow troughs, and there is an ongoing search for new and improved, high yielding cultivars that are adaptable to growing in NFT. The ideal cultivar would be one with an erect growth habit, concentrating its gynophore and ultimately, pod production around the roots. The objective of this study was to evaluate Egyptian peanut cultivars to ascertain their possible use in future space missions. Two Egyptian cultivars, 'Giza 5' and 'Hybrid 8' were compared to the control 'Georgia Red'. Hybrid 8 produced the highest foliage dry weight when compared to Giza 5 and Georgia Red (224.9 vs. 163.1 and 92.9 g/plant, respectively). The same trend followed root dry weights for the three cultivars (16.1, 12.7 and 4.1 g/plant). Pod count, pod weight and mature seed weights were highest for Giza 5 and lowest for Hybrid 8. However, there were no significant difference between the harvest index for Georgia Red and Giza 5 but both were significantly higher than Hybrid 8 (0.16 and 0.18 vs. 0.05). Based on this study, it is recommended not to use Hybrid 8 in further hydroponics studies but Giza 5 appears to be a suitable cultivar for the NFT system.

INTRODUCTION

The National Aeronautics and Space Administration's (NASA) Advanced Life Support (ALS) program is evaluating several crops for possible use in the bioregenerative life support (BLS). This will give interplanetary explorers a source of nutritious food. Bioregenerative Life Support is based on the concept of using photosynthesis and transpiration to produce oxygen, food, and potable water, while removing carbon dioxide (Tibbitts and Alford, 1982). Potential candidate crop species must meet a list of criteria including high energy concentration, high nutritional composition, palatability, relative ease of processing, acceptable serving size and frequency, and storage stability (Tibbitts and Alford, 1982).

Peanut (*Arachis hypogea L.*) is among the list of crops selected for space missions, and, in addition to meeting the above listed criteria, is a potential source of oil and protein. Peanut is the 4th most important source of edible oil depending on cultivar, maturity and environmental conditions under which the crop is grown (Sanders et al., 1995). Runner, Virginia, Valencia, and Spanish are the four major market-types of peanuts grown in the United States. The total oil content varies from 44-56% (Ahmed and Young, 1982). Peanut is also high in protein with an average of 25% and ranges between 22-33% (Ahmed and Young, 1982).

There are approximately 180,000 faddans (acres) of surface irrigated lands in the Ismailia Governorate of Egypt. These lands are mostly flood irrigated and the peanut cultivars that are grown in this region appear to be a good candidate for inclusion in Controlled Environment Life Support System (CELSS) project. As with most arid regions, lands are only productive when adequate amounts of irrigation water is supplied. This condition mimics some of the features that are found in Nutrient Film Techniques (NFT). The Egyptian Government with the understanding that irrigation methods to conserve moisture be implemented distributed some of the recently reclaimed lands. Suez Canal University and Egypt's Ministry of Agriculture place a high priority on water use efficiency (WUE). Suez Canal University in collaboration with Tuskegee University is testing various approaches and cultivars to prevent and/or reduce excessive moisture losses. Using new irrigation techniques such as drip and sprinkler irrigation systems are given priority, especially, on newly reclaimed lands. Adamson (1989) studied irrigation methods and water quality on the grade and yield of peanuts and found that irrigation methods did not impact the oil quality.

Tuskegee University is evaluating peanut growth, nutrition and physiology in controlled environments. For this program, plants are grown hydroponically using NFT. This technique allows plant roots to be exposed to a thin film of nutrient solution within a trough or channel (Cooper, 1975; Morris et al., 1989).

Because plants are grown in a soilless culture in narrow troughs, there is an ongoing search for new and improved, high yielding peanut cultivars that are adaptable to growing in NFT. The ideal cultivar would be one with an erect growth habit, concentrating its gynophore and ultimately, pod production around the taproot. The objectives of this study were to evaluate elite Egyptian cultivars as to their suitability using NFT and their possible inclusion in the space program.

MATERIALS AND METHODS

This study was conducted at the George Washington Carver Agricultural Experiment Station, Tuskegee University, Alabama. The CELSS Project (NASA) provided the facilities. The study utilized two walk-in growth chambers (Conviron Model PGW 36, Controlled Environments, Pembina, ND). The study (CMBALPN-1) was initiated on February 26, 1999 and terminated on July 6, 1999 (130 days) using two Egyptian cultivars ('Hybrid 8' and 'Giza 5') and 'Georgia Red' as a control.

Starting Transplants

Seeds of Hybrid 8, Giza 5 and Georgia Red were sown in a growth medium of moistened commercial Jiffy Mix (Batavia, IL) in TLC Pro-Trays transplant flats (TLC Polyform, Inc., Plymouth, MN). Seeds were covered with approximately 0.6 cm of the growth medium. Transplant flats were placed in a germination chamber with a 14/10 hours daily light period, a matching 28/22°C thermoperiod, and a constant 70% relative humidity. Seeds/seedlings were watered every three days with de-ionized water, and seedlings were grown for approximately three weeks.

Treatments and Planting

Four seedlings from each cultivar were transplanted into each of three NFT growth channels. Channels were 15-cm wide, 15-cm deep and 1.2 m long. Prior to transplanting into the NFT growth channels, seedlings were carefully removed from the cells in the transplant flats, and excess growth medium was removed by rinsing the roots in tap water. In this way, damage to the developing root system was minimized. Seedlings were placed 25 cm apart through openings made in a flexible perforated PVC-1 grid. The grid is 0.32 cm thick containing perforations with a diameter of 0.32 cm on 0.56-cm centers. With such dimensions, entry of the developing gynophores is facilitated in the pod production zone.

Nutrient Solution

A modified half-strength Hoagland nutrient solution (Hoagland and Arnon, 1950) with an additional 2 mM of Ca and N were used. The solution was supplied to the plants in each channel from 30.4-liter reservoirs with in-line pumps (Little Giant Pump Co., Oklahoma City, OK). Growth channels were on a 1% slope to facilitate return of the nutrient solution to the reservoir by gravity flow. The nutrient solution was replenished once per week with a weak solution (one-third strength Hoagland) and pH adjusted to 6.5. Electrical conductivity ranged between 1000 to 1300 $\mu S\ cm^{-1}$. Solution temperature was similar to that of the air within each growth chamber.

Growth Chamber Conditions

Growth chamber conditions included a constant relative humidity of 70 $\pm$ 5%. The photosynthetic photon flux (PPF) at the top of the plant canopy (approximately 20 cm above the plants) averaged 500μmol $m^{-2}\ s^{-1}$ and was provided by a mixture of cool-white fluorescent and incandescent lamps. The photoperiod was 14/10 h with a matching thermoperiod of 28/24C.

Harvest

The three peanut cultivars were harvested 130 days after transplanting. At harvest, plants were separated into foliage, roots and pods. Fresh weights of component plant parts were determined and pods removed from each plant. Pods were counted, weighed, and dried at 35°C for 72 h before separation into 'mature' or 'immature' and weighed. Pods were then shelled and seeds classified as 'mature' and 'immature', according to the technique of Rucker et al. (1994). Foliage and roots were dried at 70°C for 72 hours. Harvest index (HI) was calculated as a factor of the total weight of mature seeds over the total biological yield of the plant.

$$HI = \frac{\text{Total weight of mature seeds}}{\text{Weights of Foliage + root + mature seeds + immature seeds + pod shell}}$$

RESULTS AND DISCUSSION

To evaluate cultivars for use in the peanut CELSS program it must be realized that it is expensive and screening methods are very critical. Georgia Red is the standard cultivar used in the evaluation process because it has consistently done well over the years in NFT system. These results represent one of several runs used to evaluate Egyptian cultivars. Two weeks after transplanting the cultivars, Georgia Red started to flower and the Egyptian Cultivars (Hybrid 8 and Giza 5) flowered two weeks later.

One of the criteria that is used to indicate that a peanut cultivar is suitable for inclusion in NFT is its compact growth habit. Of the three cultivars evaluated in this study, Hybrid 8 had the greatest amount of foliage fresh weight (Table 1). Fresh weight of Hybrid 8 was 3.5 times that of Georgia Red and 1.7 times that of Giza 5. All three cultivars were significantly different from each other in both foliage and root dry weights (Table 1). Georgia Red had the lowest root and foliage weights and Hybrid 8 the most. The foliage to root (dry weight basis) ratio was 23:1 for Georgia Red; 14:1 for Hybrid 8 and; 13.1 for Giza 5. This shows that Georgia Red was the most compact of the three cultivars an indication of why it does so well in NFT trials. The foliage to root ratio also indicate the ability of Georgia Red to maximize its photosynthetic ability while reducing the overall rates of root respiration. This could possibly translate into higher pod yields.

There was no significant difference between Giza 5 and Georgia Red in the total number of pods per plant (Table 2). However, Giza 5 significantly out-yielded Georgia Red in the number of mature pods per plant (114.9 vs. 68.0) and fresh pod weight (50.3 vs. 38.3 g/plant). Hybrid 8 was significantly inferior to Georgia Red. In evaluating Giza 5 as a potential for inclusion in the CELSS program, it should be noted that it had greater than 2 times the number of mature pods as Georgia Red and four times that of Hybrid 8 (Table 2).

Table 1. Foliage and root weights of hydroponically grown peanuts.

Parameters	Cultivars GA Red	Hybrid 8	Giza 5
Foliage fresh wt. (g)	370.2^{c*}	1265.9^{a}	770.4^{b}
Foliage dry wt. (g)	92.9^{c}	224.9^{a}	163.1^{b}
Root fresh wt. (g)	15.8^{c}	179.8^{a}	131.6^{b}
Root dry wt. (g)	4.1^{c}	16.1^{a}	12.7^{b}

*Any two means within a row with the same superscript are not significantly different

The data further show that the percent mature pods of total pods harvested for Giza 5 was 93.5%; Georgia Red had 64.4%; and Hybrid 8 82.1%. The average weight per pod was also greatest for Giza 5 (Table 2). Average pod weight was 2.14 g for Giza 5; 1.44 g for Hybrid 8; and 1.14 g for Georgia Red.

Table 2. Pod number and weight of peanuts grown using Nutrient Film Technique.

Parameters	Cultivars GA Red	Hybrid 8	Giza 5
Pod #	59.5^{a*}	28.0^{b}	53.8^{a}
Pod fresh wt. (g)	68.0^{b}	40.3^{c}	114.9^{a}
Mature pods (#)	38.3^{b}	23.0^{c}	50.3^{a}
Mature pod wt. (g)	31.0^{b}	17.4^{c}	63.9^{a}

*Any two means within a row with the same superscript are not significantly different

Immature seeds often result in a reduction of the harvest index. Table 3 shows that Georgia Red had the greatest number of immature seeds (27.3) while Hybrid 8 and Giza 5 were not significantly different (8.3 and 9.3, respectively). Although there were higher amounts of immature seeds for Georgia Red plants, these weighed less than either Giza 5 or Hybrid 8.

While the highest shell weights were recorded for Giza 5 and the lowest for Hybrid 8 (Table 3), it must be remembered that Hybrid 8 had the lowest pod number and weight (Table 2).

Table 3. Immature seeds and shell weight of peanuts grown hydroponically.

Parameters	Cultivars GA Red	Hybrid 8	Giza 5
Immature seed (#)	27.3^{a*}	8.3^{b}	9.3^{b}
Immature seed wt. (g)	0.5^{a}	0.8^{a}	0.8^{a}
Shell wt. (g)	6.7^{b}	4.9^{c}	10.1^{a}

*Any two means within a row with the same superscript are not significantly different

Table 4 shows that Giza 5 had the highest mature pods for the total number of pods produced. For every pod of Giza 5 harvested there was 1.57 seeds/pod. On the other hand, there were 1.04 and 1.10 seeds for each pod of Georgia Red and Hybrid 8 harvested, respectively. Data from Table 4 also show that Giza 5 had the greatest number of mature seeds per plant while Hybrid 8 had the lowest.

Additionally, seeds from mature pods of Giza 5 plants weighed 0.63 g compared to 0.44 and 0.40 g per seed for Hybrid 8 and Georgia Red, respectively. There was no significant difference between the harvest index of Georgia Red and Giza 5 (0.16 vs. 0.18). However, both were significantly greater than Hybrid 8.

Table 4. Harvest Index and mature seed weight of hydroponically grown peanuts.

Parameters	Cultivars GA Red	Hybrid 8	Giza 5
Mature seed (#)	62.0[b*]	30.8[c]	84.5[a]
Mature seed wt. (g)	25.0[b]	13.7[c]	53.2[a]
Harvest Index	0.16[a]	0.05[b]	0.18[a]

*Any two means within a row with the same superscript are not significantly different

CONCLUSION

The edible portions of plants are very important in long-term space travel. In order for the bioregenerative life support process to be efficient, there must be a measure of the crop's productivity that we take along in space. The compact nature of the crop and its ability to produce in limited space is evident in the harvest index and other yield components. To that end, Giza 5 is well suited for further evaluation in the CELSS program at Tuskegee University and further studies have been conducted using this cultivar. While Hybrid 8 is an excellent cultivar in the flood, drip and overhead irrigation systems in Egypt, it does not appear to be a suitable candidate for the CELSS project and was removed from further evaluations.

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DETERMINATION OF OPTIMUM HARVEST INTERVAL FOR "RED PETIOLE" DASHEEN, *COLOCASIA ESCULENTA VAR. ESCULENTA*, IN DOMINICA

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ABSTRACT: An experiment on maturity was conducted to determine the optimum harvest interval for "Red Petiole" dasheen *Colocasia esculenta (L.)* Schott var. *esculenta* in Dominica. Results showed that yield components (yield/hectare, corm weight, length and width) for 8 and 9 months harvest intervals were significantly higher ($p< 0.001$) than other harvest intervals of 5, 6, and 7 months and larger and more marketable corms were produced. No significant differences were observed for specific gravity (SG) and % dry matter (DM) between different harvest intervals. Responses to sensory evaluation showed a taste preference for 8 and 7 months harvest intervals (30 and 23%). Significant differences were observed for storage life ($p<0.001$) with the storage life for 8 month harvested corms being more extended (19 days). Based on the percentage of marketable corms, taste preference and storage life the results indicate, that the harvest intervals of 8 months is the appropriate time to harvest "Red Petiole" dasheen cultivar grown under such edaphic conditions.

INTRODUCTION

Dasheen (*Colocasia esculenta (L.)* Schott var. *esculenta*) or Taro as it is more commonly referred to, is a root crop grown throughout the humid tropics and is a very important food in the Pacific. There are many cultivars which differ in: colour of the tuber flesh, which may be white, pink or yellow; the colour of the lamina and veins; with or without purple spot on the upper surface above the insertion of the petiole; the colour of the petiole, which may be various shades of green, or pinkish purple to almost black; some are streaked; the acridity of tuber and leaves (Purseglove, 1985).

Dasheen is one of the major root crops grown and exported from the Caribbean. Currently good markets (ethnic) exist for Caribbean dasheen both in the United Kingdom and the United States that is not fully exploited, though exporters enjoy a comparative advantage (Pilgrim, 1998). In Dominica many cultivars exist but the main cultivar predominantly grown for export is the "common type" (Robin, 2000). This cultivar is distinguished by a large purple spot on the lamina, dark green petiole with white flesh that turns grayish blue on cooking. It forms a single corm, which tends to be oval to round in shape.

The Dominica Export and Import Agency (DEXIA) has identified a niche market in the US with a preference for "red" dasheen. The "pink petiole" dasheen is the only cultivar on the island that seems to come close to DEXIA's described specification of the "red" dasheen. This cultivar has a pink petiole with the flesh having a slightly reddish tinge colour. Since this cultivar is not cultivated commercially, very little information is available on the stage of maturity it should be harvested.

Different maturity indicators (Purseglove, 1985; Robin, 1993) and combinations (crop age from date of planting, senescence of leaves, cracking of soil surface around the base of the plant as the mature corm forces itself upwards and specific gravity measurements) have been used to determine the optimum maturity stage for harvesting dasheen. There have been conflicting reports from the local farmers on the optimum maturity stage for harvesting the "pink petiole" dasheen ranging from 5 to 9 months after planting. This wide range makes it extremely difficult for recommendations to be made to commercial producers, as a result CARDI was mandated to fine tune optimum harvesting time of this cultivar.

METHODOLOGY

The trial began on 17/03/2000 and was conducted on young soils, montmorillonitic in nature without a silica pan (Atkins, 1983) with an average annual rainfall of 2550-5000mm. The trial consisted of six randomised blocks, each block contained five treatments. Treatments comprised five harvest intervals: 9, 8, 7, 6 and 5 months. Plots size was 25m² (270 ft²), each plot contained 54 plants, spaced at 0.61m x 0.76m (2.5 ft x 2.0 ft). The various treatments were planted one month apart (Table 1). This allowed for all treatments to be harvested on the same day (18/12/2000).

Table 1. Planting dates for each harvest interval (treatment).

Harvest Interval (months)	Date of planting
9	17/03/2000
8	18/04/2000
7	18/05/2000
6	20/06/2000
5	19/07/2000

The improved husbandry practices of dasheen (Robin 1997 Guide to Producing and Handling Quality Dasheen in the OECS) were adopted throughout the trial. All treatments were harvested during the week of December 10, 2000. Corms were cleaned to remove dirt, root and dead tissue. Tail and stem ends were cut off with a sharp knife to leave 1.3 x 4.0cm stalks. Data were collected on yield components (weight, length and width), specific gravity, dry matter and storage life of the corms. A sensory (organo-leptic) evaluation was carried out in Dominica to determine consumer acceptability. Plans to carry out similar organo-leptic evaluation in the USA were unsuccessful. The data was analysed by the Analysis of Variance method (ANOVA)

Yield Component

Corms were weighed using a Hanson Hanging Balance Scale - Model 842. A Mechanic Type 6911 caliper was used for measuring the length and width of corms. Corm length measurements were taken from the point of attachment of the leaf stalk to the base. Corm width was measured at the widest part of the corm.

Specific Gravity (SG)

Corms were washed and dried thoroughly. Corms were then weighed in air (x) and in water (y). The formula x/x-y (Burton, 1989) was used for calculating SG.

% Dry Matter (DM)

Corms were peeled, cut into small pieces and then grated. Ten grams (w_1) of each grated sample was placed in a pre-weighed crucible and oven dried (w_2) for 36 hours at 100°C. During drying, samples were periodically removed from the oven, weighed until there were no differences in weight. Percentage DM was calculated using the formula (w_2/w_1) x 100. Specific gravity and dry matter have been used as indicator of maturity for various tuber crops with high SG coinciding with crop maturity. There is also a positive correlation between specific gravity and dry matter.

Storage life

Six freshly harvested corms for each treatment were washed and stored at ambient temperature. Corms were observed daily for sprouting, shriveling, fungal growth and rotting over a storage period of 21 days. Rotted corms were cut longitudinally and examined internally.

Sensory (Taste) Evaluation

A sensory evaluation by 12 assessors, using an acceptability (good, satisfactory, poor and unacceptable) test, was used to determine corm acceptance for eating. Corm samples for each treatment were peeled then cooked for ½ hour before the assessment was conducted.

RESULTS AND DISCUSSION

Yield Components

Table 2 gives the mean values for yield components for different harvest intervals. The effects of harvest interval on yield components (yield/hectare, corm weight, length and width) were highly significant (P <0.001). Eight and 9-month harvest intervals gave highest yields - 19.6 and 24.3 t/ha respectively when compared to that of corms harvested at 5, 6 and 7 months respecively. Mean corm weight, length and width was also higher for 8 and 9-month old corms.

Table 2. Mean yield per hectare, corm weight, length and width of the "Red petiole" dasheen harvested between 5 and 9 months.

Harvest Interval	Mean yield/hectare. (t/ha)	Mean corm Weight (kg)	Mean corm length (cm)	Mean corm width (cm)
5 month	8.5	0.48	7.75	7.65
6 month	9.1	0.42	9.23	7.82
7 month	10.3	0.48	10.78	7.83
8 month	19.6	0.91	14.53	9.60
9 month	24.3	1.12	16.77	10.08
SEM (20 d. f.)	1.6	0.08	0.61	0.29

Table 4 shows corms were well shaped i.e. oval and uniform for all treatments. There was a significant difference for shape (length/width ratio) between treatments (P<0.001). Corm shape varied between round to oval (1.0 to 2.0). There was also a significant difference for percentage marketable corms (P<0.001). Corms harvested at 8 and 9 months produce larger and more marketable corms when compared with those harvested at 5, 6 and 7 months (Tables 2 and 3).

Table 3. Length/width ratio and percentage marketable corms for different harvest intervals for "Red petiole" dasheen.

Harvest Interval	Length/Width	% Marketable Corms
5 month	1.01	7.8
6 month	1.18	11.1
7 month	1.38	12.2
8 month	1.51	52.2
9 month	1.66	57.8
SEM (20 d. f.)	0.06	6.2

Specific Gravity (SG) and % Dry Matter (DM)

There was no significant difference for the specific gravity and % DM results presented in Table 4. Specific gravity varied from 0.972 to 1.616 for the different harvest intervals with 7 (1.616) and 9 (1.268) month harvest intervals having the highest SG. However percentage DM varied for different harvest intervals with 9 (38.7%) and 6 months (35.4%) having the highest % DM. Corms harvested at 5 months had the lowest SG and % DM.

Table 4. Specific gravity and percentage dry matter for different harvest intervals for "Red petiole" dasheen.

Harvest Interval	Specific Gravity	% Dry Matter
5 month	0.972	32.6
6 month	1.198	35.4
7 month	1.616	33.3
8 month	1.124	33.4
9 month	1.268	38.7
SEM	(6d.f.) 0.975	(4 d. f.) 2.2

Sensory (Taste) Evaluation

Table 5 shows the various responses to taste preference for different harvest intervals for "Red petiole" dasheen. Thirty and 23 % of the assessors rated corms harvested at intervals of 8 and 7 months respectively as having good taste. Fifty percent rated corms harvested at 9 months unacceptable taste, together with 24.8% for both 5 and 7 months

Table 5. Response to taste preference for different harvest intervals for "Red petiole" dasheen.

Harvest Interval	% Good	% Satisfactory	% Poor	% Unacceptable
5 month	19.2	28.9	0.0	24.8
6 month	15.3	20.1	39.9	0.0
7 month	23.2	24.1	0.0	24.8
8 month	30.8	12.0	20.1	0.0
9 month	11.5	15.9	40.0	50.4

Storage-life

Table 6 shows the storage life (number of days to 50% rotting) for different harvest intervals, for corms stored over a 21day period at ambient temperature. Significant differences were observed for storage-life (P<0.001). Rotting was the main cause of shelf-life reduction. Storage life of corms harvested at 8 months was more extended (19 days) than corms of other harvest intervals. No sprouting or fungal growth was observed for corms throughout the storage period. However shrivelling due to water loss affected all treatments.

Table 6. Storage life for different harvest intervals of "Red petiole" dasheen corms over 21 days of storage.

Harvest Interval	Number of Days to 50% rotting
5 month	14
6 month	12
7 month	15
8 month	19
9 month	10
SEM (16 d.f.)	1.2

CONCLUSION

Based on yields, percentage of marketable corms, taste preference and storage-life for different treatments, the harvesting interval of 8 months is the most appropriate time for harvesting the "red petiole" dasheen cultivar under such edaphic conditions. Fifty two percent corms harvested were marketable, 30.8% of the assessor thought the corms were of good taste and the corms had an extended shelf life 19 days to 50% rotting, which exceeded corms harvested at other intervals by an average of six days. Though the specific gravity and dry matter were the highest for 9-month harvest interval and are indicators of physiological maturity, other factors such as taste and storage-life were of greater significance from a marketing point of view.

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STRATEGIES FOR URBAN REFORESTATION WITH NATIVE SPECIES IN THE U.S. VIRGIN ISLANDS

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ABSTRACT: Spreading development, hurricanes and other factors on St. Croix have transformed the landscape from a forested one to an urban/agricultural setting. More information is needed regarding the suitability and propagation methods of our native trees before a successful urban forestry and/or forest restoration project with native tree species can begin. To this end, several native tree species were examined for their use in reforestation efforts and urban plantings. Beginning in June 1999, a phenology study was undertaken to determine the best seed collection time and from this a native tree calendar was created. An efficient seed cleaning technique was developed for each species. Five pregerminative treatments (24 h water soak, boiling water 1 h, boiling water 2 h, 1 h Gibberellic acid [GA3] and control) were conducted and the most effective identified for each. *Calubrina arboresence*, *Guazuma ulmifolia*, and *Hymenaea courbaril* germinated best with a boiling water treatment. *Capparis cynophallophora* and *Canella winterana* had the lowest overall rates, achieving highs of 38% (water soak) and 17% (GA3) respectively. *Solanum conocarpum* germinated at 100% with the water soak, GA3 and the control. The polyembryonic *Cordia rickseckeri* achieved rates of 130% and above with the water soak and GA3. *Crossapetalum rhacoma* and *Guaiacum officinale* were most successful with GA3. This information will assist people in the forestry field to collect, germinate, and utilize more native tree species in future projects.

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TOWARDS A GIS-BASED CARIBBEAN LAND AND WATER RESOURCES INFORMATION SYSTEM

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ABSTRACT: The management of land and water resources in the Caribbean is a major challenge due to their relatively fixed quantity and smallness, limited and decreasing quality, increasing demand, aversion to natural and human degradation and exogenous influences. For effective and efficient management of these resources, there is need for current and accurate information on the extent and status of these resources. The use of Geographical Information Systems (GIS) and remote sensing are seen as enabling technologies to combat the deficiency in the land and water resources information. The chapter presents examples on the use of GIS in land resources inventory and in evaluation of the carrying capacity of land resources. A Caribbean Land and Water Resources Information System (CLAWRIS) is being proposed that allows for the integration and dissemination of land and water resources data. The chapter underscores the need to develop a strategic development programme that would ensure effective and efficient development of CLAWRIS.

INTRODUCTION

The management of land and water resources in the Caribbean remains a major challenge for resource and economic managers. Many factors that characterize the peculiarity of these resources are responsible for this challenge. These factors include:
Fixed quantity and restricted land area
Limited and decreasing quality
Increasing demand
Aversion to natural and human degradation
Exogenous influences

1.1 Fixed quantity and restricted land area

The relatively small total landmass that forms the archipelagic Caribbean is a resource management challenge compared to the vast water mass that surrounds the region. The land mass and its internal surface and ground water constitute the limited natural resources needed for the socio-economic development of the region. Many of the island states of the region lack surface water and also have limited ground water. The topography is highly undulating and poses challenges to agriculture, housing and urban infrastructural development. The coastal zones have become the only land resource available to satisfy the countries' requirements for socio-economical activities. These limitations have compelled resource planners and managers to seek intensive use as opposed to extensive use of these resources. This has implications for the carrying capacity and sustainability of these resources.

1.2 Limited and decreasing quality

The soils and geology of the region pose challenges to resource management. Due to constraints of aerial extent and quality, the soils permit limited agricultural practices and the steep slopes of the rugged terrain expose the land to accelerated soil erosion. Current agricultural practices that favour hill-side farming, use of fertilizers, pesticides and other Non-point Source (NPS) pollution are major contributors to the loss of quality of the land and water resources of the region. Halting or reducing this effect is a challenge for the sustainable use of these resources.

1.3 Increasing demand

Population pressure is a major contributor to management and use of resources. Even though the population of the region is relatively low, the food consumption pattern is high and the use of the land and water resources for the production of export products has led to an increase in the demand for these limited resources. Large areas of agricultural lands are required not only for domestic food production, but also for production for export market. Managing increasing demand for quality land and water resources in the face of fixed quantity and decreasing quality, challenges the sustainable use of these resources.

1.4 Exposure to natural and human-induced degradation

The Caribbean region is highly prone to severe hurricanes, flooding, landslide, volcanic eruptions, coastal erosion and earthquakes. These natural disasters have caused unforeseen damage to the land and water resources of the region. Potential agricultural lands have been damaged, ground and surface water polluted and urban infrastructure destroyed due to the unpredictable and severe effects of these natural disasters. Human-induced degradation also continues to be a major challenge. Slash and burn farming, untreated sewage, indiscriminate dumping of waste, unplanned land use changes, physical developments in landslide and flood prone lands and indiscriminate exploitation and use of ground water are major causes of land and water resources degradation. Policy and social education are required to mitigate the incidence of these negative impacts.

1.5 Exogenous factors

In addition to the internal challenges, there are exogenous factors that impose constraints on the management of land and water resources in the Caribbean. Trade liberalization, fluctuating foreign exchange, trade agreements and conventions could either lead to intensive use of land and water resources or abandonment of land and water-based economic activities. The unpredictable nature of these factors has posed a major challenge to resource planners and managers in the region.

In order to effectively and efficiently address the impacts of these challenges, there is need for current and accurate information on the extent and status of these resources as well as knowledge of the social and economic factors impacting on their quantity and quality. The information, on the other hand, has varying characteristics that pose challenges for its efficient use. The information may be collected at varying accuracy resolutions, formats and differing classification standards. The use of Geographic Information Systems (GIS) and remote sensing as enabling technologies to combat deficiency in the land and water resource information is discussed in the next section.

2.0 GIS as enabling technologies

Improvements in information technology have provided unimaginable opportunities improvement in data analyses and communications in the last two decades. GIS have provided new and exciting ways of acquiring land and water resource data and also providing efficient means of processing, managing and integrating this data. GIS is an organized collection of computer hardware, software, geographic data and personnel, designed to efficiently *capture, store, update, manipulate, analyze and display* all forms of geographically referenced information (Opadeyi, 1992). Geographic information plays an important role in activities such as environmental monitoring, management of land and water resources and real estate transactions. The areas of GIS applications are numerous and growing. Listed below are major areas of applications that have benefited from developments in GIS (Goodchild and Kemp, 1990):
Management of natural resources
Environmental impact analysis (EIA)

Hazardous or toxic facility siting
Groundwater modelling and contamination tracking
Wildlife habitat analysis
Zoning and review of subdivision plans
Land acquisition and distribution
Maintenance of land ownership records

The increasing use of GIS in the varying professional fields has produced both tangible and intangible benefits that are enough to sustain its use into the future. The following benefits have been advanced for the use of GIS natural resource management (Dale and McLaughlin, 1988; Aronoff, 1989 and Star and Estes, 1990):
Provides integrated data storage and data retrieval capabilities.
Encourages a more systematic approach for the collection of data.
Leads to reduction in the overall costs of data collection and management by facilitating data sharing among users.
Increases comparability and compatibility of diverse data sets.
Makes data accessible to a wider range of decision-makers.
Encourages the spatial analysis of environmental impacts that are otherwise ignored because of analytical difficulties or high cost.

Over the past five years computer hardware and software constraints to GIS development have been reduced. Data acquisition still remains a challenge even with advances in remote sensing technology and decreasing cost of data acquisition. The removal of the intentional error in Global Positioning Systems (GPS) readings and the availability of satellite imagery with one metre spatial resolution have provided some relief to these constraints. The recent commercialization of the IKONOS satellite imagery with the one metre panchromatic and four metre multi-band resolutions is revolutionizing the use of GIS for natural resource management.

GIS has five functional components: data collection and acquisition; data preparation; data integration; data management; data analysis and application (Opadeyi, 1992). *Data collection and acquisition* provide for flexibility in the nature and format of the data required. For example, tabular data currently existing in hardcopy and digital format; graphical data in hardcopy map format; photographs, remote sensing data and analog field data can all be incorporated into a single GIS environment. *Data preparation* is the process of extracting, spatial coding and conversion of field sample data and related data in a form that will provide for easy referencing and ability to cross-reference the data with other data. *Data integration* functionality provides the unique advantage of being able to link spatial data to attribute data and the ability to add any other form of data within the GIS environment. *Data management* functionality in a computer environment provides the infrastructure for the storage, retrieval, merger and generalization of different data categories. *Data analysis and application* functionalities are the main outputs or end products for the use of GIS.

2.1 Special GIS requirements in land and water resources management

The nature and characteristics of land and water resources management applications demand that databases and the computing environments must have the following capabilities: *multi-criteria modelling, time series analysis and data integration.*

Multi-criteria modelling is a basic requirement in environmental management where several factors are investigated for the occurrence and non-occurrence of a phenomenon. The ability of an environmental management system to model the different criteria is very important. The hydrologic cycle and its entities, for example, require a large volume of incompatible data for comprehensive monitoring and management. For example, the parameters that affect the discharge and recharge of the aquifer are varying. Apart from the overlay functions, extensive multi-criteria modelling capabilities are a necessary requirement. The ability to relate changes in atmospheric parameters, domestic and industrial activities, forestry/agricultural practices and soil erosion to the quality of water in an aquifer is far from being an easy multi-criteria model.

Time series analysis is necessitated by the time-dimension or the fourth dimension of hydrologic data. The collection and analysis of hydrologic data is continuous. For prediction and modelling activities, the more historic data available, the better. Most GIS software only covers an epoch of time. Rainfall and temperature data, for example, are daily/hourly data that are forever collected. Special GIS functionalities are required to process and analyse such data.

Data integration flexibility is necessitated by the need to collect data in whatever format and be able to use it within GIS software. Water resources data can be collected using remote sensing, photogrammetry, direct field surveys and telemetric down loading from weather satellites. Data handling and conversion routines must be available for the integration of this disparate information into a common database. Very few GIS software allows for such integration. The extraction of raster images and their conversion to vector file format is an example of the required data integration capability the software must demonstrate.

3.0 The use of GIS in land and water resources management

The use of GIS technology has greatly extended the ability to analyze data on land and water resources for gap analysis, modelling and decision support systems. The increasing capacity of GIS to integrate data from a variety of sources allows for more sophisticated analysis. In this section, examples of how GIS is being used in applications relevant to land and water resources management are provided.

3.1 The use of GIS in water resource management

The use of GIS in water resource management is gaining support. For example, Turner and Kolm (1991) developed a 3-dimensional GIS for groundwater modelling of regional aquifer systems in areas with complex geologic and climatic conditions. Kilborn et. al. (1991) integrated ground water models with GIS, thus providing spatial visualization for the output of the models. Mullen (1991) demonstrated the use of GIS in the assessment of ground water, in particular, analyzing the spatial distribution of atrazine contamination in wells along with data on soil leachability. Tucker and Devine (1991) integrated water quality database with a GIS in order to highlight the spatial and temporal dimensions of the database and to undertake more sophisticated analysis. As a data acquisition tool, Richie and Cooper (1991) utilized "Landsat Multispectral Satellite (MSS)" data in a GIS environment to estimate surface suspended concentration over the Enid Reservoir in North Central Mississippi and Shih and Jordan (1992) integrated remote sensing techniques with GIS to assess regional soil moisture conditions over a 208,354ha. site in southwestern Florida.

Special purpose water quality modelling software can be interfaced with GIS for a fully integrated modelling environment. Such an interface would lead to reduction in data input problems and foster integrated analysis and visualization. This becomes important when water quality data are to be georeferenced for spatial analysis.

Fundamental to the successful development of GIS support for water quality management, is the development of land and water resource databases for the entire management area. The databases would provide support for both qualitative and quantitative analyses of hydrological queries. Attempts are currently being made by several agencies in the Caribbean, to develop such databases through the Caribbean Planning for Adaptation to Global Climate Change (CPACC) Project.

3.2 The use of GIS for Environmental Monitoring

The single most important threat to surface and subsurface water resources is non-point source (NPS) pollution. Agriculture which is vital in meeting the demands for food, is threatened by NPS pollution. GIS is being used to estimate the spatial distribution of NPS pollution such as nitrogen, phosphorus, zinc, lead, and sediment. The ability to accurately assess present and future NPS pollution impacts on the ecosystems at a local and regional scale would provide invaluable information for the management of land and water resources in the Caribbean. The integration of GIS with NPS pollution model can be used to estimate the success of management attempts to reduce pollution loads in water. Assessing NPS pollution is an integrated process and it comprises a number of complexities of scale and position, thus drawing from different fields of science and applied in a spatial context.

In the case of NPS pollutants, Corwin et al. (1999) used a mathematical model within the context of a GIS that describes the appropriate chemical, physical and biological processes involved in the transport of a solute through the vadose. Endreny and Wood (1999) in Central Oklahoma used topographically based land atmosphere transfer scheme (TOPLATS), a GIS-based watershed model, in a water table-driven hydrology routine to identify runoff zones in a specific area of agricultural watershed. Carver et al. (1996) evaluated the field-based GIS methodology for environmental characterization, modelling and decision support and noted the following advantages to the use of GIS:

Improvement of environmental models through interactive field verification procedures;

Greater confidence in data gained through direct involvement in the data collection process;

Operation of positive feedback mechanisms;

Input of local knowledge and experience.

Duguay and Walker (1996) discussed environmental modelling and monitoring with GIS. They stated that remote sensing imagery and ancillary data from GIS are important sources of information for input to ecological and climatic models of seasonal and long-term change. One of the goals of the United States Long-term Ecological Research (LTER) programme is to systematically monitor and study patterns and controls within a variety of natural ecosystems at various spatial and temporal scales. The goal of this study is to monitor changes on the earth's surface as a result of natural and anthropogenic processes. Within LTER, the integration of remote sensing and GIS data sets will be critical towards linking established and detailed ecological studies at plot and landscape levels to regional scale interpretations through ecological simulation and modelling.

Recent cases of drinking water contaminated by pathogens have under scored the importance of preventing livestock waste from entering surface water. It is to this end, that analytical techniques are needed to identify sub watersheds or livestock operations that contribute disproportionately to contamination. A GIS-based transport model (SEDMOD) is used as an index of pathogen loading potential to streams using key transport parameters (Fraser et al., 1998). The transport model together with a livestock density GIS layer, explained 50% of the variation in average faecal coliform discharged from sub-watersheds. Though not perfect in quantitative predictions, the model is useful for predicting the relative contribution of diverse livestock operations within a varied landscape, hence watershed managers can prioritize sites for NPS pollution control.

3.3 The application of GIS in a land resource inventory programme: SALIS

Guided by the need to efficiently and effectively manage land resources, the Trinidad and Tobago Ministry of Agriculture, Lands and Marine Resources (MALMR) developed a GIS parcel-based State Agricultural Land Information System (SALIS). The objectives of SALIS are as follows:

To design and develop an automated information system that could be used to collect, store, retrieve, manipulate, analyze, manage and share land-related data required for the management of state agricultural land.

To implement the use of such a system on a phased-basis in all agricultural districts.

To evaluate the strategies and resources required for a full implementation on all state lands.

To integrate SALIS with other natural resource databases existing e.g. soils, rainfall and elevation databases.

To integrate SALIS with other property management databases existing in other land-related agencies in Trinidad and Tobago.

The SALIS stores for each parcel of State agricultural land, information on the following themes:
Land parcel definition
Official record of tenure
Field investigated tenure
Information on occupier
Information on land rent
Information on land use and level of utilization
Agricultural commodity on land
Information on water supply

Figure 1 is an example of a land use map produced from SALIS and the system is being used to perform the following land management activities:
Area and commodity development planning
Natural resource management
Land rent collection and management
Land valuation processes
Land use planning and management
General estate management
Land tenure regularization
Determining water needs for agricultural development

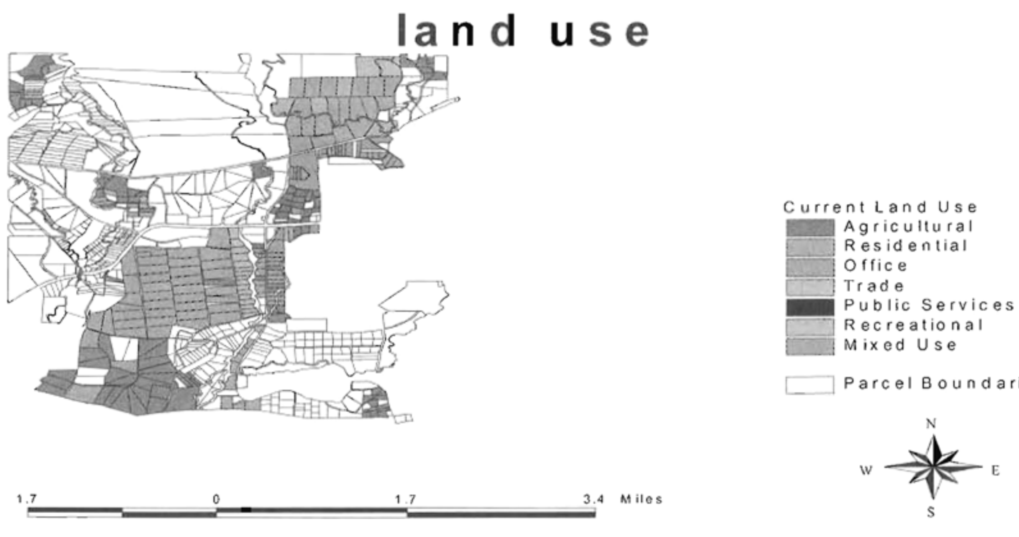

Figure 1. Current land use map derived from SALIS

3.4 GIS as a technique for evaluating the carrying capacity of land resources

The watersheds of the north and northeast Coasts of Trinidad are vitally important for the supply of potable water. The area consisting of beaches, scenic rugged terrain, forests and scattered rural communities, is also very popular for recreational activities. For this reason, the area is targeted for the

development of sustainable this activities. To evaluate its potential for these activities, a carrying capacity study with the following objectives was conducted:
To assess the ecological, physical, infrastructural, socio-cultural, economic and land use context of the study area for sustainable tourism use and development.
To determine the optimum amount and location of activity and development for the area.

The study was undertaken using GIS. Spatial analyses were conducted to objectively identify developable sites for tourism activities. In order to minimize disruption to the ecosystem of the area the following criteria were imposed for a land site to be qualified for physical development:
Be on slopes less than 20 degrees (Category 4)
Not be located on prime agricultural land and steep forested slopes
Not be on ecologically sensitive sites
Not be within Forest Reserves
Not be within existing human settlements
Not be within designated National Parks and Protected Areas
Be on State lands

The GIS data used for the analysis were:
Ecologically sensitive sites (bird and turtle nesting habitats along beaches)
Human settlements and land tenure
Forested areas including forest reserves
Designated national parks and protected areas, scientific reserves
Agricultural land capability classes
Scenic landscapes and national landmarks
Watershed boundaries

Once the digital databases were prepared, spatial analyses were conducted to select developable sites using the given criteria for each of the 12 watersheds. Figure 2 is an example of developable sites in the Maracas watershed. The selected sites were subsequently used to derive potential hotel and guesthouse locations based on the total daily carrying capacity of beaches and trails in proximity to the developable sites.

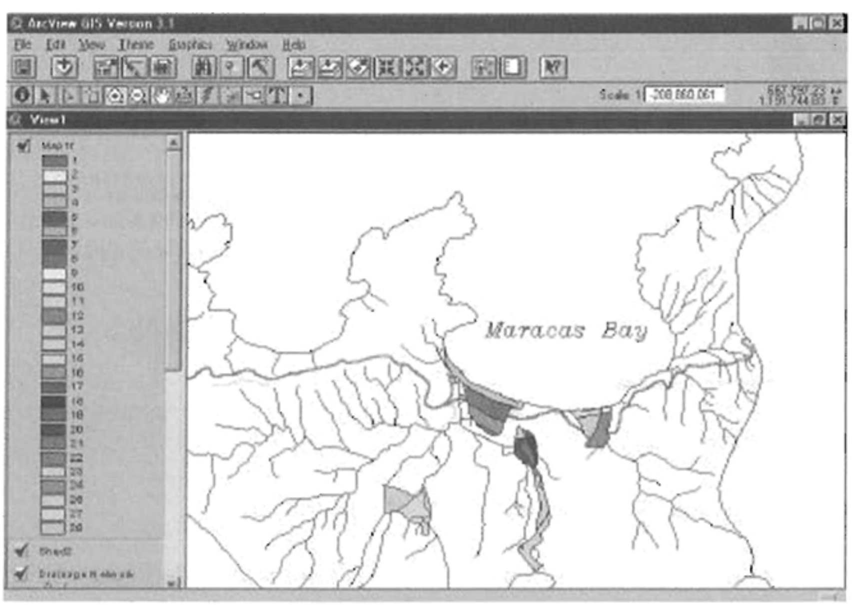

Figure 2: Developable sites in the Maracas watershed

4.0 Building a GIS-based CLAWRIS

The development of a Caribbean Land and Water Resources Information System (CLAWRIS) requires a careful and well thought out design considering the features and complexities of its environmental conditions which are to be monitored. This is particularly so when one considers the cost of data collection, the range of users and uses and the need for longevity of the system. The life cycle of information system can be subdivided into the following main stages: requirement analysis, database design, implementation and maintenance. *Requirement analysis* focuses on the peculiarities of the systems, the applications and the user environment. *Database design* is the building block of the system and it focuses on the conceptual and logical design of the database and other details that will ensure that the system can transform the data into user defined products. The *implementation* stage turns the design into action by physically automating the data and developing user interfaces needed for the effective use of the system. The most critical but often neglected stage is the *maintenance*. This stage ensures that the system remains relevant to current and future needs. This paper addresses only the requirement analysis and database design stages.

4.1 General requirement analysis

CLAWRIS is conceptualized as a regional information system that may be employed by a wide range of users for purposes ranging from simple to complex analysis of land and water issues in the Caribbean. It is therefore necessary that CLAWRIS should have the following design features shown in Figure 3:
Data-driven
Fully integrated
Portability
Multi-scale
Modularity

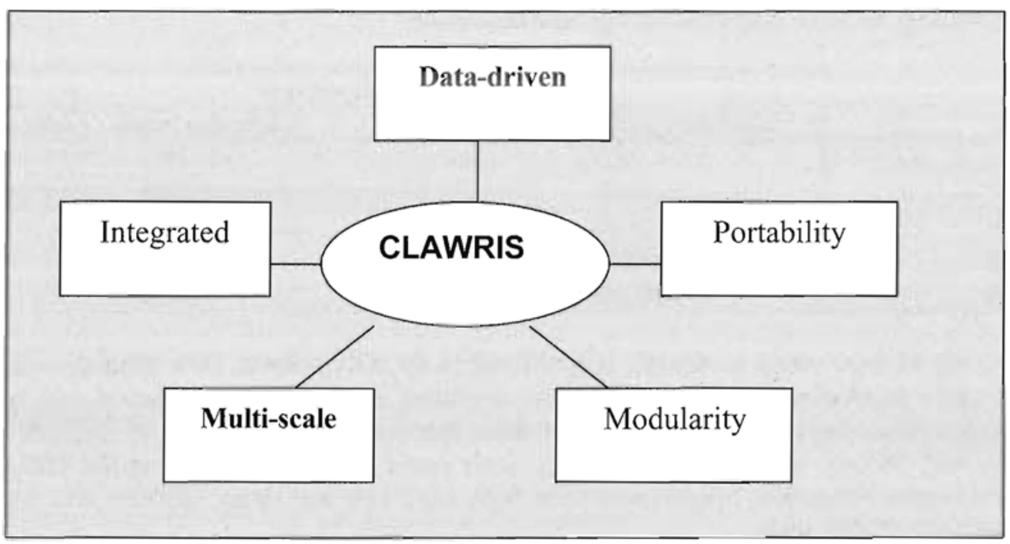

Figure 3: The design feature of CLAWRIS

The *data driven* design approach focuses on explicit characterization of the data entities with little knowledge of the user's needs. It concentrates on building a generic database that can meet the needs of current and future users and it lends itself to being managed through a phased or modular development. The application-driven design is user focused. It normally results from extensive user requirement studies. It assures the users have a clear idea of what they want. It may be inexpensive to develop but runs the risk of not meeting future needs and the needs of other users. An integration of the two design approaches is being advocated for CLAWRIS. Due to the multi-faceted nature of the parameters required for comprehensive land and water resources management, it is required that CLAWRIS has the capability to *integrate data* from different sources and formats. *Portability* should be an important feature of CLAWRIS because of the advantage of being able to implement it at both local and regional levels and it should be possible for it to be moved from one computer environment to another with minimum effort. *Multi-scale* feature allows for the integration of data compiled at different resolution and accuracy as is commonly found in the Caribbean. *Modularity* allows for a phased implementation of CLAWRIS and the capability that ensures an integrated solution. The different applications for the management of land and water resources may thus be built at different times and by different developers.

Conceptual design of CLAWRIS

In order to ensure accuracy and consistency in spatial analysis it is necessary that all the data inputs be of the same coordinate system and map projection.

4.2.1 Resolution of input data

Even though it is perceived that GIS data can be independent of scale, this is a myth. It is a fact that GIS data can be displayed at any scale, the accuracy of the output data however, cannot be better than that of the input. It is therefore important that the resolution of the input should be selected to the satisfaction of the desired output or applications since the scale of a map is directly related to its resolution. The map resolution defines the accuracy with which the location and shape of a ground feature can be shown for a given map scale. Table 1 gives an example of the ground resolution (minimum plot size and minimum length) of objects that can be accurately resolved at different map scales. If a particular application that requires that the location and shape of all buildings in a watershed be known accurately, then the scale of the input map would be 1: 1000 or better.

Table 1: Relationship between map scale and ground resolution

	Ground Resolution	
Map scale	Minimum plot size (Acres)	Minimum length (Feet)
1 : 10,000	<1	105
1 : 24,000	2 –3	250
1 : 100,000	25-50	1050
1 : 250,000	250-500	2600
1 : 500,000	500-1000	5280

The scale of input maps is directly proportional to the data volume, data integration complexity and cost of system development. Small scale or low resolution implies a low volume of data while large scale or high resolution implies a large volume of data. Whereas four map sheets at 1:75,000 cover the island of Trinidad, 38 map sheets at 1:25,000 map scale cover the island. Choosing the 1:25,000 maps will lead to 12.5metre resolution, longer input time, high input cost and larger database size compared to the use of maps at 1:75,000 scale.

Whereas it is desirable that the purpose of the application should determine the resolution of the input data, this ideal condition is sometimes difficult to establish especially in the Caribbean. Available maps exist in different map scales with no resources available for re-mapping at the desired scales. The user is therefore left with no choice but to integrate high-resolution data with those of low-resolution. When this situation occurs, the user should be prepared to interpret the final output using the low resolution and at a later time the level of resolution can be upgraded. If resources permit the generation of higher resolution data using for example IKONOS satellite imagery.

CLAWRIS advocates the acquisition of multi-scale spatial databases to facilitate the different needs of the end-users and to provide efficiency in the management of the system. It is required that the specific resolution of each potential application be defined and specified, based on the needs of the users.

4.2.2 Coordinate system of input data

GIS provide a mechanism for the measurement of spatial phenomena. This spatial measurement must, however, be based on a coordinate system for it to be meaningful to the end users. The design of CLAWRIS is faced with the challenge of selecting the appropriate coordinate system for data storage and mechanisms for converting from one coordinate system to another. Geographic data can either be stored in geographic coordinate system (GCS) or in Projected Coordinate System (PCS). GCS reference location on the surface of a three-dimensional sphere using geographic latitude (Ô) and longitude (ë) of the locations, whereas PSC reference location by employing a two-dimensional plane by measuring the northings (N) and eastings (E) coordinates from the origin. The GCS is global in nature whereas the PCS is local and unique to a small location. The PCS is the result of projecting coordinates from GCS to the two-dimensional surface. The consequence of such projections is the distortion of the spatial properties of the object. For mapping convenience and other historical reasons the States of the Caribbean have been mapped using different map projections.

The challenge in the development of CLAWRIS is in the selection of an appropriate coordinate system for data storage. A detailed understanding of the mapping parameters of each country and island is a prerequisite towards the development of CLAWRIS. In order to facilitate data integration, data sharing and comparative regional analysis, the GCS is considered best suited to CLAWRIS. This decision means each spatial database of all the countries be stored in the GCS. It therefore implies that existing digital data be converted to the GCS. The World Geographic System 1984 (WGS 84) is also considered the best option because of its global popularity. Apart from gaining knowledge of the map parameters of all the countries, it is also important that utility software is readily available to convert the data from one system of coordinates to another. The inclusion of projection utility function in GIS software has provided end-users with the ability to undertake such two-way conversions with minimum expert knowledge.

4.3 Logical database design

Using a data-driven approach, the logical design of CLAWRIS is to be independent of end-user application. Therefore the following logical design elements would be considered:
Data themes
Data layers
Feature type
Primary and related attributes
Selection criteria
Drawing methods

The design of data themes facilitates data referencing and data organization and it ensures reduction in data redundancy. The following criteria can be used to design data themes: (ESR1, 4-71)
Logical similarity among the data
Existence of coincidence feature
Topological continuity
Topological interference
Management responsibilities
Source map scale
Incompatible attributes

Table 2 is the CLAWRIS preliminary data themes. This can be further refined and regrouped to include end-users requirements. Figures 4 to 13 are subsets of digital GIS-based data themes created for Trinidad.

Table 2: CLAWRIS data themes

Natural resources data themes Soils characteristics Hydrology: rivers, dams, lakes, ponds Elevation: contours, bathymetry Land cover, land use Vegetation Forest reserve, natural parks Land tenure/ownership Geology/hydrogeology Sensitive sites, wetlands and reserves Communities and settlements Watersheds Coastlines, bays, beaches Enumeration districts/population Infrastructure data themes Transportation: roads, seaports, airports Water distribution systems Gas distribution systems Electricity distribution systems Telephone distribution systems Sewerage systems Drainage systems Industrial sites Waste disposal sites Social amenities data themes Post offices Fire services Police stations Health facilities Schools Markets Recreational Grounds/Open spaces Places of worship and Historical sites	Atmospheric / climatic data themes Rainfall Temperature Humidity Wind Ocean current Wave Salinity

Figure 4: The drainage network and watersheds of Trinidad Northern Range

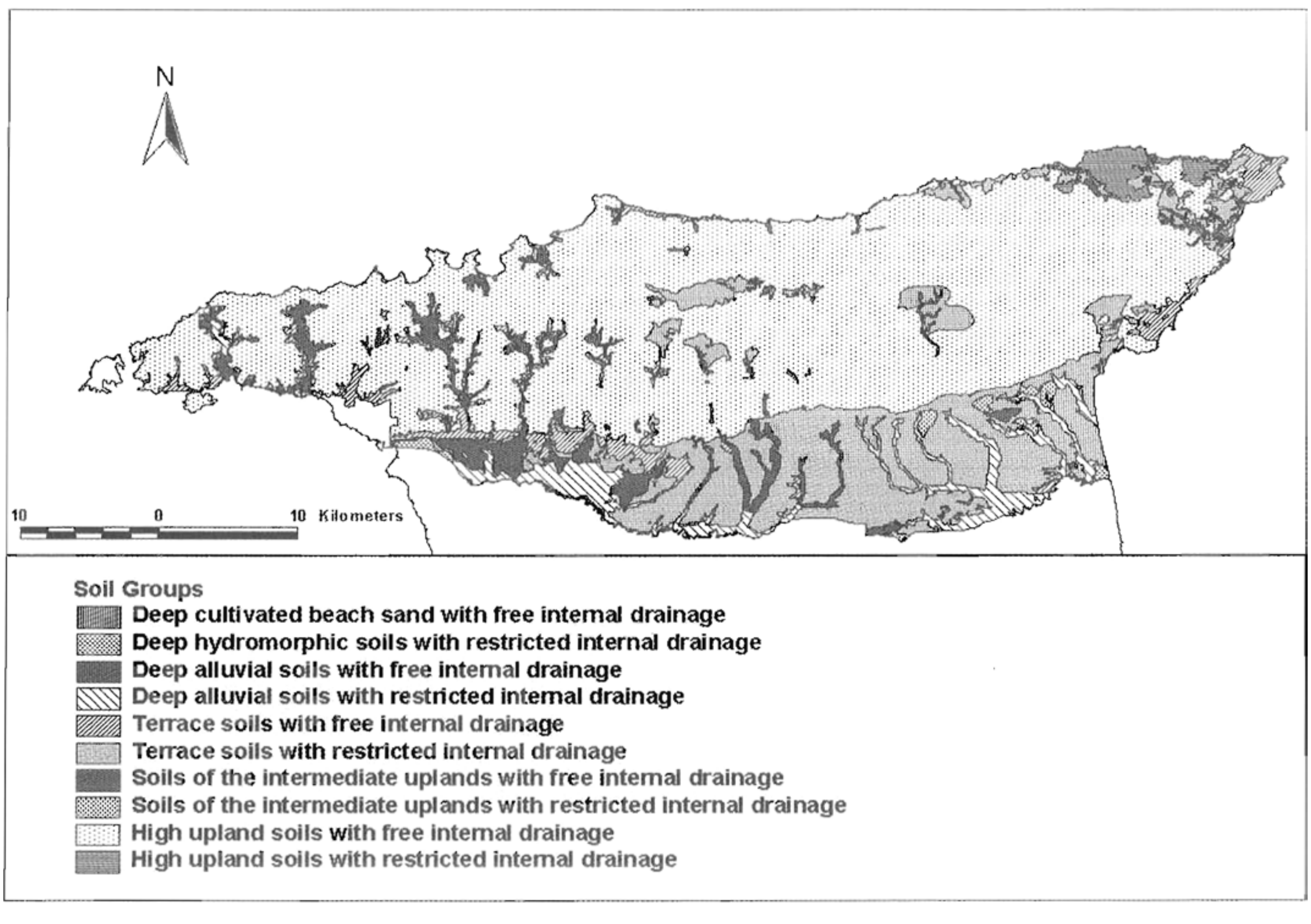

Figure 5: The soil groups of Trinidad Northern Range

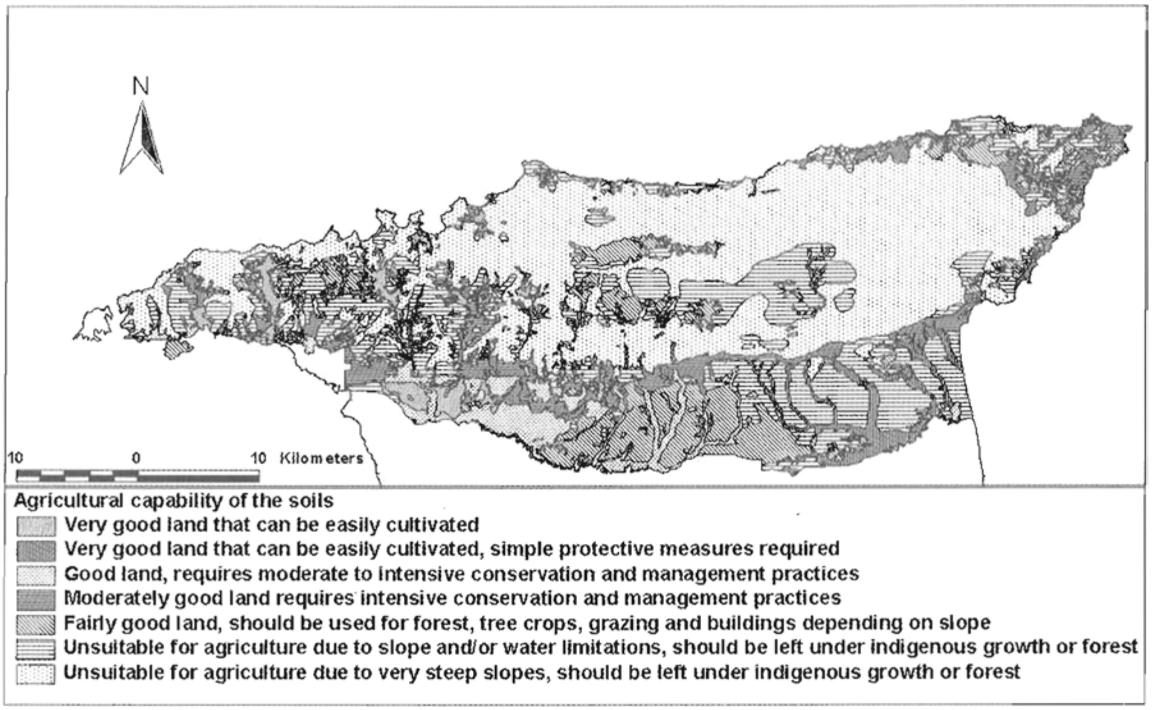

Figure 6: The agricultural capability of the soils of Trinidad Northern Range

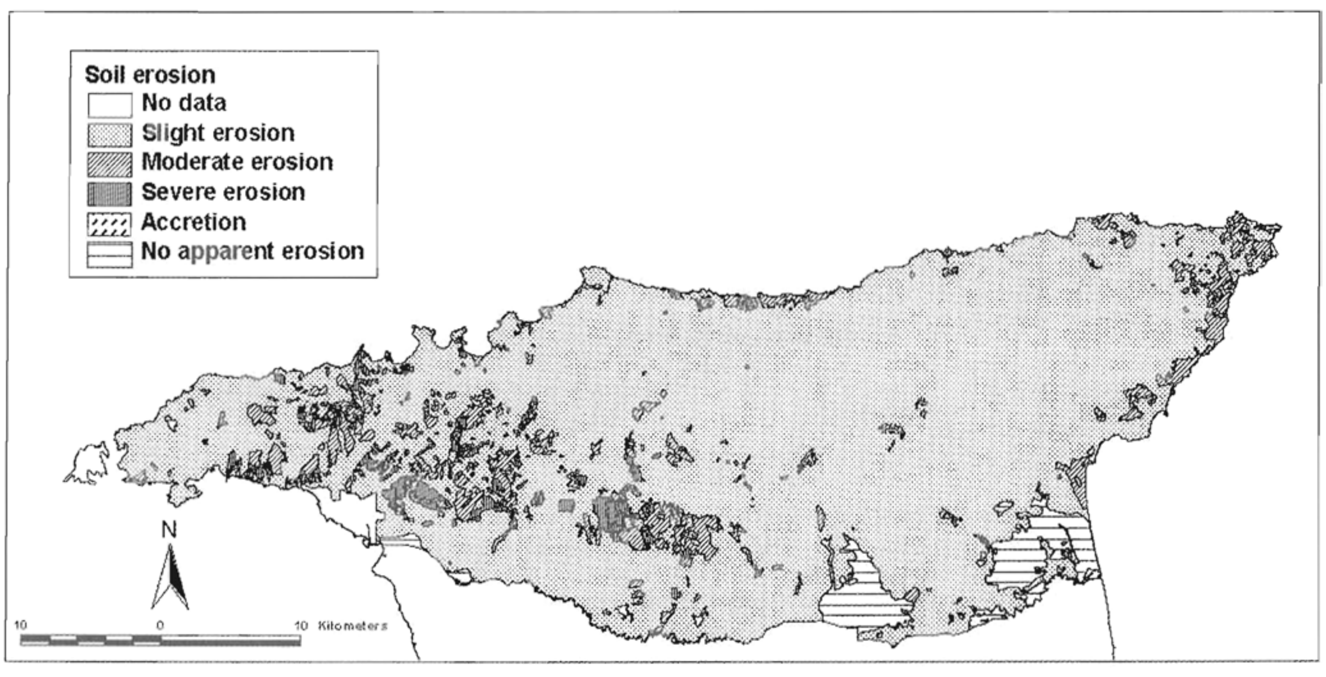

Figure 7: The soil erosion categories of Trinidad Northern Range

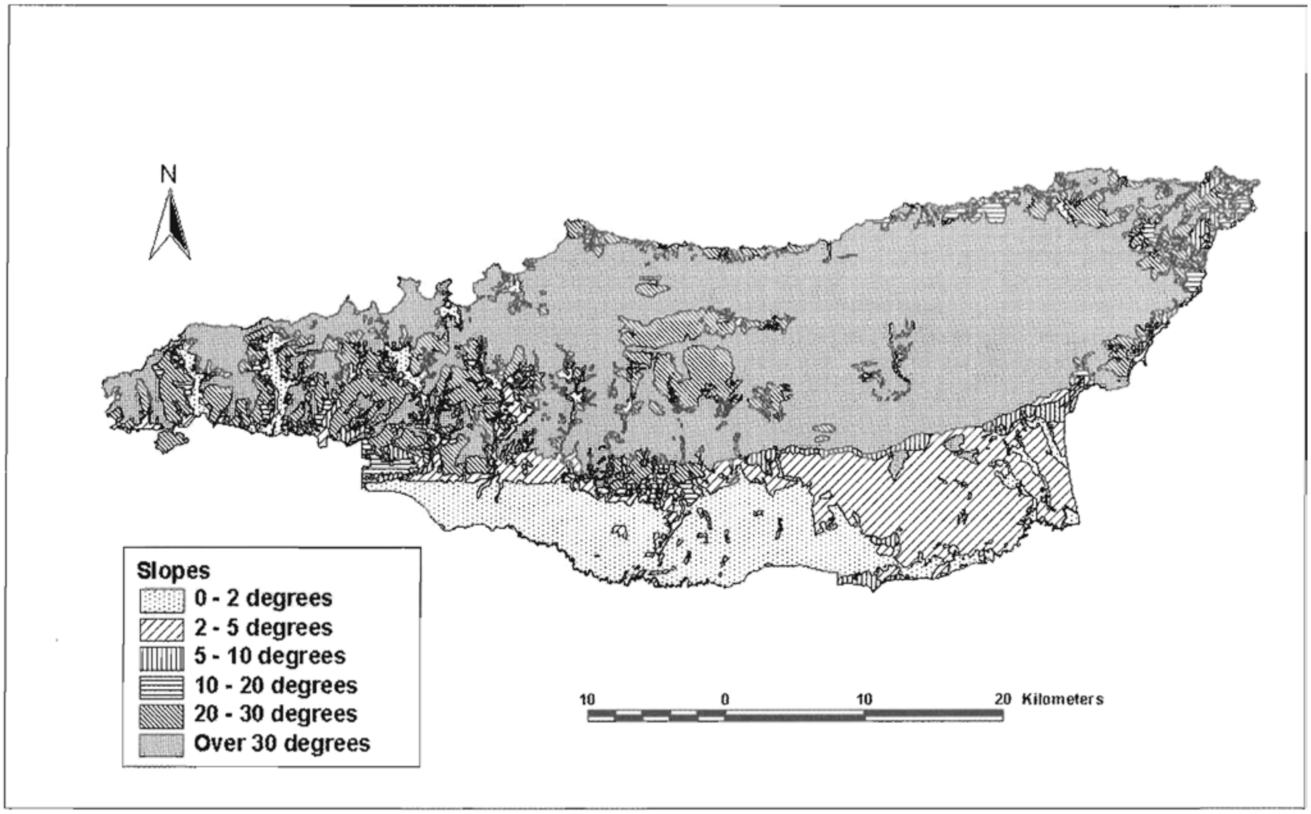

Figure 8: The slope categories of Trinidad Northern Range

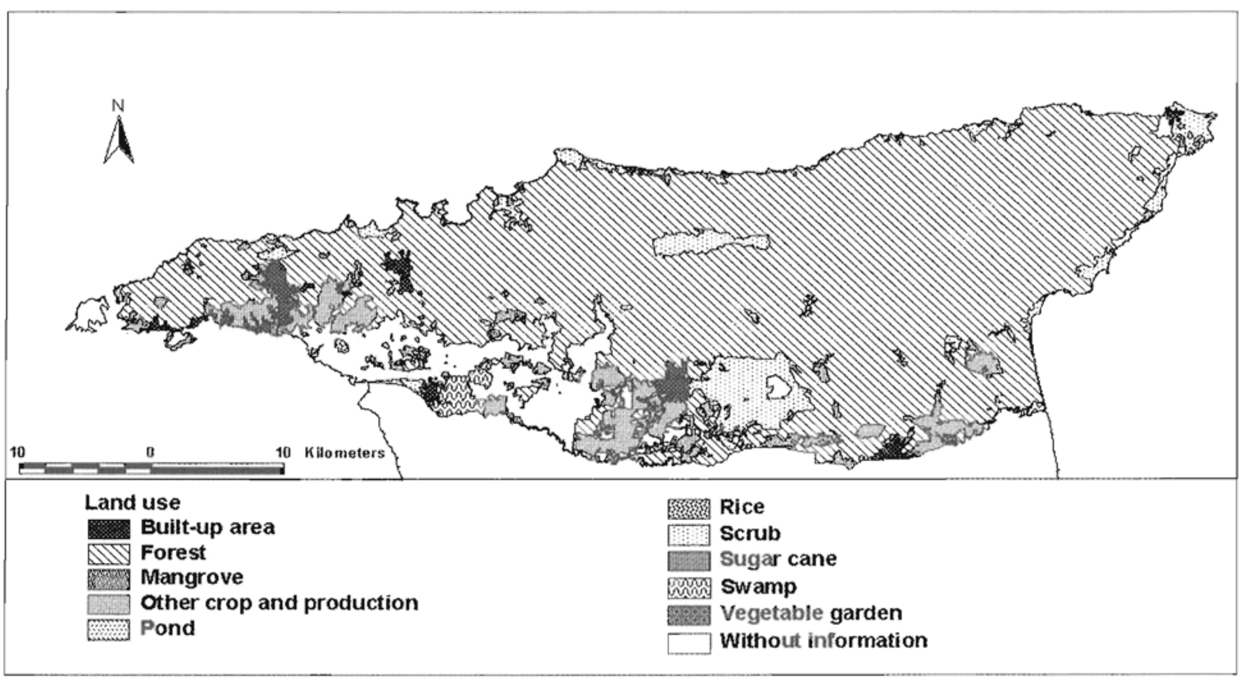

Figure 9: The land use/land cover of Trinidad Northern Range

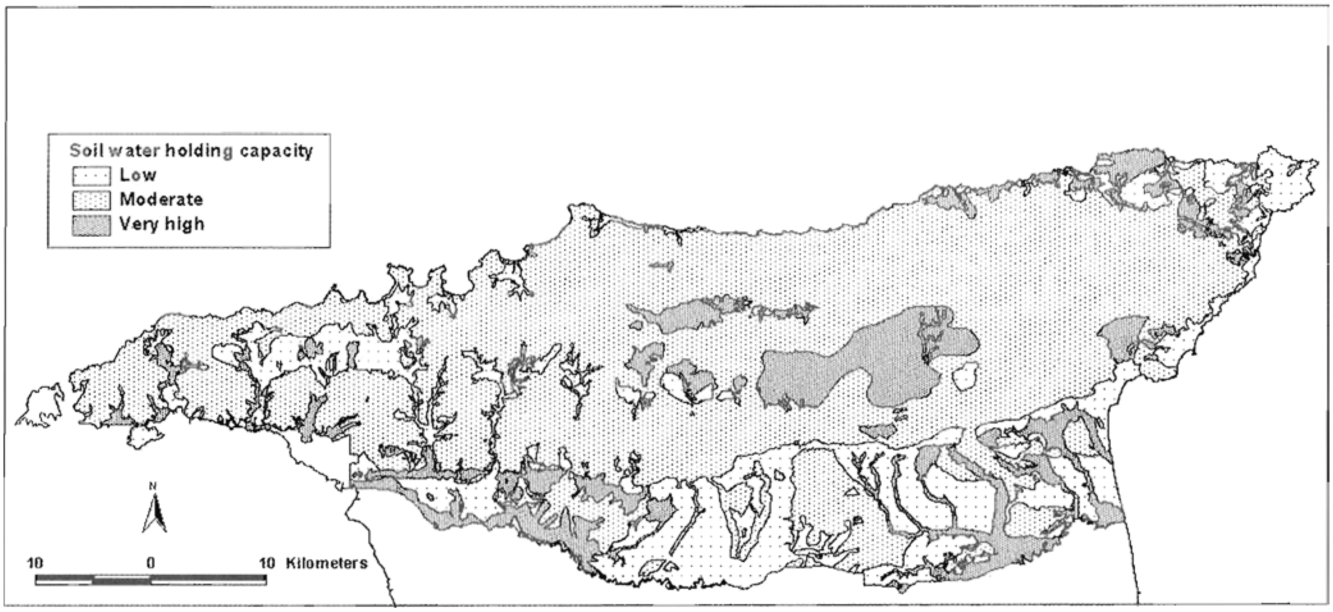

Figure 10: The soil water holding capacity of Trinidad Northern Range

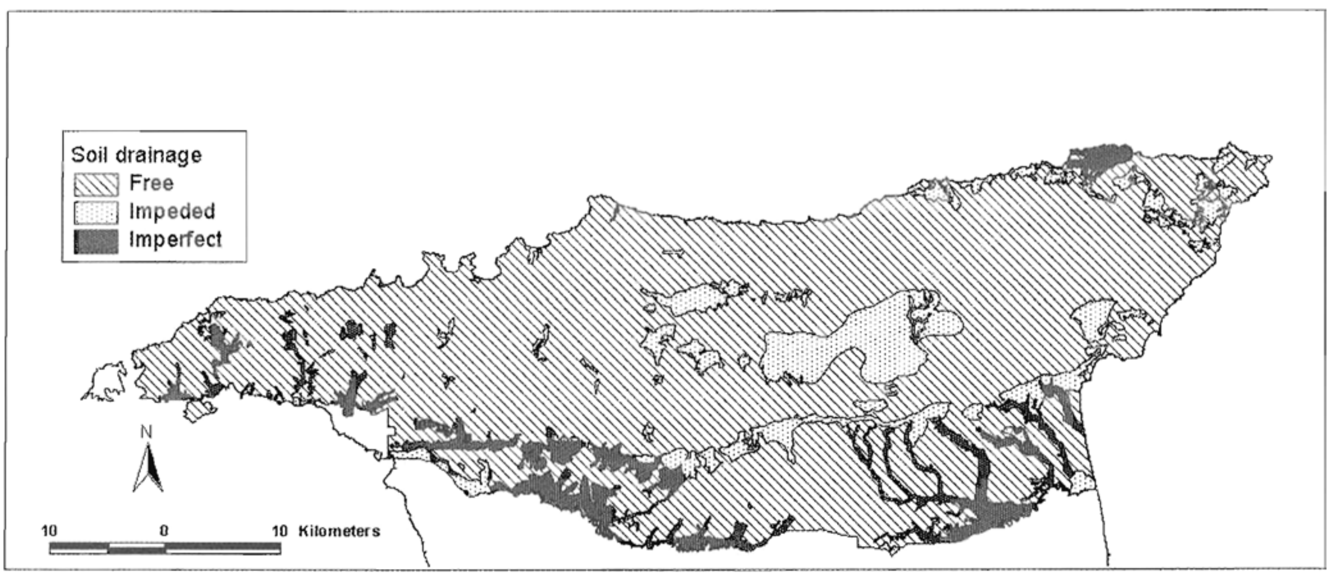

Figure 11: The soil drainage of Trinidad Northern Range

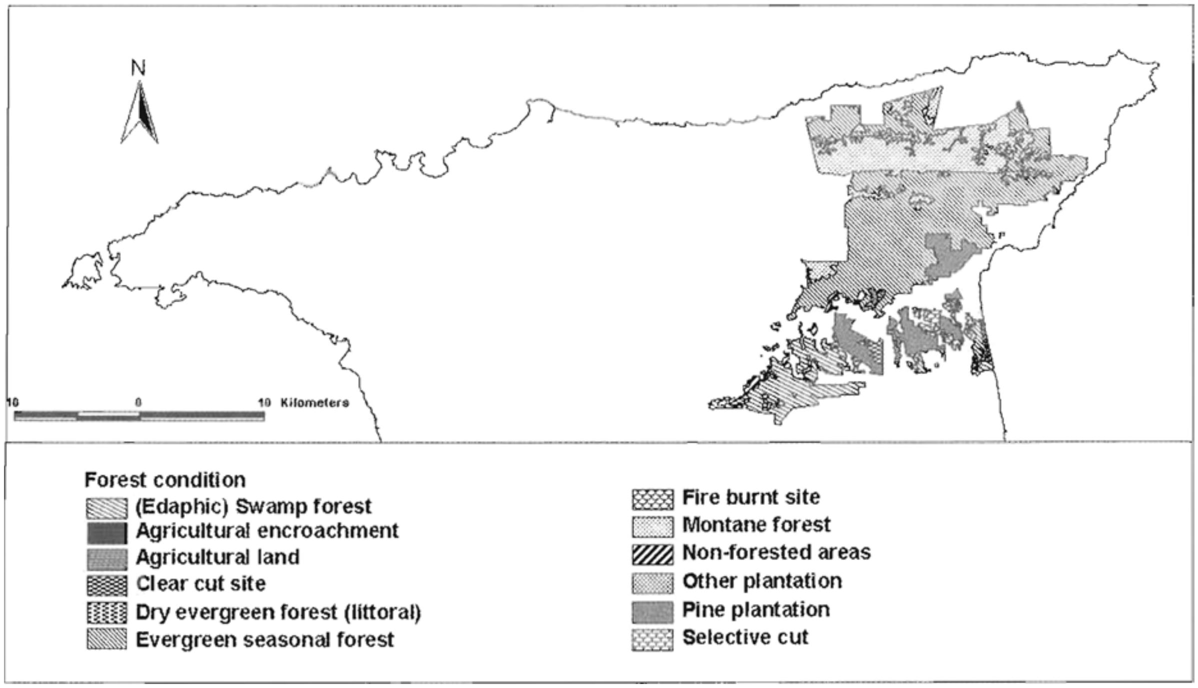

Figure 12: The forest condition of Trinidad Northern Range

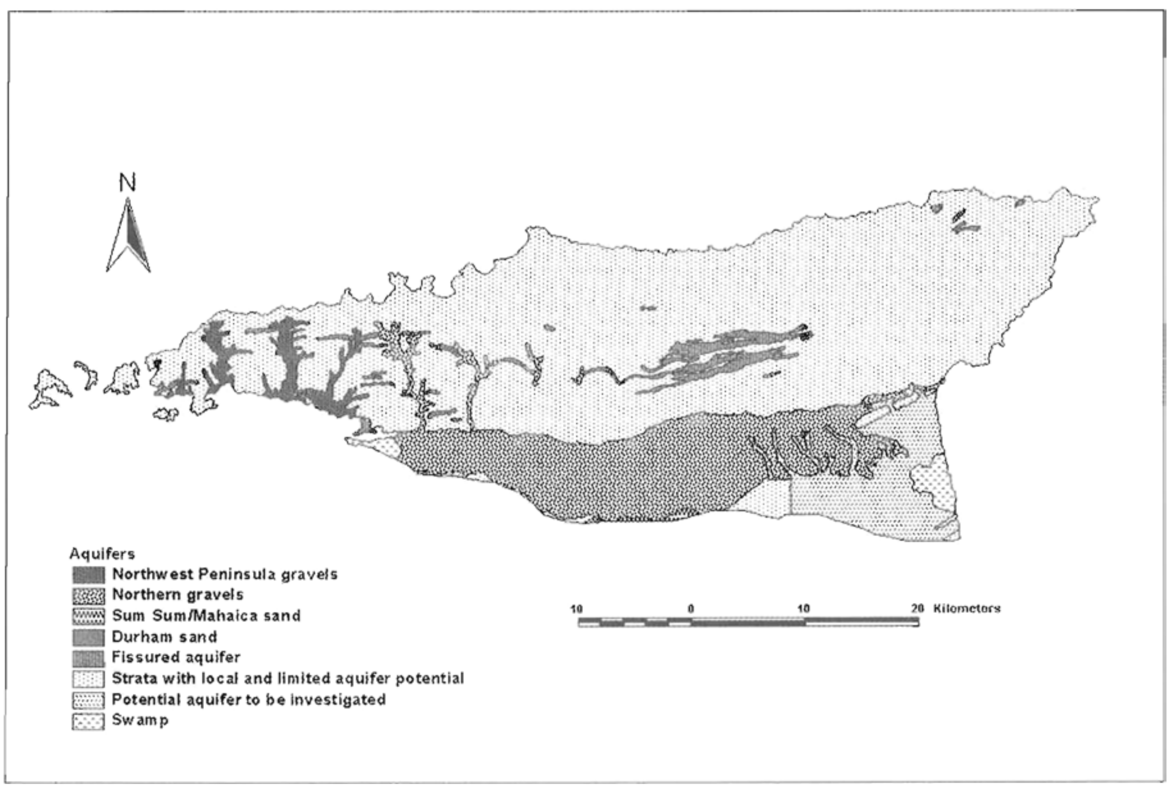

Figure 13: The aquifers of Trinidad Northern Range

5. Conclusions: Towards Effective Use of GIS in the Caribbean

In order for the Caribbean to effectively benefit from the many advantages of GIS, there is a need to develop a strategic development plan. Critical to the plan are the following elements:
Consistent data collection programme
Efficient data management plan
Capacity building
Consistent data models and integrated analysis

Consistent Data Collection Programme: The effective use of GIS for land and water resources management requires a consistent flow of data on the extent and status of these resources. Spatial analyses and resource monitoring programmes can be rendered ineffective with data gaps and incompatible data. Therefore a programme of regular data collection on the status of natural resources is imperative. The use of satellite imagery has made the undertaking of such a programme more affordable to the Small Islands Developing States (SIDS).

Efficient Data Management Plan: In addition to a consistent data collection programme is the need to develop an efficient data management plan. The high investment in data collection may go to waste if the data is not managed efficiently. Data management plans should include data sharing and data dissemination protocols, cost recovery programmes and development of data standards.

Capacity Building: An important element in the effective use of GIS is the availability of trained and experienced personnel. Whereas the SIDS of the Caribbean have invested in GIS hardware and software in the past 10 years, very little investments have been made towards the training and retraining of resource persons required to design, build, use and manage a GIS. A renewed effort is therefore required in building a structured (formal and informal) training programme. An investment in human resources will ensure the sustainable use of GIS.

Consistent Data Models and Integrated Analysis: GIS provide for integrated analysis of land and water resources. Impact analysis and cause-effect models can be efficiently built for different land use scenarios. To be able to undertake such analysis, it is important that a consistent data model be built for the different natural resources in the SIDS of the Caribbean. Land use classification, ecological or ecosystem classification, soils properties and geological features need to be modeled so that cross-island analysis can be undertaken. The absence of such a model will perpetuate the current situation of island-based analysis.

The many opportunities provided by the reducing cost of satellite remote sensing imagery and the powerful functionalities of GIS have made it the technology of today for the Caribbean. The era of planning without information on the nature and stress of the natural resource is fast coming to an end and a programmatic and strategic investment in GIS is required for the effective and efficient management of land and water resources as a matter of great urgency.

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Proceedings of the Caribbean Food Crops Society. 37:300-303. 2001

FERTILIZER EFFECTS ON FORAGE AND SEED YIELD OF GLYCINE (*NEONOTONIA WIGHTII*) IN THE US VIRGIN ISLANDS

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ABSTRACT: Glycine (*Neonotonia wightii*) is an adapted and productive forage legume for the seasonally dry areas of the eastern Caribbean islands, but lack of seed availability has limited its use. Replicated field studies from September 1999 to April 2001 assessed fertilizer application effects on forage dry matter (DM) and seed yield of glycine var. Cooper. In September 1999, fertilizer treatments (FT) included 0 fertilizer (control), 56 kg ha^{-1} P applied as triple super-phosphate; TSP, 56 kg ha^{-1} potash; K_2O, 28 kg ha^{-1} elemental sulfur; S, and 28 kg ha^{-1} micro-nutrient mixture (2.4% boron, 2.4% calcium, 14.4% iron oxide, 6% manganese, 0.06% molybdenum, and 5.76% zinc). In September 2000, FT included a control, 56 kg ha^{-1} TSP, 56 kg ha^{-1} K_2O, and 28 kg ha^{-1} S. There was no effect of FT on either forage (3,100 kg ha^{-1}) or pod yield (350 kg ha^{-1})in 1999. In 2000, however, there was a trend ($P=0.10$) for higher forage yield for FT. Response to S (forage DM yield of 3,945 kg ha^{-1}) was better than other FT. There were also differences ($P<0.05$) in pod yield. A two-fold increase in pod yield with 56 kg ha^{-1} K_2O (979 kg ha^{-1}) compared to the control (445 kg ha^{-1}) was observed. Excessive rainfall in latter part of 1999 may have affected pod yield. The positive pod yield response to K_2O in March 2001, and yield responses to sulfur justifies further evaluations.

INTRODUCTION

Pasture improvement with use of tropical legumes is a promising technology to augment both quantity and quality of forages on the well-drained calcareous soils of the eastern Caribbean, particularly during the dry season. Research work by Valencia and Adjei (2001) reported that glycine (*Neonotonia wightii*) var. Cooper, a tropical legume, was compatible with grasses (i.e., Mottgrass; *Pennisetum purpureum*) and contributed to increases in yield and nutritive value of the associated forage.

The low availability and lack of seed quality of legume seeds in the Caribbean islands has limited the development of grass-legume pasture based systems. Glycine has potential for an aggressive and dynamic seed production program in the US Virgin Islands. Peak flowering of this legume occurs in December to January to produce a single harvest per year. Seed matures in the early part of the dry season (March-April). According to Paterson (1986) harvesting of glycine can be very flexible as dehiscence (seed shattering) is not a problem as experienced with other legumes (i.e., Siratro; *Macrpotilium atropurpureum*).

Fisher and Thomas (1987) noted that the well-drained calcareous soils of the Caribbean islands have pH ranging from 7.8 to 8.3, low phosphorus (P) content, low to medium potassium (K) contents, medium magnesium (Mg) levels and very high contents of calcium (Ca). Heavy clay soils deficient in P, K and micro-nutrients [i.e., boron (B), molybdenum (Mo), copper (Cu), zinc (Z), manganese (Mn) and iron (Fe)] and their effects on forage and seed yield of Glycine are limited. Both grass and legume forage yield responses to P application rates have not been positive on high pH clay soils (M. Adjei, 2001; personal communication). Research work by Febles et al., (1983) in Cuba reported varying seed production responses of glycine to applications of 70 kg ha^{-1} P $annum^{-1}$. With temperate and tropical legumes, positive forage and seed yield responses to micro-nutrients were reported by Gupta et al.(2001). Little is known on glycine responses to K and Sulfur (S).

The objective of this study was to assess the effects of P, K, S and micro-nutrient applications on forage and seed yield of glycine.

MATERIALS AND METHODS

The experiment was conducted at the Agricultural Experiment Station (AES), University of the Virgin Islands (UVI), St. Croix, between September 1999 and April 2001. The soil was a mildly alkaline Fredensborg clay (fine carbonatic, isohyperthermic, Typic Rendolls, Mollisol) characterized by high permeability and pH of 8.3. At the initiation the experiment in 1999, organic matter was 3.5%, P soluble in $NaHCO_3$ was 20 mg kg^{-1} of dry soil, K was 18.7 mg kg^{-1}, and Ca was above 5,700 mg kg^{-1}. Large between year and within year variation on rainfall was observed. Rainfall was greatest during the months of September to November, with December to March being the driest months (Table 1).

Fertilizer treatments (FT) in September 1999 consisted of 0 fertilizer (Control), 56 kg ha^{-1} P as triple superphosphate; TSP, 56 kg ha^{-1} K; K_2O, 28 kg ha^{-1} elemental sulfur; S, and 28 kg ha^{-1} micro-nutrient mixture (2.4% boron, 2.4% calcium, 14.4% iron oxide, 6% manganese, 0.06% molybdenum, and 5.76% zinc). In September 2000, FT included a control, 56 kg ha^{-1} TSP, 56 kg ha^{-1} K_2O, and 28 kg ha^{-1} S. The micro-nutrient mixture was not available for use on 2000. A pure stand of glycine var. Cooper previously used as a nursery since 1997 was rehabilitated (hand weeding) in 1998 and used for the study. The experimental design was a randomized complete block. The FT were randomized within each of four blocks.

All FT were broadcast applied on the 16 September 1999 and on the 21 September 2000 to take advantage of moist-rainy conditions. After un-interrupted growth for 18 wks, a 0.5 x 2-m area in each FT was clipped to ground level to determine dry matter yield (DMY) and seed yield on 14 March 2000. Dry pods were removed manually from clipped area and weighed. Forage was forced air-dried at 60 C to determine DM. A 100-seed dry weight was also taken. Experimental plots were clipped twice during the dry season and also prior to re-application of FT (every 8 wks).

In year 2, FT were re-applied on the same plots, except for micro-nutrients on 21 September 2000. Forage yield and seed harvest were determined on 7 March 2001.

All data were analyzed using the general linear models procedure of SAS (SAS, 1989). Years were analyzed differently because FT differed in the 2 years. Comparisons of FT were made using Fisher's Least Significant Difference Test (LSD).

RESULTS

Rainfall in the latter part of 1999 differed from 2000 (Table 1). September-December was wetter than the same period in 2000 (Table 1).

Dry matter harvested on March 2000 was similar ($P=0.18$) for all FT and averaged 3195 kg ha^{-1}. Pod yield and 100-seed weight were not affected by FT (Table 2). Pod yield for all FT, however, were much lower than those observed the following year. Rainfall in December 1999 (149 mm) was much higher than the norm (Table 1) and may have affected glycine flowering and pod development.

There was a trend ($P=0.10$) for higher DM yield on March 2001. The highest DM was recorded for S (3945 kg ha^{-1}). This increase, however, was only slightly higher than the control (3550 kg ha^{-1}). Fertilizer treatment with K_2O was similar to the control. Earlier work by Gutteridge and Whiteman (1978) reported that they were successful in increasing the botanical composition of legume with application of K from 75 to 100 kg ha^{-1}.

There was a significant effect ($P<0.05$) of FT on pod yield on March 2001. A two-fold increase on pod yield with applications of either K_2O (979 kg ha^{-1}) or S (895 kg ha^{-1}; Table 3) were recorded. Moron and Risso (2001) reported a positive response of the legume white clover (*Trifolium repens*), particularly legume yield at a rate of 25 kg ha^{1}.

Pod yield with applications of TSP (528 kg ha^{-1}) was not different from the control (445 kg ha^{-1}). Febles et al. (1983) assessed the effect of P fertilizer application (70 kg ha^{-1}) on heavy clay soils and noted that glycine seed formation did not show any response to P dressing irrespective of years. There was also no effect of FT on 100-seed weight of glycine in March 2001.

CONCLUSIONS

Results of this study suggests that there are no benefits to P fertilization of glycine at 56 kg ha^{-1}. It is possible that the P is tied in the clay soils and not available for plant use. There was, however, potential for using elemental S and K for increasing glycine forage and seed yield, respectively. Future studies should include varying rates increasing K and Sulfur to measure the response curve and assess the feasibility of fertilizer use.

ACKNOWLEDGMENTS

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Table 1. Monthly rainfall (mm) totals on St. Croix, US. Virgin Islands, 1999 - 2000.

Month	1999	2000	Average†
January	91	82	61
February	55	74	41
March	9	26	42
April	153	24	58
May	27	46	94
June	39	21	60
July	71	60	76
August	130	69	112
September	242	125	152
October	151	173	129
November	303	98	142
December	149	49	93
Total	1420	847	1060

†20 yr precipitation average for St. Croix, USVI.

Table 2. Mean forage dry matter (DM), pod yield and 100-seed weight of glycine in year 1 as affected by fertilizer treatment (FT).

FT	DM (kg ha^{-1})	Pod yield (kg ha^{-1})	100-seed weight (mg)
Control	3095	225	672.5
TSP	3402	370	668.2
K_2O	3012	395	643.5
Sulfur	3167	387	681.7
Micro-nutrient	3302	375	698.2
F Test	P=0.18	P=0.20	P=0.62
LSD (P=0.05)	†NS	NS	NS

† Not significant.

Table 3. Mean forage dry matter (DM), pod yield and 100-seed weight of glycine in year 2 as affected by fertilizer treatment (FT).

FT	DM (kg ha^{-1})	Pod yield (kg ha^{-1})	100-seed weight (mg)
Control	3550	445	530
TSP	3300	528	646
K_2O	3617	979	673
Sulfur	3945	895	665
F Test	P=0.10	P<0.05	P=0.67
LSD (0.05)	838	470	†NS

† Not significant.

Proceedings of the Caribbean Food Crops Society. 37:304. 2001

ATMOSPHERIC CARBON SEQUESTRATION IN TROPICAL WATERSHEDS

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ABSTRACT: Soils are important sinks for carbon in the atmosphere. Eswaran et al. (1993) estimated the mass of carbon in the soils of the world to be 1,550 Pg (1 Pg = 10^{15} g), which is about twice as much the carbon in the atmosphere (750 Pg C). Increased photosynthesis and therefore carbon fixation could be upset by an increased amount of carbon oxidation in the soil as a result of higher atmospheric temperatures (Acevedo et al., 1992). Therefore, for a positive soil carbon sequestration primary production inputs to the soil must exceed carbon decomposition. Other benefits from higher carbon fixation rates and enhanced plant canopy development include interception of precipitation rain drops, which are directly responsible for soil detachment upon impact and eventual transport by concentrated runoff flow, and interception of rain water that otherwise would increase runoff flows, exacerbating soil erosion potential. In water supply watersheds, soil erosion and the subsequent siltation of reservoirs is a major problem worldwide. This proposed work is intended to show the applicability of current available technologies for the delineation of strategies for watershed management, which allows the maximizing of carbon sequestration in the soil profile, and at the same time maintain the supply of runoff water for the sustainable operation of an important water supply reservoir. This work will show that soil resources can be managed to ameliorate possible climate impacts as a result of enhanced CO_2 levels in the atmosphere. The approach for this study consists of the acquisition and interpretation of satellite imagery and the simulation of agricultural activities in the watershed. Soil erosion and other hydrological processes will also be simulated. The proposed watershed for this study is the Río Grande de Arecibo (RGA) in northern Puerto Rico.

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IMPACT OF NITROGEN FERTILIZER RATES ON YIELDS OF STAKED TOMATO AND GROUND COVER EFFECT ON MOVEMENT OF RESIDUAL NITRATES

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ABSTRACT: Nitrogen fertilizers applied to crops by Florida tomato growers may cause residual soil nitrates to pollute groundwater following tomato harvest. A study was conducted in 1998 to determine the N rates needed to maximize fruit yields of spring and fall tomato and evaluate the use of two cover crop species in preventing leaching of residual soil nitrates. N rate varied from 0 to 360 lbs/acre and 0 to 600 lbs/acre in spring and fall tomato respectively. Ground cover was sorghum sudangrass, ryegrass, polyethylene mulch, and fallow. The study was conducted at FAMU research farm on an Orangeburg loamy fine sand soil. Collected data included initial, biweekly and end of study soil sampling as well as fresh fruit yields. Results showed that N rates above 180 lbs per acre were excessive. Also that plots with sorghum sudangrass and ryegrass contained 41% and 63% nitrate-N respectively at the 1 to 8 ft. depth compared to fallow plots.

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PROCICARIBE – A NETWORKING STRATEGY FOR THE COORDINATION AND INTEGRATION OF AGRICULTURAL RESEARCH AND DEVELOPMENT IN THE CARIBBEAN

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ABSTRACT: In 1996, the Caribbean Agricultural Research and Development Institute (CARDI) was mandated by the Caribbean Heads of Government to develop an agricultural science and technology system for the region. Now termed PROCICARIBE, the Caribbean Agricultural Science and Technology Networking System provides the institutional framework within which Caribbean governments, R&D institutions, the private sector, NGOs, farmer groups and other stakeholders design and implement strategies for the integration and co-ordination of agricultural research and development efforts at both the national and regional levels with linkages to international organizations. The paper describes PROCICARIBE's Mission in light of the region's changing environment and provides details of the setting up of the system and its strategy for the next five years.

INTRODUCTION

With the pending expiration of preferential arrangements with Europe and the trend towards trade liberalisation that favours large countries with better production, marketing and transport facilities, the Caribbean agricultural sector faces a serious challenge of improving its competitiveness (Noguera-Devers, 1999). This challenge is made even more difficult by the greater need for environmental protection and biodiversity conservation that are so important to the region's economic development.

Agricultural research and development (R&D) is now characterised in the Caribbean by a decrease in grant funds and fiscal pressure on governments, making it increasingly difficult for governments to fund R&D. Added to this is that the private sector is small in most countries and is not interested in R&D of public goods. Governments, and government-funded organisations, therefore, must somehow generate new technologies under severe fiscal restraints. One positive development has been some growth in private sector and contract research creating an increasing demand for commercially valid technologies. But it is the region's large small farming community which is far removed from markets and private sector funding that is seriously under threat. Hence, there is an increasing need for technological innovation by R&D institutions to boost competitiveness and increase profitability in a framework of social equity and protection of the natural resource base.

However, the main problem facing the development of an effective agricultural R&D system in the small countries of the Caribbean is the conflict between research needs and the amount of resources available to meet those needs. Another important consideration is the relative indivisibility of research below a certain minimum critical mass effort at which levels no relevant results can be expected (Trigo, 1987).

Tropical agriculture tends to be more diversified than temperate agriculture thereby increasing research needs such as for greater replication of experiments in a greater number of different production environments. Although small countries share a number of very important common characteristics, many factors such as economic development, climate, geographical location, and historical and cultural factors differentiate one country from another and, in turn, the relevance of any particular R&D policy.

It is recognised that in order to become internationally competitive, the region's agricultural sector needs to focus on the coordination of efforts and move towards diversification away from traditional crops so as to exploit new market opportunities such as agrotourism, agroprocessing, and niche markets in the North (especially for tropical fruits, vegetables, root crops and cut flowers).

In order to improve the effectiveness of research and development investments, a 1993 World Bank review of the sector recommended that the number of organisations involved in agricultural R&D should be reduced and co-operation encouraged among institutions. Specific strategies were elaborated, one being to establish and strengthen existing research networks in the region, including ties with extra-regional institutions. This need for further regional co-operation especially one that directly involves the private sector as a means of improving the competitiveness of the sector and making better use of scarce resources has also been acknowledged by Caribbean Heads of Government (Blades, 1998).

Strategies for strengthening national R&D capacities and engendering cooperation and coordination at the regional and international levels must provide for:

- A better and more efficient pooling and utilisation of financial and human resources.
- The design and implementation of co-operative integrated commodity and thematic networks including information and communication networks.
- Mechanisms for regional agricultural research policy determination, priority setting and the development of a regional agenda for agricultural science and technology, all of which must be driven internally by the needs of the agricultural sector, its market requirements and the needs of the community at large.
- Financing of the research agenda by the region's public and private sector with external resources coming from partnerships through strategic alliances with international institutions and organisations.
- Research systems structured on the basis of regional co-operation and co-ordination among strengthened National Agricultural Research and Development Systems (NARDS).

At the Seventeenth Meeting of the CARICOM Conference of Heads of Government held in July 1996, the outline of the Regional Transformation Programme (RTP) for agriculture and the Plan of Action was endorsed. At this time, CARDI was given the mandate to implement the "technology generation, validation and transfer" sub-programme of the RTP (Blades, 1998).

In order to respond to its mandate, CARDI in its delivery of agricultural research projects and activities in support of the respective national and regional thrusts in agriculture, began working in close co-ordination with the Inter-American Institute for Cooperation on Agriculture (IICA), which had already introduced a number of similar partnerships throughout the hemisphere. Consultations were initiated in most Caribbean countries with the Ministries of Agriculture and public and private sector organisations. Arising from these consultations the concept of PROCICARIBE, the Agricultural Science and Technology Networking System for the Caribbean evolved.

THE STRUCTURE AND FUNCTION OF PROCICARIBE

PROCICARIBE's mission is to contribute to food security, poverty alleviation, improvement in the standard of living and the development of competitive agricultural enterprises for the sustainable development of the Caribbean's agricultural sector through the co-ordination and networking of science and technology programmes among the public and private sectors, NGO's, and other agricultural R&D entities.

The objectives of this networking strategy are to:

- Strengthen the applied research and development capability of NARSs to identify, address, and solve the problems of producers, marketers, processors, entrepreneurs and other dependants of improved technologies.
- Generate appropriate technologies by using existing research personnel, facilities, and other resources more effectively (this applies to the national and regional capabilities).
- Ensure stability of quality agricultural production through a strong and responsive research capability.
- Provide support (both technical and financial) needed to facilitate the co-ordination and implementation of activities at national and regional levels.

The goal of PROCICARIBE is to develop an integrated science and technology networking system, among the public and private sectors, NGOs and other agricultural entities in support of agriculturally based industries in the Caribbean region for the attainment of international competitiveness.

To establish an effective networking system amongst members of the public/private sectors, NGOs, farmer groups and other stakeholders in the Caribbean in key thematic or commodity areas in response to the priorities and demands of the agricultural sector in member countries.

PROCICARIBE's planning process in the development of its networking system has involved the participation of its stakeholders in national consultations to assist in the planning and design of the system to ensure its adequacy, proper formulation, implementation and sustainability. In this regard, since its inception in 1996, and its inaugural meeting in February 1998, PROCICARIBE has been engaged in the following planning process as a means of fully establishing the networking system:

Figure 1. Structure of PROCICARIBE

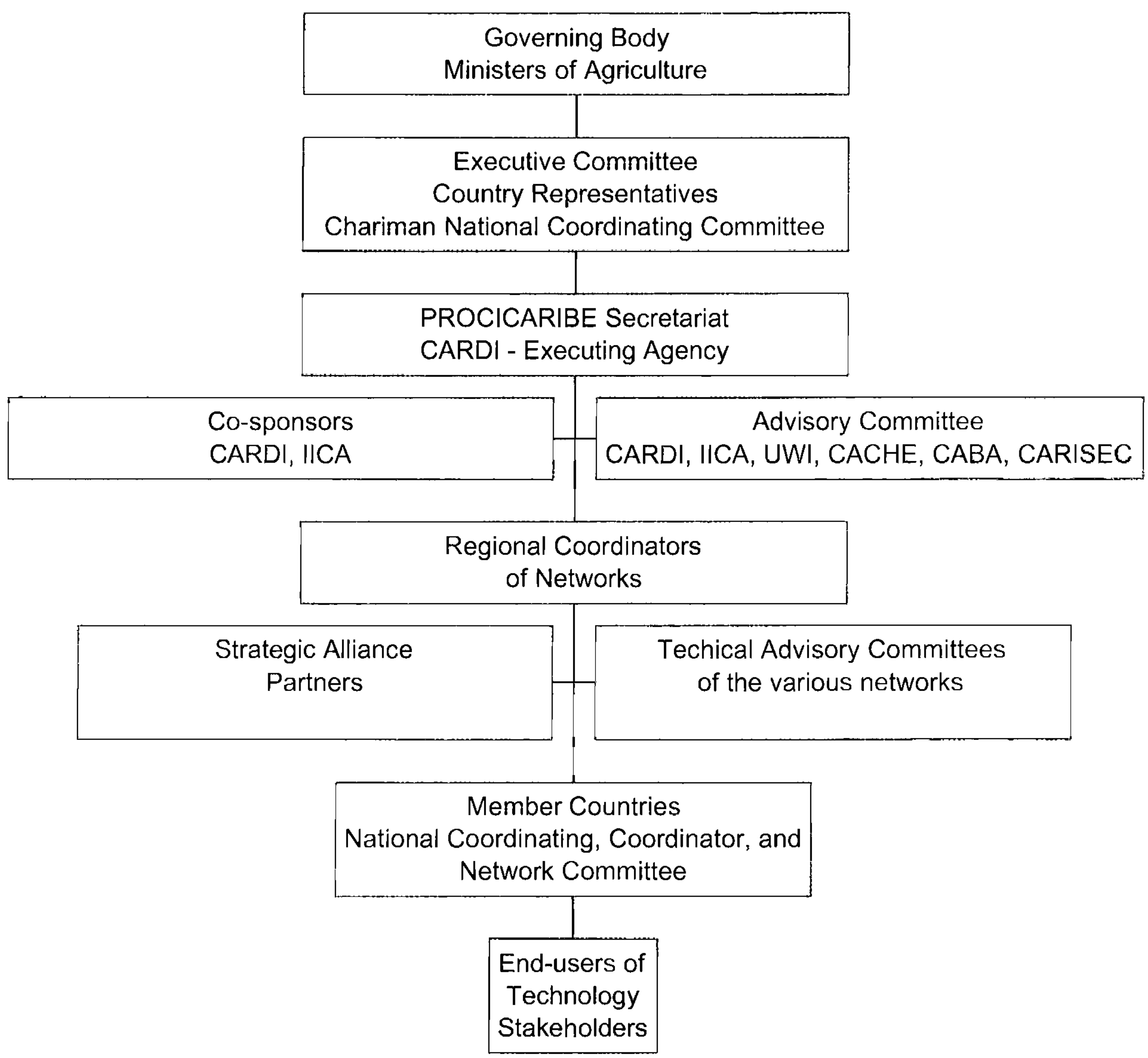
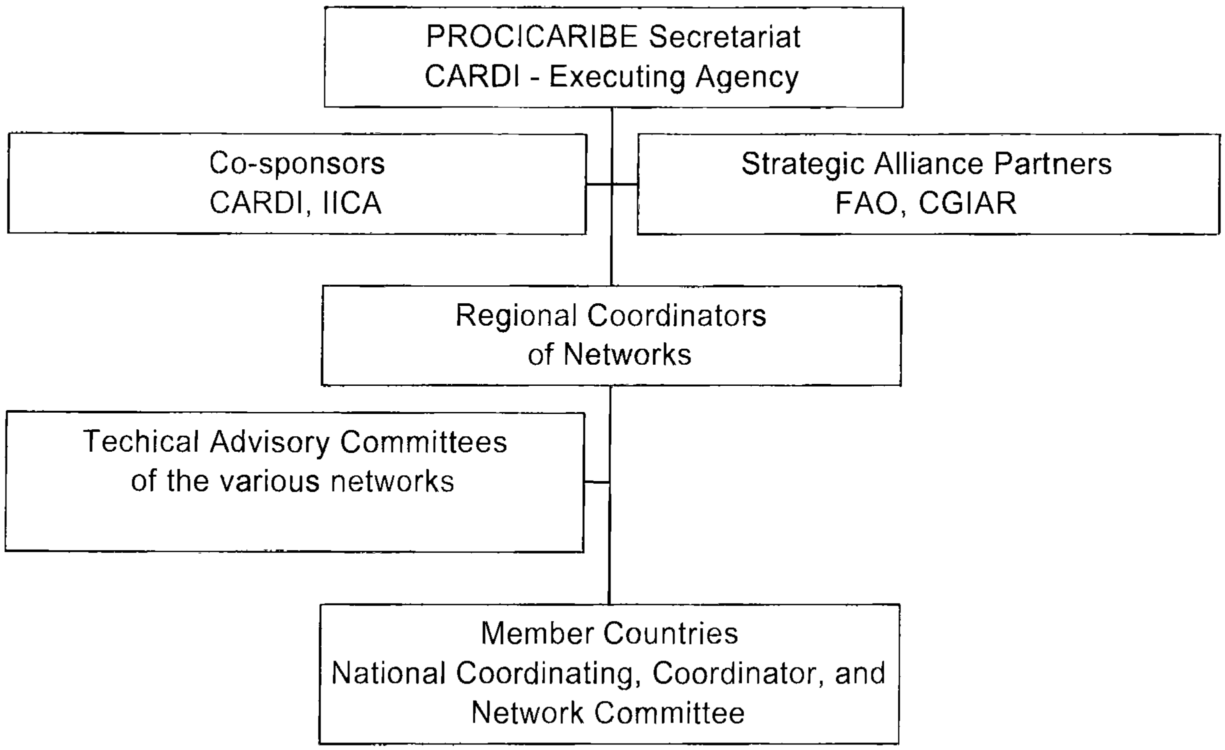


Figure 2. PROCICARIBE Network Structure



National Consultations: To ensure the input of its stakeholders in the development and design of the system, consultations were held in 18 countries with the participation of the majority of R&D stakeholders.

The Organisation and Development of Thematic and Commodity Networks: As a means of co-ordinating agricultural R&D in the region according to a thematic or commodity focus. A National Co-ordinating Committee (NCC) has been established in each country to interpret national policy and set R&D priorities (Figure 2).

The formal establishment of networking arrangements: To create structures that will be responsible for facilitating the co-ordination and co-operation of national and regional agricultural research amongst stakeholders, with contacts to international centres of excellence. In each country a National Network Committee (NNC) headed by a National Coordinator (NC) has been established for each network of the country. NCs come together regionally to form the regional networks under the coodination of a Regional Coordinator (RC) who reports to the PROCICARIBE Secretariat. The NNC facilitates the development/strengthening of the NARDS so that they are capable of implementing the national POWs and to collaborate effectively with other countries/institutions.

Establishment of Regional Networks: For each network, a regional meeting of NCs established national and regional R&D priorities and developed POWs. A Regional Co-ordinator (for each network) was appointed to ensure proper implementation of the POW under guidance from the PROCICARIBE Secretariat. A Technical Advisory Committee (TAC) of 5 - 7 members with expertise within the area of the particular network and drawn from institutions of excellence within and outside of the region was appointed to ensure scientific integrity of the POW.

Establishment of Collaborative Linkages: PROCICARIBE has established collaborative linkages at the national, regional, hemispherical and international levels so as to provide an institutional platform in keeping with a macroeconomic focus. The NCCs and NNCs address national collaboration while the networks foster regional collaboration.

At the hemispheric level, the Chairman of the Executive Committee of PROCICARIBE is a member of the Executive Committee of FORAGRO, the hemispheric forum that is one of five regional fora within the Global Forum of Agricultural Research (GFAR). FORAGRO affords PROCICARIBE network members collaboration with all R&D entities throughout the Western Hemisphere and, indeed, throughout the world.

Internationally, networks form strategic alliances with institutions of excellence such as Centres of the Consultative Group for International Agricultural Research (CGIAR) and universities worldwide. GFAR allows PROCICARIBE to be a part of the global family of R&D providers and aims to promote cost-effective partnerships and strategic alliances for poverty reduction, attainment of food security and the conservation of biodiversity. Each network also has renowned international scientists within its Technical Advisory Committees.

Established Networks and their Functions: To date 10 thematic and commodity networks have been established across the PROCICARIBE member countries of:

Antigua & Barbuda	Curacao	Haiti	St. Vincent and the Grenadines
Bahamas	Dominica	Jamaica	Suriname
Barbados	Dominican Republic	Martinique	Trinidad and Tobago
Belize	Grenada	Montserrat	
British Virgin Islands	Guadeloupe	St. Kitts and Nevis	
Cuba	Guyana	St. Lucia	

CRIDNET (The Caribbean Rice Industry Development Network)
Goal: The goal of CRIDNET is to increase the productivity in the cultivation and marketing of regionally produced rice so that Caribbean rice can improve its competitive position in the international market place while optimising regional self-sufficiency.

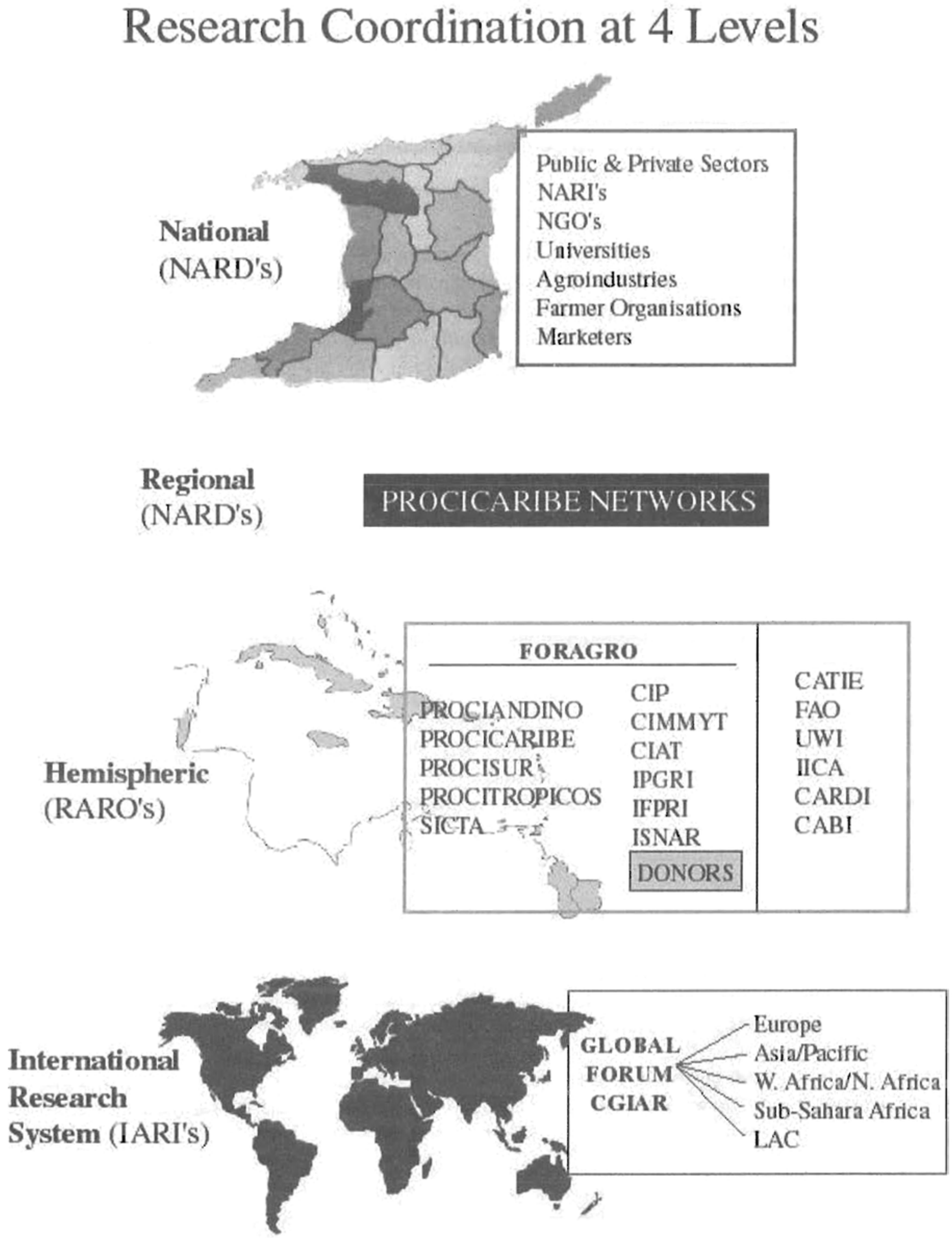
Purpose: The purpose is to enhance and improve the transfer and utilisation of improved production technologies in the regional rice sector.

CARIFRUIT (The Caribbean Fruit Network)
Goal: The goal of CARIFRUIT is to contribute to an improvement in the economic viability and sustainability of the fruit industry in the Caribbean by fostering an inter-sectoral and multi-disciplinary approach.

Purpose: The promotion and support of national and regional co-operation in technology, R&D, marketing and the distribution of selected fruit crops; and to promote greater utilisation of fruits grown in the Caribbean at the national, regional and international levels.

CIPMNET (Caribbean Integrated Pest Management Network)
Goal: To promote support and collaboration among Caribbean member states with linkages to international organisations in delivering more effective IPM as a key component of sustainable agriculture in the region.

Figure 3. Research Collaboration at 4 Levels



Purpose: The implementation of IPM strategies that encompass cost effective measures of prevention, observation and intervention in a holistic approach that enhances profitability and environmental protection while maintaining pest populations at levels above those causing economically unacceptable damage or loss.

CAPGERNET (Caribbean Plant Genetic Resources Network)
Goal: To ensure that there is improvement in the levels of efficiencies and higher levels of co-ordination in the utilisation and management of plant genetic resources in the Caribbean region.

Purpose: To provide a mechanism to foster collaboration efforts for the accession, improvement, conservation, evaluation and utilisation of crop germplasm for the benefit of the region's farmers within environmentally sound principles and policies.

CARINET (Caribbean Biosystematics Network)
Goal: The goal of CARINET is to contribute to the sustainable development of the region's agriculture and genetic resources, habitat conservation and the information needs for bioprospecting through the provision of efficient biosystematic services. It is the use of existing taxonomic resources of the sub-region whilst attracting Technical Co-operation partnerships to augment these resources to the level of realistic self-reliance.

Purpose: The purpose is to provide a regionally based biosystematic service to the Caribbean.

CASRUNET (Caribbean Small Ruminants Network)
Goal: To develop science and technology in small ruminants among public, private agricultural entities and NGOs to support agriculturally based industries in attaining international competitiveness and the sustainable development of the Caribbean region.

Purpose: To foster collaboration in small ruminants' research and development among stakeholders for the benefit of the region's farmers, entrepreneurs and other beneficiaries within sustainable agricultural systems.

CLAWRENET (Caribbean Land and Water Resources Network)
Goal: Develop Science and Technology in Land and Water Resources among public, private agricultural entities and NGOs to support agriculturally based industries in attaining international competitiveness and the sustainable development of the Caribbean region.

Purpose: Generate, validate and transfer environmentally sound technologies in land and water resources for use by agricultural producers.

CAPHNET (Caribbean Post Harvest Technology Network)
Goal: Develop post harvest technology system among public and private agricultural entities, NGOs and other stakeholders, in the development of sustainable quality assurance systems for perishable, durable and processed products in commercial enterprises in the Caribbean region.

Purpose: Co-ordinate regional research, adapt and transfer post-harvest and processing technologies to contribute to reduced losses, improved quality and improved efficiency in the preparation of Caribbean marketable products.

CAIS (Caribbean Agricultural Information Service)
Goal: To contribute to the improved access to information that will support the development of competitiveness within the Caribbean agricultural sector.

Purpose:

CAMID (Caribbean Agribusiness, Marketing and Information Development Network)

Goal: To increase the level of agricultural trade in network member countries.

Purpose: To establish a sustainable network of agribusiness marketing development service providers in CARICOM.

During 2001 the following additional networks will be established:

CAROT (Caribbean Root and Tubers Network)
Goal: To formally establish the Caribbean Roots and Tubers Network (CAROT) whose members will be responsible for developing and maintaining national and regional projects.

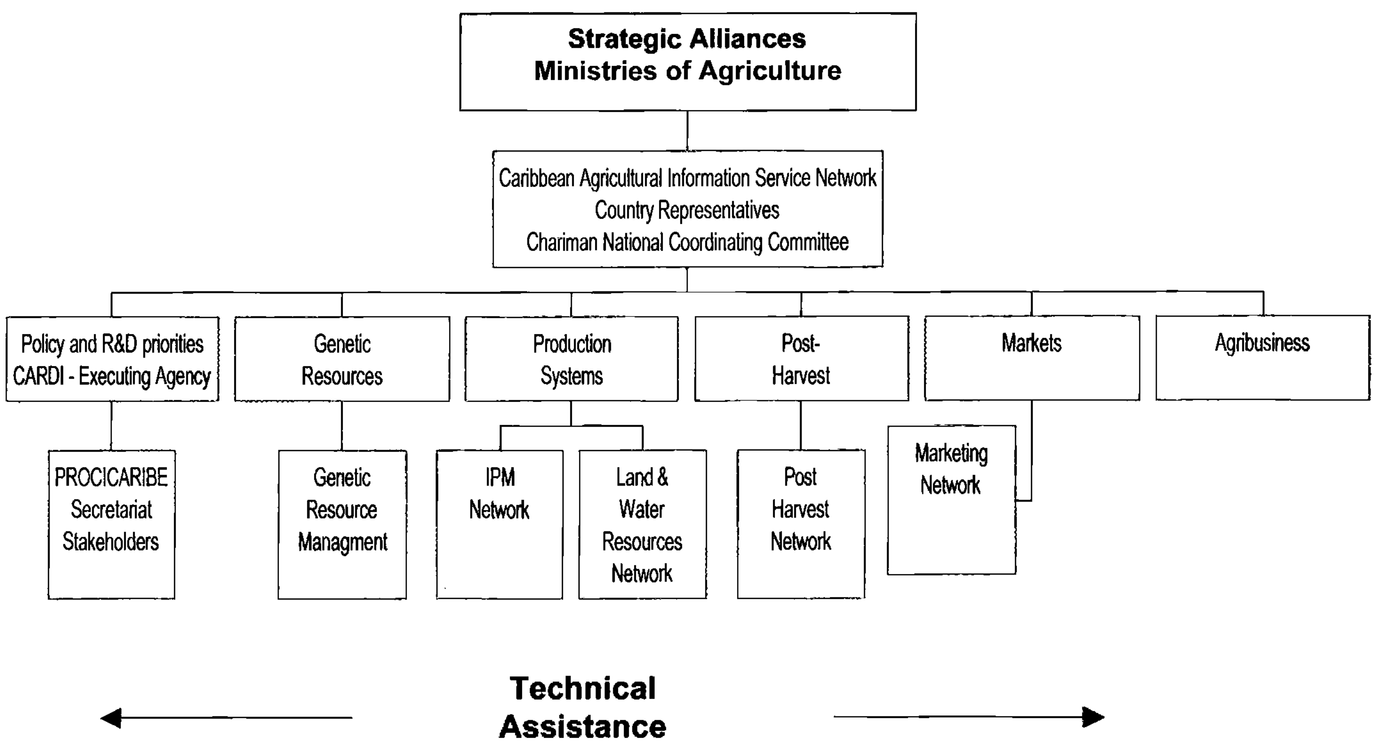
Purpose:

CARIVEG (Caribbean Vegetable Network)
Goal: To formally establish the Caribbean Vegetable Network (CARIVEG) whose members will be responsible for developing and maintaining the Caribbean Vegetable database and other regional and national projects.

Purpose:

The commodity systems approach is utilised to link commodity networks with thematic networks with access to international and regional strategic alliance partners, technical assistance and information technology. This interaction and approach is demonstrated in Figure 4.

Figure 1. Commodity Systems Approach used by PROCICARIBE networks



Collaboration is in the following main areas:

1. *Policy/planning for priority setting:* PROCICARIBE promotes the co-ordination and harmonisation of agricultural research policy and planning at the national and regional levels and enhance the capability in policy and priority analysis and research management of its members.
2. *Organisation and management of research and development (R&D):* PROCICARIBE organises the activities of various industry and thematic networks and seek financial and technical support for their functioning. The Secretariat works with the various components of the networks and their executive framework to plan, develop, monitor and evaluate priority programmes of work.
3. *Promotion of partnerships:* PROCICARIBE promotes partnerships among public and private sector, NGOs, farmer organisations and other stakeholders to advance the technological modernisation of agriculture in the region.
4. *Strengthening of regional linkages with outside R&D agencies:* PROCICARIBE provides an interface between the region and the CGIAR and other international systems and institutions of excellence and maintains strong relationships with Latin American countries and programmes through FORAGRO.
5. *Resource mobilisation:* The PROCICARIBE Secretariat, the executing agency, CARDI and the co-sponsor IICA assist in mobilising resources for R&D implemented by the networks. The Secretariat also works with NARDS in the member countries to mobilise their own resources (human and financial) for the conduction of their work programmes.
6. *Information transfer:* PROCICARIBE with the assistance of the Caribbean Agricultural Information Service (CAIS) facilitates information gathering, packaging and dissemination amongst network members.

The step-wise process from policy interpretation and priority-setting to the transfer of appropriate technology to end-users is shown in Figure 5.

Towards Strengthening the PROCICARIBE System

To date the PROCICARIBE system has led to the development of national coordinating structures in each of the 18 member countries and national and regional programmes of work. Linkages to strategic alliance partners in Latin America, the USA, Europe, Africa and Asia (through the CGIAR and GFAR) have been established and projects are being implemented where network coordinators have shown a willingness to advance the process. However, in many countries, regional and national coordinators have been inactive due to a lack of personal commitment and institutional support. Also, financial support for project implementation has not been adequate.

To overcome these drawbacks, the following steps must be taken:

Regional Coordinators (RCs) should be full-time employees reporting to the PROCICARIBE Secretariat. At the moment, RCs are employees of various institutions – the PROCICARIBE Secretariat has very little control over their activities.

National Coordinators must develop work programmes that are not additional to their normal duties. Where activities pertaining to regional network projects fall within their national project domain, such activities must be counted within their national programme of work.

Financing of national projects must come from the national budgets of the institutions represented within the National Network Committees (NNCs). The PROCICARIBE Secretariat will assist with resource mobilisation for national programmes of work.

Financing of regional projects of the various networks is expected from the European Union under the 9th EDF of the Cotonou Agreement. The PROCICARIBE Secretariat intends to work closely with the CARIFORUM Secretariat to secure this funding of close to US$6M beginning 2002. The EU financing for the IPM network CIPMNET from 7th EDF funds must be pursued vigorously by the PROCICARIBE Secretariat.

The PROCICARIBE System cannot survive without strong institutional support from its Co-Sponsors CARDI and IICA. CARDI finances the Secretariat staffing and some national and regional activities of the networks while IICA supplies some operational funds for the Secretariat and regional projects. CARDI and IICA must maintain their support.

All networks (through their RCs) must proactively source funds from regional and international sources for their programmes of work. The PROCICARIBE Secretariat will continue to facilitate project development and assist in the preparation of project proposals for the sourcing of donor funds.

Member countries must offer financial support to their National Coordinators to attend the regional Annual Technical Meetings of the Networks. This is especially necessary since countries are not presently required to pay membership fees to the PROCICARIBE system.

RCs must actively monitor the implementation of national and regional programmes of work by travelling to member countries so as to view work on the gorund and offer assistance to NCs and their NNC members. Then, they must report to the Executive Secretary in a timely fashion. In this way, the coordination of network activities will be assured.

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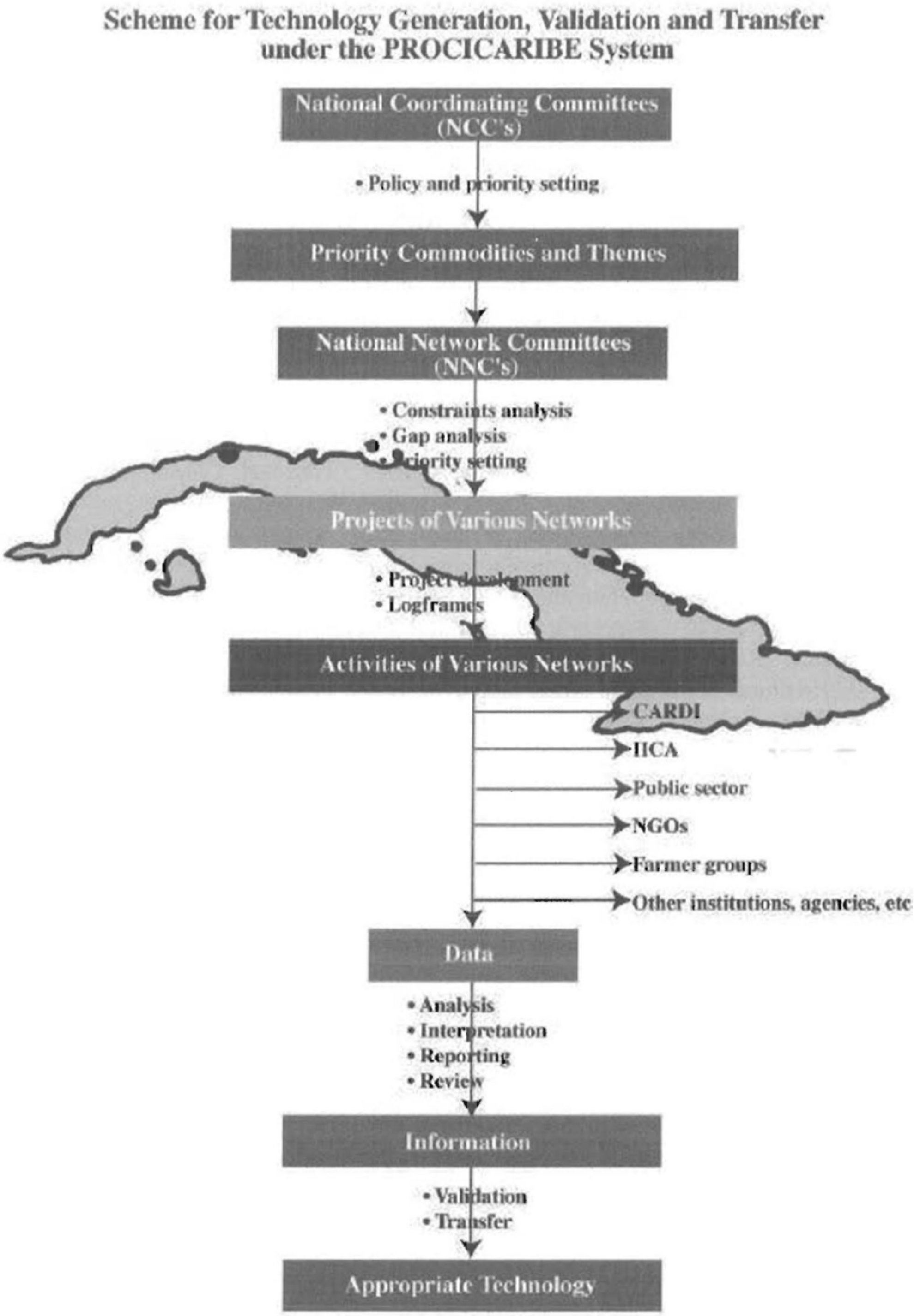
Figure 5: Scheme for Technology Generation, Validation and Transfer under the PROCICARIBE System



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LA FILIERE «FRUITS ET LEGUMES» EN GUADELOUPE : MISE EN PLACE D'UN PROGRAMME DE DEVELOPPEMENT SOUTENU PAR LA REGION, L'ETAT et L'EUROPE

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RESUME: L'ensemble des cultures vivrières, maraîchères et fruitières en Guadeloupe couvre moins de 10 % de la superficie agricole utilisée et constitue des cultures secondaires de diversification. Le programme sectoriel « Fruits et Légumes » qui a été agréé en juillet 1999, est un cadre qui vise à favoriser l'organisation de ces filières et à mettre en place des objectifs de développement sur le moyen terme (2 à 7 ans). Ce programme représente un montant de 136.568 KF et couvre une période allant de 2000 à 2006. Il présente un certain nombre d'opérations à mettre en œuvre et identifie les partenaires publics et privés pouvant intervenir et assurer la complémentarité des moyens de financement. Ce programme constitue un outil de développement cohérent et induit un effet de levier sur les interventions des différents partenaires ; cependant la lenteur et la complexité des procédures administratives, l'incapacité des maîtres d'ouvrage à mobiliser leur part d'autofinancement et bien d'autres facteurs constituent autant de freins à la bonne marche de ce système.

ABSTRACT: All of food crops, market gardening and fruit farming in Guadeloupe represent less than ten percent of the agricultural area used and constitute secondary diversification crops. The sectorial program "Fruit and Vegetable" was adopted in July 1999. It is a framework which want to organize these fields and to put an extension program in place with medium term objectives (2–7 years). This program concern the period 2000 to 2006 and represent an amount of 136 568 KF. Operations to implement, public's and private's partners which can participate and assure the complementarity's financing means are identified. This program is a coherent development tool and make in the favour of different partners interventions; however, slowness and complexity of administrative procedure, the incapacity of contracting authority to mobilize their self -financing part and others factors constitute a drawback to the smooth running of the system

INTRODUCTION

L'agriculture Guadeloupéenne est dominée par deux grandes filières : la canne à sucre et la banane. Face à ces principaux produits d'exportations, les cultures maraîchères, légumières et fruitières ont longtemps été considérées comme des cultures « de subsistance ».

Suite aux difficultés rencontrées par ces filières dominantes, les cultures de diversification ont fortement contribué au maintien de la part de l'agriculture dans la valeur ajoutée de l'économie guadeloupéenne.

Une attention plus grande est désormais accordée à ces spéculations par les pouvoirs publics. Pourtant les difficultés quant à la mise en place des programmes de développement sont bien réelles. C'est ce que nous tenterons de montrer dans ce qui suit.

LA FILIERE «FRUITS ET LEGUMES» EN GUADELOUPE

I-1 Caractéristiques de la Guadeloupe.

La Guadeloupe est un archipel de huit îles d'une superficie de 1705 km^2 et d'une population d'environ 428.000 habitants.

- Climat: La Guadeloupe est dotée d'un climat tropical à saison sèche variable. La température moyenne annuelle varie entre 24 à 27 ° C et la pluviométrie moyenne entre 950 mm à 2520 mm suivant les lieux.

- Démographie: Selon les chiffres de l'INSEE, en 1990 la population était de 386 987 habitants, elle est passée à 422 496 hab. en 1999 (DAF., 2000). Cette hausse constatée n'est pas le résultat d'une augmentation des naissances mais plutôt celui de la forte pression migratoire que subit la Guadeloupe en provenance de Haïti, Dominique et Saint-Domingue.

- Les secteurs économiques: L'économie de la Guadeloupe est basée sur deux piliers : le tourisme et l'agriculture (Préfecture., 2000).

Le tourisme

On évalue sa contribution productive à 11 % de l'économie guadeloupéenne. C'est un tourisme diversifié qui se compose de quatre sous ensembles : tourisme de séjour, de découverte, de croisière, et de plaisance.

L'agriculture

L'agriculture est le seul secteur guadeloupéen exportateur de marchandises (sucre, banane, melon, fleurs). La filière pèse environ 10 % du total de la valeur ajoutée et de l'emploi dans l'économie guadeloupéenne.

Deux filières dominent, la canne à sucre et la banane ; toutes deux soutenues par les pouvoirs publics respectivement par l'O.C.M sucre et l'O.C.M banane.

Les autres cultures contribuent essentiellement à l'alimentation du marché intérieur à l'exception du melon et des fleurs exportés vers l'Europe. Néanmoins les cultures de diversification ne couvrent que 60 % des besoins locaux.

I-2 Caractéristiques de la filière « Fruits et Légumes »

L'ensemble des productions vivrières, maraîchères et fruitières couvrent une superficie de 4443 ha soit 9 % de la SAU. A l'exception du melon qui est exporté sur la métropole, ces productions constituent des cultures secondaires en constante évolution (cf. Tableau 1)

	Surfaces en ha			% de variation	
	1997	1998	1999	97/99	98/99
Légumes racines (tubercules)	1665	1775	1835	+10,21	+3,3
Légumes frais	1474	1603	1633	10,78	+1,9
dont melon		283	261		-7,8
Cultures fruitières permanentes	603	634	714	+18,40	+12,6

Tableau 1 : Répartition des surfaces des Fruits et Légumes en Guadeloupe de 1997 à 1999 (DAF., 1999 ; DAF., 2000)

Cultures vivrières: Le jardin vivrier en tant que pilier du « jardin créole » garde une place importante dans les cultures patrimoniales de la Guadeloupe. Dans cette catégorie, la production dominante est celle de l'igname, puis on retrouve les productions de patate douce et de banane plantain
(cf. Tableau 2).

Les importations de produits vivriers (Ignames, Bananes plantains, Madères...) sont encore très importantes et proviennent essentiellement du Costa Rica, de la Dominique ou de la France (SUAD., 2000) ; seules quelques 500 T d'ignames sont exportées.

Cultures vivrières	Surface (ha)	Production (T)	Rendement (T/ha)	Exportations (T)	Importations (T)
Banane/ plantain	350	8 815	20	14,9	298,6
Igname	900	9 800	11	500	755,3
Madère	160	3 200	20	-	177,1
Malanga	300	2 700	11	-	43
Manioc	110	1 600	14,5	-	0,8
Patate douce	400	4 420	11	-	-
Total	2 220	30 535	-	514,9	1274,8

Tableau 2 : Caractéristiques des cultures vivrières en Guadeloupe - Année 1999 (Chambre d'Agriculture., 2000)

Cultures maraîchères: Dans le domaine maraîcher, les produits phares sont représentés par le melon, la tomate, le concombre, la laitue et la cristophine. Hormis le melon, les cultures maraîchères sont destinées essentiellement au marché local. Seules quelques 3 T de cristophines et 0,4 T de tomates sont exportées (cf. tableau 3).

En revanche les importations sont nombreuses et concernent une large gamme de produits en particulier les carottes et les poireaux.

La laitue, la tomate et les concombres sont cultivés en grande partie sous abris.

Cultures maraîchères	Surface (ha)	Production (T)	Rendement (T/ha)	Exportations (T)	Importations (T)
Cristophine	80	4478	55	3	22,9
Concombre	153	4080	17		1,7
Laitue	132	3150	12		72,4
Melon	261	3568	15	2 606	0,8
Tomate	201	3500	17	0,4	341,5
Total	1350	28 116	-	2609,4	3098,1

Tableau 3 : Caractéristiques des cultures maraîchères en Guadeloupe – Année 1999 (Chambre d'Agriculture., 2000)

Cultures fruitières: Les productions dominantes sont l'ananas et les agrumes. On peut considérer une autosuffisance du marché local concernant la production de l'ananas ; on note même une tentative d'exportation (cf. Tableau 4).

Cultures fruitières	Surface (ha)	Production (T)	Rendement (T/ha)	Exportations (T)	Importations (T)
Ananas	345	9 400	-	1	-
Grenadille	5	50	10	-	-
Lime	85	2 550	30	-	320
Mandarine	34	748	22	-	24
Orange	52	1 300	25	-	3 031
Pomelo	20	650	32,5	-	508
Total	541	14 698	-	1	3 883

Tableau 4. Caractéristiques des cultures fruitières en Guadeloupe – Année 1999 (Chambre d'Agriculture., 2000)

Environ 4000 T d'agrumes sont importés chaque année en provenance de la République Dominicaine, de Cuba, de France ou de Guyane pour la plupart (SUAD.,1999). La production est insuffisante pour satisfaire la demande locale.

II - LES PROPOSITIONS DU PROGRAMME SECTORIEL «FRUITS ET LEGUMES» (2000-2006).

II-1 Bilan du programme 1994 - 1998 et organisation de la filière

Le précédent programme sectoriel 1994 - 1998 s'était déroulé dans un contexte climatique peu favorable (nombreux cyclones, sécheresse…) mais avait néanmoins permis d'obtenir un certain nombre de résultats encourageants :

Le financement de 7 hectares de cultures sous abris avait favorisé le développement de la laitue, des concombres et des tomates. Dans le domaine de l'arboriculture fruitière, les aides à la plantation avait permis une augmentation de la production de plus de 3000 T.

En matière d'organisation, on pouvait noter l'émergence de plusieurs structures mono-produits telles

L'APAG

L'association des producteurs d'ananas de la Guadeloupe créé en 1994 et regroupant aujourd'hui une vingtaine d'adhérents.

Caraïbes Melonniers

Créé en 1990, cette structure regroupe une vingtaine de planteurs de melons et constitue la troisième source de revenus agricoles du département.

Le SIFRUG

Le Syndicat Inter Fruitier de la Guadeloupe créé en 1997 regroupant une quarantaine d'adhérents.

L'UPROFIG

L'Union des producteurs de la filière Igname créé en 1998 regroupant une quarantaine d'adhérents. Parallèlement à l'organisation des professionnels, on assiste à un développement des programmes de recherche pour répondre aux attentes de la profession. En 1994-1998, la plupart des programmes de recherche et d'expérimentations ont été menés à leur terme et se poursuivent actuellement.

Le CIRAD accompagne les producteurs d'ananas (l'APAG en particulier) en réalisant des travaux de sélection variétale et sanitaire, en développant des méthodes de lutte intégrée et des pratiques agronomiques adaptées aux contraintes locales et les producteurs de fruits (agrumes en particulier, mais aussi manguiers et papayers) dans la défense de leurs cultures (étude sur la *Tristeza* et sur la bactériose du papayer) ; en réalisant des travaux sur la découverte de nouvelles variétés et sur leurs résistances. Actuellement, un programme de recherche sur l'étalement des cultures (agrumes en particulier) est envisagé.

L'INRA accompagne

Les producteurs maraîchers (tomate et melon essentiellement) dans la recherche de variétés adaptées. Les producteurs d'ignames dans la réalisation de plants de qualité par la méthode de la vitro culture.

Le CADH

Le Centre d'Application et de Démonstration Horticole accompagne les agriculteurs au travers de différentes expérimentations sur tomate, chou, manioc ou igname et organise avec les producteurs des rencontres où sont effectuées des démonstrations (exemple : présentation de la billonneuse-planteuse de l'INRA).

Enfin l'industrie agroalimentaire s'est développée et constitue aujourd'hui un débouché non seulement pour la production fruitière mais aussi pour la production légumière (produits cuits en sachets sous vide).

II-2 Programme 2000 - 2006

- <u>Définition et objectifs du programme</u>

Le programme sectoriel « Fruits et légumes » est avant tout un cadre qui a pour but de favoriser: l'organisation des filières de mettre en place des objectifs de développement à atteindre au terme d'une période de 2 à 7 ans. Il a été agréé en juillet 1999 pour la période 2000 - 2006. En 2003 sera réalisé un bilan d'étape.

Il répond à des objectifs stratégiques et opérationnels:
Objectifs stratégiques

- augmenter les moyens consacrés au développement de la filière
- satisfaire en priorité la demande locale
- saisir les opportunités offertes à l'exportation
- sécuriser et pérenniser l'organisation de la filière
- équilibrer les zones de production

Objectifs Opérationnels

- soutenir l'équipement et la modernisation des exploitations
- renforcer l'encadrement technique et les actions de formation
- accompagner la structuration de la filière
- permettre à la recherche de répondre aux problèmes rencontrés
- par les professionnels

- <u>Présentation du programme</u>

Ce programme comprend un certain nombre d'actions qu'on peut regrouper en quatre axes :

- l'amélioration de l'environnement de l'exploitation
- le renforcement technique
- le financement d'opérations par type de productions (structures, programmes de plantations, programmes de recherche, encadrement des producteurs…)
- un programme d'actions spécifiques (conditionnement, commercialisation…)

Le programme identifie les partenaires publics et privés pouvant intervenir dans la filière et assurer la complémentarité des moyens de financement.

Son coût total (en KF) est réparti comme suit:

Actions opérationnelles	Coût 2000-2003	Coût 2004-2006	Coût total
Amélioration de l'environnement de l'exploitation	29.900	42.400	72.300
Renforcement de l'appui technique	9.850	9.000	18.850
Productions vivrières	6.416	1.260	7.676
Productions légumières de plein champ	5.825	-	5.825
Productions légumières sous abris	7.730	3.000	10.730
Fruits et légumes biologiques	2.330	250	2.580
Productions fruitières	10.427	2.280	12.707
Programme d'actions spécifiques	3.900	2.000	5.900
Total	76.378	60.190	136.568

Tableau 6 : Programme sectoriel « fruits et Légumes » 2000 - 2006 – fiche récapitulative des opérations (ODEADOM., 1999)

Les principaux partenaires sont :
L'ODEADOM (Office de Développement de l'Economie Agricole des Départements d'Outre Mer)
Le Conseil Régional
Le Conseil Général
Le FEOGA (Fonds Européens d'Orientation et de Garantie Agricole)

Le programme sectoriel agréé constitue un outil de développement cohérent et induit un effet de levier sur les interventions des différents partenaires.

C'est le cadre de référence des interventions de l'ODEADOM mais le fonctionnement du programme sectoriel « Fruits et Légumes » est soumis également aux règles d'intervention du DOCUP (Document Unique de Programmation) qui sont les suivantes :

	Aides publiques		Apport privé
Projet	Etat - Région - Département	Europe	
Individuel	15%	35%	50%
Collectif	25 %	50%	25%

Pour tout projet collectif par exemple la part de subvention pouvant être allouée est de 75% (50 % émanant des fonds européens - 25% des fonds nationaux) et 25 % d'apport personnel.

III - LES FREINS A UNE UTILISATION OPTIMALE DE CE PROGRAMME ET PERSPECTIVES D'ACTIONS

3-1 Freins ou blocages

On peut identifier trois grands types de blocages à une utilisation optimale de ces financements :

<u>d'ordre institutionnel</u>

Les procédures administratives du programme sectoriel sont complexes. Deux modes d'intervention doivent se coupler :

Ceux propres à l'ODEADOM

Les dossiers de demande d'aides sont envoyés à la DAF qui accuse réception dans un délai de 15 jours. Un numéro d'enregistrement est attribué au dossier.
Si le dossier est jugé complet, la DAF précise la date de passage du dossier en « Groupe local » sinon la DAF réclame les pièces manquantes au porteur du projet. Il existe en moyenne quatre groupes locaux par an. Le groupe local présidé par le préfet ou le directeur de la DAF et comprenant un certain nombre de spécialistes ou d'institutionnels donne un avis sur chaque dossier. La DAF est chargée de communiquer cet avis au porteur du projet. Le procès verbal de la séance est envoyé à l'ODEADOM. Les dossiers relevant de l'application des programmes sectoriels suivent une procédure simplifiée, c'est à dire qu'ils sont instruits au fur et à mesure de leur arrivée à l'ODEADOM et la DAF reçoit une décision dans les deux mois qui suivent pour en informer les demandeurs. Les dossiers ne relevant pas de l'application des programmes sectoriels passent en conseil de direction. Il existe 2 conseils de direction par an. Quelque soit le dossier, suite à un avis favorable, une convention est établie entre l'ODEADOM et le porteur du projet. Les justificatifs de réalisation sont ensuite envoyés à l'agent comptable de l'ODEADOM pour paiement.

La DAF, chargée de la gestion administrative des dossiers est obligée de s'assurer de la contrepartie nationale avant de se prononcer sur le financement européen. Pour les dossiers faisant intervenir un financement ODEADOM, toute décision tardive implique d'emblée un retard de l'examen du dossier quant au financement européen (ou relatif au DOCUP).

Ceux propres au DOCUP

Pour les dossiers relevant du cadre du DOCUP, trois possibilités sont envisageables :
- les dossiers bénéficiant des aides de l'ODEADOM et du FEOGA
- les dossiers bénéficiant des aides de la REGION et du FEOGA

les dossiers bénéficiant des aides de la REGION, de l'ODEADOM et du FEOGA

Les dossiers bénéficiant de l'aide ODEADOM après décision de l'office sont instruits en conséquence. Pour les autres dossiers de demande d'aides, la DAF accuse réception du dossier et lui attribue un numéro d'enregistrement.
Si le dossier est jugé complet, la DAF précise la date de passage du dossier en « Pré-Comité » si non elle réclame les pièces manquantes au porteur du projet. Il existe en moyenne un pré-comité par mois, puisque le DOCUP traite également d'autres dossiers ne relevant pas des programmes sectoriels. Le Pré-comité présidé par le Conseil Général, et où participe la DAF, la Région, la Cellule Europe et un certain nombre d'institutionnels donne un avis sur l'éligibilité et la viabilité du projet. La DAF est chargée de communiquer cet avis au porteur du projet. Le procès verbal de la séance est envoyé à l'ensemble des participants. Les dossiers relevant de l'application des programmes sectoriels en principe ne posent aucun problème. Suite à un avis favorable du pré-comité, les dossiers passent en comité de programmation qui se prononce sur l'attribution de l'aide. Une notification est envoyée au porteur du projet. La programmation donne lieu à l'établissement d'une convention signée par le préfet de région et le maître d'ouvrage qui précise la nature de l'opération, le montant de la subvention, le calendrier de réalisation de l'opération, la date d'éligibilité des dépenses et les dispositions financières. En principe le maître d'ouvrage, à partir de la date de la notification a six mois pour commencer ces travaux et deux ans pour réaliser la totalité des opérations.

Les délais tels qu'ils sont prévus à l'origine sont corrects (en moyenne 5 mois pour la décision de financement de l'ODEADOM, 3 mois dans les meilleurs délais et 8 mois au plus tard et 12 mois pour le paiement ; et entre 2 à 6 mois pour le DOCUP concernant l'instruction du dossier, son passage en pré – comité et en comité de programmation) malheureusement ces délais sont rarement tenus pour de nombreuses raisons :

Certains dossiers parviennent incomplets aux services instructeurs. Lorsque le caractère incomplet du dossier est décelé lors de la première vérification (au niveau de la DAF), la réparation peut être faite dans les 15 jours ; en revanche si les pièces manquantes sont constatées au niveau de l'ODEADOM les dossiers sont renvoyés et le retard pris peut être d'un mois ou deux.
Des retards peuvent être pris au niveau des différentes institutions dans les procédures d'instruction des dossiers ou encore lors des envois.
L'attribution de l'aide de l'ODEADOM est soumise au respect de certaines conditions que doivent préciser des cahiers des charges. Pour la plupart des aides ODEADOM, un cahier des charges doit être établi. La mise en place de ces cahiers des charges est une condition obligatoire à la poursuite de la procédure. La réalisation de ces documents nécessite un délai de réflexion pour réaliser certaines démarches auprès de personnes ressources et des réunions de travail pour bénéficier de l'assentiment du plus grand nombre. Des retards sont souvent pris dans leur élaboration.

d'ordre informationnel

Les agriculteurs face à la complexité des procédures ont souvent du mal à suivre le cheminement de leurs dossiers et de ce fait peuvent difficilement relancer les services.
Pour garantir la réalisation de son projet, l'agriculteur doit posséder la totalité du coût de l'opération et commencer ses travaux après le dépôt du dossier. Les subventions sont versées souvent en plusieurs tranches (précisées dans la convention), en remboursement des dépenses effectivement réalisées, après contrôle des opérations et au vu des pièces justificatives.
Certains agriculteurs commencent les travaux avant le dépôt du dossier et dans ce cas les factures antérieures à la date du dépôt du dossier ne peuvent être considérées ; pour d'autres, faute de fonds propres suffisants, leurs projets ne peuvent être menés à terme et le paiement des tranches suivantes ne peut être réalisé.
La gestion des projets n'est pas maîtrisée intégralement. Beaucoup de porteurs de projet ne parviennent pas à bénéficier de la totalité de leurs financements faute de pouvoir réunir toutes les conditions (paiements réalisés en espèces, factures non présentées, respect des conditions d'éligibilité, respect des cahiers des charges...)

liés au contexte socio-économique de la Guadeloupe

Si beaucoup de projets ne sont pas menés à terme ou sont pénalisés à cause de la lenteur des procédures, bien d'autres n'émergent simplement pas en raison du contexte socio-économique :

Le climat tropical et humide de la Guadeloupe est particulièrement propice à la production agricole à condition que l'eau soit disponible aux moments optimaux des cycles végétatifs. Les longues périodes de sécheresse qui sévissent ces dernières années sont fortement préjudiciables au développement de l'agriculture (exemple : la sécheresse en 2001 a duré de janvier à juin). Cela se traduit par un découragement pour certains, un endettement et un refus de se lancer dans des investissements coûteux.
Les chefs d'exploitation sont souvent âgés, la succession n'est pas assurée dans bon nombre de cas or il existe une limite d'age à l'attribution de l'aide.
Les installations se heurtent au problème du foncier. Il est difficile de trouver à un prix raisonnable une exploitation grande et bien structurée ; or c'est la condition *sine qua non* à toute installation viable et tout développement durable. Par ailleurs beaucoup de terrains sont encore en indivision et les porteurs de projet sont incapables de justifier de leur titre de propriété.
La liste des pièces principales nécessaires à la constitution du dossier représente également un frein au montage des dossiers. Elle est souvent difficile à réunir. Certains agriculteurs ne sont pas organisés (pas de comptabilité, pas de titre de propriété...)

3-2 perspectives d'actions

Les bailleurs de fonds ainsi que les différents acteurs du développement sont conscients depuis longtemps de la nécessité de mener un certain nombre d'actions pour améliorer l'efficacité des dispositifs :

Fort de leurs expériences passées, le recrutement d'un animateur a été proposé dès l'élaboration du programme pour en assurer sa réussite. Dès l'an 2000, l'ODEADOM a pris en charge le coût salarial de cet animateur qui devrait veiller à la mise en œuvre opérationnelle des programmes, sa coordination et son suivi.
Pour palier au problème des dossiers parvenant incomplets à l'office, l'ODEADOM a recruté un agent pour vérifier la totalité des dossiers de paiement avant envoi.
La cellule Europe a fait l'acquisition d'un logiciel « PRESAGE » qui devrait faciliter l'instruction des dossiers. La gestion de ce logiciel sera réalisée par la cellule Europe, en revanche une interface est mise à la disposition de la DAF et de la Région pour l'entrée et le suivi des dossiers ; Un programme établi permettra de gérer le dépassement d'un certain délai.
Pour pallier au manque de fonds propres des porteurs de projets, les demandes de dérogations introduites par les régions d'objectif I auprès de la commission européenne sont en voie d'être adoptées et prévoient de faire passer les taux d'intervention des fonds publics à :
85% pour le financement d'opérations considérées comme exceptionnelles et dûment justifiées
75 % pour les investissements dans les exploitations de dimension économique réduite
65 % dans les entreprises transformant et commercialisant des produits agricoles locaux
75 % dans les PME transformant et commercialisant des produits agricoles locaux
De nombreuses formations devraient être envisagées, certaines sont d'ores et déjà prévues.

CONCLUSION

La plupart des acteurs du développement, de la gestion ou du financement de l'agriculture s'accordent à reconnaître la nécessité du programme sectoriel « Fruits et légumes » pour le développement de la filière. Le bilan de 1998 a mis en évidence un certain nombre de résultats encourageants. Même si les procédures restent assez lourdes, on consent à des efforts de toutes parts (ODEADOM, région, DOCUP) pour trouver des solutions et aider les professionnels à atteindre leurs objectifs pour la période 2000-2006.

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A HOT PEPPER INDUSTRY IN THE CARIBBEAN: A VISION AND REQUIREMENTS OF A SUSTAINABLE AND PROFITABLE INDUSTRY

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ABSTRACT: Hot pepper (*Capsicum chinense* Jacq.) is indigenous to the Caribbean region between latitudes of approximately 1°-23° north or south of the equator. It has been consistently shown that in the region the cultivation of the hot pepper cultivars with Scoville (Heat) Test units of >200,000 (super hot group) for pungency is profitable and internationally competitive. The paper would offer a definition of "industry" and the hot pepper industry of the Caribbean would be defined. An outline of the requirements for the development of the industry would also be given. The presentation would highlight the comparative advantages of the hot pepper cultivars traditionally grown in the region and advance their international acclaim for distinct flavour, highly aromatic and super hot (*capsaicin* acid derivative).

INTRODUCTION

Hot pepper (*Capsicum chinense* Jacq.) is indigenous to the Caribbean region between the latitudes of approximately 1°-23° North and South of the equator (McDonald, 1999a). Hot pepper of the region is distinguishable for its high pungency, aroma and flavour. These peppers (*C. chinense*) are in the super-hot group, which is known to measure > 200,000 heat test units (Scoville) (McGlashan MSc Thesis, 1993). They are also highly adaptable to the climes of the region and it has been shown that hot pepper can be profitable and internationally competitive (FAO/IICA, 1998). However, for the hot pepper crop of the Caribbean to truly develop and become a sustainable and remunerative industry, specific development strategies have to be developed. The Caribbean hot pepper industry can be realised with the recognizable cultivars 'Scotch Bonnet' and 'West Indies Red' along with other developing lines or established cultivars grown specifically in some countries in the region. This peculiarity can be seen as a strength whereby each country having its own specific pepper(s) with special flavour and aroma and still be a *bona fide* participant of the Caribbean hot pepper industry.

MARKET FOR HOT PEPPER

Hot pepper (*C. chinense*) has been known to have an export potential in the United States of America, Europe and Canada. Since 1993, West Indian hot peppers are considered an elite member of the chilli pepper family and fetch premium prices in these markets (Cooper et al., 1993).

In the early 1990s, there has been an upsurge in the use of spicy foods in USA and United Kingdom though there has been little evidence of crossing-over in the consumption of the super-hot pepper from the Caribbean. The Caribbean hot pepper still remains largely a niche market product in these countries. From 1995 to 1998 imports of hot pepper to the US market grew from 87,779 to 128,920 tonnes with Mexico accounting for 99% of total imports. Suppliers making up less than 1% of imports included Canada, India, the Netherlands, the Dominican Republic (DR), St Lucia and others. The United States import market for dried, crushed and ground hot pepper in 1998 was valued at US$84 million, which was the result of a 110% growth over the 5-year period 1993 – 1998 (Medlicott, 1999).

The United Kingdom with its large and diverse ethnic populations is another potentially large market. Inputs of hot fresh pepper increased 134% from 1994 to 1997 with the largest suppliers being the Netherlands and Spain.

Very recent studies of the US markets in Miami and New York (Brooklyn, Bronx and Queens) were illuminating. These findings can be found very useful in the process of developing a Caribbean hot pepper industry. The studies showed that the markets in Miami and New York, particularly the former, are unsophisticated in terms of product differentiation. All Caribbean hot peppers are lumped either as "Scotch Bonnet" or as 'Habanero'. This product "ignorance" can be used as a motivating factor for Caribbean producers to take the necessary steps in first forming a hot pepper industry association which can collectively address the issue of "ignorance". Scott (2001) proposed a programme to show off the distinguishing characteristics of hot peppers of the Caribbean in contrast to Mexican peppers and others as well as educating the market intermediaries as to what product (s) they are carrying. The pay off can be enormous if the market trend in US of increasing demand continues for the Caribbean hot peppers.

The second elucidating point is the presence of a counter-seasonal hot pepper market in both Miami and New York which is supplied by Caribbean imports during the period October to April. This period is complementary to local production in southern New Jersey plains, Florida and Texas. The development of counter-seasonal markets has enhanced produce availability almost all year round in these markets.

The third important point is that the major supplier of hot pepper from the region is Trinidad which produces at this point in time a preferred large red pepper locally known as 'Faria'. Belize has shown to be the second major supplier, but of the cv. West Indies Red. Jamaica has been a traditional producer and exporter of the 'Scotch Bonnet' but in the past two years exports have significantly declined. Jamaica hot pepper has been reported of low quality and exacerbated by the mandatory methyl bromide fumigation due to the gall midge complex infestation on the two cultivars Scotch Bonnet and West Indies Red. The USDA/APHIS requirement is presently enforced for all Jamaican hot pepper exports on entering any port in the United States.

Production in the Caribbean region showed the concomitant increase, as the market demand, during the period 1987 to 1997. These increases, however, have shown to be erratic and due to several factors: drought, crop production technology, pests and diseases and post harvest problems.

Over the period 1991 – 1999 using data for the USA, UK and Canada, it was reported by Stewart and Fletcher (2000) that there was a 7-fold increase in the quantity of fresh hot pepper exported from the CARICOM region, with a corresponding 9.7-fold increase in value. Jamaica despite its difficulties remained the main supplier accounting for an average of 60% of the total amount exported.

AGRICULTURAL RESEARCH NEEDS IN THE DEVELOPMENT OF THE HOT PEPPER INDUSTRY

The advancement of science and technology certainly in the last century in agriculture and specifically in crop agriculture has led to the development of many agriculture-based industries. It is therefore necessary to identify the essential areas requiring research and technological advancement for the development of a hot pepper industry in the Caribbean. There have been recent publications which denoted the need for research in hot pepper (McDonald, 1999d; McDonald, 2000).

Germplasm development and improvement should be given top priority with the purpose of supplying varieties to satisfy the market demand. This should be seen as an on-going process. Breeding for resistance/tolerance to viral diseases must be undertaken using conventional breeding methods in combination with molecular biology techniques. There is the need also for identifying and breeding other varieties that are known for flavour and less pungency.

Research on agronomic improvement and efficiency in production and processing of the hot pepper produce must continue. Using advanced techniques, there is the possibility of increasing yields from 25,000 kg/ha to 50,000 kg/ha. Better understanding of spacing, fertility and the use of hormones can contribute to reaching these high production levels that would reduce cost of production. The use of plant hormones and increased plant density have shown to have the potential to raise present production of the cv. West Indies Red at least by two-fold (M. Mycoo, personal communication, 2001).

Irrigation to the hot pepper crop has shown to be critical for all year round production. Post harvest including handling, packaging and transportation must be considered for sustainability and profitability.

All these technologies new and advanced must be planned for the immediate, medium and long term achievements. This then demands a holistic approach based on the fundamentals of industry development.

DEVELOPMENT THE HOT PEPPER INDUSTRY IN THE CARIBBEAN

Stewart (2001) provided an adequate definition of "industry" as follows: "an industry can be described as consisting of the firms, institutions and individuals whose policies, decisions, actions, products and services have a direct effect on the production, processing and marketing of a specific product, service or specific group of products and services." The specific product/service affected by these entities is referred to as the industry and the firms, institutions and individuals are referred to as industry participants. Thus we can speak for example of the banana, hot pepper or tourism industry.

In summary, an agricultural based industry represents the sum activities involved in the production, marketing and processing of a specific agricultural commodity or product. Therefore by extension, a Caribbean hot pepper industry should comprise the various activities of production, marketing and processing of several products in each hot pepper producing country.

There are several theses on industry development and who can best engineer the process. It is not intended in this presentation to establish any hypothesis, but to offer considered opinions on a possible path of development of the hot pepper industry in the Caribbean and the roles of the various external agents such as CARDI to play.

The industry needs to be stabilized by moving an agriculture based industry from simply involving production to one which is characterised by elements such as well-defined markets, regulatory bodies, value-added and on-going product innovation (Harris et al., 1999). The goal of industry development is to expand the market of a particular product or group of products by: raising the demand; investing in primary supply expansion and; reduction in transaction costs.

All three approaches are important to industry development but I feel at this time that the first and second are very relevant to the hot pepper industry development in the Caribbean.

RAISING THE DEMAND

This approach is to raise the demand for hot pepper (*C. chinense*) through efforts such as product differentiation to satisfy a highly varied market with consumers of peppers of high pungency to moderate and mild.

It has been suggested by Scott (2001) that any attempt to develop a hot pepper industry must address product development and utilization with the view of end-point solutions in high-end product development and usages. It is suggested that there should be a phased development. In Phase I (years 1-5), emphasis should be placed on development and improvement of the following: Peppers for the fresh market; Sauces and seasoning; Salsa; Jerk seasoning; Flavouring.

In Phase II (years 3-10) the following areas must be developed: Dried powder; Processing of extracts for food ingredients; Processing extracts for industrial/Pharmaceutical uses

Demand expansion is not always easy to accomplish. On the other hand, if the demand is enlarged but the industry is not able to fulfill that demand, customers may become discouraged and more hesitant to buy in the future. Thus timing of promotion becomes important in demand development.

PRIMARY SUPPLY EXPANSION

The second approach in enlarging the industry is to invest in primary supply expansion. Research needs already identified in this prsentation can lead to increased efficiency, thus allowing the primary supply curve to shift out or rotate outwards. When the investment in primary supply expansion is successful the industry is more efficient and supply will have increased. This approach to industry development has been used often in the past and may be the most commonly used of the three approaches (Harris et al. 1999).

INSTITUTIONAL ARRANGEMENTS

Industry development requires the institutional arrangements between the industry participants. These arrangements as occurring: (a) horizontal, along one level of the industrial chain (Figure 1) e.g., the formation of industry association; (b) vertically, between different levels of the industrial chain e.g. a long term supply contract between a producer and an input supplier; or (c) in a combination of both horizontal and vertical links.

It is posited here that it is important at this stage of the process of developing a Caribbean hot pepper industry that a Caribbean Hot Pepper Industry Association should be formed. A sustainable industry association should future the following (Harris et al., 1999):

- Clearly defined boundaries
- Well trained appropriation and provision rules (who are the members, benefits, how products and services are accessed, etc.)
- Collective – choice arrangement (low cost mechanism to allow modifications of the rules by the users)
- Monitoring
- Graduated Penalties
- Conflict resolution mechanisms

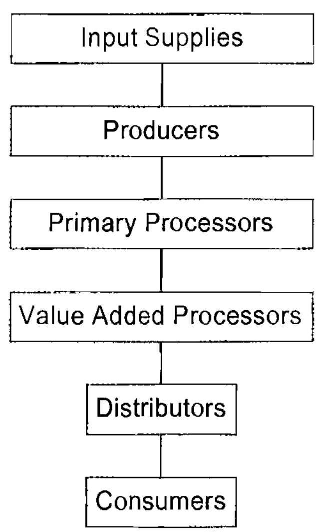

Figure 1. Illustration of a Typical Industrial Chain for Agricultural Products (Harris et al. 1999)

ROLE OF CARDI

The Role of external agents such as CARDI are definitive:

- To encourage and facilitate on-going relationships among industry participants
- CARDI can reduce the costs involved in identifying and communicating with other participants
- CARDI can encourage the development of "networking" opportunities (i.e. trade fairs, industry associations, arrange consultations and other events) and communication tools (i.e. newsletters, industry directories, and electronic bulletin boards).

These activities which foster the creation of a critical mass within the industry (i.e. a group of highly motivated individuals enthusiastic about a development initiative) can become an important component in inspiring others to act collectively.

- Providing credible information (production, processing and market information; information on alternative institutional arrangements, and information on feasible development initiatives
- Facilitating collective action
- Identifying, communicating and developing relationships with other industry participants
- Identifying and evaluating activities which would promote the development of their industry
- Assisting in the identification of the problems and needs of the group; the development of strategies to address these problems or needs; and the mobilization of resources both from within and outside of the group
- Acting as consultant to community groups; building and reinforcing leadership within the group and integrating the efforts of the group
- Assisting industry participants in putting a management structure and systems in place, a set of rules, systems for monitoring, conflict resolution and penalties.

CONCLUSION

We can all glean that in addition to technological innovations and advances in the scientific and biological fields a hot pepper industry development requires also socio-economic considerations. Institutional arrangements, raising demand for the product and that the role of external agents such as the Caribbean Agricultural Research and Development Institute (CARDI) are equally important elements in industry development.

It would be apposite to conclude that to play any role in the development of a Caribbean Hot Pepper Industry is breaking new grounds even reaching epoch proportions unless you do realise. I am unaware of any sustainable and profitable agriculture based industry developed in this region in the last century by the indigenous population except coffee, rice, coconut and banana, and you may even wish to contest this view or add to the meagre list.

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AGRICULTURAL BIOTECHNOLOGY AND FOOD SECURITY: IMPLICATIONS FOR THE CARIBBEAN

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ABSTRACT: Potential candidates of biotechnology such as poverty alleviation and enhanced food security and nutrition in developing countries have received little attention. Serageldin (1999) is of the opinion that biotechnology can contribute to future food security if it benefits sustainable small-farm agriculture but important questions relating to ethics, intellectual property rights, and biosafety must be addressed. In the Caribbean where new agricultural land is scarce, farmers must make gains in productivity if they are to compete in the global marketplace. While it is recognised that the region's agriculture must encompass a broader vision that includes effective policies; genetic improvement; sustainable production systems that incorporate integrated pest management and sound natural resource management; synergies among livestock, agroforestry, cropping systems and aquaculture; attention to post harvest technologies and quality assurance systems; and marketing and agribusiness. While current application of modern biotechnology is focused on industrial country agriculture, biotechnology holds great promise as a paradigm shift necessary for solving the problems of food security, poverty alleviation and environmental protection of the region. Collaboration among public and private sectors, NGOs, universities and other institutions, and other R&D stakeholders will be necessary to enable the complexity of issues surrounding biotechnology to be adequately addressed. The Caribbean cannot and must not stand idly by while others make use of the gene revolution and place the region at a disadvantage in its efforts to compete in the global marketplace.

INTRODUCTION

The main challenge in ensuring food security in the Caribbean region will be to sustain efficient traditional crop production while diversifying to non-traditional and increasing productivity in fast-growing commodities and higher-value products. The sector must feed a growing population while facing increasing competition from abroad. Greater attention must be given to the economies of production and the identification, selection, adaptation and transfer of technologies which are capable of enhancing the commercial viability and sustainability of production and marketing systems. The focus must be on food security, increased exports and improved income and productivity in the agricultural sector (Parasram and Paul, 1996).

The region must focus on specific commodities that offer the greatest comparative advantage either as primary products or through added value while targeting industries that are efficient. Niche markets in North America and Europe are important for extra-regional exports while regional and domestic markets must target the tourism and hospitality sectors and supermarkets.

Caribbean agriculture employs more than 20% of the labour force in several countries and is considered a key to the alleviation of poverty and food security. Generally, the poor depend on agriculture for 40-100% of their income (Mc Intosh, 1996). They farm marginal hillsides and cause severe erosion of soils leading to lower productivity, deforestation, overgrazing, biodiversity and habitat loss, and environmental degradation. About 38% (13 million) of the region's people are considered poor; in Haiti, 94% of the population lives below the poverty line. The integrated poverty index shows that Jamaica, Dominica, Haiti, Guyana and the Dominican Republic are the poorest countries (Paul, 2000c).

While agriculture provides an effective solution to the poverty and food security problem of the region, governments must provide the correct policies and infrastructure that provide services in areas where they have special advantage, e.g., rural areas where resource poor farmers operate. These policies at the national and regional levels must be based on the needs of farmers and the marketplace. Special consideration must be given to small farmers that face the prospect of annihilation in the face of trade liberalisation; unless they organise themselves into production and marketing blocs that are supported by an enabling policy and marketing environment, they will have to abandon farming.

Sustainable development of the Caribbean's agricultural sector will require advanced technology generation and application as the region's farmers intensify agriculture on decreasing arable land. There must be integration of genetic enhancement efforts with those in production systems, post-harvest technology, marketing and agribusiness development. More research must be directed to develop appropriate technology for sustainable intensification of agriculture in resource poor areas and where ecosystems are fragile.

Biotechnology is a modern tool of agricultural research that can contribute to food security by increasing agricultural productivity on smallholder farms of the Caribbean. But this cutting-edge technology raises important questions relating to ethics, intellectual property rights, and biosafety. However, governments must ensure that access to potential benefits from biotechnologies are guaranteed for poor people and environmental conservation.

WHAT IS BIOTECHNOLOGY?

Biotechnology includes any technique that uses living organisms, or substances from living organisms, to make or modify a product, to improve plants or animals, or to develop micro-organisms for specific uses (Cohen, 1994).

Bio-engineering is a part of biotechnology and is based on the discovery that certain enzymes can cut the DNA molecule at specific sites while others can join the pieces in new combinations (recombinant DNA molecules). This has increased scientists' ability to transfer genes from DNA across species boundaries, thus creating transgenic plants and animals (Cohen, 1994). One way of transferring genes is by the insertion of the desirable gene into the bacterium *Agrobacterium tumefaciens* and then infecting the recipient plant with the bacterium – the bacterium infects by inserting some of its own DNA directly into the DNA of the plant. The cells containing the new desired gene are identified and grown into a whole plant using cell culture technology. Another transfer technology is by coating small tungsten balls with DNA containing the desired genes and physically shooting the balls into the recipient plant cells (gene gun approach). Some of the genes come off the balls and are incorporated into the DNA of the recipient plant.

The development of *in vitro* tissue and cell culture techniques has occurred parallel with advances in molecular biology and genetic engineering. Tissue culture techniques make it possible to regenerate a whole plant from a small piece of tissue, and even from a single cell, by growing it in a suitable medium.

APPLICATIONS OF BIOTECHNOLOGY

Crop Improvement

Diagnosis of pests and diseases has been improved by molecular techniques. Tissue culture techniques enable the production of disease-free plantlets and the construction of transgenic plants by enabling the regeneration of transformed cells containing desirable genes. Micropropagation techniques enable rapid multiplication of vegetatively propagated crops and three species.

In 1999, approximately 40M ha of land were planted worldwide with transgenic varieties of over 20 plant species. The main countries where these are grown are the USA, Argentina, Australia, Canada, France, China, Mexico, South Africa and Spain. The commercially important varieties are soybean, corn, cotton, rapeseed, tobacco, tomato, potato and squash (James, 1999). The traits of the transgenics are mostly insect resistance, higher nutritional quality, herbicide tolerance, delayed fruit ripening and virus resistance. Benefits include better pest and disease control, higher productivity, lower cost of production, and reduced pesticide levels in the environment.

The use of genetic markers, maps, and genome information is improving both the accuracy and time to commercial use of single and polygenic traits in plant breeding.

The technical ability to transfer genes across biological organisms has markedly expanded the range of useful traits that ultimately can be applied to the development of new crop cultivars. Plant genome studies are enabling the application of recombinant DNA technology to crop improvement by identifying the genes that control agriculturally important traits and how they act to do so (Serageldin and Persley, 2000).

Characterising Biodiversity: Genomics plays a key role in the characterisation and conservation of genetic resources by identifying useful genes in germplasm accessions and wild species among the biodiversity.

Bioinformatics: Genomic data must be compiled, managed, and analysed for use in molecular biology, genome sequencing, and comparative genetics useful to genetic improvement of crops and animals. The development of genetic databases and the integration of bioinformatics systems at the national, regional and international levels are essential.

Livestock Improvement: In the Caribbean, constraints to livestock improvement include genetics, health, and nutrition. Biotechnology is being applied to speed up reproduction processes to enable more efficient selection of breeds with improved productivity. Transgenic livestock such as pigs can be used as a source of tissue and organs as transplants into humans. Human biological pharmaceuticals are presently being produced from sheep milk. Work is being carried out to find genes for disease tolerance, heat tolerance, and other adaptive and productive traits in wildlife and transferring these to domestic livestock. Molecular technologies are being used to study livestock parasites and other pathogens so that vaccines can be produced against the parasites.

Fish and Aquaculture: Molecular marking, genome mapping, trait selection, sex manipulation, and disease diagnosis are some of the biotechnology activities being used to increase fish stocks and feed efficiency conversion to protein.

CONSTRAINTS TO THE APPLICATION OF BIOTECHNOLOGY

The key policy constraints to the application of biotechnology are ethics, intellectual property rights and biosafety.

Ethics

The exploiting of the developing world's indigenous genetic resources by transnational corporations that then sell patented transformed superior plants and animals back to developing countries at high prices (biopiracy) holds questions of ethics. The transnational enterprises argue that the biodiversity in public access resources such as forests and seas should be exploited for genes useful to all mankind including the developing countries themselves.

There are also several questions of an economic, social, ecological, religious, political, or cultural nature that require open debate and regulation at the national, regional and international levels.

Intellectual Property Rights (IPR)

Scientific products of biotechnology may be protected by plant variety protection, patents, and /or trade secrets. IPR affects the commercialisation and trans-boundary movement of genetic resources and products. The 1995 WTO Agreement on Trade-related aspects of IPR (TRIPs) requires all members to adopt legislation to ensure minimum protection standards for their intellectual property. As developed countries have moved to protect their intellectual products of biotechnology, developing countries have moved to protect their genetic resources. In 1992, the Convention on Biological Diversity (CBD) enabled benefit sharing among countries if financial returns accrue from exported genetic resources.

Since the private sector holds property rights to most biotechnology products, the public sector should seek to cooperate with the private sector in research and product development. National governments should develop multilateral agreements for germplasm acquisition and transfer.

Biosafety

Biosafety involves food safety and environmental safety. Public concern over adverse effects of genetically modified foods has been based on risks related to toxins, allergens and carcinogens. Although many consumers in North America, Europe and China have been eating genetically improved food over the past several years without any demonstrated adverse effects on their health, the long-term effects are unknown. Food labeling can provide information useful for consumers' decisions on using the foods. Supporters of biotechnology argue that the testing and regulatory processes applied to genetically modified foods are capable of addressing consumers' concerns.

Critics are concerned by the potential environmental damage that might be caused by transgenic crops crossing with related species and producing superweeds resistant to herbicides or by their effects on other parts of the ecosystem (for example, genetic pollution through pollen or seed dispersal, or transfer of foreign genes to micro-organisms).

The Cartagena Protocol on Biosafety was signed by 130 countries that are signatories to the CBD in January 2000 and sets out obligations for international transfer of living modified organisms that my threaten biodiversity. The Protocol also outlines general procedures for risk assessment. But the safe use of biotechnology products requires efficient regulatory systems at the institutional and national levels, guidelines for field tests and release, labeling of novel products, and scientific research on possible short and long-term effects on the environment. Of course, national and/or regional capacity to follow these guidelines is critical (Serageldin and Persley, 2000).

IMPLICATIONS FOR THE CARIBBEAN

Scientific and technical capabilities for the development and use of biotechnologies are growing in the region. Biotechnologies are being utilised in the preservation, handling, exchange and massive propagation of plants, genetic improvement of plants, and symbiotic nitrogen fixation. Emphasis is on cell research, the most common techniques being cell culture, cloning of buds and meristems, anther and ovary culture, and protoplast culture and fusion all of which require relatively low cost equipment and give short-term results. Less importance is given to molecular biology, although genetic engineering techniques are used in Cuba and at UWI Campuses in Jamaica, Barbados and Trinidad (Chaverra, 1984).

Several international codes of ethics, protocols, and regulations (Biosafety Protocol; International Code of Conduct for the release of GMO's; Third World Network Model Biosafety Law; Codex Alimentarius Commission of FAO; and Technical Barriers to Trade (TBT), Sanitary and Phytosanitary (SPS) and TRIPs Agreements of the WTO) can assist Caribbean countries to develop regulatory frameworks and in establishing standards for the safe development, manufacture, use, release, trade and trans-boundary movement of GMO's. But the countries will require scientific and technical expertise and information systems for all aspects including risk assessment and public awareness. Therefore, there will be the need for institutional capacity development and multidisciplinary teams dedicated to finding more sustainable farming systems. This is even more important since the larger farmers are likely to capture most of the benefits from biotechnology unless small farmers have access to delivery systems, extension services, markets, transport and infrastructure.

Because improved plant material produced by biotechnology is owned by a few private multinational corporations, there is no focus on small farmers (Pinstrup Andersen and Cohen, 1999). This means that in order to tackle food security by the use of biotechnology in the Caribbean, staples such as root crops, tropical fruits and vegetables, and livestock, need to be addressed. Also, Caribbean problems of drought, poor soil fertility (nitrogen, phosphorus, trace elements), pests and diseases, low productivity and nutritional quality, and the storage life of primary products, need to be researched. But such research must be done by public institutions such as the UWI and CARDI which need to form strategic alliances with the private sector and with IARC's and other RARO's so as to ensure that biotechnology serves the poor small farmers. The best approach appears to be the use of conventional breeding and tissue culture technologies rather than the use of transgenics which are extremely expensive to produce and subject to IPR, ethics, and biosafety restrictions.

As Caribbean countries attempt to manage and protect their genetic resources, they will need to collaborate with each other. The Caribbean Plant Genetic Resources Network (CAPGERNET) under PROCICARIBE has a membership of 18 countries and can serve as the mechanism for this collaboration. CAPGERNET also has strong linkages with IARC's such as The International Plant Genetic Resources Institute (IPGRI).

The region must assess the potential social and economic benefits of biotechnology against the costs and potential risks involved. As they import products from countries that grow GMO's they must be watchful and carry out the necessary testing even if there is labeling. This is even more important since the region will face restrictions on its exports to countries such as those of the EU most of which do not permit the importation of GM products.

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THE EFFICACY OF USING SHEEP REARING AS A MEANS OF MICRO-ENTERPRISE DEVELOPMENT IN A RURAL COMMUNITY

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ABSTRACT: The Princes Town Small Ruminant Project was developed primarily to alleviate poverty in a rural community. The poverty rate in the Princes Town area is 49.3%, which places that community among the poorest in Trinidad and Tobago. Sheep production and marketing was used as the vehicle for rural transformation through micro-enterprise development. Thirty families from the community were each supplied with an average of four ewes, adequate animal housing, feed, veterinary and other ancillary supplies necessary for the successful rearing of sheep. Participants were trained in basic sheep husbandry, sheep marketing and agribusiness management. The group formed a co-operative that would be responsible for purchasing weaners from members, fattening them in a feedlot and marketing the animals thereafter. After one year, 20 families or 67% of participants remained with the project. A total of 93 animals were distributed and fifty-three lambs were born during the first six months of the project. The frustration level of the remaining participants has however increased in recent times due to internal problems in the NGO, intermittent funding and the slow rate of return on their investment. It is clear that unforeseen problems contributed to some of the frustrations seen, however, given the expectations of the participants, it would appear that sheep production alone may be insufficient to transform the socio-economic circumstances of the rural poor in a timeframe consistent with their needs. It is therefore recommended that this activity be coupled with the production of cash crops that will provide income in the short term and improve the nutritional status of the family while the sheep production enterprise is maturing.

INTRODUCTION

Trinidad and Tobago imports 1.5 million kg of sheep and goat meat annually. It has been estimated that local production accounts for only 30% of total demand. Market research (Craig and Seepersad 1993) has shown that the demand for local lamb is strong, especially but not exclusively among higher income groups and the product compares favourably with frozen imports from New Zealand and Australia. The local product is fresh; with much less fat and more flavour and as a result, has greater appeal in the market place. The problem faced by the market has been attributed to inadequate and inconsistent levels of supply. Research at CARDI and other institutions has linked this to a limited production base (Gibson and Ramlal, 1998) and poor methods of husbandry.

This study was therefore initiated by CARDI in collaboration with a rural-based NGO (The Committee for the Upliftment of the Under-Privileged [CUUP]) in order to increase local lamb production by small, resource poor farmers, utilising a co-operative approach. The focal point of the study (Princes Town) covers an area of approximately 160 square kilometres and has a population of almost 30,000 people. It is a rural district with a large agrarian population, among which almost 50% of all households are considered to be below the poverty line. The poverty rate is 49.3 percent, well above the national average of 35 percent, so that poverty alleviation has been a major focus of the study. Micro-enterprise development, utilising sheep as the main capital resource, was identified as the mechanism for improving the standard of living of the participants.

MATERIALS AND METHODS

In Phase I of the project, target families were supplied with four mature ewes, adequate animal housing, feed, veterinary and other ancillary inputs to successfully rear sheep. The delivery of these items and the commencement of feeding would have brought Phase I to completion. In Phase II the CUUP will act to facilitate the formation of a co-operative among the group that will construct and manage a feedlot. The feedlot will buy the weaned lambs from the group, fatten and sell them on the open market and all profits will accrue to the members as dividends and shares. The group will be required to give back to the CUUP, four lambs that will be distributed to other families desirous of joining the project. The second phase of the project has been delayed because of the need strengthen some aspects of Phase I, particularly animal husbandry training and marketing.

Family selection

Socio-economic status, aptitude for animal husbandry, amenability to training, character, size and composition of household and residency in the municipality of Princes Town, were the major criteria used for the selection of participants. After the candidates were selected, a contractual arrangement was entered into with each participant. The contract stipulated the obligations of both parties (participant and CUUP) and outlined fully their responsibilities.

Animal housing

Adequate animal housing was constructed on each farm at a cost of EC\$435.00 per unit. Housing consisted of a wooden structure of approximately 9.29m^2 with concrete floors and roofing made from galvanised metal sheets. Wooden forage feeders were built into the housing such that the farmer had easy access to fill the feeders without having to enter the pen and the animals could not easily contaminate the feed. Waterers, constructed from PVC, were generally designed the same way but in some cases farmers used a plastic bucket, which was filled with water and placed inside the pen. Housing was designed to be low-cost, with the farmer supplying labour only. The cost of the materials was borne by the project.

Animal procurement

Animals were obtained from various sources and differed significantly in breed, physiological state and general condition. The main breeds represented were Barbados Blackbelly, West African and their crosses. Some of the ewes were pregnant at the time of sale. The project deliberately sought to procure pregnant ewes, as it was felt that this would give farmers an added advantage in terms of the time taken to first lambing, especially since provisions for a stud service were not very well developed. A total of 90 ewes were bought and distributed to each of 25 farmers. The remaining five farmers were supplied by a later batch of animals

Feed and ancillary supplies

It was determined that animals would be reared primarily on forages that were readily available to the farmer. These consisted in the main of Tanner grass (*Brachiaria* sp.), Elephant grass (*Pennisetum purpureum*), Para grass (*Brachiaria mutica*) and a number of other local species. In some cases Kudzu (*Pueraria phaseoides*) was also available for feeding. In all cases, the semi-intensive system was used for rearing. Animals grazed for a limited time each day and were fed additional forage and supplements when penned during the evenings. The supplement, consisting of a 14% dairy ration, was supplied by the project to each farmer. Feeding rates varied between 0.2 to 0.4 kilograms of supplement per animal per day, depending upon physiological state. Each farmer was also given a supply of iodine, wound spray, disinfectant and access to anthelmintics.

Training

All participants were exposed to a basic animal husbandry course, inclusive of health and disease management, ruminant nutrition and reproductive management. Four hours of contact time was given to sheep marketing principles and practices and agribusiness management.

RESULTS

Participants' staying power

Thirty participants signed up for the project and after one year, 20 remained. This represents an approximately 67% success rate. The reasons for dropouts from the programme are shown in Table 1. There was a considerable lag time between housing construction and delivery of the animals. During this period, some participants became frustrated and opted not to receive any animals when they became available. The project targeted resource-poor families in Princes Town who were either unemployed or engaged in extremely seasonal or part-time work. Those who found full-time employment were not then able to continue with the project. Due to sickness and changes in family situations, some participants were unable to adequately care for their stock and were forced to give them up.

Distribution of stock

Stock was distributed over a six-month period between January–June 2000. This was necessitated by the low levels of local stock available, which had to be procured from several sources scattered throughout Trinidad and Tobago. The stated intention of the project to procure pregnant ewes in the main was not fully achieved since only 42% of the ewes bought were pregnant. A total of 93 animals were procured including 90 ewes and three rams. The average price paid for pregnant ewes was 34% higher (EC$283.00) than that paid for open animals (EC$208.00). The rams were bought from a Government station at a highly subsidised price of approximately EC$63.00 per animal.

Stock increases/decreases

Ninety ewes were purchased for the project, out of which two died and three were culled, leaving 85 animals to be distributed. Fifty-three lambs were born during the first six months of the project and two died. Stock inventories are shown in Table 2. Lamb mortality for this period was 3.7%, well below the first-year target of 10% expected for the project. No detailed data was available for the second crop of lambs except that there were reports of unusually high levels of mortality, occasioned by lack of adequate supplementation and some disease problems.

Income generation

Participants have earned no appreciable income as yet, however, some lambs have been sold to butchers but the details of these transactions were not readily available at the end of the reporting period. CARDI has projected that farmers will not be able to realise profits until after 2 years of operations. When the projected income per month is compared with the monthly costs of a basic basket of food items (Figure 1), the breakeven point is achieved only in year 3. This is the main reason for some of the frustration among participants, the relatively long wait for returns on their investment.

DISCUSSION AND CONCLUSIONS

The project revolved around the creation of micro-enterprises within a rural community using sheep production and marketing systems development as the primary vehicle to effect socio-economic transformation. Sheep production systems generally take about 13-15 months before the break-even point is reached and up to two years before some measure of profitability is attained. In this regard, it was expected that it would take some time before real benefits could accrue to the target community. Ideally, a period of not less than three years is needed for rural-based small ruminant projects to bear fruit. The concept therefore was sound in that improvements in income of the participants were a reasonable expectation. However, it should be noted that these improvements would be modest in nature, given the margins associated with semi-intensive sheep production systems in the tropics. After 13 months, profit margins from a four-ewe operation represent only about EC$80.00 per month for the operator and this is provided that labour costs are not charged. By Year 4 that figure is $1000.00 and in Year 5, it is $2100.00 per month. The costs used represent the contribution of concentrate feed and medication only. Nevertheless, collateral benefits accrue from empowerment through training and the manure produced can be sold or used to sustain home garden production of vegetables.

Project management

This is often a critical factor that influences project success more than any other. CARDI is increasingly recognising the need for formal collaborative arrangements with its partners when forging project alliances, with responsibilities clearly defined by signed Memoranda of Agreement (MOA). An independent project manager (not a member of the NGO) was appointed by the CUUP to oversee the project, even though CARDI had suggested that the CUUP itself should logically assume that responsibility. This advice was offered in view of the fact that the CUUP owned the project, no funds were budgeted for a project manager and therefore the NGO should have assumed full responsibility for project management. The project manager's costs were partly met by the small ruminant project and the rest was paid from a number of other unrelated projects for which he had responsibility. The problem that arose because of this arrangement was that the project manager could not devote enough time to the small ruminant project and as a consequence direct technical support to the farmers was not as frequent as it should have been. Nevertheless CARDI continued to provide technical support through the Project Management Committee and directly by limited site visits to farmers. A project management committee was formed and consisted of:

President – CUUP; Secretary – CUUP; Project Manager; Livestock Scientist – CARDI; Research Assistant – CARDI; Livestock Officer – MALMR; Extension Officer – MALMR

After initially holding monthly meetings, the committee convened on a quarterly basis to discuss and determine management issues with respect to the project and to provide guidelines for technical support. This arrangement worked well as it provided a ready forum for the discussion of problems that arose on the project, with a view to finding cost-effective solutions. The project manager had overall responsibility for project execution and was supported in the field by the extension officer. CARDI personnel and the MALMR livestock officer were responsible for technical support in all aspects of animal husbandry. CARDI personnel made regular site visits to the farmers and also provided project development and marketing support. A major limitation of the project management committee was the omission of the farmers or their representatives.

Project execution

Despite initial teething problems the 20 farmers who remained with the project after one year were generally satisfied with the manner in which the project was executed. However, after that period, it soon became apparent that the project manager simply did not have the time to visit the farmers as often as required, especially during the lambing period. One of the reasons for this, apart from his responsibilities to other projects, was that there was no suitable vehicle available to service the project. Given the widely scattered nature of the project site and the general deplorable conditions of the access roads, an appropriate means of transportation was indicated. The project had budgeted for and had acquired a vehicle for this purpose, however, during this period a number of internal problems developed within the NGO and as a result the vehicle was never made available to the project. Other internal complications arose that had the effect of severely curtailing the funds available for feed, medication and other ancillary supplies. During this period, lamb mortality was at its highest, mange became a major health issue and dissatisfaction among the farmers was a growing concern. The resignation of the NGO secretary, a founding member, had a significant impact on project execution, given her intimate knowledge of the participants and her commitment to the project. As the internal problems worsened, so too did the conduct of the project in terms of funding for basic items. The NGO has since reorganised and is now trying to sort out project financing and other internal issues. The project manager has resigned and the NGO is in the process of appointing a co-ordinator from its own ranks, to oversee the running of the project.

CONCLUSIONS AND RECOMMENDATIONS

The success of the project was premised upon a vibrant and robust NGO that had experience in the target rural community, which would serve to facilitate the technology transfer process. This premise is sound and many of the problems that subsequently arose were unforeseen and partly precipitated by an associated agency. Nevertheless, the project was owned by the NGO and they are ultimately responsible for its success or failure. CARDI should continue to forge collaborative linkages with NGOs to jointly execute rural-based projects. The twin imperatives of poverty alleviation and rural development dictate this type of approach. However, more careful research into the background, experience (with projects and working with other institutions) needs to be conducted before CARDI gets involved. A thorough SWOT analysis is indicated.

CARDI's research has shown that sheep production and marketing systems projects provide a relatively slow means of tackling rural underdevelopment and as such participants must be made aware from the start that this does not represent a get-rich-quick scheme. CARDI's findings in this project have indicated that it would be useful in the future to combine home-gardening (vegetable and food crop production) with sheep production and marketing projects to more adequately address the issues of nutrition and income, within a timeframe that is more appealing to the rural poor. Alternatively, another livestock enterprise like rabbit production that has a much higher off take and better opportunities for income in the short term may be considered in addition to sheep production. During the July-December 2001 period, the project will introduce a pilot vegetable production and rabbit-rearing scheme to test this hypothesis. Research done by the International Livestock Research Institute (ILRI) in sub-Saharan Africa has shown that the synergies derived from combining these enterprises in terms of nutrient cycling and cash flow play a major part in the success of livestock-based rural development projects. CARDI is working with its collaborators in Trinidad and Tobago and the region to bring the benefits of this type of research to the rural poor.

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Table 1. Reasons for participants dropping out.

Reasons Advanced for dropping out of the project	No. of Participants
Never started the project	3
Found full-time employment	2
Were unable to take care of the animals for reasons of incapacity	3
Death of participant	1
Unable to continue due to personal reasons	1
TOTAL	10

Table 2. Breakdown of livestock population

Class of sheep	No. of animals
Rams	3
Ewes	85
Lambs	51
Male	24
Female	27
Total	139

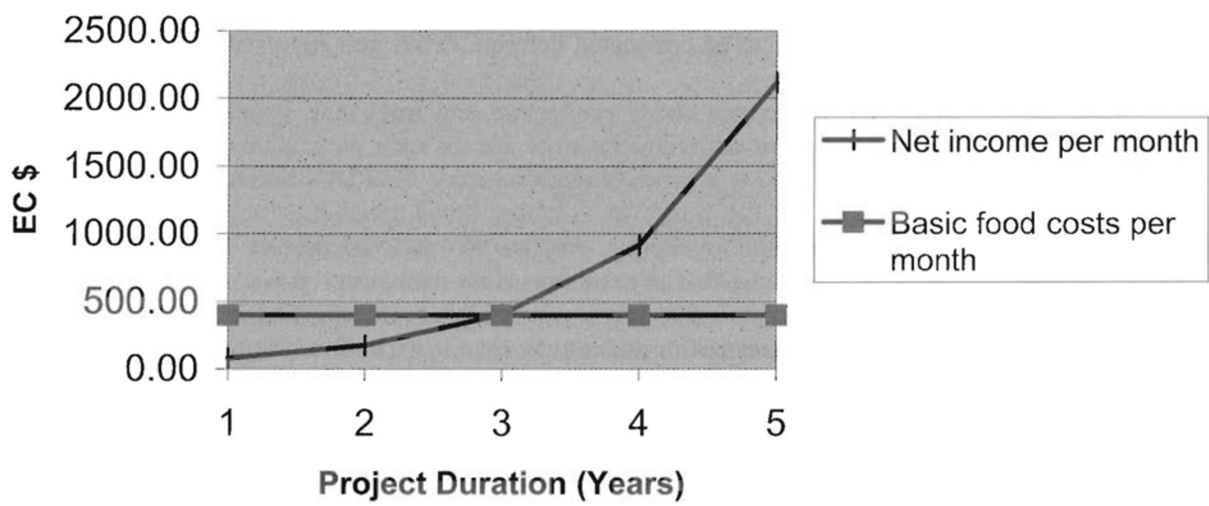

Figure 1. Comparison of net income per month by farmers on the project and the monthly cost of a basket of basic food items

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KNOWLEDGE NETWORKS IN CARIBBEAN AGRICULTURE: RECENT EXPERIENCES WITH THE CARIBBEANIPM GROUP

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ABSTRACT: In May 2000 CAB International in collaboration with the CARDI's Caribbean Agricultural Information Service set up a pilot project aimed at testing the feasibility of establishing regional knowledge networks within the Caribbean with a view to improve knowledge exchange. The activity was set up as a trial, with specific objectives and time frame using the Caribbean IPM Network as a model. The network was based primarily on email access but with additional access via the Web. Participation was initially by invitation only in order to focus on a small group of participants working in IPM. The Network has been running for one year and the experiences are discussed. Generally, the network has proven to be a useful tool for exchange of information. Using lessons learned from the activity, recommendations are made on the establishment of similar networks for other theme areas.

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LES VIROSES DE L'IGNAME *DIOSCOREA CAYENENSIS-ROTUNDATA*: IMPACT DES FACTEURS CULTURAUX ET ENVIRONNEMENTAUX SUR LES ATTAQUES DE POTYVIRUS

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RESUMEN: Les attaques de potyvirus sur igname, et notamment l'espèce *Dioscorea cayenensis-rotundata*, entraînent une forte diminution de la production en Martinique depuis plusieurs années. Afin d'étudier l'influence des facteurs culturaux et environnementaux sur la maladie, une enquête a été menée sur 50 parcelles de *D. cayenensis-rotundata*, réparties sur l'ensemble du département. Pour chaque parcelle, des tests ELISA potyvirus universel ont été réalisés à partir des stocks de tubercules-semences avant plantation puis sur feuilles prélevées en cours de culture, de manière à confronter les taux de contamination aux pratiques culturales et aux facteurs environnementaux. L'analyse des résultats montre que les facteurs suivants influent fortement sur les attaques virales: la mauvaise qualité phytosanitaire des tubercules-semences (présence de virus dans les stocks) et leur découpage sans désinfection de l'outil de coupe favorisent l'extension de la maladie, la transmission par contact étant une voie possible de contamination ; en revanche, l'association de cultures comme le dasheen ou le giraumon avec l'igname sur la même parcelle ainsi qu'un environnement parcellaire composé de bananiers ou de vergers d'agrumes paraissent défavorables à la contamination. Ce dernier point pourrait s'expliquer par le fait que les pucerons vecteurs présents en Martinique, *Aphis gossypi* et *Toxoptera citricida*, seraient respectivement plus spécifiques des cucurbitacées et des agrumes.

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AN OVERVIEW OF THE RESEARCH AND EXTENSION PROGRAMS AT THE CENTER FOR AGRICULTURAL RESEARCH IN SURINAME (CELOS)

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ABSTRACT: The Center for Agricultural and Forestry Research Suriname (CELOS), a formal Tropical Experiment Station of the Agricultural University in Wageningen, was established in 1965. Since then, CELOS has become noted for many research contributions particular in sustainable forest management and annual cropping on low acid soils. In 1975, CELOS was transferred to the University of Suriname. Functioning as an independent Agricultural Research Institute, CELOS is committed to solving problems that are constraining the Agricultural Sector in Suriname and the region. The Center is presently supported by 120 personnel and 30 staff members. The Center is led by a Director and the CELOS Council. Main divisions are Agronomy, Agricultural Extension, Tissue Culture, Medicinal Plants, Forestry, Aquaculture, and Geograhic Systems (GIS). Financial resources are funded through the Ministry of Education. Funds to carry out programs or to sustain Agricultural and Forestry activities, and to maintain the existing infrastructure at CELOS comes strictly from outside sources. The Center has also established collaborating links with National and International Institutes and donors, including the: FAO, UNDP, EU, PAHO/WHO, WWF, CARTEF, ABOS, PROCITROPICOS, the Agricultural University in Wageningen,, the University of Gent, and the Louisiana State University.

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BIOCHEMICAL CHARACTERIZATION OF BREADFRUIT CULTIVARS (*ARTOCARPUS ALTILIS*, PARKS FORB.)

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ABSTRACT: The study was done to determine the biochemical changes in two varieties of breadfruit, "Yellow" and "White" from fruit formation to maturity. This generates an age composition graph, which is invaluable to farmers and food processors, for harvesting and selecting breadfruit of ideal composition and variety for manufacturing into breadfruit chips. In this study thirty breadfruits of each variety were tagged. The fruits were tagged from appearance of the female inflorescence (mid-April). Length and breadth measurements, as well as determinations of crude fat, protein and moisture (AOAC 1975) were done on a weekly basis. Initial moisture levels in both varieties were very high 90-92%. There were sharp decreases in moisture in "Yellow" fruit at week eight and "White: fruit in week ten. The moisture leveled off at 69-75% for "Yellow" and 75-80% for "White" until maturity (14-16 weeks). There was a gradual decrease in protein and fat content from tagging to maturity in both varieties. Overall White variety appears top have slightly higher amounts of fat and protein and more moisture than the Yellow variety.

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ETUDE D'ISOLATS DE *COLLETOTRICHUM GLOEOSPORIOIDES* RENCONTRES SUR L'IGNAME *D. ALATA* L., DANS DIFFERENTES ZONES DE CULTURE DE LA GUADELOUPE

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RESEUMEN: Dans les conditions climatiques de la Guadeloupe, le feuillage de l'Igname *Dioscorea alata L.* est généralement attaqué par *Colletotrichum gloeosporioïdes* champignon responsable de l'anthracnose, qui demeure la plus importante maladie aérienne de la plante. Les traitements fongicides sont devenus inefficaces avec l'apparition de souches résistantes. Des isolats issus d'attaques sur différents organes (tige, pétiole, limbe et nervure) collectés dans les principales zones de culture de l'igname en Guadeloupe, ont été comparés sur la base de tests biologiques. Parmi les divers critères utilisés, la tolérance au benomyl (utilisé en lutte chimique contre la maladie) et le pouvoir pathogène ont montré une variabilité importante. L'étude de la diversité de ces souches à l'aide de marqueurs moléculaires neutres (issus d'AFLP) est en cours. Elle permettra d'étudier la variabilité génétique et la dynamique des populations pathogènes de façon à gérer de manière plus efficace les résistances.

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MARKETING OF LAMB IN TRINIDAD AND TOBAGO: AN ANALYSIS OF THE VALUE CHAIN

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ABSTRACT: A study was conducted to determine the price and value differentials between lamb sold at the farm gate and meat retailed in municipal markets and supermarkets and to assess the value of the so called 'fifth' quarter as a source of revenue to livestock producers. The study was executed in Trinidad and 26 farmers, seven market vendors, two roadside vendors, one abattoir, one butcher, 11 supermarkets and 14 meat shops were targeted for interviews. It was found that the average price that farmers reported receiving was TT$16.53/kg live-weight, for those farmers (60%) who sold their stock based upon weight only. The average market weight for lambs in Trinidad and Tobago was assumed to be 40kg based upon previous work done by researchers on the CSPM project. Nineteen per cent of farmers sold animals based on sight alone and it was estimated that for each animal sold using this method, the farmer lost TT$200.00. The average price paid by market and roadside vendors for live animals was TT$12.00/kg or alternatively TT$452.00 per animal based upon appearance. Abattoirs and butchers reported paying an average of TT$14.00 per kg live-weight. In the supermarkets, local lamb was generally unavailable but where it was sold, it retailed for between 24-33 TT dollars per kilogram. Butchers can earn on average an additional TT$95.00 per animal by retailing the 'fifth' quarter (head, feet, skin and entrails). Whether an animal is sold by sight or by weight is the primary determinant of who derives greater profit from the value chain. An investment in the simple technology that a weighing scale provides would go along way towards ensuring profitability for the sheep farmer.

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SELECTION FOR EARLY BEARING PAPAYAS IN THE VIRGIN ISLANDS

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ABSTRACT: Papaya production in the U.S. Virgin Islands is for the domestic market and has been plagued by the Papaya Ringspot Virus (PRSV) and seasonal hurricanes. This has resulted in papayas now being growing as an annual crop. The need exists in the U.S. Virgin Islands for papayas with early production to ensure a marketable crop within 9-10 months. The local demand is for papayas of the 1-1.5 kg size and this is considerably larger than the 0.25-0.5 kg solo varieties developed for export. Breeding and selection has been ongoing for 7 years to develop papayas with tolerance to PRSV and fruit production starting at or less than 1 m from the ground. The height at first fruit set, of papaya cultivars evaluated in the Virgin Islands, ranges from 60 cm to 253 cm. Generally, female plants start setting fruit lower on the stem than hermaphroditic plants. Through breeding and selection, 3 papaya lines have been developed which set fruit between 40 and 60 cm from the ground. These low bearing papaya lines produce fruit that are marketable one month earlier than other cultivars.

MATERIALS AND METHODS

The University of the Virgin Islands has been conducting papaya evaluations to determine cultivars for production in the USVI. To date, over 60 cultivars have been evaluated during the last seven years. The cultivars came from all parts of the tropical world. Cultivars were initially selected based on:

- Tolerance to high pH 8.5 calcareous soils
- Tolerance to papaya ringspot virus
- Fruit size greater than 0.5 kg
- Sweetness greater than 10% Brix

Cultivars with 2 years of good results were selected and maintained. Nine papaya cultivars have been selected for seed multiplication and distribution to farmers and backyard growers (Table 1). Due to the frequency of hurricanes, fruit production data was taken at the time of the first ripe fruit. The selected papaya cultivars also try to fulfill consumer demand for fruit size (Table 2), flesh thickness and flesh color (Table 3).

Papaya breeding has also been conducted to develop early bearing varieties within 60 cm from the ground. Three lines have been developed.

Development of early bearing papaya lines

Line UVI-1 was developed from a cross between '356-3' and 'Cariflora' with an F_2 selection backcrossed to '356-3'. The plants are carpellate or staminate having fruits with a 12 cm diameter and 13% brix. The first fruit is set 53 cm from the ground and has a yellow flesh color.

Line UVI-2 produces hermaphroditic plants and pear-shaped fruits. It originated from a 'PR-6-65 Dwarf' selection that was inbred and selected over 4 generations. The plants are hermaphrodites with 15 cm long yellow-fleshed 0.63 Kg fruits having 14% brix. The first fruit is set 40 cm from the ground.

Line UVI-3 was generated from in vitro somatic embryogenesis of 'Yuen Nong'. The R_1 was self pollinated and produced uniform dwarf early bearing large fruited plants. The plants are hermaphrodite, carpellate or staminate having yellow 1.98 Kg fruits that are 30 cm long, 12.5 cm wide and 12% brix. The first fruit is set 58 cm from the ground.

CONCLUSIONS

The three early bearing papaya lines have performed well under UVI field test with calcareous soils of pH 8.0-8.5. Being that they also have a medium to large size fruit, they should be desirable for the local consumers. The low bearing character will make them attractive to homeowners and backyard gardeners for fresh use or roadside sales. They have tolerance to PRSV and are vigorous enough to be productive for a year after infection. Future research will apply biotechnology to obtain resistance to locally endemic viruses.

Table 1. Papaya plant source and fruiting characteristics of selected papaya varieties.

Variety	Source	Sex[z]	Height at 1^{st} Fruit (cm)	# Fruit/Plant[y]
356-3	Hawaii	M F	62	64
Cariflora	Florida	M F	79	82
Maradol	Cuba	B F	84	62
PR Dwarf	Puerto Rico	B F	60	74
Redonda	Africa	M F	102	67
Tainung 5	Taiwan	B F	107	40
Trini Red	Trinidad	B F	109	50
Washington 5	India	M F	71	65
Yuen Nong 1	Thailand	B F	104	41

[z]M=Male, F=Female, B=Bisexual/Hermaphrodite
[y]Number of fruit set at the time of the first ripe fruit

Table 2. Fruit size for the nine selected papaya varieties from UVI.

Variety	Weight (kg)	Length (cm)	Width (cm)
356-3	0.65	14.96	10.34
Cariflora	1.21	16.31	15.85
Maradol	1.48	21.92	15.98
PR Dwarf	0.54	12.26	9.78
Redonda	1.16	18.49	11.99
Tainung 5	1.65	22.00	12.27
Trini Red	1.37	21.18	8.41
Washington 5	0.84	15.44	11.53
Yuen Nong 1	1.81	24.43	11.71

Table 3. Papaya fruit quality characteristics of the UVI-AES selected varieties.

Variety	Sweetness (% Brix)	Flesh Thickness (cm)	Flesh Color
356-3	13.4	2.67	Yellow
Cariflora	11.3	2.92	Yellow
Maradol	10.7	3.02	Red
PR Dwarf	12.6	2.12	Yellow
Redonda	10.9	2.82	Yellow
Tainung 5	11.6	2.59	Red
Trini Red	10.0	2.26	Red
Washington 5	12.4	2.77	Yellow
Yuen Nong 1	11.0	2.83	Yellow

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THREE NEW EXOTIC TROPICAL FRUITS FOR CALCAREOUS SOILS

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ABSTRACT: Three newly-introduced tropical fruit species have shown excellent potential in a minor fruit field evaluation project conducted on a calcareous soil (pH 8-9) at the University of the Virgin Islands Agricultural Experiment Station. Black Sapote (BS), *Diospyros dignya*, also called Black Persimmon and Chocolate Pudding Fruit is native to Mexico and represents the only member of the Persimmon family to grow in the tropics. Twenty–year old trees have been fruiting for the last 10 years without pest/disease or nutrient deficiency problems on a calcareous soil. Normally growing to over 30 m tall these trees have been naturally dwarfed by the marl subsoil and yet show no deficiency symptoms. Yields of 100 fruits /tree with an average of 685 g/fruit, 54 % pulp and Brix of 24% have been obtained with each fruit having 2 seeds. Demonstrations at local agricultural fairs and field days have generated great interest in the several ways in which the BS can be utilized. The Egg Fruit (EF), *Pouteria campechiana*, also from Mexico is known alternatively as Canistel, Yellow Sapote and Penny piece. In its native habitat, the EF can grow well over 15.2 m but on a calcareous soil rarely gets over 3-5 m with some trees bearing in 3 years at 1.5-2.0 m. Yields average 70 fruits/tree with a fruit wt of 630 g, width 10.3 cm, length 10.9 cm, 92 % pulp, and a Brix of 24.6 %. The vigorous, pest- and nutrient deficiency-free growth of EF coupled with its multitude of food uses has made it quite popular in the VI. Finally, the Wax Jambu (WJ) or Wax Apple, *Syzygium samarangense* from Malaysia and East Indies has also adapted well with its short compact growth habit, pest- and nutrient deficiency-free nature and yields of 1000 fruits/tree. Fruits of the WJ average 62 g and are 55 cm wide and 52 cm long with almost 100% pulp and 11.9 % Brix. The WJ makes an ideal substitute for its close relative the Malay Apple, which does not tolerate high pH and dry local conditions.

MATERIALS AND METHODS

Forty species of tropical fruits including Black Sapote, Egg Fruit and Wax Jambu were imported from certified nurseries in Puerto Rico (Jardines Eneida, Inc., Cabo Rojo, PR) and Florida (Hopkins Nursery, Ft. Lauderdale, FL) in 3 gal pots. Starting in 1997, plants were transplanted to a 2 ac site- soil type Fredensborg clay loam with a calcareous subsoil having a pH of 8-9. Because of the calcareous nature, the site was prepared under minimum tillage taking care not to expose any subsoil. Plants were set out in rows of 5 plants at a spacing of 20 ft x 20 ft and planting holes made by a tractor-operated post hole digger. A preplant herbicide (Roundup) was applied in a circular band 2-3ft around each hole and inter row grass controlled by mowing at regular intervals. After planting, a drip irrigation system of micro sprinklers (8-10 gal/hr) was installed and water applied at ½ hr/day by battery operated timers. Pest control was done as needed and plants were given a monthly application of 12-12-12 with minor elements starting at 1oz/plant. Growth was recorded as trunk diameter and plant height and fruit characteristics recorded as plants fruited. An average of 10 fruits were sampled for size measurements, pulp and seed %; sugar content (Brix%) was monitored using a portable digital refractometer. Leaf analysis was also carried out after 1 year's growth and average chlorophyll measurements made with a Minolta Spad-501 chlorophyll meter.

RESULTS AND DISCUSSION

Black Sapote, Egg fruit and Wax Jambu were among those that showed good growth as reflected by stem diameter and plant height measurements. Considerable variation in fruit size was noted from small small-fruited species such as West Indian Cherry to those with large fruits such as Eggfruit, Carambola, Sapodilla, and Black Sapote. Pulp % varied from 100% in Wax Jambu and Fig to lower values in the highly seeded fruits such as the Guavas and W.I Cherry. These are important characteristics when fruit species are being considered for preservation or processing. Sugar content as reflected by Brix% was highest for Black Sapote (24.9) and Egg fruit (24.6) as compared with the more acidic fruits such as W.I Cherry (8.7) and the medium sweet fruits such as Fig (14.3) and Wax Jambu (11.9).

Table 1 ranks the species according to their tolerance to calcareous soil condition, in terms of growth vigor, incidence of pest and diseases and their lack of minor element deficiency symptoms. Although several species showed good tolerance to high soil pH, Black Sapote, Egg fruit and Wax Jambu were exceptional remaining green throughout the year with no deficiency symptoms and almost pest- and disease-free. In addition these calcitrophic species were prolific bearers ranging from 70, 100 and 1000 fruits/tree for Egg fruit, Black Sapote and Wax Jambu respectively. Although new to the Virgin Islands these fruits have had good consumer acceptance so far with their attractive appearance and variety of uses appealing most to consumers. In the case of Wax Jambu, this fruit has special appeal to Virgin Islanders who have migrated from surrounding Caribbean islands where they are more familiar with the closely related Malay Apple or Pomerac. Unfortunately, the latter species tolerates moderately high pH soils and only grows and produces with the continuos application of minor elements particularly Fe and Mn. The pomerac also cannot tolerate drought conditions which predominate in the VI. On the contrary the Wax Jambu produces well under dry conditions and on calcareous soils. It has therefore become a real substitute for the Malay Apple in the VI.

Table 1. Relative Tolerance of Minor Fruits to Calcareous Soil.

Tolerant	Médium Tolerance	Intolerant
Atemoya	Grumichama*	Lanzón
Black Sapote	Star Apple	Lychee
Custard Apple	Surinam Cherry*	Governor Plum
Coconut	Guava (Indonisian Sedles, Indian Red)	Inga (Ice Cream Bean)
Egg Fruti	Carambola*	Jaboticaba
Fig (Magnolia, Brown Turkey, Ashia)	Cattley Guava	Cashew
Jamaica Plum	Cherry of Rio Grande*	Rose Apple
Strawberry Tree	Soursop	Jackfruit
Sapodilla	Malay Apple*	
Sugar Apple		
Wax Jambu (red and pink)		
West Indian Cherry		

* Respond to applications of trace elements.

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PERSPECTIVA DE LA PRODUCCIÓN DE LIMÓN AGRIO (*CITRUS LIMON* L.) EN LA REPÚBLICA DOMINICANA

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RESUMEN: En la República Dominicana, la producción de limones agrios (Citrus limón L.) tiene un incremento notable, debido al aumento en el área de siembra, consumo interno, mercados de destino, los volúmenes, valores de las exportaciones y la estacionalidad de la producción. Los elevados niveles de consumo estimulan la demanda del limón por los cambios de hábito en la alimentación hacia la no ingestión de productos químicos y procesados. El control de la floración usando hormona Domex y IAA (Ácido Indol Acético) y los despuntes manuales de brotes florales; además de la distribución de la mano de obra en formas homogénea en los meses del año, son los métodos que deberían utilizar los productores para disminuir los costos de producción de los limones agrios. La variación de precio del mercado tiene una relación directa con los niveles de producción en los momentos de cosecha. El resultado de la investigación denota que cuando existen, en algunos meses del año, precios altos en el mercado local, disminuye la venta al exterior. En este trabajo se presentará el comportamiento de la producción de limones agrios, así como la proyección de los mercados futuros.

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STARCH PROFILE IN TUBERS OF THE MEXICAN YAM BEAN (*PACHYRHIZUS EROSUS*) AT DIFFERENT STAGES OF TUBER DEVELOPMENT

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ABSTRACT: The Mexican Yam Bean, *Pachyrhizus erosus,* is a tuber-producing legume native to Central and South America. This underutilized crop has been reported to contain a starch content that is much lower than that of traditional root crops (cassava, sweet potato). Biochemical analysis of the carbohydrate profile of the tubers at different stages of development reveals relatively low quantities of starch (3.86-5.02% fresh weight) which consists mainly of amylopectin (98.6%). Histochemical analysis of the tubers revealed that the starch grains are concentrated around the vascular tissue but are also present in small amounts in pith cells, as the age of the tuber increased the amounts of starch grains present in the pith cells decreased, suggesting that they are being metabolised for other tissue functions. Investigations on selected enzyme systems are currently being conducted in order to understand the phenomenon of low starch accumulation in the tubers.

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USING GEOGRAPHIC INFORMATION SYSTEMS FOR THE DETERMINATION OF THE AREAL EXTENT OF HUMAN ACTIVITIES IN THE MARACAS BAY SUB WATERSHED OF TRINIDAD, W.I. (1942-1999)

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ABSTRACT: The Maracas Bay Wathershed is located on the North Coast of Trinidad and occupies a total area of 549 hectares. This area was originally a forested area, however, for many decades human agricultural activities have replaced some of the forested areas with agricultural activities with no documentation on the changes. Geographic Information Systems were used as an analytical tool to determine the areal extent of change to the natural vegetation. Digital data were derived from aerial photographs, which were then imported into Arc/Info for analysis. The analysis showed that the area converted to agricultural land during the period of study ranged from 27.01 ha in 1967 to 209 ha in 1999. The derived data were used to create land use maps for the respective years. The analysis showed trends in the forest conversion in the area and provided a guideline to further sustainable management of the watershed, which is discussed in this paper.

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OBTENCIÓN DE VARIEDADES Y LÍNEAS PURAS DE AUYAMA O CALABAZA (*CUCURBITA MOSCHATA* L.)

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RESUMEN: Desde el año 1994 hasta el 2001 se han realizado investigaciones sobre caracterización y purificación de 23 ecotipos de calabaza (*Cucurbita moschata* L.) con el propósito de obtener variedades y líneas puras con características adecuadas tanto para el mercado externo como interno. La metodología utilizada ha sido fecundación individual de plantas pertenecientes a cada ecotipo. Los resultados de 7 ciclos vegetativos de purificación genética arrojan 23 cultivares con más de un 95% de las características deseadas. El peso de los frutos ha fluctuado entre 1.14 y 6.25 kg con formas elípticas, esféricas y redondeadas y mesocarpio de color anaranjado.

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A NEW ACADEMIC PROGRAM IN AGRIBUSINESS AND FOOD BUSINESS MANAGEMENT

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ABSTRACT: The economy of Puerto Rico has undergone a transformation from an agrarian society to an economy based on services and manufacturing. Farm gate agricultural production in Puerto Rico is a $700 million dollar industry. However, the food sector is a $2.5 billion dollar industry. Higher education in agricultural sciences has concentrated its efforts on training professional in production, while not adequately addressing the need to forming entrepreneurs. Most agricultural professional join the ranks of the government, while this new academic program is focused on preparing professional who will work in the food sector in the private industry. We have identified a need to train professional to be able to establish and administer new agribusiness that can diversify the present economic structure and offer new services and products to the growing demands of the local and global community. This new academic program is based on a strong administrative curriculum with courses developed in collaboration with professors from the College of Food, Agricultural, and Environmental Science of Ohio State University. Various professors, members of the Departments of International Programs, Food Science and Technology, and Agricultural, Environmental, and Development Economics assisted in the development of the curriculum, faculty development, and the creation of case studies based on local agricultural enterprises. Another strong component is the establishment of an advisory board made up of successful general managers of key agribusiness operating in Puerto Rico.

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AN INNOVATIVE UNDERGRADUATE AGRIBUSINESS LEARNING EXPERIENCE

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ABSTRACT: All of our students at EARTH University go through a permanent course called Entrepreneurship Projects. The objectives of this course are to teach students how to start, plan, organize, and operate a business. In the classroom students receive formal training in preparation of a feasibility study, accounting, business management, marketing, and control and evaluation of the business. In practice, groups of 3 to 6 students are organized into teams. Teams must be composed of students from different social economic backgrounds and gender. Starting in their sophomore year the teams organize and operate a business offering agricultural products and/or services. EARTH provides up to US$3,000 as a start up loan. The teams have to operate the business until the second trimester of their junior year. Students are responsible for providing the labor and all of the decision-making process relating to the business. As they operate their business they must maintain major accounting books and hand in a final financial statement and an evaluation of the performance of the business. At the close of the business, students retain 67% of the profits while 33% go into special contingency fund to finance losses due to environmental factors and other causes not related to negligence of the students.

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STOCKPILING SEEDED PENNISETUM HYBRIDS FOR DRY SEASON FEED IN THE U.S. VIRGIN ISLANDS

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ABSTRACT: Availability (quantity and quality) of tropical forages during the dry season limits livestock production in the U.S. Virgin Islands. Previous studies with Pennisetum seeded hybrids [Pearl millet; *Pennisetum glaucum* (L.) R. Br and elephantgrass *Pennisetum purpureum* Schum] reported yields in excess of 10 Mg ha^{-1} (harvested every 18 wk). Little information is available on the stockpiling potential of new pennisetum hybrids during the dry season. This study assessed three pennisetum hybrids and a local selection (SVI) and compared three N rate (0, 56, and 112 kg ha^{-1}; Ammonium sulfate) effects on yield and tiller dynamics at 12-wk harvests during the dry season. There were differences ($P<0.05$) among hybrids for forage DM yield. Highest DM of 5.6 Mg ha^{-1} was recorded for SVI (a local selection). There was a linear response to N applications. Forage yield was generally higher for N application rate of 112 (4.5 Mg ha^{-1}) compared to 3.8 Mg ha^{-1} and 3.3 Mg ha^{-1} for 56 kg ha^{-1} N and 0 N, respectively. Effects of N rates on tiller dynamics will be discussed.

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PRELIMINARY RESEARCH FINDINGS ON LETTUCE CULTIVATION IN A NON-CIRCULATING HYDROPONIC SYSTEM

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ABSTRACT: Hydroponics is a system in which plants are cultivated in an nutrient solution. In this system, plants receive all required nutrients based on formulations, and an inert growing medium is being used as attachment for plant roots. One advantage of growing crops in such a way, in comparison with traditional crop systems, is that very few to no pesticides are used. In the period November 2000-January 2001 a preliminary greenhouse investigation on lettuce cultivation (Black seeded Simpson) in a non-circulating system, utilizing several inert media and fertilizers, was conducted. The non- circulating system was constructed following the methodology described by the Asian Vegetable and Research Center. Research findings revealed that: (1) rice hull and vermiculite are suitable growing inert media for this system; (2) poor lettuce growth was obtained utilizing burned rice hull as an inert growing medium in the non-circulating hydroponic system; (3) additional research need to focus on growth and lettuce quality between 4-7 weeks for the rice hull and vermiculite treatments; (4) in comparison with other media more water was used in the vermiculite treatment. (5) It appeared that pH, Eh, T, humidity, and light intensity are affecting this grow-box system, and therefore additional research is required.

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EVALUATION OF TOMATO CULTIVARS FOR PRODUCTION UNDER ADVERSE CLIMATIC CONDITIONS

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ABSTRACT: Seasonal climatic conditions such as high night temperature and periods of heavy rainfall infringe upon the cropping cycle for production of tomato in the U.S. Virgin Islands. An on-the-farm tomato cultivars evaluation was established during the late summer months of year 2000, at Estate Glynn in St. Croix. Seven, reportedly heat tolerant cultivars were compared for crop development and yield production under the climate-induced stresses of high night temperatures (20-25°C) and 3.3 cm average weekly rainfall. The cultivars studied were Tropic, Capitan, Heat Wave, Solar Set, Sunmaster, Heatmaster, and Florasette. Transplants were set in the field plots and planted in a randomized complete block design with three replications. Each plot consisted of three rows spaced 1.2 m apart with 10 plants spaced 61 cm within the rows. Data collected included, dates of first blossom and fruit set, incidence of disease and insects, stand establishment, number of fruits, total yield weights, and marketability. Plants in several plots exhibited symptoms of Tomato Mosaic Virus and soilborne fungal diseases during the growing season. Tropic and Heat Wave were the earliest to mature with fruit set recorded thirty days after transplanting. Although harvested fruits showed physiological damage such as cracking and splitting, several cultivars had marketable yields. Heatmaster had the greatest incidence of disease, and the highest average yield weight. Solar Set produced at the minimum total yield of 450 kg ha^{-1}, but had the highest marketability (80%). The least marketable cultivar was Capitan, with only 7% marketable fruits.

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