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PREFACE

The Thirty-Fourth Annual Meeting of the Caribbean Food Crops Society was jointly held with the Jamaican Society for Agricultural Sciences and from reports received, it was a huge success.

It was indeed an honour for Jamaica to host the conference and to welcome more than one hundred visitors and friends to our shores for this meeting. The Secretariat and Planning Committee was housed in the Rural Agricultural Development Authority, the extension agency of the Ministry of Agriculture.

The feature lecture entitled "***Enhancing Food Security***" was presented by Dr. Edward Wilson of the United States Department of Agriculture (USDA) and a panel discussion was held on the theme of the meeting "Enhancing Regional Food Security and Exports by Integrating National Strategies". The distinguished panelists represented organizations such as the Inter-American Institute for Cooperation on Agriculture (IICA), Caribbean Agricultural Research and Development Institute (CARDI), the University of the West Indies (UWI) and the Caribbean Common Market (CARICOM).

The technical papers presented at the meeting are documented in this proceeding. Papers are grouped into seven technical areas namely:

- Agricultural Production (Strategies/Improvement)
- Crop Production (General)
- Crop Production (Nutrition, Soil Fertility)
- Agricultural Development (Environmental Issues)
- Agro Industry/Marketing
- Animal Production
- Pest Management

A wide range of areas was covered from crop and animal production systems to environmental and pest management issues. In general, the papers documented the current research of important issues in agriculture in the Caribbean Basin and were generally well received. The emergence of new and exotic pest diseases in the Caribbean was reflected in the number of papers on pest and disease management.

This proceeding, therefore, is a short compendium of the results of some of the recent investigations carried out or currently underway in the Caribbean and should, therefore, serve as a valuable reference source.

STRATEGY FOR AGRICULTURAL RESEARCH DEVELOPMENT IN JAMAICA AND THE CARIBBEAN FOR 2000 AND BEYOND

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ABSTRACT

This paper identifies, discusses and proposes a strategy to be employed by Caribbean countries as they retool their agricultural sector to deal with the competitive challenges offered by the new international trading regime. In presenting their thesis, the authors argue that Caribbean countries, as a matter of urgency, should undertake to acquire the technological capability that will allow them to compete effectively in the new deregulated market place. In this new market environment, countries must devise and put in place procedures which are transparent and scientifically verifiable in order to meet the international standards for food safety, quality and environmental conservation promulgated in a series of protocols such as Codex Alimentarius, ISO-9000, ISO-1400 and HACCP.

The authors stress the value of interdisciplinary applied research as a viable strategy and propose a new institutional approach - a Caribbean Centre for Applied Biosystems Research - which would develop a market-driven agricultural technology system for the region. The centre will bring together a network of three USA universities, Caribbean business interests, research and academic institutions to work collaboratively in developing an international obligations. The centre will facilitate sustainable development of the region's natural resource endowment through the application of information and biotechnologies, mobilize the creative forces in the region, create technologies for producing and maintaining a competitive portfolio of products and services, and develop and maintain partnerships with international agencies having similar goals.

THE CCABR

This initiative began with the completion of a concept paper on the Caribbean Centre for Applied Biosystems Research, which was circulated to the Ministries of Agriculture, Environment and Housing, and Education, Youth and Culture, Jamaica and the U.S. Agency for International Development, Jamaica and Washington, DC. In the U.S,, a partnership of three land-grant universities – NC Agricultural and Technical State University (NCA&T) as lead institutions, Iowa State University and Louisiana State University – was formed to assist Jamaica and the Caribbean in their effort to become more competitive in the global market place through a new institutional approach, a Caribbean Centre for Applied Biosystems Research (CCABR), which would develop a market-driven agricultural technology system for the region. The CCABR will assist Jamaica and the Caribbean in their efforts to commercialize and industrialize agriculture in the region.

Allow me to emphasize however, that the Centre is not intended to compete with an agency or organization currently addressing some of these issues, but to assist where it can in furthering economic development in Jamaica and the Caribbean. It is a vision we feel will help Jamaica and the Caribbean to move forward under market-driven technologies derived from the application of the biological sciences. It includes a group of three land-grant universities offering many opportunities for training and other types of technical assistance as needed. Our greatest assets are information and knowledge - timeless assets to humanity.

With particular reference to Jamaica, agriculture and agro-industry continue to be among the pillars of the economy, despite the many difficulties under which they operate. However, given the prevailing trends in the world economy - a Western Hemisphere Free Trade Zone - these industries will soon not be able to realize their full potential of being significant contributors to the Jamaican economy, unless mechanisms can be found to put in place new initiatives for greater research, technology development and transfer and training.

With the development and application of market-driven technologies we can, as a country and region, maximize the benefits to be derived from the sustainable use of our resources. It is often felt that to observe environmentally friendly practices in the production of foods and services, requires additional costs, which some companies could well avoid. But more and more, it is becoming obvious that to produce sustainable and in an environmentally friendly way, may well be the means to ensure that a product is marketable to a wider cross-section of consumers.

THE MARKETPLACE

Current market trends are evolving under the phenomenon of globalization which has triggered many sweeping changes in several areas of human endeavour, and it is predicted that still more far-reaching changes will come, to the extent that hardly any facet of life will escape the transforming influence of this new wave. Forces driving globalization are technical innovation, international economic integration, the maturation of markets in developed countries and the demise of communism.

Technological innovation has produced new and powerful information, communication and transportation technologies. These innovations have led to better and faster communication, quicker and more efficient transportation and more and larger information networks connecting larger numbers of people globally.

International economic integration has led to the formation of mega-trading blocks like NAFTA, reduced tariffs World Trade Organization (WTO), floating exchange rates and increased global capital flows. On the hand, mature markets in the developed countries mean that there is little room for expanding market share in these developed economies. As a result, there is slower domestic growth in developed countries, which forces them to become much more aggressive in pushing exports, leading to intense competition in the market place and an increased tendency to deregulate.

In summary, these events have led to freer trading among nations and the evolution of a large single and intensely competitive market.

In this market, capital and technology move freely across national boundaries, the values of currencies are determined by market forces, and very discriminating consumers call the shots.

A NEW PHENOMENON

The advent of the Internet is going to affect trade in a remarkable way due to the large number of people currently in the food chain that will be eliminated. The number of people between a farmer and a consumer is presently estimated at about eight. The Internet has he potential to reduce this to 1:1 ration. This is because given certain conditions, the farmer will have the possibility to market his produce over the Internet for example, bananas and exotic fruits. There always will be a place in any global economy for agricultural products which extends the life cycle of agriculture beyond that of any industry. And there is good reason for this. People must eat in order to live and function normally. It should also be noted that countries which have registered significant industrial and economic growth have been those with a well developed agricultural base.

A globalized market place is not only a very large market, but a very dynamic and innovative environment in which countries must be more competitive, more flexible and responsive in nearly all their operations. This includes public as well as private institutions, manufacturing as well as service organizations. Windows of opportunity will be very narrow in a dynamic marketplace which will require continuous assessment of the wants and needs of consumers and response within a comparatively short interval. The consumer will be calling the shots! Caribbean countries do not presently appear to have this innovative ability and responsiveness.

In the Caribbean there is some evidence however, that policy makers are thinking in the right direction. For example, in Jamaica, the "Economics and Social Survey of 1996" published by the Planning Institute of Jamaica (PIOJ), reports that government has identified a number of strategies for positioning the country to compete in

the evolving global environment. One such strategy deals with identifying and promoting competitive growth industries for the future.

It is in the interest of Caribbean countries to identify growth industries for the future, so they can invest in the technologies needed to develop these industries. What are some of the growth and competitive industries of the future? It is suggested that information technology, microchip technology, machine tools, robotics, civil aviation and bioteehnology will be the competitive growth industries in the future. If this is so, what are the implications for Caribbean countries? And how can the proposed Caribbean Centre for Applied Biosystems Research assist these countries to develop a competitive edge in the marketplace?

To prepare themselves for competition in the evolving global market, Caribbean countries should organize a critical mass of scientists, dedicated solely to the development and application of market-focused, leading-edge technology. As they proceed with this preparation they should take into account their peculiar resource endowments in light of evolving patterns of consumer demand. It is imperative that Caribbean countries begin to organize to develop market-oriented innovative capacity. Especially since it is believed that right now, man-made endowments acquired through innovative capacity are more important than natural resource endowments in determining economic growth and prosperity.
Looking at the industries predicted to be of good growth potential for the future and paying attention to the value of the unique biological resources of the region, a first step could be the joint application of information technology and biotechnology to the conservation and development of the region's unique natural resources, especially in the areas of agriculture and agro-industries. Apart from its application to the production of exotic tropical fruits, nuts and vegetables, for which there is a growing market, the biotechnologies also offer exciting opportunities for producing high-value, novel, non-food crops as raw materials for industry.

Considering these opportunities, the proposed centre would work on linking information technology and biotechnology to develop the process and production technologies that would make it possible to create new produets in agriculture, agro-industry and industry, as well as develop processes for environmental protection and conservation.

THE CENTRE

Esscntially, the Caribbean Centre for Applied Biological Systems Research is conceived to be a network of Caribbean scientists and international associates. The centre is dedicated to the innovative application of biological scienecs to harness the natural resources of the region, in order to develop and promote technologies to drive competitive and sustainable enterprises in industry, agriculture, agro-industries and environmental conservation.

The centre will be wall-less, a virtual centre so to speak. It will not be another organization identified by a building or landmark edifice. It will be a facilitative arrangement capable of mobilizing existing organizations and resources to address the issues in an innovative way. It will facilitate:

- Sustainable development of the region's natural resouree endowment through the application of information and biotechnologies
- Mobilization of the creative resources in the region
- Creation of a scientific enterprise which his sensitive to the development imperatives of the region
- Creation of technologies for producing and maintaining a competitive portfolio of products and services
- Development and maintenance of partnerships with similar international agencies

FOCUS

There will be a focus on the creation and maintenance of a competitive portfolio of products and services, and development and nurturing of the human and institutional resources required to carry out the initiatives of the centre.

RESEARCH ACTIVITIES

Existing works of relevance would be updated and new findings added to create a useful and comprehensive catalogue of the Caribbean's environmental and biological resources that have the potential for economic development. These efforts would emphasize the identification of plants and animals with economic potential, as well as pest species, and also involve the identification of local ecosystem that could be exploited for specialized agricultural production systems like Mariculture or have potential interests to tourists.

For example, in Jamaica, the process will build and expand upon a baseline study supported by USDA/Forest Service that is currently underway entitled *"Natural Resources Management Needs Assessment to Facilitate Ecotoursim in the Blue Mountain/John Crow Mountain National Park"*. This study, initiated in 1995, is investigating the biophysical characteristics of sites in the park which nature tourists would find attractive and evaluate the demand for, and participation of Jamaicans in ecotourism. Ecotourism can be a very effective economic development strategy for the Caribbean. Tourism related jobs can be found in many economic sectors including food service, lodging, entertainment, retail sales, indigenous crafts, travel planning and sectors providing transport services.

As economic and population pressures mount for most Caribbean nations, it is important to take stock of the region's biological and environmental resources. Key research topics in this area include:

- Identification of economically valuable elements of the flora
- Identification and evaluation of indigenous plants and animals that have agricultural potential
- Identification of local ecosystems with tourism or agricultural/economic production potential.

ENVIRONMENTAL RESEARCH AND RESOURCE CONSERVATION

The Caribbean's appeal to the tourists lies mainly in its relatively pristine environmental conditions. This, and the reality of the Caribbean nations are small countries with limited land and freshwater resources means that any sustainable economic development must be based not only on sound economic principles but must also be based on sound environmental principles as well. Hence, conservation and resource management research are vital to any sustainable plan for economic development. The need for such research is particularly acute in tropical ecosystems. Key research topics in this area include:

- Development of integrated soil water nutrient models
- Waste management including recycling and sewage handling
- Coastal/marine ecosystems management
- Reforestation and soil erosion abatement
- Fisheries management.

BIOSYSTEMS RESEARCH

Biological systems research efforts will focus on organismal studies that are strongly focused on obtaining economically useful data on the Caribbean's fauna and flora. The emphasis of these studies will be to harness the new methods of biotechnology as well as more conventional techniques to evaluate, improve and finally, realize the economic potential of both the region's indigenous plants and animals, as well as some of the

Caribbean's currently underdeveloped, traditional crops.

For example, in plants the application of biotechnology facilitates rapid, mass propagation (micro propagation), the development of pathogen free seed and propagules critical to controlling plant virus diseases in the tropics, the conservation of germ plasma, the propagation of clonal stocks with generic and specific traits for commercial use, as well as providing efficient assays for assessing potential pharmacological agents derived from plants and animals.

For traditional Caribbean crops that show promise for specialized sector markets in the US and Europe such as yams, tropical fruits, vegetables and legumes among others, the application of modern biotechnology could bring improvements in disease resistance and product marketability. Some relevant research topics in this area include:

- The development of drought and salt resistant plants
- The development of hurricane and resistant plants
- The development of virus "clean" seed for agriculture
- Exotic fruit, vegetable and spice species development
- Assessments of the pharmaceutical potential of indigenous plants
- Bioengineering plants to produce industrial materials, pharmaceuticals or energy.

Another key area of biological systems research that is critical to sustainable agricultural success, is the area of integrated pest management. This approach to pest management promises lower costs, less environmental damage and lower chemical residues in products and pathogens and their life-cycles. That information is currently lacking for most tropical pest species.

PRODUCTION SYSTEMS RESEARCH

To complete with mainland producers, Caribbean farmers must fully utilize their natural advantages and pursue specialized sector markets that exploit the climatic and physical endowment of their island nations. Research on three production specialities would be very appropriate for many Caribbean nations:

- Organic farming techniques
- Production techniques for exotic tropical fruits and vegetables
- Mariculture and Aquaculture techniques for fish, crustacean, molluscs and algae.

THE COMMERCIALIZATION AND INDUSTRIALIZATION OF AGRICULTURE

There are many who regard agriculture as a way of life, and others, a means of livelihood. To the latter group, however, the money making and profit making side of agriculture are often fulfilling but at times disappointing, depending on the state of the market. The "market" whether local, national or international is therefore the key to success or failure in commercializing agriculture. At the trend towards trade liberalization gathers momentum, structural changes, increased production of commodities in countries in which hitherto they were non-existent, and the creation of new industries are among a range of activities to impact the consumer and the environment. The pillars of support and the enabling interventions, however, for the success of these endeavours will be determined largely by the extent to which a country's research and development capacity can be enhanced.

The potential for increased industrialization of agriculture worldwide is immense. This has reached unprecedented heights in many developed countries of the world especially in North America, Western Europe, Australia and New Zealand where agricultural products and by-products support a range of industrial activities. Each major geographical region of the world and each country have unique endowments of plants and animals from which products can be derived, capable of providing raw material for further processing. Jamaica and the Caribbean are no exceptions being endowed with considerable biological wealth and diversity which can be developed

through the acquisition of skills and knowledge, a more appropriate institutional approach to Research and Development, improved management capabilities and a better informed consumer and citizen. The earlier proposed inventory of biological resources can provide information on, for example, cultivable species from which material for industrial use could be obtained.

REGULATORY AND MARKET RESEARCH

Biodiversity data, pristine environments, economic botany or even successful production techniques will have little real impact on the economic vitality of Caribbean nations without market interest in "goods" joined with access to potential markets. It is generally appreciated that the development of any product, be it yams, a palm lined resort, or native crafts must be guided by high quality market research from the earliest stages and updated regularly to keep up with increasingly trendy consumers of the USA and Europe. Less well appreciated as we approach the "free" trade anticipated in the next decade is the role of regulatory issues as barriers to market penetration by exporting nations. In this area developing nations operate under severe handicaps relative to developed nations in the areas of food processing as well as quality and safety standards for food products that become barriers to market access in the USA and Europe. With these issues in mind, it is obvious that research on markets and regulatory issues would be very relevant to the objectives of the Centre. Research topics in this area would include studies of:

- Food processing and packaging
- Food safety standards
- HACCP systems for indigenous products
- International quality standards
- Market research techniques

ANTICIPATED BENEFITS

The scientific knowledge gained, and technologies developed in the harnessing of relevant ecological process to create a support base for a more responsive food and industrial production system, would strengthen the foundations for economic growth and development of the Caribbean.

The knowledge gained from research under the umbrella of the CCABR will bc useful for informed decision making in designing programmes needed to support management and conservation of the region's biological resources.

The Centre would generate ideas on the incorporation of industrial ecology technologies which allow planners to recycle waste harmoniously and effectively.

The linkage of the CCABR to US institutions of higher learning will help to provide a critical mass of scientists needed to accomplish the goals of the institute as envisioned. Additionally, the CCABR could serve the real interests of American and other international students and scientists in providing them exposure to international development as it unfolds in a Caribbean setting. With the current emphasis on globalizing curricula, this could be a golden opportunity for American Students in particular, to feel the pulse of technology generation and transfer in a developing country not far from home. The CCABR would be a partner in a Latin American Caribbean (LAC) network of similar institutions with similar goals differing only by the peculiarities inherent in each nation's culture.

By developing regional programme thrusts and priorities, while simultaneously mobilizing the technologies and capital aimed at new trade-driven markets, the CCABR would attract international funding and thus be able to bring about noticeable high profile coordination of development effort tin the small Caribbean nations.

COORDINATION OF EFFORT

In order to achieve the goals envisioned for the CCABR, it is planned to take an integrated team approach in the coordination of effort. The co-operators in the CCABR will be NCA&T State University, Louisiana State University, Iowa State University, USAID, Identifiable Academic and Research Institutions in the Caribbean, Private Sector Organizations and the Governments of the Caribbean Islands.

The Universities have a wealth of experience in research, education, extension and international agriculture development. USAID has played a leading role in international technology development and transfer in agriculture, industry and commerce and in education and institution building.

Government Ministries as well as the private sector organizations will be helpful in defining market-driven researchable issues relevant to rapid economic development in the island.

SUSTAINABLE FUNDING

The following international organizations are identified as possible initial sources of funding - USAID, CIDA., Rockefeller, Ford and Kellogg Foundations and the Inter American Development Bank. Support would also be sought from the Caribbean Government. Additionally, private/public partnerships would be encouraged to contribute to the effort for example, the bauxite companies (Kaiser, Reynolds) which have a tremendous stake in environmental restoration.

NEED TO RESTRUCTURE THE JAMAICAN DAIRY SECTOR

Jack Bailey and Ram Aneja
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ABSTRACT

Jamaica's 3,000 dairy farmers produced 27 million litres of milk in 1997 out of a total annual national consumption of about 150 million litres equivalent of milk and dairy products. The industry is faced with the problems of:- dumping 125,000 litres of milk so far in 1998; decline in production from 38 million litres in 1992 to 27 million litres in 1997; competition from cheap dumped imports at low duties; the highest farmgate and consumer prices in the world, a majority of small or inefficient dairy plants; high margin inefficient retailers, and dairy farmers getting only 33% of the consumer dollar. Additionally, poor veterinary and breeding services, high interest rates, high cost of inputs and market uncertainty are causes for concern. Milk producers in Jamaica are debating the formation of a milk producer federation in order to operate large processing facilities and sell milk directly to consumers at $40 - $50 per litre as compared to the current price of $60 - $68. The federation would increase production and productivity by providing cheaper inputs, improved veterinary and breeding services, provide guaranteed market for farmers' milk and save the Jamaica Hope Breed.

INTRODUCTION

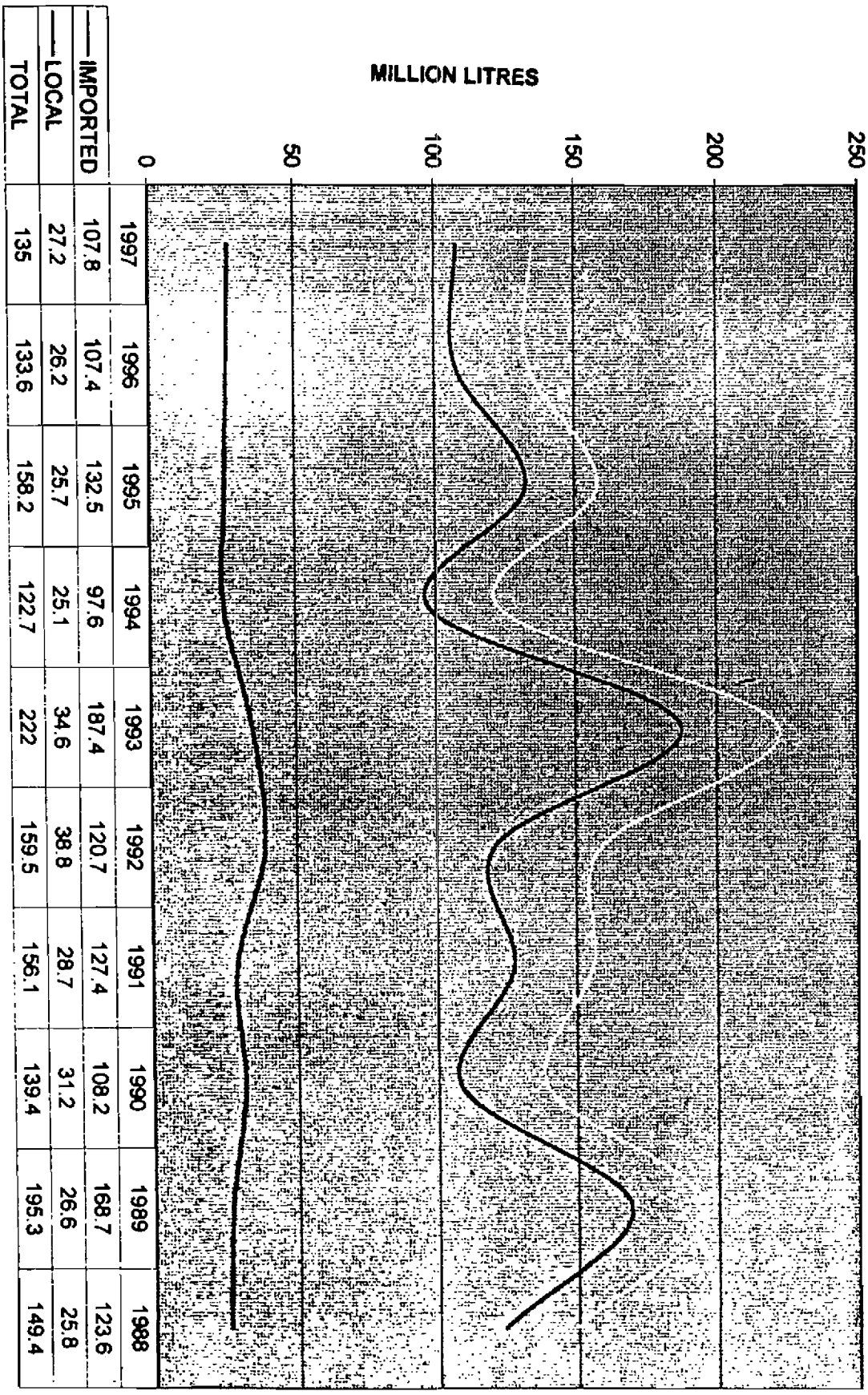
Jamaica produces 27 million-litre of milk out of a total annual consumption of about 150 million-litre equivalent of milk and milk products. The production of milk in Jamaica is limited by the size of the liquid milk market, which is reserved for locally produced milk. The other sources of supply of milk solids in Jamaica are imported, in the form of cheese skimmed milk powder, butter and butter oil and whole milk powder which is also retailed directly in consumer packs. The most important source of milk solids in Jamaica is condensed milk, which is produced out of imported milk powder and butter oil.

Raw materials for the manufacture of milk products in Jamaica are imported t a low import tariff of 5%. Local milk producers have therefore to compete with imported, cheap milk solids. The dairy industry in many countries has been stifled by the dumping of cheap milk powders, which are usually available at half the cost of their production in exporting countries.

The size of the liquid milk market in Jamaica has also shrunk because of high prices. While the milk producers in Jamaica get a price of $16-$22 per litre, the consumers pay as much as $68 per litre for their milk. While the processors add some $22 per litre for transportation and processing of milk, the retailers charge up to 33% for selling milk. The shrinking market for liquid milk has once again resulted in dumping of raw milk by the milk producers. The milk producers had to dump 646,000 litres of milk during January/June 1994, as a result of liberalization of milk powder imports, which resulted in the milk production going down from 38 million litre in 19992 to 25-216 million litre now (Figure 1). Already, some 125,000-litre of milk has been dumped since April 1998.

FUTURE POTENTIAL

Jamaica has 80,000 dairy and beef farmers who farm over 200,000 acres of pasture lands, on which 200,000 heads of dairy and beef cows and heifers are raised. Only a small portion of these dairy animals is being milked. Jamaica only needs 80,000 milking cows, giving 5 litre of milk per day to satisfy the current eonsumption of 150 million litres annually. This can be produced from well-managed grass only, thus lowering the cost of milk production and becoming competitive in the global market place. If Jamaica was to exploit this potential, it will bring in an additional $2.5 billion of milk income annually. This could lead a dramatic revitalization of the rural



	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988
IMPORTED	107.8	107.4	132.5	97.6	187.4	120.7	127.4	108.2	168.7	123.6
LOCAL	27.2	26.2	25.7	25.1	34.6	38.8	28.7	31.2	26.6	25.8
TOTAL	135	133.6	158.2	122.7	222	159.5	156.1	139.4	195.3	149.4

Figure 1. Local and imported milk

economy. This will not happen unless the farmers are assured of a market.

The World Trade Organization (WTO) is committed to removing subsidies, as it is to reducing tariffs. If Jamaica does not make the necessary policy and institutional adjustments now, then in the next 5-7 years, the imported milk powder will cost more than the cost of locally produced milk.

It will then be too late to start expanding the dairy industry since many of the remaining farmers would have been forced out of business and valuable breeding herds lost to he nation.

The potential for inereased milk production and consumption has further been limited by the false propaganda against milk. Vested interests have been cashing in on some reports that nearly 70% of the Jamaicans are lactose intolerant. These figurcs are based on tolerance tests based on consumption o one whole litter of milk in one sitting (5 gram of lactose per kg body weight or 50 GM lactose). Most Jamaicans can tolerate one glass of milk (250ml) in one sitting. The dairy industry has now started exposing this false propaganda.

THE NEED TO ESTABLISH A FEDERATION

Sincc milk producers in Jamaica had to dump milk because of the shrinking size of the liquid milk market, one way out is to expand the market by reducing the price of milk to the consumers and improving the quality of processed milk. This can best be achieved by eliminating the middleman and directly going to the consumer. All over the world, farmers get at least 50% of what the consumers pay for their milk. There is therefore no reason as to why the consumers in Jamaica should pay more than $40-$45 for a litre of milk. This can be achieved by enabling the farmers to set up their own milk collection, processing and marketing systems.

Currently, thc incfficiencies in milk collection, processing and transportation are being passed on to the producers and paid for by the consumers. Also, high cost of feed concentrates which are being marketed in Jamaica at twice the international process, have resulted in high cost of milk production. The farmers can reduce the cost of inputs by collectively organizing bulk procurement of cattle feed, veterinary and breeding services and more efficient use of their pasture lands.

Milk producers in Jamaica have already decided to form a federation so as to enable them to carry out the above activities. Currently, there is no institutional structure that takes care of the interest of the milk producers. The current structures have conflict of interest between producers, feed manufacturer s and milk processors. It is hoped that the proposed federation will be particularly useful to the small farmers who have very little control on the cost of their inputs and the market for their milk. Limiting the membership of the federation to only those milk producers who have no conflict of interest (milk processing/feed manufacturer, etc.) has become necessary to ensure its success.

It is also hoped that some of the producer/processors will give up their processing facilities and join the Federation. These facilities can then be used by the federation to jump-start it's direct marketing operations. The F.A.O. is also expected to assist in this effort. Some other processing facilities are also being considered for custom packaging of milk for the Federation.

PASSION FRUIT EVALUATION IN THE U.S. VIRGIN ISLANDS

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ABSTRACT

The drink made from Passion fruit (*Passiflora edulis*) is very popular in the Virgin Islands and can be found at roadside stands and during cultural events. Seven varieties of the yellow passion fruit, *Passiflora edulis* f. *flavicarpa,* were evaluated for growth and produetion on T-trellises in the USVI. During the first 20 days post anthesis, fruit size increases quickly at a rate of 2.7 mm/day followed by reduced growth of 0.35 mm/day from day 21 to 50. Passion fruit vines, established in the field in May, produced the first erop starting in November and lasting through January. 'Noel's Special' had the largest fruits at 81.87 g while the 'UVI Yellow' produced 263.3 fruits/vine. The lowest production, 115 fruits/vine, and smallest fruits, 51.5 g/fruit, were obtained on a Taiwanese hybrid. The high initial investment in establishing passion fruit vines can be offset by income generated from the first years production.

INTRODUCTION

The genus *Passiflora* is indigenous to the American tropics and over 400 species of this perennial woody vine are known to exist (Martin and Nakasone, 1970). Passion fruit is pleasingly aromatic, tart and a good source of vitamin A and niacin (Duke and duCellier, 1993; Chan, 1980).

The appealing flavor of passion fruit juice has lead to its development and use in commercial fruit juices, frozen concentrates, ice cream and frozen juice bars. The source of the eommercial juice is from the purple passion fruit (*Passiflora edulis* Sims.), yellow passion fruit *(P. edulis* f. *flavicarpa* Deg.) and hybrids between the two forms.

Passion fruit is one of the few tropical fruit species with production potential for the U.S. Virgin Islands because of its ability to tolerate the endemic calcareous soils. The semiarid conditions of the USVI benefit passion fruit by deterring the leaf and fruit diseases that are common in the humid tropical areas (Cole et al., 1992; Ploetz, 1991). The yellow passion fruit is self incompatible which accounts for the heterozygosity in plants derived from seed. The loeal population of carpenter bees (*Xylocarpa* spp.) pollinate the flowers to assure fruit set.

In the USVI, passion fruit is grown by small farmers and backyard gardeners for local consumption. Because passion fruit production starts within a year of planting, revenues can be obtained to offset the initial cost of the trellis and plant establishment which is not possible with most tropical fruit species (Knight, 1992; Knight, 1994). The local yellow passion fruit vines have a vigorous amount of growth and foliage but its production hasn't been compared with commereial varieties. For passion fruit to be an economically viable product of the USVI, productive and water use efficient varieties are needed.

Germplasm evaluation and development of high producing passion fruit lines has been done to improve the passion fruit production in Dominica (Bridgemohan, 1993). The objectives of this study are (**a**) to compare local passion fruit to commercial varieties and (**b**) determine the cultivars best suited for production by loeal farmers and backyard gardeners.

MATERIALS AND METHODS

During 1995, data was collected from developing fruits on the locally grown yellow and red passion fruit vines that were established on a fence row. Floral production started in March. Flowers were tagged and measured at anthesis with a calipers. Fruit length and width were recorded on a daily basis from anthesis for 50 days. At maturity, the length, width and mass were recorded.

In May 1997 vines obtained from seeds and cuttings of six (6) yellow passion fruits varieties and a hybrid between the red and yellow form (Table 1) were planted onto a 2-m tall T-shaped trellis system.

T trellises were used since it has been shown that they provide higher yields in Dominica and Puerto Rico than a fence trellis (Velez Colon, 1997; Robin, 1992). Spacing between plants was 3.5 m with 3 m between rows. There were three plants per variety per replication and there were two replications. Drip irrigation was used to supply the water and the plants were fertilized once after establishment with a granular 12-12-12. A wood-chip mulch in and between rows was used to control weeds, conserve soil moisture and cushion the landing of the mature fruits when they drop.

Data was collected on fruit production and fruit quality during the first semiannual production cycle from November, 1997 through January, 1998. Fruits were collected from the ground at two day intervals. The number of fruits and their mass was recorded. Fruit quality data included fruit size, pulp volume, % Brix and pH.

RESULTS AND DISCUSSION

Passion fruit has two major floral cycles in the USVI. The first is from mid-March through May and the second from September through November. The developing fruit of the passion fruit grows very quickly during the first 20 days following anthesis. The daily rate of size increase was 2.7 mm/day during this time. From day 21 to 50 post anthesis the daily fruit growth rate was 0.35 mm/day (Figure 1). The rapid growth following pollination and fertilization is similar to the development observed in *Datura* (Hartmann et al., 1990). Seed growth and embryo development is associated with the time following the rapid fruit growth.

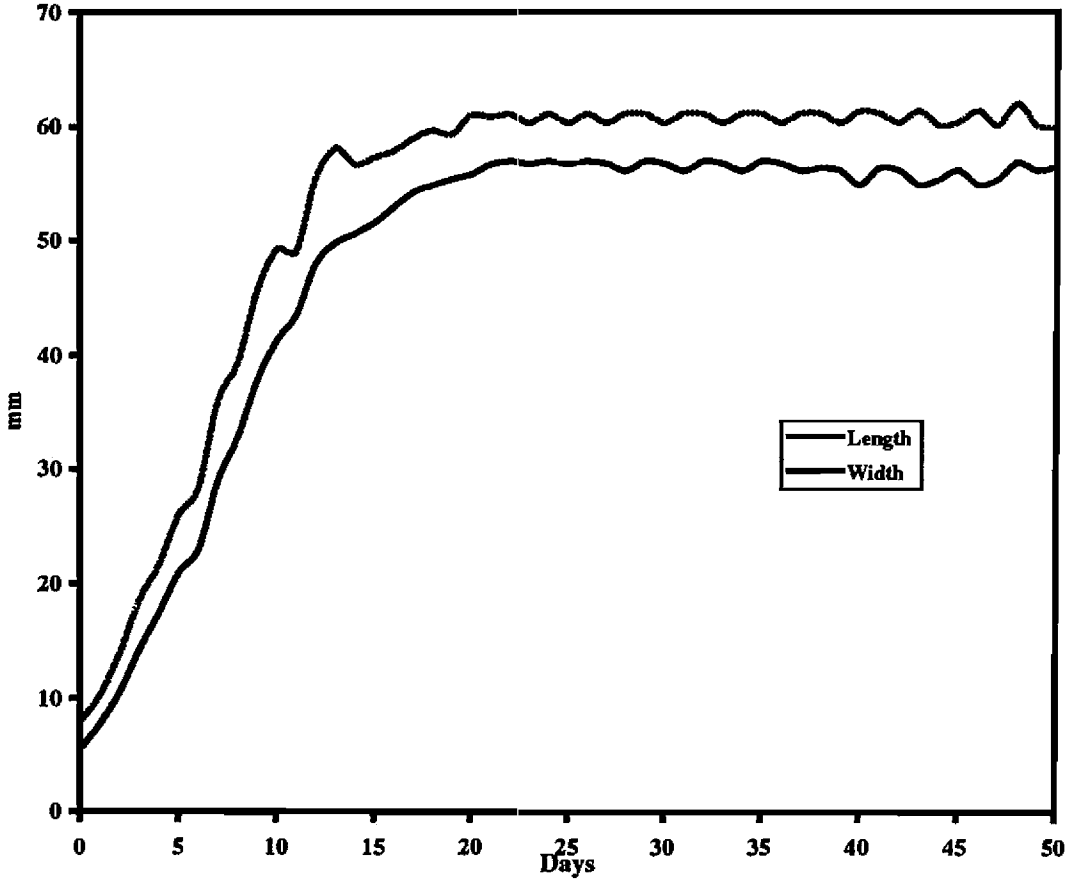

Figure 1: The changes in the development of passion fruit length and width from anthesis to the fiftieth day.

Table 1. Passion fruit varieties evaluated, fruit color and their source.

Variety	Fruit Color	Source[z]
UVI	Yellow	USVI
Columbia Market	Yellow	PSI
Espino Strain	Yellow	PSI
Taiwan	Yellow	USDA
Noel's Special	Yellow	USDA
HPAS	Yellow	USDA
TWZ (Yellow x Red Hybrid)	Redorange	USVI

[z]USVI, Locally grown on St. Croix; PSI, Passiflora Society International Seed Bank; USDA Tropical Germplasm Repository, Hilo, Hawaii.

The 'UVI' variety produced the greatest number of fruits per vine (263) which corresponded to the greatest total fruit mass per vine (21.3 kg, Table 2). Since the 'UVI' variety has been grown for years in the USVI, its greater production over the other varieties is an indication that it is more "well adapted" to the soil and climate than the other passion fruit varieties. The production of the yellow x red hybrid 'TWZ' had a low number of fruits per vine but tied for the third greatest in the total mass of fruit produced.

'Noel's Special' had the lowest fruit production which may be due the fact that it was established in the field a month after the other varieties were planted. 'Noel's Special' is a hybrid developed in Hawaii and propagated by nodal cuttings.

The 'UVI' variety yielded fruits with the greatest mass per vine per harvest (Table 3). Both 'UVI' and 'Taiwan' produced about 10 fruits per vine per harvest. However, the average mass per fruit was equal for the varieties 'UVI', 'Noel's Special' and 'TWZ' indicating that the fruit size of these varieties is the same. The variety 'Taiwan' had the lightest and smallest fruits. The 'UVI' variety had the most vigorous vine growth while the 'Taiwan' variety appeared to indicate mineral stress from the high pH calcareous soils.

Table 2. Total number of fruits and their mass produced per passion fruit vine during the first fruiting cycle from November through January.

Variety	Fruits/Vine	Kg/Vine
UVI	263.3	21.3
C Mkt	220.7	14.2
Esp	123.7	8.7
Twn	115.7	6.1
Nl Spl	29.7	2.4
HPAS	115.5	7.1
TWZ	108.7	8.7

Table 3. Average passion fruit production per vine at each harvest during the first fruiting cycle from November through January.

Variety	Fruits/Vine/ Harvest	Grams/Vine/ Harvest	Grams/ Fruit
UVI	10.12	820.3	81.1
C Mkt	8.49	545.3	66.9
Esp	7.73	545.1	65.4
Twn	9.64	508.4	51.5
Nl Spl	1.56	126.7	81.2
HPAS	5.50	337.9	62.8
TWZ	4.18	332.8	82.2

Passion fruit is grown for the juice extracted from the pulp of mature fruits. The local USVI varieties 'UVI' and 'TWZ' produced the largest amount of pulp that also had the highest % brix reading indicating a sweeter juice than the other varieties (Table 4). The pH of the juice was in a range from 3.19 to 3.65. This pH range falls between the pH for vinegar 3.0 and tomato juice 3.7. Because of the strong flavor of the passion fruit juice, it is used at a 6x dilution.

Table 4. Average fruit pulp and juice quality measurements of passion fruit during the first fruiting cycle from November through January.

Variety	Pulp Vol. (ml)	% Brix	pH
UVI	41.6	17.3	3.56
C Mkt	26.6	16.2	3.19
Esp	34.2	16.3	3.39
Twn	28.0	15.2	3.42
Nl Spl	38.2	16.0	3.65
HPAS	34.4	16.2	3.37
TWZ	40.5	16.6	3.52

Establishing passion fruit vines is expensive due to the initial investment in the trellis. However, some of the initial investment costs are recovered by the sale of the fruit produced the first year. The yellow variety 'UVI' found in the USVI is very productive during its first fruiting cycle indicating its adaptability to the local soils and climate. Its large fruit size and high pulp content was sweeter than the other six passion fruit varieties evaluated. Because these are only results from the first fruiting cycle, further data needs to be collected to determine if this variety maintains its production capability over time.

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REVIVAL OF COMMERCIAL *DIOSCOREA ALATA* CV. WHITE LISBON (YAM) PRODUCTION IN BARBADOS.

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ABSTRACT

In the Caribbean several epidemics of yam anthracnose have led to the demise of sustainable production of White Lisbon yam. Research into yam anthracnose at the University of the West Indies, Cave Hill Campus has shown that *C. gloeosporioides* isolates from yam are host-selective isolates of Yam *C. gloeosporioides* causing yam anthracnose were capable of infecting yam only, while isolates from other crops such as citrus and mango did not infect yam. RAPD analysis of these isolates showed that isolates from yam were genetically similar, but distantly related to isolates from other crop types. Moreover, phytotoxin studies supported the host-selective nature of *C. gloeosporioides* isolates causing yam anthracnose. This results and information on epidemiology on yam anthracnose were used to develop and test a model for establishing large-scale of White Lisbon yam production in Barbados.

INTRODUCTION

Anthracnose of yam (*Dioscorea alata* L.), caused by *Colletotrichum gloeosporioides* (PENZ) Sacc. is an economically important disease in the Caribbean (Degras, 1993). Typical anthracnose symptoms appear on leaves and stems as tiny dark brown or black lesions which eventually enlarge and coalesce, often resulting in severe necrosis. Tips of affected stems usually die back rapidly and plant growth may be severely restricted. The yam cultivar White Lisbon is notably susceptible to the disease and entire fields are frequently destroyed.

Yam anthracnose (*C. gloeosporioides),* is initiated by conidia that are usually soil-borne and dispersed by rain splash or wind during wet weather. Research at the University of the West Indies, Cave Hill campus has shown that rainfall episodes greater than 5-7mm are required for conidia splash from soil onto plants. Conidia germination, appresoria formation, and eventually fungal infection of yam are most favourable at 26-30°C, under conditions of 95-100% relative humidity over an 18-24 hour period, or 12-16 hours of leaf-wetness. Under these conditions, typical anthracnose symptoms emerge one week later (O'Garro, L. W. unpublished data). In addition to soil-borne inoculum, infested yam tubers have also been implicated in the spread of anthracnose (Green, 1994).

Attempts to control yam anthracnose have generally been based on the replacement of White Lisbon by tolerant yam cultivars including Plembite, Kinabayo, Belep, Florido and Langhlie (Simmons, 1994). However, organoleptic and other marketing studies have shown that White Lisbon is preferred to these cultivars. However, these replacement varieties have also begun to succumb to anthracnose (Gibbs, 1998).

Green (1994) reports that *C. gloeosporioides* lacks host-selectivity on the basis that isolates of the fungus causing anthracnose on crops such as citrus, mango, and coffee induced necrosis on detached yam leaves. Furthermore, the study suggested that these non-yam genotypes represent sources of inocula for yam infection and possibly account for the widespread occurrence of yam anthracnose (Green, 1994). In contrast Ahoussou (1989) suggested that *C. gloeosporioides* from yam was host-selective. This suggestion was based on the observation of foliar necrosis induced on yam and not tomato following treatments with toxic exudates produced by *C. gloeosporioides*. Given conflicting conclusions from studies of Green (1994) and Ahoussou (1989) further research is required to resolve whether or not *C. gloeosporioides* from yam is host-selective.

This study investigated the host-selective nature of *C. gloeosporioides* using pathogenicity and genetic tests as well as fungal exudates for phytotoxicity. The possibility of controlling yam anthracnose by applying the results

of these tests and previous knowledge of environmental conditions favouring yam anthracnose infection is also reported.

MATERIAL AND METHODS

HOST-SELECTIVE TESTS ON COLLETOTRICHUM GLOEOSPORIOIDES

Eighty-three isolates of *C. gloeosporioides* from yam (White Lisbon) and fourteen from different host plants were each used to inoculate host and non-host plants by wiping their leaf surfaces with cotton swabs soaked in a conidial suspension (10^6 conidia ml^{-1}). All treated plants were kept under humid conditions for 24 hours and observed daily for the appearance of the disease. Plants serving as controls were similarly treated with sterile distilled water. Each isolate (Table 1) was tested on two leaves of each plant and this was repeated three times. Types used were yam, mango, and citrus (orange, lime and grapefruit).

Table1: Origin and Hosts of Isolates of Colletotrichum Gloeosporioides.

GEOGRAPHIC ORIGIN	HOST	CODE[1]
Barbados (Branch Berry-St. Joseph)	Yam (White Lisbon)	BBL_{1-3}
Barbados (Boarded Hall-St. George)	Yam (White Lisbon)	BHL_{1-9}
Barbados (Bath-St. Joseph)	Yam (White Lisbon)	BTL_{1-6}
Barbados (Clare Bery-St. John)	Yam (White Lisbon)	CBL_{1-9}
Barbados (Checker Hall-St. Lucy)	Yam (White Lisbon)	CHL_{1-12}
Barbados (Guinea-St. John)	Yam (White Lisbon)	GNL_{1-10}
Barbados (Grove-St. Phillip)	Yam (White Lisbon)	GRL_{1-6}
Barbados (Pleasant Hall-St Peter)	Yam (White Lisbon)	PHL_{1-14}
Barbados (Valley-St George)	Yam (White Lisbon)	VAL_{1-12}
Barbados	Anthurium	BAN_1
Barbados	Yam (Plembite)	BPB_1
Barbados	Sugar apple	BSA_1
Barbados	Rose	BRO_1
Dominica	Yam (scully)	DSY_1
Dominica	Yam (Kinaybayo)	DKO_1
Dominica	Avocado	DAV_1
Dominica	Anthurium	DAN_1
Dominica	Mango	DMA_1
St Vincent	Yam (Oriental)	VOR_1
Dominica	Orange	DOR_1
Dominica	Grapefruit	DGT_1
Dominica	Coffee	DCF_1
St. Lucia	Mango	LMA_1

1-Abbreviations ending in L refer to isolates from D. alata cv. White Lisbon. These were all isolated in Barbados with the first letters denoting the exact location by estate from which the isolate was obtained. For the isolates the first letters denotes the country of origin (eg B-Barbados), and the last two letters represent the first two letters in the name of the host plant or crop species. Numbers in superscript represent the number of isolates collected from a particular area.

Fungal exudates were obtained from *C. gloeosporioides* isolates from yam, grapefruit, and anthurium using procedures outlined by Ahoussou, (1989) and Alleyne (1997). Aliquots of crude and purified exudates of the fungus from yam, grapefruit and anthurium designated CHL6, GNL3, DGT and DAN respectively, were tested on leaves of mango, anthurium and lime and yam cultivars White Lisbon, Plembite, and Welch. These exudates containing 10mgml^{-1} of protein, were infiltrated into intercellular spaces using a 1ml syringe without the needle (Swanson *et al.*, 1988). Plants serving as controls were similarly treated with sterile distilled water. All treated plants were placed in a growth chamber set at 26 to 28°C, 85 to 95% relative humidity and a 12 hour photoperiod from fluorescent lamps providing light intensity of 1,020$\mu E\ s^{-1}\ m^{-2}$ and observed daily for appearance of symptoms. Three leaves of each plant type were tested and each test was repeated.

Cell suspension cultures of yam, pepper, tobacco and tomato, all of which were cultured and maintained in MS media amended with 2,4-D (4mgl^{-1}) or various concentrations of 2,4-D and kinetin (Arroyo and Revilla, 1991; Hamza and Chupeau,1993) were also tested with purified and crude fungal exudates and observed for changes in viability and leakage of electrolytes. In these tests, each culture containing 6.93-7.48 x 10^5 cells ml^{-1} MS were

observed in the presence of exudates of final concentration ranging from 6.35-1.0 x 10^{-1} mg ml $^{-1}$ of protein. Viability was assessed by haemocytometer counts of cells stained with fluorescein diacetate (FDA). Electrolyte leakage was detected by increases in conductivity measured at 1-5 minute intervals over a 2- hour period. Each test was repeated three times.

Genetic relatedness between twenty isolates of *C. gloeosporioides* from yam, grapefruit, orange, sugar-apple and mango was assessed by the polymerase chain reaction (PCR) random polymorphic amplification (RPA) of polymorphic DNA technique (Alleyne, 1997).

The amplicons produced were used to determine a similarity index (F) which was taken as a measure of relatedness and was calculated as follows: $F = 2xy/ (n_x + n_y)$ where n_x represents the number of amplicons produced by DNA of isolate x, n_y the number of amplicons produced by DNA of isolate y and 2xy the number of amplicons shared by DNA of isolates x and y (Nei and Miller, 1990).

YAM CULTIVATION AND ANTHRACNOSE FORECASTING

A field (2-hectares) located at Edgcumbe St. Phillip, Barbados was selected and prepared for cultivation. The field had been previously cultivated with sugarcane for 5 consecutive years. Field preparation was mechanized and involved the formation of rows 58 cm wide, 30-46cm high and 38cm apart. White Lisbon yam setts (113g), previously disinfected with antifungal agents were germinated singly in sawdust contained in black perforated polythene bags (10x5x18cm). Germinated sets were then transplanted 165 cm apart in the field. Untreated setts of the variety Langlie were also planted directly into soil at similar spacing and occupied 12 border rows of mean length of 100m, on the eastern portion of the field. The crop was grown without irrigation and fertilized at planting with super triple phosphate and once with formulations of N/P/K trace element (12/12/17/2) at a rate of 14.5Kg per hectare. Another formulation of N/P/K (20/20/20) was applied at a similar rate two months after planting and at monthly intervals thereafter for four months. Weed control was essentially accomplished manually throughout the crop and by two applications of the weedicide gramoxzone between rows 4 months after planting.

During the growing season, yam plants were examined for typical anthracnose symptoms. Fifteen soil samples, each approximately 100g, were taken randomly over the entire field every month for six months after planting. The soil samples were suspended in sterile distilled water and tested for the presence of *C. gloeosporioides* on potato dextrose agar amended with streptomycin sulphate (250μgml^{-1}). Rainfall, temperature and relative humidity were also monitored to determine conditions favouring yam anthracnose infection. Preventive sprays of the fungicide triforine (2.5mlL^{-1}) amended with an emulsifying agent (Spraytex oil) were used when these condition prevailed. The cost of yam production and revenue obtained from the sale of tubers were recorded.

RESULTS

Host-Selectivity of Colletotrichum *gloeosporioides*

Yam leaves treated with conidial suspensions of isolates of *C. gloeosporioides* developed typical anthracnose symptoms in three days. In contrast, anthurium, lime, guava, soursop and mango were visibly unaffected by these isolates (Table 2). Each isolate tested (Table 2) induced anthracnose symptoms only on those plant types from which the isolate was obtained.

Exudates produced by *C. gloeosporioides* from yam induced an anthracnose-like foliar necrosis on yam but not on anthurium, lime and mango leaves all of which appeared visibly unaffected (Table 3). In contrast, yam leaves were visibly unaffected by exudates of *C. gloeosporioides* from anthurium but extensive necrosis was induced on the latter plant genotypes following similar treatment. Cell suspensions of pepper, tomato, and tobacco maintained their viability in the presence of exudates of *C. gloeosporioides* from yam whereas yam cells lost viability in response to similar treatment (Fig.1). These exudates also induced significant increases in conductivity ranging from 4.4 x 10^2 to 6.0 x 10^2 μho cm^{-1} in yam cell suspension cultures. On the other hand, exudates

produced by *C. gloeosporioides* from grapefruit or anthurium induced little or no change in conductivity in pepper or tomato cell suspensions (Fig. 2).

TABLE 2. Responses of Host Plants to Inoculation with Isolates of *Colletotrichum gloeosporioides.*

Occurrence of anthracnose						
	Yam			Mango	Citrus	Anthurium
Isolate	Plembite	Lisbon	Welch			
BBL_{1-3}[b]	-	+	-	-	-	-
BHL_{1-9}	-	+	-	-	-	-
BTL_{1-6}	-	+	-	-	-	-
CBL_{1-9}	-	+	-	-	-	-
CHL_{1-12}	-	+	-	-	-	-
GNL_{1-10}	-	+	-	-	-	-
GRL_{1-7}	-	+	-	-	-	-
PHL_{1-14}	-	+	-	-	-	-
VAL_{1-12}	-	+	-	-	-	-
BAN_1	-	-	-	-	-	+
BPB_1	+	-	-	-	-	-
BSA_1	-	-	-	-	-	-
BRO_1	-	-	-	-	-	-
DSY_1	-	-	-	-	-	-
DKO_1	-	-	-	-	-	-
DAV_1	-	-	-	-	-	-
DAN_1	-	-	-	-	-	+
DMA_2	-	-	-	+	-	-
VOR_2	-	-	-	-	+	-
DOR_2	-	-	-	-	+	-
DGT_1	-	-	-	-	+	-
DCF_1	-	-	-	-	-	-
LMA_1	-	-	-	+	-	-

a-Host response in the table represents the results of 2 inoculations using 3 leaves (2x3) for each isolate

b Numbers in subscripts represent the number of isolates from each data collection point in the sample

+ represents the presence of anthracnose symptoms 3 days after inoculation , and - the absence of symptoms

Table 3. Effect of Fungal Exudates Produced by *Colletotrichum. gloeosporioides* from Yam (CHL6) and Anthurium (DAN) on Several Plant Genotypes.

	Extent of foliar necrosis					
	Yam			Anthurium	Mango	Lime
Fungal exudate	Welch	Plembite	Lisbon			
DAN	-	-	-	++	-	-
DAN (crude)[a]	+	+	+	+++	-	-
CHL6	+	+	+++	-	-	-
CHL6 (crude)	++	+++	+++	-	-	-
SDW	-	-	-	-	-	-

a refers to the unpurified fungal exudate

DAN refers to purified fungal exudate from anthurium isolate

CHL6 refers to purified fungal exudate from yam isolate before gel filtration

+ refers to small necrotic pin point lesions (0.1-0.5cm). ++ larger necrotic lesions (0.5-1.5cm)

+++ coalesced necrotic lesions into large brown area (≥1.5cm)

Generally F values of yam isolates showed 85-95% homology with each other (Table 4). However among the isolates from other crops similarity values varied and were generally under 50%. Moreover when these F values were compared between isolates of yam and other crop types similarity values were very low and tended to be less than 50%.

Table 4. Similarity Matrix of Ten Isolates of *Colletotrichum gloeosporioides* From Yam and Other Crops.

	G1	V9	C3	B8	P26	VO	BS	DG	LM	BP
G1	100	50	57	66	57	40	0	50	0	0
V9	50	100	86	66	86	40	0	50	0	0
C3	57	86	100	25	66	44	0	29	0	0
B8	66	66	25	100	50	36	0	44	0	0
P26	57	86	66	50	100	22	0	29	0	0
VO	540	40	44	36	22	100	0	40	0	0
BS	0	0	0	0	0	0	100	0	0	0
DG	50	50	29	44	29	40	0	100	0	0
LM	0	0	0	0	0	0	0	0	100	0
BP	0	0	0	0	0	0	0	0	0	100

G1,V9,C3,B8 and P26 are DNA samples of *C. gloeosporioides* isolates from yam

VO, BS ,DG ,LM and BP are DNA samples of *C. gloeosporioides* from , orange, sugar apple, grapefruit, mango and passion fruit respectively.

CONTROL OF YAM ANTHRACNOSE

Fungi identified as *C. gloeosporioides*, on the basis of conidial and mycelial morphology (Domsch *et al.*, 1980) were detected in soil in which anthracnose- affected yam was found. A random sample of three such presumptive isolates of induced typical anthracnose symptoms on White Lisbon in laboratory tests. Amounts of presumptive *C. gloeosporioides* detected at monthly intervals for the first six months in soil planted with Langlie yam were 0.0, 0.1, 0.2, 0.6, 1.1 and 0.3 CFU g^{-1} dry weight of soil, respectively. No fungi with morphological features characteristic of *C. gloeosporioides* were detected in soil cultivated with White Lisbon. The portion of the field

characteristic of *C. gloeosporioides* were detected in soil cultivated with White Lisbon. The portion of the field cultivated with Langlie yam was affected by anthracnose four months after planting. Two rows of White Lisbon immediately bordering the Langlie plot were severely affected also and were roughed to provide a buffer zone between the Langlie and the remaining White Lisbon plots. Another two rows of White Lisbon, bordering the zone mentioned were moderately affected by anthracnose. Generally, anthracnose on affected portions of the yam crop was reduced to mild levels of infestation six months after planting. The remainder of the crop, that comprised White Lisbon, was anthracnose-free for of at least six months, at which time field monitoring for the disease stopped.

The yam crop experienced 15 episodes of rainfall which were in the 5-10.5mm range over a six-month period after planting and twenty one 18 to 25-hour periods when relative humidity attained 95 to 100% over the same cropping interval. Twelve of the rainfall episodes occurred at weekly intervals. Ambient temperature ranged from 23 to 30°C and there were 7 applications of triforine sprays. Harvesting commenced 9 months after planting and yielded 19545Kg of tubers. A sum of US$15,675.00 was made from the sale of all the tubers produced. Cost of production, including expenditure for labour, planting material, weedicides, fertilizers, transport, and disease

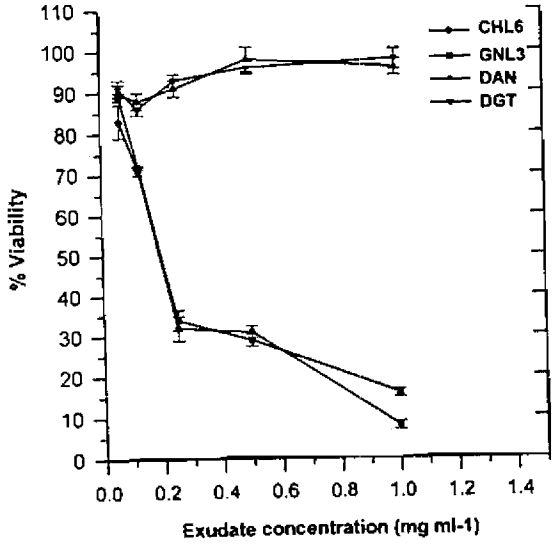

Figure 1. Effect of exudates from CHL6 (yam), DAN (anthurium) and DGT (grapefruit) on viability of yam cell suspension

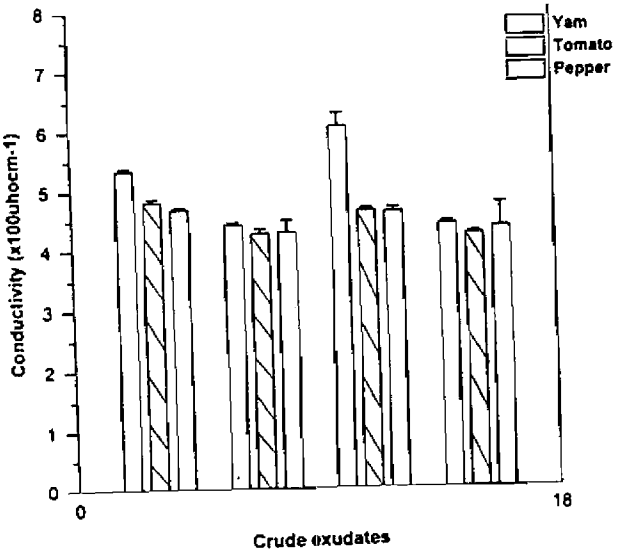

Figure 2. Conductivity of yam, tomato and pepper cell suspensions following treatment with pooled exudates from GNL3 (yam), DGT (grapefruit, CHL6 (yam) and DAN (anthurium)

DISCUSSION

C. gloeosporioides has a wide host range as is evident from the numerous plant genotypes it can infect (Jefferies *et al.*, 1990). Host-selectivity of *C. gloeosporioides* isolates on yam was determined by several different methods in the present study. Leaf inoculation studies with isolates of *C. gloeosporioides* from yam and other crop genotypes all showed that *C. gloeosporioides* is host-selective. In addition, plant cell suspension studies showed that fungal exudates which were toxic to yam are highly host-selective for yam but not pepper and tomato. Finally, host-selectivity was shown to have a genetic base when polymorphisms among isolates of the fungus from different hosts were compared. Analysis of polymorphisisms among yam isolates and isolates from other crop types showed that yam isolates were generally more similar to each other than isolates from other crop types.

Host-selective phytotoxins implicated in some fungal diseases varied in structure and mode of action (Daly and Knoche, 1982; Schafer, 1994). HV-toxin or victorin is one of several well characterised host-selective toxins from *Helminthosporium victoriae*, the causal agent of victoria blight of oats and is essential in inducing the disease. (Yoder, 1980; Johal *et al.*, 1994). In this study the fungal exudates were largely toxic metabolites which induced leaf necrosis and electrolyte leakage from cell suspensions of susceptible yam cultivars. These metabolites are thought to be glycoprotein in nature and approximately 8-9KDa in size. These toxic metabolites were also able to differentiate levels of anthracnose resistance amongst the yam cultivars Plembite, Welch and White Lisbon.

These results demonstrates the possibility of cultivating White Lisbon successfully despite its susceptibility to anthracnose. Moreover, a profit of US$4273.50 per hectare on 2 hectares was realized. Prerequisite for successful cultivation include anthracnose-free planting material, ability to forecast environmental conditions favouring anthracnose infection and prudent use of chemical sprays for disease control. The observation of yam anthracnose outbreak in the plot planted with Langlie supports the claim that tubers may be an important mode for yam anthracnose transmission, since the Langlie tubers used were not treated to remove the pathogen before planting a plot not previously infested with the disease.

On the basis of the finding that *C. gloeosporioides* from yam is host-selective, it is possible that White Lisbon can be cultivated in fields uninfested with the pathogen without the use of prolonged fungicide sprays provided that anthracnose-free tubers are planted. Such a possibility has implications for the overall cost of yam production in the Caribbean.

ACKNOWLEDGEMENTS

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EVALUATION OF PAPAYA GERM PLASM IN THE U.S. VIRGIN ISLANDS

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ABSTRACT

Demand for locally produced papaya (*Carica papaya*) fruits far outweighs supply in the U.S. Virgin Islands. Due to constraints such as mealybug inscite infestation and the high incidence of papaya ringspot virus, farmers are in need of varieties which are suitable for local growing conditions. Two papaya germplasm evaluation trials were conducted during 1996-97 and 1997-98. These varieties were evaluated for yield and fruit characteristics, and quality. In both trials, 'Cariflora' set the highest number of fruits and 'Yuen Nong' the lowest. In the first trial, 356-3 was the sweetest with brix of 13.42 % and 'Criolla' the lowest with a brix of 9.42 %. In the second trial, 'Cartegena' had the heaviest fruits (1510) and 'PR665 dwaf' was the lightest (405 g). The height at first fruit set from both trials ranged from 40 cm 'Sunrise x Cariflora' to 221 cm, 'Trini Yellow'. Productive papaya varieties can be recommended for fresh market production in the USVI to fulfill the characteristics the consumes desire..

INTRODUCTION

Papaya is one of the most widely grown fruits in the Caribbean basin. It is a favourite of both commercial growers and backyard farmers in the USVI It's fruits are used for a variety of purposes in both green and ripe forms. Demand for the ripe fruit is high in local markets, restaurants and hotels. But over the past twenty five years production has declined dramatically due to high incidences of papaya ringspot virus, mealybugs infestation and low rainfall.

Papaya ringspot virus reduces fruit quality and quantity and eventually kills the tree. Symptoms of PRSV include water soaked lesions of the stems and petiolcs, ringspots on the fruits and mottled and distorted leaves. Most papaya varieties are very susceptible to this virus and die before marketable fruits are obtained. It is estimated that production in Puerto Rico has declined 60-70% as a result of PRSV (Zimmerman, 1994). No natural resistance to PRSV has been found, but some varieties have shown tolerance, in which, plants and fruits show symptoms of the virus but the productive life of the plant remains. Most Hawaiian varieties are very susceptible to the virus and do not adapt well to the high pH soils and semi-arid climate of the USVI. Aphids are the primary vector of PRSV, but are non-persistent on papaya.

Mealybugs colonize the underside of leaves, fruits and around the apex of shoot tips. Symptoms of mealybugs include crinkled leaves, deformed fruits and blackened leaves from the sooty mold which forms on the exudate from the mealybug.

During dry seasons the mealybugs also go onto roots of thc plant. The insects are extremely difficult to control, particularly when the leaves curl, and provide a natural hiding place, and among the fruit where they are protected from insecticide spray.

Papaya trees are extremely sensitive to drought. In the Virgin Islands where evapotranspiration exceeds precipitation 10 months out of the year, it is difficult to produce papayas without some type of irrigation. Also, stressed plants are more susceptible to disease and insect damage.

This study evaluated several papaya varieties from around thc world, for growth and produetion, tolerance to PRSV, height at first fruit set, and fruit quality in USVI.

MATERIALS AND METHODS

The experiments were conducted at the Agricultural Experiment Station, University of the Virgin Islands, St. Croix. The soil is a Fredensborg loamy, fine cabonatic, isohyperthermic, shallow, typic calciustoll (Lugo-Lopez, 1980). The soil contains relatively low organic matter content (<2.0%) and the pH is approximately 8.5. The average rainfall is 1016 mm with highest precipitation occurring between October and November.

These varieties evaluated were:

Trial	Code	Trial	Code
Cariflora-G	CFL	Cariflora-G	CFL
Criolla-H	CRL	Cartegena-G	CRT
Guanica-H	GNC	Guaniea-H	GNC
356-3-G	356-3	Solo 64-H	S54
PR 665-H	P65	Pr665 Dwargf	PRD
Solo Sunrise -H	SS	Solo Sunrise -H	SS
Solo Sun X Carif-H	SXC	Tommy-G	TOM
Trini Yellow-H	TYL	Trini Yellow-H	TYL
Washington-G	WSH	Washington-G	WSH
Yuen Nong 1-H	YN1	Yuen Nong 1-H	YN1

Flower type: G=gynoecious H=hermaphrodite

The trees in were established in the field in August 1996 and August 1997. The experiments were conducted in two rows per plots with 1.83 m between plants and 2.44 m between rows. The plot was 32.9 m by 12.7 m wide. Water was supplied as needed through ¾ polyethylene tubing. Dynamax 12-12-12 fertilizer was applied monthly at a rate of 1-2 cups per plant. Granular Diaznon was sprinkled around the trees to control ants and Malathion along with Ulta-Fine Spray Oil were sprayed as needed to control mealybugs. Data collected were height at first fruit set, number of fruits produced, fruit weight, length and width, flesh thickness and brix.

RESULTS AND DISCUSSION

Gynoecious plants produced only female floral parts and required pollen from a staminated male or hermaphrodite plants to set fruit. Hermaphroditic plants have complete flowers with both male and female floral parts. Fruits from Gynoecious plants are generally round while hermaphroditic plants produce elongated to pear shaped fruits. 'Washington', originating in India has anthocyanin in the petioles and stems to give it a charaeteristic purple colour. Compact plant structure, short internodes are identifying features of 'Dwarf Puerto Rico 6-65'.

HEIGHT AT FIRST FRUIT

The height at which the first fruit sets is an important characteristic, because the lower the fruit, the earlier is set in plant development. Earlier fruit set allows for production before infection by PRSV reduced plant vigour and sustained fruit set.

In 1997, height of first fruit set ranged from 43 cm 'Solo Sunrise' X 'Cariflora' to 118 cm 'Solo Sunrise (Table 1). The variety with fruit at the lowest height set in 1998 was 'PR 665 dwarf, 53 cm, and 'Solo Sunrise, 121 cm (Table 1). The rule as a hermaphroditic plants wet fruits at a much later age corresponding to height, than Gynoecious varieties. However, the 'Solo Sunrise' X 'Cariflora' hybrid incorporated the lower fruit set characteristic to this hermaphroditic selection (Table 1).

Table 1: Average height at first fruit set 1996/97 and 1997/98.

Variety	Height (cm) 1996/97	Height (cm) 1997/98
Cariflora	79	64
Cartegena	-	102
356-3	37	-
Solo 64	-	70
Tommy	-	90
Washington	72	57
Criolla	94	-
Guanica	114	111
Puerto Rican 6-65	72	-
Puerto Rican 6-65 Dwarf-	53	-
Solo Sunrise	121	118
Solo Sunrise X Cariflora	82	42
Trini Yellow	114	82
Yuen Nong 1	105	96

NUMBER OF FRUITS PER PLANT

In both trials, 'Yuen Nong 1', a hermaphrodite, set the lowest number fruits (40 and 41, 1997 and 1998 respectively (Table 2). Also in both trails, 'Cariflora', a Gynoecious plants, set the most fruits, 80 in 1997 and 82 in 1998 (Table 2). Varieties with smaller fruit tended to set higher amounts of fruit.

MASS

'Trini Yellow' had the heaviest fruits, 1.9 kg in 1997. The lightest fruits came from 'Solo Sunrise' (638 g) (Table 3). In the second trial, 'Cartegena' bore the heaviest fruits, 1.5 kg per fruit and 'Guanica' had the lightest fruit 687 g in 1998 (Table 3).

Table 2: Average number of fruits produced per plant 1996/97 and 1997/98.

Variety	#Fruit/Plant 1996/97	#Fruit/Plant 1997/98
Cariflora	80	82
Cartegena	-	64
356-3	56	-
Solo 64	-	70
Tommy	-	68
Washington	51	55
Criolla	41	-
Guanica	57	52
Puerto Rican 6-65	64	-
Puerto Rican 6-65 Dwarf	-	54
Solo Sunrise	66	67
Solo Sunrise X Cariflora	79	72
Trini Yellow	56	56
Yuen Nong 1	40	41

Table 3: The average weight of the papaya fruits during 199697 and 1997/98.

Variety	kg 1996/97	kg 1997/98
Cariflora	1.23	1.05
Cartegena	-	1.20
356-3	1.14	-
Solo 64	-	96
Tommy	-	1.38
Washington	.75	.77
Criolla	.84	-
Guanica	.84	-
Puerto Rican 6-65	1.27	.40
Puerto Rican 6-65 Dwarf	-	-
Solo Sunrise	.64	.84
Solo Sunrise X Cariflora	t.20	.1
Trini Yellow	.88	.73
Yuen Nong 1	t.16	t.51

FRUIT SIZE

The length, width and ratio of length to width give an indication of the fruit shape. The fruit shape varied from the almost perfectly round fruits of the gynecious varieties to elongated fruits of the hermaphroditic varieties. A length to width ratio close to 1.0 indicates a round fruit. In 1997, 'Trini Yellow' had the highest length to width ration (3:31) Table 4). The fruits from this variety were long and thin. 'Solo Sunrise' X 'Cariflora' had the lowest ratio (1:09) (Table 4). 'Trini Yellow' had the highest length to width ratio with 2:69 and 'Washington' had the lowest (1:17 (Table 4) in 1998.

PERCENT BRIX

The percent brix is a measurement of the soluble sugar content. The higher brix value indicates a sweeter fruit. The percent brix will change over time as the plant becomes stressed from insects, disease and drought. A stressed papaya plant looses its leaves which reduces the production of sugar that accumulates in the developing fruit. The cultivar which had the sweetest fruits were '356-3' with a brix of 13.42 (Table 5). The fruits with the lowest brix were 'Trini Red' (8.47) (Table 5). The hermaphroditic cultuvar tended to have lower brix than the gynecious ones. The lower brix found in the hermaphroditic cultivar may relate to later fruit set. The later the fruit set in plant development, the greater that of infection with PRSV and other stresses.

Table 4: Average length to width ratio of the papaya fruits.

Variety	Ratio
Cariflora	1.29
Cartegna	1.37
356-3	1.37
Solo 64	1.32
Tommy	1.55
Washington	1.19
Criloa	1.56
Guanica	2.06
Puerto Rican 6-65	1.40
Puerto Rican 6.65 Dwarf	1.17
Solo Sunrise	1.64
Trini Yellow	3.00
Yuen Nong 1	2.29

PSRV TOLERANCE

The plants showed a wide variety of tolerance to the virus. In both trials virus symptoms were observed within months of planting. None of the varieties were productive for over a year.

Table 5: Papaya fruit quality characteristic.

Variety	% Brix Flesh	Thickness (cm)	Colour
Cariflora	11.3	2.71	Orange
Cartegna	11.6	2.77	Orange
356-3	13.4	2.57	Orange
Solo 64	11.3	2.45	Orange
Tommy	11.1	2.63	Yellow
Washington	11.4	2.38	Yellow
Crilloa	9.4	2.49	Yellow
Guanica	10.4	2.46	Red
Puerto Rican 6-65	10.9	2.46	Yellow
Puerto Rican 6.65 Dwarf	11.3	1.87	Yellow
Solo Sunrise	11.0	2.54	Yellow
Solo Sunrise X Cariflora	9.8	2.88	Orange
Trini Yellow	8.9	2.34	Yellow
Yuen Nong 1	10.3	2.85	Orange

CONCLUSIONS

PSRV will continue to be the constraint to payapa production in the U.S.V.I. By planting varieties such as '365-3' and 'Cariflora' that set fruit early, farmers can get some production out of the plants before they are weakened by diseases and pests. Future research should include continued trials to identify varieties suitable for the soil type and climate of the U.S.V.I.

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A PRELIMINARY EVALUATION OF THE IMPORTED BREADFRUIT GERMPLASM AT THE UNIVERISTY OF THE WEST INDIES, TRINIDAD

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ABSTRACT

In 1990, 30 breadfruit varieties were imported into Jamaica and Trinidad by the Faculty of Agriculture on behalf of the Jamaica Agricultural Development Foundation. The accessions were established in the field in 1992 in Trinidad and are being evaluated for growth, yield and bearing characteristics, pest and disease susceptibility and their performance compared with the already existing cultivars, "Yellow" and "White". This paper presents data on performance during the first five years and identifies accessions which appear suitable for more widespread evaluation of their commercial potential.

INTRODUCTION

In 1793, breadfruit (*Artocarpus altilis* (Park.) Fosberg) was introduced into St. Vincent and Jamaica as a carbohydrate staple. Although it took several decades to achieve acceptance, today, it is considered to be an important traditional food source in rural areas throughout the Caribbean and it is widely appreciated by the urban population. Demand for breadfruit on the ethnic markets in United Kingdom and North America resulted in the development of an export trade which was led by Jamaica up to 1988 when 196,065 kg were exported. Since then, St. Lucia has become the major exporter.

Several constraints to breadfruit commercialisation were previously identified (Ferguson, 1980; Roberts-Nkrumah, 1990). Among the most important were:

- tree height, which made harvesting difficult and caused high post-harvest losses
- seasonal bearing
- short shelf-life
- very limited germplasm.

All of these negatively affected the potential sustainability of the trade in this non-traditional commodity. It was felt that these problems could be overcome and the establishment of commercial orchards promoted by the availability of germplasm with superior horticultural characteristics to those noted above. Based on a preliminary survey conducted in Jamaica in 1990, Roberts-Nkrumah described the extant germplasm which apparently consisted of some seven to eight cultivars of which the "Yellow Heart" was, by virtue of its excellent eating quality, the most highly-valued.

In 1990, the Jamaica Agricultural Research Programme of the Jamaica Agricultural Development Foundation provided funding to the Faculty of Agriculture, University of the West Indies to introduce additional germplasm from the South Pacific and to evaluate its commercial potential. This paper presents a preliminary comparison of the performance of selected cultivars extant in the Caribbean and the imported materials.

MATERIALS AND METHODS

In November 1990, root cuttings of thirty nine-to- twelve year-old breadfruit accessions were collected at the United States germplasm repository for the *Artocarpus* spp., in Hawaii and shipped to Jamaica and to Trinidad. These accessions had been collected during previous missions to the South Pacific territories. All the root cuttings taken to Jamaica died before rooted adventitious shoots could be produced for field establishment. In Trinidad, five of the accessions never produced adventitious shoots. Plants from those which did, were shipped

to Jamaica for establishment at the Bodles Experimental Station of the Ministry of Agriculture, the Faculty of Agriculture field site at the Mona Campus - U.W.I. and at the College of Agriculture, Science and Education in Portland. Nine accessions survived at Mona up to January, 1997 but no information has been collected due to the absence of technical assistants.

In Trinidad, the field-establishment of the breadfruit collection began in 1992 with one plant of each of the surviving 25 imported cultivars, including Cv. Yellow and Cv. White (listed below as accession no. 810290) which had been imported to Hawaii from the Caribbean. Additionally, five plants of "Yellow" and four of "White" from the local germplasm were included in the collection. Table 1 presents a list of the imported cultivars and the local breadfruit cultivars.

All trees were established at approximately 5 months old and 45 to 60 cm tall. Plant spacing was 10 to 12 m x 10 m depending on the size of the mother tree in the Hawaiian collection. Annually, 450 g/tree^{-1} of the NPK fertiliser 13-13- 21was applied during the last rains in December, at the onset of the rainy season in early May and in September after the harvesting period of most of the cultivars. Carbofuran (5%) is applied at 25 g/tree^{-1} three times annually, copper hydroxide (77 %) as a fungicide during the rainy season and the insecticide, dimethoate as a preventative measure at bi-monthly intervals.

Data are collected on vegetative growth, yield characteristics, fruit characteristics and observations are made on pest and disease incidence and eating quality of the accessions. The data presented in this paper relate to the 4 to 5 year old trees in the collection which in 1997 would have been in their second year of bearing.

RESULTS AND DISCUSSION

After five years in the field, (four years for cv. Ulu Tala) the accessions can be placed into two height classes, using the local 'Yellow' which attained a height of 10 m at December, 1997, as a reference (Table 2). In Class 1 which consisted of cultivars with tree heights less than 10 m at that time, there were 11 cultivars including the local 'White'. Tree height ranged from 5.50 m in 'Hue Hue' to 9.75 m in 'Ahani'.

Table 1: A List of the Breadfruit Accessions Established at the University Field Station, Trinidad in 1992 and 1993.

Accession No.	Cultivar	Accession No.	Cultivar
UW 001	Ma'afala#	UW 017	Porohiti
UW 002	Fafai	UW 018	Pu'upu'u
UW 003	Momolega	UW 019	Mei Tehid
UW 004	Tapeha'a	UW 020	Pii Piia
UW 005	Puou#	UW 022	Roiha'a
UW 006	Ulu Tala*	UW 023	Rave
UW 007	Ulue'a	UW 024	Hue Hue
UW 010	Otea	UW 025	Pua'a
UW 011	A'anue	UW 027	Toneno
UW 012	Aipu'u	UW 028	810290
UW 013	Cv. Yellow	UW 030	Mein Patak
UW 014	Afara	UW 031	Yellow (local)
UW 015	Mahani	UW 032	White (local)
UW 016	Ahani		

Died in 1996; new plants were established the same year.

* Established in 1993; all other accessions were established in 1992

Missing accession numbers denote materials which died before successful propagation

Caution is necessary in interpreting the data on tree height (and most of the other variables presented in this paper) in that, except for the local accessions, the information was based on single trees, therefore, allowance should be made for variability. The same is true for the collection in Hawaii to which reference will be made. Several factors influence tree height, including genotype, susceptibility to environmental stresses, disease and the age of the plant. 'Ma'afala' and 'Puou', for which data are not presented, were likely to have fallen into Class I since in 1996, before they died, they were among the shorter cultivars in the field and in the American collection their heights ranged from 11 to 13 m after 12 years in the field. The presence of disease in these cultivars and in 'Ahani,' which died in 1997, and in 'Aipu'u,' which began dying back in the same year, may have affected their height at the time of measurement. Plant height of 'Ulu Tala' in 1997 might have been affected by its relatively younger age. 'Hue Hue', 'Pu'upu'u', 'Porohiti' and 'Pii Piia' appear to be inherently shorter cultivars , since the heights of the mother plants in the American collection ranged from 7.6 to 12 m , whereas that of 'Otea' was about 20 m tall.

In Class II, all imported cultivars, except Accession No. 810290, were taller than the local 'Yellow', the tallest cultivar being 'Mei Tchid' with a height of 11.25 m after 5 years. In the American collection the heights of the cultivars in this class ranged from 9 to 18 m, with 'Mei Tehid', 'Mein Patak' and 810290 being among the shorter cultivars. It is of interest to note

Table 2. Plant Height of Breadfruit Accessions in 1997.

Height Class I (< 10 m)		Height Class II (≥ 10 m)	
Cultivar	Height	Cultivar	Height
Ahani	9.75	Mei Tehid	11.25
Pii Piia	9.75	A'anue	11.00
Momolega	9.50	Roiha'a	10.75
Ulu Tala	9.50	Pua'a	10.75
Mahani	9.50	Fafai	10.50
Porohiti	9.50	Ulue'a	10.50
Otea	9.25	Cv. Yellow	10.50
White (local)	9.20	Afara	10.50
Pu'upu'u	8.25	Toneno	10.50
Aipu'u	7.75	Mein Patak	10.50
Hue Hue	5.50	Yellow (local)	10.00
		810290	10.00

that the cv. 'Yellow' was taller than the 'White' (or 810290) in both the imported and the local materials.

Another important observation was that wind affected tree height especially during the period of heavy bearing. Fruit-laden, exposed upper branches broke easily.

Time to Bearing

Ten of the accessions including the local 'Yellow', bore fruit in 1994, two years after field establishment (Table 3). Such early bearing is not unusual, since the first plants established at the Botanical Gardens in St. Vincent began bearing fruit two years after establishment (Powell, 1979). Another ten cultivars, including the local 'White', entered the reproductive phase after three years and the remaining six, after four years. The behaviour of 'Momolega' is notable since it was the first accession to flower in 1994 when it produced only male flowers but fruit were produced for the first time in 1996.

Harvesting Period

Of the 27 accessions described, 17 had a harvesting period of 6 to 9 months, whereas, the other 10 bore fruit for 1 to 5 months in 1997 (Table 3). Those cultivars with the longer bearing period had two bearing periods. Flowering for the first season began between October to December of the previous year to produce a minor crop

between January and March. Flowering for the second and major period began in February and extended to April, or later for the late-bearing cultivars. Those cultivars which bore fruit in only one season tended to flower during this period as well. Noticeable among the cultivars with the tendency to year-round bearing are 'Pu'upu'u', 'Ulu Tala', 'Hue Hue' and possibly, 'Puou'. 'A'anue', 'Afara' and 'Mei Tehid' are also worthy of attention. 'Momolega' may be a shy-bearer since it bore only in August in 1997 and from May to August in 1996. Among the single-season cultivars, 'Pii Piia' was an early bearer with most fruit being produced between June and July, whereas, the late-bearers were 'Porohiti', 'Mein Patak', 'Ulue'a' and 'Toneno'. Even with the caveat noted previously, there is obviously the possibility of extending the bearing season of breadfruit and increasing the supplies throughout the year by using a wider range of germplasm. Further evaluation is necessary to determine whether 'Pu'upu'u', 'Ma'afala' and 'Puou' in particular are equally productive in both seasons.

Table 3 Time to First Bearing, Harvesting Period and Duration of Harvest in 1997 of the Breadruit Accessions.

Cultivar	Harvesting Period	Duration of Harvest (months)
	Time to first bearing - 2 years	
Ahani**	Feb. - Aug.	6
Yellow (local)	Feb. - Sept.	7
Pua'a	Feb. - Sept.	7
A'anue	Feb. - Oct.	8
Cv. Yellow	Mar. - Sept.	6
810290	Mar. - Sept.	6
Mahani	Mar. - Sept.	6
Roiha'a	Apr. - Sept.	5
Porohiti	June - Nov.	5
Toneno	July - Nov.	4
Ma'afala*	Aug. - Dec.	4
	Time to first bearing -3 years	
Ulu Tala	Jan. - Oct.	9
Puou*	Jan. - Oct.	9
Hue Hue	Jan. - Oct.	9
White (local)	Feb.- Sept.	7
Afara	Feb.- Oct.	8
Fafai	Mar.- Sept.	6
Rave	Mar.- Oct.	7
Aipu'u**	May - Sept.	4
Pii Piia	June - Oct.	4
Mein Patak	July - Oct.	3
	Time to first bearing - 4 years	
Pu'upu'u	Jan. - Oct.	9
Mei Tehid	Feb. - Sept.	7
Ulue'a	Feb. - Oct.	8
Otea	May - Sept.	4
Tapeha'a	May - Sept.	4
Momolega	Aug.	1

* Tree died in 1996, therefore data for 1995 are presented
** Tree started declining or died in 1997

Yield and Yield Components

The local cultivars, 'Yellow' and 'White' have been used as the reference point for rating yield performance. Therefore, based on the data for 1997, a yield of 200 - 300 kg tree^{-1} was considered as average. Six other cultivars, including the imported Accession No. 810290 ('White'), fell within Yield Class II with the local materials (Table 4). Fourteen cultivars were in the lower-yielding class I, with trees bearing 11 to 194 kg tree^{-1}. Again, the factors cited earlier undoubtedly affected yield especially in 'Ma'afala', 'Puou', 'Ahani', 'Aipu'u' and 'Ulu Tala'. Other cultivars were subject to praedial larceny and wind, both of which, through branch damage, can also reduce the future production capacity of the tree. Differences in susceptibility to water stress during the dry season can also affect yield. The highest yielders were in Class III with tree yields ranging from 330 to 500 kg. On a ha^{-1} basis at the current plant population, some cultivars have a potential maximum yield of 50 tonnes which compares with the yield estimates of Weir et al. (1982) and Fownes and Raynor (1993). It appeared that of the two yield components, fruit number and fruit mass , the former was most closely related to yield since in Yield Class III, mean fruit number was 221 whereas in Classes II and I it was 161 (141 without 'Pu'upu'u') and 56 , respectively. Fruit mass was 2.0, 1.9 (without 'Ma'afala', 2.0) and 1.7 kg (without 'Pu'upu'u', 1.8 kg), in Class III, II and I, respectively. Among the high-yielding 'Mei Tehid' and 2Ulue'a', fruit number was also associated with a long bearing period and tree height. Small fruit size in'Pu'upu'u" and 'Ma'afala' may be a desirable characteristic in export markets but the larger fruits of 'Mahani', 'A'anue' and 'Fafai' are more suitable for processing. Beside the previous caveat, praedial larceny has contributed to underestimation of both yield components and ultimately, yield.

Pest and Disease Incidence

Except for the effect of the Pink Mealy Bug which attacked some of the trees in 1995, there has been no serious pest problem, though scale insects and spider mites have been observed. Generally, the major problem related to a quick decline problem which cause trees to die in one year. 'Ma'afala' and 'Puou' died in 1996; 'Ahani' died in 1997, and 'Aipu'u' also began showing the typical decline symptoms of premature leaf and fruit fall and die-back of the stems. The causal organism has not been identified conclusively, however, applications of Phyton (a.i. copper sulphate pentahydrate 21.36 %) appear to have arrested the progress of the disease on the lower branches of this accession. During the rainy season, some cultivars, especially the local 'Yellow' and 'Porohiti' have shown Anthracnose infection on some of the fruits. This observation requires more thorough evaluation since some cultivars, as they mature, develop large brown patches on the fruit which does not denote fungal infection.

Eating Quality

Organoleptic evaluation of the accessions have not been conducted on a consistent basis. In the author's view all the cultivars are of , at least, good eating quality, except 'Toneno', which has a very high latex content even at maturity. Some consumers, however, consider this accession desirable due to its bright yellow flesh colour. The cultivars differ in mouth-feel and taste. Many consumers have expressed a preference for 'Afara', 'Roiha'a', 'Ulue'a' and 'Porohiti' even over the local 'Yellow', mainly on the basis of their soft, smooth flesh texture.

CONCLUSION

This collection of breadfruit germplasm clearly offers an opportunity to build a breadfruit industry on the basis of a much wider germplasm than the region has had for the last two hundred years. There is still need for more detailed information on the extant germplasm. Given this constraint,as well as the age of the accessions and the limitation of evaluation to one location, it not possible at this time to draw firm conclusions on the commercialpotential of the new materials. Current research effects are geared at reducing some of these limitations including work on propagation to promote wider distribution of the germplasm, and studies on phenology, yield manipulation , fruit maturation and storage in which local 'Yellow' is being used as the standard. Other materials from Jamaica and St. Vincent have also been added to the collection for evaluation.

Table 4 Yield and Yield Components of Breadfruit Accessions on 1997.

Cultivar	Fruit No.	Mean Fruit Mass (kg)	Fruit Mass (kg tree^{-1})	Yield Potential (tonnes ha^{-1})
		Yield Class I (< 200 kg tree^{-1})		
A'anue	80	2.43	194.4	19.4
Mahani	74	2.59	191.7	19.2
Tapeha'a	100	1.71	171.0	17.1
Cv. Yellow	83	2.03	168.5	16.9
Fafai	67	2.40	160.8	16.1
Hue Hue	80	1.96	156.8	15.7
Ulu Tala	85	1.79	152.2	15.2
Pua'a	69	1.98	136.6	13.7
Ahani	54	1.60	86.4	8.6
Otea	35	1.98	69.3	6.9
Aipu'u	18	1.56	28.1	2.8
Puou	19	1.15	21.9	2.2
Ma'afala	18	0.88	15.8	1.6
Momolega	5	2.22	11.1	1.1
		Yield Class II (200 - 300 kg tree^{-1})		
Rave	133	2.23	296.6	29.7
Roiha'a	175	1.57	274.8	27.5
Yellow (local)	154	1.78	274.1	27.4
Mein Patak	129	2.03	261.9	26.2
Afara	158	1.40	221.2	22.1
White (local)	139	1.52	211.3	21.1
Pu'upu'u	299	0.69	206.3	20.6
810290	100	2.05	205.0	20.5
		Yield Class III (> 200 kg tree^{-1})		
Mei Tehid	262	1.91	500.4	50.0
Ulue'a	262	1.91	500.4	50.0
Porohiti	194	2.09	405.5	40.6
Toneno	193	1.80	347.4	34.4
Pii Piia	162	2.04	330.5	33.1

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EVALUATION OF FOUR OPEN-POLLINATED AVRDC TOMATO CULTIVARS UNDER JAMAICAN CONDITIONS.

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INTRODUCTION

Alafua Winner, Alafua Large, Alafua Early and Tomatoll are four tomato cultivars developed in Fiji as a part of the Asian Vegetable Research Development programme.

These cultivars are reportedly heat tolerant and resistant to Bacterial wilt (*Pseudomonas solanacearum*). Heat tolerance is an important feature as excess heat decreases tomato yields (Ramsay, 1981). Another important characteristic is open pollinated which makes seed collection possible and seed availability affordable. These cultivars have exhibited varied growth habits in their host country varying from short and bushy (determinate) to tall and requiring staking (indeterminate).They mature at varying times providing a continuous supply to the market. Fruit size ranges from the very small cooking processing type (30g), to the large sandwich/salad type (100g).

For these reasons above, these cultivars are potentially useful to Jamaica's tomato production. These preliminary investigation were carried out to determine their adaptability to Jamaican conditions, specifically these at Bodles Research Station.

MATERIALS AND METHODS

The experiments were conducted at Bodles Agricultural Research Station, St. Catherine; located 17° 56' N; 77° 80' W and 35m above sea level. The soil is Bodles Clay Loam (No. 217) with moderate drainage and high moisture retaining capacity (Cries, 1982).

Alafua Early, Alafua Winner, Alafua Large, Tomatoll, three cultivars - Gemstar, Floradade and Tropic were transplanted on the 9th July 1977 in trial 1. Gemstar and Gempear were planted along with Alafua Early, Alafua winner, Alafua Large and tomatoll on the 5th January 1998 in trial 2. A completed Randomized Block design with four replicates was used. Plots were 3m x 2.7m and plants spaced at 1m x 0.3m. There were 28 experimental plots in trial 1 and 30 experimental plots in trial 2 with 30 plants in each plot.

Once established, the plants were fertilized once every three weeks with N-P-K 8-21-32 at 12.5g per plant. Irrigation was done twice weekly and pest control implemented when advised by the Plant Protection division of the Bodles Research Station. On fruiting, a mixture of Muriate of Potash and Sulphate of Ammonia in a 1:1 ratio was added at a rate of 10g per plant. Irrigation was then done once weekly. Harvesting began on the 11th September 1997 for trial 1 and on the 16th March, 1998 for trial 2 and lasted five weeks.

Data collected from both experiments include days to 20% flowering, fruit weight, yield, pest incidences and average daily temperatures.

RESULTS

Flowering

All cultivars except Tropic and Floradade flowered within 30 days after transplanting (Table 1a).

Table 1a. Tomato Cultivars and Days to 20% Flowering.

CULTIVARS	TRIAL #1 July - October	TRIAL #2 January - April
Alafua Large	30	>30
Alafua Winner	27	20
Alafua Early	27	13
Tomatoll	14	30
Gemstar	15	10
Floradade	>30	-
Tropic	>30	-
Gempear	-	>30

Early, Medium and late maturity was determined using flowering data (Table 1b.)

Table 1b. Observed and Expected Maturities ot Tomato Cultivars for Trials 1 and 2.

Cultivars	Trial 1	Trial 2	Expected
Alfua Large	Late	Late	Late
Alfua Winner	Medium	Medium	Medium
Alfua Early	Medium	Early	Early
Tomatoll	Early	Medium	N/A
Gemstar	Early	Early	Medium
Floradade	Late	N/A	Medium-late
Tropic	Late	N/A	Medium-late
Gempear	N/A	Late	Medium

YIELD

Five harvests per trial were achieved. Alafua Winner was the highest yielder followed by Tomatoll (Table 2) in trial 1. Gemstar and Alafua Winner were the highest yielders in trial 2.

Pests

Upward and downward curling of leaves, chlorosis along leaf margin of young leaves, flower abscission and stunted plant growth were noticed on some tomato plants approximately 33 days after transplanting in the first trial. Leaves were collected from plants in a non-random sampling technique and taken to the Biotechnology Unit of the University of the West Indies. The above mentioned symptoms were later confirmed to be that of the Tomato Yellow Leaf Curl Virus (TYLCV). The presence of the TYLC Virus was first noted in the Tomatoll

cultivars 33 days after transplanting. The virus proceeded to spread to other cultivars with levels as high as 90% in some cases in trial 1 (Table 3). Virus incidence was lower in trial 2.

Table 2. Mean Yield of Seven Tomato Cultivars per (8.4m²) Plot for Trials 1 and 2.

Cultivars	Trial #1 July - October	Trial #2 January - April
Alafua Large	5.088	18.400
Alafua Winner	11.450	27.200
Alafua Early	3.190	24.900
Tomatoll	8.638	25.100
Gemstar	3.944	31.900
Floradade	0	N/A
Tropic	0	N/A
Gempear	N/A	23.900

Fruit Weight

Fruit was determined with gross yield (kg) and the number of fruits harvested (Table 4.)

Average Daily Temperatures

Daily temperatures were taken from the local meteorological station at Bodles Research Station.

Table 3. Percentage TYCL Virus incidence in tomato cultivars for trials 1 and 2.

Cultivar	Trial #1	Trial #2
Alafua Large	86.0	12.5
Alafua Winner	88.0	25.4
Alafua Early	65.0	40.5
Tomatoll	90.0	17.9
Gemstar	63.0	<5.0
Floradade	>90.0	N/A
Tropic	>90.0	N/A
Gempear	N/A	0

DISCUSSION

Flowering

The tomato cultivars were grouped into early, medium and late maturity based on the flowering data (Table 1b). This was then compared with the expected maturities based on information received about the cultivars. All cultivars excepting Alafua large and Alafua Winner showed slight variations from their expected maturities.

Table 4. Fruit Weights/g (Observed and Expected) of Tomato Cultivars.

Cultivars	Observed		Expected
	Trial 1	Trial 2	
Alafua Large	46-53	156	76
Alafua Winner	38-50	102	52
Alafua Early	20-25	39	25
Tomatoll	25-36	70	37
Floradade	0	-	medium/large
Tropic	0	-	large
Gemstar	56-75	138	100-150
Gempear	0	195	80-90

Table 5. Daily Temperatures (°C) During Seasons of Trials 1 and 2.

Trial 1			Trial 2		
Month	Max	Min	Month	Max	Min
July	33.5	22.0	January	31.1	19.5
August	34.0	22.5	February	30.5	18.8
September	32.1	22.7	March	-	-
October	-	-	April	31.3	20.3

Yield

Alafua Winner and Tomatoll, two of the AVRDC cultivars were the best yielding cultivars in trial 1. They showed significant differences ($p < 0.001$) in yield from the other cultivars. There were no significant differences($p=0.213$) in yield among cultivars in trial 2.

There are obvious differences in yield performance between trials with trial 2 showing much higher yields. This may be attributed to climatic differences. Messiaen (1992) pointed out that June plantings of tomato gave poor results especially if diurnal temperature differences are less than 10° C.

In trial 1, diurnal temperature differences gradually decreased to less than 10° C (Table 5). This appears to be a reason for the overall poor yields as compared to trial 2 where diurnal temperature differences were 10-12° C - considered best for plant growth and flowering (Messiaen, 1992). Fruit set of solanaceous crops decrease as day temperatures as high as (Messiaen,1992).Trial 1 had average day temperatures as high as 34° C- this could be another supporting factor for lower yields in trial 1. The AVRDC cultivars reputed heat tolerant did better in trial 2 - a somewhat cooler season. The cultivar Alafua Winner was the eonsistent high yielder.

Fruit Weight

Fruit weighty, with the exception of Alafua large was close to the expected for trial 1 (Table 4) but far exceeded them in trial 2.

Pests

The incidence of TYLCV varied among cultivars and between trials. The higher TYLCV incidence occurred in trial 1, was due to a higher vector population at that time of the year; as confirmed by the Biotechnology Unit of the University of the West Indies. Floradade and Tropic were the only cultivars that appeared to have been affected by the virus as they did not set fruit. Yields for the other cultivars appeared not to be affected as fruits were borne on even the most dwarfed virus stricken plants

Few cases of Bacterial leaf spot (*Xanthomonas vesicatoria*) were observed. An Isopod commonly known as the sow bug was isolated from specimens showing a wilted appearance. The fungus Fusarium was also detected but only as a secondary pathogen. There were no cases of Bacterial Wilt. Repeat trials to confirm results are in order. These trials should include shelf life assessments.

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THE INFLUENCE OF MULCH TYPE ON YIELD OF PARSLEY AND CHIVE PRODUCTION IN THE U.S. VIRGIN ISLANDS.

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ABSTRACT

Studies were conducted to compare the effects of various mulch types on the growth and yield of parsley (*Petroselinum sativum*) and chives (*Allium schoenoprasum L.*). The mulch treatments were black fabric (weed barrier), silver plastic, white plastic, grass straw and a non-mulch bare treatment. Data on plant height, fresh and dry matter yields were collected for each crop at harvest. Weed population and weed weight were determined before each weeding operation, which was usually performed weekly. Results for both crops indicated that all mulches significantly reduced the number and biomass of weeds compared with the plots without mulch. The various mulch types also significantly influenced plant height, total fresh yields and dry matter yields. The straw mulch plots consistently produced higher yields of both fresh and dry parsley and chives. Production of chives from the white plastic mulch plots was the lowest of all the mulches and were similar to the plots without mulch. The results of these studies indicate that the use of locally available grass (straw) as mulch has potential for increasing production of parsley and chives in the Virgin Islands.

INTRODUCTION

Culinary herbs are important horticultural crops in the USVI. These crops are a major source of income for the many small-scale growers in St. Thomas and St. Croix. Because of their economic importance there is still a great need to conduct more research to provide information on ways to improve field production, processing and marketing of these crops.

Culinary herbs are grown and marketed fresh or dry. The preference in the local markets is for the fresh product but there is also a market for dried herbs. Additionally, as production increases and exceeds local demand is exported preferably in the dried form.

Substantial quantities of dried culinary herbs are imported annually into the USA Estimates by the USDA Foreign Agricultural Service showed that more than $349 million of dried condiments, seasonings and flavorings were imported into the USA in 1988 (USDA, 1989). In recent years, consumption of culinary herbs and spices has steadily increased in the USA. The trend of increased consumption of fresh, frozen, processed and dried culinary herbs and spices by Americans continues (Simon, 1990, Buzzanell and Gray, 1997). Factors that account for increased consumption include the rapid growth of the health food industry, interest in new foods and tastes, availability of more fresh herbs, advertising, and the expanding ethnic populations who crave for the foods and flavorings of their homeland.

The Caribbean Islands, including the USVI, have demonstrated the potential for commercial production of herbs and spices but more focused research needs to be conducted for improving the production capability. The need exists for the development of sustainable crop management practices, including to improve production levels and enhance culinary herb production through the use of organic mulches, composts, green manures, intercropping and micro-irrigation.

Mulches are used to suppress weeds, reduce erosion, conserve soil moisture and modify soil temperature and structure and improve aeration. The use of plastic mulches to control weeds is well documented. Palada et al., reported that plots of basil mulched with synthetic mulches had a smaller weed biomass expressed as dry weight

than did the plots with organic mulches or without mulch. Organic mulches have, however, been found to be beneficial in weed control. Municipal solid waste compost was found to have potential as a viable mulch for weed control in vegetable crop alleys by (Roe et al., 1993). The benefits of weed control by mulches translate into savings of energy, labor, water and herbicides. Plastic film (polyethylene) mulches are the most commonly used mulch in the USVI. Black plastic mulch is popular among growers because it is easily available and has excellent weed control properties. A drawback to its use is the elevation in soil temperature, which though desirable in temperate areas, may not be beneficial to all crops grown in the tropical USVI.

Concern for the environment has been the main factor causing the focused attention on the use of environmentally sound farming systems. The use of organic mulches and manures is a significant feature in such systems. Organic mulches such as straw acts to buffer soil temperature whereas synthetic mulches permit more divergent temperature fluctuations (Ashworth and Harrison, 1983). Palada et al., (1995) reported that organic mulches were found to reduce the daytime temperature of the surface soil, 0-15 cm, by 2-6°C more when compared with synthetic mulches and 1-4oC more, compared to bare soil in the USVI.

Organic mulches provide additional benefits compared to synthetic mulches because they add organic matter and nutrients to the soil as they decompose. Following harvest of the crop they can be incorporated into the soil. This results in enhanced soil fertility and aeration. In a study evaluating two organic and six synthetic mulches, Ashworth and Harrison (1983) found that no single mulch produced consistently higher plant yield or better growth in a temperate environment. The organic mulches reduced the range of diurnal temperature changes and maintained cooler temperatures from noon until evening.

The use of polyethylene in the Virgin Islands has some drawbacks. Because it has to be imported, it is expensive and not always readily available. There is also the environmental concern regarding the disposal of used polyethylene mulch. This task has been reported to be an unpleasant job that adds to the farms labor cost (Anderson et al., 1995). It adds to the landfill and may also leave unsightly litter on the farm.

Research conducted on culinary herbs in the USVI has provided some indications of responses to mulching. The application of black polyethylene mulch in combination with microirrigation resulted in reduced yields of thyme from the mulched treatments due to a higher incidence of soil borne diseases (Collingwood et al., 1991; Palada et al., 1993a). In a comparison of synthetic and organic mulches Palada et al., (1995 and 1993b) reported positive responses from the use of organic mulches. Ram and Kumar (1997) obtained yield improvement of mint (*Mentha arvenis*) by the recycling of organic wastes (distillation wastes, pea straw and farmyard manure) as mulch.

In a comparison of black plastic, ground newspaper and wood chips on collard production, it was found that mulch type significantly affected collard yield. Fall collard yields were highest under bare ground or wood chips and spring yields were highest under black plastic (Guertal and Edwards, 1996). Tindall et al., (1991) compared the effect of mulch type (black plastic mesh and straw) and microirrigation on soil physical properties and growth of tomatoes in Georgia. Straw mulch resulted in a significantly greater water infiltration rate, and lower pH, bulk density, surface evaporation, soil temperature and matric potential than the plastic mulch. Yields were higher under the straw mulch compared to the plastic mulch. They concluded that straw mulches have the potential to improve tomato yields in high temperature environments, provided soil pH is controlled.

The objectives of this study were to determine the effect of various mulches on yield of chives and parsley; and observe the influence of mulches on weed growth.

MATERIALS AND METHODS

The study was conducted on the farm of a local grower in St. Croix, USVI. The soil is a Glynn gravelly loam (clayey, skeletal, mixed, superactive, isohyperthermic, typic, argiustoll). Treatments consisted of white on black polyethylene mulch, black fabric weed barrier, silver plastic film, grass mulch (hay) and a non-mulched bare

soil treatment. All treatments included the application of microirrigation. The irrigation system was comprised of 15mm polyhose submains (Hardie Irrigation, El Cajon, CA) and laterals of 15ml New Hardie Tape with laser drilled orifices spaced 30 cm apart.

The experiment was established using randomized complete blocks with four replications. Each treatment plot was 1.2 m x 3.6 m, consisting of three rows 0.4 m apart. Plants were spaced 0.3 m within the rows. All plots were drip-irrigated to maintain soil moisture at 30 kPa. Tensiometers (Irrometer, Riverside, CA) were installed in each plot of two of the four replications. The grass mulch was applied to the soil surface in a 10cm layer.

All plots were hand weeded when necessary, usually on a weekly basis. Prior to each weeding operation weed samples were taken from the same area that would be used to obtain the harvest yield data. The fresh weight of the weed biomass was recorded and the samples were oven dried for dry matter determination.

Fertilizer was applied to all treatments at the rate of 100 kg N, 50 kg P and 50 kg K.ha^{-1}. Cow manure was used to provide 50 % of the N and ammonium sulfate, triple super phosphate and sulphate of potash to complete the required amounts of nutrients. Individual chive tillers were transplanted on December 23rd, 1996 and harvested on March 27th, 1997. Parsley seedlings were transplanted on March 27th, 1997, immediately following the harvesting of the chives. The parsley was harvested on May 30th, 1997. The data collected at harvest were plant height and fresh weight. The harvested materials were then placed in an oven at 65 °C and dried to a constant weight for dry matter determination.

RESULTS AND DISCUSSION

The plots were weeded on a regular basis which prevented weed seedlings from getting big enough to accumulate any appreciable biomass. The weed population data gives an indication of potential weeds that would be encountered if plots were not weeded as often as they were in this trial.

Problems were encountered regarding the use of the silver mulch. A combination of rainfall and high temperatures caused this mulch to lose the silver coating on a large percentage of the surface area. This caused light penetration through the transparent areas of the mulch and contributed to a high weed population under the plastic mulch in the chives trial. The mulch also started deteriorating before the trial was terminated. Prior to planting the parsley the silver plastic mulch was replaced and the loss of coating problem was less severe during the dry season and the shorter duration of this trial.

The chives suffered from a severe infestation of onion thrips (*Thrips tabaci*) and a root knot nematode problem developed during the latter stages of the parsley trial. A higher nematode infestation was observed in the synthetic mulch plots probably indicating that these mulches create a micro-environment that is ideal for the development of nematodes.

Table 1. Plant height (cm), fresh and dry yield (t.ha^{-1}) of chives grown with various mulches in the Virgin Islands.

Mulch Type	Plant Height	Fresh Wt.	Dry Wt.
Bare	43.6 c[z]	8.6 b	1.1 c
Weed Barrier	49.4 ab	12.3 ab	1.5 abc
Silver Plastic	46.0 bc	11.8 ab	1.6 ab
Straw	51.9 a	15.2 a	1.9 a
White Plastic	40.7 c	9.8 b	1.3 c

[z] Within columns, means followed by the different letters are significantly different by the LSD test (P≤ 0.05).

Chives

The application of mulches significantly (P≤ 0.05) affected plant height and the production of fresh and dried chives. Chives from the straw mulched plots with a mean height of 51.9 cm, were significantly taller than plants from all other treatments except weed barrier (Table 1). The shortest plants were from the white plastic mulch and bare soil plots.

The straw mulched plots produced the highest yield of fresh and dry chives. The yield of fresh and dried chives of 15.2 and 1.9 $t.ha^{-1}$, respectively from the straw mulched plots was significantly ($P \leq 0.05$) higher than yields from the white plastic mulched plots (9.8 and 1.3 $t.ha^{-1}$) and the plots without mulch (8.6 and 1.1 $t.ha^{-1}$). The 1.6 $t.ha^{-1}$ of dried chives from plots mulched with silver plastic was also significantly higher than from both the white plastic and bare soil treatments. These results indicate that grass straw used as a mulch may provide a more suitable environment for the growth of chives in the USVI than does white plastic. Despite the problems mentioned encountered with the silver mulch chive production from this treatment was similar to the straw mulch.

Table 2. Weed count ($\#/m^2$) and weed fresh and dry weight ($g.m^{-2}$) from chive plots grown with various mulches in the Virgin Islands.

Mulch Type	Number of	Fresh Wt. weeds	Dry Wt.
Bare	256 a'	936 a	233 a
Weed Barrier	32 c	65 c	11 b
Silver Plastic	62 b	329 b	67 b
Straw	48 bc	94 bc	19 b
White Plastic	27 c	38 c	7 b

' Within columns, means followed by the different letters are significantly different by the LSD test (P≤ 0.05).

The data in Table 2 show that mulching substantially reduced the number of weeds that occurred in each treatment. All mulched plots had a significantly (P? 0.05) lower number of weeds with less fresh and dry weed biomass than the plots without mulch, which had an accumulated weed count of $256/m^2$. The weed barrier and white plastic mulched plots had fewer weeds and a lower fresh biomass of weeds than plots with the silver plastic mulch. The dry weed biomass was similar for all mulch treatments. The performance of black colored mulches in controlling weeds was evident in this trial, as both the black weed barrier and the white on black plastic mulch were the most effective in controlling weeds. However, the ability of the straw mulch to control weeds was statistically similar to both mulches.

Parsley

The height of the parsley plants was affected by the application of mulches. Plants grown under the straw mulch, with a mean height of 26.2 cm were significantly (P? 0.05) taller than from all other treatments (Table 3). Parsley grown with the weed barrier mulch were taller (23.6 cm) than those grown in plots without mulch. The fresh parsley yield of 3392 $kg.ha^{-1}$ obtained from the straw mulched plots was significantly superior to the yield from the weed barrier plots which produced 2763 $kg.ha^{-1}$ (Table 3).

Table 3. Plant height (cm), fresh and dry yield (kg.ha^{-1}) of parsley grown with various mulches in the Virgin Islands.

Mulch Type	Plant Height	Fresh Wt.	Dry Wt.
Bare	20.8 c[z]	3125 ab	718 b
Weed Barrier	23.6 b	2763 b	622 b
Silver Plastic	21.4 bc	3392 ab	764 b
Straw	26.2 a	4858 a	1065 a
White Plastic	21.6 bc	3163 ab	695 b

[z] Within columns, means followed by the different letters are significantly different by the LSD test (P? 0.05).

The straw mulch plots also yielded the highest quantity of dried parsley (1065 kg.ha^{-1}). This amount was significantly higher than was obtained from all other plots. The yield responses obtained from this parsley trial has some similarities to those reported by Crossman et al., 1997 when they conducted an identical trial at a different location.

Table 4. Weed count (#/m^2) and weed fresh and dry yield (g.m^{-2}) from parsley plots grown with various mulches in the Virgin Islands.

Mulch Type	Number of weeds	Fresh Wt.	Dry Wt.
Bare	173 a[z]	32 a	10.0 a
Weed Barrier	23 b	5 b	2.0 b
Silver Plastic	5 b	1 b	0.6 b
Straw	23 b	8 b	3.0 b
White Plastic	7 b	1 b	0.2 b

[z] Within columns, means followed by the different letters are significantly different by the LSD test (P? 0.05).

The data in Table 4, shows that the application of mulches are beneficial in the control of weeds when growing parsley. The plots with mulch had a significantly (P? 0.05) lower amount of weed than all of the bare soil treatment. There was no significant differences between mulches for any of the parameters measured.

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PRODUCING POTTED POINSETTIAS FOR CHRISTMAS IN THE VIRGIN ISLANDS.

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ABSTRACT

Both local poinsettia (Xmas snowflake, *Euphorbia leucocephala* Lotsy) and the traditional imported poinsettia (*E. pulcherrima* Willd) can be produced as potted plants for Christmas in the U.S. Virgin Islands. Xmas snowflakes can be grown from seed in August and forced to flower by December 19 using a combination of pruning and Cycocel drench at 3000ppm. No imposed photoperiod is required thus reducing cost of production. Traditional poinsettia of the 'Annette Hegg' type can also be forced but require the application of much more potent growth retardants and the imposition of short days if they are to flower in time for the Xmas market. The Red 'AH' required the application of Uniconazole (UZ) at 0.25mg.liter^{-1} for the production of the most attractive plants while the White 'AH' flowered best when treated with Paclobutrazol (PZ) at 1mg.liter^{-1}. The 'AH' types necessitated the imposition of artificial short days from 8am to 5pm using black shade cloth starting on November 1 for optimum bract development and coloration.

INTRODUCTION

Both Christmas Snowflake, *Euphorbia leucocephala* Lotsy, (Standley and Steyermark, 1949) and traditional poinsettias *Euphorbia pulcherrima* Willd are common landscape plants found throughout the Caribbean (Hawkes, 1974) where the warm tropical weather and high light intensity encourages rapid growth with consequent large flowering plants at Christmas time. Although well adapted to this area of the world, virtually all potted poinsettias are imported in the USVI and most of the Caribbean islands. Production of potted plants can be a vital import substitute and save on foreign exchange. Poinsettia size can be controlled culturally by pruning or by propagating plants late in the year using short cuttings. However the use of plant growth regulators (PGR), particularly growth retardants, provides a more efficient and less costly method of dwarfing poinsettias and producing potted plants. There are several reports on the use of PGRs on poinsettias (Bailey and Miller, 1991; Lewis, 1983; MacDaniel, 1986), but only few reported in the Caribbean (Ruiz-Sifre, 1995). The efficacy of growth retardants varies with the method of application (Barret and Bartuska, 1982). Cycocel soil drenches were more effective than sprays when applied to Mikkelsen cvs (Larson, 1967). Similarly Sumagic root-zone soak was an effective application method for this growth retardant in 'Annette Hegg' poinsettia (Bearce and Singha, 1992).

Cycocel soil drench retarded poinsettia growth more than cycocel or SADH sprays but reduced bract size slightly (Joiner and Sheehan, 1964). A nine-hour photoperiod was found adequate for full bract development in 'Paul Mikkelsen' poinsettia (Joiner and Sheehan, 1967). Cycocel sprays in concentrations higher than 1000 ppm, caused chlorosis, but soil drenches of up to 5000 ppm did not show any deleterious effects (Conover and Vines, 1972).

Ancymidol has been used to reduce height and flowering in many floricultural crops (Furuta et al., 1982; Tjia, 1987). Spray and drench treatments were effective on 18 Mikkelsen poinsettia cultivars but a 0.5 ml/l drench at 25 ml/pot, applied nine weeks before flowering, was the most effective treatment (Coorts and Schraader, 1971). Concentrations of up to 0.25 mg ai/15 cm pot applied as soil drenches at or two weeks after flower bud initiation gave optimum height reduction (Tjia and Buxton, 1973). Although terminal stem cuttings of Christmas snowflakes were difficult to root, both Cycocel and Ancymidol were effective in reducing plant height and increasing flower production (Ramcharan et al., 1975).

This paper reports on two experiments on growing local and traditional poinsettias using growth retardant

chemical. The first experiment was designed to determine the effects of soil drenches of Cycocel and Ancymidol on growth and flowering of Christmas snowflakes started from seeds and grown under greenhouse conditions and normal year-end photoperiods in St.Croix, USVI. The second was conducted to determine the efficacy of 7 growth retardant drench treatments in conjunction with photoperiod manipulation on 'Hegg' dark red and white poinsettias, a traditionally imported cultivar.

MATERIALS AND METHODS

Experiment 1:

Five- to 7.5-cm seedlings of Christmas snowflakes were collected in April and potted into 10-cm diameter pots using Metro Mix 500 growth medium (W.R. Grace and Co., Cambridge MA). Plants were kept in a 53% shade greenhouse and transplanted into 15-cm diameter pots in August at the University of the Virgin Islands Agricultural Experiment Station (UVIAES) St.Croix, USVI. Plants were watered daily and fertilized biweekly with a soluble 20N-8.8P_2O_5-16.6K_2O fertilizer at 150ppm N.

A randomized complete block design experiment with six replicates and each pot representing an experimental unit was set up October 1. Growth retardant treatments applied as soil drenches were: 0.125, 0.25, 0.50 mg ai ancymidol(ARest)/pot (A1, A2, A3 respectively), 1500, 3000, 6000 ppm 11.8% cycocel (Chlormequat)(C1, C2, C3 respectively) and an untreated control. Fertilizer as described above was applied until the last week in November when floral initiation was observed.

Measurements taken at the end of the experiment on Dec 19, were plant height, plant size (height + width)/2, bract size (length x width), number of cyathia and a visual grading of 1 to 10 based on plant size, compactness and floriferousness. Data was analyzed by ANOVA method and treatment means were separated by Duncan's New Multiple Range Test.

Experiment II:

This investigation evaluated the potential of producing traditional poinsettia as a Christmas pot crop in the U.S. Virgin Islands by manipulating photoperiod in conjunction with the application of Cycocel, Bonzi (Paclobutrazol) and Sumagic (Uniconazole) plant growth retardants (GR).

Rooted cuttings (7.5 - 10 cm) of 'Annette Hegg' dark red and white poinsettias were potted, 3 per 1.3 liter (15cm diam) pot, on September 13 and placed in a greenhouse under 47% light exclusion shade cloth. Rooting medium consisted of promix and sand (1:1 v/v) and plants were fertilized biweekly with a 20N-10K-20P liquid fertilizer (Peters Fertilizer Products, PA). Vegetative growth was maintained by the use of incandescent light from 2200 to 0200 Hr daily starting September 30. Short days were imposed on November 1 using black shade cloth over plants from 1700 to 0800 Hr daily for the remainder of the experiment. Ambient temperatures averaged 28°C during the day and 22°C at nights during the experimental period. Light intensity varied from 1000-2000 foot candles. Plants were not pinched and Growth Retardant treatments were applied on October 15. Treatments were Cycocel at 1500 (C1) and 3000 (C2) mg.liter^{-1}, Bonzi at 1.0 (B1) and 1.5 (B2) mg.liter^{-1} and Sumagic at 0.25 (S1) and 0.375 (S2) mg.liter^{-1}. Each pot was drenched with 150 ml of appropriate treatment solution.

Plant height was recorded from the top rim of the pot to the plant apex initially and to the top of the bract canopy at the end of the experiment on Dec 19. The differences were used to calculate plant height increment.

Plant width was recorded as the average of the two widest plant canopy diameters. Bract size was calculated as length x width of 3 randomly chosen bracts/pot and each pot with 3 plants was graded visually on a 0 to 10 scale where 0 represented a non flowering, non-compact plant and 10 a highly floriferous, deep colored compact plant. The experiment was conducted using a completely randomized block design and data analyzed by ANOVA.

RESULTS AND DISCUSSION

Experiment 1:

Ancymidol reduced plant height and size more effectively than cycocel with only the highest concn. of cycocel (C3) reducing plant height over the control (Table 1). Growth was reduced in proportion to increased concn. of ancymidol with a 13% and 19% reduction in plant height and size respectively effected by the A3 treatment. The C3 cycocel treatment reduced plant height by 17 % but did not affect plant size. This suggested that while ancymidol retarded both vertical and horizontal stem elongation cycocel apparently affected only vertical growth.

Both growth retardants increased flowering as reflected by the number of cyathia (Table 1). Again there was a proportional increase in flowering with increasing concentration of ancymidol with the A3 treatment inducing five times the number of cyathia and more basal flowers than in untreated plants. Unlike the ancymidol treatments, the medium (C2) and not the highest concentration of cycocel (C3) induced more flowers than in control plants with no significant differences between the C2 and C3 treatments. Individual bract size was increased almost three-fold over that in control plants by the highest concentrations of both growth retardants. While all ancymidol treatments induced larger bracts only C2 and C3 of the cycocel drenches had increasing effects on bract size.

It was therefore apparent that while ancymidol increased flowering and bract size at the expense of vegetative growth cycocel increased flowering but not necessarily at the expense of shoot growth.

Table 1. Effect of Ancymidol and Cycocel soil drenches on Growth, Flowering and Quality of Christmas Snowflake, *Euphorbia leucocephala* Lotsy.

Treatments	Plant Ht.	Plant Size[1]	No. Cyathia (cm)	Bract Size[2] (cm)	Visual Grade[3] (cm^2)
Control	22.4a[4]	22.0a	54a	0.22a	2.7a
Ancymidol					
A1 (0.125 mg)	20.2ab	19.2b	126b	0.37b	3.5b
A2 (0.25 mg)	18.0b	18.1b	164bc	0.39b	5.4c
A3 (0.50 mg)	19.5b	17.9b	264d	0.65c	5.9c
Cycocel					
C1 (1500 ppm)	23.0a	22.6a	134b	0.20a	4.4b
C2 (3000 ppm)	22.4a	21.5a	209cd	0.36b	6.6d
C3 (6000 ppm)	19.0b	19.8ab	162bc	0.60c	5.5c

[1]. Calculated from (H+W)/2
[2]. Calculated from length x width
[3]. Graded on a 1 to 10 basis; 1 = Plant with extended growth, few flowers and non-compact appearance. 10 = Floriferous plant with deep white bracts, non-chlorotic foliage and compact uniform appearance
[4]. Means followed by the same letter in a column are not significantly different at $p \geq 0.05$ according to Duncan's Multiple Range Test.

All growth retardant drenches resulted in improved visual appearance of plants over non-treated controls with the medium and highest concentrations producing the better plants. Untreated plants or those receiving the lowest concentrations of growth retardant were generally non-compact, leggy and had relatively fewer flowers that were incomplete or greenish-white with small bracts. Such plants were more susceptible to breakage and their later flowering would necessitate earlier potting and more pruning to get the desired effect of chemically-treated plants. It was difficult to visually differentiate between A2-, A3-, C2- and C3-treated plants although

ancymidol tended to produce smaller plants overall particularly at the A3 level. The C2- treated plants were significantly more attractive because of their increased floriferousness, compact shape and non-chlorotic leaves. Although this cycocel treatment did not reduce plant size over untreated plants, it apparently induced increased branching and together with the increased flowering and bract size effect produced the highest visual impact. In an earlier study (8), ancymidol at 0.125 mg ai was found to produce the highest quality plants but these were forced in 7.5-cm pots and plants were started from terminal tip cuttings under climatic conditions in Gainesville, Florida.

Experiment II:

Dark Red Poinsettia: All Growth Retardant treatments resulted in shorter plants than the controls (Table 2) with the higher concs. of each treatment reducing height more than the lower. Several researchers (have reported sumagic as the most effective height controlling compound for poinsettias. In this trial sumagic also effectively controlled plant height with the S1 conc. just as effective as the C2 cycocel and the B2 bonzi treatments. At S2 level, sumagic reduced plant height almost 4 times as the non-treated controls. Although plant width was not as highly affected as height, sumagic also appeared to be the most effective growth retardant. Bract size was correspondingly increased by all growth retardant treatments over controls. The largest bracts were induced by the S1 sumagic treatment with some reduction at the higher S2 conc. Because of plant size reduction with increased flower size, and numbers, sumagic-treated plants had higher visual grades over controls. Cycocel-treated plants were less compact than other treated plants and their visual impact was further decreased by slight chlorosis of leaves and bracts. Although a higher concentration of cycocel might be used to further reduce plant size and increase bract width thus increasing attractiveness, it may also simultaneously increase chlorosis. Bonzi-treated plants were compact with large-sized bracts but this growth retardant also induced leaf chlorosis and incomplete bract coloration thus negatively affecting visual impact. At the S1 level sumagic did produce higher quality plants with the largest and deepest-colored red bracts, and most compact plants. Unlike other growth retardants, sumagic did not induce any visible chlorotic effects but resulted in plants with deeper green leaves which could be quantified by chlorophyll and or leaf photosynthesis measurements in future experiments. The S1 application therefore appeared to be optimum for dark red Hegg poinsettia; at S2 level, visual grade was lowered due to over reduction of plant, leaf and bract size. This often led to large gaps between individual plants in pots, which also contributed to reduced visual impact.

White Hegg Poinsettia: Like the red poinsettias, all growth retardants reduced plant height over controls (Table 1) with the higher concentrations of cycocel and bonzi more effective than the lower levels.

Cycocel at C2, Bonzi at B2 and Sumagic at both levels had similar height-reducing effects with a 6x-7x decrease over control plants. Diametric size of plants were also similarly reduced but with the sumagic treatments most effective. This indicated that the white poinsettias were generally more responsive to growth retardant treats than the red cultivar with growth retardant effects on elongation of both terminals and axillary branches being affected. This growth retardation was also evidenced in bract-size reduction where all growth retardants produced bracts equal to or smaller than in control plants. The higher levels of cycocel and sumagic were particularly effective in this aspect. However this flower inhibiting effect of cycocel and sumagic was a major factor in decreasing their visual impact and hence overall quality of white plants drenched with these compounds. As with the red cultivar, cycocel also induced leaf chlorosis and sumagic at its higher concenttration caused over-reduced plant size in the white cultivar. Because of its reducing effect on plant size without simultaneously affecting bract width and chlorosis, bonzi appeared to produce the best quality white poinsettias and therefore a more appropriate growth retarding agent for the white poinsettias vs the red cultivar.

SUMMARY AND CONCLUSIONS

The results of these experiments indicated that Christmas snowflake started from seedlings can be tailored as a pot crop using the growth retarding chemicals Ancymidol or Cycocel. Seedlings collected under stock plants

in April, an transplanted to 15-cm pots in August and grown under greenhouse conditions can be treated with growth retardant drenches in October for flower production by December 19. Although ancymidol retarded

Table 2. Effects of 7 GR drench treatments on Growth, Flowering and Quality of 'Hegg' Red and White Poinsettia on St.Croix, USVI.

Treatments	Ht.Incr. cm	Wi.Incr. cm	Bract Size[x] cm^2	Visual Grade[y]
	Dark Red			
Control	28.5a[z]	13.6ab	24.3a	3.6a
Cycocel ($mg.liter^{-1}$)				
1500 C1	19.1b	20.9a	41.8bc	4.7b
3000 C2	12.3c	11.9b	30.0ab	4.8b
Paclobutrazol ($mg.liter^{-1}$)				
1.0 B1	16.6b	14.1ab	37.8b	7.1c
1.5 B2	12.2c	12.2b	48.2c	6 8c
Uniconazole ($mg.liter^{-1}$)				
0.25 S1	14.7bc	11.8b	57.5d	8.6d
0.37 S2	7.4d	8.1b	41.7bc	7.2c
	White			
Control	46.7a	35.3a	64.6a	3.0a
Cycocel ($mg.liter^{-1}$)				
1500 C1	17.2b	18.2b	54.3b	6.7bc
3000 C2	9.6c	13.8c	39.7c	5.7b
Paclobutrazol ($mg.liter^{-1}$)				
1.0 B1	20.6b	22.6b	59.4ab	7.7c
1.5 B2	8.5c	12.0c	68.9a	7.5c
Uniconazol ($mg.liter^{-1}$)				
0.25 S1	8.3c	7.1d	59.1ab	6.7bc
0.37 S2	10.5c	9.1cd	44.3c	7.3c

x. Calculated from length x width of bract.

y. Based on 1 - non-flowering, leggy non-compact plant
10 - floriferous, deep-colored, compact plant

z. Means followed by the same letter within a column for each cultivar are not significantly different at $p \geq .05$ according to Duncans New Multiple Range Test.

plant growth more effectively both chemicals increased flowering, bract size and color over untreated plants. Cycocel at 3000 ppm produced the most attractive plants overall because of the compact nature and the non-chlorosis effect on leaves of treated plants. The growth retarding effect of these chemicals reduces the time, labor and expense involved in pruning potted plants of Christmas snowflake. The increased flowering in treated plants adds to the effectiveness of these chemicals in modifying this species as a good potential Christmas pot crop. Local production of chemically-forced plants would not only reduce the number of the traditionally imported poinsettias into the Caribbean region and the consequential foreign exchange expenditure but add a new pot crop to local industries. Potted Christmas snowflakes could also complement regular poinsettias in floral and landscape designs. With careful manipulation of photoperiod and the use of more potent growth retardants such as Paclobutrazol (Wilfret. 1981) it may even be possible to schedule flowering for Easter when white-flowering pot crops are quite popular. In the second project, short-day imposition together with growth retardants used in this investigation were generally more effective on the white Hegg than the red Hegg poinsettia. While Sumagic

at the S1 level could be recommended for the Christmas production of the red cultivar, Bonzi at the B1 level would be best recommended for the white Hegg cultivar. Future trials need to record numbers of cyathia and inflorescences, inflorescence diameter and a quality comparison made with imported flowering plants.

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PLANTING DENSITY AFFECTS GROWTH AND YIELD OF BUSH OKRA

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ABSTRACT

A field experiment was conducted to determine the optimum plant population for maximum plant yield and productivity of bush okra (*Corchorus olitorius*). Treatments consisted of two row spacings (0.30 m and 0.50 m) and three in-row or plant spacings (0.20, 0.31 and 0.41 m). These combinations resulted in plant population ranging from 49,261 to 166,667 plants per hectare. Treatments were arranged in randomized block design with three replications. Data on plant height, number of stem-branches, leaf and stem fresh weight, total plant fresh and dry matter weight, leaf area and leaf area index (LAI) were collected at harvest. On a per plant basis, results indicated a highly significant linear response ($P<0.0001$) in stem number, plant, leaf and stem fresh weight, leaf area and leaf dry matter weight to planting density. As row and plant spacings increased or planting density decreased, total plant fresh weight increased due to increasing number of stems and wider leaf area. However, LAI decreased with wider spacing and increased with closer spacing. Maximum LAI of 1.94 was attained at the highest planting density (166,667 plants.ha^{-1}). Leaf fresh yield per unit area increased as planting density increased. Highest leaf fresh yield of 453 g.m^{-2} was obtained at a spacing of 0.50 m x 0.20 m or a planting density of 98,522 plants.ha^{-1}. This treatment resulted in highest total productivity of 3.31 g.m^{-2}.d^{-1}. Results of this study indicate that a planting density of 98,522 plants.ha^{-1} would be optimum for maximum yield of bush okra.

INTRODUCTION

Bush okra is one of the popular tropical leaf vegetables in Africa, Asia and some parts of the Middle East. It is known by several common as well as vernacular names. Bush okra is also known as Jew's mallow, jute mallow or long-fruited jute as it is related to a commercial fiber jute (Martin and Ruberte, 1979). In Ghana, bush okra is known by several vernacular names such as 'singli', 'nkuruma', 'muomi pinpesi', and 'enmomi' (Tindall, 1965). In Nigeria, it is commonly known as 'krin-krin' with several local names such as 'oyo', 'eyo', 'ahu hara', 'malafiya', and 'turgunnuwà'. However, in Sierra Leone, it is called 'krenkre', 'n genge', 'n genle', 'an-kin-kiri', 'an-kirin-kirin or 'ṣoren' (Tindall, 1965). Bush okra is also popular in the Philippines and it is called 'pasaw', 'saluyot', 'tagabang' or 'taka yaka' (De Padua and Pancho, 1989).

The plant belongs to the family *Tiliaceae* and is characterized as an annual upright, branching, glabrous, slightly woody herb. Leaves are narrow and serrate, about 5-13 cm in length. Flowers are small, yellow-petioled, and borne in small clusters in the leaf axils. The cylindrical capsules of 2 to 5 cm are produced in large numbers, especially during the short days (Martin and Ruberte, 1979). Seeds are dark bluish-green, angular and about 2 mm long.

Bush okra is one of the leading leaf vegetables in West Africa and is often stored dry. It is also commonly used in Malaysia, the Philippines and parts of Latin America. It is the most important leaf vegetable in Egypt, where it is cultivated from March to November (Oomen and Grubben, 1978). The nutritional value of bush okra compares very well with other common tropical leaf vegetables. It is high in protein, fiber, calcium, iron and carotene (Table 1). The edible shoot tips and leaves are always eaten and cooked as a potherb. Their edible qualities are widely appreciated in West Africa where the shoots and leaves are combined in stews to be eaten as a starchy paste. In India the shoots are cooked with rice. Leaf infusion is considered a tonic, diuretic, demulcent and useful in cases of chronic cystitis (De Padua and Pancho, 1989; Iwu, 1993). The leaves may be dried and retained for future use, either as a tea or a cooked vegetable (Martin and Ruberte, 1979). The older leaves are high in protein, calcium and fiber content. Seeds are given as powder with honey and ginger for diarrhea and

fever (De Padua and Pancho, 1989).

Table 1. Nutritional value of tropical leaf vegetables (per 100 g edible portion).

Species	Protein(g)	Fiber(g)	Calcium(g)	Iron(g)	Carotene(g)	Ascorbic acid (mg)
Amaranth	4.8	2.4	525	6.1	6.4	65
Basella	1.6	0.6	105	1.6	3.5	85
Bush okra	5.6	1.7	270	7.7	7.9	55
Mustard green	2.4	1.0	160	2.7	1.8	75
Pakchoy	1.7	0.7	100	2.6	2.3	55
Sweet potato	3.2	1.6	85	4.5	2.7	20
Taro	4.1	1.2	160	1.1	5.5	65
Water spinach	2.7	1.1	60	2.5	2.9	45

Adapted from Oomen and Grubben, 1978.

Although bush okra is a popular leaf vegetable in many countries of the tropics, little research and development work to improve its culture and production have been reported. According to Oomen and Grubben (1978) seed yields of bush okra are low, and germination is often very poor due to dormancy which can be overcome by soaking in hot water. Leaf production is also low compared to other tropical leaf vegetables, but dry matter content is high. No studies have been reported on the effect of crop management practices such as plant spacing and fertilizer application on leaf yield and total productivity of bush okra. This study was conducted to determine the optimum plant population density for maximum yield of bush okra.

MATERIALS AND METHODS

Seeds of bush okra were sown in 72-cell Styrofoam trays containing Promix, under greenhouse conditions. Seedlings were grown for 40 days in the greenhouse and field planted on 28 February 1997. The various planting density treatments were achieved by varying the row and plant spacings. Treatments consisted of two row spacings (0.30 m and 0.50 m) and three in-row plant spacings (0.20, 0.31 and 0.41 m) for each row spacing. These combinations resulted in plant population densities equivalent to 4.9, 6.5, 8.2, 9.8, 10.9 and 16.7 plants.m^{-2}. Table 2 summarizes the row and plant spacing, area per plant, and planting density. Each treatment plot consisted of 4 rows x 4 m long. Treatments were arranged in randomized complete block with 3 replications.

Table 2. Row and plant spacing, area per plant and planting density for bush okra. UVI/AES, 1997.

Row Spacing (m)	Plant Spacing(m)	Area (m^2.plant^{-1})	Plant Density (plants.m^{-2})	Plant Density (plants.ha^{-1})
0.30	0.20	0.0609	16.7	166,667
0.30	0.31	0.0915	10.9	109,290
0.30	0.41	0.1218	8.2	82,102
0.50	0.20	0.1015	9.8	98,522
0.50	0.31	0.1525	6.6	65,574
0.50	0.41	0.2030	4.9	49,261

Plants were fertilized with 100 kg N.ha^{-1}, 50 kg P.ha^{-1} and 50 kg K.ha^{-1}. One half of the total N was provided by cow manure (2% N). All of the P and K and half of the N from cow manure were applied 2 weeks after planting. The remaining half of N fertilizer was applied after the first harvest. All plots were drip-irrigated with soil moisture tension maintained at 30 kPa as determined by soil tensiometers installed in two blocks and plots were handweeded regularly.

The plants were harvested on 15 May and 15 July. Harvest samples were taken from two middle rows consisting of 5 plants each. Stem-branches were cut with pruning shears and leaves were separated from stems. For each harvest, plant height was measured, and fresh weight of stem-branches and leaves were determined. Leaf area from 5 plants were measured using the CI-202 Area Meter (CID, Inc., Vancouver, WA). Stem and leaf samples were oven-dried to constant weight for the determination of dry matter content.

Data were analyzed using the Statistical Analysis procedures (SAS, 1989) of general linear model (GLM).

RESULTS AND DISCUSSION

Plant Height and Stem-Branches. Plant height was not significantly influenced by planting density (Table 3). However, the tallest plants (69 cm) were observed from spacing of 0.30 m x 0.41 m or a planting density of 82,102 plants.ha^{-1}. A highly significant (P<0.0001) linear response to planting density was observed in the number of stem-branches (Table 3). As row and plant spacing increased the number of stem-branches per plant increased. The number of stem-branches was highest (11.5) at spacing of 0.50 m x 0.41 m and lowest (5.85) at spacing of 0.30 m x 0.20 m. According to Martin and Ruberte (1979), plants of bush okra can reach more than a meter in height and 0.50 m in diameter. Tindall (1965) reported a height of 1.20 m at a row spacing of 46 cm. The taller plant height reported in these studies is based on plants grown for an extended period which is over 6 months. In the present study, growth duration was 5 months. The higher number of stem-branches in wider spacing can be explained by more space per plant and reduced competition.

Plant, Leaf and Stem Fresh and Dry Weight. Fresh weight of plants, leaves and stems were significantly influenced by planting density (Table 4). As row and plant spacing increased or planting density decreased, fresh

Table 3. Effect of planting density on plant height and number of stem-branches of bush okra.

Spacing (m)	Plant Density (plants.m^{-2})	Plant Height (cm)	Stem-Branches (no.plant^{-1})
0.30 x 0.20	16.7	61.2	5.85
0.30 x 0.31	10.9	63.1	7.30
0.50 x 0.20	9.8	64.1	7.79
0.30 x 0.41	8.2	69.0	6.70
0.50 x 0.31	6.6	59.1	10.71
0.50 x 0.41	4.9	66.8	11.50
Linear		NS	***
Quadratic		NS	*

*=P<0.05, ***=P<0.0001; NS=not significant

weight of plant, leaves and stems were significantly increased. This response was both linear (P<0.0001) and quadratic (P<0.05). The highest leaf fresh weight (70 g.plant^{-1}) was obtained from the widest spacing of 0.50 m x 0.406 m while the lowest leaf yield (25g.plant^{-1}) was produced from the closest spacing of 0.30 m x 0.203 m.

Similar results were observed for plant and stem fresh weight (Table 4). The data suggest that the more space the plant occupies the higher the yield. This is attributed to reduced competition for light, nutrient and soil moisture. Oomen and Grubben (1978) reported an average leaf yield of 32 g.plant^{-1} at a planting density of 25 plants.m^{-2} or 250,000 plants.ha^{-1}.

This yield is close to the yield obtained from the second highest planting density (10.9 plants.m^{-2}) used in this study. However, it is not clear whether the yield reported by Oomen and Grubben (1978) was the total of several harvests. The difference in leaf yield due to planting density is a clear indication that yield is influenced by plant spacing.

Table 4. Effect of planting density on plant, leaf and stem fresh weight of bush okra.

Spacing (m)	Plant Density (plants.m^{-2})	Fresh Weight(g)		
		Plant	Leaf	Stem
0.30 x 0.20	16.7	71.2	25.0	45.8
0.30 x 0.31	10.9	100.2	36.0	62.6
0.50 x 0.20	9.8	133.4	46.0	83.4
0.30 x 0.41	8.2	130.2	42.4	82.6
0.50 x 0.31	6.5	149.4	53.8	91.8
0.50 x 0.41	4.9	205.4	69.6	131.4
Linear		***	***	***
Quadratic		*	*	*

*=P<0.05; ***=P<0.0001

Dry weight of plants, leaves and stem-branches were also significantly influenced by planting density. The trend was similar to that observed in fresh weight (Table 5). There was a highly significant (P<0.0001) linear response in plant, leaf and stem dry weight to planting density or plant spacing. As row and plant spacing increased, total plant, leaf and stem dry weight increased. Leaf dry weight is an important parameter since some farmers dry and store the leaves for future use or for making tea.

Leaf Area and Leaf Area Index (LAI). The relationship between leaf area and leaf area index (LAI) is shown in Table 6. On a per plant basis, leaf area increased as row and plant spacing increased and this response was linear (P<0.001). This trend is similar to the response observed for plant, leaf and stem fresh and dry weight. The wider the spacing, the bigger the plant producing wider leaves. Highest leaf area (2764 cm^2) was obtained from the widest spacing (0.50 m x 0.41 m) while the lowest leaf area (1182 cm^2) was observed in the narrowest spacing (0.30 m x 0.20 m).

However, there seems to be an inverse relationship between leaf area and LAI. As leaf area per plant increases, LAI decreases (Table 6). The highest LAI of 1.94 was obtained from the highest planting density while the lower LAI of 1.31 and 1.36 were obtained from wider spacings (0.50 m x 0.31 m and 0.50 m x 0.41 m, respectively). Although the narrower spacing produced smaller plants with lower leaf area, on a per unit area basis, a factor in determining LAI, more plants in narrow spacing resulted in higher LAI. This indicates that higher

number of plants per unit area in the narrow spacing compensated for the lower leaf area per plant resulting in higher LAI.

Table 5. Dry weight of bush okra plant, leaf and stem as affected by planting density.

Spacing (m)	Plant Density (plants.m^{-2})	Fresh Weight(g)		
		Plant	Leaf	Stem
0.30 x 0.20	16.7	14.8	6.8	8.0
0.30 x 0.31	10.9	18.0	8.6	10.0
0.50 x 0.20	9.8	23.8	11.0	12.2
0.30 x 0.41	8.2	28.8	11.4	15.2
0.50 x 0.31	6.5	28.4	13.2	15.4
0.50 x 0.41	4.9	39.6	17.4	21.8
Linear		***	***	***
Quadratic		*	**	*

*=P<0.05; **=P<0.001; ***P<0.0001

Table 6. Leaf area and leaf area index (LAI) of bush okra as affected by planting density.

Spacing (m)	Plant Densit (plants.m^{-2})	Leaf Area (cm^2.plant^{-1})	Leaf Area Index (LAI)
0.30 x 0.20	16.7	1182	1.94
0.30 x 0.31	10.9	1279	1.40
0.50 x 0.20	9.8	1496	1.51
0.30 x 0.41	8.2	1836	1.47
0.50 x 0.31	6.5	1999	1.31
0.50 x 0.41	4.9	2764	1.36
Linear		**	**
Quadratic		*	NS

*=P<0.05; **=P<0.001; NS=not significant

Total Leaf Fresh Yield and Productivity. Productivity in terms of leaf yield per unit area or leaf yield per unit area per day is shown in Table 7. There is a significant (P<0.05) linear response in leaf yield and productivity to planting density, and there is a tendency for yield to increase with increasing planting density. Highest yield of 453 g.m^{-2} was obtained from planting density of 9.8 plants.m^{-2} or a plant population equivalent to 98,522 plants.ha^{-1}. At this planting density, leaf productivity was the highest (3.31 g.m^{-2}.d^{-1}). The lowest leaf yield and productivity was obtained from wider spacing and lower planting density. The data suggest that optimum planting density for maximum leaf yield and productivity of bush okra can be achieved at a spacing of 0.50 m x 0.20 m or a plant population density of 98,522 plants.ha^{-1}

Leaf yield obtained from this study is within the range (300-1000 g.m^{-2}) reported by Oomen and Grubben (1978) at a much higher plant population (250,000 plants.ha^{-1}). However, in a study on germplasm evaluation for tropical leaf vegetables, Palada et al. (1996) reported lower leaf yield and productivity (106 g.m^{-2} and 3.22 g.m^{-2}.d^{-1}, respectively) at a spacing of 0.50 m x 0.30 m. The results and effect of planting density on plant and leaf productivity obtained from the present study are consistent with results reported by Singh and Whitehead (1993) on vegetable amaranth where they concluded that yield increased quadratically as intra-row spacing decreased.

Table 7. Total leaf fresh yield and productivity of bush okra at various planting density.

Spacing (m)	Plant Density (plants.m^{-2})	Leaf Fresh Yield (g.m^{-2})	Productivity (g.m^{-2}.d^{-1})
0.30 x 0.20	16.7	410	3.00
0.30 x 0.31	10.9	392	2.87
0.50 x 0.20	9.8	453	3.31
0.30 x 0.41	8.2	348	2.54
0.50 x 0.31	6.5	352	2.57
0.50 x 0.41	4.9	342	2.50
Linear		*	*
Quadratic		NS	NS

*=P<0.05; NS=not significant.

SUMMARY AND CONCLUSIONS

This study was conducted to determine the optimum plant population density for maximum yield of bush okra. Bush okra was planted at various row and intra-row spacings resulting in six planting densities ranging from 4.9 plants.m^{-2} to 16.7 plants.m^{-2}. Results indicated that on a per plant basis, there was a linear response in fresh and dry weight of plants, leaves and stem, leaf area and number of stem-branches to increasing plant spacing. However, in terms of LAI and leaf productivity, the higher planting density resulted in higher LAI and leaf yield compared to lower planting density. For maximum leaf yield and productivity the optimum plant spacing for bush okra was achieved at 0.50 m x 0.20 m or a plant population of 98,522 plants.ha^{-1}.

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COMPARISON OF TRANSPLANTING AND DIRECT SEEDING TECHNOLOGY FOR FOUR ONION CULTIVARS

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ABSTRACT

While transplanting onions is practiced widely in tropical and temperate regions, in Jamaica this practice is uncommon as an alternative method of planting. A study was conducted at the Bodles Research Station from September 1997 to March 1998. to determine the optimum transplant age for bulb yield, and to compare yields of direct seeded and transplanted onions. Yields of the former were higher but the difference was not significant(P=0.0092).Highly significant interactions of mean yields among cultivars were found. At both transplanting dates, significantly higher percentages of double bulbs were produced with direct seeding. The survival rate of plants was highest for direct seeding (81%) and lowest for transplanting at six weeks (66%). There were significant differences between planting methods and among cultivars with respect to bulb size.

INTRODUCTION

Onion (*Allium cepa* L.) is second only to tomato in the world vegetable production and demand is generally inelastic (Chandler, 1994). It's production in Jamaica is beset by many constraints among which are: lack of irrigation water in the major producing areas, low bulb yield, poor shelf life and market competition from imported types which sell at the same price as the locally grown onions, thus, not benefiting the consumer.

Onion imports soared from US$233,000 in 1993 to US$1.3 million in 1997 (The Gleaner, March 12, 1997. Pg. A5).

Transplanting age does affect bulb yield and yield components and caution should be exercised in generalization in respect to this factor as it may vary with cultivars (Oladiran and Sangodele, 1992). Research in India has shown that differences among production methods and dates are highly significant. The transplanting method has given better results in improving bulb weight (80.5 - 441.5g) and increasing bulb yield (5.2 - 31.4t/ha) than direct seeding (20.8 - 177.8g) and (6.4 - 26.8t/ha) respectively.

Vachnani and Patel (1988) have reported a yield increase with four-week-old seedlings to seven-week-old seedlings, but then a gradual decrease with ten-week-old seedlings. Onions may either be direct seeded or transplanted, with each technology having it's advantages and disadvantages in terms of production factors (Appendix A).

Table 1.: Estimated Annual Usage of Selected Agricultural Commodities Compared With 1996 Production Levels.

Item	Estimated Annual Usage	Local % of Usage	Estimate of 1996 Production	Locally supplied Usage as % of 1996 Production
Onion	504,312 kg	56.6	4,238,000 kg	8.1

Source: Data Bank and Evaluation Division, MINAG, 1997.

The objective of this study was to establish the best age at which seedlings of four cultivars should be transplanted for optimum bulb yield and to compare yields of the direct seeding and transplanting methods.

MATERIALS AND METHODS

The experiment was conducted at the Bodles Agricultural Research Station, Old Harbour, St. Catherine, in a clay loam soil [pH=6.8; Total nitrogen = 0.17%; Troug's $P_2 0_5$ = 152 ppm; $K_2 0$ = 318 ppm]. The experimental treatments were arranged in a split plot design replicated three times. Four cultivars were used(Arad, Grandstand, Lexus, Texas).Seeds were direct seeded on September 23, 1997 and transplanting was done at four (October 21, 1997) and six weeks (November 4, 1997) after sowing.

The experimental plot size was 4.0m x 2.7m. Plant population of each plot was 240 plants with a planting distance of 0.10m (along rows) and 0.20m (between rows) being used.200kg/ha NPK(14-28-14)was incorporated a week after transplanting, 250kg/ha$(NH_4)_2SO_4$ at four weeks and 875kg/ha$(NH_4)_2SO_4$ was used as side dressing at the time of bulbing. Pest and disease control was carried out as to recommendations from the Plant Protection Division, Bodles. Other cultural practices such as irrigation, weed control and mulching were carried out as necessary. Harvesting began on March 6, 1998(165 days after sowing) when most leaves had dried down and fallen over. Data were collected on Gross Yield, Percentage of Double (split) Bulbs, Percentage survival and Bulb diametre. Ten bulb samples were randomly selected from each plot for diameter measurements. Data were statistically analysed by ANOVA.

RESULTS AND DISCUSSION

Results in Table 2, reveal no significant differences (p = 0.092) among planting methods. However, the borderline nature of the non-significance apparently suggests higher yields of the two transplanting dates over direct seeding.

Table 2. Gross Yield of planting methods and cultivars(kg/plot).

Planting Method	Arad	Grand-stand	Lexus	Texas	Mean
Direct Seeding	47.6	35.5	58.2	46.7	47.0a
1st Transplant	45.7	32.0	82.1	63.6	55.9a
2nd Transplant	47.6	38.7	68.5	69.2	56.0a
Mean	47.0a	35.4b	69.6c	59.9d	

SED for Planting Method = 4.48
SED for cultivar = 5.17
Means in column followed by a common letter do not differ significantly (P = 0.092)
Means in row followed by different letters differ significantly (P< 0.001).

There were significant differences (P < 0.001) among cultivars, with Lexus giving the highest yield while the lowest yield was recorded for Grandstand. Transplant age/size has been reported to have positive correlation with bulb yield.(Sabota and Downes, 1975; Guimaraes et. al, 1988). The high and low bulb yields which characterised Lexus and Grandstand respectively was due to their bulb sizes (Table 5).

In relation to percentage of double bulbs (Table 3), the transplanting methods had significantly higher (P<0.001) percentages of double bulbs than the direct seeding method. Plants transplanted at four weeks were significantly higher than those transplanted at six weeks. Significant differences (P<0.001)

Table 3. Percentage of Double Bulbs recorded for planting methods cultivars.

Planting Method	Arad	Grand-stand	Lexus	Texas	Mean
Direct Seeding	31.9	5.5	5.5	24.8	16.9a
1st Transplant	43.9	14.5	12.9	46.8	29.5b
2nd Transplant	38.1	12.0	7.8	32.0	22.5c
Mean	38.0a	10.7b	8.7c	34.5d	

SED for Planting Method = 2.75
SED for cultivar = 3.18
Means in column followed by different letters differ significantly (P< 0.001)
Means in row followed by different letters differ significantly (P< 0.001).

in percentage of double bulbing among cultivars are also shown, with the lowest incidence for Lexus and highest for Arad. This may be partly due to the susceptibility of the cultivars to double bulbing, attributable to genetic factors. Abdalla,1967; Robinson,1971 reported that high temperatures may also increase the tendency for double bulbing. The amount of double bulbs produced may contribute to total yield of a cultivar but they detract from yields of marketable bulbs.

Table 4. Percentage of Plant Survival for planting methods and cultivars.

Planting Method	Arad	Grand-stand	Lexus	Texas	Mean
Direct Seeding	79.3	78.2	81.4	85.0	81.0a
1st Transplant	72.9	76.7	73.6	79.1	75.6ab
2nd Transplant	66.9	64.2	69.3	63.7	66.0c
Mean	73.0a	73.0a	74.8a	75.9a	

Means in column followed by one or more letters in common do not differ significantly (P = 0.055)
Means in row followed by a common letter do not differ significantly (p = 0.965).

Table 4 presents data on percentage of plant survival. There are indications of no significant differences (p = 0.965) in survival rates among cultivars. However, the difference in survival among planting methods was significant (p = 0.055). Direct seeding recorded the highest survival rate (81%) although the difference between that and transplanting at four weeks (75.6%) was not significant. It was however significantly higher than transplanting at six weeks. It is suggested that the poor survival rate of onion transplants may possibly be due to stress during the transplanting process.

Table 5: Bulb Diameter recorded for planting methods and cultivars (cm).

Planting Method	Arad	Grand-stand	Lexus	Texas	Mean
Direct Seeding	7.367	6.900	8.300	8.333	7.725a
1st Transplant	6.667	6.433	8.333	7.667	7.275a
2nd Transplant	7.933	6.700	8.400	7.833	7.717a
Mean	7.322a	6.678b	8.344c	7.944d	

SED for Planting Method = 0.2067
SED for cultivar = 0.4134
Means in column followed by a common letter do not differ significantly (P = 0.063)
Means in row followed by different letters differ significantly (P < 0.001)

There was a borderline non-significance for bulb diameter among planting methods (Table 5) with significant differences being recorded among cultivars($p<0.001$).Lexus and Texas generally produced medium to large size bulbs which will be profitable for the hotel industry and also for export. Arad and Grandstand on the other hand did produce small size bulbs whieh are of traditional preference in the market and for domestic consumption.

CONCLUSION

Both planting methods behaved similarly with respect to yield whereas direct seeding recorded the least percentage of double bulbs and the highest percentage of plant survival over both transplanting dates. It was shown to be more advantageous and with the labour eost factor involved,farmers would prefer adopting the method.

Arad, Grandstand and Texas seem to produce high yields when transplanted at six weeks. All four cultivars produced the highest percentage of double bulbs at four weeks of transplanting.
Preliminary data on storage tests suggests that,Arad and Grandstand store better than Texas and Lexus.

RECOMMENDATION

Yield results between both planting methods will be worthwhile to consider in any future work. The trial should be repeated during the out-of-season period for wider verification.

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DETERMINING THE MOST OPTIMAL TIME FOR HARVESTING DASHEEN (*Colocasia esculenta* (L.) Schott var. *esculenta*) CORMS GROWN IN CONTRASTING AGRO-ECOLOGICAL ZONES OF DOMINICA

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ABSTRACT

The age at which dasheen corms are normally harvested, is based on a single factor such as corm age, leaf senescence, farmer experience of the crop in the environment in which it is grown, the demand pressures of the local, regional and extra-regional market or a combination of these factors. Scientific assessments of the effects of maturity on shelf life, nutritional status, taste and the effects of different agro-ecological zones on maturity have not been considered when determining time for harvest. This study uses a combination of age, traditional and scientific parameters to arrive at a more holistic and therefore more optimal time for harvesting corms. The study showed that the optimal age for harvesting dasheen corms in wet areas, where annual rainfall was approximately 5300 mm and soil types were sandy clay loams was 10 months. In the drier areas, where annual rainfall was approximately 2400 mm and soils were characterised as sticky clay loams without a silica pan, corms were best harvested at 9 months.

INTRODUCTION

The choice of dasheen corms for export is normally based on physical specifications - weight between 0.9 and 1.8kg, oval to round in shape, 10 to 10.5cm in diameter, 15.5 to 17.0cm long, scar and disease free (Medlicott, 1990; Crucefix, 1992). The effects of environment, location, seasonality, spacing and depth of planting on these specifications were examined (Robin, 1993). Presently, very little emphasis is placed on age, maturity, texture and taste characteristics, all of which can affect corm quality and consumer acceptance. Studies by Constantin et al., (1974), Purcell et al., (1976), Tom and Hernandez (1978) and Bradbury and Holloway (1985); indicated that the environment and degree of maturity of rootcrops (sweet potato, yam and Colocasia spp.) affects their nutritional composition and yield.

In Dominica, dasheen corms are normally harvested between 6 and 10 months after planting. However, the time to maturity for dasheen corms may vary from one agro-ecological zone to another. Farmers reported that in Grand Bay on soils characterised as plastic sticky clay loams without a silica pan, where average annual rainfall is approximately 2400mm dasheen corms can mature in as early as 6 months. In the Wet Area where soils characterised as sandy clay loams, and average annual rainfall of approximately 5300mm, dasheen corms mature in 8 to 9 months after planting.

Batch exports of dasheen corms from Dominica are not location specific. Therefore exported corms while appearing similar in shape, size and weight may differ in age, maturity and origin. These differences are thought to affect shelf life and eating quality, and require investigation.

The objective of this study was (1) to examine the effects of corm age at harvest on yield and yield characteristics, nutritional composition, shelf life and taste of dasheen corms grown in two contrasting agro-ecological zones and (2) using the above parameters to determine the most appropriate time for harvesting corms in the two contrasting agro-ecological zones. In this study corm age is taken to be the time between planting and harvesting of the crop.

MATERIALS AND METHODS

Four commercially established dasheen farms were selected in Grand Bay and the Wet Area respectively. Suckers were used as planting material on these farms. The dasheen farms selected were located on homogenous, well managed portions of land. At the time of selection, the age of the plants on each farm was recorded. On each farm in each location a stratified random sample made up of four strata was established. There were a total of 16 strata within each location. Each strata contained approximately 30 to 40 plants. Within each strata, three randomly selected plants were harvested monthly. Harvesting commenced when the plants were six months old and ended when the plants were 12 months. Twelve plants were harvested monthly from each stratified random sample. A total of 48 plants were harvested each from the Grand Bay and Wet Area locations. Data from the main corms in the 16 strata in each location were pooled together when calculating monthly means. Corm diameter and length measurements were made using a calliper. Corm shape was approximated by the diameter to length ratio (DLR). Corms were weighed, then submerged in water to measure their volumes by displacement. The weight of the corm (g) divided by the volume of the corm (cc) was used to determine the specific gravity of the corms.

Fifty percent of the above corms were then randomly selected for dry matter, crude protein and palatability studies. The other 50% were used for shelf life studies.

For corm dry matter studies, longitudinal sections from each corm, approximately 4cm wide and 15cm long were peeled then grated into small bits. Ten grams of the grated corms were then placed in pre-weighed crucibles and dried to a uniform weight over 16 hours at temperatures of 100° C. The crucibles were then allowed to cool in a desiccator before weighing. Moisture percentages were calculated as follows:

$$W3 - \frac{(W2 - W1)}{W3} \times 100\ \%$$

W1 = Weight of crucible
W2 = Weight of crucible + dried dasheen
W3 = Weight of dasheen sample (10g)

After drying, dasheen samples were ground into a fine powder. Percentage nitrogen and crude protein were measured using the Kjeldahl method.

Palatability tests were undertaken by a group of 15 to 20 panellists, using longitudinal sections from the same corms used for dry matter studies. The sections were peeled, then boiled until the flesh became soft.

The sections were then cut into 2.5cm cubes, labelled with a three-digit number using a table of random numbers and then placed randomly on plates of similar size. Panellists tasted each sample. After each sample was tasted, panellists were required to gargle with water in order to remove left over tastes. A scale ranging from 1-5 (1=Dislike a lot, 2=Dislike a little, 3=Neither like nor dislike, 4=Like a little and 5=Like a lot) was used to quantitatively assess the degree of acceptance.

For shelf life studies, corms were cleaned in running water within 3 - 4 hours after harvest and then dipped for 2 - 3 seconds in a solution of Ridomil mbc 60WP (14g/28 litres of water). The corms were allowed to air dry and then stored in a cool aerated room at temperatures between 26 to 30° C. Corms were monitored daily for incidence of softening, sprouting, fungal infections and shrivelling. Corms which showed symptoms of the above were removed from storage, and the number of days from harvest up to the time of removal were recorded.

RESULTS AND DISCUSSION

Table 1 indicates that in Grand Bay dasheen corms between the ages of 7 and 12 months satisfied the required export weight specifications. However none of the corms satisfied the export shape specifications (DLR 0.6 - 1.0).

Table 1. The effects of corm age on physical and nutritional characteristics, shelf life and palatability of dasheen corms, produced in the Grand Bay and Wet Area locations of Dominica.

Parameters measured	Location	Corm Age (months)								
		6	7	8	9	10	11	12	Mean 15df	SEM
Weight(g)	Grand Bay	706	936	975	1145	1263	1200	1265	1070	78
	Wet Area	560	933	990	1144	1178	1094	996	995	78
Length (cm)	Grand Bay	16.9	18.3	19.9	20.4	20.2	21.4	21.4	19.5	0.4
	Wet Area	16.0	18.5	18.3	18.2	18.2	18.3	17.2	17.8	0.4
Diameter	Grand Bay	9	9.9	10.3	11.1	11.1	10.7	11.3	10.5	0.2
(cm)	Wet Area	9.3	10.9	10.5	11.1	11.1	10.7	11.3	10.5	0.2
Shape	Grand Bay	0.532	0.541	0.522	0.558	0.554	0.5	0.528	0.539	0.004
(DLR)	Wet Area	0.581	0.573	0.574	0.660	0.621	0.6	0.596	0.596	0.013
Specific	Grand Bay	0.974	0.984	1.000	0.955	0.955	0.9	0.975	0.985	0.004
Gravity (g/cc)	Wet Area	0.905	0.959	0.959	0.990	1.007	0.9	0.996	0.974	0.013
Dry Matter	Grand Bay	39.2	41.9	40.6	38.2	36.0	31.0	36.4	37.4	1.4
(%)	Wet Area	-	37.3	44.5	35.9	40.3	36.7	40.1	39.1	1.3
Protein	Grand Bay	1.9	2.8	2.3	3.4	1.7	2.3	1.5	2.3	0.2
(%)	Wet Area	-	4.0	3.7	2.8	2.4	1.7	1.3	2.7	0.4
Shelf Life	Grand Bay	17.5	19.2	21.4	24.5	25.1	36.9	-	24.4	3.1
(Days)	Wet Area	14.3	14.4	25.3	28.8	33.8	-	-	23.3	3.9
Palatability	Grand Bay	2.7	2.3	3.8	3.1	3.7	3.6	2.9	3.2	0.2
(Score)	Wet Area	3.5	3.0	3.4	3.5	4.1	3.5	2.2	3.3	0.2

Nine-month-old corms though not oval in shape (DLR 0.558) were the closest to the required market specifications. Specific gravity was highest in 8-month-old corms. Bowers et al (1964), suggested that high corm specific gravity indicates maturity. In the Wet Area, corms between the ages of 9 and 11 months satisfied both the required market weight and shape specifications. Specific gravity was highest at 10 months.
In Grand Bay dry matter percentages were the highest for 7 (41.9%) and 8 (40.6%) month old corms. In the Wet Area, dry matter percentages for the 8 (44.5%), 10 (40.3%) and 12 (40.1%) month old corms were the highest. Corms in Grand Bay seem to have high corm dry matter percentages at an early age i.e. 7 to 8 months; whereas corms in the Wet Area seem to have high-sustained corm dry matter percentages between 8 and 12 months.

The crude protein content of the corms in Grand Bay seemed to increase up to a maximum of 3.4% at 9 months and then decreased thereafter. In the Wet Area the percentage crude protein seemed to be higher in the younger corms; i.e. corms between the ages of 7 and 8 months, had crude protein percentages of 4.0 and 3.7 respectively. The effects of corm age on corm shelf life for corms produced in Grand Bay and Wet Area, shows that there

were marked increases in shelf life as the corms got older. In Grand Bay the younger corms (6 to 7 months) seem to have a longer shelf life than corms of similar ages in the Wet Area. Whereas, in the Wet Area; the corms of 8 to 10 months seem to have a longer shelf life when compared to corms of similar ages in Grand Bay.

The effects of corm age on corm palatability for both Grand Bay and Wet Area shows corm palatability in Grand Bay was more acceptable when the corms were harvested between the ages of 8 to 11 months; the 8 month old corms having the most aceeptable taste. Whereas in the Wet Area corm palatability was acceptable between the ages of 6 and 11 months; with the 10 month old corms having the more acceptable taste. Corm taste in the Wet Area was acceptable over a longer harvest period. Reduced corm palatability was observed at 12 months for both Grand Bay and the Wet Area.

Review of the data shown in Table 1 indicates that, in Grand Bay the average maximum corm weight per plant was obtained when corms were harvested at 12 months and that the older the corm the longer the shelf life. Maximum mean dry matter and crude protein were obtained from 7 and 9-month-old corms respectively; and the best tasting corms were harvested at 8 months. In the Wet Area, maximum average corm weight per plant was obtained when the corms were harvested at 10 months. The best corm shape (DLR 0.621) was also obtained when the corms were harvested at 10 months. However maximum mean dry matter and mean crude protein were obtained when corms were 8 and 7 months old. Palatability was best when corms were harvested at 10 months.

In determining the most appropriate time to harvest corms in Dominica consideration was given to the producers, exporters and the consumers. Dasheen producers normally use weight, followed by shape, as the main criteria for exporting dasheen. However, using weight as the number one priority would necessitate harvesting corms at 12 months in Grand Bay. The 12-month-old corms have an additional advantage of a long shelf life (38.9 days); which is favourable for export. However, the dry matter (36.4%) and the crude protein (1.5%) content of 12-month-old corms were low. In addition, corm palatability ratings of 2.9 were not highly acceptable.

Since consumers and exporters are primarily concerned with a quality product, consideration should ideally be given to physical characteristics (weight and shape), nutritional characteristics (dry matter and protein) and palatability. Therefore, if corms are harvested when dry matter and crude protein percentages were at their maximum (i.e. 7 and 9 months respectively), and palatability was best (8 months); corm weights would not be at the maximum but within the acceptable export weight specifications. Nine-month-old corms were the closest to GRADE-A specifications (i.e. 1145g and DLR 0.558) and the shelf life of 24.5 days falls within the acceptable time frame for shipping to Europe. The palatability of nine-month-old corms was also acceptable. It seems that in Grand Bay, the best possible time for harvesting dasheen is at approximately 9 months.

Using weight as the main criteria for harvest would mean harvesting corms at 10 months in the Wet Area. The best shaped corms were also harvested at 10 months. Since GRADE-A corms and corm palatability were best at 10 months, and dry matter percentages (40.3%) and corm shelf life (33.8 days) at 10 months were high, it seems that dasheen harvest in the Wet Area would be most appropriate at 10 months.

CONCLUSION

Agro-ecological conditions affect corm quality and maturity, therefore harvesting recommendations have to vary depending on location. Harvesting dasheen corms at 9 and 10 months in Grand Bay and Wet Area respectively assures farmers of good economic returns and the consumer also receives a quality product.

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BREEDING ANTHURIUMS (*Anthuriums andreanum* L.) FOR RESISTANCE TO BACTERIAL BLIGHT CAUSED BY *Xanthomonas campestris* pv *dieffenbachiae.*

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ABSTRACT

Ornamentals are of growing importance in the crop diversification policy of most Caribbean countries. Cut flowers, including anthuriums, alpinias and helicopnias are considered to have considerable potential as an export commodity. In the French Antilles, the development of ornamental production in the early seventies was based on anthuriums. This flower was leading the export market until 1983 when the accidental introduction of bacterial blight (*Xanthomonas compestris* pv *diffenbachiae*) practically destroyed the whole crop. After developing preventative measures to control the disease, a breeding programme was initiated for resistance to the pathogen. In 1995, resistance in one anthurium clone growing in a shade-house was identified. The high level of this resistance was confirmed by inoculating the plants with a bacterium strain, representative of the local population of the pathogen. The resistant clone can easily be crossed with the commercial cultivars, so that it will be possible to breed varieties which meet the demands of both the export and local markets.

INTRODUCTION

In most Caribbean countries, ornamentals are of growing importance in the crop diversification policy. Anthuriums are one of major demand on the market. However, a number of factors impact negatively on the production (Paulraj, 1996) among which are lacking of adapted varieties, high cost of importing planting material and high start-up costs (Lucas and Zahalka, 1992). Moreover, production is increasingly being curtailed by diseases, the most difficult control being bacterial blight caused by *Xanthomonas campestris* pv. *dieffenbachiae* (Norman and Alvarez, 1994) and bacterial decline caused by *Acidovorax anthurii* (Garden et al, 1998). Of those, bacterial blight as the most economically important. Native of Central and South America (Geier, 1990), the anthurium, (with about 600 species) is the largest genus (25%) of the *Araceae* family. Edward André took it to England from Colombia in 1978. Modern cultivated forms have resulted from intensive hybridisation mainly in the Netherlands and Hawaii. In the genus, A. *andreanum* Lind. dominates the cut flower market. The world import market size for anthuriums is over US$20 million annually, second among tropical flowers only to that of orchids, (Galinsky and Laws, 1996). Major markets include the USA, Europe and Japan (ACE, 1996). For many years anthuriums were grown under natural shade in the forest, banana plantations, or tree crops. This type of cultivation still persists with the << Standard >> varieties whereas hybrids are grown under artificial shadehouses, on different kind of substrates.

CONTROL OF BACTERIAL BLIGHT IN ANTHURIUM CROPS

Description of the disease

Bacterial blight was first reported in 1960 in Brazil (Hayward, 1972), then in 1971 in Hawaii (Higaki et al 1994). It has since being reported in most anthurium producing countries including the Caribbean, Florida and California, and recently on plants from the Netherlands (Sathyanarayana 1998). First reported in Guadeloupe in 1982 by Prior and Rott, the disease seems to have been introduced accidentally with planting material from Venezuela (Anaïs et al 1983).

It's spread resulted in massive destruction of the anthurium crop, causing considerable economic damages in the French Antilles (Prior and Sunder 1987).

The first symptoms usually begin along the leaf margins where bydatodes are located, in the form of small, scattered, irregularly shaped, water-soaked spots. They are more pronounced on the underside of the leaves. The tissue surrounding the spots turns bright yellow then dies. The bacterium spreads quickly throughout the entire plant. A characteristic symptom of advanced systematic infection is the discoloration of the vascular system. The leaves close to the point of entry turn a dull yellow as the bacterium clogs the vascular system preventing the translocation of water and nutrients. The petiole of plants with advanced infection are often easily removed due to the formation of the abcission layer and the discoloured vascular bundles appears as scattered brown spots. Longitudinally cut stems or petioles may have brown streaks formed by the dead vascular system. Brown to black necrotic spots can be observed on the spathes. In most cases the disease leads irreversibly to the death of the plant. Culltivars vary in susceptibility to the systematic phase.

The bacterium is suspected of being able to infect plants without exhibiting visible symptoms. It cannot survive outside of the plant for long periods (5 to 6 weeks). The most important ways of spreading are splashing rain or irrigation water; contaminated cutting tools; planting infected materials; people walking through and brushing against infected plants; movement of infected soil on footwear, vehicles, tools and other equipment. Passing in the drainage water, the bacterium can also penetrate the roots, multiply in the vessels and invade the plant. The spread in small water droplets (aerosols) probably occurs but is not considered of major incidence (Higaki et al 1994).

MEANS OF CONTROL

Sanitation measures

Because of the systematic and highly contagious nature of the disease, anthurium blight is very difficult to control. It is important to prevent the introduction and spread of the pathogen. Effective plant quarantine measures must be enforced. Chemicals such as agromycin, copper and zinc-based bactericides are currently being used but are proven to be largely ineffective in controlling the disease. In some areas sanitation measures have helped to maintain the pathogen population under control (Hostachy et al 1986). Any measure that minimizes the wetting of foliage in the production fields should reduce the spread of the disease.

Preventative measures that must be taken include:

- Installing a foot bath with disinfectant at the entrance of each shade-house.
- Disinfecting the tools and clothing as frequently as possible (working with an alternating a minimum of two tools lengthens the exposure to the disinfectant and increases the probability of killing the bacterium on the blade surface).
- Not using the same tools on different plots.
- Avoiding exchange of material between shade-houses.
- Using drip irrigation or micro-sprinklers instead of overhead.
- Not exchanging planting material between farmers if not of disease free *in vitro* origin.
- Avoiding poor drainage of the substrates.
- Avoiding the presence of visitors or personnel not attached to the farm.
- Replanting every 7 years and disinfect the shade house before replanting. Replanting must be done by

using disease-free substrate and *in vitro* planting material produced under strict disease free conditions.

Use of Resistant Varieties

In the island of Trinidadd certain commercial cultivars has shown a good level of resistance to *Xanthomonas* and/or *Acidovorax* at the growers' farms or when spray inoculated on Centeno experimental station (Dilbar 1997 pers.com., Table 1) This resistance still has to be confirmed regarding the bacterium strains and growing conditions of the French Antilles.

Table 1: Resistance to *Xanthomonas* and/or *Acidovorax* in anthurium cultivars (observed at growers* or inoculated on the Station) (Dilbar, 1997).

Xanthomonas	Acidovorax	Santhomonas and Acidovorax
Avanti, Florida beauty Florida exotic, Heart's desire, Margaretha, Rapsody	Amaru, Allexis*, Fantasia* Jacqueline* Lunette* Sibilla*, Victoria	Acropolis, Brazil* Coral, Hawaiian orange*, Honduras, Miriam*, Success, Trinidad pink, Venus.

In Guadeloupe a clone, apparently resistant to anthurium blight was identified in 1994 growing under a heavily infested shade-house. The suspected resistance of this clone encoded A-971 was confirmed by inoculation in the bacteriology laboratory, and shown to the of high teristics to fit the Caribbean local or export cut flower market. Nevertheless it can be used in the breeding program for resistance to Xanthomonas.

Breeding for Resistance to Bacterial Blight - Preliminary Results.

Selection and/or breeding of disease resistant varieties remains necessarily an important component of the integrated control strategy. At the start, due to the emergency situation and the high economic incidence of the disease priority is given to breeding for resistance to Xanthomonas. The objective of this programme is to release blight resistant varieties with characteristics that satisfy the growers and market requirements.

MATERIAL AND METHODS

Growing Conditions

The plants were grown in a shade-house under a shade level of 70%. The growing media was 2/3 andesitic pumice (pozzolane) 5mm grade, and 1/3 composted wood shavings. Mist irrigation was supplied for 3 periodss of 5 minutes at the hottest hours of the day. A complete formula soluble fertilizer (14-12-15-2 + micro elements) was applied every two weeks.

Plant Material

This preliminary work was to test the resistance of the F1 hybrid between the resistant clone A-971 and the susceptible <<Standard rose>> (<<Pink Standard>>), which is still very popular in the French Antilles despite it's susceptibility to Xanthomonas. Five plants each of the clone << Standard rose>> and five of the clone of the resistant <<A-971>> and fifteen plants of the hybrid [<<Standard>> x << A-971 >>], were used in each treatment.

Bacterial Strain

Strain N°32 was ehosen from a collection of local isolates of *Xanthomonas campestris* pv. *dieffenbachiae*, for its' ability to discriminate between the susceptible "Standard" and the resistant "A-971" and because it is

representative of the major group of the French Antilles strains (Darasse et al, in preparation).

Inoculation Methods

The bacterium was grown for 48 h on YDA medium (yeast extract 5 g, bactopeptone 5 g, glucose 10 g, agar 15 g at pH 7). A bacterial suspension in distilled water was adjusted at a concentration of 10^7 CFU.ml^{-1}, using a spectrophotometer. Three inoculation methods were compared: infiltration (1 ml) of the bacterium in two leaves of the plant, drenching the growing substrate (30ml) and spraying the plants with the suspension, followed by bagging of the plants in transparent polyethylene bags to maintain saturating humidity.

Notations

On the infiltrated plants symptoms were recorded as follows: no symptom (0), water-soaked lesions in the infiltrated area (1), necrosis (2), development of the symptoms out of the infiltrated area (3), systematic infection (4), plant death (5). On the drenched and sprayed plants, as follows: no symptom (0), water-soaked lesions generally starting at the margins (1), necrosis (2), development of the necrosis on at least two leaves (3), systemic infection (4), plant death (5).

RESULTS AND DISCUSSION

The infiltration method was the most effective in developing symptoms of the disease (1 week after inoculation on the susceptible check) and discriminating the resistant "A-971" and F1 plants from the susceptible "Standard after 3 weeks (graph 1). Spraying was effective in developing systems only after 3 weeks but it confirmed the resistance of <<A-971>>. Drenching was not at all effective as some leaf spots appeared on a few plants only after 7 weeks. On the infiltrated "A-971" and F1 plants symptoms of the disease were confined to the inoculated leaves which turned yellow and abscised showing that the resistance observed in A-971 is not immunity and must be managed in an integrated way where sanitation measures are compulsory. Nevertheless, no symptom was observed on the other parts of the Flas of the resistant plants up to 10 months after inoculation, when plants were rated 0, whereas, after dropping the two inoculated leaves the "Standard" developed symptom on non-inoculated leaves and the disease was still progressing. Behaviour of the F1 suggested that the resistance observed was dominant (graph 2) but further work with F2 and back-crosses is necessary to study the heredity of the resistance observed in the F1.

CONCLUSION

We have the tools of breeding for resistance to bacterial blight in anthurium with the resistant clone << A-971 >>, and a reliable method to discriminate the resistant from the susceptible clones and manageable crossing of the different plants.
There are good prospects of breeding cultivars resistant to blight in medium term but this resistant will then have to be combined with the resistance to *Acidovorax*. In the meantime implementation of sanitation measures remains compulsory to maintain and develop the crop. In the short term we have to confirm the resistance found in Trinidad to the strains of *Xanthomonas* of the French Antilles, to eventually recommend those clones to our growers. Certain of those varieties can also be used to enlarge the genetic variability in our breeding programme.

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AN IMPROVED PROTOCOL FOR ANTHURIUM CALLUS INDUCTION

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ABSTRACT

Researchers have found that callus growth in many anthurium (*Anthurium andreamum* Andre) cultivars is too slow and inconsistent for exploitation in large-scale micropropagation. Thidiazuron (TDZ) (N-phenyl -N'-1,2,3-thiadiazol - 5-yl-urea, and several substituted pridyl phenyl urea compounds have shown strong cytokinin-like effect in a wide range of species including those that have little response to conventional adenine-based cytokinins. We have initiated experiments on the use of TDZ for *in vitro* regeneration of anthurium from leaf explants. In readily regenerating anthurium geneotypes using TDZ, the first signs of callus formation were visible from as early as three weeks and whole plants were regenerated and rooted within six months.

INTRODUCTION

The first report on callus induction in *Anthurium andreamum* Andre was by Pierik *et al* (1974). A low percentage of embryos was found to generate calli even in the absence of hormones. The addition of 340 MM PBA [6-benzylamino) -9-(2-tetrahydropyrany) -9H-9 purine] to the culture medium resulted in inconsistent callus formation. Cytokinin was found to be essential for callus induction from sections of lamina, petiole and spathe.

Pierik *et al* 1974, examined 38 genotypes of anthurium and observed moderate to strong callus formation from leaf segments in 31 genotypes, very poor callus production in four and no response in the three remaining ones, using benzyl adenine (BA) as the cytokinin.

Leffring *et al*, 1976, in a series of experiments with leaf segments from a large number of genotypes came to the conclusion that in most genotypes callus growth was too slow and inconsistent for exploitation in large scale micropropagation. Similar experience was obtained with Caribbean genotypes at the Caribbean Agricultural Research and Development Institute's (CARDI) Tissue Culture Laboratory CARDI Annual Report, 1994/5).

Thidiazuron, (N-phenyl -N'-1,2,3-thiadiazol -5-yl-urea) (TDZ) has been shown to have cytokinin-like activity (Fiola *et al*, 1990; Mok *et al*, 1982 & 1987); Thomas and Katterman, 1986. Thidiazuron and several substituted pridyl phenyl urea compounds appear to have strong cytokinin-like effect in a wide range of species and even in the species that respond little to conventional, adenine based cytokinins (Reynolds, 1987). Application of TDZ to *in vitro* callus is widespread, especially for woody species (Huetteman and Preece, 1993; Lu, 1993). The potential of TDZ to stimulate adventitious shoot proliferation was also reported (Chaulpa, 1985; Kerns and Meyers, 1986; Van Nieuwkerk *et al, 1986).* Synergisms of TDZ and benzyl adenine (BA) in axillary shoot formation was studied by Nielsen *et al,* (1995) in *Miscanthus ogiformis 'Giganteus'*, a monocot (Family-Poaceae).

Experiments were conducted to investigate the effect of TDZ on callus induction in anthurium at the CARDI tissue culture laboratory. TDZ was found to significantly shorten the time required for callus induction and complete plants could be regenerated on TDZ containing media.

MATERIALS AND METHODS

Six cultivars (JR 1, Diamond Sunset (DS)m CWI, RBI, CWO 1, CWO 2) were chosen from a grower in Barbados. Young leaves were used as explant materials. Leaves were cleaned in running water, soaked in 0.2% physan and

rinsed in sterile distilled water. This was followed by a soak in 25% sodium hypochlorite for 30 minutes and rinsing in sterile distilled water. Finally, leaves were soaked in 10% sodium hypochlorite for 15 minutes and rinsed repeatedly in sterile distilled water. Explants of 1 cm square were cut from the lamina and placed onto the culture medium.

The standard medium, MS 32 used for callus induction contains Murashige & Skoog (MS) salts (Murashige and Skoog, 1962) and supplemented with required hormones (Pierik, 1976).

Two sets of experiments were conducted. In the first, higher concentrations of TDZ were used. AC1 (Anthurium Callus, AC) control medium contained 10mM TDZ as cytokinin and no BA. AC2, AC3 and AC4 contained 10, 15, 20 mM TDZ respectively. MS 32 with cytokinin BA and no TDZ was used as a control for activity of BA. In the second, lower concentrations of TDZ were used. AC10 and AC 13 contained 0.5, 0.05 mM TDZ respectively. 20 explants per cultivar and six cultivars were used as replicates.

The pH was adjusted to 5.8 and the complete media were autoclaved for 20 minutes at 121°C. The Explants were cultured in 25 mm culture tubes. The cultures were incubated at 25 +1°C. For callus induction and multiplication, the cultures were maintained in continuous darkness.

Following callus induction sprouts were regenerated on MS 34 medium which contained kinetin (13.8 mM). Shoot sections were isolated and subcultured on shoot proliferation medium. Rooting occurred spontaneously when cultures were allowed to stand for long periods under illumination. More rapid and consistent rooting was achieved by transferring shoots to a rooting hormone-free medium. Rooted plants were weaned.

RESULTS

In readily generating cultivars, first signs of callus formation were visible as early as three weeks from treatment. Poorly regenerating types required as long as eight weeks before showing any signs of callus formation. It was observed that callus initiation first began in those explants with a midrib. Among the experimental media AC4, 62.9% followed by AC3 55.4% showed responses for callus initiation (Tables 1&2)

Irrespective of the callus initiation medium, shoot regeneration was effective on NS 34 medium. Etiolated sprouts were grown in light to form chlorophyll and to develop leaves. After four weeks of growth, shoots were subcultured onto hormone-free-medium for tooting and tooted plantlets were weaned.

DISCUSSIONS

AC1 (Anthurium Callus), produced short compact shoots with short internodes. Generally media supplemented with TDZ along gave short thick shoots consistent with the results of Gray and Klein, 1989. Since cytokinin generally inhibits shoot elongation (Hutteman and Preece, 1993) this effect is expected, and also consistent with the high cytokinin activity of TDZ. After transferring to the proliferation medium without cytokinin as reported by Van Nieuwkerk *et al* (1986), these shoots were elongated.

In MS 32 control medium, the percentage of callus induction was 43.7% This can be explained by the lower cytokinin activity of the adenine-type cytokinins.

The addition of BA along with TDZ resulted in more elongated shoots. The mode of action by which TDZ exhibits cytokinin activity is not understood. It has been suggested that TDZ promotes the conversion of cytokinin ribonucleotide to a biologically active form in callus tissue of *Phaseolus lunatus* (Capelle *et al.*, 1983). Nielson *et al* (1995) repsorted that sequential applications are needed for a synergistic effect in *Miscanthus ogiformis* 'Giganteus'. In the case of anthurium, cytokinins TDZ and BA used together increased callus induction by 20 percent. TDZ has been shown to interact with other cytokinins to increase their activity (Ellis and Bilderback, 1989).

Table 1: Percentage of explants forming callus one month after initiation in three different cultivars on the experimental initiation media.

	Callus Induction Medium*				
Cultivars	**AC1**	**AC2**	**AC3**	**AC4**	**MS32**
JR 1	50.0	60.0	12.5	100.0	47.5
DS	0.0	57.5	80.0	62.5	75.0
RB 1	25.0	40.0	40.0	75.0	25.0
CW	0.0	0.0	0.0	50.0	0.0
CWO1	40.0	15.0	100.0	15.0	15.0
CWO2	25.0	50.0	100.0	75.0	100.0
Mean [a]	**25.3**	**37.1**	**55.4**	**62.9**	**43.7**

[a] AC 1 Anthurium Callus medium 10mM TDZ AC 2 Anthurium Callus medium 10mM TDZ + 4.4 mM BA
AC 3 Anthurium Callus medium 15mM TDZ + 4.4mM BA
AC 4 Anthurium Callus medium 20mM TDZ + 4.4mM BA
MS 32 Murashige & Skoog (MS) + 4.4mM. BA
[b] F0.05 = 3.27
P = 0.028
[c] 20 explants per treatment were used

Table 2: A comparative study of the effect of lower concentrations of cytokinin in callus induction.

	Callus Induction Medium*		
Cultivars	**AC4**	**AC10**	**AC 13**
JR1	100.0	50.0	33.3
DS	75.0	80.0	25.0
RB1	18.0	0.0	16.0
CW	60.0	18.0	100.0
CWO1	30.0	60.0	95.0
6[a]			
Mean [b]	**56.0**	**41.6**	**53.**

AC 10 Anthurium Callus medium 0.5mM TDZ + 4.4mM BA
AC 13 Anthurium Callus medium 0.05mM TDZ + 4.4mM BA
[b] F_0 0.05 = 3.38
P = 0.037
[c] 20 explants per treatment were used
6[a] -all explants died due to contamination

AC4 (20mM TDZ) increased callus induction by 15 percent over AC10 (o.5mM TDZ). Generally, TDZ evokes sits cytokinin-like effect at lower equimolar concentrations than adenine-type cytokinins, but this does not appear to be the case in monocotyledons (Nielsen *et al*, 1995). Diverse pathways of cytokinin action in plant cells explain this difference.

At lower concentrations of TDZ fewer shoots and more roots were produced.

This is probably due to higher auxin and lower cytokinin activity. Auxins have been used in media to enhance rooting. Fersing and Lutz (1977) used 0.05 to 0.5mM 2-4-D or 4.92uM IBA (Inodole butyric acid) for rooting of shoots of anthurium.

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PRELIMINARY FINDINGS ON THE EFFICACY OF THREE HOUSEHOLD DISINFECTANTS TO SUPPRESS ANTHURIUM DECLINE

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ABSTRACT

Radopholus similis is the primary cause of anthurium (*Anthurium andraeanum*) "root rot and decline". Phenamiphos is the most effective nematicide to suppress the nematode and forestall decline; ethoprop is a good substitute, while oxamyl and carbofuran are less effective. However, most traditional nematicides are becoming unavailable to growers, for various reasons. Dettol, Jeyes Fluid and bleach are proving very efficacious in disinfesting soil and some plant materials of noxious nematodes. These household disinfectants and cadusafos were compared with phenamiphos for control of *R. similis* and decline in anthurium. The treatments or water were initially applied to 12-week old plants, then every five months. Leaf height, width and number, and *R. similis* populations in roots were measured initially, then at five, 10, and 14 months. After 14 months, leaves of the Dettol-, Jeyes Fluid- and bleach-treated plants were shorter, and somewhat smaller than at the outset. These and the control plants put on approximately 50% more leaves, while the phenamiphos- and cadusafos-treated plants almost doubled and tripled leaf numbers respectively. Leaves of phenamiphos-treated plants were marginally shorter than at the outset, but laminae were somewhat larger, while those of the cadusafos-treated plants were approximately 20% taller, and 30% larger. Only the cadusafos treatment suppressed *R. similis*. There is evidence of injury to plants treated with the household disinfectants.

INTRODUCTION

At every anthurium holding where observations have been made, a disorder called "root rot and decline" has been noticed. *Radopholus similis* has been associated with every instance of decline. Affected plants develop slowly, leaves gradually become off-colour, yellow, then dry, starting with the oldest. Early on, a light brown to chocolate-coloured rot in spots is noticed on roots. In time, as the spots merge, most or all of the root system is rotted, steles are exposed as the rotted cortexes slough off, and the root system becomes sparse and non-functional. High numbers of the nematode might be recovered from growing media, or infested roots before rotting becomes extreme. The plants themselves tend to become prostrate and are easily pulled from the beds. The stunted, unthrifty plants bear few blooms which are mainly of the smaller grades, lack lustre and also tend to be prostrate. Affected beds soon become sparse of plants, as many die, are weedy and need to be remade and replanted earlier than normal. Hutton *et al.* (1980) first recorded the association of *R. similis* with anthurium in Jamaica in 1974. The fungus Pythium *splendens* also causes rotting of anthurium roots in Jamaica (Leather, 1967; Naylor, 1984), and elsewhere.

Investigations have virtually proven *R. similis* to be the cause of anthurium decline. Nematicide treatments before and/or after planting anthurium infested with both *R. similis* and *P. splendens* resulted in more vigourous and bigger plants having abundant root systems with little rotting, and which suckered adequately. However, the greatest continuing economic benefits of the most effective treatments were increased production in quality and quantity of blooms, and that treated beds were long-lived, compared with untreated ones (Hutton, 1989 and 1990). Fungicide treatments alone were not significantly effective, suggesting that *R. similis* was the more important of the two organisms in the disease complex (Hutton *et al.*, 1980; Hutton and Edman, 1993). Both *R. similis* and *P. splendens* are associated with anthurium decline in Hawaii where the nematode is also considered to be the primary pathogen (Higaki *et al.*, 1979).

Many pesticides, including several nematicides, are becoming more unavailable worldwide, because of high toxicity, harm to non-target plants and animals, environmental contamination, and high costs. In Jamaica, the nematicidal effectiveness of several "safe" chemicals, including household disinfectants and certain plant extracts

or residues is being investigated in the search for alternatives to traditional nematicides. Crude pimento oil or the isoeugenol fraction, bleach, Dettol antiseptic, Phisohex and Jeyes Fluid, household disinfectants, were as lethal as oxamyl, a nematicide/insecticide, to several plant and non-parasitic nematode *in vitro* (Hutton, 1996). Bleach, Dettol antiseptic and Jeyes Fluid were as or more effective, compared with as oxamyl, to disinfest soil of *Meloidogyne incognita, Rotylenchulus reniformis* and other plant nematodes, and yam planting material of *Pratylenchus coffeae* (Hutton, 1997*a* and 1997*b*).

This trial was carried out to determine the effectiveness of bleach, Dettol antiseptic or Jeyes Fluid, compared with phenamiphos or cadusafos, a nematicide recently introduced into Jamaica, to suppress *R. similis* and forestall anthurium decline.

MATERIALS AND METHODS

Beds which had been rebuilt and replanted three months earlier were used for the trial. The six treatments, Jeyes Fluid (a blend of high boiling tar acids and washed neutral oil, solubilised in vegetable soap), bleach (NaOCl), Dettol antiseptic (chloroxylenol), phenamiphos (ethyl 3-methyl-4-(methylthio) phenyl(1-methylethyl) phosphoamidate) G, cadusafos (O-ethyl S,S-di-sec-butyl phosphorodithioate) G, and water (the control), were arranged in an Alpha design where the control and phenamiphos replications were doubled. Three beds were over 47.0 m long, and 0.86, 0.91 or 1.30 m wide and accommodated five replications; a 24.0-m long by 0.8-m wide bed accommodated the sixth. Each plot was 3.0 m long by the bed width.

The liquids (Jeyes Fluid, bleach or Dettol) were diluted in water and applied over the plots, while the granular nematicides were sprinkled onto the coir/coconut husk growing medium around the cv. Kaumana plants. The beds were sprinkler-irrigated to about 1 cm after the treatments were applied. The treatments were applied at the outset and every five months. Initially, six plants per plot were tagged. The tallest leaf, width of the two largest leaves and number of leaves on these plants were measured initially, and five, 10 and 14 months after. Root samples were taken from five untagged plants per plot at the outset, and at five, 10 and 14 months. *R. similis* was extracted from these roots by a modified Baermann funnel technique (Hooper, 1985), and counted. All data were subjected to analysis of variance.

Plants were grown under 70% shade saran at roughly 0.3 m^2 spacing. Beds were given about 1.0 cm of water daily, but this could be made up by rainfall, and supplied with 100 gm of a 7-14-7 fertilizer/5m^2 monthly. Beds were hand weeded and repacked as necessary, but there was no plant replacement. Disease and/or pest control was according to a specially developed schedule.

RESULTS AND DISCUSSION

After 14 months, leaves of anthurium plants treated with water (control), Dettol, bleach or Jeyes Fluid were approximately 20 % shorter than at the outset, while those of phenamiphos-treated plants were marginally shorter and cadusafos-treated plants much taller than initially (Table 1).

Leaves of the bleach- and water-treated plants remained unchanged in size, while leaves of Jeyes Fluid- and Dettol-treated plants were somewhat smaller; phenamiphos-treated laminae were slightly bigger and cadusafos-treated plants had much larger leaves than initially (Table 2). Cadusafos-treated plants put on almost three times as many leaves over the 14-month period, phenamiphos-treated plants put on almost twice as many while water-, Dettol-, and Jeyes Fluid-treated plants put on 50% or so more leaves, and bleach-treated plants approximately 40% more (Table 3). Thus, after 14 months, the cadusafos-treated plants were more rigorous, and these plots stood out from the others, while the plants treated with bleach, Dettol or Jeyes Fluid were unthrifty, some appeared moribund, and several had died, such that these plots already had missing plants. In this trial, the plants did not respond to the phenamiphos treatment as in previous trials where this treatment elicited vigorous plant growth and suckering, and high bloom production (Hutton *et al.*, 1980; Hutton, 1989 and 1990).

Table 1. Anthurium leaf height in a trial to determine the efficacy of three household disinfectants, compared with two traditional nematicides, to suppress *Radopholus similis* and decline of the crop.

Treatments*	Leaf height (cm) at			
	start	5 months	10 months	14 months
CONTROL (water)	34.6[a]	32.5[a]	31.7[a]	28.0[b]
BLEACH 25 l a.i./ha	32.2[a]	29.7[a]	27.1[a]	25.0[a]
DETTOL 20 l a.i./ha	31.0[a]	29.8[a]	27.0[a]	22.1[a]
JEYES FLUID 30 l actual/ha	35.2[a]	35.4[a]	33.4[ab]	28.1[b]
PHENAMIPHOS G 20 kg a.i./ha	33.7[a]	35.8[a]	33.5[ab]	31.0[b]
CADUSAFOS G 30 kg a.i./ha	34.2[a]	38.0[ab]	36.8[abc]	41.7[c]

*Treatments were put on at the outset, then every five months.

[abc] In each column, means followed by different letters are significantly different (p = 0.5).

Table 2. Width of anthurium leaves in a trial to determine the efficacy of three household disinfectants, compared with two traditional nematicides, to suppress *Radopholus similis* and decline of the crop.

Treatments*	Leaf width (cm) at			
	start	5 months	10 months	14 months
CONTROL (water)	10.3[a]	11.2[a]	9.3[a]	10.0[a]
BLEACH 25 l a.i./ha	10.4[a]	10.3[a]	9.0[a]	10.7[ab]
DETTOL 20 l a.i./ha	10.3[a]	10.4[a]	8.3[a]	8.5[a]
JEYES FLUID 30 l actual/ha	10.0[a]	11.5[a]	9.3[a]	9.4[a]
PHENAMIPHOS G 20 kg a.i./ha	10.3[a]	12.1[ab]	10.0[ab]	10.9[ab]
CADUSAFOS G 30 kg a.i./ha	10.4[a]	12.6[ab]	11.7[bc]	13.5[bc]

*Treatments were put on at the outset, then every five months.

[abc] In each column, means followed by different letters are significantly different (p = .5).

The cadusafos treatment held *R. similis* in check, moreso than phenamiphos. *R. similis* populations increased substantially in the bleach-, Dettol-, or Jeyes Fluid-treated plots, and more than ten-fold in the water treatment (Table 4). In previous trials, vigourous top and root growth and substantially reduced anthurium root rotting were associated with suppression of *R. similis* (Hutton *et al.*, 1980; Hutton, 1989 and 1990).

Anthurium plants, especially of the hybrid varieties, are sensitive to several factors (Hussey *et al.*, 1969). In previous trials, DBCP, isozafos or diazinon treatments substantially injured anthurium plants (Hutton, 1989 and 1990; Hutton and Edman, 1993). Symptoms of injury were severely stunted growth, yellowing and unthrifty

appearance, poor production, prostration, decline and eventual death of many plants. In this trial, bleach-, Dettol- and Jeyes Fluid-treated plants are showing these symptoms. It therefore seems unlikely that these disinfectants will find a place in nematode control in this crop. Previous work has shown that judicious use of certain nematicides before or at planting, then at intervals during the anthurium crop, will give effective nematode control. Phenamiphos has proven to be the most efficacious nematicide, and ethoprop a good substitute; carbofuran

Table 3. Number of leaves on anthurium plants in a trial to determine the efficacy of three household disinfectants, compared with two traditional nematicides, to suppress *Radopholus similis* and decline of the crop.

Treatments*	No. of leaves/plant at			
	Start	5 months	10 months	14 months
CONTROL (water)	2.1[a]	1.6[a]	3.9[a]	3.2[a]
BLEACH 25 l a.i./ha	1.9[a]	1.5[a]	3.5[a]	2.6[a]
DETTOL 20 l a.i./ha	1.9[a]	1.4[a]	3.2[a]	2.9[a]
JEYES FLUID 30 l actual/ha	2.2[a]	1.8[a]	4.1[ab]	3.0[a]
PHENAMIPHOS G 20 kg a.i./ha	2.0[a]	1.8[a]	4.6[bc]	3.7[ab]
CADUSAFOS G 30 kg a.i./ha	2.1[a]	2.1[ab]	5.9[cd]	5.9[bc]

*Treatments were put on at the outset, then every five months.
** In each column, means followed by different letters are significantly different (p = 0.5).

Table 4. Numbers of *Radopholus similis* infesting anthurium plant roots in a trial to determine the efficacy of three household disinfectants, compared with two traditional nematicides, to suppress the nematode and decline of the crop.

Treatments*	No. *R. similis*/100 gm root at			
	start	5 months	10 months	14 months
CONTROL (water)	410[a]	930[b]	790[b]	4500[c]
BLEACH 25 l a.i./ha	320[a]	1680[b]	650[b]	1355[b]
DETTOL 20 l a.i./ha	495[a]	670[a]	855[b]	1190[b]
JEYES FLUID 30 l actual/ha	520[a]	570[a]	465[a]	1550[b]
PHENAMIPHOS G 20 kg a.i./ha	850[a]	875[b]	725[b]	1150[b]
CADUSAFOS G 30 kg a.i./ha	485[a]	305[a]	330[a]	370[a]

*Treatments were put on at the outset, then every five months
** In each column, means followed by different letters are significantly different (p = 0.5).

or oxamyl were only moderately effective (Hutton, 1993). However, phenamiphos is not now available in Jamaica, having been "delisted". Aldicarb is said to provide exceptional nematode control, although there is no local research supportive of recommending it, but it seems that it too might soon become unavailable.
From the results of this trial, which is ongoing, cadusafos seems to have the potential to replace phenamiphos for effective *R. similis* control in anthurium.

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DRY WEIGHT ACCUMULATION AND NUTRIENT UPTAKE BY ARRACACHA GROWN UNDER CONTROLLED CONDITIONS

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ABSTRACT

In Puerto Rico, the commercial production of arracacha (*Arracacia xanthorrhiza*) is concentrated in low fertility soils. Crop development and yield depend heavily upon supplementary fertilization. Information on arracacha's growth and nutrient uptake is scarce. This study was conducted under controlled conditions to determine the pattern of dry weight accumulation and to estimate nutrient uptake in arracacha. Plants were grown in concrete boxes filled with topsoil. Samples were harvested at 28-day intervals from 30 to 198 days after emergence. At each harvest, the plants were divided into the lamina, petiole and corm. Tissues were oven-dried to determine dry weight and concentration of N, P, K, Ca and Mg. Dry weight accumulation in the whole plant and in the corm increased linearly throughout the season. Concentrations of N, Ca and Mg tended to be higher in the lamina than in other parts. Estimates of maximum uptake were 279 kg/ha for K, 128 kg/ha for N, and 106 kg/ha for P. Uptake estimates for Ca and Mg were 32 and 26 kg/ha, respectively.

INTRODUCTION

In Puerto Rico, arracacha (*Arracacia xanthorrhiza* Banc.) is a specialty crop planted for its yellow-fleshed corm. Its commercial production is essentially restricted to soils of low fertility, primarily Ultisols. In these soils, crop development and yield depend heavily upon supplementary fertilization (del Valle et al., 1995). Information regarding the dry matter accumulation pattern and estimates of nutrient uptake are crucial for the improvement of crop and fertilizer management strategies. However, this information is scarce for arracacha.

A preliminary study on nutrient uptake for arracacha revealed that K and N uptakes were higher than for P and Ca, whereas that of Mg was the lowest (Ortiz and Acín, 1997). The above study was conducted under rainfed conditions. Lack of precipitation resulted in stress conditions; thus, results obtained tended to underestimate the potential for nutrient uptake. Better estimates of nutrient uptake can be obtained if plants show adequate growth and development. The objective of this study was to gather information on arracacha's dry weight accumulation pattern and to estimate N, P, K, Ca and Mg uptake in carefully managed plants grown under controlled conditions.

MATERIALS AND METHODS

The field activities were conducted on the Agricultural Experiment Station farm of the University of Puerto Rico at Adjuntas. Elevation was 549 m. The experiment was planted in May 3, 1995. The traditional cultivar Criolla was used. Freshly harvested corm buds, 45 to 50 g of fresh weight, free of disease symptoms were selected for planting. The planting material was stored at room temperature for two days to promote wound periderm formation. After this procedure the buds were planted in two 12.2 X 1.2-m concrete boxes filled with loose topsoil. The planted area was divided to accommodate four replications. Each replication contained 8 plots of 6 plants each. Plots within replications were randomly assigned to dates of sampling. Dates of sampling were at 28-day intervals from 30 to 198 days after emergence (DAE).

Emergence occurred 20 days after planting. Plots were maintained weed-free throughout the season. Fertilizer of 14-3-13 formulation was side-dressed at a rate of 28 g per plant at 2 and at 4 months after planting. To avoid

water stress, the plants were irrigated manually as needed.

At each sampling the two plants at the center of the plot were pulled from the soil as samples. The rest of the plants within the plot were guard plants. Sampled plants were cleaned with pressurized water and allowed to dry at room temperature, then divided into the leaf lamina, leaf petiole and corm.

All parts were dried to a constant weight by using a forced-air oven adjusted to 65°C. N and P concentrations in the tissues were determined colorimetrically, whereas K, Ca and Mg were determined by spectrophotometry as described by Ortiz et al. (1997). Nutrient concentration was expressed as a percentage of the dry weight.

Dry weight of the parts and the combined dry weight (whole plant) were regressed to dates of sampling (days after emergence). Data on nutrient concentration were analyzed as a 3 X 8 factorial arrangement of the plant part and dates of sampling. Nutrient uptake was calculated by considering average concentration in the plant part and the dry weight. To estimate nutrient uptake per unit of land area, a stand density of 45,200 plants per hectare was used.

RESULTS AND DISCUSSION

Dry weight accumulation in the whole plant increased linearly throughout the season (Table 1). This increase was directly associated with an increase in the dry weight of the corm. Dry weight in both the lamina and the petiole increased throughout the season but were best fitted by cubic equations.

Table 1. Parts dry weight and dry matter partitioning for arracacha plants sampled at 28-day intervals from 30 to 198 days after emergence.

Days After Emergence	Dry weight						
	Plant Part			Whole	Dry Matter Partitioning		
	Lamina[1,5] g	Petiole[2,5] g	Corm[3,5] g	Plant[4,5] g	Lamina %	Petiole %	Corm %
30	6.6	9.4	11.2	27.1	23	34	41
58	25.8	37.1	39.5	102.3	25	36	39
86	26.7	45.7	52.8	125.2	21	36	42
114	22.7	35.3	81.0	139.0	16	25	59
142	14.2	22.1	118.3	154.6	9	14	76
170	14.5	20.2	117.6	152.4	9	13	77
198	30.9	44.0	237.9	312.7	10	14	76
LSD_{005}	12.4	18.8	65.1	88.1			

[1] Best fitting curve for lamina, _ = -41.5 + 2.18 X - 0.02 X^2 + 6 X 10^{-5} X^3
[2] Best fitting curve for petiole, _ = -69.0 + 3.51 X - 0.03 X^2 + 1 X 10^{-4} X^3
[3] Best fitting curve for corm, _ = -37.05 + 1.15 X
[4] Best fitting curve for whole plant, _ = 1.33 + 1.25 X
[5] In the equation _ = Dry weight in g, and X= days after emergence.

Across dates of sampling the dry weight partitioning into the corm was higher than into the other plant parts. In this study the dry matter accumulation pattern for arracacha can be divided into two major stages. The first stage, from 30 to 86 DAE, was characterized for relatively high dry weight partitioning into the aerial parts (Table 1).

In the first stage, percentages of dry weight partitioning into the lamina and petiole were from 21-25% and from 34-36%,respectively, whereas partitioning into the corm was 39-42%. The second stage occurred after 142

DAE, and was characterized by a significant increase in the dry weight partitioning into the corm (Table 1). In the latter stage dry weight partitioning into the lamina decreased to 9-10%, partitioning into the petiole was 13-14%, whereas partitioning into the corm increased to more than 75%.

The above results suggest that corm bulking begins between 86 to 114 DAE. Also, results from the present study confirm that in arracacha the corm is the highest sink for photosynthates. In a previous study a dry weight partitioning into the corm at harvest was calculated in 81% (Ortiz and Acín, 1997). The high matter partitioning into the commercially important part of the plant, the corm, makes arracacha comparable to yam. *(Dioscorea* spp.). Irizarry and Rivera, (1985) reported 80% dry matter partitioning into the tuber of yam at harvest. In our study, values for dry matter partitioning into the corm for arracacha after 142 DAE are, by far, higher than the dry matter partitioning into the corm for taro in upland conditions (30 to 35%) (Goenaga, 1995; Ortiz, C. E and A. Gonzalez; unpublished data).The plant part by dates of sampling interaction was a significant source of variation for nutrient concentration. Average nutrient concentrations by date and plant part combinations have been summarized in Table 2.

Table 2. Mineral concentration in arracacha plant parts sampled at 28-day intervals from 30 to 198 days after emergence.

Plant Part	Days After Emergence	% of Dry Weight				
		Mineral				
		N	P	K	Ca	Mg
Lamina	30	1.97	0.69	0.07	1.07	0.38
	58	3.12	0.75	3.35	0.90	0.38
	86	3.01	0.74	3.70	0.53	0.33
	114	2.61	0.67	3.76	0.44	0.29
	142	2.55	0.73	3.53	0.91	0.34
	170	3.09	0.82	3.85	0.83	0.36
	198	2.84	0.76	3.83	0.80	0.32
Petiole	30	0.47	0.40	0.05	0.30	0.18
	58	0.57	0.44	2.58	0.42	0.23
	86	0.47	0.41	2.71	0.34	0.16
	114	0.59	0.43	2.61	0.35	0.14
	142	0.39	0.43	2.67	0.01	0.13
	170	0.40	0.45	2.72	0.29	0.13
	198	0.38	0.44	2.55	0.26	0.11
Corm	30	0.68	0.70	5.16	0.55	0.11
	58	1.41	0.77	6.50	0.49	0.23
	86	0.85	0.69	4.54	0.04	0.18
	114	0.83	0.72	0.09	0.09	0.16
	142	0.83	0.77	4.30	0.49	0.18
	170	0.92	0.85	0.10	0.19	0.19
	198	0.76	0.81	0.09	0.13	0.18
$LSD_{0.05}$[1]		0.27	0.11	0.67	0.07	0.04

[1] LSD value to compare means within the column.

Concentrations of N, Ca and Mg tended to be higher in the lamina than in the other parts independently of the dates of sampling (Table 2). Similar results have been reported previously (Ortiz et al., 1997). In contrast to previous findings, there was not a definitive tendency for these nutrients to be more concentrated in the petiole than in the corm. N and P concentrations in the petiole tended to be similar throughout the season. At individual dates of sampling, concentration of P in the petiole was lowest the compared to concentration in the other parts (Table 2). Concentration of K increased significantly from 30 to 58 DAE in all plant parts. After 58 DAE, K concentrations in both the lamina and the petiole remained stable up to the end of the season (Table 2). How-

ever, relatively low values for K concentration in the corms were obtained at 114, 170 and 198 DAE. On the basis of previous experiences, higher concentrations of K were expected.

Across plant parts, averaged for dates of sampling, the concentration of nutrients obtained in this study presented the pattern reported for arracacha. Concentration of K and N in tissues tended to be higher than P, whereas Ca and Mg were the least concentrated nutrients. This result implies the need to supply higher quantities of K and N than of the other nutrients in supplemental fertilization.

The estimates of nutrient uptake for arracacha obtained in this study were higher than those previously reported by Ortiz and Acín (1997). Estimates of maximum uptake per unit of area were 128.3 kg/ha for N, 106.5 kg/ha for P, 30.2 kg/ha for Ca and 25.9 kg/ha for Mg (Table 3). The above estimates occurred at maximum dry weight (Tables 1 and 3). The estimate of maximum uptake for K was 279.2kg/ha which occurred 142 DAE. The relatively low estimates for K uptake at 114,170 and 198 DAE were the result of low concentration of this element in tissues, especially in the corm (Tables 2 and 3). The controlled condition used in this study provided adequate dry weight accumulation and plant development. Sampled plants were similar in growth and development to those that are successfully grown in commercial field conditions. Therefore, the estimates of nutrient uptake obtained in the present study are considered more representative for arracacha than those previously reported.

Table 3. Estimates of nutrient uptake by arracacha during the crop cycle based upon 45,200 plants per hectare.

Days after Emergence	Nutrient (kg/ha)				
	N	P	K	Ca	Mg
58	70.9	29.9	198.0	26.2	12.4
86	66.1	33.9	208.8	14.2	11.4
114	66.5	39.8	83.5	13.1	10.8
142	64.6	50.1	279.2	32.1	12.8
170	72.8	54.7	55.4	17.9	13.6
198	128.3	106.4	113.7	30.2	25.9

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NITROGEN RELEASE FROM BIOSOLIDS APPLIED TO SANDY SOIL AMENDED WITH LIME

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ABSTRACT

Most bahiagrass pastures in Florida are nutrient deficient; however, ranchers have been reducing fertilizer application due to the low cattle prices. Pelletized biosolids applied to bahiagrass pastures on an acid sandy soil increased forage yield and quality linearly with rates up to 17.6 Mg/ha and between 50 to 80% of the N was made available within the first year of application. Soil pH may have a pronounced effect on mineralization from biosolids, though. The objective of this laboratory study was to investigate the effects of variable soil pH attained by liming of an acid sandy soil, on the mineralization of N from pelletized biosolids. Biosolids at the rate of 0, 1,-.1, 2.2, 4.4, 8.8 and 17.6 Mg/ha and calcitic limestone at the rate of 0, 2.2, 4.4, and 8.8 Mg/ha were added to a myakka fine sand. Soil pH values were determined bi-weekly after the addition of lime and biosolids
The N mineralization process at the various lime/pH levels was assessed by a non-leached incubation system. Soil samples were removed bi-weekly and extracted with water for the determination of NH_4 and NO_3. The soil pH values varied from 5.5 to 6.7 with increasing lime application rates. Increasing biosolids resulted in slight decreases in ssoil pH within each lime level. Ammonium was the predominant form of N within the first two weeks of incubation; however, as time progresses, NO_3 predominated. Nitrogen mineralization stabilized at 10 weeks and was reduced by the highest lime rate.

INTRODUCTION

Bahiagrass pastures in Florida are frequently under-fertilized although positive responses to N addition are obtained (Sveda et al., 1992). Reasons for that include reduced fertilizer inputs to lower production cost due to the low cattle prices, as well as coneems about environmental degradation (Muchovej and Rechcigl, 1994, 1995).

Application of biosolids (sewage sludge) to pastures has resulted in increase forage growth and quality, since it contain many essential nutrients, including N, P, and Fe. Furthermore, since sandy soils of Florida, which have a very low nutrient holding capacity, biosolids may be an important alternative slower release organic fertilizer for farmers to use. Results from a field study conducted on an acid sandy soil at the Rangd Cattle Research and Education Center, Ona, Fl (Muchovej, 1998; Muchovej 1997), indicated that pelletized biosolids application to pastures, at rates up to 17.6 Mg/ha, increased yield and quality of bahiagrass pasture linearly and that more than 50% of the N was made available within the first year of application. However, soil characteristics may heavily influence the rate of mineralization of nutrients from biosolids. Soil pH is quite variable in Florida, ranging from aeid (~4.5) to alkine (>7.5) and soil pH may have a pronounced effect on nutrient release from biosolids.

The objective of this laboratory incubation study was to investigate the effects of variable soil pH, attained by liming an acid sandy soil, and varying rates of pelletized municipal biosolidss on the mineralization of N from the biosolids.

MATERIALS AND METIIODS

The soil used for the study was a Myakka fine sand and some of its characteristics are presented in Table 1. The biosolids product was of municipal origin and contained several essential and non-essential elements (Table 2). All experiments were conducted in a randomized complete design with 3 replications. Moisture retention capacity

of each soil-biosolids mix was pre-determined. Water was added to each flask to obtain an "optimum" condition for microbial activity (approximately 70% of water holding capacity) and this moisture condition was maintained in all studies.

Table 1. Soil Characteristics of a Myakka Fien Sand (Sandy, siliceous hyperthermic Aeric Hapalaquod).

Horizon	Depth Cm	OM G/kg	C/N	pH	NO_3-N	NH_4-N ug/g
Ap	0-15	8.0	23	4.9	2.0	22
A22	15-30	1.0	6.0	5.9	2.0	2.0
Bh	35-45	29.8	50	4.6	0	0

Table 2. Composition of the Municipal Biodolids (Dry Weight Basis) (Average Values from 3 Analyses Performed).

Element	Concentration
N (TKN) (%)	4.14
NH_4-N (%)	0.35
NO_3-N (%)	<0.01
P (%)	1.91
K (%)	0.11
S (%)	3.43
Ca (%)	2.0
Mg (%)	0.60
Na (%)	0.15
Fe (ug/g)	14,400
Mo (ug/g)	4.75
Mn (ug/g)	430
Cu (ug/g)	777
Zn (ug/g)	1,105
Cd (ug/g)	7.47
Ni (ug/g)	45.9
Pb (ug/g)	26
PH	7.02

A preliminary study was conducted in which limestone, in the form of $CaCO_3$, at the rates of 0, 2.2, 4.4 and 8.8 Mg/ha, was added to 1 kg of soil, in triplicates, and placed in plastic bags. After homogenization, distilled water was added to bring the moisture content to 70-80% water retention capacity. Sub-samples were removed every 7 days for determination of water pH (1:10 soil:water ratio). The procedure was repeated for 7 weeks, when stability appeared to have been achieved (Table 2).

The soil was then air-dried and amended with biosolids at the following rates: 0, 1.1, 2.2, 4.4, 8.8 and 17.6 Mg/ha, and moisture content re-adjusted. Sub-samples were taken at 0, 21 and 42 days after the addition of biosolids and the water pH was determined (Figures 1a-d).

The mineralization process from pelletized biosolids at the various lime/pH levels was assessed in the soils by a non-leached incubation system (Keeney and Barmner, 1967; Keeney and Nelson, 1982; Ryan et al., 1973). For this experiment, the same lime and biosolids rates were applied to 50g soil and placed in Erlenmeyer flasks and optimal moisture restored. Incubation was done at approximately 24-30°C in a room equipped with a heating -

air conditioning unit, for a period of 26 weeks. At two weeks intervals, samples of approximately 2g (exact

Table 3. Soil pH after addition of lime as a function of time, before addition of biosolids

Time	0 Lime	1 lime	2 Lime	3 Lime
7 days	5.59	5.58	6.10	6.72
14 days	5.41	5.82	6.10	6.56
21 days	5.54	5.89	6.09	6.56
28 days	5.51	5.82	6.07	6.57
35 days	5.42	5.85	5.15	6.64
42 days	5.45	5.76	5.96	6.31
49 days	5.41	5.77	6.00	6.43

OL=no lime; 1L=2.2 Mg $CaCO_3$/ha; 2L=4.4 Mg $CaCO_3$/ha; 3L= 8.8Mg $CaCO_3$/ha

weight recorded) were removed from each flask and extracted with 20 ml of extracting solution. Two extractants, water and 2N KCL, were used in a 1:10 soil:solution ratio. The extraction with 2N KCL was done for NH_4 and NO_3 assessment (Garau et al., 1986). The soil extracts were maintained in a freezer until analyzed. Major (P, K, Ca, and Mg) and micro-nutrients (Fe, Mn, Cu and Zn) and NH_4 and NO_3 concentrations were determined in water extracts. All samples were analyzed at the Analytical Research Laboratory, University of Florida, Gainesville, Fl. Rates of mineralization of N were calculated as the sum of NH_4 and NO_3 present in the soil, taking into consideration the amounts present in the control treatments.

At the end of the incubation period, soil samples (2g/20ml) were removed and extracted with water and Mehlich 1 for analyses of major, micro and trace metal content.

RESULTS AND DISCUSSION

Soil pH values varied from 5.5 to 6.7 with increasing lime rates (Table 3). Increasing rates of biosolids resulted in very slight decreases in soil pH within each lime level (Figures 1a-d). This result is not unexpected since the pH of the biosolids used was in the vicinity of 7.0.

Nitrogen mineralization is presented as the concentrations of inorganic N ($NH_4 + NO_3$) for the incubation period. Values obtained for un-amended soils were subtracted from the biosolids treatments. Ammonium was the predominant form of N within the first two weeks of incubation; however, as time progressed, the predominant form was NO3 (Figures 2a,b.c), indicating the time required for nitrification to occur. The aerobic conditions maintained throughout the experiments are responsible for its prevalence over ammonium, especially in the absence of plants to absorb it. Since the incubation conditions were neither anaerobic (responsible for losses by denitrification), nor arid (volatilization losses due to lack of moisture) and there was no external factor removing N from the system, the tendency to stabilization is already evident during the incubation period. Some volatilization losses could be contributing, in part, to the reductions in total inorganic N with the highest lime rate. Nitrogen mineralization tended to reach a level of stabilization at 10 weeks and was reduced with highest lime rate.

At the lower biosolids rate a high priming effect was indicated, where N was mineralized from the soil organic matter fraction in addition to the N in the biosolids.

Since N was limiting, increasing lime rates had no effect on the concentration of inorganic N forms released. At all lime rates, mineralization of N from biosolids was close to or higher than 90% (Table 4). However, as the rate of biosolids increased, increasing rates of lime reduced N mineralization. Soil pH was increased from an average of 5.4 (0 Lime) to approximately 6.5 at 8.8 Mg $CaCO_3$/ha (Table 3). Therefore, one unit pH increase

resulted in nearly 40% decrease in the N mineralized at 10 weeks.

For the soil:biosolids samples extracted at the end of the incubation period (Data not shown), water extracts presented no detectable Fe, Cd, Pb, Ni, Cl, and NH_4 or NO_3. Sodium was detected in the range of 2 to 6 ppm. The KCl extracts from the periodically removed samples contained between 8 and 15 ppm of NH_4 and 3 to 12 ppm or NO_3. This is expected since KCl is a stronger extractant for N forms than water. The concentrations of the other elements, extracted, extracted by Mehlich 1, appear to be within normal acceptable range (data not presented), and in nearly all the sample concentrations were not detected after the first 10 weeks of incubation. Concentrations of trace metals (pb, Cd, Ni) were below detection limits, with the procedures used for evaluations.

Table 4. N mineralization after 10 weeks of incubation, as percentage of the total, as affected by lime rates, at various biosolids rates.

Biosolids	0 Lime	1 Lime	2 Lime	3 Lime
1.1 Mg/ha	100	97.0	87.0	96.7
4.4 Mg/ha	100	67.0	68.0	58.0
17.6 Mg/ha	100	88.0	71.7	61.0

OL=no lime; 1L=2.2;Mg $CaCO_3$/ha; 2L=4.4 Mg $CaCO_3$/ha; 3L= 8.8Mg $CaCO_3$/ha

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INFLUENCE OF SALINITY ON THE MORPHOLOGY AND PHYSIOLOGY OF *AMARANTHUS DUBIUS* [CALLALOO] AND *CAPISCUM CHINESE* VAR. SCOTCH BONNET.

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ABSTRACT

The effects of salt stress on the morphology, growth and physiology of *Amaranthus dubious* [callaloo] and *Capsicum chinense* [var. scotch bonnet pepper] were investigated. Various concentrations of sea salt have been used to obtain different salinity levels of the soil from 0 to 10 dS m^{-1}. Low levels of salinity at 2 dS m^{-1} actually enhanced the growth of the plants as measured by the shoot height. Concentrations higher than this inhibited the growth of callaloo. For pepper, salinity level of 4.0 dS m^{-1} was also not that inhibitory. However, salt levels above that level inhibited growth and the older leaves first turned yellowish in colour. There was a positive correlation between the increase in the level of proline in the plant tissues and salt concentration. Proline content was higher in the shoot than the root. Soluble carbohydrates increased with increasing salinity levels in both callaloo and pepper. The protein levels decreased with increasing salinity levels in callaloo but remained unchanged in pepper. The activity of the enzyme nitrate reductase was inhibited above concentrations of 4.0 dS. m^{-1} in both plants and the inhibition was severe in the roots. The results indicate that callaloo is more sensitive to salt stress than scotch bonnet pepper and slightly different mechanisms are involved in the salt tolerance in callaloo and pepper.

INTRODUCTION

Salt stress is one of the principal factors causing reduction in plant growth and generally in agricultural production. Salinity can inhibit plant growth by reduced external water potentials, toxicity through excess ions and general imbalance of ions [Greenaway and Munns, 1980]. Plants differ in their response to salinity depending upon the genotype and environmental conditions. The salinity of Caribbean soils have been increasing due to the frequency of droughts and faulty irrigation systems. In Jamaica about 25% of the total arable land is believed to be under some sort of saline stress. The situation could be similar in other Caribbean countries. Considering the fact that most of these countries are hilly and the total arable land is relatively less [between 30 to 50%], salt stress does create serious problems for agricultural productivity. Therefore, it is important to identify the level of tolerance to salt stress in some important crops in the Caribbean so that currently underutilized/ unutilized lands could be brought in to production thereby increasing agricultural productivity in the Caribbean.

Callaloo is an important leafy vegetable and scotch bonnet pepper is an important commodity crop in Jamaica. The present work has been undertaken to study the effects of salt stress on these two crops.

MATERIALS AND METHODS

Seeds of callaloo and scotch bonnet pepper were obtained from local farmers. They were germinated in small trays on sterile sand/soil mixture in the green house. Plastic pots 22cm in diameter and same depth were filled with 5kg of sandy loam sterile soil. Holes were drilled for drainage in these pots. Two seedlings of uniform size and at four-leaf stage were transplanted in to each pot. After one week, the pots were subjected to the following saline treatments: control, salinity levels [EC] of 2, 4, 6, 8, and 10dS m^{-1} Salinity levels were obtained with the help of crude sea salt dissolved in tap water. Each treatment had 10 pots. The root medium salinity levels were maintained through leaching and replenishing with appropriate salt solution every three days. The plants were protected from rain but otherwise grown in open for 6 weeks.

OBSERVATIONS

The following parameters were observed:

Shoot height [cm], proline content of the shoot and root [Bates et al. 1973], soluble carbohydrate content [Dubois et al. 1956], protein content [Lowry et al. 1951], sodium and potassium content [flame photometry] and the activity of the enzyme nitrate reductase [Davison and Stewart, 1984].

RESULTS

Shoot height: Shoot height actually showed a slight increase in both plants at salinity levels of 2dS m^{-1}. [Table 1] In callaloo, there was severe reduction above salinity levels of 4.0dS m-1 and the plants in 10dS m^{-1} died with in 4 weeks. In scotch bonnet pepper, the plants were looking healthy up to 6.0dS m^{-1} except for a slightly stunted appearance. Above these salt levels, plants showed brittle leaves, older leaf yellowing, and brittle stems. Shoot tips started showing necrosis, however, the plants survived even at the highest salt level used.

Table 1. Effect of various concentrations of salt onthe shoot height of Amaranth and Capsicum.

Salt concn. 0.0dS	0.2	0.4	0.6	0.8	1.0
Plant sp.	Shoot height in mm				
Amaranth	45+4.8	52+4.4	41+4.7	31+3.8	18+4.2 nm
Capsicum	38+4.1	42+3.5	37+3.9	31+2.3	19+1.2 13+1.1
nm = not measured					

Proline Content: There was a positive correlation between the proline content and salt levels used in both plants and in shoots as well as roots [Table-2]. However, scotch bonnet pepper showed a higher increase in proline in the shoot than callaloo. The highest proline levels [38.8µ mol] were observed in pepper grown at 8 dS m^{-1} while at the same concentration of salt, callaloo had a proline level of 23.9µ mols. In general, the proline content of the shoot was much higher than the roots.

Table 2. Effect of salt concentrations on the Proline content of Amaranth and Capsicum.

Salt conc. [dS]		0.0	2.0	4.0	6.0	8.0
Plant sp.		Proline content (m mol. g-1 fresh wt)				
Amaranth	Shoot	3.8+0.2	4.1+0.2	18.8+0.9	23.6+0.8	23.9+0.8
	Root	1.2+0.1	1.3+0.1	3.7+0.2	4.5+0.2	4.5+0.1
Capsicum	Shoot	4.5+0.3	5.8+0.2	21.6+0.9	33.4+1.1	38.8+1.8
	Root	1.6+0.1	1.8+0.1	3.4+0.2	4.6+0.1	4.8+0.1

Protein content: The protein content of callaloo decreased from 11.6% in the control to 7.3% in plants grown at 8 dS m^{-1} salt levels [Table 3]. There was a corresponding decrease in roots also but this was not as pronounced as in the shoot. On the other hand, protein levels in pepper have not changed markedly in

responded to salt stress. There was only a slight decrease from 10.5% protein in the shoot in control plants to 9.7% in plants grown at 8 dS m^{-1}.

Table 3. Protein content of shoot and root of Callaloo and peppersubjected various levels of salt stress.

Salt conc. [dSm^{-1}]	0.0	2.0	4.0	6.0	8.0
Plant sp.	Protein content [% dry wt.]				
Shoot Amaranth	11.6+0.3	11.8+0.3	10.3+0.4	8.3+0.2	7.3+0.3
Root	7.3+0.2	7.2+0.3	6.8+0.2	6.3+0.2	nm
Shoot Capsicum	10.5+0.3	11.3+0.4	10.6+0.3	9.8+0.2	9.7+0.2
Root	6.8+0.1	6.8+0.2	6.9+0.2	6.4+0.4	6.5+0.2

nm = not measured

Carbohydrate content: Soluble carbohydrate content increased from 18.8% in the shoot of callaloo control plants to 31.5% in the plants grown at 8 dS m^{-1}[Table 4]. A similar increase from 21.1 to 29.8% was seen in pepper. Roots also showed an increase in carbohydrate content but the increase was not substantial.

Table 4: Soluble carbohydrate content of Callaloo and pepper subjected to various levels of salt stress.

Salt conc. [dSm^{-1}]	0.0	2.0	4.0	6.0	8.0
Plant sp.	Carbohydrate content [% dry wt.]				
Shoot Amaranth	18.8+0.8	21.4+0.7	24.3+0.7	29.9+0.8	31.5+0.6
Root	14.4+0.7	14.8+0.5	15.3+0.6	18.8+0.6	nm
Shoot Capsicum	21.1+0.5	23.8+0.8	26.4+0.6	28.9+0.9	29.8+0.6
Root	15.5+0.3 1	5.8+0.6	17.5+0.4	17.7+0.6	17.8+0.5

nm – not measure

Potassium and sodium levels: Sodium levels were much higher in roots than in shoots in callaloo [table 5]. However, in pepper, there were more or less similar. There was a sudden jump in the sodium levels of the shoot between plants grown at 4dS m^{-1} and 6 dS m^{-1} salt levels, from 28 $mg.kg^{-1}$ to 67 $mg.kg^{-1}$ in callaloo and from 33 to 71 in pepper. Potassium levels also increased but gradually in response to increasing salt levels.

Nitrate reductase: The activity of this enzyme showed a decrease in both plants. The decrease was more in the shoots of callaloo, decreasing from 1.5 $\mu mol.\ gm^{-1}$ in control to 0.5 $\mu mol.g^{-1}$in plants grown at 6 dS m^{-1} salt levels. In pepper, the corresponding decrease was less, from 1.3 to 0.8 [Table 6]. However, activity of nitrate reductase was very severely inhibited in the roots of pepper compared to the roots of callaloo.

DISCUSSION

The results clearly indicate that low levels of salinity is actually beneficial for the growth and metabolism of both plants – Amaranthus dubious [callaloo] and Capsicum chinense [var. scotch bonnet]. The growth

parameters and biochemical composition indicate that there is no substantial decrease in any of the useful components of the two plants up to 4 dS m-1 salt levels.

Table 5: Effect of salinity stress on the sodium and potasium content of Callaloo and pepper [expressed as mg.Kg^{-1}].

Salt concn. [dS.m^{-1}]	Concn. of sodium and potassium [mg. Kg^{-1} dry st.]							
	0		2		4		6	
	Na	K	Na	K	Na	K	Na	K
Plant sp.								
Amaranth Shoot	7+0.4	26+1.3	16+0.9	48+2.1	28+3.2	71+4.4	67+3.8	94+5.4
Root	8+0.3	28+1.8	18+1.4	44+2.2	43+3.4	56+4.3	nm	nm
Capsicum Shoot	8+0.3	28+1.2	18+0.9	54+3.6	33+2.2	71+4.3	71+4.5	101+5.4
Root	9+0.4	22+2.1	17+1.8	34+3.4	39+4.3	73+4.4	nm	nm

nm = not measured

Table 6. Effect of salt stress on the activity of the enzyme nitrate reductase in Callaloo and pepper.

Salt Concn .[dS]	Nitrate Reductase Activity [mmol nitrite. g^{-1} fresh wt.]			
	0	2	4	6
Callaloo Shoot	1.5+0.03	1.7+0.03	1.1+0.02	0.5+0.01
Root	0.5+0.02	0.7+0.1	0.4+0.1	0.15+0.01
Pepper Shoot	1.3+0.02	1.6+0.03	1.2+0.03	0.8+0.02
Root	0.4+0.01	0.4+0.01	0.35+0.01	0.02+0.01

Most of the work on the effects of salt stress on Capsicums has been carried out on *Capsicum annum* and *Capsicum fruitescens* and to a lesser extent on a few other species but not on C. chinense. Hasheem et al. [1991] studied the germination ability of seeds of C. annuum . They found that at higher concentrations of sea salt, seedling growth was inhibited while germination was not. Cornillon and Palliox [1997] studied the influence of NaCl on four cultivars of C. annuum and observed that cv. Yolo wonder [sweet pepper] was most sensitive. *Capsicum chinense* var. scotch bonnet in the present study showed a similar behavior in that salt levels up to 4.0dS m^{-1} were actually beneficial and even at 6.0dS m^{-1}, the growth was not severely affected. In this respect, C. chinense appears to be more tolerant than sweet pepper varieties.

It has been well established that environmental stress, specially water stress and salt stress, results in the accumulation of organic compounds like proline in many plants [Dix and Pearce, 1981; Katz and Tal, 1980; Pandey and Ganapathi, 1985; Stewart and Lehrer, 1980, Aspinal and Paleg, 1981, Devi Prasad and Potluri, 1993, 1996]. Proline accumulation is generally believed to be as an osmo-regulation process and general protection for cytoplasmic enzymes [Aspinall and Paleg, 1981]. In both Amaranthus dubious and Capsicum chinense in the present study, proline levels increased due to salt stress, though more proline accumulation was evident in pepper than in Callaloo. The accumulation was more in the shoot than in the root suggesting that there was more protection in the shoot against salt stress. The proline levels did increase in the roots but to a lesser extent. Roots are in direct contact with the soil solution and therefore would normally be expected to develop protective mechanisms to withstand the osmotic shock. If they cannot protect the membrane system, then more ion

accumulation, especially that of Na, will result. The root system is poorly developed at higher concentrations and more Na is accumulated in the shoot system in both callaloo and scotch bonnet pepper. It appears that while the root system in general is inhibited, the xylem transport is not that hampered as higher ion accumulation is observed in the shoot system. Al-Bahrany [1994] and Gunes et al. [1996] observed increased levels of proline in the leaf tissue of *C. annum.*

Carbohydrates are also important for withstanding the osmotic shock and several salt stressed plants accumulate higher amounts of carbohydrates[Misra and Dwivedi, 1995, Devi Prasad and Potluri, 1993, 96,]. Very little information is available on the accumulation of carbohydrates due to salt stress on both Amaranths and Capsicums. In the present study, soluble carbohydrates increased in both plants.

The accumulation was higher in the shoot but in the roots, the accumulation was not inhibited compared to the control. This suggests salt stress did not cause transport problems for carbohydrates.

In Amaranth it is possible that higher carbohydrate accumulation was at the expenses of proteins as lower protein levels were observed. But in scotch bonnet pepper, protein content was not affected by salt stress. The accumulation of carbohydrate therefore must be either due to increased photosynthetic activity or at the expense of some other growth parameter. Since the plants were stunted at higher concentrations of salt, it is possible that the unavailability of carbohydrate for growth may be the reason for reduction in shoot height.

The levels of Na and K as affected by salt stress have been used to determine the level of salt tolerance in many plants. In the present study, levels of both Na and K increased in callaloo and pepper, though the increase was more in Na content. The ratio between K and Na changed in favor of Na with the increase in the level of salt. The levels of these ions were higher in shoot than the root, indicating that transport was not a problem. Similar higher levels of both Na and K in leaves and stems were found in Artiplex [Aslam et al. 1986], in tomato [Gill, 1990], in Capsicum annum [Al-Bahrany, 1994, Gunes et al. 1996, Gomez et al. 1996] and in Amaranths caudatus [Breus et al. 1994].

Studies on the effects of salt stress on enzymes is usually concentrated on polyphenol oxidase, however, N nutrition is an important factor in plant growth. Nitrate is usually transported to shoot and reduced there by the enzyme nitrate reductase. Comparatively lower levels of NR activity is found in roots. This was confirmed in the present results with both plants. In callaloo, the shoot NR activity was more affected.

This would increase metabolic cost to the plant, as roots will have to reduce nitrate for their use instead of receiving from leaves. The opposite happened in pepper, where the root NR was severely inhibited compared to the shoot. As overall protein content in callaloo declined, decrease in NR activity may partly be attributed to the inhibition of synthesis of the enzyme, which is a protein. However, the inhibition in pepper seems to be at the activity level than the synthesis of the enzyme, as protein content did not decrease significantly.

The present results clearly establish that the scotch bonnet pepper is more tolerant of salt stress than callaloo and that both plants follow slightly different mechanisms of tolerance. Callaloo can be grown successfully up to EC levels of 4 dSm^{-1}.

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PEANUT (Arachis hypogaea L.) GROWTH AND YIELD USING THE NUTRIENT FILM TECHNIQUE.

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ABSTRACT

Peanut plants, cvs 'Georgia Red' (GARED) and New Improved Spanish (NISP), were grown in polyvinyl chloride (PVC-1) trays using the nutrient film technique to study pod and seed yield for NASA's Advanced Life Support (ALS) program. Four 14-day-old seedlings each of both genotypes were transplanted into each of two growth trays (0.15 x 0.15 x 1.2 m), allotting 0.045 m2 per plant for growth. Plants were grown in reach-in growth chambers with a diurnal temperature of 28/22°C, relative humidity of 70 + 5%, 12/12 h photoperiod, irradiance at canopy level of 600 ?mol m-2 s-1, and a CO2 concentration of 700 ?mol mol-1. A modified half Hoagland nutrient solution was used. Solution pH was adjusted manually and ranged between 6.4 and 6.7, by additions of 1M NaOH or HCl. Solution electrical conductivity (EC) ranged between 1100 and 1200 ?S cm-1. All plants were harvested after 120 days. Total mean plant fresh weight was 546.5 g and 769.0 g per tray, respectively, for Georgia Red and New Improved Spanish. The total number of pods and pod fresh weight per tray averaged 152 and 190 g for GR and 138 and 154 g for NISP, while seed dry mass averaged 70 g and 81 g per tray, respectively, for GARED and NIS. The harvest index was 0.39 for GR and 0.36 for NISP. Seed yield was equivalent to or exceeded that of field-grown peanuts. Generally, the proximate nutrient composition was similar to that of field-grown peanuts. The results demonstrate that the nutrient film technique can be used for peanut production with acceptable yields.

INTRODUCTION

Peanut growth, nutrition, and physiology are being investigated at Tuskegee University as part of the National Aeronautics and Space Administration's (NASA) Advanced Life Support (ALS) research program to provide food for long term and extended space missions. For extended space missions that will involve a large number of crew members, a life support system relatively independent of resupply from earth is envisioned. ALS technologies must regenerate air, water and food, manage and recycle wastes to achieve optimum resource recovery, and minimize involvement of the crew while assuring proper monitoring and control of essential systems. Higher plants are ideal candidates for use in an ALS because they produce food and provide most of the nutrient needs of humans, and are capable of air and water revitalization.

Because of the substantial costs involved in launching large payloads into orbit, plant production systems for space agriculture will use no solid media, or a very minimal quantity (especially in light of current research evaluating plant growth in Lunar and Mars simulants). Although it will also be costly to launch large amounts of water, the nutrient film technique (NFT) provides an approach to plant growth where solid media are eliminated and total water volume can be minimized (Cooper, 1979).

In NFT systems, plants are grown in channels, troughs or trays through which a thin film (5 mm or <) of nutrient solution is circulated continuously to supply nutrients and water to the plant roots.Very little information is available on peanut growth in solution culture. Zharare et al. (1993) reported normal pod development (pods containing seeds) of a Spanish cultivar in darkened, aerated, nutrient solution. However, this occurred after the gynophores had initiated on plants in a soil based media. In this report, results are presented from a series of studies in which peanuts were grown to harvest without the use of any solid rooting medium and the nutrient solution was continuously recirculated.

MATERIALS AND METHODS

The study was carried out in 0.75 m x 1.8 m reach-in growth chambers. Peanut plants [cv 'Georgia Red' (GARED) and 'New Improved Spanish (NISP)] were grown in eight rectangular PVC plastic channels (0.15 m x 0.15 m x 1.2 m).

A modified half Hoagland nutrient solution (Hoagland and Arnon, 1950; Table 1.) was continuously pumped from each 30.4 L reservoir to each growth channel at a flow rate of about 1 L min-1 by a small in-line magnetic drive pump. The flow rate was set by using a bypass return line to each reservoir with a control valve. The solution spread across the bottom of each growing channel in a thin film and emptied into a reservoir. Nutrient solution pH was maintained between 6.4 and 6.6 by manually adding either dilute NaOH or HCl. Growth chamber conditions included a temperature of 28/22oC, 70% relative humidity, a 12/12 h photoperiod and irradiance of 600 ?mol m-2s-1.

Table 1. Nutrient solution used to grow peanut in a recirculating nutrient film technique system.

Major elements	Concentration (mmol L^{-1})	Minor elements	Concentration (μmol L^{-1})
N	3.51	Fe	45.5
P	0.50	Mn	9.2
K	3.01	Zn	0.8
Ca	2.00	Cu	0.3
Mg	1.00	B	46.0
S	1.00	Mo	0.1
Cl	4.0		

Peanut seeds were sown in moist commercial Jiffy Mix medium in Speedling transplant trays and covered with about 0.6 cm of the medium. Trays were placed in a growth chamber with a 12/12 h daily light period, a matching 28/22oC thermoperiod, and a 70% relative humidity. Seeds were watered as needed and transplants were grown for approximately two weeks.

Four seedlings were transplanted into each of four NFT growing channels. Transplants were spaced at 25 cm apart within each growing channel and 7.6 cm between channels. Before transplanting, seedlings were carefully removed from each cell and the excess medium removed by washing roots gently in tap water, ensuring minimal damage to the developing root system. Seedlings were placed through openings made in a perforated PVC grid. The small perforations in this grid facilitated the entry of the developing gynophores into the pod production zone. Plants were harvested at 120 days. Stems and leaves were separated and oven-dried at 70°C for 72 h for dry weight determination. Pods were removed from each plant, counted, weighed and dried at 35oC for 72 h and separated into mature and immature and weighed. Pods were then shelled and seeds classified into mature and immature according to the technique of Rucker et al. (1994).

RESULTS

Plants of both genotypes grown in NFT exhibited vigorous leaf and stem development, similar to that of previous studies in which plants were grown in a solid rooting medium under controlled environmental conditions. The majority of developing gynophores were able to pass through the perforated PVC grid and reach the pod production zone. At final harvest, pods and seeds that formed in NFT were normal for shape, size and colour.

Georgia Red plants produced the greater yield in terms of total number of pods and pod fresh weight, but a lower total pod dry weight than plants of New Improved Spanish [NISP; (Table 2)]. Shoot fresh and dry weights were higher for NISP plants than for GARED plants. However, harvest index [HI; (seed mass/total plant mass) was

similar for both genotypes.

When expressed on a unit area basis, total above ground fresh and dry biomass and pod fresh weight were higher for GARED plants than those of NISP, while the yield of dry pods were higher for NISP(Table 3). The total number of seeds per square meter was greater among Georgia Red plants but mature and total seed yields were greater among NISP plants.

Table 2. Pod and shoot fresh and dry weights and harvest index for two peanut cultivars grown in NFT for 120 days.[1]

Cultivar		Pod		Shoot		HI[2]
	No. (tray)	Fresh weight (g/tray)	Dry weight (g/tray)	Fresh weight (g/tray)	Dry weight (g/tray)	
GARED[3]	152+/-26.3	190+/-34.4	84+/-16.7	531+/-69	98+/-14.2	0.39+/-0.04
NISP	138+/-12.0	154+/-4.2	96+/- 2.1	769+/-426	130+/-27.6	0.36+/-0.06

[1]Data represent averages of 4 NFT growth channels comprising 16 plants.
[2]Harvest Index (seed mass/total plant mass)
[3]GARED = Georgia Red; NISP= New Improved Spanish

Table 3. Total foliage, pod, and seed yield of two peanut cultivars grown in NFT for 120 days.

Cultivar	Total Foliage		Total Pod		Seed Yield		
	Fresh weight	Dry weight (kg m^{-2})	Fresh weight (kg m^{-2})	Dry weight (kg m^{-2})	No. (kg m^{-2})	Mature	Total
GARED[1]	2.95+/-0.38	543+/- 79	1056+/-191	468+/-93	845+/-146	382+/-79	388+/-78
NISP	4.27+/-2.40	719+/-153	856+/- 24	530+/-12	769+/-67	443+/- 8 4	49+/-12

[1]GARED = Georgia Red; NISP= New Improved Spanish

When seed yield for both cultivars was extrapolated and expressed on a per hectare basis, it was determined that yield was equal to or higher than that obtained for field grown peanuts (Table 4).

Table 4.Total seed yield of peanuts grown in a recirculating NFT hydroponic system vs. field-grown plants.

Cultivar	Field-grown (kgha^{-1})	NFT-grown (kgha^{-1})
GARED[1]	3734	4806
NISP	3000	5171

[1]GARED = Georgia Red; NISP= New Improved Spanish

NFT-grown plants averaged 32% greater total seed yield (dry weight basis) than field-grown plants. Proximate nutritional analyses (Georgia Red only) showed that crude protein, crude fat, and carbohydrate levels were 30.4%, 30.8%, and 30%, respectively.

DISCUSSION

These results clearly demonstrate that peanut plants can be grown to harvest successfully in a recirculating nutrient film technique hydroponic system. Peanut plants were identical in terms of physiological events (time to appearance of first flower, fertilization, gynophore emergence and development, pod growth and pod "filling") to plants grown in a solid substrate; this suggests that NFT did not adversely affect plant growth and yield. Vegetative biomass (Table 2) averaged 2.9 kg m-2 and 4.3 kg m-2, for Georgia Red and NISP, respectively. Although the harvest indices (HI) for both cultivars were typical for field grown plants (Bell et al., 1992), a low vegetative biomass production would have improved these HI values markedly.

The high pod and seed dry mass of both cultivars (Tables 3 and 4) generally exceeded those of the same cultivars grown in the field. This suggests that a solid substrate is not necessary for pod and seed development, and that NFT is a viable growth medium for production of peanut on a small to moderate scale. Proximate nutritional analyses of both cultivars showed that crude protein (30%) compared favorably with the 22 to 30% obtained in field grown plants (Pancholy et al., 1978). The carbohydrate level of 30% included crude fiber, starch, pentosans, and sugars was greater than the 20% reported in field grown plants (Duke and Atchely, 1986). However, the fat (oil) content was lower than the 44% to 50% reported in field grown plants (Ahmed and Young, 1982). This lower fat content can partly be explained by the fact that the plants were grown at relatively cooler temperatures particularly during the dark period, and this may have affected seed maturity.

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UTILIZATION OF PHOSPHOGYPSUM ON PASTURE GRASSES

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ABSTRACT

Phosphogypsum is a by-product of the manufacture of phosphoric acid from phosphate rock and is a potential source of sulfur and calcium for crops. There are currently more than 700 million Mg of phosphogypsum in Florida alone stacked in waste piles and an additional 30 million Mg produced annually. A field study was conducted to determine whether addition of phosphogypsum to bahiagrass would increase production and quality. Results indicate that addition of up to 4.0 Mg/ha phosphogypsum increased bahiagrass yields, protein content, and *in vitro* digestibility of forage. This study has demonstrated that phosphogypsum can be used as an alternative source of sulfur and calcium for forage crops.

INTRODUCTION

Sulfur deficiencies in plants have been reported in more than 45 states, including Florida. Although sulfur is usually considered a secondary plant nutrient, it still needs to be viewed as one of the major nutrients essential for crop growth along with nitrogen, phosphorus, and potassium. Sulfur is required by plants for the synthesis of certain amino acids which are required for protein production. If sulfur is limiting, forage quality, as well as quantity, will be reduced. In fact, sulfur deficiencies are often confused with nitrogen deficiency. While in less severe cases of sulfur deficiency visual symptoms may not always show up, crop yield and quality can be adversely affected.

Until recently, little attention has been given to the need for sulfur fertilization in Florida and other parts of the country. This is understandable since in the past low analysis fertilizers contained sulfur impurities sufficient to meet the nutrient requirements for crop production. However, fertilizer manufacturing technology has now become highly advanced and consequently high analysis fertilizers, such as triple superphosphate and diammonium phosphate, are free of sulfur impurities. As a result, sulfur deficiencies are becoming more pronounced and widespread throughout the world. Coarse textured soils, such as those commonly found in Florida, may also exhibit sulfur deficiencies because of their very low nutrient holding capacity. It is important to note that sulfur fertilization will increase yields and improve the quality of crops only if the plants are deficient in sulfur. The sulfur status of a crop is best determined by having plant tissue samples analyzed for sulfur. Tissue analysis is better correlated to crop yield than soil tests for sulfur. For grasses, the level of sulfur in plant tissue should range from 0.2 to 0.5 percent. If the level of sulfur falls below 0.2 percent, sulfur deficiency is indicated and the grass should respond to sulfur fertilization.

Over the years, we have demonstrated that the addition of sulfur can increase production of harvested forages, such as bahiagrass (*Paspalum notatum* Flugge), by as much as 25 percent and protein by 1.2 percent. In these studies, the sources of sulfur were ammonium sulfate and potassium sulfate which are relatively expensive. Bahiagrass, which is an important forage crop in Florida, is grown on nearly five million ha, exceeding production of all other improved grasses combined. To provide sulfur for this land area would be a considerable expense.

There is a need to find an alternative economic source of sulfur which would be more affordable to growers than traditional sulfur fertilizers. Phosphogypsum, which is primarily gypsum ($CaSO_4.2H_2O$), is a by-product of the wet-acid production of phosphoric acid from rock phosphate, is a potential low cost source of sulfur and calcium for forages and other crops. In Florida alone, there are more than 700 million Mg of phosphogypsum stored in waste stacks, with 30 million tons being added to the stacks annually. In the entire country the total amount of phosphogypsum in stacks is estimated at seven billion tons. Until now, phosphogypsum has had little commercial

use because it contains low levels of radium (8-30 pCi Ra-226/g), raising concern over its potential harmful effects.

This paper presents the results of the agronomic effects of phosphogypsum, applied at agronomic rates, on bahiagrass.

MATERIALS AND METHODS

Over the past ten years, we have evaluated the agronomic and the environmental impact of phosphogypsum use on pastures in Florida. The studies were conducted at the University of Florida Range Cattle Research and Education Center at Ona, Florida. The analysis for the phosphogypsum used in the study are shown in Table 1.

Yearly phosphogypsum rate of 0.4 Mg/ha and one-time rates of 2.0 and 4.0 Mg/ha were applied to long-established bahiagrass plots located on a Myakka fine sand soil. No-phosphogypsum plots served as controls. Bahiagrass forage was harvested monthly from May until December in order to assess the influence of phosphogypsum on forage production and quality. Soil samples were collected annually to a depth of 1.0 meter. Water samples were collected after each heavy rain to a depth of 1.5 meter. Forage, soil samples, and groundwater samples were analyzed for various plant nutrients. Fluorides were also determined in forage and groundwater samples.

Table 1. Chemical analyses of phosphogypsum (PG) used in the study.

Elements	Concentration (Unit)
Major nutrient:	%
Calcium (Ca)	26.2
Sulfur (S)	19.5
Phosphorus (P)	0.7
Micro nutrient: mg kg^{-1}	
Iron (Fe)	860-1, 000
Sodium (Na)	520
Potassium (K)	200-230
Molybdenum (Mo)	2.2-11
Magnesium (Mg)	<940
Boron (B)	<3.0
Zinc (Zn)	<340
Copper (Cu)	<82
Manganese (Mn)	25
Chloride (Cl)	<150
Nickel (Ni)	<2.0
Phytotoxic:	
Fluoride (F)	5,000
Aluminum (Al)	2,000

RESULTS AND DISCUSSION

Forage Yield

Regardless of the rate or time of application, phosphogypsum tended to increase regrowth and mature (hay) bahiagrass yields by approximately 20 % (Figure 1) over the 3-year period. Increases in regrowth and hay yields were noted for the 0.4 Mg/ha as well as at higher rates, for at least two years, and over the 3-year period for all rates. Other studies have also shown that addition of phosphogypsum, mined gypsum, or other sources of sulfur can increase forage production when sulfur is deficient (Alcordo and Reehcigl, 1993).

Forage Quality

Phosphogypsum tended to increase crude protein content of the mature bahiagrass forage, by as much as 1% in all years and over the 3-year period (Figure 2), and the digestibility, by as much as eight percentage units (Figure 3) in some individual harvests during the first year (1990). This is in agreement with other studies showing that addition of sulfur will increase the nutritive value of forages on sulfur deficient soils. Increases in both digestibility and protein content of forage are known to increase the weight gains in livestock. Phosphogypsum increased the sulfur (Figure 4) and calcium (Figure 5) content of the bahiagrass tissue. The calcium content ranged from 0.42 to 0.60%. Sulfur content ranged from 0.18 to 0.40% for the 0 and 4.0 Mg phosphogypsum/ha treatments, respectively.

Phosphogypsum also slightly increased the fluoride content of the bahiagrass tissue from 7.2 mg/kg for the control to 8.6 mg/kg for the 4.0 Mg phosphogypsum/ha (Figure 6). However the content was well below the 30 ppm maximum acceptable level for livestock intake. The low levels of tissue fluoride found in this study are of some importance since high levels of fluoride may bring about the loss of teeth in cattle.

This study demonstrates that phosphogypsum can increase both the yield and quality of bahiagrass, and possibly other forage grasses. This can, in turn, lead to greater livestock weight gains and increased stocking rates, resulting in increased profits of ranchers. Phosphogypsum may, thus, be a viable and an economical source of sulfur and calcium for forage production.

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EFFECTS OF FERTILISER AND GOAT MANURE ON NUTRIENT PRODUCTION OF KING GRASS IN JAMAICA

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ABSTRACT

In a continuing effort to establish its potential as a basic fodder grass for goat production in Jamaica the effects of different manure treatments on the nutrient production of 9-week regrowths of King grass were studied over two years using a randomised block design with six replications. The manure treatments were inorganic fertiliser (F), goat manure (GM) and inorganic fertiliser + goat manure (FGM), all providing the equivalent of 150 kg N/ ha/yr, and a control (no manure, N). There were significant ($P<0.001$) differences between the treatments for nutrient production. F produced the highest amounts of crude protein (CP, 3.2 t/ha/yr) and digestible organic matter (DOM, 13.1 t/ha/yr) as a result of high dry matter yield (DM, 26 t/ha/yr) and high contents of CP (13.2%) and *in vitro* organic matter digestibility (IVOMD, 52.7%). FGM, GM and N followed in that order for DM yield (22.1, 13.0 and 8.4 t/ha/yr), CP yield (2.8, 1.5 and 0.9 t/ha/yr) and DOM yield (11.3, 6.6 and 4.2 t/ha/yr) although FGM had similar CP (13.2%) and IVOMD (52.5%) contents as F. However, the cost per tonne of DM (US$13), CP (US$105) and DOM (US$26) produced with FGM was 12, 17 and 13% lower than for F and GM.

INTRODUCTION

King grass, one of the tall varieties of the *Pennisetum purpureum* x *P. glaucum* hybrids is a high yielding forage crop used for ruminant livestock production in tropical and subtropical areas; from Asia (Bai, Yang, Gu, and Zhou 1994; Balaraman 1995) through Latin America (Herrera 1990) to southern United States of America (Cuomo, Blouin and Beatty 1996) and northern Australia (Muldoon and Pearson 1977). The grass was introduced into Jamaica from Cuba in 1983 (Logan 1986) and since then it has been used fairly extensively by small to medium dairy farmers in dairy schemes in the island.

About six years ago the promotion of the use of King grass for economic goat production in the island began. However, most of the goat producing areas of Jamaica, unlike those of dairy, are located in the dry ecozone. Such ecozones or dry spells in a normally wet ecozone are generally not conducive to high productivity of King grass. For example in Venezuela the yield of the grass in dry locations was found to be 14 per cent that in wet locations (Guzman 1983). Similarly in the Jiangsu province of China only 14 per cent of the annual dry matter accumulation occurred during the dry season (Bai et al. 1994), although in Cuba 30 to 40 per cent of King grass dry matter production has been reported (Herrera 1990) to have taken place in the dry season. Therefore in order to make King grass an integral component of a sustainable goat production programme in the dry ecozone a strategical management system that concentrates on the short wet periods and utilises appropriate plant nutrients should be developed. The study reported here was undertaken in order to determine whether the productivity of the King grass in the dry ecozone of central Jamaica could be improved with strategic application of inorganic fertiliser and goat manure.

MATERIALS AND METHODS

Site

The study was conducted at the Hounslow Demonstration and Training Centre (HDTC) in the parish of St. Elizabeth, Jamaica (18°00'N, 77°37'W). Average (over 30 years) annual rainfall for the locality is about 1100

mm with 24 per cent falling in May/June and 42 per cent in September/November. However, during the two-year period of the study rainfall was only 50 (1997) to 60 (1996) per cent of the long-term average. The soil at the HDTC is St. Ann Clay Loam (Stark 1963) with pH 6.4.

Experimental design

The experiment was superimposed on two years old (initial establishment - spring 1993) King grass. There were four treatments that were randomly assigned to 24 plots, each 2 x 2 m, in six replications. The four treatments were: inorganic fertiliser (F), goat manure (GM), inorganic fertiliser +goat manure (FGM) and a control of no manure (N). The manure was applied at a rate equivalent to 150 kg N/ha/yr as 0.44 kg/plot/yr of 14-28-14 (N-P-K) fertiliser, 5 kg/plot/yr of goat manure and 0.22 kg/plot/yr of 14-28-14 fertiliser + 2.5 kg/plot/yr of goat manure for F, GM and FGM respectively. The application was made in four splits at the beginning and towards the end of the rainy seasons of May-June and September-November.

Forage harvesting

The plots were cut back on 30 March 1995 to a stubble height of 4 to 8 cm (one aboveground node) and the treatments applied thereafter. Subsequently they were harvested at 9-week intervals (Table 1). On each harvesting date the number of tillers was counted, total forage yield recorded and two subsamples of 500 to 1000 g each were taken. One subsample was oven-dried at 60 °C for 72 hours for total dry matter yield and nutrient content determination, while the other subsample was separated into leaf and stem fractions and also dried.

Chemical analyses

The dried subsamples were milled through a 1 mm mesh screen and analysed for crude protein (CP, AOAC 1984), *in vitro* organic matter digestibility (IVOMD, Moore and Mott 1974) and neutral detergent fibre (NDF, Goering and Van Soest 1970).

Table 1. Harvesting Dates.

Year 1 (1995/96)	Year 2 (1996/97)
1 June 1995	13 June 1996
3 August 1995	15 August 1996
5 October 1995	17 October 1996
7 December 1995	19 December 1996
8 February 1996	20 February 1997
11 April 1996	24 April 1997

Statistical analyses

The data were analysed using GENSTAT 5 Release 3.2 statistical package (Lawes Agricultural Trust 1996) and the means compared by LSD.

RESULTS

The responses of tillering, dry matter yield and leaf fraction to the treatments varied significantly ($P<0.001$) for the four treatments. F produced the highest number of tillers, the highest dry matter yield and the lowest leaf fraction (Table 2). FGM produced similar number of tillers as F but its leaf fraction was some three-percentage points more and its dry matter yield 15 per cent lower than F. The application of goat manure alone (GM) showed better responses to tillering and dry matter production than the control (N), but the response to leaf

fraction was four percentage points lower (Table 2).

Table 2. Effect of Manure on Proportion of Leaf, and Content and Yield of Nutrient of King Grass.

	None (Control)	Fertiliser	Goat manure	Fertiliser + Goat manure	SED[1] (235 df)
Leaf (% DM[2])	64.4	54.7	60.3	57.3	0.59
Crude protein (% DM)	11.0	13.2	12.2	13.2	1.03
IVOMD[3] (%DM)	48.6	52.7	51.4	52.5	0.53
NDF[4](%DM)	64.1	63.3	64.6	63.1	0.29
Tillers (no./sq. m)	32.0	59.4	40.7	63.5	2.74
Dry matter yield (t/ha/yr)	8.4	26.0	13.0	22.1	1.12
Crude protein yield (t/ha/yr)	0.9	3.2	1.5	2.8	0.14
Digestible organic matter yield (t/ha/yr)	4.2	13.1	6.6	11.3	0.58

[1]SED = Standard error of a difference; [2]DM = dry matter; [3]IVOMD = In vitro organic matter digestibility [4]NDF = Neutral detergent fibre

The trends in the responses to the treatments were different between leaf fraction on one hand and dry matter yield and tiller numbers on the other. The fraction of leaf in the dry matter for F, GM and FGM declined (and stem increased) drastically during the period of maximum growth (September – November rainy season, Figure 1), while that of N remained high throughout the growing period. Dry matter yield and tillering did not show such dramatic disparity between the control (N) and the manure treatments (F, GM, and FGM) yet there were sufficient differences to distinguish between the treatments (Figures 2 and 3). Tiller production during the dry season as a percentage of the annual total was 23.4, 31.4, 27.0 and 25.8 for N, F, GM and FGM respectively. Similarly, dry matter accumulation during the dry season accounted for 15.1, 19.6, 15.2 and 17.6 per cent of the annual total for N, F, GM and FGM respectively.

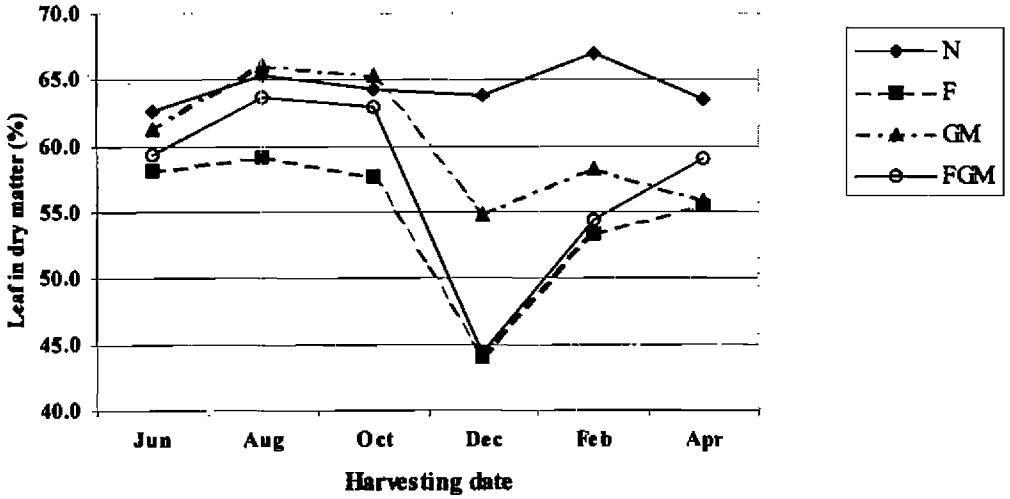

Figure 1. Effect of manure on king grass leaf fraction (mean of two years)

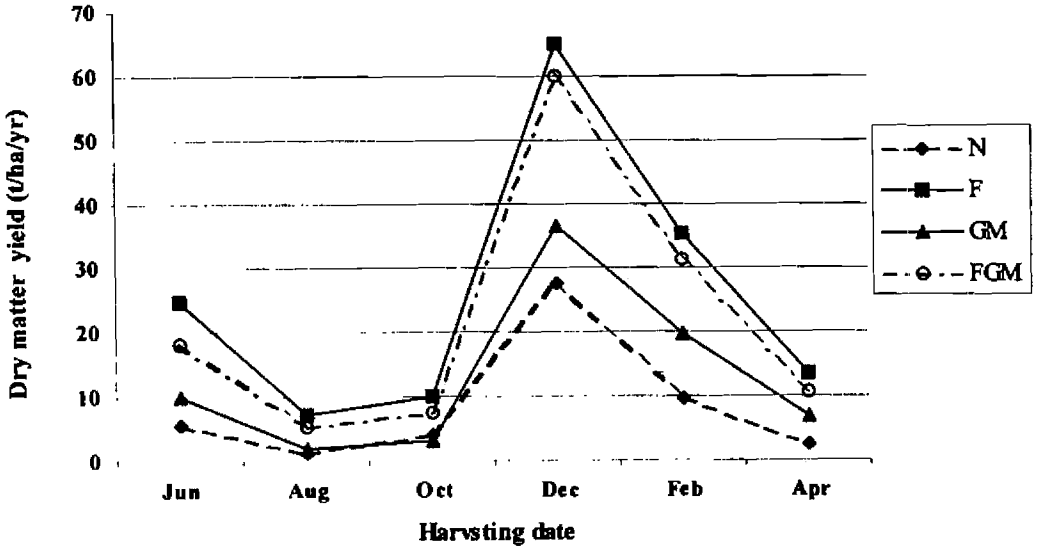

Figure 2. Effect of harvesting date on king grass yield (mean of two years)

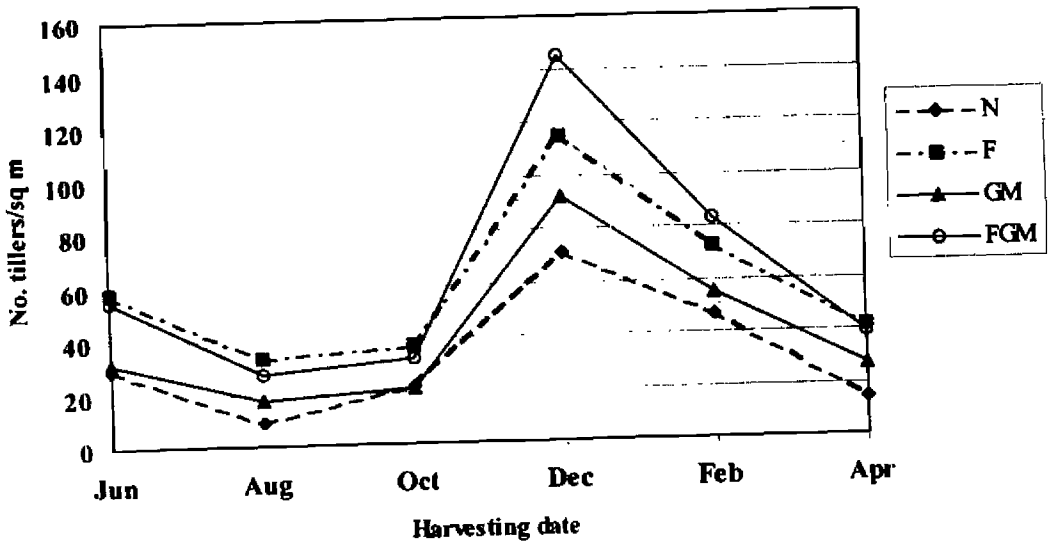

Figure 3. Effect of harvesting date on king grass tillers (mean of two years)

Both F and FGM gave significantly ($P<0.001$) higher crude protein content than the control, N and were also more digestible than n and GM (Table 2). The latter two treatments had higher ($P<0.001$) NDF and lower digestibility contents. The combined positive effects on dry matter production, and crude protein and *in vitro* digestibility contents of f and FGM resulted in significantly ($P<0.001$) higher crude protein and digestible organic matter production than either N or GM (Table 2).

DISCUSSION

The manure treatments produced different responses in dry matter yield although the rate of nitrogen application was the same and thus indicating varying efficiency of utilisation of the applied nitrogen. Inorganic fertiliser gave the highest dry matter production, averaging 26 t/ha/yr over the two years. That was similar to the yield of another tall *Pennisetum* hybrid (MEF1) in St. Croix fertilised with 75 kg N/ha yr (Adjei, Gentry, Schank and Sotomayor-Rios 1994). The dry matter production from goat manure alone was particularly low and even lower than the yield of similar hybrid *Pennisetum* cultivar (average 16.9 t/ha/yr) grown with 60 kg N/ha/yr in the US Virgin Islands under rainfall conditions similar to those at the HDTC (Adjei 1995). Combining the goat manure

with an equal amount (as applied nitrogen) of inorganic fertiliser increased dry matter production by more than 180 per cent. Goat manure and other farm yard manure tend to mineralise slowly and it would seem that their first role is to hold the soil moisture in order to facilitate the initial mobilisation of the nutrients in the inorganic fertiliser while their own mobilisation proceeded slowly. Cuban scientists working on King grass also observed similar synergy between cattle manure and inorganic fertiliser (Herrera 1990).

The unit structure of the King grass plant is the tiller and forage production of the grass is a summation of the productivity of the component tillers. Kamel, Abdel-Raouf, El-Din, and Abbas (1983) showed that nitrogen fertilisation increased tiller numbers and forage yield of *Pennisetum purpureum*. In this study the treatments which developed most tillers (F and FGM) were the ones which produced most dry matter. These two treatments also revealed that stem development and elongation (inverse of leaf accumulation) contributed substantially to the overall forage production capacity.

The distribution of dry matter yield and its components during the growing season followed the expected pattern, with more tillers and dry matter produced during the wet period than during the dry season. Nevertheless it appears the strategic split application of the manure might have helped to prolong the growing season as reflected in the production of 27 to 31 per cent of the tillers and 18 to 20 per cent of the dry matter by F and FGM during the dry season. This is in contrast to the figure of 14 per cent obtained by Guzman (1983) and Bai et al. (1994).

The application of manure resulted in a reasonably high crude protein content (12.9% average over the three treatments) of King grass, which was quite expected and also was similar to the value obtained for the cultivar MEF1 (Adjei et al. 1994). The differences between the treatments in crude protein content were reflected in the contents of *in vitro* organic matter digestibility and neutral detergent fibre too. This is consistent with the observed significant relationship between digestibility and crude protein contents for King grass (Leon, Ibarra, Acosta and Flores 1984). Knowledge of the nutrient contents of the grass as influenced by the treatments is important but so also is that of the yield of the nutrients since that is more indicative of the number of goats that could be fed from a give area of King grass pasture.

The data presented in Table 2 gives a ranking of the manure treatments in order of crude protein and digestible organic matter yield as F>FGM>GM. Thus as a purely scientific study inorganic fertiliser would be the best source of nitrogen for the production of King grass nutrients. But in terms of the potential for applicability of the results the cost associated with the production of the nutrients from the manure would be more relevant. The manure cost per unit of dry matter, crude protein and digestible organic matter is presented in Table 3. FGM is about 12 to 15 per cent more cost effective than the F and 11 to 19 per cent more cost effective than GM alone.

Table 3. Fertiliser and Manure Cost Per Unit Nutrient Produced.

	Fertiliser	Goat manure	Fertiliser + Goat manure
Fertiliser/manure cost (US$/ha/yr.)	392.3	194.56	293.41
Dry matter (DM) yield (t/ha/yr.)	26.0	13.0	22.1
Crude protein (CP) yield (t/ha/yr.)	3.2	1.5	2.8
Digestible organic matter (DOM) yield (t/ha/yr.)	13.1	6.6	11.3
Fertiliser/manure cost/t DM yield (US$)	15.09	14.97	13.28
Fertiliser/manure cost/t CP yield (US$)	122.59	129.71	104.79
Fertiliser/manure cost/t DOM yield (US$)	29.95	29.48	25.97

The results have shown that the production of nutrients by King grass in the dry ecozone of Jamaica could triple with the application of inorganic fertiliser or inorganic fertiliser plus goat manure in a ratio of 1:1 of nitrogen applied. However, the cost per tonne of DM (US$13), CP (US$105) and DOM (US$26) produced with FGM was, on average, 12, 17 and 13 per cent lower than for F and GM. Therefore it is concluded that a combination of inorganic fertiliser and goat manure applied strategically at the beginning and towards the end of the rainy season would facilitate economical production of nutrients by King grass even in dry ecozone.

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PRELIMINARY STUDY INTO NUTRIENT EFFECT ON PLANT GROWTH, PRODUCTION AND SELECTED PESTS AND DISEASES INCIDENCE IN SCOTCH BONNET PEPPER

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ABSTRACT

Scotch Bonnet pepper is a non-traditional export crop, with an expanding market. It is also an important ingredient in jerk seasonings and the local cuisine. Production and productivity are often hampered by poor agronomic management and attacks from a range of pests and diseases particularly TEV and PVY. Previous studies have shown varying response to nutrient application. On the basis of the crop demand and preliminary pot studies, levels of N, P, and K were proposed. The study was a RCB with four replicates of five treatments.

Seedlings were established 60 cm apart in rows that were 90 cm apart. The levels of nutrient used were: T1 (control, no fertilizer); T2 (187 kg N/ha, 31 kg P/ha, 75 kg K/ha); T3 (374 kg N/ha, 62 kg P/ha, 150 kg K/ha); T4 (748 kg N/ha, 62 kg P/ha, 300 kg K/ha); and T5 (foliar application of N15:P30:K30). The N and K were split into three applications. The P was applied with a third of the N and K seven days after transplanting. The nutrient effect on plant growth, production and the relationships between nutrient levels and pest and disease incidence were studied on the Bodles Research Station.

The results showed significant impact of fertilizer on plant height ($P<0.05$), and spread (length x width) ($P<0.05$) as well as number of fruits ($P=0.036$). There were also significant differences among treatments for aphids and mites ($P<0.001$). The study with several modifications is being evaluated for a second season.

INTRODUCTION

Pepper production

Hot peppers (*Capsicum spp.*) are grown throughout Jamaica and the wider Caribbean. Over the past decade Scotch Bonnet pepper has played an important part in the Jamaican economy being the third largest non-traditional agricultural export crop. Its market potential has been recently reviewed by Reid and Graham (1997). Pepper has found wide-scale use as part of the Caribbean cuisine. It is used in soups and stews for the flavour but it also forms part of the ingredients for salads and a number of dishes. Spicy food is now a specialty even with the fast food industry. Jerk seasoning is peculiar to Jamaica and is now growing in export. The hot pepper fruit is a rich source of Vitamins C and A and can also be used fresh, dried or processed into sauces or pickles.

The hot pepper crop can be produced from sea level to 2000m in areas with precipitation between 750 and 1500mm. Ideally, the rainfall should be well distributed throughout the growing season. However, for optimum production irrigation is strongly recommended, as the crop is susceptible to drought especially in the early stages.

The production of hot pepper in Jamaica increased from 1700 tonnes in 1989 to 9000 tonnes in 1996. There was a decline in production in 1997 which may have been associated with severe drought conditions experienced locally at that time. Hot pepper production (Scotch Bonnet in particular) has also been affected by an increased incidence of viruses.

Although the crop can be grown on a range of soils, a well drained fertile loam or clay loam is desirable. The most suitable pH range is between 6.0 and 7.5. Soil nutrient management is a major problem in need of further study. The soil nutrient requirement and plant nutrient sufficiency levels in *Capsicum spp.* are summarised in Tables 1 and 2.

In recent years several arthropod pests and diseases, especially viruses, have been severely restricting production. The most common viruses include Tobacco etch (TEV), Tobacco mosaic (TMV) and Potato Y (PYV). Tobacco etch and PYV are transmitted by aphids. Other arthropod pests (thrips, gall midges, fruit worms and mealybugs) are proving problematic especially for the export market. The seasonal incidence of hot pepper pests in the major pepper growing areas of Jamaica has been recently reported by Martin et al (1998) while some of the important diseases of hot pepper in the Caribbean have been noted by McDonald and Muller (1992).

Table 1. Generalized nutrient NPK suggestions for soil applications for hot pepper.

Nutrient	Soil nutrient Status	Soil Nutrient Requirement (kg/ha)
N	Low	100-130
P_2O_5	Low High	200 100
K_2O	Low High	200 100

Table 2. Sufficiency range of selected macro-nutrients in pepper leaves.

Macro-nutrients	Sufficiency Range (%)
Nitrogen	4.00 - 6.00
Phosphorus	0.35 - 1,00
Potassium	4.00 - 6.00
Calcium	1.00 - 2.50
Magnesium	0.30 - 1.00

Nutrient studies in hot peppers

There have been several studies on the nutrient requirements of peppers. Robinson and Baker (1992) showed that N had a positive effect on yield, P had a negative effect and the NxP interaction was significant. The levels of N used were 0, 83.5, 194.2, 229.2 kg/ha. For P the values used were 0, 65.5, 98.2, and 196.3 kg/ha. Smith and McGlashan (pers communication) have done a recent pot study to assess different levels of nutrients on Scotch Bonnet pepper. On the basis of their findings and the suggestion of nutrient levels for peppers by Lorenz and Maynard (1986) the treatments used in this study were selected.

This particular study was undertaken as part of the IPM strategy in Jamaica. The main objectives were to assess the effect of varying NPK levels on crop growth and fruit production and pest and disease incidence.

MATERIALS AND METHODS

Scotch Bonnet pepper seedlings were grown at the CARDI greenhouse facilities and transplanted to the experimental plots at Ministry of Agriculture, Bodles Research Station, St Catherine. The seedlings were planted 60 cm within rows and 90 cm between rows with a total of 30 plants per plot. Plots were watered by overhead sprinkler irrigation once or twice weekly.

to no treatment (control plots) showed no deficiency levels of nutrient for the efficient production of a crop.

Table 3. Levels of pH, organic matter, nitrogen, phosphorus, potassium, calcium and magnesium detected in soil samples collected from Scotch Bonnet pepper plots six weeks after transplanting.

Treatment	pH	OM (%)	N (%)	P_2O_5 (mg/kg)	K_2O (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
T1	7.4	2.36	0.14	139	490	5925	1681
T2	7.0	2.67	0.15	315	609	5725	1594
T3	6.9	3.06	0.18	351	810	6050	1531
T4	6.6	2.40	0.17	350	679	5270	1641
T5	7.5	2.69	0.16	220	577	6563	1606
SED (11 df)	0.254	0.371	0.0267	124	153	598.4	177.7
P	0.029	0.387	0.634	0.394	0.355	0.349	0.934

Table 4. Levels of pH, organic matter, nitrogen, phosphorus, potassium, calcium and magnesium detected in soil samples collected from Scotch Bonnet pepper plots 12 weeks after transplanting.

Treatment	pH	OM (%)	N (%)	P_2O_5 (mg/kg)	K_2O (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
T1	7.4	2.13	0.13	93	471	4625	1600
T2	7.2	2.38	0.13	166	556	5088	1528
T3	7.2	2.74	0.16	211	748	5063	1494
T4	7.2	2.02	0.14	81	459	4970	1659
T5	7.6	2.24	0.14	167	612	4738	1500
SED (11 df)	0.302	0.279	0.0189	78.0	131	602.0	103.5
P	0.603	0.167	0.635	0.450	0.237	0.914	0.473

A randomised complete block design was used with 4 replications and 5 treatments. The fertilizer treatments were as follows: T1 (control, no fertilizer); T2 (187 kg N/ha, 31 kg P/ha, 75 kg K/ha); T3 (374 kg N/ha, 62 kg P/ha, 150 kg K/ha); T4 (748 kg N/ha, 62 kg P/ha, 300 kg K/ha); T5 (foliar application of N15:P30:K30). Fertilizer treatments were chosen by consultation among collaborators (MOA, Lincoln University and CARDI) based on experience and published recommendations. The sources of fertilizers were ammonium sulphate, triple superphosphate and muriate of potash. The total amount of phosphorus in each treatment was applied five days after transplanting while N and K were divided into three equal portions and applied one week after transplanting, seven weeks after transplanting and 12 weeks after transplanting (after flowering). The fertilizers were applied

in bands (ring) and incorporated into the soil. The fertilizer used in the foliar treatment was 15N:30P:30K soluble fertilizer which was applied every two weeks.

Before planting, composite soil samples were collected from the experimental plots and assessed for N, P, K, Ca, Mg, organic matter (OM) and pH. Additional samples were collected from each plot; 6 weeks after transplanting during vegetative growth of the crop; after flowering (12 weeks after transplanting) and at the end of the experiment (19 weeks after transplanting). These additional samples consisted of four cores taken 15 cm from each of four plants. The cores were taken from the top 15 cm of soil. Fifteen recently expanded leaves were also collected from each plot and assessed for N, P, K, Ca and Mg. The plots were visited weekly and six inner plants were assessed for virus disease symptoms, arthropod pests, plant height and spread and yield. Arthropod incidence was measured by dividing the plants into four sections based on the natural branching pattern and assigning a score from 0 to 4 based on presence or absence on each of these four sections. Yield was assessed as number and weight of fruit.

Data were analysed using GENSTAT statistical software. Overall treatment effects, on nutrient levels in soil and leaf samples as well as on pest incidence, were assessed using analysis of variance.

RESULTS AND DISCUSSION

The mean values for selected soil nutrients, 6, 12 and 19 days after transplanting, shown in Tables 3-5 indicate a difference only in pH value which was lowest for Treatment 4 which had the highest level of nitrogen (748 kg/ N). The nitrogen source used, ammonium sulfate, has an acidifying effect on the soil but this is probably short lived and localised. Organic matter, P, K, Ca and Mg contained in the soil seemed to be adequate for average growth and production of pepper because the plants subjected

Table 5. Levels of pH, organic matter, nitrogen, phosphorus, potassium, calcium and magnesium detected in soil samples collected from Scotch Bonnet pepper plots 19 weeks after transplanting.

Treatment	pH	OM (%)	N (%)	P_2O_5 (mg/kg)	K_2O (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
T1	8.3	1.79	0.14	72	305	4725	1265
T2	7.4	2.26	0.15	124	535	4575	1197
T3	7.0	2.43	0.16	131	718	4425	1153
T4	6.5	2.06	0.16	67	678	4185	1173
T5	8.4	2.25	0.14	176	480	5050	1190
SED (11 df)	0.383	0.238	0.0101	76.4	134	472.3	148.1
P	0.002	0.151	0.159	0.605	0.064	0.475	0.952

Nutrient content in leaf samples collected 6, 12 and 19 weeks after transplanting are shown in Tables 6-8. These compare favourably with suggested values by Lorenz and Maynard (1986) with the exception of calcium which was low.

There were significant differences among fertilizer treatments in the incidence of aphids and mites ($P<0.001$ and $P<0.05$ respectively; Figs 3 and 4). Plots to which the highest amount of nutrients were applied (T4), and which had significantly higher leaf N over time, had significantly higher incidence of aphids and mites than the control. While no insecticides were used in this study, on farm, the higher levels of these pests may result in farmers applying higher levels of pesticides. Increased health and environmental concerns are therefore attached to the higher fertilizer application (T4). This makes the lower levels of fertilizer (T2 and T3) more

Table 8. Nutrient levels in leaf samples collected from Scotch Bonnet pepper plots 19 weeks after transplanting.

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
T1	4.00	1.48	3.50	0.62	0.60
T2	4.35	1.18	4.05	0.54	0.52
T3	5.05	1.07	3.88	0.48	0.41
T4	4.76	1.33	3.96	0.51	0.46
T5	4.44	1.73	4.38	0.59	0.49
SED (11 df)	0.462	0.248	0.226	0.0979	0.069
P	0.133	0.136	0.033	0.570	0.151

Table 9. Weight (g) and total number of fruits per plot from eight harvests.

Treatment	ln Total weight (g)	SEM (11d.f)	Total weight of fruits	Ln Total number	Total number of fruits	SEM (11 d.f)
T1	5.22	0.443	185	3.03	20.7	0.376
T2	6.26	0.443	523	4.14	62.8	0.376
T3	6.37	0.443	584	4.25	70.1	0.376
T4	6.10	0.527	446	4.06	58.0	0.448
T5	4.59	0.443	98.5	2.62	13.7	0.376
P	0.069			0.036		

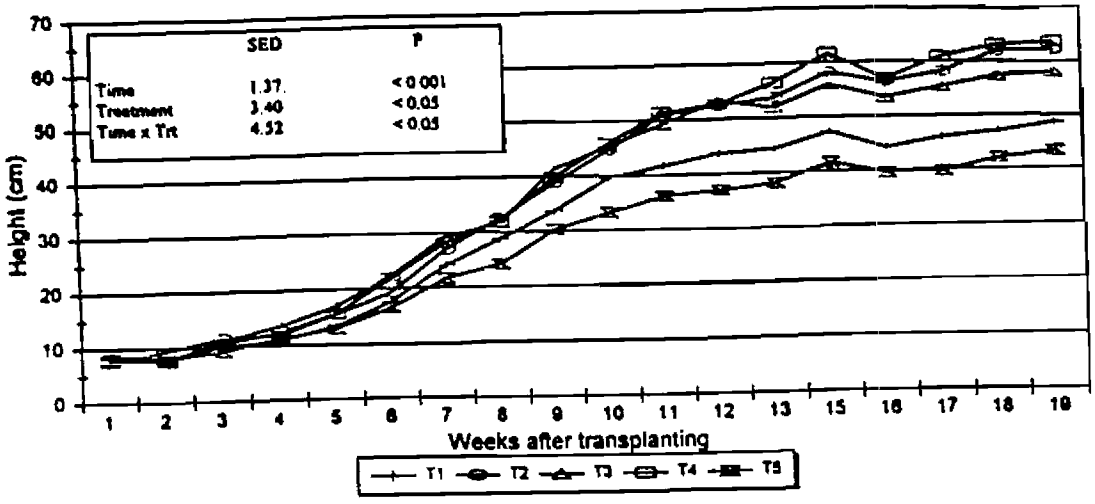

Figure 1. Effect of five fertilizer regimes on height of pepper plants

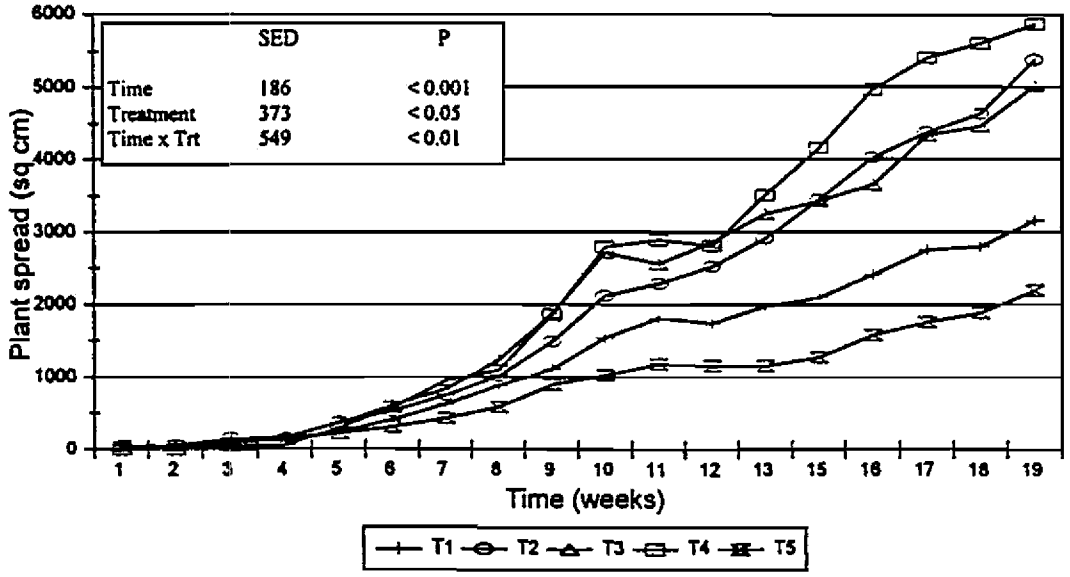

Figure 2. Effect of five fertilizer regimes on plant spread of pepper plants

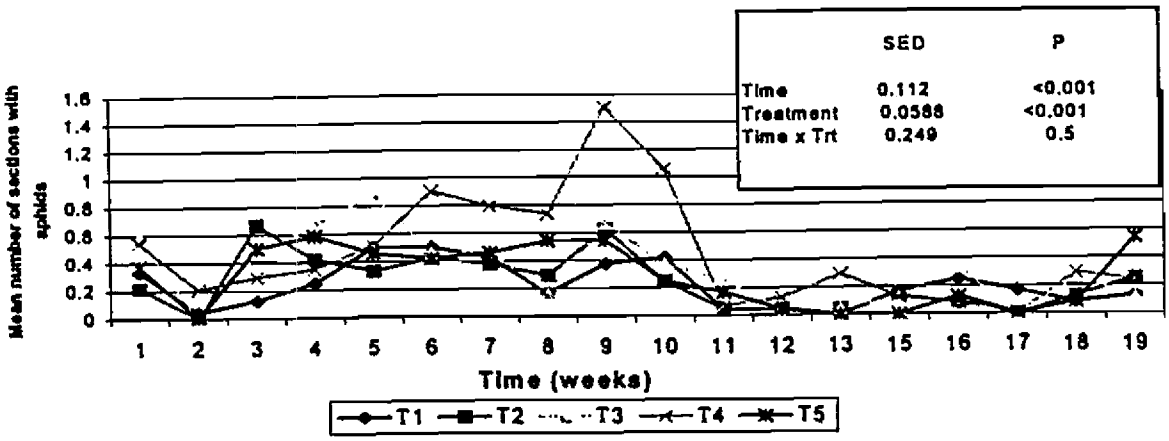

Figure 3. Effect of five fertilizer regimes on aphid count on hot pepper branches over time

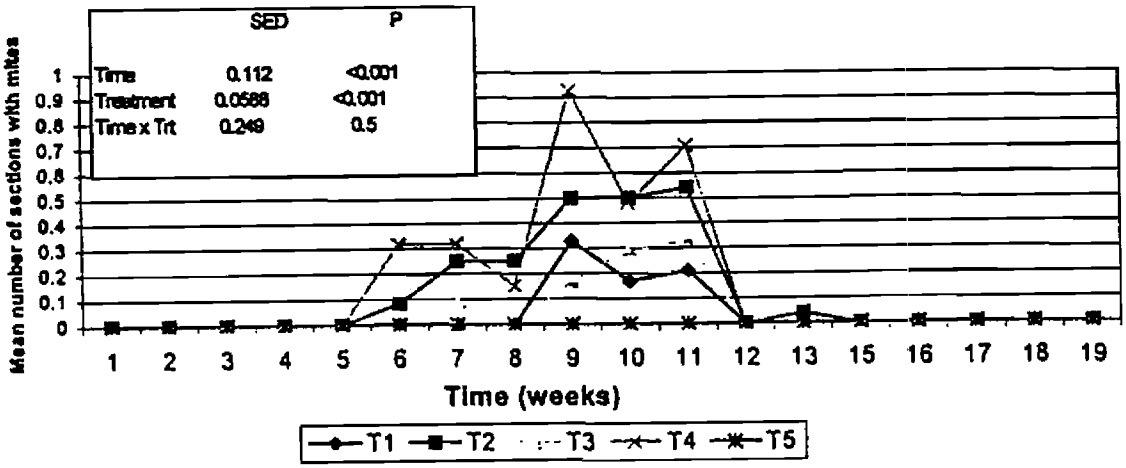

Figure 4. Effect of five fertilizer regimes on mite count on hot pepper branches over time

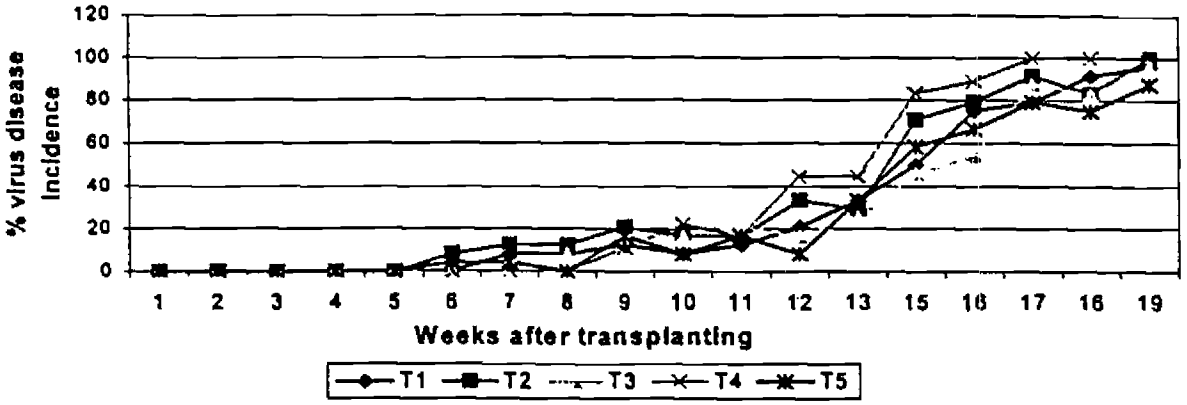

Figure 5 Effect of five fertilizer regimes on virus disease incidence over time

Figure 5. Effect of five fertilizer regimes on virus disease incidence over time

Symptoms of virus disease were detected 6 weeks after transplanting in T2. By week 6 virus disease was in all treatments. One hundred percent infection was reached in week 16 in T4 (Fig 5). The presence of viruses in the plots would have affected the results as other studies (CARDI Jamaica Annual Report, 1998), have shown that viruses reduce the yield of Scotch Bonnet by 50%. Some farmers apply foliar fertilizers to offset the impact of viruses on yield. This study shows that by itself foliar application does not provide adequate nutrient. However, further studies are required to assess the effect of using foliar applied fertilizers in conjunction with soil applied fertilizers.

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EVALUATION OF PHYSICAL AND *CHEMICAL* CHARACTERISTICS OF *PARVIN* AND *TOMMY ATKINS* MANGOS AND A PULP PRODUCT

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ABSTRACT

The objectives of this study were to evaluate the physical and chemical characters of *Parvin* and *Tommy Atkins* mango varieties; and to determine the shelf life of "fruit rolls" developed with the ripe fruit using four different concentrations of potassium sorbate (0.0%, 0.03%, 0.05% and 0.10%) to preserve the product. The mangoes were harvested at the Fortuna Experimental Substation on three different ocassions. The physical characteristics measured were texture, ascorbic acid, ß-carotene and total sugar. The shelf life of the fruit roll was determined by the microbial stability and chemical analysis. The shelf life of the product was six month without refrigeration. The product treated with 0.03% of potassium sorbate was the favorite of the panelist.

INTRODUCCION

La fruta de los dioses, mejor conocida como mango, se ha propagado durante aÔos por todo el mundo (Chadha, 1988). Su comportamiento de crecimiento y produccitÙn es Ùptimo en el trÙpico; especialmente desde el TrÙpico de Cáncer (25°N) hasta el Trópico de Capricornio (25°S) (Reyes-Soto y Cedeño-Maldonado, 1991). El mango (*Mangifera indica L.*), perteneciente a la familia *Anacardiacecae*, es una fruta tropical original de Asia que fue introducida a Puerto Rico durante la colonización. En términos de producción y popularidad, es la fruta más importante en las regiones tropicales y subtropicales del mundo (Nagy et al., 1993).

Las dos variedades de mango utilizadas para investigación fueron árboles injertados localizados en la Subestación de Frutales Fortuna, Juana Diáz; del recinto Universitario de Mayagüez de la Universidad de Puerto Rico. Los árboles estaban sembrados en un suelo arcilloso, con pH de 7.3 y precipitación anual de 76.8cm (Cedeño-Maldonado et al., 1987 y Reyes-Soto y Cedeño-Maldonado, 1991). Estas condiciones son favorables para su producción(Cedeño-Maldonado et al., 1987).

En Puerto Rico, La producción comercial de mango comenzó a intensificarse al principio de la década pasada (Troche, 1997). Dicho aumento se debe a las investigaciones realizadas para mejorar las características de producción y calidad (Cedeño-Maldonado et al., 1987). El aumento de la producción de mango en la Isla trae como consecuencia la oportunidad de buscar nuevas alternativas para aprovechar al máximo las futuras cosechas (segal, 1993). De esta forma se podrían utilizar los excedentes de producción o simplemente se disfrutariá de producto derivado de esta fruta durante todo el año. En Puerto Rico se elaboran varios productos comerciales a partir de mango, entre ellos el néctar y la pasta (Fernández y Cruz-Cay, 1993).

Actualmente, la agroindustria del mango en Puerto Rico tiene problemas económicos y technológicos (segal, 1993). Un problema económico es que el desarrollo de una empresa o industria se detiene al estar subcapitalizada. Al presente existen pocas alternativas de productos elaborados a base de dicha fruta (Fernández y Cruz Cay, 1993). Por esta razón se necesita diseñar nuevos productos para aprovechar al máximo futuras cosechas.

El consumidor actual está consciente de la buena salud y trata de buscar nuevas alternativas nutricionales. Entre las mismas se encuentran el consumo de las frutas y los productos naturales. Con esta nueva visión y con el propósito aprovechar al máximo la cosecha de mango, se intenta lograr el desarrollo de nuevos productos. Una

de esta alternativas es la elaboración de productos a partir de pulpa de mango (Cooke et al., 1976; Fernández y Cruz-Cay, 1993 Swi-Bea Wu et al., 1993).

En este estudio se elaboraron rollitos de mango a partir de las variedades *Parvin* y *Tommy Atkins*, junto al patrón *Julie* utilizando un deshidratador casero. El propósito fue elaborar un producto nuevo de mango con el mínimo de ingredientes añadidos al producto pero estable y duradero. El largo de vida del producto y sus caraterísticas fisico – químicas fueron determinadas.

MATERIALES Y METHODS

Para este estudio se utilizaron frutas de mango de las variedades *Parvin* y *Tommy Atkins*. Se llevaron a cabo tres muestreos de la fruta fresca durante los meses de mayo a agosto. Los tres muestreos se obtuvieron al azar de tres bloques diferentes. En cada muestreo se cosechó 15 frutas fisiológicamente hecha del lado derecho central de cada árbol. Las frutas cosechadas se almacenaron a tempertura de ambiente hasta determinar manualmente que la fruta estaba madura y lista para procesar.

En la determinación de textura se procedió a evaluar la madurez de la fruta utilizando el método manual. Se obtuvo la fruta y se presionó con el dedo pulgar la nariz de la misma. Si el área de la nariz se flexiona indica que la fruta está madura. Una vez determinada manualmente la madurez, se procedió con la determinación mecánica de la textura. Para la determinación mecánica de textura se utilizó el analizador de textura (Stable Micro Systems modelo TA-XT2) con un émbolo ("punch") de 5mm dc diámetro. La prueba se llevó a cabo midiendo la fuerza de penetración comenzando desde una distancia de 20mm a una velocidad de 5mm/s, lo cual resultó en una medida de fuerza de penetración de la superficie del mango. Se analizó el lado de la superficie del mango denominada nariz.

En la determinación de rendimiento se utilizó una balanza (Mettler modelo PC16) y se pesó cada fruta a evaluarse. Se le removió la cáscara con cuchillo de acero inoxidable y nuevamente fue pesada la misma. Después se le extrajo la semilla y se pesó. Por diferencia se calculó el por ciento de rendimiento de la pulpa de la fruta.

Para la elaboración del puré, se colocó la pulpa del mango en el procesador de alimentos y se molió hasta formar un puré homogéneo (Panasonic model MK-8010). Luego se almacenó en bolsas plásticas selladas al vacío (Koch modelo X-200). Las bolsas conteniendo las pulpas de las frutas preparadas se almacenaron en el congelador por 24 horas (General Electric model CAF16DA).

Se obtuvo el puré de mango y se le añadió el por ciento correspondiente de preservativo para el tratamiento indicado. Para las elaboración del rollito de mango, se utilizó un control y tres concentraciones de preservativo al 0.03, 0.05 y 0.10%. El preservativo que se utilizó fue sorbato de potasio. Se indenficaron las distintas bandejas del deshidratador casero (Modelo Snackmaster Dehydrator 2200) de acuerdo a la concentración del preservativo y se procedió a colocar el puré de mango por espacio de 24 horas a uno temperatura constante de 70°C y un flujo de aire contínuo de 125m/s. Al finalizar las 24 horas, se obtuvo uno lámina parcialmente seca del producto, se cortó en tiras de aproximadamente 4" x 5" y se enrollaron. Luego se empacaron en bolsas plásticas identificadas y se les realization las pruebas fisico-químicas y microbiológicas.

Se analizó el color del producto desarrollado utilizando un colorímentro (MiniScan modelo MS-4500L). Se inició la prueba con el sistema de lectura L, a, b; donde L mide las tonalidades desde blanco hasta negro, a percibe desde rojo a verde y b desde amarillo a azul. Una muestra del producto desarrollado se colocó en un plato Petri (50x 9mm) que se ubicó en el "ojo" del colorímetro. Después se inició la prueba con el sistema de lectura ya mencionado. En las pruedas realizadas se procedió a tomar promedio de cuatro lecturas.

Se determinó pH, sólidos solubles totales, ß-caroteno, ácido ascórbico, actividad de agua y acidez titulable siguiendo los métodos establecidos por el A.O.A.C. (AOAC, 1990).

El producto elaborado fue analizado microbiológicamente para evaluar su comportanmiento microbiano. Se réalizaron pruebas de recuento total en platos aerobios y anaerobios de bacterias, hongos y levaduras por espacio de seis meses a temperatura ambiente y a 35°C.

El análisis sensorial se utilizó la prueba de preferencia hedónica para determinar el prototipo del producto preferido utilizando 50 panelistas. La variable de este producto fue la cantidad de preservativo utilizado y la combinación preferida por los panelistas. La evaluación sensorial del producto elaborado se llevó a cabo con la veriedad *Parvin* junto al patrón Julie.

RESULTADOS Y DISCUSION

La textura de la fruta fresca fue evaluada manualmente para detectar el grado de madurez de la misma. Una vez determinada por el examen fisico de la fruta que estaba madura, se procedió con la eyaluación mecánica de las misma. El propósito de esta segunda prueba era recopilar información de la fruta fresca de manera que se puedan establecer valores objeetivos en la evaluación de su estado de madurez.

Como se observa en la Tabla 1 el rango de valores resultó bien amplio no obstante los promedios de los tres muestreos fue similar. Esta diferencia no resultó ser significativa, quizás por la diferencia entre cada fruta. Se compararon ambas variedades y su comportamiento fue similar, resultando en variaciones no significativas. En la mayoría de frutas ocurre un ablandamiento según avanza su estado de madurez. Lo mismo ocurre con el mango, mientras la fruta va madurando, la textura disminuye, afectando directamente la fortaleza del tejido vegetal.

En la Tabla 2, se presentan los valores de textura del producto elaborado de mango. No se encontraron diferencias signigicativas entre los tratamientos dentro de una variedad. Al evaluar los productos durante el almacenamiento, no se observron tendencias claras y significativas durante el periodo de almacenamiento del producto elaborado.

Tabla 1. Valores de textura en gramos (g) medidos como la fuerza de penetractión de la fruta (P≤0.05).

	Variedad de la fruta	
	Parvin	***Tommy Atkins***
Muestreos		
A	3574.63+/- 404.7	4125.54 +/- 798.9
B	3491.81+/- 862.8	3724.09 +/-631.8
C	3997.14 +/-619.5	4019.22 +/-885.3
Promedio	3687.86 +/-274.5	3956.28 +/-629.3

En general, la textura del producto elaborado depende del método en que se removió la humedad (DeLong, 1992; Fennema, 1975). En este caso el proceso de secado o desorción fue lento pero uniforme. En las Tablas 1 y 2 se muestran una pérdida insignificante en la fortaleza de los productos para ambas variedades. Se demuestra además que la utilización del preservativo no tiene un efecto significante en cuanto a textura del producto. Esto demuestra la estabilidad del producto a las condiciones de almacenamiento. Si un alimento seco es higroscópico, que absorbe humedad se detectarían cambios en la textura de los mismos. De lo contrario, si pierde humedad debería ser más duro.

Los resultados del rendimiento se muestran en las Tablas 3 y 4. Estos representan el promedio del análisis de 15 mangos de cada variedad evaluados en tres muestreos diferentes. La Tabla 3 muestra los resultados del peso de la semilla, cáscara y pulpa de ambas frutas. Como se observa en la Tabla 3, la semilla de la variedad *Parvin*

resultó ser ligeramente mayor que la variedad *Tommy Atkins*. Esto se asocia a las características naturales de la planta original.

Table 2. Valores de textura en gramos (g) del producto elaborado con ambas variedades durante almacenamiento (P≤0.05).

	Producto elaborado de la variedad *Parvin*			
Semanas	**Control**	**0.03%**	**0.05%**	**0.01%**
0	2095.46+/-239.0	2063.60+/-137.0	2228.18+/-202.5	2243.37+/-136.5
1	2213.54+/-214.9	2059.27+/-162.7	2210.11+/-233.9	2251.53+/-140.7
4	2222.63+/-203.5	2104.25+/-129.4	2232.18+/-180.3	2177.37+/-139.3
12	2309.53+/-206.4	2116.59+/-114.6	2216.62+/-213.4	2159.92+/-144.4
24	2370.15+/-229.2	2074.53+/-144.4	2094.95+/-198.7	2185.12+/-142.6
	Producto elaborado de la variedad *Tommy Atkins*			
Semanas	**Control**	**0.03%**	**0.05%**	**0.01%**
0	2267.71+/-268.9	2251.29+/-136.3	2132.77+/-163.4	2181.87+/-163.7
1	2283.89+/-256.3	2167.60+/-148.6	2200.32+/-157.9	2147.93+/-172.1
4	2258.38+/-235.6	2204.37+/-138.5	2129.50+/-120.3	2148.53+/-150.5
12	2291.87+/-181.6	2191.59+/-118.1	2054.85+/-123.9	2163.00+/-154.6
24	2204.55+/-223.1	2191.68+/-171.0	2037.27+/-72.9	2165.31+/-149.5

El por ciento de pulpa de la fruta que se utilizó en la elaboración de rollitos de mango varío entre 64 a 78%(Tabla 4). Debido a que la fruta se cosechó madura y el proceso de despulpado no fue automatizado, se perdió jugo de mango lo cual afeetó directamente al rendimiento del producto. La pérdida del jugo de mango fue natural ya que mientra la fruta va madurando ocurren cambios fisiológicos como lo son la velocidad de respiración y cambios de color entre otros.

El la Tabla 4 la variedad *Parvin* presentó un rendimiento de 65.1% y varió desde un mínimo de 53.8% hasta 71.0% entre las 45 muestras evaluadas. En cuanto a la variedad *Tommy Atkins*, entre las 45 muestras evaluadas el mínimo fue de 61.4% hasta un máximo de 78.1%. Estudios de rendimiento realizados por Iguina et al, 1969, han reportado un promedio de 66.25% de rendimiento para la variedad *Parvin*, lo cual se asemeja a la cantidad reportada en este estudio. No se encontraron diferencias significativas entre las variedades, quizás por la diferencia entre cada fruta.

Por lo general, el color y la descoloración de los alimentos son cualidades importantes para el productor y el consumidor. El color puede conducir a la aceptación o el rechazo de los alimentos (Meilgaard, 1991). En la mayoría de las frutas, el color es utilizado como índice de maduración (Fennema, 1975; Pomeranz, 1994). El contenido de carotenoides aumenta mientras que el contenido de clorofila disminuye. La estabilidad del color de

los alimentos deshidratados o de baja actividad de agua es pobre (deMan, 1990). Debido a que los carotenoides son altamente insaturados, el deterioro en el color es causado mayormente por la presencia de oxígeno y luz. Para evitar la oxidación el producto debe ser almacenado al vacío, empacado con un gas inerte, o en empaques que excluyan el oxígeno y la luz.

Tabla 3. Tamaño de la fruta en gamos (g) para ambas variedades.

Variedad	Muestreos	Rendimiento de la fruta (g)		
		Cáscara	Semilla	Pulpa
Parvin				
	A	113.6+/-16.1	56.5+/-5.2	365.7+/-10.2
	B	94.1+/-12.3	70.7+/-7.8	336.5+/-12.8
	C	84.9+/-20.3	57.9+/-10.1	324.8+/-11.3
	Promedio	97.5+/-15.4	61.7+/-6.3[a]	342.7+/-10.6[a]
Tommy Atkins				
	A	113.2+/-10.3	49.9+/-12.3	435.1+/-9.3
	B	124.4+/-16.7	47.0+/-5.1	440.2+/-10.7
	C	120.6+/-11.6	39.8+/-9.4	462.7+/-9.1
	Promedio	119.4+/-10.8	45.6+/-9.2[b]	446.0+/-10.2[b]

Tabla 4. Rendimiento de la pulpa de la fruta para amba variedades.

	Variedad de la fruta	
	Parvin	*Tommy Atkins*
Muestreos		
A	64.71/-4.91	73.4+/-4.43
B	64.71/-3.56	71.8+/-2.91
C	65.81/-5.53	73.7+/-3.36
Promedio	65.11/-3.71[a]	73.0+/-3.25[b]

Durante el proceso de deshidratación, una de las caraterísticas principales es el cambio de color. En el análisis de color se utilizaron muestras durante todo el proceso de almacenamiento. Este análisis constó de tres diferentes valores colorimétricis: L, a y b. El valor colorimétrico L midió la claridad del color analizado y comprendió desde blanco hasta negro. El blanco se representó con un valor de 100 y el negro con 0. El valor clorimétrico a reflejó los colores desde rojo (+100) a verde (-80). El último valor colorimétrico, el b, representó los colores desde amarillo (+70) hasta azul (-80) (Pomeranz, 1994).

El color de la fruta depende de la variedad utilizada. Exteriormente, la fruta de la variedad *Parvin* es completamente verde mentras que la variedad *Tommy Atkins* es verde-rojizo. Sin embargo, visualmente, la pulpa de ambas frutas utilizadas, muestran una diferencia en color, pues la pulpa de la variedad *Parvin* es más clara que la de *Tommy Atkins*. Colorimétricamente el rollito de mango de la variedad *Tommy Atkins* resultó ser un poco más oscura que la variedad *Parvin*. Esto se debe a las características de cada variedad (Morton, 1987).

Tabla 5. Valores colorimétricos L para la pulpa de la fruta con ambas variedades durnate almacenamiento.

	Variedad de la fruta	
	Parvin	*Tommy Atkins*
Muestreos		
A	58.93+/-3.39	56.09+/-3.51
B	57.99+/-4.94	53.55+/-1.65
C	56.56+/-5.98	54.98+/-6.32
Promedio	57.83+/-3.24[a]	54.87+/-2.61[b]

Como se observa en la Tabla 5 se encontraron diferencias significativas entre variedades para el parámetro L. Anteriormente se mencionó que el parámetro L comprende de los espectro blanco, valor 100 hasta negro, valor 0. Confirmando la evaluación visual, la variedad *Parvin* resultó la variedad más clara según se determinó colormétricamente por el instrucmento. La variedad *Tommy Atkins* resultó significativamente más oscura.

Tabla 6. Valores colorimétricos L del producto elaborado con ambas variedades durnate almacenamiento.

	Producto elaborado de la variedad *Parvin*			
Semanas	**Control**	**0.03%**	**0.05%**	**0.01%**
0	53.22+/-1.2	54.60+/-1.3	51.70+/-1.3	52.16+/-1.1
1	53.64+/-1.3	52.05+/-2.1	49.95+/-1.3	51.87+/-2.3
4	53.04+/-1.1	52.83+/-1.1	50.06+/-0.7	51.98+/-1.3
12	52.14+/-1.3	53.57+/-0.8	50.07+/-1.2	50.67+/-1.1
24	53.06+/-1.5	52.39+/-1.1	48.90+/-2.3	50.59+/-0.9
	Producto elaborado de la variedad *Tommy atkins*			
Semanas	**Control**	**0.03%**	**0.05%**	**0.01%**
0	53.67+/-1.1	53.12+/-1.8	54.90+/-1.4	55.47+/-1.9
1	54.27+/-0.8	56.00+/-1.1	53.34+/-1.2	55.44+/-0.6
4	53.39+/-1.4	56.05+/-1.4	51.46+/-1.1	54.87+/-1.3
12	53.65+/-1.1	56.28+/-1.6	50.41+/-1.3	54.81+/-1.1
24	53.56+/-1.3	55.78+/-1.1	49.59+/-1.2	54.86+/-0.8

En la Tabla 6, se presentan los resultados de los valores colorimétricos L del producto elaborado con las variedades *Parvin* y *Tommy Atkins* durante almacenamiento. El valor más alto en la variedad *Parvin* fue el tratamiento al 0.03% y por el contrario, visualmente fue el tratamiento al 0.10%. Sin embargo, en la variedad *Tommy Atkins*, la muestra más clara, visual y colormétricamente fue el tratamiento al 0.10%. Esto demuestra que la agudeza

visual humana no es capaze de distinquir colores muy cercanos como resultó ser este caso. No se encontraron diferencias significativas entre los muestreos dentro de cada variedad ni tratamiento.

En la Tabla 7 se presentan los resultados del valor colorimétrico a para la pulpa de la fruta ambas variedades. No se encontraron diferencias significativas entre muestreos ni variedad. En la Tabla 8 se presentan los valores colormétricos a para los productos elaborados de con ambas variedades durante almacenamiento. El producto elaborado de *Tommy Atkins* mostró una tendencia más rojiza mientras la variedad *Parvin* mostró una coloración más verde amarrillenta. Como resultado, la variedad *Tommy Atkins* es más oscura; lo cual confirma la evaluación visual.

Tabla 7. Valores colorimétricos a para la pulpa de ambas variedades (P≤0.05).

	Variedad de la fruta	
Muestreos	*Parvin*	*Tommy Atkins*
A	19.96+/-2.87	17.20+/-2.08
B	24.32+/-2.38	23.33+/-2.80
C	22.45+/-4.90	23.36+/-5.32
Promedio	22.24+/-1.71	21.29+/-1.77

Para el valor eolorimétrico b (Tablas 9 y 10), el tratamiento al 0.05%, para ambas variedades resultó ser la muestra más oscura pero entre variedades fue *Tommy Atkins*. Esto es de esperarse debido a las características naturales de cada variedad. La pulpa de la variedad *Tommy Atkins* es más oscura en comparación a la variedad *Parvin* y visualmente fue comprobado (Morton, 1987).

En la Tabla 11 se muestran los valores de pH para el promedio de las pulpas de ambas variedades. La variedad *Parvin* presentó un pH promedio 4.32. En cuanto a la variedad *Tommy Atkins*, el pH fue de 4.23. Estos resultados son el promedio de las 45 muestras analizadas para cada variedad. Esta diferencia resultó ser no significativa, quizás por la diferencia entre cada fruta dentro de las variedades. Se compararon ambas variedades y su comportamiento fue similar, resultando en variaciones entre variedades no significativas.

El valor de pH de la variedad *Parvin* reportado por estudios previos es 4.15 (Iguina et al. 1969). No es encontró en la literatura valores de pH para la variedad *Tommy Atkins*. El pH del producto elaborado se presenta en la Tabla 12. Este valor se mantuvo constante demostrando la estabilidad y calidad del producto. El pH de las variedades frutas utilizadas era similar por lo que no se encuentraron diferencias significativas entre las variedades ni entre los tratamientos. El no aumentar el pH durante el tiempo de almacenaje favoreció directamente la estabilidad microbiana del producto ya que el pH es un de los factores determinante en el crecimiento y controlde los posibles microorganismos presentes.

En la Tabla 13 se encuentran los valores de sólidos solubles totales (°Brix) promedio de las frutas utilizadas. El promedio en la variedad *Parvin* fue de 15.8 . Este valor es similar al reportado por Iguina et al. 1969, de 15.5. En la variedad *Tommy Atkins* el resultado fue 16.2. No se encontró una diferencia significativa entre los resultados de los °Brix de las frutas.

Tabla 8. Valores colorimétricos a del producto elaborado con ambas variedades durante Almacenamiento.

Semanas	Producto elaborado de la variedad *Parvin*			
	Control	**0.03%**	**0.05%**	**0.01%**
0	16.55+/-1.1	17.08+/-1.1	20.56+/-1.2	18.53+/-0.9
1	16.35+/-1.0	20.35+/-1.6	20.45+/-1.1	18.36+/-0.9
4	16.86+/-0.9	20.70+/-1.2	20.79+/-1.7	18.64+/-1.5
12	16.33+/-1.2	22.36+/-1.0	20.94+/-1.3	18.42+/-1.5
24	16.58+/-0.8	22.98+/-0.9	20.02+/-1.2	18.37+/-0.9
Semanas	**Producto elaborado de la variedad *Tommy Atkins***			
	Control	**0.03%**	**0.05%**	**0.01%**
0	16.86+/-1.1	17.62+/-1.4	21.45+/-1.2	21.32+/-1.0
1	17.21+/-1.3	20.91+/-0.8	21.31+/-1.1	21.34+/-0.8
4	16.93+/-0.9	21.44+/-0.9	21.03+/-1.1	21.34+/-1.1
12	17.36+/-1.1	21.79+/-1.1	20.27+/-1.2	21.64+/-1.5
24	17.92+/-1.3	22.62+/-1.0	19.66+/-1.2	20.78+/-1.0

Tabla 9. Valores colorimétricos b para la pulpa de la fruta con ambas variedades.

Muestreos	Variedad de la fruta	
	Parvin	*Tommy Atkins*
A	60.52+/-5.30	61.96+/-3.83
B	66.14+/-4.24	68.26+/-1.74
C	64.60+/-5.57	60.60+/-6.60
Promedio	63.75+/-3.09	63.64+/-1.92

Tabla 10. Valores colorimétricos b del producto elaborado con ambas variedades durnate almacenamiento.

Semanas	Producto elaborado de la variedad *Parvin*			
	Control	**0.03%**	**0.05%**	**0.01%**
0	56.88+/-1.2	63.22+/-1.1	59.15+/-1.4	57.86+/-1.3
1	57.20+/-1.3	60.77+/-0.9	58.16+/-1.1	57.60+/-1.7
4	54.55+/-0.9	59.57+/-0.7	57.24+/-1.3	57.43+/-1.3
12	58.70+/-0.6	59.17+/-1.2	56.25+/-0.9	57.31+/-1.6
24	59.33+/-0.9	59.60+/-1.1	54.42+/-1.1	56.79+/-1.1
Semanas	**Producto elaborado de la variedad *Tommy Atkins***			
	Control	**0.03%**	**0.05%**	**0.01%**
0	64.93+/-1.1	61.00+/-1.1	54.32+/-1.4	60.82+/-1.3
1	64.74+/-1.3	56.98+/-1.3	58.66+/-1.1	60.78+/-0.8
4	64.19+/-0.9	58.66+/-1.1	53.54+/-1.3	60.69+/-1.1
12	64.75+/-1.1	58.75+/-0.7	52.33+/-1.1	60.45+/-0.9
24	64.80+/-1.7	57.30+/-1.1	50.83+/-1.3	59.88+/-1.2

Tabla 11. Valores de pH para la pulpa de la fruta con ambas ($P \leq 0.05$).

	Variedad de la fruta	
	Parvin	*Tommy Atkins*
Muestreos		
A	4.30+/-0.48	4.29+/-0.41
B	4.39+/-0.38	4.25+/-0.25
C	4.35+/-0.39	4.27+/-0.46
Promedio	4.32+/-0.28	4.23+/-0.31

Tabla 12. Valores de pH del producto elaborado con ambas variedades durante almacenamiento ($P \leq 0.05$).

	Producto elaborado de la variedad *Parvin*			
Semanas	Control	0.03%	0.05%	0.01%
0	4.33+/-0.2	4.15+/-0.3	4.23+/-0.1	4.24+/-0.1
1	4.27+/-0.2	4.15+/-0.3	4.18+/-0.1	4.28+/-0.1
4	4.26+/-0.1	4.18+/-0.2	4.18+/-0.1	4.20+/-0.1
12	4.26+/-0.1	4.17+/-0.2	4.24+/-0.1	4.19+/-0.2
24	4.23+/-0.2	4.18+/-0.1	4.17+/-0.1	4.24+/-0.1
	Producto elaborado de la variedad *Tommy Atkins*			
	Semanas	Control	0.03%	0.05% 0.01%
0	4.16+/-0.3	4.21+/-0.3	4.21+/-0.1	4.20+/-0.1
1	4.20+/-0.2	4.18+/-0.2	4.24+/-0.1	4.22+/-0.1
4	4.19+/-0.2	4.27+/-0.1	4.20+/-0.2	4.18+/-0.2
12	4.22+/-0.2	4.23+/-0.1	4.23+/-0.2	4.18+/-0.1
24	4.20+/-0.1	4.14+/-0.2	4.23+/-0.1	4.20+/-0.2

Tabla 13. Valores de sólidos solubles totales para la pulpa de la fruta con ambas variedades ($P \leq 0.05$).

	Variedad de la fruta	
Muestreos	*Parvin*	*Tommy Atkins*
A	14.8+/-2.6	16.0+/-2.3
B	16.8+/-1.6	16.2+/-1.7
C	16.7+/-1.6	16.3+/-2.5
Promedio	15.8+/-1.7	16.2+/-2.1

En la Tabla 14 se presentan los resultados de los sólidos solubles totales del producto elaborado. No se encontró

diferencia significativa entre los tratamientos, las variedades ni el almacenamiento.

Tabla 14. Valores de sólidos solubles totales (°Brix) del producto elaborado com ambas variedades durante almacenamiento (P≤0.05).

	Producto elaborado con la variedad *Parvin*			
Semanas	**Control**	**0.03%**	**0.05%**	**0.01%**
0	32.07+/-1.1	32.09+/-1.4	33.15+/-1.0	33.88+/-1.1
1	33.28+/-1.2	32.43+/-1.1	33.49+/-1.0	33.98+/-1.2
4	33.40+/-0.9	32.66+/-1.1	33.04+/-1.1	33.93+/-1.3
12	34.37+/-1.3	33.11+/-0.9	33.86+/-1.3	33.99+/-1.1
24	34.64+/-1.1	33.34+/-0.7	33.77+/-1.3	33.96+/-1.1
	Producto elaborado con la variedad *Tommy atkins*			
Semanas	**Control**	**0.03%**	**0.05%**	**0.01%**
0	30.72+/-1.6	31.76+/-1.1	32.00+/-0.5	32.13+/-1.9
1	32.38+/-1.1	32.28+/-1.1	32.25+/-0.7	32.59+/-1.4
4	32.99+/-1.7	32.63+/-1.1	32.50+/-0.9	32.83+/-1.1
12	32.88+/-1.3	32.49+/-0.9	32.72+/-1.0	33.11+/-0.9
24	33.50+/-1.1	32.80+/-0.8	32.75+/-0.9	33.61+/-1.3

Tabla 15. Valores de actividad de agua para la pulpa de la fruta con ambas Variedades (P≤0.05).

	Variedad de la fruta	
Muestreos	***Parvin***	***Tommy Atkins***
A	0.987+/-0.005	0.985+/-0.003
B	0.984+/-0.004	0.987+/-0.004
C	0.987+/-0.004	0.987+/-0.003
Promedio	0.987+/-0.004	0.987+/-0.003

Tabla 16. Valores de actividad de agua del producto elaborado con ambas variedades.

	Producto elaborado con la variedad *Parvin*			
Semanas	**Control**	**0.03%**	**0.05%**	**0.01%**
0	0.469+/-0.004	0.469+/-0.001	0.478+/-0.002	0.472+/-0.003
1	0.466+/-0.003	0.464+/-0.003	0.475+/-0.003	0.469+/-0.003
4	0.467+/-0.003	0.467+/-0.003	0.476+/-0.002	0.470+/-0.001
12	0.467+/-0.003	0.467+/-0.001	0.476+/-0.003	0.470+/-0.003
24	0.468+/-0.003	0.466+/-0.002	0.476+/-0.001	0.470+/-0.003
	Producto elaborado cou la variedad *Tommy Atkins*			
Semanas	**Control**	**0.03%**	**0.05%**	**0.01%**
0	0.485+/-0.001	0.484+/-0.001	0.486+/-0.003	0.485+/-0.003
1	0.482+/-0.002	0.481+/-0.001	0.484+/-0.001	0.482+/-0.002
4	0.483+/-0.001	0.481+/-0.003	0.485+/-0.002	0.484+/-0.003
12	0.483+/-0.001	0.482+/-0.001	0.485+/-0.002	0.484+/-0.004
24	0.483+/-0.002	0.482+/-0.003	0.485+/-0.002	0.484+/-0.003

La actividad de agua (a_w) es un factor importante en las reacciones que causan deterioro en los alimentos. La actividad de agua de la fruta fresea es aproximadamente 0.99, tal y como se esperaba en este tipo de alimento fresco (Tabla 15). El deterioro principal para alimentos freseos con este valor de a_w es el deterioro microbial.

El a_w del producto elabarado se presenta en la Tabla 16. No hubo diferencia significantiva en la actividad de agua del producto durante almacenamiento. El a_w del producto elaborado fue de aproximadamente 0.47 lo cual no permite el crecimiento de microoganismos, pero resulta ideal para las reacciones de pardeamiento enzimático como no enzimático (Fennema , 1975). Quizás por esta razón se observan leves cambios en color (en el valor L) según pasa el tiempo de almacenamiento. Aunque estas tendencias no ocurren en todos los tratamientos y por esto no se encontraron diferencias significativas durante almacenamiento.

La Tabla 17 muestra los resultados del por ciento de acidez titulable para la pulpa de la fruta. Estudios realizados por Iguinina et al encontró 0.27% de acidez titulable para la fruta de la variedad *Parvin*; mientras que las variedades evaluadas reflejaron un por ciento mayor. La diferencia entre la variedad *Parvin* evaluada por Iguina et al (1969) y la de este estudio se puede asociar al estado de madurez en que se cosechó la fruta. Los datos obtenidos muestran que el por ciento de acidez titulable en ambas variedades fue similar resultando en una diferencia no significativa. Estudios anteriores encontraron que el por ciento de acidez titulable fluctuo entre 0.22% a 0.60% (Iguina et al 1969; Nagy, et al 1993, Swi-Bea Wu et al, 1993).

Como se observa en la Tabla 18, la variedad *Parvin* fue la de mayor acidez mientras que *Tommy Atkins* fue la menor. A pesar de la pequena diferencia, el por ciento de acidez se mantuvo en 0.5%, lo cual se asocia a su pH que es relativamente bajo.

Tabla 17. Contenido de acidez titulable (%) para la pulpa de la fruta con ambas variedades ($P \leq 0.05$).

	Variedad de la fruta	
Muestreos	*Parvin*	*Tommy Atkins*
A	0.42+/-0.021	0.37+/-0.008
B	0.46+/-0.023	0.41+/-0.032
C	0.32+/-0.022	0.43+/-0.016
Promedio	0.40+/-0.059	0.40+/-0.025

En todos lo alimentos procesado se pierden nutrientes, entre ellos se encuentra la vitamina C, o mejor dicho, el ácido ascórbico. Además del proceso de manufactura, esisten otros parámetros que afectan directamente el contenido de nutrientes en los alimentos como lo son la variedad utilizada , el estado de madurez, condiciones climatológicas, fertilizantes utilizados e intensidad de luz entre otros (DeMan, 1990)

La Tabla 19 muestra los valores obtenidos de ácido ascórbico para la pulpa de la fruta de cada variedad. Estos valores dependen de la variedad analizada, pues en diversos estdios se han encontrado variedades como *Francisque* con

un contenido de ácido ascórbico de 52% mientras que en otras variedades el contenido de ácido ascórbico es mucho menor, como la variedad *Davis Haden* con 0.04% (Iguina et al , 1969, Nagy et al 1993). En frutas, la mayor pérdida del ácido ascórbico se asocia con reacciones no enzimáticas (fennema, 1975). En la Tabla 20 como era de esperarse, se perdió ácido ascórbico durante el tiempo de almacenamiento. La variedad *Parvin* fue la que mayor cantidad de vitamina retuvo, mientras que la de menor retención fue la *Tommy Atkins*. Como ya sabemos, los resultados obtenidos fueron los esperados ya que la vitamina C es altamente sensible a la degradación y a otros factores como lo son el pH y la temperaturas entre otros. La misma observación se ha demostrado en

diferentes estudios como el de Iguina et al (1969) 1 y Nagy et al (1993) entre otros.

Tabla 18. Contenido de acidez titulable (%) del producto elaborado con ambas variedades ($P \leq 0.05$).

Semanas	Producto elaborado de la variedad *Parvin*			
	Control	**0.03%**	**0.05%**	**0.01%**
0	0.54+/-0.008	0.54+/-0.002	0.55+/-0.002	0.57+/-0.001
1	0.52+/-0.002	0.53+/-0.001	0.53+/-0.003	0.55+/-0.001
4	0.51+/-0.002	0.52+/-0.001	0.52+/-0.003	0.57+/-0.002
12	0.52+/-0.010	0.52+/-0.001	0.52+/-0.001	0.54+/-0.002
24	0.51+/-0.002	0.52+/-0.002	0.51+/-0.001	0.54+/-0.001
Semanas	**Producto elaborado de la variedad *Tommy atkins***			
	Control	**0.03%**	**0.05%**	**0.01%**
0	0.51+/-0.002	0.50+/-0.002	0.53+/-0.001	0.55+/-0.002
1	0.51+/-0.001	0.51+/-0.002	0.50+/-0.001	0.55+/-0.002
4	0.51+/-0.001	0.51+/-0.002	0.52+/-0.002	0.56+/-0.002
12	0.51+/-0.002	0.51+/-0.002	0.52+/-0.002	0.53+/-0.001
24	0.50+/-0.002	0.50+/-0.001	0.52+/-0.002	0.53+/-0.001

Tabla 19. Contenido de ácido ascórbico (mg/g) para la pulpa de la fruta con ambas variedades ($P \leq 0.05$).

Muestreos	Variedad de la fruta	
	Parvin	*Tommy Atkins*
A	0.62+/-0.134	0.60+/-0.160
B	0.61+/-0.157	0.66+/-0.133
C	0.59+/-0.179	0.65+/-0.156
Promedio	0.61+/-0.134	0.64+/-0.111

Tabla 20. Contenido de ácido ascórbico (mg/g) del producto elaborado con ambas variedades durante almacenamiento ($P \leq 0.05$).

Semanas	Producto elaborado de la variedad *Parvin*			
	Control	**0.03%**	**0.05%**	**0.01%**
0	0.463+/-0.11	0.404+/-0.09	0.402+/-0.10	0.392+/-0.11
1	0.458+/-0.12	0.400+/-0.11	0.398+/-0.11	0.392+/-0.12
4	0.450+/-0.11	0.396+/-0.12	0.395+/-0.12	0.389+/-0.09
12	0.441+/-0.11	0.388+/-0.11	0.391+/-0.09	0.386+/-0.12
24	0.426+/-0.09	0.382+/-0.13	0.384+/-0.11	0.384+/-0.11
Semanas	**Producto elaborado de la variedad *Tommy atkins***			
	Control	**0.03%**	**0.05%**	**0.01%**
0	0.418+/-0.12	0.408+/-0.12	0.406+/-0.09	0.417+/-0.09
1	0.412+/-0.11	0.402+/-0.11	0.405+/-0.11	0.415+/-0.07
4	0.402+/-0.09	0.401+/-0.11	0.403+/-0.08	0.413+/-0.11
12	0.391+/-0.18	0.399+/-0.11	0.399+/-0.09	0.410+/-0.11
24	0.377+/-0.12	0.394+/-0.09	0.397+/-0.08	0.408+/-0.11

La estabilidad del *B*-caroteno depende de varios factores como el proceso utilizado y el tiempo de almacenamiento entre otros (Iguina et.al., 1969). Estudios realizados por Labuza (1966), demuestran que durante el proceso de secado de la fruta, la cantidad principal de *B*-caronteno se va disminuyendo. El por ciento de la degradación depende del proceso utilizado en el alimento. Como se muestra el al Tabla 22 durante el tiempo de almacenaje, se va perdiendo *B*-caroteno. Esto resulta debido a la presencia de oxígeno, ya que se va oxidando. Además de la presencia de oxígeno, el producto elaborado se empacó en bolsas translúcidas lo cual cotribuyo a la exposicion directa dc la luz durante su almacenamiento. Ambos factores contribuyen a la perdida de *B*-caroteno.

En este caso, se utilizó una combinación de varios factores lo cual afectó directamente al producto elaborado. Como consecuencia para ambas variedades, la pérdida resultó ser significativa durante el almacenamiento. Esto era de esperarse por las razones previamente descritas.

En la determinación del largo de vida se analizó la estabilidad microbiana del producto. En general, las bacterias requieren altos niveles dc humedad para su crecimiento en comparación a las levaduras y hongos. Las bacteras requieren una actividad de agua mayor de 0.0900; mientras las levaduras y hongos necesitan por lo menos 0.065 a 0.075 dc agua.

En este producto dicho factor redujo los posibles contaminates debido a que factores como el pH y a_w son muy bajos. La actividad microbiana en muestro producto es muy limitada ya que las condiciones para su desarrollo no son favorables. Lo cual es indicativo que la presencia del preservativo no es necesaria para combatir la carga microbiana del producto.

Tabla 21. Contenido de ß-caroteno (IU/100 g) para la pulpa de la fruta.con ambas variedades ($P \leq 0.05$).

	Variedad de la fruta	
Muestreos	*Parvin*	*Tommy Atkins*
A	2047+/-182.1	2084+/-221.8
B	1931+/-235.5	1938+/-213.7
C	1959+/-118.1	2115+/-221.0
Promedio	1979+/-92.1	2046+/-152.1

Tabla 22. Contenido de ß-caroteno del producto elaborado can ambas variedades durante almacenamiento (IU/100 g) ($P \leq 0.05$).

	Producto elaborado de la variedad *Parvin*			
Semanas	Control	0.03%	0.05%	0.01%
0	1300+/-118.1	1421+/-115.9	1452+/-118.9	1267+/-114.9
1	1267+/-117.9	1387+/-114.8	1264+/-112.9	1249+/-118.7
4	1243+/-116.9	1277+/-120.1	1158+/-120.3	1182+/-118.7
12	1075+/-118.6	1163+/-121.3	1031+/-118.9	1042+/-118.7
24	983+/-120.3	1061+/-118.9	995+/-201.3	978+/-118.3
	Producto elaborado de la variedad *Tommy atkins*			
Semanas	Control	0.03%	0.05%	0.01%
0	1457+/-118.9	1385+/-124.9	1463+/-116.4	142+/-811.5
1	1376+/-120.3	1328+/-201.6	1474+/-123.8	1386+/-118.7
4	1423+/-204.6	1391+/-118.7	1130+/-117.5	1264+/-112.9
12	1129+/-118.7	1231+/-117.9	1078+/-118.4	1195+/-204.3
24	1257+/-118.7	1034+/-114.6	976+/-119.2	1012+/-117.8

Los resultados estadísticos demostraron que no existe diferencias significativas para los recuentos totales aeróbicos y anaeróbicos tanto para bacterias como para hongos a diferentes temperaturas.

Para el análisis sensorial la variedad utilizada fue *Parvin* por ser la variedad comercial. En los datos obtenidos por los panelistas se encontró que en cuanto a los tratamientos, se prefiere el do 0.03% quien es el que más se asemeja al control y el menos preferido fue el tratamiento al 0.10% de sorbato de potasio. El tratamiento al 0.10% resultó caracterizarse por un sabor amargo, lo cual se le atribuye a la cantidad de preservativo utilizado. En general, el producto fue aceptado por los panelistas.

Tabla 23. Resultados del análisis sensorial de preferencia para el producto elaborado con la variedad *Parvin*.

	Control	0.03%	0.05%	0.01%
Mujeres	10%	14%	18%	8%
Hombres	8%	28%	8%	6%
Totales	18%	42%	26%	14%

CONCLUSION

Dentro los límites de este estudio, ambas variedades estudiadas mostraron cierta diferencias en sus características físico-químicas. Como ya mencionamos la variedad de mayor rendimiento fue *Tommy Atkins*, debido a su gran tamaño; más dulce resultó ser la mientras que la variedad *Parvin*.

En general, los parámetros analizados estadísticamente no fueron significativos ni para la variedad ni los tratamientos excepto el análisis colorimétrico; ya que la variedad *Tommy Atkins* resultó obtener un color más oscuro.

Los diferemtes tratamientos estudiados demostraron que en la deshidratación casera no es necesario utilizar preservativos porque con la reducción drástica de la actividad de agua del porducto es suficiente para disminuir la carga microbiológica del producto durante su almacenaje. La elaboración de rollitos de mango es una alternativa para utilizar al máximo las cosechas de dicha fruta.

Se utilizaría en la elaboración del producto la variedad *Tommy Atkins* para obtener mayor rendimiento y la *Parvin* por tener un color más claro. Concluyendo que ambas variedades pueden utilizaese para dicho propósito.

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FOOD VALORIZATION OF AGRICULTURAL RESOURCES

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ABSTRACT

In spite of the low volume of industrial activities from local agricultural resources, food industry is an important potential for the countries of the Caribbean basin. The current situation and future prospects are in relation with the recent history, featured by a multicultural encounter. Development could occur by the rational association of some potentialities. Food technology research is a powerful lever to collect information allowing to manage and to rationalize sustainable transformation processes and activities.

Successful work has been done with distilleries wastewaters treatment and valorization. The first commercial yeast strain, selected for rum production, is issued from our collection. We are experimenting lactic fermentation as dressing and/or preserving means for local production.We contribute to local bioresources best knowledge and valorization.

INTRODUCTION

The current Caribbean populations are the result of a non-conciliatory encounter of human groups, after the Medieaval era. Firstly, there was a shock between preexsisting American Indian culture and European and African cultural elements. Then were added Asian elements from India and China. The food, natural resources, the processed products and valorization perspectives are in relation with those successive contributions.

PATRIMONIAL CONSIDERATIONS

The food pattern of the aboriginal population, from warm areas in Central America and Amazonia, was based upon hunting, fishing, picking, and an itinerant agriculture where cassava (*Maniho utilissima*) was the basic food; other foodstuffs were : cush-cush (*Dioscorea trifida*), sweet potato (*Ipomea batata*), tannia (*Xanthosoma sagittifolium*), arrow-root (*Maranta arundinacea*), bay (*Pimenta racemosa*), peanut (*Arachis hypogea*). In Central America and in Mexico the prevailing agricultural crop production centred on corn (*Zea mays*), which lead to the great Maya and Aztec civilizations. It is noteworthy to underline that dairy produce were not used, except in Andean areas. About fruits, American tropical areas have largely contributed to the world foodstuff pattern with : pine-apple (*Ananas comosus*), avocado (*Persea americana*), papaya (*Carica papaya*), guava (*Psidium guajava*), the genus *Anona* of which soursop (*Anona muricata*), passion fruit (*Passiflora edulis*), black apple (*Diospyros digyna*) , cashew nut and cashew apple (*Anacardium occidentale*), cherry (*Malpighia pucniciflora*). The sweet taste was given by various types of honeys. There were also the beverages contribution with the fermented ones : the chicha from corn, the pulque from agave (*Agave atrovirens*) and others from sweet-potatoes ; we have also to mention the cocoa (*Theobroma cacao*), and the exciting and narcotic drinks made of coca (*Erythroxylum coca*).

Spices and condimentary plants which were used in food seasoning and/or body care by the American Indians are today well known : annatto (*Bixa orellana*), vanilla (*Vanilla fragrans*), chillis (*Capsicum annuum* and *frutescens*), allspice (*Pimenta dioica*), pink peppercorn (*Schimus terebinthifolius*).

In the XVIIth century, appeared the *encomienda* subjecting the American Indians, and the slavery plantation imported from the Mediterranean basin. Caribbean societies were featured by dependence on an overseas motherland. The sugarcane, originating from New-Guinea, was introduced in Middle East, during antiquity ;

then it was spread in the Mediterranean basin, and finally was imported to America by Christopher Colombus and Cabral. *Saccharum barberi*, the creole sugarcane, was introduced by Colombus and Cabral ; then *Saccharum officinarum*, Otaheite, was introduced around the end of XVIII th century, after Bougainville and Cook voyages. Sugarcane had and still has a prominent part in the relations, structuration and economy of Caribbean islands and countries.

Food plants introduction was done with the colonization; one of the most famous was the breadfruit (*Artocarpus altilis*). With the tropical plants, other plants from Mediterranean and temperate areas were acclimatized. Out of the three thousand plants recorded in the Antilles, one third has been introduced. So, some culinary touches (African and Indian) contribute to the local cooking.

Constraints from the plantation economy have played a determining part in the importation flow structuration (flour, grains, salt meat) which is perpetueted and is an explanation to some activities low development, such as fishing. Import substitution has become the food industry aim. Definition and obtainment of plant varieties appropriate to be processed is often the key for projects success.

AIMS OF RESEARCH

Our research activities, at the Station de Technologie des Produits Végétaux, INRA Antilles-Guyane, aim at elaborating knowledges on plants from the Caribbean. Some of them like pine-apple, banana are already well known, they are consumed fresh and processed. Others are much less known, outside and even in the Caribbean basin. Often those are, picking produces with a great biological and mechanical fragility. Their traditional processing frequently involved canesugar (jam, pastry) and rum (punch, cocktail); produces are preservation and/or dressing forms.

Microbial agents -yeasts and bacteria- are at the centre of our research activities. The objectives are to characterize these flora from the natural tropical media, to control their presence and activities. The expected result is to obtain edible products, regarding the consumer expectations on the various markets.

The generated knowledges on the raw materials and processes allow know-how valorization on tropical agricultural resources, particularly Caribbean ones.

Caribbean populations are young and consequently their traditional products are not numerous. Raw canesugar, rums, derived products from their association with tropical fruits are with culinaries dishes among the Caribbean's most original products.

Among the tens edible fruits and vegetables less known, originating from tropical America, there are approach works to undertake, in order to do emerge species with high agricultural, technological and commercial potential.

SOME RESEARCH OUTPUT

It is a necessity for the agro-industry units to be respectuous towards environment, particularly because of the insularity and the tourism activity. Therefore we have decided, since twenty years, to work in our research structure, on the self purifying capacity from the natural environment, with the perspective of its domestication in reactors. Interesting results have been yield, about vinasses treatment and valorization, some of them are valorized. We are carrying on our works on secondary treatments to improve the wastewaters purifying rate and discolouration.

The perspective for a better control of rum fermentation media lead us to select yeast strains. Since 1995 Lallemand S.A. sells the world first commercial yeast strain, selected for rum distilleries. This strain is issued from our collection. EDV 493 is its commercial name. We continue to work on microorganims -yeast and bacteria- for rum technology, generating aromatic products.

In our Unit, we also work for the lactic fermentation application like a process to dress and/or preserve agricultural products. It is not a traditional fermentation in the french Antilles. We tested it in a successfully manner on okra (*Hibiscus esculentus*). We obtained an highly appreciated aperitive form. We are fermenting various local resources for ready-to-use vegetables corresponding to an expressed demand of collective restoration.

PERSPECTIVES

The organization in chain of Caribbean agro industrial potentialities could offer possibilitics to economic animation. Some countries have an important potential of agricultural production with a high competitivness ; others have capacity to realized technological operations but with a limited agricultural capacity. Political choices seem to be done to help efficiently the wills going this sense at various levels.

Research in food technology could contribute to:

- raw-materials knowledge and determination of varieties adapted to transformations processes,
- study and rationalization of domestic and traditional transformations, expressing our respective identities, for valorization
- innovations.

Table1 : Main basic food production in the world, in million ton.

Resource	Year 1976	1986	1996	1997
WHEAT	419	528	586	608
CORN	351	478	590	586
RICE	347	469	569	570
POTATO	272	286	310	291
CASSAVA	113	134	163	164
BARLEY	166	177	156	156
SWEET POTATO	133	121	142	138
SORGHUM	61	70	70	63
SUGARCANE	687	932	1229	1251

Source FAO year book.

QUALITY CHANGES IN CHILI PLUMS (*Spondias purpurea* L.) DURING STORAGE

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ABSTRACT

Chili plums (*Spondias purpurea* L.) harvested and classified as immature (M1), mature green (M2) and slightly turning or breaker (M3) were stored at 4-5°C, 9-10°C, 20-21°C and 30-31°C and evaluated for changes in total soluble solids (TSS), total titratable acidity (TTA), pH, sugar-acid-ratio (TSS/TTA ratio), total sugars, reducing sugars, vitamin C, marketable fruits and decay over 15 days. Sensory evaluation was also done on stored samples. In addition fruits stored for 15 days at 4-5°C and 9-10°C were transferred to 20-21°C for 1 day to assess the development of chilling injury symptoms. Decay due to a fruit rot fungi of the *Phoma* spp terminated the shelf-life of fruit at all three stages of maturity after 8 days at 20-21°C. However, at 30-31°C shelf-life was only six days. M2 and M3 fruit at 20-21°C and 30-31°C had lower TTA and higher TSS, pH, vitamin C, sugar-acid-ratios and total and reducing sugar contents compared to fruit stored at 4-5°C and 9-10°C.

Pitting and shrivelling among M1 fruit rated as moderate and slight after 1 day at 4-5°C and 9-10°C respectively, accelerated to very severe after 7 days. M2 fruit at 4-5°C which appeared marketable during continuous storage for 15 days showed visible symptoms of severe chilling injury upon transfer to the warmer temperature while similar fruit stored at 9-10°C did not. M3 fruit at 4-5°C showed no chilling symptoms but were unmarketable after 11 days due to rapid softening. It was concluded that chili plums harvested at the M2 stage of maturity maintained the best quality when stored at 9-10°C in view of the absence of decay, severe chilling injury and shrivelling as well as the highly acceptable sensory evaluation scores after 15 days of storage.

INTRODUCTION

The Chili plum (Spo*ndias purpurea* L)is a common fruit grown in the Caribbean and Central and South America where it is also known as 'Lapa', Job, Moyo, Sta Roseno, 'Jismoyo' and De Cocer (Barbeau,1994). It is a member of the Anacardiaceae family and attains a height of 3 - 10 meters. The tree has a grayish, smooth bark with leaves which are 2.5 - 6.5 cm long with 5 –23 leaflets. Fruiting usually occurs between the months of September to November (Adams,1972). The fruit is a smooth and shiny ellipsoid drupe that measures 2.5 to 4cm in length and 1.5 - 2.5 cm in diameter and ripens rapidly (2-3 days) from the mature-green stage (Barbeau,1994). Immature green fruit are made into pickled and candied products while the mature and ripened fruit are eaten fresh (Barbeau,1994).

While studies have been reported on freshly harvested chili plums pertaining to total soluble solids and total titratable acid contents (Pilgrim,1994) there are no data on other major compositional changes of the chili plums during storage. This study investigated quality changes in chili plums during storage at refrigerated and non refrigerated temperatures.

MATERIALS AND METHODS

Fresh 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. The fruits 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 dipped for 2 minutes in 200 ppm sodium hypochlorite solution (72ml commercial bleach, Chlorox, in 18.9 litres of water) at 20 - 21°C and air dried on

tissue paper with an oscillating fan for 20 minutes. After a second sorting only blemish-free fruits at the 3 maturity stages M1, M2 and M3 and were stored at 4 - 5°C (T1), 9 - 10°C (T2), 20 - 21°C (T3) and 30 - 31°C (T4).

Chemical analyses were conducted at harvest (day 0) and every 5 days up to 15 days. Each treatment was replicated three times with each replicate consisting of 25 fruits. Data were taken for the following parameters:- total soluble solids(TSS), total titratable acidity(TTA), pH, ascorbic acid content (Vit.C), sugar-acid-ratio, total and reducing sugars, taste evaluation, chilling injury, percentage marketable fruit and incidences of decay.

Decay was rated on each fruit using the following scale 1=no decay, 2=slight, 3=moderate, 4=severe and 5=complete breakdown. Percentage decayed fruits was obtained by calculating the number of fruits with the rating above. Marketable quality was rated as 1=very poor quality, 2=poor quality, 3=moderate quality (marketability limit), 4=good quality and 5=excellent. pH was determined with an Orion Research digital pH meter Expandable Ion Analyser EA 920 (Boston, MA) which was first standardized with two buffer solutions of pH 7.41 and 4.01.

Total soluble solids (TSS) were determined by the use of a hand-held Leica refractometer (model #10431) with a measuring range of 0-50°Brix. Total titratable acidity (TTA) was determined on a sample extract (25g of the edible portion of the fruit macerated in 100ml of distilled water by a Osterizer 8-speed blender for 1 minute). The acidity was measured by titration with phenolphthalein as an indicator, using standard 0.1M NaOH and expressed as mg citric acid $100g^{-1}$ fresh weight(A.O.A.C.,1975).

Ascorbic acid was determined by using a 100ml sample of plum extract plus 1ml of 10% potassium iodide and 2ml sulphuric acid with 0.01 N Iodate. The ascorbic acid equivalent of the iodate was calculated and expressed as mg. $100g^{-1}$ fresh weight (Kefford, 1957).

Total sugars was determined on a 100ml sample of plum extract plus 5mls of 54% HCl, which was then neutralized with 25% NaOH. Two mls of a mixture of sodium potassium tartrate and 3,5, di-nitro-salicylic acid (150g in 250mls distilled water and 5g in 100mls 2N NaOH respectively) were then added to the neutralized mixture. The absorbance reading was taken at 540 nm on a Perkin-Elmer Lambda 3B UV/VIS spectrophotometer (model #C618-0437) (Miller, 1959).

Reducing sugars was determined using a 100ml sample of plum extract plus 2mls of a mixture of sodium potassium tartrate and 3, 5, di-nitro-salicylic acid (150g in 250mls distilled water and 5g in 100mls 2N NaOH respectively). The absorbance reading was taken at 540mm on a Perkin-Elmer Lambda 3B UV/VIS Spectrophotometer (model #C618-0437) (Miller, 1959).
Sugar to acid ratio (TSS/TTA ratio) was determined by dividing the total soluble solids (TSS) values of the plum samples by their respective total titratable acidity values (Ranganna, 1986).

Comparative sensory evaluations of flavour and taste were performed using a 20 member semi-trained panel. Panelists used a hedonic scale of 1-5 with 1 representing unacceptability and 5 extremely acceptable according to 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).

$$\text{CI Index} = \sum_{0}^{5} \frac{\text{(injury level) x (number of fruits at this level)}}{\text{total number of fruits}}$$

This experiment consisted of a completely randomized design with a factorial arrangement of variables. Significance of the data was tested by the F-test. Mean separation was done using the Least Significant Difference (LSD) method.

RESULTS AND DISCUSSION

Percentage Marketable Fruits, Taste, Decay and Chilling Injury.

Percentage marketable fruit declined over time irrespective of storage temperature and stage of maturity (Tables 1-4). M3 fruit accounted for 100% marketable fruits at 4-5°C after 7 days and declined for each additional day to 50% after 11 days (Table 1). Rapid softening and surface discolouration resulted in M3 fruit becoming unmarketable beyond 11 days (Table 1). The absence of chilling injury among M3 fruit during the first 8 days of storage at 4-5°C was responsible for the significantly higher percentage marketable fruits compared to M1 fruit. M2 fruit had higher percentages marketable fruit with lower incidences of chilling injury than M1 fruit (Table 1). M1 fruit after 5 days at 4-5°C showed a progressive decline in percentage marketable fruit which coincided with increasing severity of chilling injury.

At 9-10°C percentage marketable fruit was generally higher at all 3 stages of maturity than fruits stored at 4-5°C (Tables 1 and 2). This was due to less chilling injury damage. Chilling injury for example in M1 fruit at 9-10°C was slight to moderate after 5 days with 86% fruits being marketable whereas at 4-5°C chilling injury was rated as severe and this accounted for only 69% of the fruits being marketable over the same period (Tables 1 and 2). M2 fruit at 4-5°C after 12 days had a chilling injury rating of 4.00 (severe) and this accounted for 59% being marketable whereas at 9-10°C over the same period chilling injury was rated as 2.00 (slight) and 85% were marketable (Tables 1 and 2). M3 fruit at 9-10°C had the least chilling injury indicating that fruits at an advanced stage of maturity exhibited a greater tolerance to low temperature storage.

M3 fruit stored at 20-21°C and 30-31°C did not store as well and had variable ratings for taste when compared to M1 and M2 fruit (Tables 3 and 4). For example M3 fruit at 20-21°C after 6 days accounted for 60% marketable fruits and had a 1.67 (slightly acceptable) taste rating whereas M1 and M2 fruit each had 27% more marketable fruits than M3 but the taste rating for M2 fruit was the highest (2.67-acceptable). The variable ratings for taste among M3 fruit at 20-21°C and 30-31°C (Tables 3 and 4) suggested that maximum eating quality was between day 3 and 4. Beyond this period due to overripening, the initiation of senescence and decay (Table 5) due to a fruit rot fungi of the *Phoma* spp, significant reductions in taste were recorded (Tables 3 and 4).

Total Titratable Acidity (TTA) and pH

The pH values of the freshly harvested chili plum fruits prior to storage were 2.79, 2.96 and 2.98 for M1, M2 and M3 fruit respectively (Table 5). However during storage, the pH values changed significantly ($P<0.001$) due to temperature, maturity and their interactions with time. Table 5 showed that after 5 days at 4-5°C M1 fruit had the lowest pH value while M2 fruit had the highest pH. However fruit stored at 9-10°C, 20-21°C and 30-31°C pH values were higher as fruit maturity advanced from M1 to M2 to M3. Storage of the chili plums for an additional 5 days at 4-5°C and 9-10°C resulted in increases in pH with time and with each successive maturity stage at 4-5°C while at 9-10°C M1 fruit maintained a lower pH value than M2 fruit (Table 5). However after 15 days, while fruits stored at 4-5°C experienced increases in pH values, the opposite occurred among fruits stored at 9-10°C. Also at both 4-5°C and 9-10°C M1 fruit maintained lower pH values than M2 fruit (Table 5). The general trend of increases in the pH of the chili plums with advanced fruit maturity and increased storage duration mentioned above were expected since according to Jackson (1986) mature fruits usually undergo a reduction in their level of acidity with the initiation of ripening. This was confirmed even further on the basis of the total titratable acidity results shown in Table 5. Data in Table 5 revealed that after 5 days at 4-5°C M1 fruit had the highest TTA value and M2 fruit the lowest but at 9-10°C, 20-21°C and 30-31°C TTA of the chili plums decreased with fruit at an advanced stage of maturity. Storage of the chili plums for an additional 5 days at 4-5°C and 9-10°C resulted in decreases in TTA with time except for M2 and M3 fruit at 4-5°C and M1 fruit at 9-10°C. There were also decreases in TTA with advanced fruit maturity at 4-5°C and 9-10°C (Table 5). However after 15 days, while fruits stored at 4-5°C experienced decreases in TTA values, the opposite occurred among M1 fruit stored at 9-10°C. Also at both 4-5°C and 9-10°C M1 fruit maintained higher TTA values than M2 fruit (Table 5).

Table 1. Changes in Percentage Marketable Fruits, Taste and Chilling Injury of Chili Plums Stored at 4-5 °C After 15 Days.

Storage Duration (Days)	Marketable Fruits (%)			Taste Ratiings			Chilling Injury Index		
	M1	M2	M3	M1	M2	M3	M1	M2	M3
1	94op[y]	100q	100q	1.00a	1.33ab	1.33ab	3.00c	2.00b	1.00a
2	891m	100q	100q	1.00a	1.00a	2.00cd	3.00c	2.00b	1.00a
3	83k	100q	100q	1.00a	2.00cd	3.00f	3.00c	2.00b	1.00a
4	77j	98pq	100q	1.00a	2.33de	2.67ef	3.00c	2.00b	1.00a
5	69i	98pq	100q	1.00a	2.33ed	2.67ef	4.00d	2.00b	1.00a
6	61h	95op	100q	1.00a	2.67ef	3.67g	4.00d	2.00b	1.00a
7	53ef	93mo	100q	1.33ab	2.67ef	4.00g	5.00e	2.00b	1.00a
8	47c	87i	95op	133ab	3.00f	3.67g	5.00e	3.00c	1.00a
9	44c	82k	88i	1.00a	3.00f	2.67ef	5.00e	3.00c	2.00b
10	39b	75j	70i	1.00a	3.00f	2.00cd	5.00e	3.00c	2.00b
11	35b	67i	50de	1.00a	2.67ef	2.00cd	5.00e	3.00c	3.00c
12	28a	59gh	ND[x]	1.00a	2.67ef	ND	5.00e	4.00d	ND
13	25a	55fg	ND	1.00a	2.00cd	ND	5.00e	4.00d	ND
14	25a	45c	ND	1.00a	2.00cd	ND	5.00e	4.00d	ND
15	25a	45c	ND	1.00a	1.67bc	ND	5.00e	4.00d	ND
LSD (0.05)		**4.82**			**0.50**			**0.12**	

NDx = no data due to fruit decay. M1-immature M2 - Mature Green M3 - Breaker

Table 2. Changes in Percentage Marketable Fruits, Taste and Chilling Injury of Chili Plums stored at 9-10 °C after 15 Days.

Storage Duration (Days)	Marketable Fruits (%)			Taste Ratiings			Chilling Injury Index		
	M1	M2	M3	M1	M2	M3	M1	M2	M3
1	98kl[y]	1001	1001	1.00a	1.00a	1.00a	2.00b	2.00b	1.00a
2	93j	1001	1001	1.00a	1.00a	3.00de	2.00b	2.00b	1.00a
3	881	1001	1001	1.33ab	1.67bc	3.33ef	2.00b	2.00b	1.00a
4	86hi	99kl	1001	1.33ab	1.67bc	3.33ef	3.00c	2.00b	1.00a
5	86hi	99kl	1001	1.33ab	1.67bc	3.33ef	3.00c	2.00b	1.00a
6	80g	97jkl	1001	1.33ab	2.67d	3.67f	4.00d	2.00b	1.00a
7	75f	97jkl	95jk	1.33ab	2.67d	3.33ef	5.00e	2.00b	2.00b
8	68e	93j	75f	1.00a	3.00de	2.67d	5.00e	2.00b	2.00b
9	65e	86hi	50c	1.00a	3.00de	2.00c	5.00e	2.00b	3.00c
10	58d	85hi	ND[x]	1.00a	3.67f	ND	5.00e	2.00b	ND
11	49bc	85hi	ND	1.00a	3.67f	ND	5.00e	2.00b	ND
12	45b	85hi	ND	1.00a	3.33f	ND	5.00e	2.00b	ND
13	45b	85hi	ND	1.00a	3.00de	ND	5.00e	2.00b	ND
14	45b	83gh	ND	1.00a	3.00de	ND	5.00e	3.00e	ND
15	40a	80g	ND	1.00a	3.00de	ND	5.00e	3.00c	ND
LSD (0.05)		**4.82**			**0.50**			**0.12**	

NDx = no data due to fruit decay. M1-immature M2 - Mature Green M3 - Breaker

Table 3.Changes in Percentage Marketable Fruits and Taste of Chili Plums stored at 20-21 °C after 7 Days

Storage Duration	Marketable Fruits (%)			Taste Ratiings		
	M1	M2	M3	M1	M2	M3
1	100f[y]	100f	100f	1.00a	1.67bc	2.33de
2	100f	100f	100f	1.00a	1.67bc	3.33f
3	100f	100f	94e	1.33ab	2.67e	4.00g
4	100f	100f	87d	2.00cd	3.67fg	4.67h
5	100f	100f	87d	2.33de	4.67I	3.33f
6	87d	87d	60c	2.00cd	2.67e	1.67bc
7	53b	27a	ND[x]	1.33ab	1.67bc	ND
$LSD_{(0.05)}$		4.82			0.50	

ND[x] = no data due to fruit decay. M1-Immature M2- Mature Green M3- Breaker

Table 4. Changes in Percentage Marketable Fruits and Taste of Chili Plums stored at 30-31 °C after 6 Days.

Storage Duration	Marketable Fruits (%)			Taste Ratiings		
	M1	M2	M3	M1	M2	M3
1	100h[y]	100h	100h	1.00a	1.67bc	2.67ef
2	100h	96gh	98gh	1.33ab	2.33de	3.33gh
3	100h	90ef	91ef	1.67bc	2.33de	4.00ij
4	100h	83cd	87de	2.00cd	3.00fg	4.33j
5	93fg	80c	ND[x]	2.00cd	3.67hi	2.33de
6	51b	35a	ND	1.33ab	1.67bc	ND[x]
$LSD_{(0.05)}$		4.82			0.50	

ND[x] = no data due to fruit decay. M1-Immature M2- Mature Green M3- Breaker

Table 5. Changes in pH, total titratable acidity, TSS/TTA ratio and decay of chili plums after 15 days.

Parameters	Days Storage	Temperature (°C)											
		4 - 5			9 - 10			20 - 21			30 - 31		
		M1	M2	M3	M1	M2	M3	M1	M2	M3	MI	M2	M3
.pH	5	2.79a[y]	3.16.i	3.09h	2.93e	3.05g	3.23k	2.89b	3.16l	3.29m	2.92d	3.09h	ND[x]
	10	2.89b	3.05g	3.23k	3.09h	3.26e	ND	ND	ND	ND	ND	ND	ND
	15	2.94f	3.17a	ND	2.90c	3.09h	ND	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$							0.01						
TTA	5	1.14m	0.73a	0.76b	0.95h	0.87e	0.73a	1.06k	0.78c	0.76b	0.98l	0.82d	ND
	10	1.01j	0.93g	0.90f	0.98.i	0.76b	ND	ND	ND	ND	ND	ND	ND
	15	0.95h	0.76b	ND	1.09c	0.76b	ND	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$							0.02						
TSS/ TTA Ratio	5	3.50a	10.90e	11.80e	6.30b	10.30e	18.40h	15.10fg	2030i	28.20j	13.80f	20.20.i	ND
	10	8.00bc	11.90e	20.60.i	8.17c	14.40fg	ND	ND	ND	ND	ND	ND	ND
	15	8.40cd	10.50e	ND	10.22de	15.74g	ND	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$							1.86						
Decay	4	0a	0a	0a	0a	0a	0a	0a	0a	13.33c	0a	20.00d	13.33c
	5	0a	0a	0a	0a	0a	0a	0a	0a	13.33c	6.70b	20.00d	26.70e
	6	0a	0a	0a	0a	0a	0a	13.33c	1333c	40.00f	53.30h	73.30.i	86.70j
	7	0a	0a	0a	0a	0a	0a	46.70g	7330i	86.70j		ND	ND
$LSD_{(0.05)}$							1.37						

Table 6. Changes in total sugars, reducing sugars and vitamin C content of chili plums after 15 days

Parameters	Days Storage	Temperature (°C)											
		4 - 5			9 - 10			20 - 21			30 - 31		
		M1	M2	M3	M1	M2	M3	M1	M2	M3	MI	M2	M3
Total Sugars	5	2.00b[y]	4.30h	4.91k	3.80f	5.63l	8.63p	8.36o	12.81q	12.89r	6.56m	6.80n	ND[x]
	10	2.06b	3.00d	4.50l	3.33e	4.06g	ND	ND	ND	ND	ND	ND	ND
	15	2.38c	3.38e	ND	1.80a	4.81j	ND	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$							0.07						
Reducing Sugars	5	0.95b	2.57l	2.97n	1.24c	2.08j	3.42o	1.88h	2.88m	2.98n	1.56e	2.25k	ND
	10	0.98b	1.51e	2.51l	1.33d	1.66f	ND	ND	ND	ND	ND	ND	ND
	15	1.33d	2.00l	ND	0.70a	1.75g	ND	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$							0.07						
Vitamin C	5	9.60b	9.60a	11.20c	9.60b	11.20c	11.20c	11.20c	11.20c	11.20c	9.60b	11.20c	ND
	10	9.60b	11.20c	6.40a	12.80d	14.40e	ND	ND	ND	ND	ND	ND	ND
	15	11.20c	11.20c	ND	11.20c	11.20c	ND	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$							0.09						

Sugar-Acid-Ratio

Fruits generally experienced increased sugar-acid-ratio values with advanced fruit maturity throughout storage with the only exception being after 5 days at 4-5°C as M1 fruit had a lower ratio compared to M2 and M3 fruit which showed no significant differences (Table 5). At 4-5°C M1 and M3 fruit recorded higher levels of TSS/ TTA ratio between days 5-10. At 9-10°C sugar-acid-ratios increased among M1 and M2 fruit over the same period (Table 5). Increases obtained in sugar-acid-ratio values were due to increases in total soluble solids (Table 7) and simultaneous decreases in the total titratable acidity (Table 5).

Total and Reducing Sugars.

The temperature x maturity interactions at the ($P<0.001$) and ($P<0.05$) levels on total and reducing sugars respectively are shown in Table 6. Table 6 showed that after 5 days in storage total and reducing sugars levels increased with each successive maturity stage among the chili plums stored at 4-5°C, 9-10°C and 20-21°C, while at 30-31°C M2 fruit recorded higher levels of total and reducing than M1 fruit. Storage of the chili plums at 4-5°C and 9-10°C for 10 and 15 days resulted in increases in the levels of total and reducing sugars with advanced fruit maturity. However, after 10 days lower values were recorded in total and reducing sugars among all except M1 fruit stored at 9-10°C which had higher levels (Table 6). It was also observed that fruits stored at 20-21°C had higher total and reducing sugars levels than those stored at 30-31°C after 5 days. There was a general increase in the levels of both total and reducing sugars among the plums during storage with increased maturity throughout the 15 days storage duration. Such increases could possibly be attributed to the breakdown of complex polysaccharides and subsequent conversion into sugars mainly sucrose, fructose and glucose. This is characteristic of ripening and results in significant increases in the level of sugars in fruits (Jackson,1986). Lower levels of total and reducing between 5 and 10 days during storage at 4-5°C and 9-10°C could probably be due to the sugars being utilized for respiratory proeesses. A possible explanation for fruits stored at 30-31°C having lower total and reducing sugars levels than those stored at 20-21°C is that the fruits stored at 30-31°C experienced higher rates of respiration hence there was a greater depletion of sugars from such fruits. Similar findings were reported by Gur,(1986) with plums of the *Prunus* spp. It was reported that at 30°C sugar and acid depletion of the plums was greater when compared to plums stored at 10°C and 25°C.

Vitamin C

The significant ($P<0.05$) interaction of temperature x maturity is shown in Table 6. Storage of the chili plums for 5 days at 4-5°C resulted in M3 fruit recording the highest vitamin C content and M1 fruit the lowest at 9-10°C (Table 6). At 30-31°C M1 fruit had a lower vitamin C content than M2 fruit. However, after 10 days at 4-5°C M2 fruit had the highest vitamin C level and M3 the lowest while at 9-10°C M1 fruit recorded a lower vitamin C level than M2 fruit (Table 6). Increased storage duration from 5 to 10 days at 4-5°C resulted in M2 fruit undergoing an increase in its vitamin C content and M3 fruit a decrease while at 9-10°C fruits recorded increased levels. Between 10 and 15 days, at 4-5°C M1 fruit had increased vitamin C levels while at 9-10°C both M1 and M2 fruit were reduced (Table 6). Based on the data presented in Table 6 it was evident that mature chili plums (M2 and M3) were of a higher nutritional value (in terms of higher vitamin C values) than immature (M1) plums. Shani and Khurdiya,(1989) claimed that a reduction in vitamin C in ripening mangoes occurred simultaneously with increases in pH. This was attributed to the oxidation of the ascorbic acid as it's a reducing agent. They cited the work of Hulme,(1970)in which it was reported that the rate at which the change occurs is largely conditioned by pH. As the pH increased the vitamin C level decreased. Maybe a similar explanation is possible for declines in the vitamin C content of M3 fruit after 10 days at 4-5°C and M2 fruit after 15 days at 9-10°C. Such reductions in both instances were accompanied by increases in pH (Tables 5).

Total Soluble Solids (TSS)

Increases in TSS were obtained with advanced fruit maturity up to 10 days of storage (Table 7a). M1 fruit had increased levels after 5 and 15 days but reduced levels after 10 days. M2 fruit on the other hand had higher TSS after 5 days followed by lower levels thereafter (Table 7a). M3 fruit had the highest TSS levels up to 10 days in

Table 7a. Interaction effects on chili plums after 15 days.

Parameter and Interaction	Storage Period (Days)	M1	M2	M3
TSS	0	5.33a	6.50b	8.00c
	5	9.87d	12.38f	14.67g
Day x Maturity	10	8.00c	11.00e	18.50b
	15	9.50d	10.00d	ND
$LSD_{(0.05)}$			0.94	

Table 7b. Interaction effects on chili plums after 15 days.

Parameter and Interaction	Storage Period (Days)	T1	T2	T3	T4
TSS	0	-	-	-	6.61a
	5	7.00ab	9.50c	17.83f	15.00e
Day x Temperature	10	12.50d	9.50c	ND	ND
	15	8.00b	11.50d	ND	ND
LSD (0.05)			1.30		

Table 7c. Interaction effects on chili plums after 15 days.

Parameter and Interaction	Storage Period (Days)	T1	T2	T3	T4
TSS	M1	6.67a	8.33bc	16.00g	9.42cd
Maturity x Temperature	M2	9.00bc	10.67de	16.00g	11.50e
	M3	13.75f	13.50f	21.50h	8.00b
LSD (0.05)			1.30		

T1:- 4-5°C T2:- 9-10°C T3:- 20-21°C T4:- 30-31°C

storage. Data in Table 7b showed that after 5 days increases in TSS were experienced across T1, T2 and T3. After 10 days TSS declined with increased storage temperatures but the opposite occurred after 15 days. TSS peaked at 12.50° brix after 10 days at 4-5°C and dropped to 8.00° brix by day 15. At 9-10°C peak levels were attained after 15 days. At 30-31°C increased levels were observed after 5 days (Table 7b). Based on data presented in Table 7c it was evident that TSS increased with increased storage temperature among M1 and M2 fruit except those stored at 30-31°C which recorded lower levels than those at 20-21°C. Among M3 fruit, those stored at 20-21°C had the highest TSS levels and those at 30-31°C the lowest (Table 7c). At 4-5°C and 9-10°C TSS increased with advanced fruit maturity while at 20-21°C M3 fruit had the highest levels. At 30-31°C M3 fruit were responsible for the lowest TSS levels and M2 fruit the highest (Table 7c). Increases in total soluble solids could be attributed to the increases in the total and reducing sugar levels of the chili plums (Table 6), since according to Jackson (1986) most of the soluble solids in fruits are in fact sugars.

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PARTICIPATORY TECHNOLOGY DEVELOPMENT IN A MARKET- DRIVEN ENVIRONMENT - A Case Study on Marilissa Farms

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ABSTRACT

The Caribbean Agricultural Research and Development Institute (CARDI) identified the need for agricultural technology development to be market driven to afford regional producers a competitive edge even in their domestic markets. This paper looks at participatory technology development on Marilissa Farms, a CARDI small ruminant project farm in Trinidad. An examination of the impact of technical and business development interventions (undertaken between 1994-97) is made on a production system which is geared primarily towards the provision of high quality lamb into a niche market developed and implemented by CARDI.

Increases in the quality and size of forage banks and pastures (from 1.2 ha to 4.4 ha) over the period contributed to a decrease in average monthly concentrate feed and health costs from TT$9,000 to TT$3,500 despite a 10 fold increase in the sheep population. Consequently ewe mortality rates due to pregnancy toxaemia have been reduced from 36% to 0.7% with corresponding decreases in lamb mortality from 65% to 20%. With an increase in the size of the breeding flock from 23 to 226 breeding ewes between October 1994 and October 1997, Marilissa Farms is on target to stabilize at 500 breeding ewes by the end of 1998 without any external sourcing of breeding ewes.

This will facilitate an estimated target annual production of 22,000 kg of dressed lamb carcasses supplied under strict market quality control parameters compared to a 700 kg production level in 1994. It is expected that revenues from sheep production at Marilissa will increase from the 1994 level of TT$15,000 to TT$530,000 via supplies to the CARDI- developed niche market alone.

INTRODUCTION

It is without a doubt that agricultural research, particularly in the Caribbean region, must be prioritised and focused on the needs of producers and players in the region's agricultural sector. Tripp (1991) indicated that "the idea of planned agricultural change needs to be organised around an understanding of farmers' conditions and priorities." Given the increasing levels of globalization of markets and threats of economic liberalization to the region's agricultural sector, producers need to be guided by production and marketing strategies which would allow them to effectively compete in the harsh and dynamic environment in which they are mandated to operate.

Hosein, et al (1995) noted that more than 25% of the meat consumed in CARICOM comes from sheep and goats. This is particularly true for Trinidad and Tobago (T&T). Domestic production levels in T&T have however seldom exceeded 5% of the total quantities consumed with shortfalls being facilitated via cheaper lamb, mutton and chevron imports. To enhance the competitiveness of producers in Trinidad, CARDI developed a highly specialised niche market for "fresh chilled local lamb" with the country's largest supermarket chain. Significant strides have been made in streamlining local small ruminant production systems to cater for this market through on-farm research and Participatory Technology Development (PTD).

Bechstedt (1996) identified that the PTD farmers were a powerful resource of change. Researchers and farmers act as collaborators in simultaneously developing and validating on-farm technologies. These technologies are realistic and readily adopted by farmers because they consider the availability of resources and the external environment in which the farmer operates.

Marilissa Farms in Trinidad is owned and operated by Mr Lincoln Thackorie. Through strategic technical and business development interventions by CARDI, Marilissa Farms has moved from a subsistence production level in 1994 to the single largest supplier into the niche market managed by CARDI. The farm has also been developed into a production system model which facilitates the transfer of technologies developed on-site to other small ruminant farmers.

METHODOLOGY

On farm visits by the CARDI Animal Scientist and Research Assistant were the essential means used to develop a sound working relationship with the farmer. Initial investigations encompassing a review of existing farm records and interviews with the farmer and workers were conducted in 1994. These investigations revealed the following constraints in the sheep production system:

(i) high lamb mortality rates
(ii) high ewe mortality rates due to pregnancy toxaemia
(iii) inadequate/poor quality forage
(iv) non existence of pastures
(v) high concentrate feed costs
(vi) lack of structured markets

To enhance this production system to satisfy the requirements of the niche market developed by CARDI it was necessary to advise on a number of management practices incorporating:

- Business development
- Animal nutritional requirements (forage development and by-product feeding)
- Health maintenance
- Breeding management and general husbandry (including record keeping)

Technical assistance was facilitated by routine site visits over the period. Each visit lasted from 1-4 hours depending on the complexity of the problem being addressed. The farmer also benefited from several workshops conducted by CARDI on small ruminant production and breeding management. He also made site visits to the Blenheim and Studley Park Sheep Breeding and Multiplication facilities in Tobago and held active discussions with members of the Tobago Sheep Farmers Association (TSFA) as well as numerous other local producers.

BUSINESS DEVELOPMENT AND MARKETING RESULTS

The Relative Value of Sheep And Goat Enterprises At the start of the project, the farmer focused on goat rearing as the mainstay of his livestock production system.. With the development and emergence of a highly structured and organised market for lamb, there were obvious advantages to be obtained by shifting production from chevron to lamb. The farmer responded to market forces which guaranteed a specific price for lamb and he was able to considerably reduce the hassle and irregular purchase intervals of butchers and traffickers (Hosein. et al 1995).

In addition, under his predominantly cut and carry system, the sheep recorded faster growth rates and more efficient feed conversion than the goats. This led to a planned reduction in the size of the goat herd and a systematic increase in size of the sheep flock. This decision was essentially based upon market forces, production efficiency considerations and certainly not least of all, the level of technical support CARDI was offering to sheep producers. This latter consideration in fact provided much of the impetus that was needed for the farmer to feel secure in the decision he was taking. It was felt that without this level of technical assistance, the farmer would not have pursued this course. The indication here is that with the backing of a reputable agricultural research and development organisation, the farmer believed in the future prospects of the endeavour, since his long-term technical requirements (responding to market forces, and production constraints) were being met.

The impact of marketing on the development process at Marilissa farms is dealt with in a later section.

Number of Breeding Ewes

This is a parameter that immediately sets out the scale of an enterprise and generally distinguishes between subsistence production at one end of the scale and commercial production at the other. It is generally recognised by the CARDI research staff in Trinidad (resulting from simulated production models) that the minimum economic unit suitable for sheep production in Trinidad is approximately 50 breeding ewes.

The long term plan for Marilissa Farms is to stabilise at 500 breeding ewes. Expanding the production base is however a slow process, due mainly to the unavailability of quality breeding stock. In 1996, CARDI assisted in securing two pedigree Barbados Blackbelly rams from exporters in Barbados for this farm. Additionally, continuous monitoring of the farm enterprise has lead to progressive changes in the farmers' management of sheep production.
This is necessary to ensure that the farmer is fully equipped to adequately manage a large commercial flock. This can only be realised by continuous technical support throughout the growth period, until the 500 ewe system can be validated.

MARKETING

CARDI, having identified one of the obstacles to the expansion of the region's small ruminant sub-sector as limited marketing alternatives, successfully established a high value niche market for domestically produced lamb in 1994 for producers in Trinidad and Tobago. This niche afforded producers a premium price for their product. Small ruminant producers are regularly forced to accept lower prices to compete with high levels of the imported product (Aziz and Bennett 1993). Mr Thackorie is one of the farmers who took advantage of this CARDI-led marketing initiative.

This marketing arrangement sought to supply 'fresh chilled local' lamb to a chain of upscale retail centres in Trinidad while providing sheep producers with a secure market at a guaranteed price for their product. It is a collaborative effort between CARDI, the Sugarcane Feeds Centre (SFC) which is a local livestock research institution and HILO Food stores Limited (the largest supermarket chain in the country).

Market studies conducted by CARDI in 1995 estimates the demand for fresh chilled local lamb to be between 39,000 - 43,000 kg of meat annually at seven of the 18 upscale retail centres belonging to the HILO supermarket chain.

The Marketing Arrangement

On a phased basis, schedules of delivery for live animals and carcasses are developed by CARDI (after monitoring potential output from project farms) and forwarded to the retail centres and suppliers. These indicate the dates of delivery and quantity of live animals and carcasses scheduled for delivery to the abattoir and respective retail outlets.

Live animals are normally delivered by the producer on Monday afternoons to the approved abattoir (SFC). The animals are subsequently fasted for 12 - 24 hours (given only water), slaughtered on Tuesdays (under strict veterinary public health codes) and hung in a chilling unit at 4°C for 24 - 48 hours. The whole carcasses are then packaged and delivered to the respective outlets on Wednesdays and Thursdays. Payments are made directly to the supplier by the purchaser within two weeks of delivery of the carcasses to the retail outlet. These are based on the carcass weight at the point of delivery. For the purpose of payment CARDI issues an invoice on behalf of the supplier.

Results of marketing

While the marketing initiative was officially launched in July 1994, Mr Thackorie did not supply this market until November 1994. Table 1 illustrates on an annual basis the relevant data for animals supplied by Marilissa Farms. Perhaps the two most important items on the table are the number of animals supplied and the revenue generated per carcass. Both are represented graphically in figures 1 and 2.

Table 1. Comparative Supply Data For Marilissa Farms (1994 to 1997).

	1994	1995	1996	1997	Total
Number of animals	8	43	36	60	147
Total pre -slaughter weight (kg)	332	1682	1122	2280	5416
Total hot carcass wt (kg)	162	827	529	1094	2612
Average hot carcass wt (kg)	20.2	19.2	14.7	18.2	17.8
Total cold careass wt (kg)	152	799	516	1049	2516
Average cold carcass wt (kg)	19.0	18.6	14.3	17.5	17.1
Average revenue per carcass TT$	377.00	406.00	312.00	420.00	388.00

During the period November 1994 to Deeember 1997, Marilissa Farms supplied a total of 147 live animals into the marketing programme. Of these, 137 were rams since ewes produeed on the farm were added to the flock to inerease productive capacity. These 147 animals were slaughtered at an average live weight of 37 kg each and produced a total of 2612 kg of fresh (hot) meat. This translates into an average hot dressing percentage of 48.2%. After being ehilled, packaged and delivered to the retail centre, however, the weight upon which payments were made (delivery weight) was equivalent to 2516 kg. This represents an average cold earcass weight and eold dressing percentage of 17.1 kg and 46.5% respectively. The careasses supplied experieneed a shrinkage rate of 3.7% during the chilling and distribution process.

The marketing arrangement thus far has generated TT$56,913.00 in gross revenues for the producer at an average price of TT$388.00 per carcass over the period. This includes two 10% cumulative price increases from the original priee of TT$19.84 to TT$21.82 and subsequently to TT$23.99 per kg during the period of supply.

Strategic Interventions

Several interventions were made by CARDI to address the constraints which were previously identified. The sueeess of these interventions were however
largely due to the responsiveness of the farmer. Tables 2 and 3 respectively summarises comparative produetion and farming systems information and critieal areas of impaet data during the pre and post intervention periods.

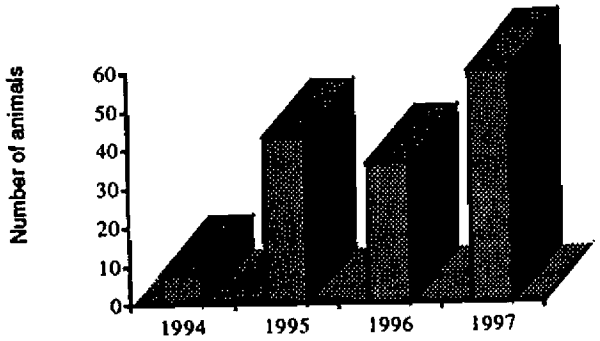

Figure 1: Number of animals supplied

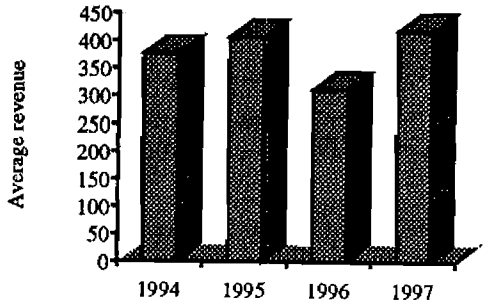

Figure 2: Average revenue per carcass (TT$)

Table 2. Production and Farming Systems Information for Marilissa Farms.

Production And Farming Systems	Net change (%)	Pre Intervention Oct. '94	With Intervention Oct. '97
Size of holding * (ha)	-	5	5
Main Enterprise	-	Goat	Sheep
Main Breed/Type	-	Anglo Nubian	Barbados Blackbelly
Other Enterprises	-	Sheep/Ducks	Goats/Ducks
Number of Breeding does	-56%	450	200
Number of Breeding ewes	+883%	23	226
Number of ducks	+600%	10	70
Number of hired labour	+40%	5	7
Area of improved forage (cut and carry) (ha)	+150%	1.2	3
Area of improved pastures (grazing) (ha)	-	0	1.4
Pen area for sheep and goat (m^2)	+68%	520	875

* Includes infrastructure such as pens, roads and 2 irrigation ponds.

Zero Grazing/ Forage Development

In moving from subsistence to commereial sheep systems production, adequate nutrition is often the first limiting

factor in the tropics. Given the high costs of imported supplements and the inconsistent supply and quality of agro-industrial by-products, it is advisable that as much as possible, ruminant production should hinge on forage based feeding systems. This is the cheapest means of feeding ruminant animals for acceptable levels of meat production. Against this background, the farmer was advised to increase the existing area (1.2 ha) of Elephant Grass *(Penisetum purpureum*) to adequately feed the growing numbers of sheep stock. The Elephant Grass which was harvested at 6-8 weeks and chopped, maintained an average crude protein content of 8%. This material was planted essentially for a zero-grazing system and was especially suited to feedlot lambs. At October 1997 the area of elephant grass was 3.0 ha, representing an increase of 150 %.

Table 3. Critical Areas of Impact.

Areas of Impact	Pre Intervention October 1994	With Intervention October 1997
Average monthly feed costs (sheep and goats)	TT$ 9,000.00	TT$ 3,500.00
Lamb mortality	65%	20%
Ewe mortality due to Pregnancy Toxaemia	36%	0.7%

Grazing Systems For Breeding Ewes

At the start of the project, the farmer had zero hectares of improved pasture. It was necessary to find a grass species that was high yielding, drought tolerant, persistent and of good nutritive value. The species also had to be adaptable to the local ecozone and planting material should also be readily available. The species selected was Coast Cross 1 (*Cynodon spp*), a high yielding, nutritious trailing grass. Just over 1.2 hectares were established with planting material obtained from the Ministry of Agriculture, Land and Marine Resources research centre at Centeno, Trinidad. The reasons for establishing improved pastures included:

- Reducing feeding costs (The labour associated with cut and carry as well as the machinery operating costs of chopping the forage before feeding, the opportunity costs of labour and the reduced reliance on expensive supplements).

- Providing exercise for pregnant ewes (There is a demonstrated need for exercise during pregnancy, as shown by reduced parturition problems, post partum deaths and lamb mortality).

On this farm, the technical advice offered was to use cut and carry for the feed-lot lambs and grazing systems for the breeding ewes. This allows for optimal use of the land and maintains a healthy cost-benefit relationship, as demonstrated by a measured reduction in feed cost over the life of the project.

CRITICAL INDICATORS

Monthly Feed Costs

Even though there was a systematic reduction in the number of goats since the start of the project, there was no commensurate reduction in feeding costs. This was because over the same period, increasing levels of feed were given to the sheep, since it was felt that they were now the mainstay of the farm. At the start of 1996, feed costs (essentially the cost of buying supplements) were still unacceptably high. A comprehensive programme to reduce the level of supplements being fed to the sheep was devised and explained in detail to the farmer. Analysis of feed samples were done to determine nutrient content (crude protein and fibre were used as the main indicators of feed quality).

It was found that some animals were being fed in excess of 1.4 - 1.8 kg of a 14% crude protein (CP) ration per day and that in some instances the CP content of the ration was as high as 19%.Since protein is generally the costliest ingredient, it was decided to:

- Reduce the level of CP in the diet to a maximum of 14%
- Institute a feeding regime based upon the physiologieal states of the animals. Reduction of the CP content of the ration was aehieved by reducing the level of brewers dried grain in the diet (the farmer commonly mixed this with a commercial 14 - 16% supplement).

Lactating ewes were fed at higher levels than dry ewes, whereas before all animals were fed the same quantities of supplements. It was suggested that dry animals should be fed at the rate of 0.23 kg/head/day, increasing up to 0.90 kg/head/day in early lactation.

With the development of improved pastures, breeding ewes will be fed supplements only in late pregnancy and during lactation, their maintenance and production requirements being otherwise met from improved pasture. Most of the feeding eosts will then be attributed to the fatteners. As a result of these preliminary interventions average monthly feed costs wcre reduced from TT$9,000.00 to TT$3,500.00. The precise level of feed with respect to total consumption and costs, feed conversion efficiency and their interrelation to carcass quality, market age and market weight, is now the subject of an ongoing research project. The results will be available in the year 2000. As shown in figure 3, real savings were made in feeding cost as a result of the measures outline above.

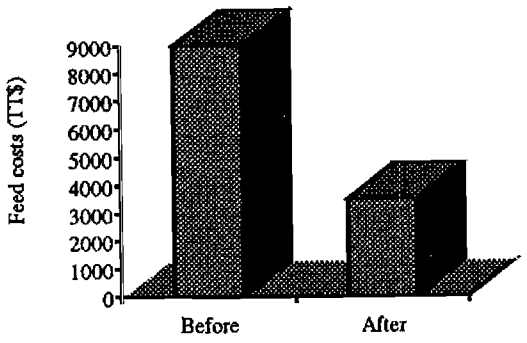

Figure 3: Monthly feed costs before and after CARDI interventions

Lamb Mortality

The viability of sheep production enterprises often depends upon the throughput of lambs. The survival of each lamb is vital and so adequate measures must be taken to ensure that lamb morbidity and mortality are well managed. Ideally, lamb mortality should never rise above 20% and farmers should strive to keep this figure well below 15%. At thc start of the project, lamb mortality was in the region of 65%. Some of this was related to ewe mortality, including pregnancy toxaemia and post-partum shock. Lambs that lost their mothers had a much lower survival rate then than now. Improvements in management have allowed better care to be given to orphan lambs, thereby increasing survival. In addition, the drastic reduction in maternal deaths has impacted positively on lamb survival. With better care being given to pregnant and lactating ewes more lambs have tended to survive to weaning, so that pre-weaning mortality has been reduced to 20%. The main factor impacting on this turnaround is essentially improved management. Lamb mortality is a good indication of the level of management in a sheep production enterprise.

The reduction in lamb mortality recorded after interventions by CARDI's technical staff is illustrated in figure 4.

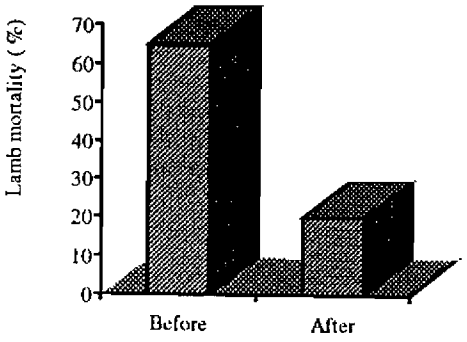

Figure 4: Lamb mortality before and after CARDI interventions

Pregnancy Toxaemia

This is a metabolic disorder that is often fatal. It is also called twin-lamb disease, since it is associated with ewes that have twin or multiple births. It is brought on by severe hypoglycaemia in late pregnancy and it is not easily treated. The best way to deal with this problem is through prevention. At the start of the project, maternal deaths due to pregnancy toxaemia stood at 36%. Each mature ewe death represented lost production capacity that required at least 13 months to replace. This was therefore a problem that impacted significantly on productivity and had to be dealt with immediately.

It was recognised that ewes were being overfed in early pregnancy and were becoming too fat. This meant that in late pregnancy when they needed to take in more nutrients for the rapidly developing foetuses, they simply lacked capacity. This led to glucose deficiency at a critical period.

It was also found that molasses formed an integral part of the diet in the pregnant ewes. Studies have shown that the end products of molasses digestion are precursors of compounds that induce pregnancy toxaemia (Steel and Leng 1973). The other critical factor hinged upon the fact that ewes were reared in a cut and carry or zero-grazing system, which severely limited the amount of exercise available to them. The literature indicates that lack of exercise during pregnancy is a contributing factor to pregnancy toxaemia. At the Blenheim station in Tobago where over 300 ewes are bred each year, pregnancy toxaemia is non-existent. This is largely attributed to the feeding regime and the exercise given to pregnant ewes.

The recommendations made included a reduction (by more than 50%) of the level of supplementation given to the pregnant ewes, the cessation of molasses use as part of the feeding regime, and the introduction of a grazing system for pregnant ewes to allow them adequate exercise each day. These recommendations have led to a reduction in the incidence of pregnancy toxaemia from the extremely high level of 36% in 1995, decreasing slightly to 32% in 1996, and then a dramatic reduction to 0.7% in 1997. This represents a considerable cost saving to the farmer and an increase in production efficiency. This is illustrated in Figure 5.

CONCLUSION

Of the numerous techniques that have been used to transfer and validate technology on farm, farmers themselves

have often been the best means of disseminating the type of technological information that often leads to successful technology transfer. Farmers readily learn from other farmers and once a model farm (farmer) has been established, technology transfer efforts can be better channelled and directed to the larger farming community. Model farm establishment is however a long and sometimes complicated process. It requires long hours working closely with the farmer and though the gains made are significant, the short term interaction with the farmer and the developmental work undertaken must be seen as an investment in longer term technology transfer, if it is to be justified. The results obtained at Marilissa Farms have clearly indicated that farmers, especially the more progressive ones, stand to benefit in real terms from this type of exposure.

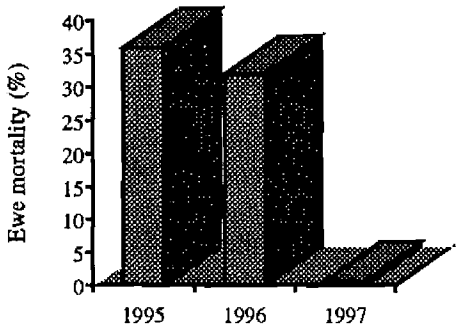

Figure 5: Ewe mortality (due to pregnancy toxaemia) before and after CARDI interventions

The improvements made in biological and economic terms were a direct result of the interventions made in production and marketing. A considerable amount of goodwill has also been established, based upon the reputation of CARDI as a regional agricultural research organisation and the consistent support from its scientific and technical staff. This composite has resulted in the development of an excellent working relationship with the farmer that facilitates on-farm research and development activities and ultimately, the technology transfer process.

FUTURE PROSPECTS

Already, more than 20 small commercial farmers in Trinidad and Tobago have either visited Marilissa Farms or otherwise interacted with Mr Thackorie with respect to his sheep production enterprise. As a result, some farmers have bought stock from Marilissa (mostly breeding rams) whilst others have implemented some of the improved management systems demonstrated there. There are clear prospects for Marilissa to be developed as a full fledged model farm for sheep production. Much of the ground work has already been laid and the development process is well underway. Over the next year, there are plans to purchase additional stock from Barbados to quickly realise the objective of 500 breeding ewes. This will place Marilissa as a technology transfer centre not only for the production of lamb fatteners, but also for pedigree Barbados Blackbelly sheep. This is in keeping with stated CARDI project objectives to establish satellite breeder farms as a means of decentralising the sheep breeding and multiplication activity.

With 500 breeding ewes, Marilissa Farms has the potential to produce 1100 animals (22,000 kg of meat) for this market on an annual basis given that production parameters remain stable at existing levels. At present prices this translates to TT$530,000 in revenues compared to TT$15,000 earned by the Farm in 1994.

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ELIMINATION ENZYMATIQUE DE L'AMIDON DANS LA PULPE DE PRUNE DE CYTHERE (*Spondias dulcis*) VERTE APPLICATION POUR LA PRODUCTION DE NECTAR

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RESUME

Aux Antilles, la prune dc cythère verte (*Spondias dulcis*) est très souvent consommée sous forme de nectar. L'amidon, principal glucide de réserve des végétaux, est présent dans la pulpe de ce fruit à raison de 2,3% (p/p). Généralement éliminé par décantation au froid, il constitue un sous-produit de fabrication du nectar. L'hydrolyse enzymatique a pour but dc le valoriser par conversion en sucre simple soluble (glucose) directement assimilable par l'homme. Deux méthodes de dosage de l'amidon ont été utilisées pour quantifier avec fiabilité ce composé et plusieurs expériences ont été menées afin de déterminer les conditions optimales d'enzymage. Deux enzymes ont été testées avec succès. Les modifications physico-chimiques et sensorielles entraînées par le traitement ont été évaluées. Des nectars ont été reconstitués à partir de la pulpe enzymée, au stade laboratoire puis au stade industriel, et leurs caractéristiques physico-chimiques et sensorielles ont été étudiées sur 12 mois : il n'y a pas eu de différences significatives entre le nectar enzymé et le nectar traditionnel. L'hydrolyse enzymatique semble donc être un moyen intéressant de valoriser l'amidon de la prune de cythère verte puisqu'elle permet d'enrichir la pulpe en sucre soluble endogène.

INTRODUCTION

Originaire de la Polynésie, la prune de cythère (*Spondias dulcis*) est un fruit tropical dont le noyau dur et rugueux est hérissé de logs filaments adhérant à la pulpe. Cultivée aux Antilles depuis 150 ans, elle est consommée fraîche (verte ou mûre), en confiture ou sous forme de boisson, jus ou nectar. Aussi, les industries agro-alimentaires n'hésitent-elles pas à faire figurer la prune de cythère dans l'évantail des parfums proposés.

Le nectar est élaboré à partir de la pulpe des fruits non encore parvenus à maturité qui se caractérise par son acidité et sa teneur élevée en amidon (2,3 % p/p) **[NAHAR N, RAHMAN** et al, 1990**]**. Dans le procédé de fabrication usuel, l'amidon est éliminé par décantation au froid (dépôt blanchâtre) car il confère au nectar une saveur désagréable. Cela constitue une perte non négligeable puisque ce dépôt représente environ 7 % (v/v) de la pulpe totale.

L'unité de recherche et développement de ROYAL S.A (jus et confiture) a donc envisagé de valoriser ce sous-produit de fabrication (sucre complexe insoluble) en l'incorporant dans la pulpe sous forme de sucre simple soluble (glucose).

Pour ce faire, nous avons décidé de dégrader l'amidon par voie enzymatique ; le choix de cette technique se justifie par le fait que l'utilisation d'enzymes en tant qu'auxiliaires technologiques est relativement répandu dans l'industrie des jus de fruit.

RAPPELS SUR LA STRUCTURE ET LES PROPRIETES DE L'AMIDON

L'amidon,glucide de réserve le plus répandu chez les végétaux, est un polymère d'anhydromaltose de formule $(C_6H_{10}O_5)n$. Il se présente sous forme de grains intracellulaires (amyloplastes) denses, d'aspect et de structure souvent caractéristiques de la plante d'où ils proviennent ; **[BRUNEL,** 1949**]**. Il est constitué de deux fractions polyosidiques :

- **l'amylose** : polymère linéaire de résidus D-glucose reliés par des ponts osidiques a 1-4. Ce polymère existe sous forme cristalline dans le grain d'amidon. En solution, il se présente une conformation helicoïdale et se colore en bleu par l'iode. [**CHEFTEL** et al, 1986]

- **l'amylopectine** : structure moléculaire très ramifiée, arborescente. C'est un squelette de D-glucose reliés en a 1-4 sur lequel sont branchés, en a 1-6, d'autres chaînes de D-glucose. Ce polymère se colore en pourpre par l'iode en solution.

Les proportions relatives d'amylose et d'amylopectine varient avec l'origine botanique, les conditions de culture et le stade de développement du végétal. [**BRUNEL**, 1949].

De par son organisation cristalline, l'amidon est insoluble dans l'eau. Mais, sous l'effet de la chaleur, le grain gonfle et se déchire pour libérer une partie de son contenu : l'amylose qui se solubilise. Ce phénomène, appelé **gélatinisation**, s'accompagne d'une élévation de la viscosité et conduit à la formation d'une solution **d'empois d'amidon**. la gélatinisation se produit dans une fourchette de température caractéristique de l'origine végétale. [**BRUNEL**, 1949 ; **AYMARD**, 1993].

L'empois d'amidon et l'amidon se colorent en bleu / violet par l'iode. Le complexe amidon – iode absorbe à 660 nm. Cette propriété est utilisée pour le dosage quantitatif réalisé sur l'amidon gélatinisé. [**BRUNEL**, 1949].

De plus, l'action des enzymes utilisées ici pour hydrolyser l'amidon est optimale sur le polymère **empesé**.

MATERIELS ET METHODES

Materiel

La pulpe utilisée dans le cadre de cette étude provient de fruits locaux. Elle est obtenue par pressage et tamisage puis est stockée en chambre froide négative (-20°C) dans des seaux de 30 litres.

Methodes

caractérisation physico-chimique de la pulpe de prune de cythère

Dosage de l'amidon

Avant d'être dosé, l'amidon est solubilisé par voie thermique (gélatinisation) : la pulpe de prune de cythère décongelée est homogénéisée pour remettre l'amidon insoluble en suspension, puis elle est portée à 80°C au bain-marie bouillant pendant une durée qui varie en fonction du volume de l'échantillon.

Dosage à l'iode

En mesurant l'absorbance, à 660 nm, de différentes solutions d'empois d'amidon de concentrations connues, en présence d'iode, nous avons établi une courbe étalon qui a servi de référence pour déterminer la teneur en amidon de la pulpe. Nous avons obtenu une droite d'équation $y = 0,3858 * x$ (y = densité optique et x = teneur en amidon en % p/v).

L'absorbance de la pulpe chauffée diluée au 1/10 ème est lue au spectrophotomètre puis en se rapportant à la courbe étalon on détermine la teneur en amidon correspondante.($x = y / 0,3858$).

Dosage enzymatique

Cette méthode repose sur une hydrolyse enzymatique de l'amidon suivie d'une phosphorylation et d'une oxydation des dérivés glucose formés en présence d'un coenzyme : le $NADP^+$ (kit enzymatique Boehringer – Mannheim). La quantité de NADPH formé par réduction reflète le D-glucose libéré par l'hydrolyse de l'amidon. En mesurant son absrbance à 340 nm, nous déduisons par le calcul, la teneur en amidon de la pulpe ;

Mesure des autres paramètres physico-chimiques

Afin de suivre l'évolution de la pulpe au cours du traitement enzymatique, il convient de connaître au préalable ses principales caractéristiques physico-chimiques. La gélatinisation de l'amidon, étant une étape indispensable à l'action des amylases, il est nécessaire de connaître les paramètres de la pulpe brute et de la pulpe chauffée. Ceci nous permettra d'évaluer, dans un premier temps, l'influence du traitement thermique appliqué.

***pH** : pHmètre

***degré brix** (matière sèche soluble) : réfractomètre

***matière sèche totale** : 20 g de sable de Fontainebleau mélangés à 5 g de pulpe sont placés dans une étuve sous vide à 70°C pendant 2h30 mn.

***cendres** : 10 g de pulpe sont placés dans un four à moufle à 525°C pendant 6 h.

***teneur en glucose** : La méthode utilisée repose sur une réaction enzymatique qui consiste à phosphoryler le glucose puis à oxyder, en présence de NADP+, le dérivé glucose formé. En mesurant l'absorbance du NADPHà 340 nm, on détermine, par le calcul, la teneur en glucose.

***acidité** : 10 g de pulpe sont neutralisés avec de la soude 0,1 N en présence d'un indicateur coloré : la phénolphtaléïne qui vire au rouge à pH = 8,1

***viscosité** : Nous utilisons un viscosimètre rotatif de type Couette dans lequel la substance à étudier est soumise à un mouvement laminaire de cisaillement entre 2 surfaces solides : l'une au repos l'autre mobile. Le système de mesure est relié à un ordinateur qui permet, grâce à un logiciel, de lancer les programmes de mesure. On obtient ainsi le listing des résultats et les représentations graphiques très diverses.

conditions optimales d'enzymage

Deux enzymes du commerce (A et B) ont été testées séparément. Ce sont des complexes enzymatiques d'origine fongique possédant des activités amylase et amyloglucosidase en proportions différentes. Elles sont très souvent utilisées dans l'industrie de jus de pomme pour la transformation de l'amidon en glucose.

Les essais ont consisté à faire varier les doses d'enzyme et le temps d'incubation pour déterminer le domaine d'étude sachant que les contraintes de production imposent de travailler rapidement : 15 à 20 mn.

Pour chacune des deux enzymes (A et B), les doses testées sont 50-75-100 mg / 100 ml de pulpe. La température d'incubation est 60°C (température d'activité optimale des enzymes). Le mode opératoire est le suivant :

- Chauffer, au bain-marie bouillant, 300 ml de pulpe homogénéisée jusqu'à 80°C pour gélatiniser l'amidon (l'amidon empesé est plus sensible aux attaques enzymatiques).

- laisser refroidir à 55°C puis placer le bécher au bain-marie réglé à 60°C. Mettre sous agitation (hélice rotative)

- introduire, à l'aide d'une micropipette, la dose d'enzyme testée. Déclencher le chronomètre simultanément et prélever au temps t, 5 ml de pulpe. Doser à l'iode l'amidon résiduel.

influence de l'enzymage sur les paramètres physico-chimiques

Les paramètres des pulpes enzymées sont mesurés suivant les modes opératoires décrits au III – 2 – A.

reconstitution des nectars et analyse sensorielle

***Reconstitution des nectars** : : A partir des pulpes enzymées, nous avons reconstitué des nectars selon la recette ROYAL.

300 ml de pulpe chauffée sont enzymés avec la dose d'enzyme retenue (d'après le II-2-B) pendant 20 m, à 60°C et sous agitation. Puis les quantités d'eau et de sirop requises pour la fabrication du nectar sont ajoutés à la pulpe. Nous procédons enfin à une pasteurisation au four à micro-ondes (95°C – 5mn) ;

***Analyse sensorielle** : trois nectars sont soumis à une analyse sensorielle (test hédonique).

désignation	Caractéristique de la pulpe
nectar 1 : témoin naturel	amidon éliminé par décantation au froid procédé de fabrication industriel usuel
nectar 2 : essai enzymé A	amidon total éliminé par l'enzyme A
nectar 3 : essai enzymé B	amidon total éliminé par l'enzyme B

38 juges, recrutés à l'usine et à l'extérieur, ont participé à cette analyse sensorielle et ont exprimé leur avis concernant le caractère agréable ou désagréable des 3 échantillons, sur une échelle de cotation à 9 points qui va de " excellent " à " inacceptable ". L'outil statistique utilisé pour le traitement des résultats est une analyse de variance à un facteur (**ANOVA**). Le facteur correspond à la source de variation ; ici, il s'agit du procédé de fabrication (nous disposons de 3 procédés différents et nous désirons savoir s'ils sont perçus de façon identique ou si au contraire, les sujets décèlent entre eux des différences significatives)

Essai pilote

Nous avons reconduit sur la chaîne industrielle la fabrication des nectars enzymés avec l'enzyme retenue à l'issue de l'analyse sensorielle et physico-chimique.

Deux essais ont été réalisés : nectar enzymé et témoin naturel.

RESULTATS ET DISCUSSIONS

Caractérisation Physico-chimique de La Pulpe

Dosage de l'amidon

Dosage à l'iode	Dosage enzymatique
3,7 % p/v	2,5 % p/v

Nous constatons que les deux méthodes conduisent à des résultats différents.

Le dosage enzymatique vise spécifiquement l'amidon alors que la réaction à l'iode se produit également avec

des composés de classes très diverses contenus dans la pulpe [**BRUNEL**,1949], ce qui explique la valeur élevée : 3,7 %. De ce fait, la teneur en amidon la plus réelle est celle déterminée avec le kit enzymatique : 2,5 %. Néanmoins, nous avons pu établir, par expérimentation, une corrélation entre les deux méthodes : amidon iode = 0,65 * amidon kit. Le dosage à l'iode, peu coûteux et facile à mettre en œuvre, a donc été retenu pour déterminer les teneurs en amidon.

mesure des autres paramètres physico-chimiques

	pH	brix	Matière sèche totale % p/p	Cendres % p/p	Glucose % p/p	Acidité meq/l	Viscosité cP
Pulpe brute	2,78	7,6	10,7	0,40	2,21	160	3,40
Pulpe chauffée	2,78	10	11,2	0,42	2,29	163	23,40

Les paramètres qui varient le plus, sous l'effet du traitement thermique, sont : le degré brix et la viscosité ; L'augmentation du degré brix reflète la solubilisation de l'amidon : la proportion d'éléments solubles augmentent d'environ 2,4 %, ce qui correspond à la teneur initiale en amidon (2,5 %) déterminée avec le kit enzymatique.

Au cours de la gélatinisation, la viscosité de la pulpe passe de 3,40 à 23,40 centiPoises. Ceci traduit le phénomène d'empesage : les amyloplastes gonflent et adhèrent entre eux. C'est surtout l'amylopectine qui en est responsable car sa structure ramifiée lui confèrent une très forte capacité de rétention d'eau [**AYMARD**, 1993].

Conditions Optimales D'enzymage

Dans les deux cas (enzyme A et enzyme B), la destruction quasi-totale de l'amidon est obtenue le plus rapidement (20 mn) avec la dose de **100 mg / ml** de pulpe. La teneur en amidon résiduel est très faible (0,04 %)

Influence de L'enzymage

	Viscosité cP	Glucose % p/v	Amidon iode % p/v
Pulpe chauffée	23,4	2,3	3,7
Pulpe chauffée enzymée A	3,1	5,1	0,04
Pulpe chauffée enzymée B	2,97	4,7	0,01

L'augmentation du taux de glucose résulte de l'hydrolyse des chaînes d'amidon ; Cette augmentation égale à 2,8 % pour l'enzyme A et 2,4 % pour l'enzyme B correspond sensiblement à la teneur initiale en amidon : 2,5 %.

La diminution de la viscosité témoigne de la dégradation des chaînes de glucose constituant l'amidon (amylose et amylopectine).

Reconstitution Des Nectars et Analyse Sensorielle

Le traitement statistique des résultats (analyse de variance : ANOVA) sur Mac-Intosh montre qu'il n'existe pas de différence significative entre les nectars enzymés et le témoin naturel (avec un risque de 5%). Ceci indique que l'enzymage n'altère pas la saveur naturelle de la prune de cythère.

Essai Pilote, Rendements et Couts

Dans la mesure où aucune différence (sensorielle ou physico-chimique) n'a été relevée entre les deux nectars enzymés, le seul critère de sélection de l'enzyme pour l'essai pilote a été le prix. C'est l'enzyme A que nous

avons choisie.

Avec l'enzymage de la pulpe, nous obtenons environ 20 % de nectar supplémentaire. Le surcoût lié à l'enzymage est de 2,7 centimes / l de nectar. Tous calculs effectués, le différentiel entre le surcoût entraîné et le gain de produit fini est négatif.

Suivi des Essais

Le suivi sur une année met en évidence que le témoin naturel et le nectar enzymé ont la même évolution tant au niveau physico-chimique qu'organoleptique.

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DEFOLIATION MANAGEMENT EFFECTS ON TROPICAL GRASS-LEGUME YIELD, QUALITY AND PERSISTENCE. I. LOW RAINFALL SITE.

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ABSTRACT

The effect of mob-grazing interval (35, 70, 105 and 140 d) on forage dry matter yield, crude protein concentration, in vitro organic matter disappearance (IVOMD) and persistence of grass-legume mixtures was studied on a private ranch located on a leeward site (<900 mm annual rainfall) on St. Croix. Seasonal forage dry matter (DM) yield (7.6 Mg ha^{-1}) was not affected (P>0.05) by grazing interval because of drought towards the end of the season. Crude protein (CP) concentration in both legume (145-240) and grass (50-124) declined quadratically with increasing grazing interval. Although IVOMD of forage also generally declined (P<0.05) with increasing grazing interval, differences in varietal response were observed. The decline in IVOMD with forage maturity for desmanthus (*Desmanthus virgatus)* and glycine (*Neonotonia wightii*) occurred in a quadratic manner whereas the decline for leucaena (*Leucaena leucocephala)* and teramnus (*Teramnus labialis)* was linear. 'Bisset' creeping bluegrass (*Bothriochloa pertusa)* retained a higher IVOMD with increasing grazing interval than the guinea grass (*Panicum maximum).* 'Bambatsi' panicum (*Panicum coloratum* var. Makarikariense) and leucaena were more persistent at the 70-105 grazing interval than the other forages at this dry site.

INTRODUCTION

The livestock industry in the Caribbean Basin is largely supported by poorly managed guinea grass pastures which, during recurrent dry season, provide forage that is deficient in both quantity and quality, resulting in reduced animal performance. There is a need to develop cost-effective supplemental forage feeding systems. This report is part of a larger study covering three contrasting sites on St. Croix separated along a rainfall gradient. On St. Croix in the US Virgin Islands, the southeast and southwest coastal areas (leeward) are driest sections experiencing less than 900 mm annual rainfall. The northwest (windward) is the wettest area receiving more than 1250 mm rainfall. Rainfall also varies during the course of the year. The wettest months are September to December and the driest months are January to April. A minor peak in rainfall may occur in May although this has been absent the last few years.

Appropriate forage grass-legume germplasm along with grazing defoliation management systems needed for sustained productive use must be developed for specific rainfall sites. The objective of this study was to evaluate the effect of mob-grazing frequency on performance of several tropical grass-legume mixtures in the Virgin Islands.

MATERIALS AND METHODS

This portion of the study was conducted on Castle Nugent farm, a Senepol cattle breeding operation, located on 830 ha. of brush on the dry east end of St. Croix. Annual rainfall was less than 900 mm and the soil was a mildly alkaline (pH>7.8) Fredensborg clay (fine carbonatic, isothermic, Typic Rendoll Mollisols). The experiment was a split-plot, randomized complete block design with two replicates. Main plots consisted of four grazing intervals (35, 70, 105 and 140 d) and subplots consisted of 10 forage types. The forage types were 1) pure guinea grass control, 2) guinea grass + desmanthus var. CPI 92802, 3) guinea grass + glycine var. CPI 52614, 4)

Bambatsi + desmanthus, 5) Bambatsi + glycine, 6) Bisset + desmanthus, 7) Bisset + glycine, 8) leucaena + teramnus, 9) pure desmanthus, and 10) pure glycine. Forages were established from seed during the raining season of November, 1996. Seed was broadcast with a manual cyclone seeder onto a prepared seed bed and lightly raked into the soil.

Guinea grass was seeded at 10 kg ha^{-1}, and all remaining forages at 5 kg ha^{-1}. Seed for grass-legume systems were hand mixed, together with the appropriate legume inoculant, just prior to broadcast. Annual fertilization rates for the pure guinea grass and grass-legume mixtures were 100-30-60 N-P-K and 0-30-60 N-P-K kg ha^{-1}, respeetively. The N for the pure guinea grass was split in two applications (December 1996 and July 1997).

Each forage type plot was 4.6 x 4.6 m with a 0.6 m-wide perimeter border kept free of vegetation during establishment by regular close mowing and rototilling. Each of the two main plot replicates consisted of four 0.03 ha paddoeks eaeh eontaining established plots of all 10 forage types. Grazing interval treatments were randomly assigned to paddoeks in duplicates. Paddocks were rotationally grazed at the prescribed interval to approximately 15-cm stubble from late July 1997 to May 1997. At each grazing, 30 steers /$acre^{-1}$ were allowed to consume forage within a 1- to 2-d period (mob-grazing). The animals were then removed and grass was allowed to regrow.

Pregrazed forage for each forage type within a paddock was sampled from a 0.61 x 1.52 m strip to a stubble of 15 cm for the *Panicum, Desmanthus* and *Leucaena* spp. and 10 cm for the other forage species. Sub-samples of harvested forage were weighed and separated into grass and legume components before drying at 60 °C to constant weight for percentage DM determination. Postgrazed forage was mowed to a 15-cm stubble after each grazing episode to remove residue and reduee contamination of the next pregrazed forage harvest.

Dried pregrazed sub-samples were ground and analyzed for CP (Gallaher et al. 1975, Hambleton 1977) and IVOMD (Moore and Mott 1972). Combined (grass + legume) yield data and component grass and legume CP and IVOMD data were subjected to statistical analyses of variance (SAS Institute Inc. 1987). For significant treatment effeets, forage type means were separated by Duncan's Multiple range test and grazing interval by the least significant difference method.

RESULTS AND DISCUSSION

Herbage mass of the initial 8-month establishment growth ranged from 3.7 to 7.9 Mg ha^{-1} depending on forage type ($P<0.0001$). The initial yield was greatest for forage types based on *Panicum* species (guinea/grass and Bambatsi) and lowest for pure legumes (Table 1). After the imposition of grazing in July 1996, pregrazed forage yield of the aftermath was also greatest from *Panicum*-based forage systems (Table 1). Panicums are naturalized in most Caribbean Islands and exhibit prolific regrowth at the onset of the growing season, especially under a rotational grazing management system. The gross seasonal pregrazed DM yield ranged from 9 Mg ha^{-1} for the pure legumes to 17 Mg ha^{-1} for guinea grass-desmanthus mixture (Table 1).

The initial herbage mass prior to the imposition of grazing was similar across paddoeks (4.2 to 5.5 Mg ha^{-1}, Table 2). This was indicative of uniformity of forage establishment. After the initiation of grazing, aftermath pregrazed forage yields were also independent of grazing interval (Table 2). The lack of aftermath forage yield response to grazing interval was mainly due to the occurrence of drought spells towards the end of the season which had a more negative impact on the 105 and 140 d treatments.

Glycine and desmanthus were similar in CP concentration (170 g kg^{-1}). Crude protein concentration in pregrazed legume component declined linearly from 240 to 145 g kg^{-1} with increasing grazing interval (Table 3). Mean CP concentration in pre-grazed grass forage was not affected ($P>0.05$) by forage type despite a trend towards a lower CP coneentration in guinea grass-based systems (Table 4). Generally, grass CP concentrations depend on the level of N fertilization. Pure guinea grass plots received 100 kg N ha^{-1}, annually, but exhibited no overall improvement in CP concentration over grass forage from grass-legume mixtures. As expected, pregrazed grass

CP concentration declined uniformly in a quadratic manner from 124 to 50 g kg^{-1} with increasing grazing interval (Table 4).

Table 1. The effect of forage type on initial, aftermath and seasonal total pregrazed forage dry matter yields at Castle Nugent Farm.

Forage Type	Initial Mg ha^{-1}	Aftermath Mg ha^{-1}	Total Mg ha^{-1}
Guinea grass	7.9 a*	8.6abc	16.5a
Guinea grass + Desmanthus	6.1 ab	10.7a	16.8a
Guinea grass + Glycine	6.2 ab	7.0bcd	13.2abc
Bambatsi + Desmanthus	6.3 ab	9.6ab	15.9ab
Bambatsi + Glycine	6.1 ab	8.9abc	15.0ab
Bisset + Desmanthus	4.4 bc	7.5bcd	11.9bc
Bisset + Glycine	4.4 bc	7.5bcd	11.9bc
Leucaena + Teramnus	3.5 c	6.8bcd	10.3c
Desmanthus	3.6 c	5.2d	8.8c
Glycine	3.7 c	6.2dc	9.9c

*Values in a column followed by the same letter are not significant at P = 0.05.

Table 2. The interactive effect of harvest date and grazing interval on pregrazed forage dry matter yield at Castle Nugent Farm.

Grazing interval (d) 1-23-97 (Mg ha^{-1})	Initial (7-31-96) 2-27 (Mg ha^{-1})	Aftermath 9-4-96 3-24 (Mg ha^{-1})	Harvest dates 10-10 4-28 (Mg ha^{-1})	Aftermath 11-19 total (Mg ha^{-1})	Gross 12-18 total (Mg ha^{-1})
35	5.50	0.23	2.37	0.71	1.89
1.71	0.76	——	——	7.7	13.2
70	5.86	——	2.67	——	2.80
——	2.97	——	——	8.4	14.3
105	5.06	——	——	2.92	——
——	——	3.36	——	6.3	11.3
140	4.26	——	——	——	5.71
——	——	——	2.22	7.9	12.2
LSD (0.05)	NS	NS	NS		

The combination of leucaena + teramnus had the highest legume CP concentration of 234 g kg^{-1} (Table 3).

The IVOMD of desmanthus was lower than the IVOMD for the other tropical legumes, especially at the early stage of growth (35 d) (Table 5).. From previous studies (Adjei et al. 1993), young desmanthus forage is known to be high in tannin content which becomes diluted with DM as plant matures. The response of pregrazed legume IVOMD to grazing interval was variable among the species. Pregrazed legume IVOMD declined in a linear manner for leucaena + teramnus forage but in a quadratic manner for glycine and desmanthus forage (Table 5). The IVOMD of pregrazed grass forage was similar for the forage types at the early stage of growth (35 d) but differences among grasses became pronounced with increasing grazing interval. Differences in grass IVOMD response to advancing maturity is reflective of variable lignification rates among the grasses. Bisset creeping bluegrass, was the least fibrous among the grasses and retained the highest pregrazed forage IVOMD with increasing grazing interval (Table 6).

Table 3. The effect of forage type and grazing interval on pregrazed legume crude protein concentration at Castle Nugent Farm.

Forage Type	Grazing interval (d)				
	35 g kg^{-1}	70 g kg^{-1}	105 g kg^{-1}	140 g kg^{-1}	Mean g kg^{-1}
Guinea grass	—	—	—	—	—
Guinea grass + Desmanthus	—	—	—	—	—
Guinea grass + Glycine	—	—	155	146	151 c*
Bambatsi + Desmanthus	280	181	142	129	183 b
Bambatsi + Glycine	193	183	165	160	175 b
Bisset + Desmanthus	239	193	150	136	179 b
Bisset + Glycine	—	179	159	137	158 bc
Leucaena + Teramnus	307	257	185	186	234 a
Desmanthus	215	175	158	139	172 b
Glycine	200	175	157	126	165 b
Mean	239	192	159	145	

LSD (0.05) for Grazing Interval Means: 16

* Means of forage type followed by the same letter are not different at P = 0.05.

Table 4. The effect of forage type and grazing interval on pregrazed grass crude protein concentration at Castle Nugent Farm.

Forage Type	Grazing interval (d)				
	35 g kg^{-1}	70 g kg^{-1}	105 g kg^{-1}	140 g kg^{-1}	Mean g kg^{-1}
Guinea grass	110	82	55	49	76 a*
Guinea grass + Desmanthus	120	80	51	39	74 a
Guinea grass + Glycine	125	88	43	27	71 a
Bambatsi + Desmanthus	136	99	88	38	90 a
Bambatsi + Glycine	128	110	63	45	87 a
Bisset + Desmanthus	122	100	83	75	95 a
Bisset + Glycine	113	116	67	74	93 a
Leucaena + Teramnus	—	—	—	—	—
Desmanthus	—	—	—	—	—
Glycine	—	—	—	—	—
Mean	124	96	64	50	

LSD (0.05) for Grazing Interval Means: 31

* Means of forage type followed by the same letter are not different at P = 0.05.

Table 5. The interactive effect of forage type and grazing interval on in vitro organic matter disappearance of pregrazed legume component at Castle Nugent Farm.

Forage Type	Grazing interval (d)				
	35 g kg^{-1}	70 g kg^{-1}	105 g kg^{-1}	140 g kg^{-1}	Mean g kg^{-1}
Guinea grass	—	—	—	—	—
Guinea grass + Desmanthus	—	—	—	—	—
Guinea grass + Glycine	—	—	638 c*	631 a	635
Bambatsi + Desmanthus	477 b	580 b	516 c	431 c	501
Bambatsi + Glycine	—	712 ab	670 bc	620 a	667
Bisset + Desmanthus	—	750 ab	610 c	436 c	599
Bisset + Glycine	—	908 a	814 ab	599 a	774
Leucaena + Teramnus	698 a	687 ab	622 c	508 b	629
Desmanthus	441 b	759 ab	578 c	430 c	552
Glycine	586 ab	891 a	841 a	603 a	730
Mean	551	755	661	532	

* Means of forage type within each grazing interval followed by the same latter are not different at P=0.05. Forage type x grazing interval interaction P<0.05.

Table 6. The interactive effect of forage type and grazing interval on in vitro organic matter disappearance of pregrazed grass component at Castle Nugent Farm.

Forage Type	Grazing interval (d)				
	35 g kg^{-1}	70 g kg^{-1}	105 g kg^{-1}	140 g kg^{-1}	Mean g kg^{-1}
Guinea grass	600 a*	654 b	630 b	484 b	585
Guinea grass + Desmanthus	661 a	662 b	548 b	552 ab	606
Guinea grass + Glycine	614 a	685 b	591 b	531 ab	605
Bambatsi + Desmanthus	628 a	656 b	577 b	540 ab	600
Bambatsi + Glycine	601 a	673 b	664 ab	494 b	608
Bisset + Desmanthus	634 a	831 a	737 a	566 a	692
Bisset + Glycine	635 a	855 a	741 a	586 a	709
Leucaena + Teramnus	——	——	——	——	——
Desmanthus	——	——	——	——	——
Glycine	——	——	——	——	——
Mean	627	717	637	536	

* Means of forage type within each grazing interval followed by the same latter are not different at P=0.05. Forage type x grazing interval interaction P<0.05.

Visual assessment of forage stands after a year of rotational grazing (data not included) suggested a greater persistence of Bambatsi and leucaena entries.

CONCLUSIONS

At a dry leeward site in the Caribbean Basin, seasonal pregrazed forage DM production, without N application, was more than 15 Mg ha^{-1} for *Panicum*-legume mixtures under a rotational grazing management system. When grazed at 70 to 105 d intervals, the range in CP concentration in legume and grass components were 159-192 and 64-96 g kg^{-1}, respectively. Corresponding ranges in IVOMD were 661-755 for the legume and 637-717 for the grass components. Potential exists for selecting appropriate tropical grass-legume mixtures for specific sites to boost livestock production in the region. Bambatsi could become an alternative to guinea grass pasture since it seems to be more persistent on a dry site.

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STRATEGIES TO ENHANCE BROILER MEAT PRODUCTION DURING SUMMER HEAT STRESS

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ABSTRACT

Broiler meat is generally considered to be an economical source of meat protein for the average consumer in many areas of the world. In order for this product to maintain its competitive edge, production volume and efficiency of production in less developed countries must be improved. One factor which generally disrupts production in certain geographical areas is heat stress. The adverse effect of heat stress on production is primarily due to decreased weight gain and increased mortality. This paper reviews four studies conducted to assess the effects of high environmental temperature on broiler growth and meat yield as well as to evaluate the impact of dietary mineral additives on performance. In the first experiment, commercial broilers were reared from 22 to 49 days of age at either 23.9 constant temperature (thermoneutral, TN) or 23.9°C to 35 °C cycling high temperature (heat stress, HS). Birds grown in the HS environment weighed 21% less ($P < .05$) than those raised under TN conditions. Whole carcass weight and carcass part weight from TN birds were greater than from HS birds. In the second experiment, birds reared under HS received potassium chloride (KCl) in the drinking water either continuously; during the hot portion of the daily heat cycle only, or were not allowed to consume KCl. Birds receiving KCl continuously gained 7% more weight ($P < .05$) than the untreated controls. In the third experiment, HS broilers were provided either no water additive, KCl, or sodium chloride (NaCl) in the drinking water. Administration of NaCl resulted in increased gain ($P < .05$) relative to controls receiving no electrolytes. In the fourth experiment, the relative biological availabilities of manganese from Mn proteinate, $MnSO_4$ and No were compared under TN and HS growth environments. Based on ratios of slopes from multiple regression analysis of bone Noon Nointake from different sources, the biological availabilities of NoProteinate and No relative to $MnSO_4$ (100%) were 125 and 83% respectively in TN birds and 145 and 82% respectively in HS birds.

INTRODUCTION

Economic losses associated with the detrimental effects of heat stress on poultry production are at times substantial. Producers and consumers are affected similarly in that the return on investment for the producer is severely curtailed while the consumer is faced with elevated prices. Typically, there is an decline of 3-4% in average live weight of broilers between March and August if summers are hot. The adverse effects of heat on bird weights is partly due to the fact that broilers exposed to high growing temperatures reduce their feed consumption (Smith and Teeter, 1993) which may result in nutrient deficiencies. These problems are economically significant and geographically widespread. Tropical countries with near constant high environmental temperatures are particularly vulnerable, thus there is a need for solutions that hinge on easily implemented techniques.

Maximal growth rate of poultry is influenced by several factors. Ambient temperature, relatively humidity, light duration and intensity, air movement as well as population density have all been cited as environmental factors having a major impact on production (National Research Council 1981). It may be justifiably argued, that among these factors, heat has the single most detrimental effect on growth and performance. Domestic birds, like all homothermous, maintain a relatively constant body temperature through physiological responses that equilibrate heat gain and heat loss. In growing poultry, heat is generated from basal metabolism and cellular metabolism for growth. Metabolic heat, combined with heat absorbed from the micro-environment constitutes the total heat load experienced by the bird. With an increase in ambient temperature above the zone of thermoneutrality (21 - 26°C), birds have great difficulty in removing body heat they generate or absorb from the environment (Smith and Oliver, 1971). This inability to dissipate heat in a high environmental temperature -

relative humidity situation results in heat prostration (Reece et.al. 1972).

Minerals play very important roles in growth and maintenance of tissues. However, the amount of research conducted concerning some trace minerals have been minimal. Minerals that are generally adequate or only slightly deficient in practical diets, have traditionally been overlooked. Requirements of some of these minerals may vary because of the biological availability in practical diets. Early studies demonstrated the necessity of including potassium and sodium in the diets of chicks (Ben Dor, 1941; Gillis, 1948; Burns et.al., 1953). Addition of sodium and potassium salts are of value as electrolytes for the metabolic system of the bird.
The studies reviewed were conducted to assess the effects of high environmental temperature on broiler growth and meat yield as well as to evaluate the impact of dietary mineral additives on performance.

MATERIALS AND METHODS

One thousand and eight commercial broilers were used in four experiments. Newly hatched chicks were reared on deep litter for 21 days posthatching. During this time chicks were brooded at 33.3°C for the first 7 days with the brooding temperature reduced 2.8°C/week to 23.9C. Incandescent light supplemented natural daylight to provide 23 hours light: 1 hour dark.. Chicks were fed a corn-soybean meal-based mash diet (Table 1) and provided with water for ad libitum consumption.

Experiment 1

On day 22, chicks were randomly allocated to 240 individual 60 x 40 x 45 cm wire cages within two environmental chambers with controlled temperature and humidity. Cages in each chamber were fitted with feed and water-dispensing equipment that facilitated monitoring individual consumption patterns. Birds were allowed to adapt to chamber surroundings while peak ambient temperature was gradually increased in the heat stress chamber (HS) to 35C. Birds were exposed to 8 hours of 23.9 C, 4 hours of 23.9 to 35C, 4 hours of 35C and 8 hours of 35 to 23.9 C over each 24 hour period. The temperature in the thermoneutral chamber (TN) was maintained at 23.9°C over each 24-hour period.

Following a 12-hour period during which feed was removed but water continued to be available, 36 birds from each environment were randomly selected and processed. Each bird was hung on rail, stunned with an electrical knife and killed by severing the jugular vein. Birds were scalded, feathers removed and carcasses manually eviscerated. Carcasses were chilled, weighed, and cut up into various market portions. Each part was weighed to the nearest gram and recorded. Data from these measurements were used to calculate the percentage of each part relative to carcass weight and this percentage designated as yield .

Data were subjected to analysis of variance using the General Linear Models procedure of SAS7 software (SAS Institute, 1987) with the error term being birds within treatment. Least square treatment means were compared if a significant F statistic (5% level of probability) was detected by analysis of variance (Steel and Torrie, 1960).

Experiment 2

On day 22 following an overnight fast, 288 chicks were placed in grower batteries within the heat stress chamber and the chamber allowed to cycle as in Experiment 1. Birds were assigned to treatments as follows: No water additive (control); .48% potassium chloride (KCl) continuously in the drinking water; and .48% KCl in the drinking water only during the hot portion of the daily 24-hour cycle. On day 49 feed and water intake along with body weighed gain were calculated.

Experiment 3

On day 22, chicks were randomly allocated to the heat stress chamber as in Experiment 1. There were three treatment groups; no water additive (control) .48% KCl in the drinking water and .376% sodium chloride

(NaCl) to provide an equimolar amount of chloride as the .48% KCl.

Experiment 4

Five replicate groups of six chicks each were randomly assigned to 10 dietary treatments. The basal diet contained 26 ppm Mn on a dry matter basis. Manganese was supplemented at four levels (0, 1000, 2000 and 3000 ppm) from each of three sources: No, $MnSO_4$ and Mn proteinate. On day 22, one chick from each pen was killed and tibia Mn determined by atomic absorption spectrophotometry. Twelve chicks from each treatment were randomly selected and transferred to individual cages in each of two environmental chambers as in Experiment 1. On day 49, birds were killed and tibia Mn determined. Manganese bioavailabilities were estimated using slope ratio methodology (Finney, 1978) and $MnSO_4$ as the standard. Multiple linear regression equations were calculated by regressing tibia Mn (y) on diet Mn intake (x) from each of the three sources. Regression equations were of the general form: $y = a + b_1x + b_2x + b_3x$, where b1, b2 and b3 are slope estimates for each of the three Mn sources.

RESULTS

The rearing of birds under heat stress conditions resulted in 21% lower weight gain ($P < .05$) than those in the normal growth environment (Table 2). Birds in the TN environment also exhibited greater efficiency ($P < .05$) in the conversion of feed to body weight gain. When processed into meat, the carcass weights of HS birds were 13% lighter ($P < .05$) than TN birds. This difference was also evident in the weights of the cut-up parts. In Experiment 2, HS birds that were supplemented with KCl continuously in the drinking water during the 21 day study gained 7% more weight ($P < .05$) than unsupplemented birds (Table 3). There were no differences in feed consumption, however, birds supplemented with KCl continuously also consumed more water than untreated birds.

Table 1. Composition of experimental diets.

Starter diet Ingredients and composition	Grower diet 0 to 21days %	22 to 49 days %
Ground yellow corn	52.0	58.0
Soybean meal (48% CP)	36.5	32.0
Fatso 8-85[1]	6.0	5.4
Fish meal (Menhaden)	1.5	...
Dicalcium phosphate	1.5	2.38
Limestone	1.1	.9
Vitamin mix[2]	.6	.6
Salt	.4	.4
DL-methionine	.15	.1
Trace mineral mix[3]	.15	.15
Coban[4]	.1	.1
Total	100	100
Nutrient composition		
ME, kcal/kg	3,078	3,089
CP	22.8	20.7
Ether extract	8.2	8.6
Calcium	.95	.91
Total phosphorus	.72	.83
Sodium	.18	.17
Potassium	.28	.29

[1] A blended dried fat product; Morgan Manufacturing Co., Inc., Paris, IL 61944.
[2] Supplied per kilogram of diet; vitamin A, 4,175 IU; cholecalciferol, 750 ICU; choline, 468 mg; pantothenic acid, 7.3 mg; riboflavin 4.78 mg; vitamin B_{12}, .011mg.
[3] Provided per kilogram of diet; Mn, 120 mg; Zn, 80 mg; Fe, 60mg; Cu, 10mg; I, 1 mg.
[4] Elanco Products Co. Indianapolis, IN 46285.

AGF= African goat flock.
Regiatration numbers are abbreviated for privacy

Table 2. Effect of heat stress on broiler performance from 22 - 49 days of age.[1]

Variable	Rearing Temperature	
	23.9C	23.9 - 25 C
Body weight gain (g/day)	61.1[a]	48.4[b]
Gain: feed (g/g)	.45[a]	.40[b]
Water Consumption (ml/day)	214[a]	252[b]
Carcass weight (g)	1371	1199[b]
Breast weight (g)	409[a]	356[b]
Thigh weight (g)	235[a]	210[b]
Drumstick weight (g)	216[a]	192[b]

[1] Smith, 1993.
[ab] Means in rows with no common superscripts differ significantly (P < .05)

Table 3. Feed, gain and water consumption of birds supplemented with KCl in drinking water.[1]

Treatment	Feed/Day (g)	Water/day (ml)	Gain/Day (g)
No additive	103.2	251.6[b]	43.7[b]
KCl continuously	105.3	340.6[a]	46.7[a]
KCL during hot period	105.6	310.9[ab]	44.6[ab]
Pooled SEM[2]	.71	11.5	.29

[1] Smith and Teeter, 1992.
[2] Standard error of the means.
[ab] Means in columns with no common superscripts differ significantly (P < .05).

Table 4. Effects of dietary electrolytes on body weigbt gain, feed and water con-sumption and body temperature of heat stressed broilers from 22 - 49 days of age.[1]

Variable	Treatment		
	Control	NaCl	KCl
Water consumption (ml/day)	231[b]	268[a]	283[a]
Body temperature (° C)	42.6	42.5	42.5
Body Weight gain (g/day)	52.3[b]	53.0[ab]	52.6[a]
Feed consumption (g/day)	132	127	136

[1] Smith, 1994.
[ab] Means in rows with no common superscripts differ significantly (P < .05).

Heat stressed birds receiving either KCl or NaCl in the drinking water (Experiment 3) consumed more (P <.001) water than unsupplemented birds (Table 4) but with no effect on body temperature. The NaCl treated birds gained more weight than unsupplemented controls but similar to birds supplemented with KCl. Feed consumption was unaffected by treatment regimen.

In Experiment 4, analysis of the tibia to determine Mn content (Table 5) indicated that Mn concentrations increased linearly in response to Mn intake. The relative biological availabilities of Mn for birds housed in the TN environment were 83 and 125% for No and Noproteinate respectively, where $MnSO_4$ was fixed at 100%. In the HS environment, the corresponding values were 82 and 145%.

Table 5. Bone manganese concentration and relative biological availabilities of manganese from different sources.[1]

Supplemental Mn Source	Supplemental Mn level (mg/Kg)	Enviroment: Thermoneutral [2] Mn Intake (g)	Thermoneutral [2] Bone Mn (m g/Kg)	Heat stress[3] Mn Intake (g)	Heat stress[3] Bone Mn (m/Kg)
	0	.1	9.4	.1	.91
	1,000	3.6	24.4	3.3	23.6
$MnSO_4$	2,000	5.9	38.7	5.2	35.4
	3,000	8.9	46.6	7.5	48.9
	1,000	3.4	19.6	2.4	24.0
MnO	2,000	5.9	29.5	6.1	35.7
	3,000	11.0	51.4	8.2	42.7
	1,000	4.6	24.6	3.2	27.7
Mn Proteinate	2,000	6.8	40.0	6.2	48.4
	3,000	7.9	61.1	7.2	63.9
		Biological Availabilities [4]			
MnO			83		82
Mn Proteinate			125		145

[1] Smith et. al, 1995.
[2] Regression of tibia [Mn] (milligrams per kilogram) on supplemental Mn intake (grams) yielded the regression equation: Tibia Mn=11.7 + 3.94 (± .56) x $MnSO_4$ + 3.3 (± .45) x MnO + 5.0 (± .56) x Mn proteinate (R^2 = .90).
[3] Regression of tibia [Mn] (milligrams per kilogram) on supplemntal Mn intake (grams) yielded the regression equation: Tibia Mn = 11.7 + 4.5 (± .65) x $MnSO_4$ + 3.7 (± .55) x MnO + 6.3 (± .69) x Mn proteinate (R^2 = .89).
[4] Values are percentages relative to $MnSO_4$, which was assumed to be 100% bioavailable. Values are significantly different (P < .05) from 100% with Mn proteinate greater than $MnSO_4.H_2O$ and $MnSO_4H_2O$ greater than MnO.

DISCUSSION

Broiler meat is generally considered to be quite economical as a source of high quality protein. This is of particular importance to populations in developing countries where economics play an intergral part in nutritional adequacy. A disproportionate number of developing countries are subject to year round tropical climate where high environmental temperatures is considered normal. In order for broiler chickens to grow well and meat production enhanced under these conditions, significant management and nutritional modifications must be made.

In the studies reviewed here, heat stress greatly reduced growth rate. Strategies involving nutritional interventions to combat these adverse effects of heat stress were largely successful and centered on the dietary addition of minerals and electrolytes. The addition of KCl and NaCl to the drinking water resulted in increased water consumption and subsequently increased gain. It is speculated that water acts as a heat sink to reduce possible metabolic insularity which could result from extensive heat exposure.

Supplementation of poultry diets with inorganic manganese has been necessary because of the high manganese requirement of chicks as a result of their extremely rapid growth rate (Henry et. al. 1989). Furthermore, feedstuffs most commonly used in poultry diets such as corn and sorghum grains are low in manganese and may actually decrease intestinal uptake of manganese by chicks (Halpin and Baker, 1987) . The accumulation of manganese in the bones of chickens is a good indicator of the biological availability of this mineral. In the study reported here, heat stress increased manganese concentration in the tibia as dietary manganese increased regardless of the source of manganese. The greater biological availability of manganese from manganese proteinate when compared with inorganic sources invited speculation that requirements could be met at lower dietary manganese levels if

manganese proteinate is used as a dietary supplement. The extent to whieh this produet is used will depend on the cost relative to other more traditional sources.

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THE IMPACT OF IMPROVED BREEDS ON GOAT PRODUCTION IN JAMAICA

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ABSTRACT

There is evidence that goats were imported into Jamaica as early as 1894 either from the Canary Island or Africa. There was however, no organized importation until the mid eighteenth century when the Nanny and Rupi goats were imported from Europe and Spain. Thereafter the Angora, Anglo-Nubian, Toggenburg, Saanen, Alpine, LaMancha and Boer have been introduced. The Caribbean Agricultural Research and Development Institute (CARDI) under the European Development Fund (EDF) Technology Transfer and Applied Research Project (TTARP) embarked on a goat development project in 1990. The activities included the introduction of improved genetic material, improved feeding, improved management and husbandry practices. Under the CARDI/EDF TTARP, eight Purebred Anglo-Nubian bucks and 36 does were imported from the UK into Jamaica in 1992. The first organized importation of Boer goats was in December 1996 when 17 and 4 Boer bucks and does respectively were imported from the USA. The present purebred Anglo-Nubian population in Jamaica is approximately 178 (75 bucks and 103 does), while that of purebred Boers is about 159, comprising 95 bucks and 64 does. To date over 10,000 native or graded does have been bred to the improved breeds, producing more than 16,000 crossbred Anglo-Nubian and Boer goats. Reproductive and growth performance of the Anglo-Nubian have been monitored over the past five years while data collection on the same parameters for the Boers commenced a year ago. The influence of the two breeds on the Jamaica goat industry is discussed within the context of socio-economic impact and effect on farm family income.

INTRODUCTION

The goat (*Capra hircus*) is one of the smallest domesticated ruminants which has served mankind earlier and longer than sheep and cattle (Haenlein, 1992). Although they are often kept as supplement animals by small holders, there are more than 460 million goats worldwide, producing more than 6 million tons of milk, meat, cheese, hair and leather. The goat population in Jamaica is estimated to be 450,000 owned by approximately 35,000 farmers (FAO, 1994). Because of their wide adaptability, goats are able to survive under diverse weather conditions and on marginal lands with low quality forages.

The importation of goats to Jamaica is not a new phenomenon as there were indication of importation as early as 1494 when the goat was brought in from the Canary Islands, Africa or Spain (Fielding and Reid, 1994). In the mid eighteenth century, goats referred to as the Nanny goat, the Rupi goat and the Bastard Ibex were imported from Europe and Spain. The first mention of a modern breed was the Angora in 1897 (JAS, 1897) while the presence of the Anglo-Nubian was documented in as early as 1907 followed by the Toggenburg in 1910. The Saanen was introduced from the USA in 1929 but it was not until 1945 the Alpine was introduced. The LaMancha, which never flourish as a breed in Jamaica, was introduced from the United States in 1980. Since the early 1970's there has been limited importation from England, the United States and Canada of mainly Nubian, Alpine, Saanen and Toggenburg.

A survey of the industry in 1991 (Robertson, 1992) indicated that there were several weaknesses in the industry the most glaring ones being; no organized rearing system, small size of the animals, no recording, low producing goats and absence of improved husbandry practices. This was in line with Gatenby, (1982) who stated that the major factors limiting productivity in most countries are poor nutrition and diseases coupled with inappropriate

genetic resources.

In 1992 CARDI using its multi mode dynamic technology generation and transfer to provide goat production technology (Asiedu and Fearon, 1996) imported forty-four purebred Anglo-Nubian goats (8 males and 36 females) from England under the Small Ruminant Sub-Project of the EDF Technology Transfer and Applied Research Project (TTARP). The interest stimulated by the early performance of this breed (Fearon and Asiedu 1996) paved the way for the first organized importation of the Boer towards the end of 1996.

Description of the Nubian: Although there are several instances where Nubians were brought into Jamaica, the earliest of the present breeds of goats were Anglo-Nubians brought in as early as 1907. The Anglo-Nubian was developed in England by crossing British goats with bucks of African and Indian origin. This all-purpose goat is useful for meat, milk and skin production. The Anglo-Nubian breeding season is much longer than that of the Swiss breeds so it is possible to produce milk year round. The Anglo-Nubian is regarded as an "aristocratic" appearing goat and has very long pendulous ears that hang close to the head. They carry a decidedly Roman nose and are always shorthaired. Any solid or parti-coloured coat is permitted in the Anglo-Nubian, but black, red and tan are the most common colours, any of which may be carried on combination with white. A mature doe should stand at least 75 cm at the withers and weigh 60 kg or over, while the males should stand at least 85 cm at the withers and weigh at least 80 kg.

Description of the Boer: This breed is regarded as the key to upgrading rural goats for meat production compared to other goats they are superior meat producers. This is the latest improved breed of goat imported into Jamaica. The Boer is an improved indigenous South African breed with some infusion of European, Angora and Indian goat breeding many years ago.

The name is derived from the Dutch word "Boer" meaning farm and was probably used to distinguish the native goats from the Angora goats which were imported into South Africa during the 19th century. The present day Boer goat appeared in the early 1900's when ranchers in the Eastern Cape Province started selecting for a meat type goat. The Boer goat is primarily a meat goat with several adaptations to the region in which it was developed. The dominant colour is white with red head. It is horned breed with lop ears and showing a variety of colour patterns. Producing weaning rates in excess of 160% the Boer doe is a low maintenance animal that has sufficient milk to rear a kid that is early maturing. The mature Boer buck weighs between 110-135 kg and ewes between 90 and 100 kg. Performance records for this breed indicate exceptional individuals are capable of average daily gains over 200 g/day in feedlot. More standard performance would be 150-170 g/day. The ovulation rate for Boer goats ranges from 1 to 4 eggs/doe with an average of 1.7. A kidding rate of 200% is common for this breed. Puberty is reached early, usually about 6 months for the males and 10-12 months for the females. The Boer goat also has an extended breeding season making possible 3 kidding every 2 years.

While reproductive and growth performances of the goat are the major tools for measuring the impact, the bottom line for any business is the cost of production and subsequently the profit margin. The socioeconomic implications can also be a determining factor for the success or failure of an enterprise. While there are few studies on performance of imported goats in Jamaica their overall impact on the industry is not documented. This paper, therefore, seeks to measure the impact of the Anglo-Nubian and the Boer goat on goat production in Jamaica. The socioeconomic impact and the way forward will also be discussed.

MATERIALS AND METHODS

Location: The study was conducted in the central parishes of St. Catherine, Clarendon, Manchester and St. Elizabeth in Jamaica. Participants included 25 goat farmers and the Bodles and Hounslow Research Stations of the Ministry of Agriculture.

Animals: The goats used in this study were reared under 5 different production systems. The breeds used were Native (less than 50% improved breed), Graded Nubian (at least 50% improved), Purebred Nubian or Boer

goats. The does were mated to Purebred Anglo-Nubian, Purebred Boer or Graded Nubian (more than 75% Nubian) bucks.

Management of Animals: All animals were managed according to prescribed production practices which included Improved forages, improved housing, preventative health management, dehorning and hoof trimming. All animals were subjected to supplemental feed, mainly agro and industrial by-product rations.

Data Collection: Each participant was monitored constantly and records were checked to measure parameters. Informal surveys and personal communications were used to collect marketing and socioeconomic information from farmers, meat shops, supermarkets and other producers. Pre-intervention data collection on the Native commenced in 1992, while information on the Nubian and Boer were captured from 1993 and 1997, respectively. To measure the impact of both breeds, the distribution of all purebred animals was tracked.

Statistical Analysis: The data were subjected to an analysis of variance for a Completely Randomized Design (CRD) using the Genstat Software Package. The major effects included in the analysis were, year and breed or type of animals. Reproductive variables were measured by, litter size, kid mortality, productivity index (PI), birth and weaning weights; while growth performances of the offspring were measured from pre-weaning, and post weaning average daily gains (ADG).

PI = litter size x survival to weaning x weaning weight.

Weaning weight is adjusted to 90 days and disposal weight to 240 days. (Animals would either be sold for meat or incorporated into the breeding herd at 240 days).

Pre-weaning ADG is calculated from birth to 90 days. Post-weaning ADG from 91 – 240 days.

RESULTS AND DISCUSSION

Distribution: The ability of goats to adapt to various eco-zones and production systems is an economically important bearing on producing ability, demand for breeding stock and return on investment, (Casey and Van Niekerk, 1988). It is therefore important to track the distribution of all improved breeds introduced for genetic resources. The purebred Anglo-Nubian population up to March 1998 was approximately 178 (75 bucks and 103 does) (**Figure 1**). The animals were distributed throughout Jamaica with St. Elizabeth, St. Catherine and Clarendon having the bulk of the purebred Nubian. This is mainly due to the Bodles Research Station in St. Catherine, Hounslow Sheep and Goat Station in St. Elizabeth and small enterprise breeders in Clarendon. The imported Boer distribution, shown in **Figure 2.** indicated that the majority of these animals are found in St. Thomas, St. Catherine and Clarendon; with the headquarters of the Jamaica Boer Goat Association located in St. Thomas. Based on the doe population of 10,000 on farms where imported bucks have been distributed, and an average litter size of 1.65 kids per doe, it was estimated that there are over 16,000 crossbred Anglo-Nubian and Boer goats in Jamaica.

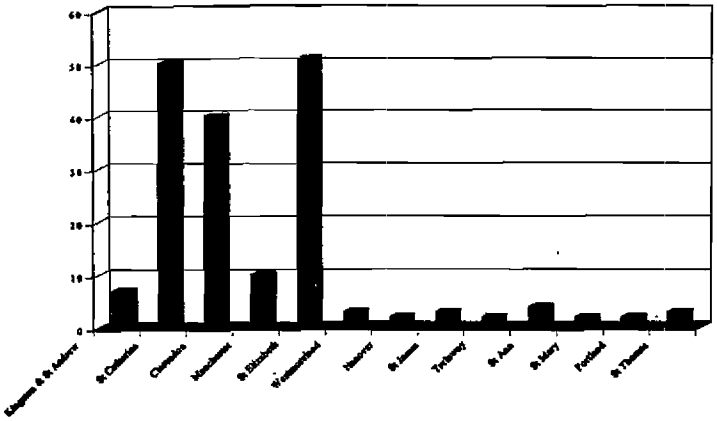

Figure 1: Distribution of purebred Anglo-Nubian in Jamaica

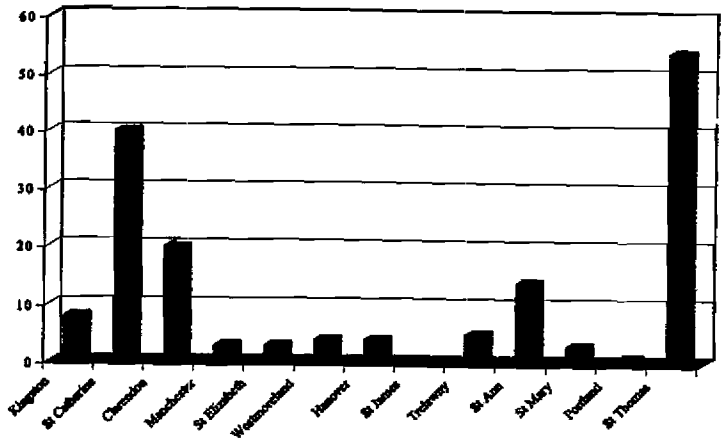

Figure 2: Distribution of purebred Boer goats in Jamaica

Reproductive performance: Kidding rate or prolificacy, defined as the number of kids born per doe kidding is an important contributing factor to reproductive efficiency, (McGowan and Nurse, 1992). High rates of reproduction and low pre-weaning mortality are very important requirements for goats because of their high litter size when compared to other domestic animals (Devandra & Burns, 1983; Shelton, 1978). According to Das, 1992, the productivity index derived from litter size and kid survivability can be used as a selection tool in developing the goat industry. Litter size, pre-weaning mortality and productivity index of the goats are shown in **Table 1.** The data indicated that the Boer and Anglo-Nubian litter sizes of 1.99 and 1.79 respectively, were above the national averages of 1.6 (Muschette et. al, 1989). The litter size of 1.99 for the Boer was significantly higher ($P<0.001$) than all the breeds or types of goats the lowest being the native with 1.43. There was an increase in the litter size of all breed combinations over the Native breed. The kidding rate of the Anglo-Nubian and Boer are comparable with those in studies conducted in Mexico and the United States (Montaldo et. al, 1995; Gipson, 1996). The high ($P<0.001$) pre-weaning mortality (17.16) exhibited by the purebred Anglo-Nubians seems to suggest the long period of adaptation and could be partly attributed to the fact that the imported animals were kidding for the first time. While there were wide ($P<0.001$) variations in the productive index of the breeds studied from a high of 23.85 kg for the Boer to a low of 14.08 kg for the Native goats all the cross showed increases in productivity index. The data presented in **Table 2** shows an improvement in litter size and productivity index from 1992 to 1997, highlighting the contribution of the improved breeds. On the other hand, there was a steady decrease in kid mortality.

Table 1. Litter size, pre-weaning mortality and productivity index of major goat breeds/types in Jamaica.

Breed/Type	Litter Size	Mortality (%)	Productivity Index (kg)
Purebred Nubian	1.79	17.16	22.22
Graded Nubian	1.69	13.8t	19.06
Native Goats	1.43	11.40	14.08
Purebred Boer	1.99	13.66	23.85
Boer x Graded Nubian	1.88	10.79	23.64
Nubian x Local	1.59	11.38	21.61
Boer x Local	1.68	13.81	21.52
Nubian x Boer	1.82	11.30	23.20
Degree of freedom	1208	582	582
S.e.d.[1]	0.80	2.76	1.59

[1]S.e.d. Standard error of difference between means

Table 2. Litter size, pre-weaning mortality and productivity index of major goat breeds/types in Jamaica from 1992 - 1998.

Year	Litter Size	Mortality (%)	Productivity Index (Kg)
1992	1.52	18.68	14.83
1993	1.68	17.41	17.24
1994	1.65	13.13	18.74
1995	1.72	11.89	19.36
1996	1.64	12.95	18.95
1997	1.82	12.05	22.32
1998[1]	1.73	11.37	22.62
Degrees of freedom	1208	582	439
S.e.d.[2]	0.50	1.62	0.92

[1] Data collected to march 1998

[2] S e.d. Standard error of difference between means

Growth Performance: Growth expressed as average daily gain (ADG) can be effectively divided into two periods, growth before weaning and growth after weaning. A high pre-weaning ADG reflects both the genetic potential of the kid and the mothering ability of the doe. Where kids are not sold as weaners, the post-weaning ADG becomes an important production factor. The average birth, weaning and 8-month weights are presented in **Table 3**. Variations exist among the breeds and crosses for all 3 parameters, from the fast growing Boer to the slow growing Native goats. The pattern, however, is the same for birth, weaning and 8-month weights with the Boer highest ($P<0.001$) at 3.34, 18.37 and 37.61 kg and the Native the lowest at 2.20, 11.54 and 23.17 kg for birth, weaning and 8-months weights respectively.

Table 3. Birth, weaning and 8-month weights of major goat breeds/types in Jamaica.

Breed/Type	Birth Weight (kg)	Weaning Weight (kg)	8-Month Weight(kg)
Purebred Nubian	3.26	16.85	32.95
Graded Nubian	2.79	14.58	28.81
Native Goats	2.20	11.54	23.17
Purebred Boer	3.34	18.41	37.61
Boer x Graded Nubian	3.24	18.37	37.03
Nubian x Local	2.43	12.47	25.47
Boer x Local	2.81	13.21	30.12
Nubian x Boer	3.47	20.71	30.37
Degrees of Freedom	1203	1058	596
S.e.d.[1]	0.18	1.04	1.57

[1] S.e.d. Standard error of difference between means

The data in **Table 4** shows an increase in growth parameters from 2.35, 11.08 and 21.21kg in 1992 to 3.09, 17.07 and 33.88kg in 1988 for birth weight, weaning, and 8-month weights respectively. The pre-weaning ADG of the Boers (191gm/day) Shown in **Table 5** are consistent with those in the United States (Gipson, 1996), while the Nubians were higher (151gm/day vs. 115gm/day). The Native goats again recorded the lowest pre and post-weaning ADG. The data in **Table 6** demonstrates a steady increase in pre-weaning and post-weaning ADG from 96.78 and 75.72gm/day to 155.62 and to 120.50gm/day from 1992 to 1998 respectively. This is an indication that as the influence of the Anglo-Nubian and Boer becomes entrenched, the growth performance increased gradually.

The Market: While the status of goat production is on the improve (Fearon and Asiedu, 1996) the marketing is rather haphazard with substantive variations in the availability of animals, slaughter facilities, carcass characteristics and standard processing techniques. According to Pinkerton et. al., (1993), rationalization of production and marketing of slaughter goats seem essential if future demands is to be met without destructive price rises and equitable returns. The changes in prices presented in **Table 7** indicated that there was a 264% increase in the price of meat from US$1.25 and 3.15 to US$3.30 and 8.33 for live weight and dress weight respectively, from 1992 to 1998. The change in the costs of breeding stock is even more dramatic with over 500 % increase in prices. This high increase, however, may be attributed to the introduction of the Boer genetics, which are imported at high costs.

Farm Family Income: If goat production is to flourish as an industry, it must be sustainable and profitable. The assets, expenditures, income and profit margin are presented in **Figure 3**. The information is indicating that the farmers have increased their asset base substantially mainly, due to the improved breeds of animals they possess. While farmers are spending more over the years on production, their profit margin at worst remain constant.

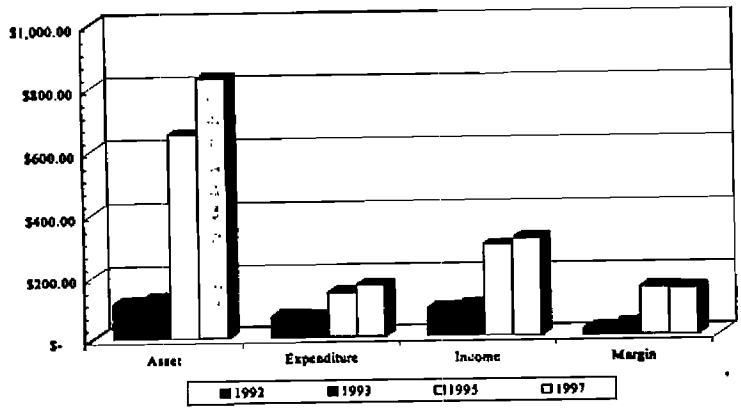

Figure 3: Asset, expenditure, income and profit margin of selected goat farmers in Jamaica.

Socioeconomic Impact: The income generating potential of the improved breeds will contribute to an improvement in the farm family income since large-scale goat production can now be a reality. Where goat production was practiced as a hobby the operations are now trending towards businesses. The nature of the animals enables the entire family to participate in the production and management aspects. The successful goat industry will always have spin-off effect on the community at large as seen in the fact that four feed companies in Jamaica are now for the fist time producing formulated supplements for goats. In an effort to structure the industry the Goat Breeders Society of Jamaica (GBSJ) was established in 1997 with over 200 members. One way to validate production is to display ones work to the public and this was evident in livestock shows where the improved goats and their crosses dominate the exhibits. All the above activities are conducive to the creation of jobs.

Table 4. Birth, weaning and 8-month weights of major goat breeds/types in Jamaica from 1992-1998.

Year	Birth Weight (kg)	Weaning Weight (kg)	8-MonthWeight (kg)
1992	2.35	11.08	21.21
1993	2.57	12.49	25.26
1994	2.64	12.79	26.64
1995	2.80	12.99	26.80
1996	2.89	13.17	28.17
1997	2.93	16.93	31.67
1998[1]	3.09	17.07	33.88
Degrees of freedom	1204	579	579
S.e.d.[2]	0.08	0.42	0.66

[1] Data collected to march 1998

[2] S.e.d. Standard error of difference between means

Table 5. Pre-weaning and post-weaning average daily gains of major goat breeds/types in Jamaica.

Breed/Type	Pre-weaning ADG[1] (gms/day)	Post-weaning ADG[2] (gms/day)
Purebred Nubian	151.00	108.16
Graded Nubian	130.54	97.93
Native Goats	104.66	83.22
Purebred Boer	167.26	135.52
Boer x Graded Nubian	168.01	123.96
Nubian x Local	111.55	86.34
Boer x Local	115.57	111.73
Nubian x Boer	191.62	103.44
Degrees of freedom	1058	582
S.e.d.[3]	11.02	9.35

[1]*Pre-weaned ADG, Birth to 90 days*

[2]Post-weaning ADG, 91-240 days

[3] S.e.d. Standard error of difference between means

Table 6. Pre-weaning and post-weaning average daily gains of major goat breeds/types in Jamaica from 1992-1998.

Year	Pre-weaning ADG (gms/day)	Post-weaning ADG (gms/day)
1992	96.78	75.72
1993	110.09	87.04
1994	112.81	88.09
1995	113.15	91.74
1996	113.85	99.93
1997	155.04	101.06
1998[1]	155.62	120.50
Degrees of freedom	1058	582
S.e.d.[2]	4.40	3.91

[1] Data collected to march 1998 [2] S.e.d. Standard error of difference between means

Table 7. Changes in cost for meat and breeding stock from 1992-1998 Year.

Year	Average Price (US$)			
	Meat (price/Kg)		Breeding Stock (price/head)	
	Live Weight	Dress Weight	Does	Bucks
1992	1.25	3.15	43.00	72
1993	1.55	3.80	58.00	86.63
1994	2.35	4.70	75.75	108.75
1995	2.92	5.42	93.75	148.50
1996	3.19	6.33	108.75	195.00
1997	3.30	8.25	130.00	216.5
1998	3.30	8.33	222.00	420
%Increase	264.00	264.00	516.00	580.00

CONCLUSION

The result from the study suggests that the improved breeds of goats have high productive capacity with opportunities to exploit their potential to improve the productivity of the Native goat. The increased activity on goat production and on marketing over the past five years is steering the enterprise into a self-sustaining one. The introduction of the Anglo-Nubian and more recently, the Boer has changed the economic outlook of the goat industry stimulating the participation of other agencies. While there are structured production practices, the market is undefined and haphazard.

RECOMMENDATION

The present system of marketing is haphazard, therefore, there is the need for the development of structured marketing system that will take into consideration the development of local standards for meat and breeding stock. The farm level record keeping system for individual animal is partially in place but there is the need for a national database in order to assess performance, enabling selection and retention of superior genetic resources. The high price of breeding stock is a major concern, so in order to expedite the breed improvement process the possibility of artificial insemination (AI) should be explored not only to lower cost but to capture the dominant traits of elite sires to improve or standardize production. In order to maximize profits more attention must be paid to the value added products of the industry. A few that comes to mind is the promotion of goat milk and cheese as a health therapy, leather craft for the craft market and the use of manure for vegetable production.

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LAYING THE FOUNDATION FOR GENETIC IMPROVEMENT OF THE JAMAICAN GOAT: SELECTION AND PERFORMANCE OF IMPORTED BOER GOAT SEED STOCK

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ABSTRACT

Consumers are demanding high quality leaner meat at lower prices. Demand for meat that is tender, low in fat, and low in cholesterol is forcing livestock producers to look to genetics for the challenge. Over the past five years goat producers throughout the United States have been using the South African Boer goat extensively to improve the meat quality and productivity of the Spanish, Angora, and Tennessee Stiff-legged herds. The Boer goat has adapted very well to a variety of environmental conditions, ranging from hot, dry semi-arid to humid and tropical bush. The Boer goat has the necessary characteristics which include size, uniform carcass, fast growth rates, high reproductive rates and long breeding season. They are good foragers, good milkers, and have excellent mothering ability. A characteristic feature of the Boer goat is a large frame with either solid or red markings or white hair and red markings on the head and neck. Mature animals weigh between 180-280 lbs for males and 110-165 lbs for females.

Cross breeding experiments are being conducted using the Boer, Jamaica Creole, and graded Nubians. There are several critical factors to consider when embarking on a cross breeding program. These include criteria for selecting seed stock for the foundation herd, selecting a herd sire, management, and environmental conditions under which the animals will exist. This study is a summary of the selection, processing, importation, and performance of imported Boer goat seed stock that will form the genetic base for the improvement of the Jamaican goat. Imported Boer goats were evaluated to determine the performance of this animal under Jamaican tropical management conditions.

INTRODUCTION

Goat meat is considered a delicacy and is the most consumed red meat in Jamaica when it is available. The supply of goat meat generated by domestic production has not met the demand by consumers. Seventy-six (76%) percent of goat meat consumed is imported from New Zealand and Australia. The goat industry in Jamaica is still considered to be a small farm enterprise contributing to the livelihood of some 27,000 farmers (Miller et al., 1996).

Despite the large volume of goat producers and a local production of 0.82 million kilograms of goat meat each year Jamaica continues to import over 1.2 million kilograms of goat meat and mutton at an annual cost of JA$22.1 million. According to Miller et al., (1996) a number of constraints has contributed to the slow growth of the industry. These factors include: low productivity of the native goat, lack of improved technical service in the area of health, breeding, nutrition, disease and health problems associated with imported goats, lack of artificial insemination service for goats, and a high incidence of praedial larceny.

The introduction of the Boer goat to Jamaica is of paramount importance in upgrading the local goat population.

Many countries throughout the world have recognized the potential of the Boer goat for its improvement in growth performance, carcass yield, and meat quality in their local goats (Dahl,1995, Newton,1995, Shelton,1990). The objective of this research project is to provide the highest quality Boer goat genetics to the Jamaican Ministry of Agriculture (Bodles Experiment Station) and the Jamaican small stock producers to improve the genetic quality and performance of the Creole and Nubian cross bred Jamaican goats. This study is also designed to evaluate the performance of imported Boer goats and Boer goat semen into Jamaica and to determine the potential for use in crossbreeding programs to improve the native goat productivity.

IMPORTATION OF BOER GOATS

The Route of the Boer Goat from Africa to Jamaica

The eventual landing of the Boer goat genetics in Jamaica in 1996 greeted the industry with great enthusiasm. The initial importation of semen and live animals had their original roots in the form of embryos which were collected in Zimbabwe in 1987. South African Angora goats were the main animals which were collected for embryos. A few South African Boer goats were included in the agreement which was a part of a New Zealand project to bring in new fiber and meat goat genetics. The plan called for all the embryos to be transferred to waiting recipient females which were to be maintained in long term quarantine. Two approved quarantine facilities were able to start the program at that time. One operated by Landcorp, Ltd and the other by Dr. Rob Moodie under the name African Goat Flocks, Ltd. Embryos were transferred and Boer goat kids were born five months later. Boer goats shipped to Canada originated from the same group of embryos through an agreement between Landcorp and Olds University in 1992. All animals born then served as seed stock for prolification of fullblood boer numbers. After five years of quarantine, the original animals born were sacrificed and all tissues inspected and tested for various diseases. Having passed this hurdle, all other animals which were born from these initial animals were then able to be released from quarantine. Thus, in 1993, both Landcorp and African Goat Flocks offered their stock for sale in the United States. This started the large scale importation of Boers into the United States. The Canadian Agricultural Ministry modified and adopted their importation protocol to directly import South African Boer embryos from South Africa. South African Boer goat Genetics were imported from Canada to the United States. After a few years of selection, these genetics found their way into Jamaica by an agreement between Prairie View A&M University and the Jamaican Ministry of Agriculture. The first shipment occurred in November 1996.

Sire and Dam Selecting

Two hundred purebred Boer bucks and one hundred and fifteen purebred Boer does were evaluated on several Texas Goat Ranches to select breeding stock for the Bodles experiment station and the Jamaican goat producers. Fifteen (15) full blooded Boer bucks between the age of 5 and 8 months old were selected, and 4 purebred Boer females between the ages of 4 months to 1 year were the first group selected on the basis of breed type characteristics, structural correctness, volume, capacity, muscelling, breed, sex characteristics, frame size, color markings, size for age, body weight, testicular conformation, soundness in mouth, number of teats (Campbell,1984, Castlebery,1995). Records were examined to determine time and frequency of kidding, number of offsprings born and weaned and growth rate of offspring. After the first shipment forty seven (47) mature bucks and thirty (30) does were selected and shipped into Jamaica. A few purebred animals were shipped in from Canada later.

Health Testing

All animals were selected with evidence of good health, physical soundness, and free from clinical signs of diseases including Caseous lymphadentitis (CL), Caprine Arthritis Encephalitis (CAEV) and Scrapies. Serum samples were then taken from each individual animal and tested for CAEV, *Brucellosis melitensis, Brucelia abortus,* Leptospirosis (PICGH), and Tuberculosis. Goats were vaccinated against haemorrhagic septicemia, *Clostridium septicum, and Clostridium chauvei.* Animals were examined and treated for external parasites and dewormed for internal parasites.

Quarantine and Shipment

All animals selected for export to Jamaica were isolated and grouped according to sex, size, and body weight. They were fed high quality hay and water ad lib. They were observed over a one week period while awaiting final test results. The selected animals were loaded on to a trailer and taken on a two day drive to Florida where they were quarantined at the United States Department of Agriculture Animal and Plant Inspection Service (USDA/APHIS) Miami International Airport. After inspection, the animals were loaded into crates and shipped by air to Jamaica. Immediately after arrival into Jamaica the animals were unloaded watered, fed, and quarantined at the airport facilities for two to three weeks. All animals were inspected by a board certified veterinary officer during the duration of the quarantine.

Acclimatization of animals

Once the animals left the quarantine station at Norman Manley International Airport they were distributed to the research station and to the local farmers. The animals were weighed and fed hay and a local concentrate feed. Table 1. represent the genetic pedigree of fifteen bucks and twelve does imported in late 1996 and early 1997.

Table 1. Pedigree of 5-8 Months of Age Boer Goats Exported to Jamaica.

Parents	Imported Bucks	Parents	Imported does
Sire: K554/93 Dam: 92016 (Minnie Pearl)	305B	Sire:5401 (bubba) Dam: 42034(156/91)	H26
Sire: 58002(Big Mac) Dam: 26000/(64G)	99G	Sire: 42030(G10) Dam: 81087	H20
Sire 53007 (Mustang) Dam: 25133(4488)	55G	Sire: 2440022 (Inglis6) Dam: 086033 (113 one-thurdeen)	H06
Sire 53007 (Mustang) Dam: 26004(54G))	57G	Sire: 43115(Botha Ennoled) Dam: 49008	H190
Sire: 45014 (Jenkins Dam 64039	115GI	Sire: 86013(89 Rambo) Dam: 086017(ww227)	J77
Sire: 243155 (Botha Ennobled) Dam: 249008	H191	Sire: 86013(89Rambo) Dam: 047004Rudy	J107
Sire: 92003 (En Genesis) Dam: 92002 (Capragen 31/93)	H01	Sire: 41021(21) Dam: 41019(92)	279B
Sire:63007 (Mustang) Dam: 26004 (54G)	71G	Sire: 21011 (Jake) Dam: 58012	241B
Sire: 243155 (Botha Ennobled) Dam: 240070	H185	Sire: 86013(89Rambo) Dam: Nubelle	H95
Sire: 8601(w1274 Joe) Dam: 47003	J11	Sire: 49060(AGF 439) Dam: SP9	Sandra 9
Sire: 98304 (Fred) Dam: 34123 (Homelite)	J40	Sire: 49060(AGF 439) Dam: SP10	Sara 10
Sire: 249060 (439) Dam: SP12	Stacy	Sire: 49060(AGF 439) Dam: SP22	Music 22
Sire: 98304 (Fred) Dam: 34119 (Hedda)	J66	Sire: Reg Dam: Reg	H4
Sire: Reg Dam: Reg	J60	Sire: Reg Dam: Reg	H45
Sire: 44022 (Inglis) Dam: 55033 (Myriad)	H86	Sire: Reg Dam: Reg	H49

Table 2. Growth Rate of Imported Purebred Boer Bucks (5-8) months old over a 30 day period December 31, 1996 to January 30, 1997.

Animal ID #	Weight A (lbs)	Weight B (lbs)	Number of days	Growth Rate (lbs)
305	108	122	30	14
099	068	086	30	18
241	090	116	30	26
185	060	076	30	16
190	060	078	30	18
191	068	088	30	20
H26	096	120	30	24
115	078	092	30	14
H20	096	126	30	30
071	072	090	30	18
107	090	108	30	18
999	104	112	30	08
279	090	112	30	22
H01	098	126	30	28

Mean weight A = 84.1 lbs; Mean weight B = 103.7 lbs; Growth rate 19.05 lbs; T prob>.0001

Table 3. Average Weights of Boer Goats in Jamaica 1997.

	Buck	Does
Yearling Boer (age range in age = 8-15 months)	170 n=20	120 n=14
Mature Boer (age range in age = 2-5 years)	260 n=16	170 n=8

Adaptability

Preliminary Data Indicate that the Boer goats adapted well to the tropical climate of Jamaica. They were heat tolerant and appear to be similar with respect to disease resistance of the native goat.

Adaptation was measured by feed consumption, weight gain, and reproduction performance. Yearling imported Boer bucks averaged 19.5 lbs. per month for the first 3 months after arriving on the island (Table 2). They displayed typical breeding behavior, were aggressive and used for breeding to local creole goats. Mature bucks averaged 260 lbs. while the mature does average 170 lbs. Yearling bucks average weight was 170 lbs. and does weighed 120 lbs (Table 3).

Fertility and Reproduction

All Boer bucks were fertile except for one. They were all used to crossbreed the native Jamaican goat and graded Nubian. Conception rate was as high as 95% on some farms. Although the nutritional needs of the Boers vary from farm to farm nutrition did not seem to affect breeding and conception rate. The young females reached puberty at seven (7) months of age and may have bred early during the time of adjustment to the new tropical environment. The average female gave birth to twins.

Nutrition and Growth

The Boers were constantly feeding compared to the native Creole and Nubian goats which account for the increase in weight gain.

CONCLUSION

The Jamaica goat industry is potentially a 50 million Jamaican dollar per year industry, when one consider income for small farm families, impact on the feed industry, supermarket, hotels, and restaurants, the festive demand and home consumption needs for goat meat. The exact dollar amount is difficult to determine because most of the goats are slaughtered in back yards without inspection or documentation. Current agricultural emphasis in developing countries is agricultural diversification, sustainability and the need for healthier meats.

The partnership between Prairie View A&M University, the Jamaica Ministry of Agriculture, and the goat producers have seen significant activities in the importation of Boer seed stock for cross breeding programs. The potential for expanded meat goat production and marketing has never been more favorable in Jamaica. The goat industry over the past two years is the fastest growing agricultural industry. In order to ensure profitability for goat producers on the island and to address the increasing demand for "Chevron or mutton" breeding stock must be subjected to selective pressures to improve genetics and productive traits. In addition to marketing and infrastructure development, emphasis must be placed on genetics, health, nutrition, management and value added products. The importation of over 170 Boers between 1996 and 1997 has provided the country with high quality Boers as foundation stock for genetic improvement of the local goats. The imported Boer goats from Texas has adapted well to the tropical environment as demonstrated by growth, body weight, and reproductive efficiency

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THE IMPACT OF HIGH ENVIRONMENTAL TEMPERATURE ON AFLATOXICOSIS AND THE EFFECTS OF MANNANOLIGOSACCHARIDE (MOS) AS A BINDING AGENT

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ABSTRACT

Aflatoxin continues to be a serious hazard to high quality grains, animal productivity, and health and food security in many countries. Poor growth, feed efficiency, immuno suppression, organ damage, carcinogenicity, and toxin residue in foods are some of the adverse effects of aflatoxicosis. To reduce aflatoxicosis several binding agents have been suggested including sodium bentonites, synthetic zeolite, activated charcoal, H.S.C.A.S. and yeast. MOS is a non-digestible carbohydrate from the extract of yeast and has been very effective as a binding agent for aflatoxin in feeds. The objectives of these studies were to show the; (1) effects of aflatoxin on growth, and feed utilization, (2) relationship between aflatoxicosis and environmental temperature, and (3) effects of non-digestible carbohydrate (MOS) on the reduction of aflatoxicosis. In these separate studies commercial broiler chicks were fed aflatoxin-treated feed to 4 wks of age. In the first and second studies, the effect of aflatoxin on performance was examined under two separate environmental temperatures, 21° and 32 °C. In the third study, the effects of MOS on aflatoxicosis under the two different temperatures were examined. Parameters measured were body weight, feed utilization, mortality and relative organ weights.

Results showed that body weight of broiler chicks at 4 weeks of age was severely suppressed by 59% with the ingestion of 3 ppm of aflatoxin. Feed utilization was also significantly reduced. Among the internal organs examined, the liver, proventriculus, spleen and heart were severely affected by the feeding of aflatoxin. Under different environmental temperatures, the effect of aflatoxicosis was more severe at 32 °C. MOS applied at 2 lbs per ton of feed was extremely effective in reducing aflatoxicosis by 85 percent. Irrespective of the temperature, body weight and feed utilization improved markedly compared to the control with the dietary inclusion of MOS at 2 lbs per ton of feed. In conclusion, MOS has been proven to be an effective binder for aflatoxins.

INTRODUCTION

Aflatoxin which has elicited the greatest public health concern is widespread and found in several feed grains, especially corn, which comprises between 50-60% of many poultry diets (Phillips *et al.*, 1988). Decreased weight gains, poor feed utilization, hemorrhage, anorexia, susceptibility to environmental and microbial stresses and decreased activities of amylase and trypsin (Campbell *et al.*, 1983) are some of its clinical signs (Edds and Bortell, 1983). To control aflatoxicosis in birds cyclopiazonic acid (Doerr *et al.*, 1983) antioxidant (Larsen et al., 1985), ethoxyquin and butylate hydroxytoluene (Ehrich *et al.*, 1986) and hydrated sodium calcium aluminosilicate (Kubena *et al.*, 1990) have been used with limited success. The inclusion of *Saccharomyces cerevisiae (S. cerevisiae)* in the diet at 0.1% of the feed, has been recently shown to be successful in suppressing the severity of aflatoxin (Stanley *et al.*, 1993; Devegowda *et al.*, 1993) in chicks.

The results obtained by Stanley *et al.* (1993) and Devegowda *et al.* (1993) with *S. cerevisiae* in controlling the severity of dietary aflatoxin has promoted the thought that Bio-Mos, a probiotic and cell wall of *S. cerevisiae* could produce similar effects. *S. cerevisiae* has been shown to alter stress in animals by providing a source of vitamins, an unidentified growth factor for reducing stress (Phillips and Von Tungeln, 1984) enzymes (Krause *et al.*, 1989) and crude protein (Crumplen *et al.*, 1989). Therefore, the objective of this study was to examine the effect of Bio-Mos to enhance growth and to suppress the severity of aflatoxicosis in broiler chicks rearing under two separate temperatures.

MATERIALS AND METHODS

Two hundred and forty day-old male unvaccinated broiler chicks of Cornish Rocks strain, were wing-banded, blocked by temperature zones (21 and 32 C), and randomly assigned to 24 pens to measure a 3-way interaction of Bio-Mos, aflatoxin by temperature on the performance of the chicks. The experimental design was a 2 x 2 x 2 factorial arrangement of treatments, consisting of two levels of Bio-Mos, 0 and .05% of the diet, two levels of aflatoxin, 0 and 5 ppm, and 2 rearing temperatures, 21° and 32 °C. Each treatment group was replicated three times and the duration of the experiment was three weeks.

With feed and water made available for *ad libitum* consumption, the chicks were fed a corn-soybean meal basal diet containing 22% CP and 3300 kcal/kg of metabolizable energy (ME) from day-old to 3 wk of age. To satisfy the National Research Council (NRC, 1984) requirements, the experimental diets were supplemented with amino acids, minerals, and vitamins. The Bio-Moss, cell wall and residue of *Saccharomyces cerevisiae (S. cerevisiae)* were supplied by Alltech Laboratory, Lexington, Kentucky, USA, and were applied at 0 and .05% of feed equivalent to the appropriate diets. The Bio-Mos was added to the feed in the mixer as the last step in mixing, as would occur commercially. Before the Bio-Mos was added, aflatoxin was incorporated into the mixed feed. To maintain accurate and safe control the diets containing the various treatments were placed in already labeled plastic bin feed containers with lids and stored in the growing house.

Aflatoxin Production

As described by Shotwell *et al.* (1966) the aflatoxin was produced through the fermentation of rice by *Aspergillus parasiticus* NRRL2999. The fermented rice was steamed and ground to a powder. To determine the aflatoxin purity and content of the toxin, a spectrophotometric analysis as described by Nabney and Nisbitt (1965) and modified by Wiseman *et al.* (1967) was used. The rice powder was then incorporated into corn-soybean meal basal diets to provide the aflatoxin level desired. The rice powder never exceeded 1% of the diet.

Data Collection

The chicks were weighed weekly and their body weight recorded. Mortality was recorded as it occurred to 3 wk of age. At the end of the 3 wk experimental period the chicks were bled by cardiac puncture and killed by cervical dislocation. The liver, pancreas, proventriculus, gizzard, spleen, gall bladder, bursa of Fabricius, and heart, the selected internal organs were removed and weighed, and expressed as relative organ weights (gram of organ per 100 g of body weight). To determine the effects of treatments on total protein, albumin, cholesterol, uric acid, and glucose, as well as the activities of selected enzymes, alanine transaminase, and aspartate aminotransferase, the serum was extracted and analyzed. The serum variables were measured on a clinical chemistry analyzer according to the procedure recommended by the manufacturers.

Statistical Analysis

Data for all variables were subjected to ANOVA using the General Linear Models (GLM) procedure of SAS® software (SAS Institute, 1990). Variable means for treatments showing significant differences in the ANOVA were compared using the Duncan's multiple range tests (Duncan, 1955). A probability level of .05 was applied to all statements of significance.

RESULTS AND DISCUSSION

The effects of temperatures (21 and 32° C), aflatoxin (5 ppm), Bio-Mos (.05%), and their interactions on body weight are presented in Table 1. At the lower temperature (21° C) neither aflatoxin, Bio-Mos nor their combination had any significant effect on body weight from 1 to 2 wk of age. By 3 wk of age there were significant changes, as the mean body weight of the toxin-treated group was 454 g, compared to 609 g for the control. The addition of Bio-Mos to the toxin-treated diet at the lower temperature increased the body weight of chicks from

454 to 472 g at 3 wk of age. At the higher temperature (32°C) the effect of aflatoxin on body weight was significant and was noticeable as early as 1 wk of age, and the effect on body weight continued to 3 wk of age. The addition of Bio-Mos to the toxin-treated diet and fed to chicks at 32° C suppressed aflatoxicosis significantly by increasing body weight of chicks from 392 to 456 g.

Table 1. Interaction of temperature, aflatoxin (AF) and Bio-Mos (BM) on body weight of broiler chicks at 1 to 3 wk of age.

Treatments		Body weights (g)		
AF (ppm)	BM(%)	wk 1	wk 2	wk 3
			21° C	
0	0	143 ± 6.04[a1]	328 ± 10.89[a]	609 ± 13.28[a]
0	.05	146 ±4.49[a]	334 ± 17.74[a]	632 ± 9.99[a]
5	0	142 ± 6.9[a]	264 ± 16.09[b]	454 ± 16.67[b]
5	.05[2]	141 ± 5.68	285 ± 16.09[b]	472 ± 15.96[b]
			32° C	
0	0	154 ± 5.89[a]	361 ± 11.73[b]	679 ± 14.30[a]
0	.05	159 ± 5.87[a]	395 ± 15.34[a]	703 ± 11.80[a]
5	0	129 ± 5.23[b]	239 ± 16.69[c]	392 ± 13.98[c]
5	.05[2]	141 ± 5.68[b]	272 ± 14.01[d]	456 ± 19.19[b2]

[a,b,c]Values within columns with no common superscripts differ significantly (P < .05) accordingly to Duncan's multiple range test.
[1]Values represent the x ± SEM of three groups of ten chicks per treatment less mortality.
[2]Represents significant AF by BM interaction (P < .05).

Feed efficiency was depressed by aflatoxin, while the addition of Bio-Mos to the diet yielded feed efficiency comparable to the control. The combination of Bio-Mos and aflatoxin did not significantly change feed efficiency. Mortality was not a factor, as the few chicks that died, were not confined to any particular treatment (data not shown).

At 21° C the relative weights of the liver, and gizzard increased significantly with the feeding of aflatoxin and the combined treatment of aflatoxin and Bio-Mos. The addition of Bio-Mos reduced the relative weight of the heart only at the high temperature. Compared to the control at 32°C aflatoxin significantly increased relative weight on the heart from .72 to .85 g, and the liver from 2.81 to 5.5 g. When .05% Bio-Mos was added to the aflatoxin-treated diet, chicks reared at 32°C had the relative weight of the liver reduced from 4.5 to 3.68 g; the proventriculus from .82 to .78 g, and the heart from .85 to .75 g (Table 2).

Table 2. Influence of temperature on the effects of aflatoxin (AF) and Bio-Mos (BM) singly and combined on relative weight of liver, proventriculus, gizzard, bursa of Fabricius, and heart[1].

Treatments		Relative organ weights (g/100g BW)				
AF (ppm)	BM (%)	Liver	Proventriculus	Gizzard	bursa of Fabricius	Heart
			21 °C			
0	0	3.38±.18[b]	.69±.02[a]	2.79±.08[b1]	.34±.04[a]	.91±.05[a]
0	.05	3.14±.10[b]	.73±.02[a]	3.08±.4[ab]	.26±.02[ab]	.89±.04[a]
5	0	4.70±.30[a]	.77±.03[a]	3.29±.14[a]	.23±.03[b]	.84±.07[a]
5	0.5[6]	5.16±.29[a]	.75±.07[a]	3.37±.15[a]	.24±.02[b]	.96±.06[a]
			32 °C			
0	0	2.81±.09[c]	.64±.03[b]	2.90±.17[a]	.30±.04[a]	.72±.04[b]
0	.05	2.85±.12[c]	.65±.03[b]	2.97±.16[a]	.30±.04[a]	.69±.04[b]
5	0	4.50±.13[a]	.82±.06[a]	3.25±.21[a]	.28±.03[a]	.85±.05[ab]
5	.05	3.68±.12[b]	.78±.04[a]	3.24±.14[a]	.31±.01[a]	.75±.02[ab]

[a,b,c] Values within columns with no common superscripts differ significantly (P<.05) according to Duncan's multiple range Test.
[1] Values represent the x ± SEM of three groups of ten broiler chicks.
[2] Represents significant AF by BM interaction (P<.05).

Table 3. Relationship between temperature and the effects of aflatoxin (AF) and Bio-Mos (BM) on selected serum chemical values.

AF (ppm)	BM(%)	Treatments - Serum chemical values			
		Cholesterol[2]	Glucose[3]	Total protein[3]	Uric Acid[2]
			21 C		
0	0	137.05±6.72[a]	241.85±23.54[a]	2.96±.20[a]	6.10±.49[a]
0	.05	140.34±6.64[a]	237.04±10.75[a]	2.81±.08[a]	5.50±.34[ab]
5	0	89.80±8.12[b]	144.52±34.78[b]	1.89±.12[b]	5.23±.44[ab]
5	0.5[2]	90.49±9.68[b]	157.21±13.69[a]	1.87±.20[b]	3.89±.87[b]
			32 C		
0	0	121.57±7.91[a]	204.78±15.72[ab]	2.53±.15[a]	4.92±.53[a]
0	.05	122.92±9.74[a]	229.38±11.89[a]	2.77±.13[a]	4.94±.36[a]
5	0	67.72±5.51[b]	258.61±9.52[a]	1.52±.08[b]	5.18±.80[a]
5	.05	67.11±5.13[b]	139.81±8.59[b]	1.49±0.12[b]	5.09±.36[a]

[a,b,c] Values within columns with common superscripts are not significantly different according to Duncan's Multiple Range Test (P<.05).

[1] Values represent the $\bar{x}$ ± SEM of means of ten chick per pen.
[2]Measured in mg/100 mL
[3]Measured in g/100 mL

The relative weight of the bursa of Fabricius decreased significantly only at the lower temperature. The liver was the only organ significantly affected by both treatments at the two temperatures. Table 3 shows that the serum total protein and cholesterol values were significantly lower in the aflatoxin-treated group, while the glucose and uric acid values were elevated. The uric acid value was affected only at 21° C. Bio-Mos applied singly produced no significant changes in serum total protein, glucose, and cholesterol values, irrespective of temperature.

At 21° C the activity of both alanine transaminase and aspartate aminotransferase decreased with the ingestion of aflatoxin and Bio-Mos. However, these enzymes were elevated at 32° C (Table 4). The addition of Bio-Mos to the aflatoxin-contaminated diet increased significantly the activity of alanine transaminase at both temperatures.

Table 4. Effects of aflatoxin (AF) and Bio-Mos (BM) singly and combined on serum concentration of alanine transaminase and aspartate aminotransferase[1].

Treatments		Serum concentration (U/L)[2]	
AF (ppm)	BM (%)	Alanine transaminase 21 °C	Aspartate aminotransferase 21 °C
0	0	30.27±1.10[ab]	185.38±5.42[a]
0	.05	28.82±.99[ab]	172.34±4.55[ab]
5	0	28.00±1.12[b]	166.43±8.99[ab]
5	.05[2]	33.05±1.42[a]	159.36±5.06[b]
		32 °C	32 °C
0	0	24.97±2.50[b]	167.12±3.98[a]
0	.05	31.11±2.17[ab]	186.62±8.82[a]
5	0	35.78±3.96[b]	182.70±12.85[a]
5	.05	29.17±2.50[a]	174.30±5.01[a]

[a,b] Means within columns with no common superscripts differ significantly (P<.05) according to Duncan's multiple range test.
[1] Represents significant AF by BM interaction (P<.05).
[2] International units.

The influence of high and low temperatures on the intensity of effective dietary aflatoxin and the ability of Bio-

Mos to promote growth and suppress aflatoxicosis in broiler chicks provide new information. Bio-Mos is the cell wall and residues in the production of *S. cerevisiae* which was reported by Stanley *et al.* (1993) and then by Devegowda *et al.*, (1993) to suppress aflatoxin in broiler chicks. Being the cell wall of *S. cerevisiae* it was postulated that Bio-Mos could have similar biological properties to *S. cerevisiae* in promoting growth and controlling the effect of aflatoxin. The results demonstrated that Bio-Mos was effective in suppressing aflatoxin. However, the effect of Bio-Mos was more evident at the higher temperature (32°C). Bio-Mos, apparently has the ability like *S. cerevisiae* to produce a wide assortment of biological enzymes to detoxify aflatoxin (Mybodile *et al.*, 1975). Another possibility is that, *S. cerevisiae* suppresses aflatoxicosis by binding the toxin, which is then eliminated from the intestinal tract (Cooney, 1980). Also, it is possible that the nutritional deficiency induced by aflatoxin could have disrupted the activity of the digestive enzymes and the absorption of essential nutrients (Bolden and Jensen, 1985). Bio-Mos like *S. cerevisiae* may have replaced enzymes blocked by toxins, thus resulting in increased feed utilization (Day *et al.*, 1987). The inability of Bio-Mos to raise body weight of chicks fed aflatoxin-treated diet to the levels of the control, as in the *S. cerevisiae* study, could be dose related. The levels of Bio-Mos was .05% while *S. cerevisiae* was fed to .1% of the feed.

Temperature extremes have been reported to decrease body weight and performance of broiler chickens. Temperatures outside the comfort zones of thermoneutrality (below 21° C and above 32° C) reduce the performance of chicks, and even result in mortality. High temperature reduces feed intake while low temperature interferes with the digestive process by accelerating the movement of the ingesta through the gastrointestinal (GI) tract to satisfy high demand for basal metabolic energy, consequently reducing digestion efficiency (Church *et al.*, 1988). The failure of aflatoxin to affect body weight during the first week of growth and the inability of Bio-Mos to suppress aflatoxin at the lower temperature could be due to the rapid movement of the ingesta through the GI tract.

In conclusion, Bio-Mos applied at .05% of the diet promotes growth and suppresses the severity of aflatoxicosis in broiler chicks. Also, the effects of aflatoxin and Bio-Mos, on the performance of broiler chicks are influenced by temperature extremes.

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ADAPTABILITY OF THE ANGLO-NUBIAN GOAT AS MEASURED BY IT'S REPRODUCTIVE PARAMETERS IN A NUCLEUS HERD.

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ABSTRACT

In recent years, the Anglo-Nubian breed of goat has been used extensively in crossbreeding work with the native Jamaican goat for improving the productivity of the native. The purpose of this study is to establish parameters of reproductive performance in the Anglo-Nubian goat in the nucleus herd at the Bodles Research Station. Forty nine (49) purebred Anglo-Nubian does were observed through 136 kiddings between April 1993 and December 1997. The parameters measured include prolificacy, kidding interval, age at first kidding, frequency of multiple births and the relationship between parity and multiple births. The seasonality of kidding was also examined.

The Anglo-Nubian does at Bodles were found to have a prolificacy rate of 1.69 ± 0.67 with a kidding interval of 355 ± 90 days (range of 185 - 688 days) and age at first kidding of 517 ± 164 days. The data shows that the Anglo-Nubian exhibits some seasonality in the pattern of kidding with 91.91 % of does kidding between November and April. This is typical of the temperate breeds, which tend to kid in the cooler and drier months.

INTRODUCTION

In September of 1992, thirty six (36) female and eight (8) male Anglo - Nubian goats ranging from 5 to 6 months old were imported into the island from England, by the Caribbean Agricultural Research and Development Institute (CARDI). This formed the basis of the present Herd Improvement programme in Jamaica. The animals have been housed at the Bodles Agricultural Research Station where their productive parameters are being evaluated. Male offspring from this nucleus herd of purebred Nubians have been disseminated to the farming community as part of the continued attempt to upgrade the "Native" stock.

One of the main indicators of environmental compatibility of a breed is it's level of reproductive performance. Heat stress is one of the adverse conditions that face temperate breeds imported into the tropics. Indeed, under heat stress, domestic animals will experience a reduction in their metabolic rate which results in extended kidding intervals, late maturity, and low milk yield (Devendra, 1970). This study attempts to establish the reproductive parameters of the Anglo-Nubian breed at the Bodles Research Station.

MATERIALS AND METHODS

The study was carried out at the Bodles Agricultural Research Station using data gathered from 49 purebred Anglo - Nubian does over the period April 1993 through December 1997. A total of 136 kiddings were observed during the period. The parameters measured included prolificacy expressed as kids per birth (litter size), kidding interval (period between two consecutive kiddings), age at first kidding, frequency of multiple births, relationship between parity and multiple births, and the pattern of kidding.

The system of husbandry employed in the management of the goats at the station is a semi-intensive one where the goats were allowed to graze pastures in rotation during the day and housed at night where they are given supplementary feed (grain and cut grass/hay). The breeding programme utilized a pen mating system where a buck was walked through the doe pen on a daily basis to deteet heat. Once identified, a particular buck as determined by the breeding programme mated the doe on heat. Accurate records were kept on all matings and subsequent births.

RESULTS AND DISCUSSION

The seasonality of kidding is shown in **Table 1**. When the data for all years are combined it is seen that although the Anglo-Nubian exhibited estrus throughout most months of the year, and kidded in every month except August (**fig. 1**), the pattern suggests an increase in sexual activity beginning in June and peaking in August to November. This is reflected in the high percentage of kiddings in November to December (11.03 %), and January to April (80.88%), with only 5.15% kidding in May to July and 2.94% in September to October (**fig. 2**). The indication that Nubians rarely kid in July and August (0.74%) is supported by work done previously by Muschette and Miller in 1988.

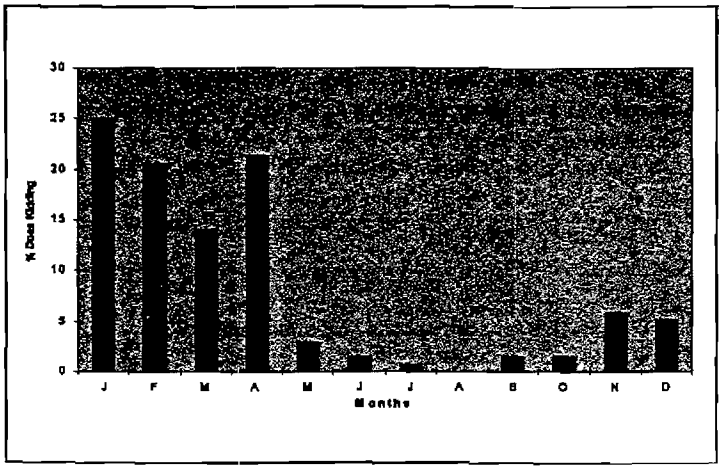

Figure 1: Kidding pattern by months

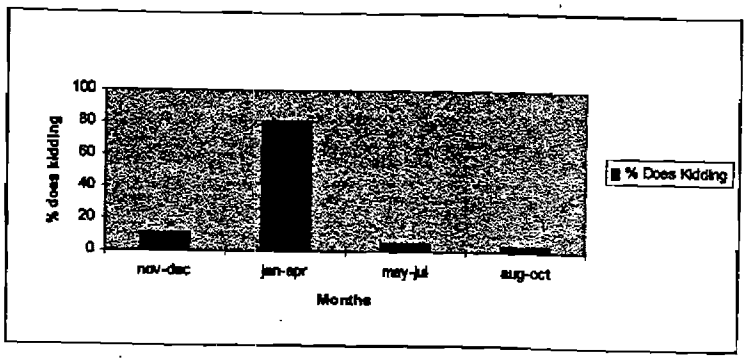

Figure 2: Kidding pattern - Nubians

Prolificacy of does by year of kidding is shown in **Table 2.** In this study prolificacy of the female goat is taken as the number of kids per birth. The mean rate over the 5 year period was found to be 1.69 ± 0.67. This figure indicates that twinning is quite common among the Anglo-Nubian does and compares well with previous work done by Muschette and Miller, 1988, at

Table 1. Seasonality of kidding.

Year	1993		1994		1995		1996		1997		All Years %Does
Month	Does Kidding	Kids born	Does Kidding	Kids born	Does Kidding	Kids born	Does Kidding	Kids born	Does Kidding	Kids born	
Jan.	0	0	9	14	13	22	11	18	1	1	25
Feb.	0	0	8	15	5	10	7	13	8	18	20.59
Mar.	1	1	4	8	3	5	5	6	6	8	13.97
Apr.	21	32	1	1	0	0	2	3	5	11	21.32
May	1	3	0	0	3	3	0	0	0	0	2.94
Jun.	0	0	0	0	0	0	1	1	1	2	1.47
Jul.	0	0	0	0	1	3	0	0	0	0	0.74
Aug.	0	0	0	0	0	0	0	0	0	0	0.00
Sept.	2	4	0	0	0	0	0	0	0	0	1.47
Oct.	2	3	0	0	0	0	0	0	0	0	1.47
Nov.	0	0	1	2	1	2	3	5	3	3	5.88
Dec.	0	0	3	5	2	4	1	2	1	2	5.15
Total	**27**	**43**	**26**	**45**	**28**	**49**	**30**	**48**	**25**	**45**	**100.00**

Table 2. Prolificacy of does by year of kidding.

Year	No. Does Kidding	No. Kids Born	Prolificacy
1993	27	43	1.59
1994	26	45	1.73
1995	28	49	1.75
1996	30	48	1.60
1997	25	45	1.80
All Years	136	230	1.69 ± 0.67

the Hounslow Station, where they found a prolificacy rate of 1.64. Estimates of litter size in Anglo-Nubian does in various countries are given in **Table 3.** Those in Malaysia (1.43) and Israel (1.75) compare favorably with the local findings but estimates in Mauritius (2.29) are greater. Although prolificacy is a good indication of the maternal ability of the doe, a measure of greater practical importance is reproductive efficiency. This is the number of kids reared to weaning. If a doe does not carry her kids to weaning then she is of little value.

The incidence of multiple births as analyzed over the five year period (1993 - 1997) involving 136 observations indicated 42.65% singles, 45.59% twins, and 11.76% triplets (**Table 4**) among the Anglo-Nubians studied.

Table 3. Comparison with other Anglo-Nubians.

Location	Prolificacy	Kidding Interval	Age at 1st Kidding
Bodles, Ja.	1.69 ± 0.67	355 ± 90	517 ± 164
Malaysia	1.43	480	
Israel	1.75		365 - 730
Mauritius	2.29	363	870

The relationship between parity and multiple births is shown in **Table 5.** The data suggests that as the level of parity increases from 1 to 5, the incidence of multiple birth (twins and triplets) increases with figures of 67.12%, 67.21%, 79.59%, 90.91%, and 92.86% for parity 1 to 5 respectively. This is supported by earlier work by Shanmugasundaram, 1957, on Malabar goats. His study showed that the proportion of twins and triplets increased from 19% at first kidding to 79% in second and subsequent kiddings.

Yarkin and Eker, 1961, studied the Kilis goats in Turkey and found the maximum number of kids per birth was produced at the 6th parturition or approximately at 5 years of age. Similar work done by Moulick et al in 1966 showed that in Black Bengal goats maximum litter size occurred at 5 to 6 years of age with a peak of 67 months. These studies suggest that fertility in goats increases up to about 5 to 6 years of age.

Table 4. Frequency of multiple births.

Type of Birth	No. Does kidding	% of Total Does	No. Kids Born	% of Total Kids
Single	58	42.65	58	25.22
Twin	62	45.59	124	53.91
Triplet	16	11.76	48	20.87
Total	136	100.00	230	100.00

Table 5. Relationship between parity and multiple births.

Parity	1		2		3		4		5	
Type of birth	No. Born	% of Total	No. Born	% of Total	No. Born	% of Total	No. Born	% of Total	No. Born	%of Total
Single	24	32.88	20	32.79	10	20.41	3	9.09	1	7.14
Twin	40	54.79	32	52.46	24	48.98	24	72.73	4	28.6
Triplets	9	12.33	9	14.75	15	30.61	6	18.18	9	64.3
TOTAL	73	100	61	100	49	100	33	100	14	100

One of the parameters of significant economic importance is age at first kidding. Goats that kid at a relatively early age will have a greater population turnover and will allow for more rapid genetic progress than goats that kid for the first time at a later age. **Table 6** shows age at first kidding in the Anglo-Nubian goats studied. Of 48 does studied the average age at first kidding was 517 ± 164 days with a range of 319 - 968 days. The findings are quite similar to that reported by Devendra, 1970, where a pattern of 12 to 24 months was established.Kidding interval or the period between two consecutive kiddings is shown in **Table 6.** The average interval for the Bodles

does is 355 ± 90 days. This is a far cry from the 240 days that's required to achieve three kiddings in two years, but compares with Anglo-Nubians in Malaysia (480 days, Devendra, 1962) and Mauritius (363 days, Delaitre, 1965).

Table 6. Age at 1st kidding and kidding interval.

Parameter	No. of Does	Average age (Days)	Range (Days)
Age at first kidding	48	538 ± 164	319 - 968
Kidding interval	39	355 ± 90	185 - 688

CONCLUSION

The findings outlined above suggest that the Anglo-Nubian goats have acclimatized quite well in Jamaica and are comparable in their reproductive performance to Anglo-Nubians in other parts of the Tropics.

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PERFORMANCE TESTING IN BEEF CATTLE IMPROVEMENT PROGRAMMES

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SUMMARY

Eight batches comprising 298 weaner bull calves of the Jamaica Brahman, Jamaica Red Poll, Jamaica Black and composite breeds have completed the 140-day post weaning performance at the Minard facility since 1992. Calves were fed on a group basis, and data on pre-weaning and weaning parameters collated. Final indices and ranking were based on average daily gain, 400-day weight, and weight per day of age.

Average daily gain on test over all breed groups by batch were: 1.40; 1.19; 1.15; 1.30;1.24;1.23; and 1.25 Kg respectively. 400-day weights over all breed groups by batch were: 365.36; 382.14; 388.82; 421.45; 415.41; 392.41; 405.05; and 378.20Kg. Weight per day of age was 0.73; 0.86; 0.90; 0.93; 0.86; 0.88; 0.96; and 0.83 Kg.

Breed and batch differences were observed among the three traits.

INTRODUCTION

Jamaica, has boasted during the past 40 years, the development of three tropically adapted breeds of beef cattle, the Jamaica Red Poll, the Jamaica Black both of *Bos indicus* and *Bos taurus* origins, and the Jamaica Brahman, a *Bos indicus*. All three breeds have over time, exhibited differing levels of adaptation and productivity resulting from long term selection for beef characteristics.

The ability of any breed to survive is dependent on its contribution to the production and productivity of the specific commodity for which it has been selected. For the meat industry, optimal weight gains on feedlot or whichever feeding system employed, high final weights, dressing percentages and quality and grade yield are indicative of the breed's utility. The ultimate value of feeder calves and culls, from the breeding herds, is the weight of carcasses produced for the wholesale and retail markets.
While the ruminant is expected to display acceptable levels of production from forages, feedlot performance on high energy/protein rations, complimented with backgrounding, can determine the value of the product of a given genotype in the beef operation. Traits such as average daily gain, final weight, 400-day weight and weight per day of age, are used to determine the intrinsic value of the genotype.

Over the years, individual farmers, and the Ministry of Agriculture, Grove Place, have conducted feedlot performance tests to evaluate beef sires , and to select young bulls as future sires. This process ensured the continued development of the breeds and resulted in a measurable increase in genetic progress.

The feedlot performance test, while not necessarily a perfect indication of the average husbandry environment, is the quickest method of effectively and objectively evaluating the animal's growth performance. All animals are given an equal opportunity to perform through a uniform feeding and management system , while the records of performance are systematically collected, collated , and later evaluated on a constant age-basis.

Performance records are therefore a critical part of genetic progress within a breed and ultimately in the beef industry. The evaluation of these performance data will provide estimates of Expected Progeny Differences (EPDs) which allow producers to compare or rank the superiority of individual bulls for each trait. These values provide a prediction of future performances of one bull's progeny , compared to another, within or across

breeds, for a specific trait; that is a prediction of performance differences.

Genetie progress in beef traits, as well as in any other trait, is a measure of the amount, or degree of change in value, for the trait on an annual basis. This progress is dependent on factors such as the heritability of the trait, the selection differential applied and the generation interval, as determined by the culling rates and average age of the herd.

Beef traits , in general, and in particular the traits under study here, have always indicated medium to high levels of heritability, e.g. feedlot gain (0.45-0.60) final weight 0.50-0.60) efficiency of gain (0.40). There is also a high genetic correlation between efficiency of gain and pounds beef produced. With these relatively high values of heritability, intense seleetion of young sires for these traits will , in all probability result in progeny with above average performance levels, thereby improving the possibility of inereased genetic progress and ultimately levels of production.

MATERIALS AND METHODS

Between 1992 and 1998, 8 batches comprising 298 weaned bull calves were placed on a 140-day post-weaning gain performance testing programme at the Minard facilities in Browns Town.
Calves were preselected on weaning weight and age, and taken into the facility for a pre-conditioning period of 14 days; thereafter initial (shrunken) weights were recorded and a high energy beef ration fed at the rate of 2% body weight . The ration was offered each morning for a period of 3- 4 hours, thereafter the calves were backgrounded on pastures of Guinea grass, *Panicum maximum*.

Animals were weighed each fortnight, when ration amounts were adjusted. Water and minerals were offered *ad libitum*. Eaeh batch of animals was removed from the test on the 140th day of the trial when final weights were taken. Data eollected and parameters estimated were:

- ealf identifieation
- Sire , Dam
- date of birth
- birth weight (estimates used if not available)
- weaning weight , weaning age
- initial weight, initial age
- fortnightly weights
- final weight
- 210-day weight
- avèrage daily gain on test
- 400-day weight
- weight per day of age

Results of individual traits were then ratioed against the contemporary group average and indices for each trait estimated. Comparisons of these ratios were confined within contemporary groups for ranking of young sires.. Final indices for selection were based on;

- average daily gain
- 400-day weight
- weight per day of age
- breed type
- conformation

RESULTS AND DISCUSSION

Table 1 and Figure 1 show the summary statistics of calves entering the test by breed and batch. The Jamaica Brahmans comprised the largest group (133), the Jamaica Red Polls, 112, and the Jamaica Blacks, 36. Crossbreds were the smallest group with 17 calves.

Data analysis and discussions will now be confined to our local breeds as they form the genetic base for our beef industry.

Average daily gain

Jamaica Red Polls displayed gains ranging from 1.25 Kg/day to 1.46 Kg/day, while Jamaica Brahmans ranged from 1.17 Kg/day to 1.53 Kg /day. Jamaica Blacks from 1.17 to 1.53 Kg/day as indicated by the least square means for breed and batch number presented in Table 2 and illustrated in Figure 2.

Calves of the Jamaica Red Poll breed showed highest daily gains over all batches except batches 1 and 5. Jamaica Black calves had highest gains in those batches. Mean values over all breeds ranged from 1.19 Kg/ day to 1.40 Kg/day. Analyses show a significant difference ($P<0.05$) between the Jamaica Brahman gains (1.20Kg / day) and the Jamaica Red Poll (1.29 Kg/day). Differences between the Jamaica Black (1.27 Kg/day) and the Jamaica Brahman were not significant. On a batch basis, there were significant differences. ($P<0.05$). Batch 1 (1.40 Kg/day) was significantly different from both Batch 2 (1.19 Kg/day) and Batch 3 (1.15 Kg/day).

400-day weight

400-day weights ranged from 387.98 Kg to 485.05 Kg for the Jamaica Red Polls; 340.88 Kg to 399.03 Kg for the Jamaica Brahmans; and between 344.30 Kg and 431.40 Kg for the Jamaica Blacks ,as shown in Table 3 and Figure 3

Liveweight at 400 days was influenced by breed. There was a significant difference ($P<0.05$) between the Jamaica Red Polls (418.82 Kg) and the Jamaica Brahmans (375.91 Kg), and the Jamaica Red Polls and the Jamaica Blacks (375.5 Kg). Differences between the Jamaica Blacks and the Jamaica Brahmans were not significant. On a batch basis, differences, ($P<0.05$), were between Batch 1 (365.36 Kg) and Batch 4 (421.45 Kg); Batch 5 (415.41 Kg); Batch 6 (392.41 Kg); Batch 7 (405.05 Kg) and Batch 8 (378.20 Kg).

Weight per day of age

Weight per day of age ranged from 0.75 to 0.98 Kg for the Jamaica Red Polls; 0.73 to 0.88 Kg for the Jamaica Brahmans; and 0.72 to 0.98 Kg for the Jamaica Blacks as shown in Table 4 and Figure 4.

Jamaica Red Poll calves displayed highest weight per day of age, 0.93 Kg, followed by Jamaica Blacks and the Jamaica Brahmans 0.83 Kg and 0.82 Kg respectively. There were significant differences between the Jamaica Red Polls and the other breeds. Significant differences were also displayed between Batch 1(0.83 Kg) and all other batches. Differences between Batch 2 (0.86 Kg) and Batch 7 (0.91 Kg) were also significant ($P<0.05$).

The implications of these results are that the Jamaica Red Poll with its superior performance in all three traits would produce calves of marketable weights in a shorter time than the other two breeds. While there appears to be no significant differences between the Jamaica Brahman and Jamaica Black for the traits studied, this difference may be attributed to the smaller number of animals of Jamaica Black breed which has been on test. On the other hand the lowered performance of the Jamaica Brahman may be explained by their apparent propensity for a low voluntary dry matter intake when compared to *Bos taurus* cattle of the same weight (Ledger et al. 1970).

Voisinet et al in a 1997 report indicated that animals with Brahman breeding had a higher mean temperament rating or were more excitable than animals with no Brahman influence, and that increased temperament scores

Table 1. Batch Summary Statistics of Weaner Bull Calves on Performance Test.

Batch No.	Jamaica Red Poll	Jamaica Brahman	Jamaica Black	Crossbreds	Total
1	4	19	4	3	30
2	8	25	0	2	35
3	17	17	5	1	40
4	16	13	1	0	30
5	10	16	1	2	29
6	22	15	9	6	52
7	20	21	12	1	54
8	15	7	4	2	28
TOTAL	**112**	**133**	**36**	**17**	**298**

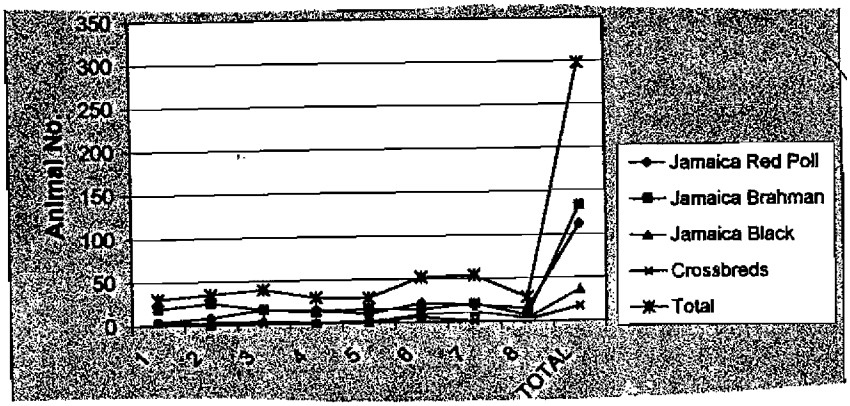

Figure 1. Batch population by breed

Table 2. Least Square Means by Batch and Breed Type for Average Daily Gains.

Batch No.	Average Daily Gain (Kg)				
	Jamaica Red Poll	Jamaica Brahman	Jamaica Black	Crossbred	Overall
1	1.46	1.37	1.53	1.28	1.40
2	1.31	1.14		1.32	1.19
3	1.25	1.04	1.21	1.35	1.15
4	1.36	1.23	1.35		1.30
5	1.25	1.33	1.44	1.80	1.34
6	1.31	1.18	1.17	1.25	1.24
7	1.28	1.17	1.25	1.35	1.23
8	1.31	1.11	1.24	1.34	1.25

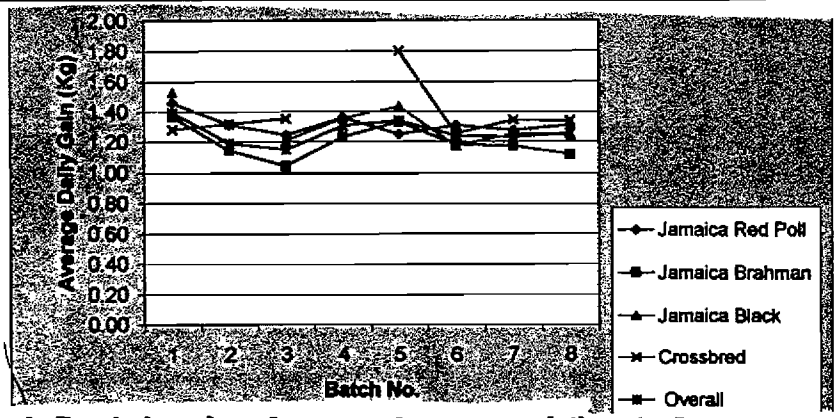

Figure 2: Batch, breed performance for average daily gain (least square means)

Table 3 Least Square Means by Batch and Breed Type for 400-day Weight.

Batch No.	400-day weight (Kg)				
	Jamaica Red Poll	Jamaica Brahman	Jamaica Black	Crossbred	Overall
1	387.98	358.94	378.22	358.75	365.36
2	395.53	373.80	-	433.18	382.14
3	395.38	390.30	349.05	450.86	388.82
4	439.71	399.03	431.40	-	421.45
5	485.05	373.94	344.30	434.57	415.41
6	415.03	370.64	357.53	416.22	392.41
7	424.36	384.83	406.79	421.69	405.05
8	397.84	340.88	360.02	397.95	378.20

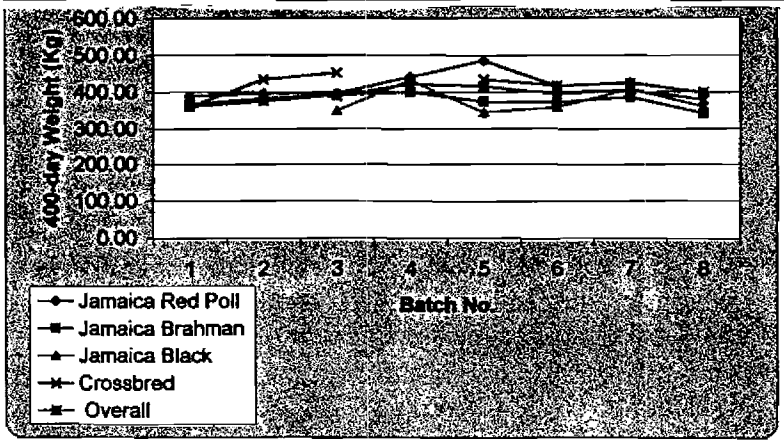

Figure 3: Btcb, breed performance for 400-day weight (least square)

Table 4. Least Square Means by Batch and Breed Type for Weight Per Day of Age.

Batch No.	Weight per day of age (Kg)				
	Jamaica Red Poll	Jamaica Brahman	Jamaica Black	Crossbred	Overall
1	0.75	0.73	0.72	0.70	0.73
2	0.89	0.84		0.99	0.86
3	0.94	0.87	0.82	1.14	0.90
4	0.98	0.88	0.98		0.93
5	0.95	0.80	0.72	0.91	0.86
6	0.94	0.81	0.80	0.94	0.88
7	0.97	0.85	0.92	0.91	0.96
8	0.88	0.77	0.75	0.82	0.83

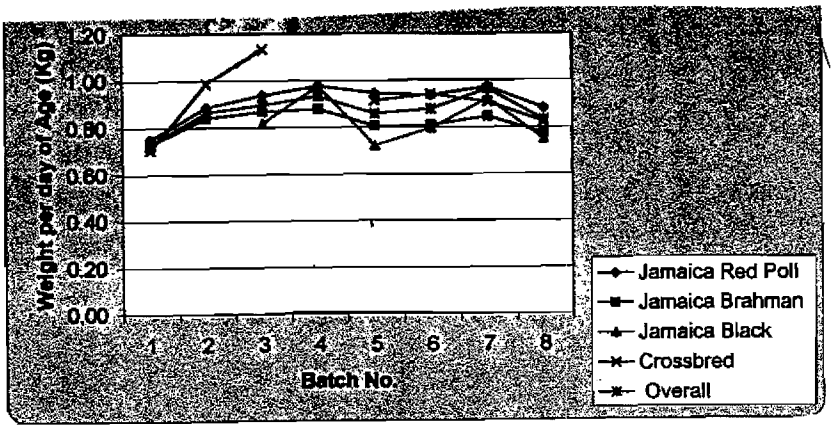

Figure 4: Batch, breed performance weight per day of age (least square means)

resulted in decreased average daily gains ($P<0.05$). The data concluded that cattle that were quieter and calmer during handling had greater average daily gains than cattle that became agitated during routine handling. The Jamaica Brahman has evolved from a group of cattle which was bred and selected for the hot environment of the tropics. Its place in the industry cannot be overlooked as it can still provide the base and source of animals for our local farming systems environment with low quantity, poor quality feed.

Based on these results, it is fair to say that the trends, phenotypic and genetic, appear to be positive within our local beef breeds, but further evaluations will determine their productive values and continued relevance in an ever changing market environment. It is obvious however, that more intense selection pressure should be applied to all breeds for their continued improvement.

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WEED POPULATION RESPONSES TO HERBICIDE-CROP ROTATIONS

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ABSTRACT

Yam (*Dioscorea*)is an important staple food throughout the Caribbean. Weed competition is a major limitation to production of yam crops. Because of reduced interest in herbicide registration for limited-acreage crops such as yam, farmers need alternative weed control methods. Herbicide-crop rotations may become an alternative strategy for weed control in crops such as yams. The objective of this study was to determine weed population responses and yam production under herbicide-crop rotations. A two year study was conducted at two locations. Treatments were:

- a) fallow-yam-yam,
- b)bean-bean-bean-yam,
- c) cabbage-cabbage-cabbage-yam,
- d) bean-cabbage-bean-yam and
- e) cabbage-bean-cabbage-yam.

Weed species were different at Coropal and Isabela. The former *Sorghum halepense* was reduced after the two-year herbicide-crop rotation but other weed densities were not different among treatments. At the latter, common weeds were *Echinochloa colona, Eleusine indica, Digitaria sanguinalis*, and *Amaranthus dubius*. At both locations weed densities were lower in the final yam planting than at the beginning of the study and no significant differences in tuber yields were detected among treatments. Data obtained in this study did not provide conclusive results, but dramatic changes in the *S. halepense* density demonstrate the potential of crop-herbicide rotation for the control of specific weeds.

INTRODUCTION

Yams (*Dioscorea.*) are an important staple food in Puerto Rico and throughout the Caribbean. Weed interference is a major limitation to production of yam crops. Season-long weed competition may reduce yam yields up to 47% (Liu *et al.*, 1994). Practices for weed control include combinations of pre- and post-emergence herbicides and manual weeding. Numbers of pre-emergence herbicides for use in tropical root and tuber crops are notably limited (Esta. Exp. Agric.-UPR, 1997). For example, ametryn is the only pre-emergence herbicide registered for use in yam; if it were withdrawn, farmers would have to resort to manual weeding for pre-emergence control.

Because of reduced interest in herbicide registration for limited-acreage crops such as yam, farmers need alternative management strategies for weed control. Under these circumstances, agronomic practices such as rotation or herbicide-crop rotation become alternatives for change in the conventional patterns of crop-weed competition.

Weeds are suppressed by crop rotation (Buchanan *et al.*, 1975; Johnson and Coble, 1986; Glaze *et al.*, 1984). Researchers have reported weed population shifts in rotational studies over several years (Coble and Schrader,

1974; Johnson and Coble, 1986; Glaze *et al.*, 1984). In a three-year herbicide-crop rotation study, Hauser *et al.* (1974) found the major change in population to be a reduction in yellow nutsedge (*Cyperus esculentus*). Unfortunately, most of the research related to crop rotation-herbicide sequence and their effects on weed composition have been conducted in temperate regions. It is essential to understand these relationships in tropical environments for the improvement of weed control programs throughout the Caribbean Basin.

In Puerto Rico, a study was conducted to determine weed population responses and yam yields under herbicide-crop rotations.

MATERIALS AND METHODS

The study was conducted between November 1995 and November 1997 at two locations, the Corozal and the Isabela Agricultural Experiment Substations of the University of Puerto Rico. The Corozal substation is located in the north-central region of the island where the soil is a Corozal clay (Aquic Haplohumults) with a pH of 5.8. The Isabela substation is in the northwest of the island. The soil there is a Coto clay (Typic Hapludox) with a pH of 6.2.

To determine the effect of vegetable herbicides on a tuber crop, yam was planted as the final crop in the rotation. Treatments were: **a**) fallow-yam-yam (y-y) (control), **b**) bean-bean-bean-yam (b-b-b-y), **c**) cabbage-cabbage-cabbage-yam (c-c-c-y), **d**) bean-cabbage-bean-yam (b-c-b-y), and **e**) cabbage-bean-cabbage-yam (c-b-c-y). Bean breeding line 9418-2 was planted 10 cm apart in rows spaced at 0.60 m. Seedlings of cabbage cv. Blue Vantage were transplanted 30 cm apart in rows spaced at 0.91 m. Yam cv. Diamante (*D. alata*) was planted at the same spacing as cabbage. At both locations, the treatments were arranged in a randomized complete block design with four replications.

In all bean plantings, trifluralin at 0.56 kg.ai/ha was incorporated pre-planting. Metolachlor (at 1.68 kg. ai/ha) as pre-emergence and sethoxydim (at 0.22 kg.ai/ha) as post-emergence were used only in the first bean planting. In cabbage, oxyfluorfen at 0.56 kg.ai/ha was used pre-emergence.

In the last yam planting of the y-y rotation, paraquat (POE, 0.56 kg.ai/ha) was applied a month after planting. Herbicide sequences were the same at both locations. Because of differences in weed species by location, yam required one hand weeding at Corozal and three weedings at Isabela.

Weed population (density and species composition) was determined before each herbicide application or hand weeding by sampling ten 0.25 m^2 random quadrats per plot. Yam yield data were recorded as fresh weight of the tuber. Data were statistically analyzed and means were compared by Least Significant Difference test at the 0.05 probability level.

RESULTS AND DISCUSSION

Weed species were different at the two locations, therefore statistical analyses were made by location. At the beginning of the study (1995), the most abundant weed at Isabela was *Sorghum halepense* with a density of 48 plants/m^2. Other weeds were *Digitaria sanguinalis*, *Cyperus rotundus*, and *Euphorbia heterophylla* having densities that ranged from 4 to 8 plants/m^2. *Sorghum halepense* was reduced by all treatments after the two-year herbicide-crop rotations. Its density was reduced to 7.8 plants/m^2 in the c-c-c-y rotation and to 8.3 plants/m^2 in the c-b-c-y rotation. The use of oxyfluorofen in cabbage cause suppression of *Syurghum helepense*.

Weed densities in the final yam planting, except for S. *halepense* and E. *heterophylla*, were not different among treatments (Table 1). The density of E. *heterophylla* was higher in the b-c-b-y rotation than in the other rotations (Table 1). In the final yam planting, *Eleusine indica* appeared as a weed. However, this weed was not common in 1995.

Table 1. Effect of herbicide-crop rotations on populations/density of common weeds at , Isabela, Puerto Rico.

Crop Rotations	no. plants/m2						
	Sorghum halepense	Digitaria sanguinalis	Eleusine indica	Echinochloa colona	Ricardia scabra	Euphorbia heterophylla	Amaranthus dubius
Y-Y[1]	17.2	5.6	0	1.0	5.1	7.8	0.8
B-B-B-Y	15.6	5.6	12.9	0.2	0.2	9.5	2.5
C-C-C-Y	7.8	10.1	4.1	0.4	2.1	9.3	2.2
B-C-B-Y	19.6	8.7	5.3	1.6	1.3	24.7	5.9
C-B-C-Y	8.3	2.1	2.0	2.7	0.3	3.8	2.1
LSD (0.05)	7.9	N.S.	N.S.	N.S.	N.S.	7.9	N.S.
Mean	13.7	6.42	4.8	1.18	1.8	11.0	2.7

[1] Y = Yam , cv. Diamante (Discorea alata).
B = Bean , breeding line 9418-2
C = Cabbage , cv. Blue Vantage

No significant differences were detected among treatments for yam yield (Table 3). Average yield was 11,406 kg/ha. The density of 13 plants /m^2 of S. *halepense* in combination with other weed species was high enough to cause interference to yam.

At Corozal, common weeds at the beginning of this study in 1995 were *Echinochloa colona, Eleusine indica*, D. *sanguinalis*, and *Amaranthus dubius* with densities of 76, 51, 33 and 19 plants/m^2, respectively. Weed densities were lower in the final yam planting than in 1995 (Table 2). At this location, *Portulaca oleracea* and *Lepidium virginicum* were common in the final yam planting. However, densities of these weeds were low in 1995. Similarly as for Isabela, at Corozal no significant differences in yam and tuber yields were detected among treatments. (Table 3). The yam yield at Corozal (24,086 kg/ha) was higher than that at Isabela.

Table 2. Effect of herbicide-crop rotations on population densities of common weeds at Corozal, Puerto Rico.

Crop rotations	plants/m^2				
	Digitaria sanguinalis	Eleusine indica	Echinochloa colonum	Portulaca oleracea	Lepidium virginicum
Y-Y[1]	9.9	3.5	21.9	7.7	6.3
B-B-B-Y	2.8	3.4	14.8	6.0	3.2
C-C-C-Y	3.1	1.6	18.9	7.3	5.6
B-C-B-Y	3.8	2.6	22.9	17.9	5.8
C-B-C-Y	3.8	3.2	20.3	8.0	6.3
LSD (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	4.68	2.86	19.76	9.38	5.54

[1] Y = Yam, cv. Diamante (Dioscorea alata).
B = Bean, breeding line 9418-2
C = Cabbage, cv. Blue Vantage.

Data obtained in this relatively short term study may not provide conclusive results. More than two years of study are required to establish the true effects of crop-herbicide rotation as alternative weed management strategies. Dramatic changes, however, occurred with *S. halepense* at Isabela when using cabbage as a previous crop. The above response demonstrates the potential of crop herbicide rotation for the control of a specific weed.

Table 3. Tuber production by yam plants after different crop herbicide rotations in trials at Corozal and Isabela, Puerto Rico. 1997.

Crop rotations	Corozal		Isabela	
	No./ha	kg/ha	No./ha	kg/ha
Y-Y[1]	13,756	30,901	13,662	7,309
B-B-B-Y	21,531	18,577	15,616	9,454
C-C-C-Y	20,136	21,839	26,414	19,603
B-C-B-Y	20,734	21,930	14,619	8,344
C-B-C-Y	29,107	27,186	17,443	12,323
LSD (0.05)	N.S.	N.S.	N.S.	N.S.

[1] Y = Yam, cv. Diamante (*Dioscoreo alata*).
B = Bean, breeding line 9418-2
C = Cabbage, cv. Blue Vantage

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WEED MANAGEMENT IN DRY BEANS IN PUERTO RICO

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ABSTRACT

An experiment with Arroyo Loro bean was conducted at Isabela, Puerto Rico in 1998 to evaluate potential weed management strategies for dry beans. Trifluralin (0.75 kg/ha) and pendimethalin (1.24 kg/ha) both preplanting, and imazethapyr (0.06 kg/ha) and metholachlor (2.8 kg/ha) both preemergence, were equally effective reducing broadleaf weeds. Preemergence imazethapyr and postemergence bentazon were less effective for grasses than metolachlor, trifluralin, pendimethalim, and bentazon which in combination with sethoxydim at third week controlled 100% of grasses. Bean yield ranged from 1,555 kg/ha (with pendimethalin plus bentazon) to 1,970 kg/ha (with imazethapyr at 5 days) but did not differ significantly (P = 0.05). Harvesting by hand maximized yield recovery since most of the herbicides reduced weed biomass and potential grain loss.

INTRODUCTION

Bean (*Phaseolus vulgaris* L.) is an important component in the puertorrican diet. Around 160 mt of fresh beans and 7 mt of dry beans are produced locally, however, more than 5,000 mt are imported annually at a cost of $15.0 million. Consumers prefer beans instead of other grains and for this reason an increase in production is desirable.

Weed control studies with dry beans have been limited in Puerto Rico. One study conducted at Lajas in 1980 reported that trifluralin, profluralin, and DCPA provided good yields of snap and dry beans (Almod\var and Semidey, 1980). Weed interference may reduce dry bean yield up to 30% (Dawson, 1964). Studies conducted in Arkansas (USA) indicates that a single weed species such as pigweed (*Amaranthus hybridus* L.) reduced snap bean yield over 50% (Lugo and Talbert, 1994). According to Burnside et al. (1998) weed biomass ean be controlled in red kidney beans, either mechanically or chemically, but a combination of the two methods is the most effective and dependable weed control strategy.
The lack of effective weed management strategies in beans are limiting its production in Puerto Rico. The objective of this study was to develop weed management strategies for the control of late germinating weeds in dry beans.

MATERIALS AND METHODS

One experiment with white bean was conducted at Isabela, Puerto Rico in 1998. Arroyo Loro bean was planted 28 January 1998 at about 320,000 seeds/ha. A randomized complete block design with four replications was followed. Plots measured 3.65 m by 6.1 m, with six rows of beans, 60 cm apart. Information of herbicide treatments is presented in Table 1. Sprinler irrigation was applied nine times from January 28 to April 7, 1998. Plots were fertilized with 112 kg/ha, each of N, P_2O_5 and K_2O at second week of planting.

Weed density within a 0.5 m^2 frame was recorded three and six weeks after planting (WAP). Row-crop cultivation was performed in the whole area 4 WAP. Weed samples were collected 9 WAP and biomass determined. Dry beans from 14.8 m^2 were harvested 22 April 1998.

Table 1. Herbicide treatments applied to beans in Isabela, Puerto Rico in 1998.

Treatment number	Common name	Application		
		kg ai/ha	L/ha	timing (Days)*
1, 2, 3	Trifluralin	0.75	1.75	PPI (1 DBP)
3, 6	Imazethapyr	0.06	0.23	PRE (2 DAP)
4	Imazethapyr	0.06	0.23	AE (5 DAP)
5, 7	Metolachlor	2.80	2.90	PRE (2 DAP)
2, 6, 7, 8	Sethoxydim	0.37	2.30	POE (21 DAP)
9, 10	Pendimethalin	1.24	3.50	PPI (1 DBP)
8, 10	Bentazon	0.75	1.75	POE (14 DAP)

*Abbreviations: PPI = preplant incorporated, PRE = preemergence, AE = at emergence, POE = postemergence, DBP = days before planting, DAP days after planting.

RESULTS AND DISCUSSION

Predominant weed species in the experimental area were wild poinsettia (*Euphorbia heterophylla* L.), junglerice [*Echinochloa colona* (L.) Link], horse purslane (*Trianthema portulacastrum* L.) and johnsongrass [*Sorhum halepense* (L.) Pers.]. There were no significant ($P < 0.05$) in density of broadleaf weeds at 3 WAP (Table 2). At 3 WAP, trifluralin, metolachlor, and pendimethalin treatments were more effective for grasses than imazethapyr (Treat. 6) and bentazon (Treat. 8).

Trifluralin (Treat. 1, 2, and 3) and pendimethalin plus bentazon (Treat. 10), and imazethapyr (Treat. 3, 4, and 6) and metholachlor (Treat. 5 and 7) were equally effective reducing broadleaf weeds at 6 WAP (Table 2). All these treatments reduced broadleaf weeds density more than bentazon alone (Treat. 8) for the first three weeks. At 6 WAP, imazethapyr at 5 DAP was less effective for grasses than metolachlor, trifluralin, and bentazon treatments, which in combination with sethoxydim (at third week) controlled 100% of grasses.

Table 2. Weed density three and six weeks after planting dry beans at Isabela , Puerto Rico in 1998.

Treatment	Broadleaves		Grasses	
	3 WAP no./0.5m²	6 WAP no./0.5m²	3 WAP no./0.5m²	6 WAP no./0.5m²
1	17 a[1]	7 bc	1 d	0 b
2	10 a	5 b	1 d	0 b
3	7 a	4 b	1 d	2 b
4	20 a	4 b	11 c	7 a
5	10 a	5 b	0 d	0 b
6	16 a	9 ab	38 a	0 b
7	9 a	6 b	0 d	0 b
8	33 a	15 a	26 b	0 b
9	6 a	8 ab	0 d	0 b
10	8 a	4 b	0 d	1 b

[1]Means within columns followed by the same letters are not significantly different according to LSD (0.05) test.

Weed biomass at 9 WAP and dry bean yield is presented in Table 3. All herbicide combinations were more

effective reducing broadleaf weeds biomass than imazethapyr applied 5 DAP (Treat 4, Table 3). However, imazethapyr applied 5 DAP was more effective reducing broaleaves than pendimethalin combinations (Treat. 9 and 10). Trifluralin, imazethapyr, and metolachlor , all alone or combined with sethoxydim provided better biomass control of broadleaf weeds than pendimethalim alone (Treat. 9). Bean yield ranged from 1,555 kg/ha (with pendimathalin plus bentazon) to 1,970 kg/ha (with imazethapyr at 5 DAP) but did not differ significantly. Harvesting by hand maximized yield recovery since most of the herbicide treatments reduced weed biomass and potential grain loss at the end of the growing season.

CONCLUSION

An effective weed management strategy for dry beans should include: 1) the application of a preplant incorporated herbicide such as trifluralin or pendimethalin , if not possible bean planting must be followed by 2) a preemergence herbicide such as imazethapyr or metholachlor , which can be followed by 3) postemergence sethoxydim for grasses at third week, and finally 4) mechanical cultivation at fourth week is recommended.

The application of postemergence bentazon 14 days after planting, followed by sethoxydim one week later, plus cultivation at the fourth week may successfully substitute the above mentioned strategy.

Table 3. Weed biomass nine weeks after planting and bean yield at Isabela, Puerto Rico in 1998.

Treatment	Weed biomass		Bean yield kg/ha
	Grasses g / 0.5 m²	Broadleaves g / 0.5 m²	
1	0 b[1]	23 bc	1,930 a
2	4 b	16 bc	1,820 a
3	2 b	12 bc	1,820 a
4	82 a	3 c	1,710 a
5	8 b	23 bc	1,840 a
6	1 b	21 bc	1,970 a
7	4 b	18 bc	1,690 a
8	24 b	18 bc	1,880 a
9	1 b	66 a	1,575 a
10	0 b	45 ab	1,555 a

[1]Means within column followed by the same letters are not significantly different according to LSD (0 05) test.

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AMERICAN FOULBROOD DISEASE AND OTHER BEE PESTS IN THE CARIBBEAN WITH SPECIFIC EMPHASIS ON JAMAICA.

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ABSTRACT

The Caribbean has been plagued by bee pests with each island taking steps to eradicate and or control these pests. In an effort to determine the status of American Foulbrood Disease and other bee pests in Jamaica, 3901 hives in 185 randomly selected apiaries were inspected over two successive periods, August - December, 1996 and June - August, 1997. The results of the survey suggested that the disease is still not wide spread as it was only found affecting 43 hives in three apiaries; all in one parish (Manchester). Wax moth was the most frequently found and widely distributed pests affecting 39 apiaries.

INTRODUCTION

The occurrence of Pests and diseases affecting bees is not unique. Some of these are slightly , while others though they attack only individual bees, can so weaken a colony that its very existence is threatened and its entire population may be killed in a year or two (FAO, 1986).

The plant pests of economic importance reported in the region covered by the Caribbean Plant Protection Commission (1989) has listed *Acarapis woodi*, *Apis mellifera scutellata*, *Ascosphaera apis*, *Bufo marinus*, *Melissococcus pluton*, *Nosema apis*, and *Bacillus larvae* as some of the bee pests present in the region.

Acarapis woodi (Acrine mite) has been reported in Colombia, Mexico, United States of America and Venezuela. It is of quarantine importance as it can be serious.

Trinidad is in close proximity to Venezuela. This enabled the flying of *Apis mellifera scutellata* (Africanized bees) from South America into Trinidad (Taylor, 1985).

Ascosphaera apis (Chalk Brood) has been reported in the Caribbean Plant Protection Commission (CPPC) areas such as North and Central America, and Jamaica. In addition both *Bufo marinus* (Giant toad) and Nosema apis (Nosema disease) has been reported in Bermuda. The latter was reported in Cuba (FAO, 1986).

Melissococcus pluton (European Foul Brood disease) has been identified in North and Central America, Bermuda , Columbia, and Venezuela. In 1987, *Varroa jacobsoni* (Varroa mite) was found in U.S.A., in 1990 it was found in Canada and in 1997 the United Kingdom. It is now present in Grenada (Murillo-Yepes, 1998).

American Foul brood disease has been reported by the CPPC affecting areas such as Bermuda, Belize, Colombia and Panama. It has also been found in Cuba, Haiti and Jamaica.

American Foulbrood Disease (AFB) is caused by a bacterium, *Bacillus larvae*. The disease affects only the immature stages of the honey bee and can be highly contagious (Canadian Association of Professional Apiculturists, 1990)

Morse and Nowogrodzki, (1990), stated that the American Foul brood Disease is one of the most dreaded bee disease in the world. The micro-organism is a spore former, capable of developing a protective cover around

itself. In the spore stage, the bacteria are able to exist for long periods away from their host. They can live in honey, and may even withstand boiling in water for twenty minutes.

The spore forming characteristics of *Bacillus larvae* makes it difficult to destroy (Anonymous , 1997)

Larvae feed on bee milk. The bacterial spores are ingested as a contaminant of royal jelly. The incubation period (24-48hrs),is proceeded by the germination of spores and the growth of vegetative cells. This occurs under less than a 2% sugar content. The process is inhibited as long as the sugar content is in excess of 3 and 4 percent (Anonymous 1997).

In the pre-pupal stage, a bee body utilizes sugar in the metabolism connected with its metamorphic processes. This results in a drop in the sugar content below 2% . An increase in bacterial growth produces toxins which kill the larvae . (Anonymous 1997)

Dadant and Son's (1992) in a review indicated that, a comb with AFB diseased larvae may exhibit the pepper box symptom. This may not appear when the infection is light. The same review made it clear that cappings over diseased broods are dark brown, usually punctured and sunken into the cells. The infected cells change from dull white to brown and finally black with progress of the disease. A match stick will show a ropy remains.

Jamaica is one of the few countries where AFB disease is not endemic. Outbreaks only occur when contaminated bee, honey, pollen or used beekeeping equipment have been introduced into the country (Murray , 1990).

Murray (1994) indicated that there have been six recognized outbreaks of AFB disease in Jamaica since 1918. The worst was in 1943 and most recent in 1989. The Ministry of Agriculture inspection records (1996/97) indicated that AFB disease has been found in small pockets of St. Andrew, St. Thomas, Manchester and St. Elizabeth.

Jamaica's policy is aimed at eradicating AFB disease. The present emphasis is on the prompt destruction of all diseased hives by burning. Apiaries in which AFB hives have been identified are quarantined for six months. The ban is lifted or extended based on monthly re-inspection results.

The importance of other bee pests to the country has recently been recognized by beekeepers. These pests include Wax moths, Termites, Black ants, Red ants and Chalk Brood.

The present status of American Foul brood Disease and other bee pests is one of great importanee to both local beekeepers and other interest groups. This has prompted the Ministry of Agriculture to conduct an Island wide survey of AFB and other pests.

MATERIALS AND METHODS

Thirteen experienced beekeepers were trained in the identification of American Foulbrood Disease and other bee pests. Data for the survey were collected during two consecutive periods namely, August 1 to December 31, 1996 and June 10 to August 16,1997.

In the first year, 316 (20%) of the apiaries of Agriculture records for inspection. A minimum of two frames with scaled worker brood cells, was inspected for each single hive 'body' colonies with one extra frame per additional hive 'body' occupied by bees.
The same method was applied to 290 apiaries selected for inspection in 1997.

RESULTS

In 1996, 106 apiaries were inspected from ten of the 13 parishes (using Kingston and St. Andrew as one). Two

thousand, one hundred and thirty five out of 2367 hives present were inspected for AFB Disease and other bee pests. (Table 1)

During the second year inspection was conducted in seven parishes. One thousand seven hundred and sixty six (94%) of the hives present in 79 apiaries were inspected.

Results showed that a total of five AFB positive hives were found in two apiaries in 1996. An additional thirty eight diseased hives were found in one apiary in the following year. All AFB disease hives were found in Manchester.

The data collected revealed the presence of wax moths, red ants, black ants, chalk brood and termites.

Twenty nine percent (31) of the apiaries inspected in 1996 had wax moth with Westmoreland accounting for just over 25 percent wax moth found in ten percent (8) of the apiaries inspected in 1997.

Fifteen (16) and ten percent (8) of the apiaries had red ants in 1996 and 1997 respectively. Portland accounted for in excess of 15 percent of the red ants found in both years.

Black ant which is a nuisance to bees, were found in eight (8) and ten percent (8) of the apiaries inspected over the two inspection periods.

Kingston and St. Andrew had three apiaries with chalk brood.

Excluding AFB Disease, in 1996, 50 percent (53) of the apiaries inspected revealed the presence of other bee pests. Just over 37 percent (40) of the apiaries inspected were found to have one pest per apiary.

During the second inspection year, twenty six percent (21) of the apiaries inspected revealed the presence of other bee pests. Fifteen apiaries had in excess of one pest per apiary.

Wax moths and red ants were the most prevalent combination, of other bee pests found over the two inspection periods.

Rustic hives accounted for 0.5 percent (10) hives in four of the apiaries which were inspected in 1997. Kingston and St. Andrew accounted for two apiaries having three rustic hives. The others were identified in the parish of Hanover.

DISCUSSION

Not all apiaries selected from the Ministry of Agriculture's record were inspected. Some of these apiaries were no longer in existence, sold and or relocated. On the other hand One hundred and thirty two and One hundred and thirty six of the apiaries selected in 1996 and 1997 respectively were not inspected as persons employed did not collect data for the program.

American Foulbrood disease can quickly spread to other colonies in an apiary as a result of robbing, drifting workers, or contamination through the beekeepers hive manipulation (Akratanakul, 1987). Although an out-break of AFB in Jamaica occurred nine years ago, the results indicated that only a few colonies in Manchester were diseased. This could have been due to the bees ability in resisting AFB . Another possibility is the strategy of inspection and the burning of diseased hives with their contents, employed by the Ministry of Agriculture. This method has been used successfully by many countries. The help of antibiotics in preventing the disease is not a factor presently, as the use of chemotherapeutic methods in controlling AFB is not acceptable in Jamaica. No data were obtained from St. Elizabeth for 1996. However in February, 1997 it was discovered that AFB was

present in the parish. All 200 apiaries in the parish were inspected. AFB was identified in 38 apiaries.

Thirty one were quarantined and the other seven apiaries completely burnt. No apiaries were selected from St. Elizabeth for the 1997 period as all were inspected at the same time the survey was in progress.

The results indicate that AFB is not widespread in Jamaica while wax moth is widely distributed. More than twice the number of wax moths were found during the period August to December 1996 when compared to that of June to August 1997. The difference in results could have been due to Westmoreland having most apiaries with the pest in 1996 and no results available for 1997.

The level of other pests present in Jamaica is minimal as the results indicate. Not surprisingly the level of toad infestation was low as they are nocturnal creatures (as data were collected during the days and not at nights).

The use of rustic hives in Jamaica is illegal, but some beekeepers do maintain these hives because of high equipment cost for replacement.

Table 1. Number of Apiaries and hives selected and inspected in 1996.

Parish	Number of Apiaries			Number of hives		
	Select.	Inspect.	AFB+	Present	Inspect	AFB+
Kingston & St. Andrew	32	6	0	145	145	0
St. Thomas	66	0	0	*	*	*
Portland	16	8	0	119	80	0
St. Mary	15	13	0	373	305	0
St.Ann	9	8	0	143	143	0
Trelawny	6	6	0	198	198	0
St.James	18	14	0	225	225	0
Hanover	23	11	0	169	169	0
Westmoreland	27	19	0	428	428	0
St.Elizabeth	37	0	*	*	*	*
Manchester	11	9	2	232	213	5
Clarendon	27	12	0	335	240	0
St.Catherine	29	0	*	*	*	*
Total	**316**	**106**	**2**	**2367**	**2135**	**5**

* No data collected

Table 2. Number of Apiaries and hives selected and inspected in 1997.

Parish	Number of Apiaries			Number of hives		
	Select.	Inspect.	AFB+	Present.	Inspect	AFB+
Kingston & St.Andrew	24	11	0	188	188	0
St. Thomas	42	0	*	*	*	*
Portland	22	5	0	105	90	0
St.Mary	24	14	0	376	376	0
St.Ann	19	19	0	370	370	0
Trelawny	6	0	*	*	*	*
St. James	20	15	0	463	463	0
Hanover	25	12	0	150	150	0
Westmoreland	24	0	*	*	*	*
St.Elizabeth	0	0	*	*	*	*
Manchester	20	3	1	129	129	38
Clarendon	31	0	*	*	*	*
St.Catherine	33	0	*	*	* *	
Total	**290**	**79**	**1**	**1881**	**1766**	**38**

* No data collected

Table 3. Other pests found during the 1996 inspection.

Parish	Number of Apiaries having other pests.			
	Wax moths	Termites	Red ants	Black ants
Kingston & St. Andrew	0	0	0	0
St. Thomas	*	*	*	*
Portland	2	1	4	1
St. Mary	5	5	2	4
St. Ann	5	0	0	2
Trelawny	1	1	0	0
St. James	4	0	1	0
Hanover	3	2	2	1
Westmoreland	8	2	4	0
St.Elizabeth	*	*	*	*
Manchester	0	3	2	0
Clarendon	3	1	1	0
St. Catherine	*	*	*	*
Total	**31**	**15**	**16**	**8**
% of apiaries inspected	**29**	**14**	**15**	**8**

* No data collected

Table 4. Other pests found during the 1997 inspection.

Parishes	Apiaries inspected	Number of Apiaries having other pests			
		Wax moths	Red Ants	Black Ants	Chalk Brood
Kingston & St. Andrew	11	1	0	0	3
St. Thomas	0	*	*	*	*
Portland	5	1	4	3	*
St. Mary	14	0	1	5	0
St.Ann	19	0	0	0	0
Trelawny	0	*	*	*	-
St. James	15	2	1	0	0
Hanover	12	3	0	0	0
Westmoreland	0	*	*	*	*
St.Elizabeth	0	*	*	*	*
Manchester	3	1	2	0	0
Clarendon	0	*	*	*	*
St.Catherine	0	*	*	*	*
Total	**79**	**8**	**8**	**8**	**3**
% of apiaries inspected		**10**	**10**	**10**	**4**

Table 5. The number of Pests per Apiary in 1996.

Parishes	Apiaries Inspected	Number of pests per Apiary				Total	Infected Apiaries (%)
		One	Two	Three	Four		
Kingston & St. Andrew	6	0	0	0	0	0	0
St. Thomas	0	*	*	*	*	*	*
Portland	8	3	1	0	1	5	62.5
St. Mary	13	2	2	2	1	7	53.8
St. Ann	8	5	1	0	0	6	75.0
Trelawny	6	3	0	0	0	3	50.0
St. James	14	3	1	0	0	4	28.6
Hanover	11	6	1	0	0	7	63.6
Westmoreland	19	8	3	0	0	11	57.9
St.Elizabeth	0	*	*	*	*	*	*
Manchester	9	0	0	0	0	5	55.5
Clarendon	12	5	0	0	0	5	41.7
St.Catherine	0	*	*	*	*	*	*
Total	**106**	**40**	**9**	**2**	**2**	**53**	**50.0**

* No data collected.

Table 6. The number of other pests per apiary in 1997.

Parishes	Apiaries Inspected	Number of pests per Apiary				Total	Infected Apiaries(%)
		One	Two	Three	Four		
Kingston & St. Andrew	11	2	1	0	0	3	27.3
St. Thomas	0	*	*	*	*	*	*
Portland	5	0	3	0	1	4	80.0
St. Mary	14	6	0	0	0	6	42.8
St. Ann	19	0	0	0	0	0	0
Trelawny	0	*	*	*	*	*	*
St. James	15	1	1	0	0	2	13.3
Hanover	12	3	0	0	0	0	25.0
Westmoreland	0	*	*	*	*	*	*
St.Elizabeth	0	*	*	*	*	*	*
Manchester	3	3	0	0	0	3	100.0
Clarendon	0	*	*	*	*	*	*
St.Catherine	0	*	*	*	*	*	*
Total	79	**15**	**5**	**0**	**1**	**21**	**26.6**

* No data collected.

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THE EFFECT OF TOBACCO ETCH VIRUS ON THE GROWTH AND YIELD OF TWO *Capsicum chinense* PEPPER VARIETIES

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ABSTRACT

The effect of tobacco etch virus (TEV) on the growth and yield of two hot pepper (*Capsicum chinense)* varieties, Scotch Bonnet and West Indian Red pepper was investigated in a field trial under natural virus/vector pressure. Four treatments comprising covered and uncovered treatments were investigated.

The effect of TEV on plant height and foliage cover was not significant in covered and uncovered Scotch Bonnet and West Indian Red treatments. This was due to the delay in virus introduction within treatments. When virus was first detected maximum vegetative growth was already attained.

Despite the delay in virus onset there was a 52.5% yield reduction in uncovered Scotch Bonnet treatments. Virus infected uncovered West Indian Red treatments on the other hand showed only a 14% yield reduction in the presence of virus. Due to the relatively high temperature and humidity under covered treatments, little or no yield data were obtained for analysis.

A negative correlation was found between total marketable yield, after eight weekly harvests and virus disease incidence at 91, 98 and 106 DAT for uncovered Scotch Bonnet pepper treatments. This correlation was even greater between the latter four weekly harvests and virus disease incidence at the same dates. No correlation existed between these variables in uncovered West Indian Red pepper treatments.

It was concluded that host genotype, the time of infection and virus incidence were factors which influenced the effect the virus had on growth and yield.

INTRODUCTION

Tobacco etch virus (TEV) is widespread in pepper growing areas in Jamaica and has been reported as a limiting factor to hot pepper production (McGlashan, 1994; Myers, 1996; Myers and Prasad, 1997). The virus has been linked to reductions in yield and overall productivity of the crop (McGlashan, 1994; Myers, 1996; Myers and Prasad, 1997). However no quantifiable information exists on the effect of this virus on hot pepper growth and yield in Jamaica.

This study was undertaken to determine the effect of this virus in uncovered and covered treatments on the growth and yield of two hot pepper varieties: Scotch Bonnet pepper a local pepper which fetches a high price on the export market and West Indian Red pepper which is new to the Jamaican environment but has been noted for its high level of productivity.

MATERIALS AND METHODS

Field study

Research was conducted at the Bodles Research Station in St. Catherine in summer 1997. Scotch Bonnet pepper and West Indian Red pepper seeds were sown in steam sterilized soil in seedling trays. At the second-true-leaf stage, the seedlings were transferred to potting bags and kept in an insect proof glasshouse for eight weeks.

Pepper seedlings were transplanted in the field on July 8.

Each experimental plot consisted of a single pepper genotype. Four treatments comprising of covered and uncovered Scotch Bonnet and West Indian Red pepper were arranged in a randomized incomplete block (RCB) design. The blocks ran parallel to each other. Typar®, a spun bound polyester material was used in covered treatments. Uncovered treatments were replicated nine times while covered treatments were replicated three times.

Plot size was 3.0 x 6.0 m. Plots consisted of two double row beds with seven plants per row. Distance between plots was 3.0 m. Plant to plant distance was 1.0 m and between rows was 0.9 m.

Sprinkler irrigation was provided once a week. Cultural practices were done according to standard farmer practice. No chemicals were applied to treatments with the exception of covered treatments, to control very high aphid populations. In that instant plants were sprayed with soap and dimethoate applications.

The inner two rows consisting of five plants in each row were monitored and the following assessments made. The end row plants were not included to minimize edge effects.

Virus incidence

Both primary and secondary virus spread within treatments occurred by natural means. Leaves from the top middle and lower levels of each plant were collected and pooled and assayed for TEV and potato virus Y (PVY) by dot blot immunobinding assay (DIBA) according to Tolin (personal communication from Sue Tolin who is a Pathology professor at Virginia Polytech Institute). PVY often occurs in mixed infections with TEV.

Disease severity

Symptoms were scored weekly using the following scale: 0 = no symptoms, 1 = vein-clearing, 2 = vein-clearing and mosaic, 3 = mosaic and leaf deformation 4 = severe leaf deformation, mosaic and stunting.

Yield parameters

Fruit harvesting commenced 70 DAT. Marketable yield and fruit number were recorded weekly. A total of eight harvests was conducted. Marketable fruit were selected on the following criteria:(1) A minimum diameter or length of 2.5 cm,(2) fresh and turgid, (3)green stem and calyx, (4)free from skin breaks, mechanical injuries, bruises or decay, (5)no discoloration nor insect or bird damage and (6) no distortion due to virus infection.

RESULTS

Virus incidence

Fruit set had already occurred when virus was first detected in uncovered treatments. Tobacco etch virus was confirmed by DIBA in plants manifesting virus-like symptoms. TEV was detected as early as 49 and 56 DAT in uncovered West Indian Red (WIR) and Scotch Bonnet plots respectively. TEV incidence reached 100% in virus infected uncovered treatments by 98 DAT. Two periods of virus spread were observed in uncovered treatments. Primary spread occurred 49-70 DAT and secondary spread 70-98 DAT. The time of onset of virus disease and the rate of virus spread varied within uncovered treatments. It must be noted that uncovered treatments in blocks 1-3 were not infected with virus, while uncovered treatments in blocks 4-6 were infected with virus during the course of the experiment. No virus was detected in covered treatments.

Relationship between virus disease severity and yield

There was a significant ($P<0.05$) negative correlation between virus disease severity and Scotch Bonnet yield. There was no correlation between these variables in uncovered West Indian Red treatments.

Relationship between virus incidence and yield

Highest marketable yields were obtained from uncovered treatments with no virus disease (Table 1). West Indian Red pepper and Scotch Bonnet healthy uncovered treatments showed similar levels of productivity (Fig. 1a), however West Indian Red pepper gave higher yields.
Virus disease had a marked effect on the productivity and yield of uncovered Scotch Bonnet treatments (Table 1 and Fig. 1b). The productivity of West Indian Red uncovered treatments was not as adversely affected by the presence of virus (Table 1 and Fig. 1b).

Table 1. Marketable yield parameters of healthy and virus infected Scotch Bonnet(SB) and West Indian Red (WIR)pepper uncovered treatments.

	Harvests 1-4 Fruit no.	Yield(g)	Harvests 5-8 Fruit no.	Yield(g)	Total fruit no.	Total yield(g)
Healthy SB	127	1289.07	227	1752.6	354	3041.67
Healthy WIR	181	1437.10	246	2087.81	427	3524.91
Virus infected SB	112	1084.86	56	453.65	168	1538.51
Virus Infected WIR	161	1539.3	198	1494.26	359	3033.56

Little fruit was harvested from covered Scotch Bonnet treatments as only one of three replicates produced fruit. There was little or no flowering in these treatments. Covered West Indian Red treatments produced fruit but the quantities were insufficient for analysis. High temperature and humidity under the covers may have inhibited fruit set.

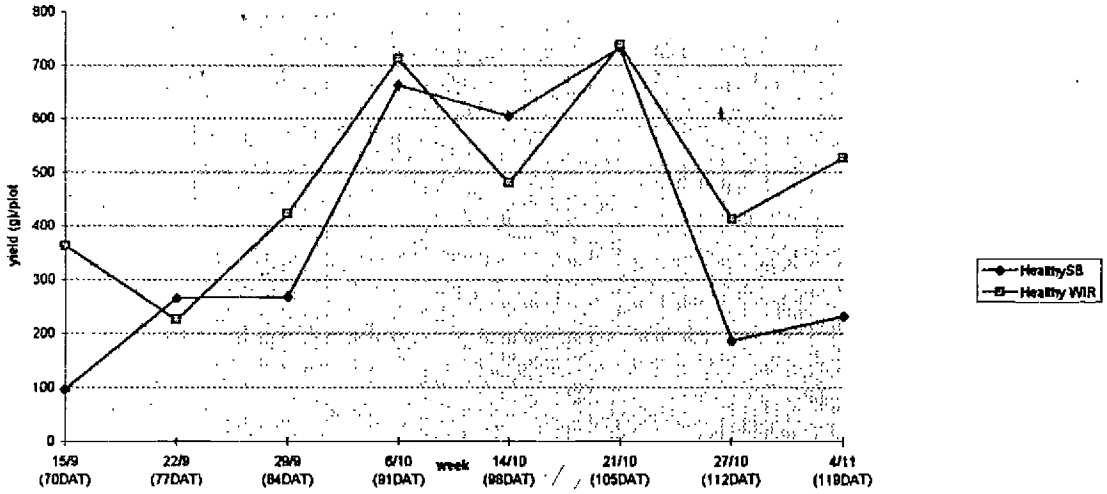

Figure 1a. Mean marketable yield of uncovered healthy Scotch Bonnet and West Indian Red Pepper treatments against time

There was a negative correlation between total yield and virus disease incidence at 84, 91, 98, and 106 DAT in uncovered Scotch Bonnet treatments. There was an even higher negative correlation between the last four harvests and virus disease incidence on these dates (Fig. 1b). The highest correlation occurred with virus disease incidence 84 DAT ($r=-0.765$; $p=0.07$). There was no correlation between the first four harvests and virus disease incidence (Fig. 1b).

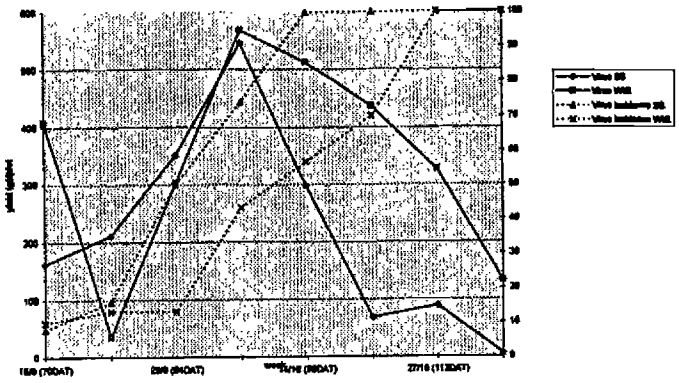

Figure 1b. Mean marketable yield and virus incidence of uncovered virus infected Scotch Bonnet and West Indian Red Pepper treatments against time

There was no correlation between yield parameters and virus disease incidence in uncovered West Indian Red pepper treatments.

DISCUSSION

It was always the belief that the late appearance of virus disease would have a low impact on yield (Bos 1981). However in this study, Scotch Bonnet pepper was found to be more susceptible to tobacco etch virus disease, although virus disease came in after the vegetative growth period. West Indian Red on the other hand appeared more tolerant to the disease. This may have important implications in efforts to develop virus control measures, that delay the introduction of the virus unto plants. This study showed that yields were comparably high in Scotch Bonnet and West Indian Red treatments up to the fourth harvest but dropped drastically in the case of Scotch Bonnet treatments. This occured as the virus disease incidence increased rapidly in Scotch Bonnet plots after the fourth harvest. Villalon (1981) investigated the effects of TEV on yields of eight bell pepper types. Yield reductions varied from 4.6% in resistant cultivars to as high as 58.7% in susceptible cultivars (Villalon, 1981). In this study there was a 52.5 % reduction in Scotch Bonnet yield and a 14% reduction in West Indian Red yield in the presence of TEV. Comparatively higher levels of virus incidence during early harvest may have negatively impacted on the level of productivity of Scotch Bonnet pepper later on in the season. The interaction of varying parameters such as host genotype, virus disease incidence and disease severity contributed to the impact of the virus on yield. Hence measures which act in controlling any of these parameters will go a long way in affording proper management of the disease.

ACKNOWLEDGEMENTS

This study was supported by the IPMCRSP programme. We thank Mr. Sheldon Elliot, Mr. Adrian Mckenzie and Mr. Anthony Patterson for their assistance with harvesting and data collection; Mr. Alfred Barret and Mr. Micheal Daley for lining up the plots at the start of the experiment; Drs. F.W. Ravlin and Sue Tolin for their guidance and support.

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OUTBREAK OF GINGER (*Zingiber officinale* Rosc.) RHIZOME ROT IN THE MAJOR GROWING AREAS OF JAMAICA

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ABSTRACT

In recent years, the domestic and international markets for ginger have grown. In Jamaica, grower interest in this crop has fluctuated with traditional price-induced gluts and shortages. Nevertheless, numerous farmers still rely on ginger as a major seasonal source of income. Since 1995, the major ginger growing areas experienced a rhizome rot whieh has since intensified and spread. This disease complex now presents a major threat to the ginger industry in Jamaiea as present average total damage levels approximate 55%. The pathogens *Fusarium* spp., *Pythium* spp., *Rhizoctonia* spp., *Pseudomonas* spp. and *Verticillium* spp. were isolated from diseased rhizomes. The disease eomplex has adversely affected both exports and local supply, forcing prices up and restricting availability of planting material. An experiment was established to evaluate chemical disease control. Pre-plant fungicide/bacteristatic/baetericide rhizome dips were superior to the untreated control (farmer practice). Results are presented.

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) was introduced to Jamaica by the Spanish around 1525. It has since been grown ehiefly for export and in 1547, over one million metric tons were exported. By 1740, the crop was being grown in the so-called Christiana mountains of central Jamaica where climatic conditions are particularly suitable for growth (Rodriguez, DW. 1971). These hills became the principal growing area$_1$, a position retained until today. The eommodity has played a major role in the economic development of the area up to three decades ago and is still widely grown today.

In reeent years, demand for ginger has grown in the major overseas **(Table 1, Fig. 1)** and local markets. Jamaican peeled, dried ginger has long been regarded as and remains the quality standard worldwide, as reflected in relative prices for the commodity **(Table 2, Fig. 2)**. Local use has grown through the production, of an internationally acclaimed beverage, a wide range of natural fruit juices and other products. This has prompted a 27% increase in area planted since 1995 **(Table 3, Fig. 3)**. Despite the potential for meaningful contribution to those communities, the agricultural sector and national economy, Jamaican ginger is pricing itself out of the international market. In recent years, competitors have been supplying growingly comparable products. The challenge for improved productivity and marketing thus presents itself.

During the crop of 1995. an abnormal incidence of rhizome rot (GRR) was experienced in the parish of Clarendon. Reported pre- and post-harvest losses averaged 10% and 15%, respectively, of total yield.

Symptoms appear on foliage and underground parts of the plant. Leaves of affected plants wilt, curl downwards, become yellow then dried. The collar region weakens, the plant bends, topples and may be easily pulled from the underground portion. Rhizomes exhibit soft or dry rots and abnormal brighter yellow or darker translucent colours. These symptoms seem to be associated with the presence of different causal agents.

The disease is spread in infected planting material and infested soil. The former promotes pre-emergence rotting and reduced sprouting. Post-harvest rotting of apparently healthy rhizomes may occur in storage weeks or months after reaping,.

Several pathogens were isolated from diseased material. These include the fungi *Fusarium oxysporum, F. solani var. coerulum, F.* spp., *Pythium* spp., *Rhizoctonia solani, Verticillium* spp. and the bacterium *Pseudomonas* spp. The saprophytes, *Aspergillus* spp. and *Penicillium* spp. were also isolated.

Reports from India indicate that ginger is affected by several species of *Fusarium spp.* (Dake, 1995, Mathur et al, 1984, Sampath Kumar, 1977, Pandey et al, 1992, Dohroo, 1994, Joshi et al, 1980) causing Ginger Yellows, *Pythium aphanidermatum* and other *Pythium* spp. (Dake 1995, Manomohan Das et al ?, Mathur et al 1984, Sarma et al 1978) causing soft rot and *Pseudomonas solanacearum* (Dake 1995, Manomohan Das et al 1986, Joshi et al 1980, Sarme et al 1978, Indrasenan et al 1981) causing bacterial wilt. *Rhizoctonia* spp. (Ridley 1912), causing dry rot and *Rosellinia* spp. (Leather 1967), Black Rot, have been reported from Jamaica. Plant parasitic nematodes and maggots have also been reported associated with rhizome rot (Ghorpade et al 1982). All these diseases produce a rotting of rhizome tissues, termed ginger rhizome rot (GRR). Several management tactics have been attempted in India, with varying, sub-optimal levels of success. Integrated management is therefore recommended (Dake 1995).

In 1996, an extensive GRR outbreak was observed in the production belt of central Jamaica where four parishes (Clarendon, St. Ann, Manchester, Trelawny) meet. Since then, the disease has also been observed some 60 km to the west in Westmoreland, which received planting material from Clarendon in 1995.

Farmer reports suggest that the disease first appeared around 1993 but the low levels did not arouse concern. Many farmers continued to acquire ginger planting material from infested sources, spreading the disease to other areas and raising infestation levels. At March 1997, average losses reached 30% at harvest with overall pre- and post-harvest farm losses closer to 55% total yield. Extension personnel estimated 240 hectares grown by 1 500 farmers as affected.

This reduced supply has resulted in price increases of fresh rhizomes from J$33/kg in 1996 to J$88/kg today. In the worst affected areas, farmers reap prematurely in an effort to minimize losses from GRR. High levels of post-harvest rot now force farmers to sell the entire harvest as fresh ginger, significantly reducing the supply of planting material as well. Drying ginger increases the risk of losses from the disease. Supply of the dried product has therefore fallen. This has led to reduced export volumes (**Table 4, Fig. 4**) as only dried product is exported.

In 1996, the use of field sanitation, healthy planting material, crop rotation and a fungicide soil drench proved inadequate. In June, 1997, an experimental plot was thus established, to find an effective pre-plant fungicide treatment for planting material (setts).

MATERIALS AND METHODS

The experiment was conducted at Mt. Moriah, St. Ann, in the major ginger growing belt, on the predominant Wirefence clay loam soil type. The plot had been in ruinate fallow for 21 years, grazed periodically by livestock.

Setts were obtained from the farmer's previous harvest which experienced some 30% total GRR. The farmer visually inspected outer and internal tissues, in an effort to exclude diseased material. Setts (ca. 6-10 cm long) comprising one or two nodes with one or more axillary branches were broken from rhizomes and weighed in woven polypropylene bags.

Treatments

Two fungicides and one fungicide/bacteristatic/bactericide were compared with an untreated control (farmer practice), replicated three times in a randomized complete block design. These comprised:

Table 1. Imports of ginger ('000 MT) – (US & UK, 1992-95).

Year	1992	1993	1994	1995	1996
USA	8,240	8,100	14,500	15,300	13,770
EUROPE	12	11	12	13	N.A
TOTAL	**8,252**	**8,111**	**14,512**	**15,313**	

Source : Eurostat June,1998

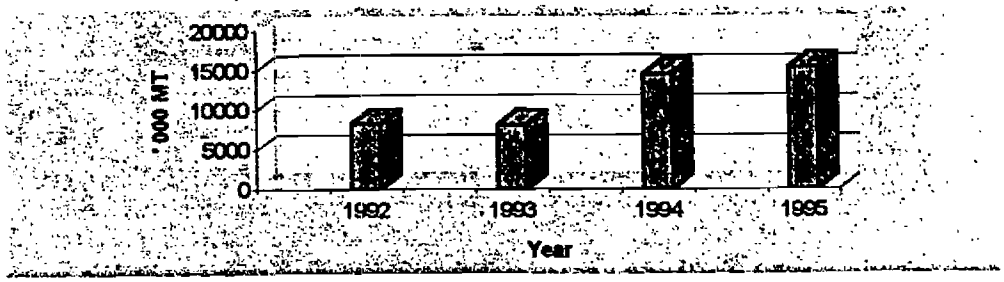

Figure 1. Imports of ginger ('000 MT) – (US 1992-95)

Table 2. Prices of Peeled, Dried, Whole Ginger Rhizomes (C.I.F. United States, 1998).

ORIGIN	China	India	Jamaica
PRICE (US$/MT)	1 800 - 1 920	1 985 - 2 030	8 340

Source : Market News Service, April, 1998, Intl. Trade C. Geneva

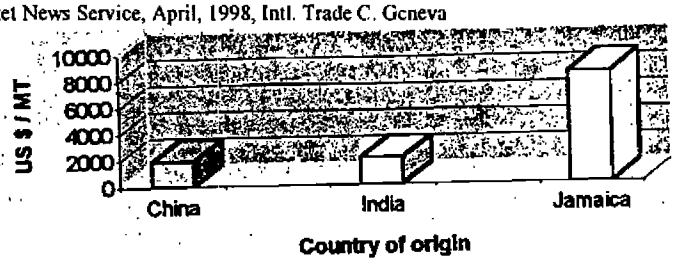

Figure 2. Prices of peeled, dried, whole ginger rhizomes (C.I.F. United States, 1998)

Table 3. Production of ginger - Jamaica (1993-1997).

Year	1993	1994	1995	1996	1997
Area (Ha)	205	207	161	182	204
Volume (T)	731	782	452	617	513
Yield (T/Ha)	3.1	3.8	2.8	3.4	2.5

Source : MinAg Data Bank & Evaluation Division.

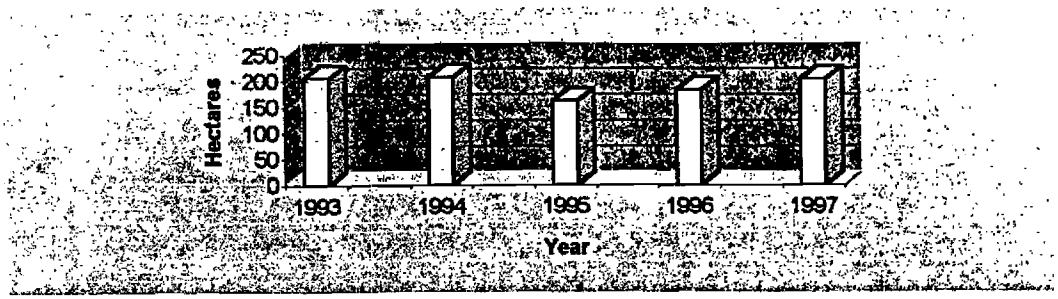

Figure 3. Area of ginger produced - Jamaica, 1993 - 97

Table 4. Peeled, dried ginger exports - Jamaica.

YEAR	1993	1994	1995	1996	1997	1998
VOLUME (MT)	110	100	90	125	125	40
PRICE (J$)	121.00	66.00	110.00	165.00	220	231.00

Source : Pimento Export Division, 1998

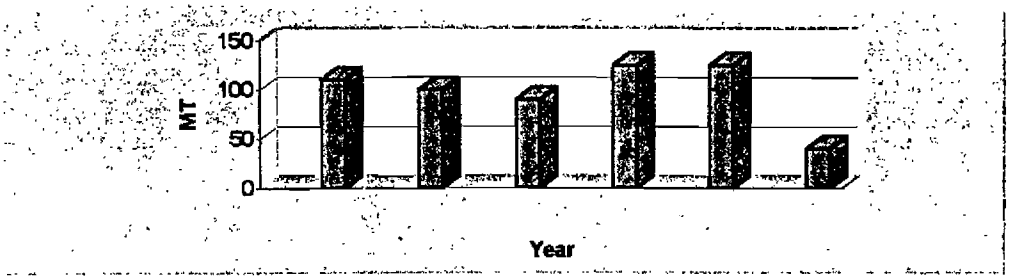

Figure 4. Exports of peeled, dried ginger (MT) - Jamaica, 1993-98

Table 5. Effect of pre-plant fungicide dips on rhizome rot of ginger, Mt. Moriah, St. Ann (Jun-Dec 1997).

Treatments	T	TB	TBR	C	P	SED
Symptoms 106 dap (no. plants)	3.33a	6.68b	3.91a	21.08c	<.001	1.085
152 DAP (no. plants)	1.67a	7.12b	5.57b	10.98c	0.002	1.111
Ground cover 106 DAP (%)	54.7a	58.6a	57.2a	33.8b	0.077	7.89
Marketable yield (Kg/plot)	17.8a	15.9a	15.8a	4.4b	0.077	4.23
Proportion.						
Mktbl : Total Yield	0.91a	0.86a	0.88a	0.54b	0.003	0.055

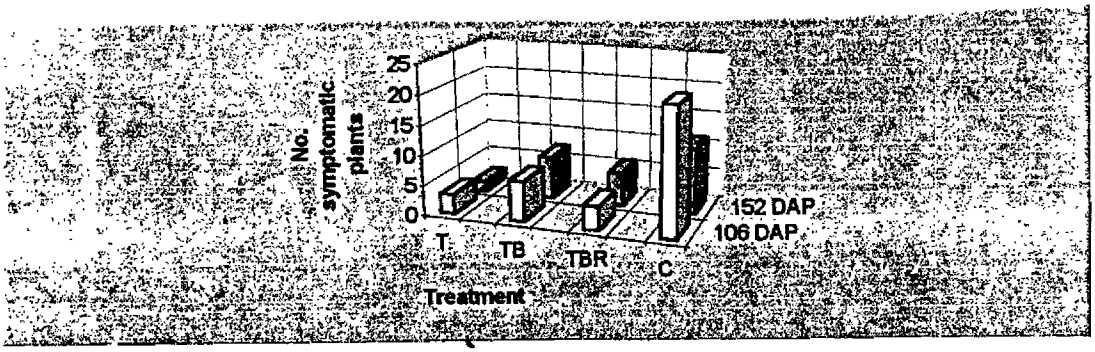

Figure 5. Foliage disease levels, Ginger rhizome rot trial, Mt. Moriah, St. Ann (1/98)

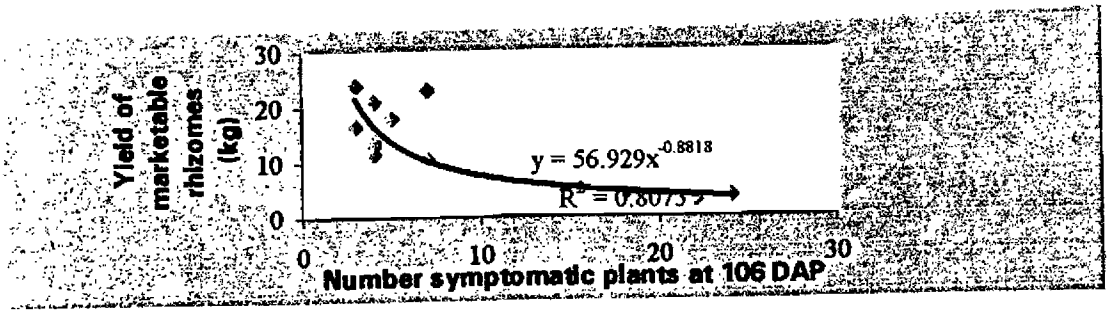

Figure 6. Relationsbip between symptom expression and marketable yield, Ginger rbizome rot trial, Mt. Moriab, St. Ann (1/98)

1. 0.7% Topsin-M (70% thiophanate methyl) (**T**)
2. 0.7% Topsin M+ 0.4% Bravo C/M (27% chlorothalonil; 5.4% maneb; 45.8% copper oxychloride) (**TB**)
3. 0.7% Topsin M + 0.4% Bravo C/M + 1.3% Ridomil MZ (8 % metalaxyl; 64% maneb) (**TBR**)
4. No treatment (farmer practice) (**C**)

Chemicals were mixed in 75 L water in a 200 L plastic drum and setts in bags immersed for 20 minutes with periodic (every 2-minutes) agitation.

Plot size/plant population

Setts were drained for 10 to 15 minutes then planted out 3-5 cm deep, at 20 cm intervals in drills 30 cm apart. Plot size was 4m x 3m, giving a plant population of 195 per plot.

Data Recorded

Numbers of emerged sprouts were recorded 45 and 56 days after planting (DAP). Numbers of plants showing disease symptoms (yellowing and wilting of foliage) and estimates of percentage ground covered by ginger foliage were recorded 106 and 152 DAP. Yields were recorded 196 DAP, separating marketable (visibly healthy rhizomes), discoloured (evidently diseased) and rotted material. A composite sample comprising ten rhizomes from each treatment was held in the farmer's storage area to observe for post-harvest rotting.

RESULTS

Emergence

No significant difference was observed between treatments ($p=0.925$ 45 DAP; $p=0.988$ 56 DAP).

Foliage symptoms

At 106 DAP, all chemical treatments gave significantly less foliage symptoms than **C**. **T** and **TBR** were similar and superior to **TB**. ($p\leq0.001$) (Table 5, Fig. 5)
At 152 DAP, **T** was significantly better than **TB** and **TBR** ($p=0.002$). A strong negative relationship was observed with marketable yield (Table 5, Fig. 6).

Ground Cover

At 106 DAP, all chemical treatments were similarly superior to the control ($p=0.077$) (Table 5, Fig. 7). A strong positive correlation existed between this parameter and marketable yield (**Fig. 8**). At 152 DAP, differences were no longer visible ($p=0.297$).

Yield

All chemical treatments produced similarly significantly higher yields of marketable rhizomes than the control ($p=0.077$) (Table 5, Fig. 9). Treatment **T yielded** the equivalent of 14.8 T/Ha, compared to 3.7 T/Ha for **C**. No significant differences were detected for either rotted ($p=0.205$), unmarketable rhizomes (rotted + discoloured, $p=0.415$) or total yield ($p=0.128$).

Proportion of marketable to total yields ($p=0.003$)(Table 5, **Fig. 10**) showed significant differences between chemical treatments and control. There were no differences between chemical treatments.

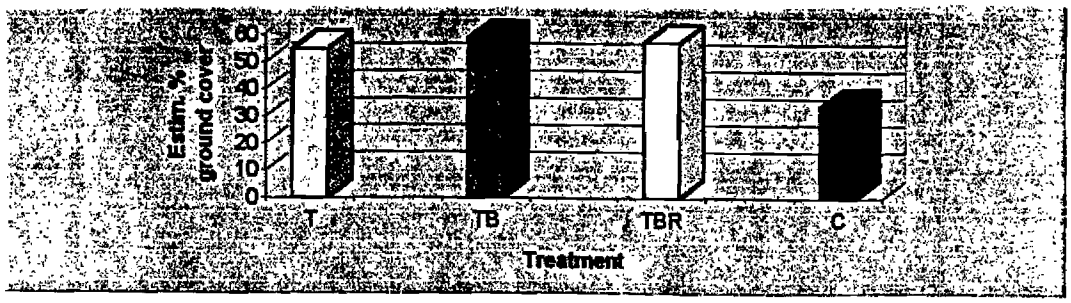

Figure 7. Ground cover - 106 DAP, Ginger rhizome rot trial, Mt. Moriah, St. Ann (1/98)

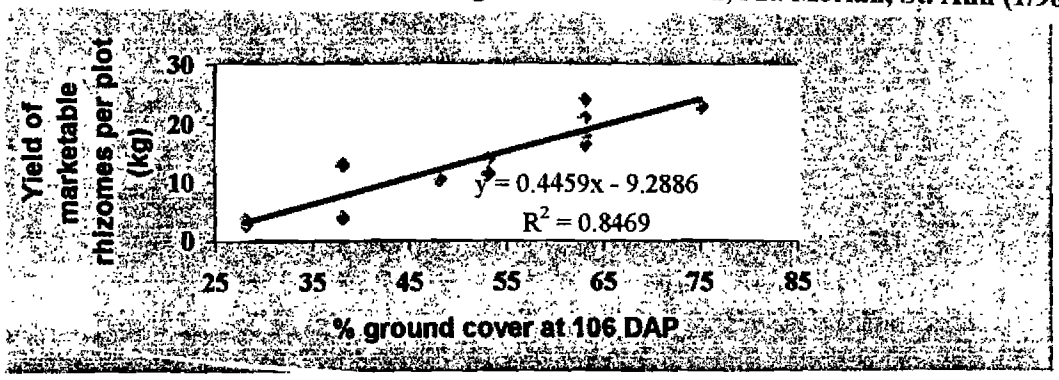

Figure 8. Regression - percentage ground cover on marketable yield, Ginger rhizome rot trial, Mt. Moriah, St. Ann (1/98)

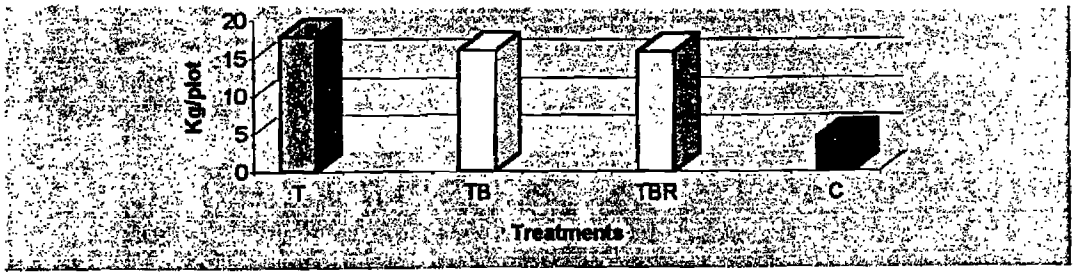

Figure 9. Marketable yield (kg/plot) - Ginger rhizome rot trial, Mt. Moriah, St. Ann (1/98)

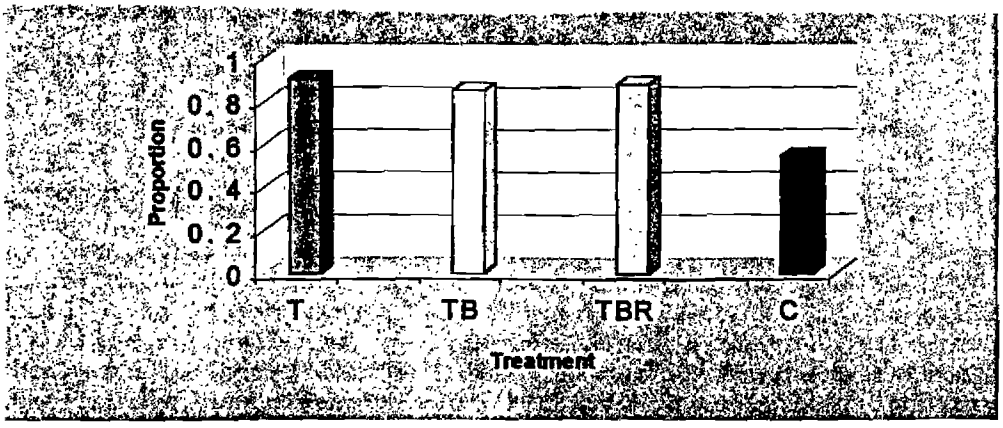

Figure 10. Proportional yields - Marketable to total, Ginger rhizome rot trial, Mt. Moriah, St. Ann (1/98)

Post-harvest Rot

Readings for this parameter were, unavoidably, not taken.

DISCUSSION

Late detection date of the area-wide GRR outbreak (January, 1997), high disease severity and distribution and the fixed planting season (Feb - Jul) demanded a rapid, even if interim, response. As such, the study concentrated on a restricted number of observations, guided by limited background information (Almost all references were obtained after plot establishment).

Treatments were restricted to chemicals, and were based on their activity spectra. Combinations were used to foster success against the different pathogen taxonomic groups involved. Similarly, the less detailed approach allowed only an indication of chemical efficacy and possible relative roles of the pathogens involved. Findings are thus preliminary.

Findings generated agree generally, with similar work on chemical management of fungal GRR in India where most reports on the disease referred to in this study, originated (Dake 1995, Dohroo 1994, Joshi et al 1982, Sahrma et al 1979, Haware et al 1976).

Emergence

The absence of differences in sprout emergence contrasts with most work encountered (Manomohan et al ?, Mathur et al 1984), although one trial (Sharma et al 1979) did show similarity between some chemical treatments and the control. Similar low infestation levels of setts throughout, could account for this. Determination of pre-emergence rot would have allowed clearer indications of differences in eradicant versus protectant chemical activity.

Foliage symptoms

Lower levels of foliage symptoms for chemical treatments compared to the control at 106 DAP, indicate chemical protectant activity. Between-chemical treatment differences are however, inconsistent with activity spectra of the chemicals used. Toppling of symptomatic plants 152 DAP, reduced numbers present then in T and C below levels at first reading.

Ground cover

The more dense ground cover among treated plots at 106 DAP could be due to superior drought tolerance conveyed by greater chemical activity. Increased rainfall in October (**Table 4, Fig. 11**) could have promoted inereased foliage growth throughout the plot at 152 DAP, erasing earlier observed differences. Treated plots would still have an advantage as this earlier growth would foster enhanced assimilation. A close positive correlation observed with marketable yield (**Fig 8**) supports this.

Yield

Superiority of chemical treatments is clearly established by differences in marketable yield and proportions of marketable to total yields. The noted significantly higher markctable yields produced by chemical treatments, suggest potential for a significant improvement in the industry. Absence of differences in total, rotted and unmarketable yields could be due to high variability in the data.

The farmer reported variable unquantified levels of post-harvest rotting among harvested rhizomes. This parameter needs to be properly assessed before a complete chemical GRR management programme can be established.

Table 6. Rainfall, Mt. Moriah, St. Ann - 1997.

Month	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Level (mm)	262	94	112	115	236	70	64	953

Source : Baron Hall Farms weather station

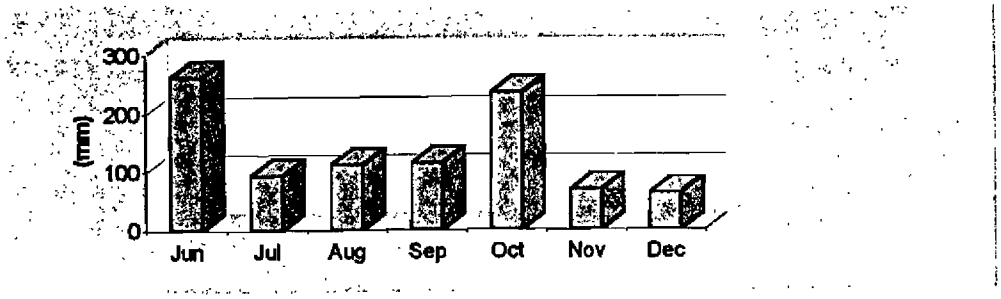

Figure 11. Ginger rhizome rot trial, Mt. Mariah, St. Ann (1977)

Early post-harvest treatment of setts is also indicated. Implications for shelf-life of the green product, pesticide residues in food material, quality of the dried product and supply of planting material are significant.

The work is to be repeated in the 1998/99 crop, with a longer dipping period, counts of toppled plants, determination of post-harvest rot and the inclusion of an organic soil amendment.

This work also indicates the need for further studies as follows:

- Confirm identification of pathogens to the species/sub-species levels.
- Establish disease(s) aetiology and epidemiology including the role (if any) of plant pathogenic nematodes and plant nutrition in development of the disease.
- Validate complementary disease management tactics (e.g. clean planting material/tissue culture, soil amendments, soil solarization, bio-control) and integrated management system(s).
- Pursue possibilities for genetic engineering in disease management and overall commodity development.

Significant yield increases in ginger production may be possible from the use of treated setts. This would support the industry through an increased availability of reasonably healthy planting material. In combination with other disease and crop management tactics, increased volumes could thus be produced at more competitive prices. This should augur well for farmers and the future of Jamaican ginger in the new global economy.

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IDENTIFICATION OF MAJOR PESTS AND A SAMPLING PLAN FOR LEPIDOPTERA LARVAE IN *AMARANTHUS VIRIDIS* (CALLALOO) IN JAMAICA

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ABSTRACT

Major species in the pest complex on callaloo are moth caterpillars (Lepidoptera) *Spodoptera frugiperda, S. exigua; Herpetogramma bipunctalis, Spoladea recurvalis,* beetles (Coleoptera) *Disonycha* spp. *Diabrotica baleteata,* , leafhoppers (Homoptera) *Empoasca* spp. and mites (Acarina) *Tetranychus* sp. Baseline surveys on 15 callaloo farms in the major callaloo producing area of Bushy Park, St Catherine indicated that of these pest species, the lepidoptera complex ranked highest in importance. Adult and larval populations of the five lepidoptera species on callaloo, were monitored over three cropping seasons between April 1997 and March 1998 at Bodles Experimental Station, St Catherine. There was significant correlation between moth flights and larval populations which suggests a potential for using adults as an early warning to intensify in-field scouting. The frequency distribution of the larval populations was determined and a sequential sampling plan developed for use by farmers in scouting. Comparison between a sequential sampling plan and a sampling plan based on a fixed sample size of 25 plants per farm showed the former to be 46% more efficient (mean 13.5 sample plants per farm) while giving the same pest management decision as the latter on 87.5% of the farms. Of the remaining 12.5% of farms in the validation exercise the sequential sampling plan recommended additional samples on 9.4% of them and only gave inaccurate decisions at 3.1% of the sites. This work will allow greater efficiency and structure for implementing scouting programmes in callaloo production systems.

INTRODUCTION

Callaloo, *Amaranthus viridis* which has been an important leaf vegetable in Jamaica has in the past decade gained recognition as a non traditional export commodity. This improved economic status has mandated closer examination of quality standards at all levels of crop production.

Pest management is a critical part of production of this crop. Callaloo is plagued by numerous speeies of leaf eating insects some of which threaten the profitability of callaloo production. Chemical control has essentially been the unilateral approach to pest management of this crop. Farmers have historically used calendar based schedules for timing pesticide applications. This system has resulted in excessive use of pesticides and all the attendant problems (pesticide residues and resistance, environmental contamination and user hazards) of injudicious pesticide use.

As an initial step to the development and implementation of an integrated pest management system for callaloo, research activities have been geared toward minimising pesticide inputs through identification of major pests, scouting and deeision making based on pest densities. Baseline surveys were first conducted to identify the major culprits in the pest complex inflicting economic damage.

Scouting techniques should accurately measure the pest status and in order to do this the geographical limits within the field and within the plant must be identified (Morris, 1960). Information on the expected frequency

distribution is also important for the development of statistically sound sampling techniques (Southwood, 1978). It was therefore assumed that the development of effective sampling and decision making protocols for major pests would lead to a reduction in the number of spray applications made in the production of this vegetable amaranth.

MATERIALS AND METHODS

Baseline Surveys

Fifteen callaloo farms in Bushy Park, St Catherine, a major callaloo growing belt, were selected and informal farmer interviews and field surveys conducted to identify and to gather qualitative information on arthropod species associated with callaloo and their relative importance. Crop damage levels caused by pest species were assessed based on the effect on salability of the crop. Crop loss levels reported by farmers were also used to determine the relative potentials of pest species to inflict economic damage. Taxonomic classification of species found was done through networking with local, regional and US scientists.

Monitoring lepidoptera populations

Populations of lepidoptera larvae were monitored twice per week for three cropping seasons in field plots located at Bodles, St. Catherine between April and July 1997, August and November 1997 and December 1997 and March 1998 (during the vegetative to late reproductive phases of each crop). The size of experimental plots was 137 m^2 with 1000 plants. Two transects divided the field into four quadrats each containing 250 plants.

Four central plants were selected by systematically walking a zigzag path through central plants in each quadrat and tagging one plant after every ten paces. Similarly four plants were tagged per quadrat among the designated edge plants. Six leaves each from the inner and outer whorl of each tagged plant were randomly selected, searched for lepidoptera larvae and records made of number, position and size of larvae found. Size of larvae were recorded as one of four categories: small, < or = 10 mm ; medium, 10.1- 20 mm and large >20 mm.

Lepidoptera adults were monitored by using a sweep net to catch moths. Two sweeps were done per row per quadrat among the designated centre plants. The number of each species of moth caught was recorded. Four sweeps were also done per quadrat along the designated edge of the field. The variation of lepidoptera populations with respect to crop phenology and the association between adult and larval lepidoptera populations were analyzed using Pearsons ranked correlation.

Development and validation of a sequential sampling plan

Equations in Elliot (1997) and Waters (1955) were used to model the probability density function of larval populations and to prepare a computer spreadsheet for calculating sequential sampling plans (Clarke-Harris and Fleischer,1998). A suitable plan was designed based on an action threshold of 1 larva per plant, the level of accuracy required balanced with the need for the process to be practical to the farmer. A chart was designed to be used as a field tool to guide in making pest management decisions based on the sequential sampling plan. In order to determine the efficieney of the sequential sampling plan compared to a sampling plan based on a fixed sample size, 32 callaloo farms within a 28 km^2 radius in St. Catherine were monitored. Twenty-five plants were sampled per farm. The pest management decision reached based on the sequential sampling plan was compared to a decision based on a fixed sample of 25 plants using a threshold of 1 larva per plant. This procedure for validation was described by Luna et al (1983).

RESULTS AND DISCUSSION

Survey of fauna

Forty-eight arthropod species found on callaloo were both pest and beneficial speeies belonging to seven orders

(20 insect families and one mite species) (Tables 1 and 2).

Table 1: Inventory of pest species found in callaloo fields in Bushy Park, Jamaica.

Order /Family	Number of species
Hemiptera/Homoptera	
Cicadellidae	3
Coreidae	1
Cixiidae	1
Pentatomidae	5
Tessarotomidae	1
Aleyrodidae	1
Coleoptera	
Chrysommelidae	7
Lepidoptera	
Pyralidae	3
Geometridae	1
Noctuidae	4
Acarina	
Tetranychidae	1

Table 2: Inventory of natural enemies found in callaloo fields in Bushy Park, Jamaica.

Order /Family	Number of species
Hemiptera/Homoptera	
Miridae	3
Reduvidae	1
Coleoptera	
Coccinellidae	3
Diptera	
Sarcophagidae	1
Syrphidae	2
Carcinophoridae	4
Hymenoptera	
Braconidae	2
Chalcididae	2
Cheloninae	1
Vespidae	1

Major pest species

The primary pest species of the observed pest complex were moth caterpillars (Lepidoptera) *Spodoptera frugiperda*

(J. E. Smith) *S. exigua* (Hb.); *Herpetogramma bipunctalis* (Fabr.) *Spoladea recurvalis* (F.) beetles (Coleoptera) *Disonycha laevigata* (Jacoby); *Disonycha gowdeyi, Disonycha leptolineata taxana* Blake, *Diabrotica baleteata* LeC; leafhopper (Homoptera) *Empoasca* spp.; and mites (Acarina) *Tetranychus* sp. These pests were either constant with seasonal variation in population levels or sporadic but were identified as the major culprits causing damage losses.

Of these pests lepidoptera species ranked highest as they were frequently damaging to the crop throughout the cropping season, were present on all farms and would cause up to 100 % loss in yields. Pesticide inputs by farmers were primarily to reduce 'worm' damage. The leaf eating beetles were sporadic pests and were not as widespread however high populations could devastate a crop. Mite damage levels varied from farm to farm causing high losses on some farms while on others were maintained at relatively moderate to low levels. Leafhopper damage which is characterised by yellow etches on the leaf surface is more consumer tolerable at low levels compared to other pest damage but extensive damage at higher levels affects leaf texture and aesthetics.

Temporal and spatial distribution of lepidoptera pests

Seasonal dynamics was considered to determine generally when to intensify sampling activities. The total number of lepidoptera larvae observed per sampling date ranged from 19 to 238 during crop 1, 0 to 322 during crop 2 and 2 to 193 during crop 3 (Figure 1). Population monitoring data collected for the three cropping seasons substantiated farmer perception of the hot months being the season of highest pest pressure. Although the highest number of lepidoptera larvae was recorded in October, a comparison of the means and medians of individual crop seasons (Table 3) showed consistently higher pest numbers during the April to July crop, followed by August to November, and lowest numbers between December and March.

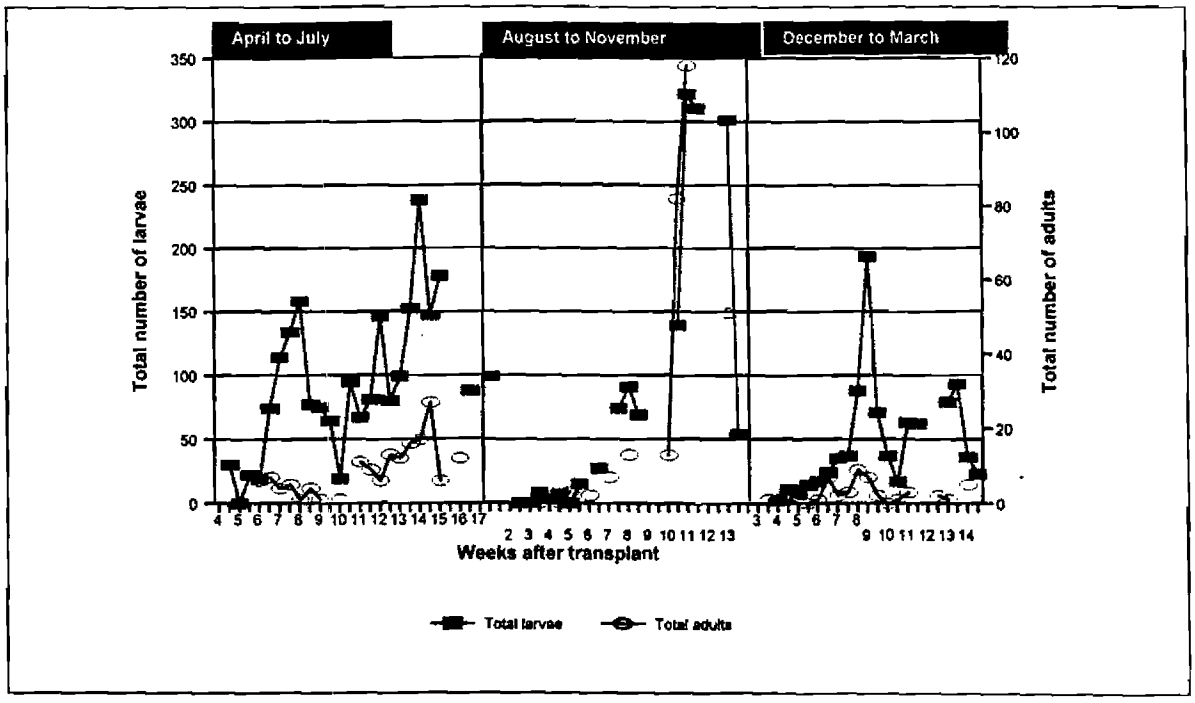

Figure 1: Larval and adult population changes of lepidoptera species during three callaloo seasons between April 1997 and March 1998- Bodles, St Catherine, Jamaica

Table 3. Population levels of lepidoptera larvae observed during three cropping seasons at Bodles, St Catherine.

Duration	Crop 1 *April to July*	Crop 2 *August to December*	Crop3 *November to March*
Maximum	238	322	193
Minimum	19	0	2
Median	88	40.5	36
Mean	98.09	88.75	47.89
Standard Deviation	53.59	113.52	43.82

The correlation between total adult and total larval lepidoptera populations over all crop seasons (Table 4) was very significant ($P < 0.0001$). The more visible sign of increased moth activity can therefore be used as a signal to increase sampling activity for lepidoptera larvae. Proposed studies to assess pheromone and light traps as early warning devices will complement these findings.

Table 4. Correlation of adult and larval (number per 12-leaf sampling units using a visual search) populations of lepidoptera observed between April 1997 and March 1998 at Bodles, St. Catherine.

Lepidoptera species	Correlation coefficient
Spoladea recurvalis	0.714
Herpetogramma bipunctalis ($P< 0.0001$)	0.724
Spodoptera spp. ($P<0.0001$)	0.611
Total All species ($P<0.0001$)	0.722

Crop phenology was also found to significantly correlate with larval population of lepidoptera. A positive correlation ($r = 0.525$) between total lepidoptera larvae and number of weeks after planting was highly significant ($P=0.0070$).

The within-plant distribution of the pest was investigated to define specifics of the sampling unit. Analyses carried out on a partial data set revealed significantly greater ($P= 0.001$) number of larvae on outer whorl leaves than on the inner whorl. Larval size was also found to affect within plant distribution. More larvae in the small size class were found in the outer whorl, while larger larvae were found more often in the inner whorl ($P= 0.002$). Within field distribution (edge versus center) was not significant ($P= 0.428$). These early analyses were the basis of sample allocation (3 inner and three outer whorl leaves per 6-leaf sample) using sampling plans in field validation activities. To ensure that sampling for decision-making would consider both small and large size classes, further work was conducted with a 6-leaf sampling unit, comprising 3 inner leaves and 3 outer leaves.

The sequential sampling plan

In designing the plan a minimum requirement of 10 samples was set to reduce decision errors and the maximum number of samples was fixed at 25 based on the estimated time required (forty-five minutes to an hour) to take

these samples. The sampling chart (Table 5) was further modified to be used as a field guide to sampling and decision making in pest management of lepidoptera larvae on callaloo. In the chart pre-determined decisions as to whether or not to apply pesticides were listed based on the cumulative number of larvae found after a given number of 6-leaf samples. Additional samples are recommended when counts fall within the range of uncertainty.

Validation

To date, validation has been done in 32 callaloo fields (Table 6). Of these fields, 87.5% gave the same management decisions using the sequential sampling plan as a fixed sampling plan of 25 samples (estimated farmer tolerance threshold). Inaccurate decisions were only reached in 3.1% of the fields while 9.4% of the fields resulted in no decision (after 25 samples) with the sequential sampling plan. Overall the sequential sampling plan gave 87.5% accurate decision with a mean of 13.5 samples, this represents 46% savings in sampling time when compared to 25 samples per field using the fixed size sampling plan.

Table 5. Sequential sampling plan for lepidoptera larvae on vegetable amaranth.

Sample Number	Cumulative Frequency of Larvae		
	Do not Spray	Take another sample	Spray Now
10	3	4 to 15	16
11	4	5 to 16	17
12	5	7 to 16	18
13	6	7 to 18	19
14	7	8 to 19	20
15	8	9 to 20	21
16	9	10 to 21	22
17	10	11 to 22	23
18	11	12 to 23	24
19	12	13 to 24	25
20	13	14 to 25	26
21	14	15 to 26	27
22	14	15 to 27	28
23	15	16 to 28	29
24	16	17 to 29	30
25	17	18 to 30	31

CONCLUSION

Identifying the major pests from the large complex of arthropods in callaloo fields has formed the foundation for all future work in the development of Integrated Pest Management programme for callaloo. These species can now be targeted collectively and individually for IPM component research. The lepidoptera larvae have been identified as the most important of all pests on callaloo and this finding has informed the process of prioritisation of research efforts in IPM.

Population dynamics studies have helped to identify when to concentrate sampling efforts, and has defined a sampling unit that considers the within plant distribution of the major defoliating pest species and brackets larval size classes. Expected frequency distributions using these sampling units were modeled, and a common model developed for the range of conditions and pest densities observed in local agroecosystems (Clarke-Harris and Fleischer, 1998). These probability density functions were combined with empirical, expert opinion regarding farmers, and then used to develop a sequential sampling plan that could optimize allocation of sampling

labour resources.

Table 6. Pest management decisions based on sequential sampling plan compared to decisions based on a fixed sample size of 25.

Field No.	Pest Management Decision		
	N using the Sequential Plan	Sequential Size Sampling Plan	Fixed Sample (25 samples)
1	10	No Spray	No Spray
2	10	No Spray	No Spray
3	10	No Spray	No Spray
4	12	No Spray	No Spray
5	10	Spray	Spray
6	11	No Spray	No Spray
7	15	No Spray	No Spray
8	10	No Spray	No Spray
9	10	Spray	Spray
10	10	No Spray	No Spray
11	17	No Spray	No Spray
2	10	No Spray	No Spray
13	10	Spray	No Spray
14	23	No Spray	No Spray
15	10	No Spray	No Spray
16	19	No Spray	No Spray
17	17	Spray	Spray
18	10	Spray	Spray
19	25	No Decision	No Spray
20	10	No Spray	No Spray
21	10	No Spray	No Spray
22	15	Spray	Spray
23	10	Spray	No Spray
24	10	No Spray	No Spray
25	25	No Decision	No Spray
26	21	Spray	Spray
27	25	No Decision	No Spray
28	18	Spray	Spray
29	15	No Spray	No Spray
30	10	Spray	Spray
31	10	No Spray	No Spray
32	10	No Spray	No Spray

Validation trials of the selected sampling plan generated from the developed model suggest that it is effective, resulting in savings of >40% of the sampling resources. This work will be reviewed, adding the formal hypothesis testing to the modeling effort and completing the validation work. If necessary, additional sampling plans can be generated to improve the efficiency, and validation work will now move into educational and implementation efforts.

Two educational and implementation tools for IPM in callaloo have been developed: an identification guide for major pests of callaloo (Clarke-Harris et al. 1998) based on field collection and collaborative taxonomic research,

and a sampling plan, based on field research and collaborative statistical research. Both have been formatted for use in educational programmes with extensionists and farmers. These programmes have already been initiated with a training workshop and will subsequently include on-farm training and assessment of audience knowledge of major pests and level of adoption of scouting procedures. Select groups in other geographic locations will also be targeted to implement scouting systems.

In tandem with these activities, other pest management components are being tested, namely, assessment of the use of early warning devices as a signal of pest immigration, evaluation of new chemistries to replace existing pesticides which are no longer effective, assessment of exclusion as a method of preventing pest attack, conservation of natural enemies through the use of biopesticides and formulation of a list of best management options to be used at pre and post harvest stages of callaloo production.

Farmer adoption of scouting activities will have positive implications for pesticide use management as it relates to insecticide resistance management for new chemicals, conservation of natural enemies, pesticide residue levels, consumer safety, and environmental contamination. The number of pesticide applications in a growing season would be reduced especially during periods of redueed pest pressure, and detection of early stages of lepidoptera larvae will allow for increased, effective use of safer pesticides such as *Bacillus thuringiensis* while cost of labour and pesticide to the farmer would also be reduced.

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DISTRIBUTION AND INCIDENCE OF A NEW PEST (DIPTERA: CECIDOMYIIDAE) IN WESTERN PARISHES OF JAMAICA.

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ABSTRACT

Most recently, a gall midge (Diptera: Cecidomyiidae) was deteeted in shipments of hot pepper to the United States. This was the first record of the pest in hot peppers in Jamaica. Its discovery and quarantine significance prompted the formation of a national task force which had the mandate of identifying and implementing a strategy to reduce infestation levels. Under the directive of the task force, the Caribbean Agricultural Research and Development Institute conducted a survey to determine the distribution and incidence of the midge in the Western parishes of the island where, based on interceptions, the incidence appeared to be highest. A relationship between infestation levels and fruit maturity was observed; mature fruits had the highest levels of infestation The gall midge was present in all parishes visited with the highest level of infested mature fruit being found on farms in Hanover (100%). Based on the production systems and the levels of the pest observed, possible strategies, which may assist in reducing the levels of infestation, are identified and discussed.

INTRODUCTION

In February 1997 the APHIS representative in Jamaica was notified that larvae of the genus *Contarinia* were detected in shipments of hot pepper to the United States. As there is zero tolerance for this pest, shipments in which the pest was detected were rejected and a warning given that the crop may be removed from the preclearance list. This had serious economic/social implications and thus it was critical that basic information on the pest was obtained so that appropriate management options could be developed.

The report of *Contarinia* was the first record of its presence in Jamaica. Subsequent to the survey, adult specimens were reared and sent through APHIS to the USDA where they were identified as *Prodiplosis longifila*. At present it is uncertain whether one or both pests are present in the island. Detection of the pest was highest in export produce from western parishes. The survey was, therefore, conducted in this section of the island in the parishes of St Elizabeth, Westmoreland, Hanover and St James to determine the distribution of the pest.

Biology of the pest

The genera *Contarinia* and *Prodiplosis* belong to the Dipteran family Cecidomyiidae which includes gall midges. Adult gall midges are minute delicate flies with hairy wings and long moniliform antennae bearing conspicuous whorls of hairs. The larvae are white at first but when fully grown they are bright yellow and are able to leap several centimeters into the air (Barnes, 1946). Successful pupation demands damp soil. The larval stage is approximately 8-10 days; the pupal stage 9-10 days. The total cycle is 18-22 days (Barnes, 1946).

Barnes (1946) lists *Contarinia lycopersici* as a pest of tomato in the West Indies. This pest is reported to attack the flower buds leading to premature bud fall or malformed fruits. There are no reports, however, of this pest attacking the pedicel of the fruit as occurs on peppers in Jamaica. A scar on the pedicel of the pepper usually marks the site of infestation. However, the pest could also be present in fruits without scarring.

MATERIALS AND METHODS

Description of Survey Area

St Elizabeth

The main pepper growing districts in the parish of St Elizabeth were located in the northern hilly interior (Elderslie and Maggotty), and in the south in an area to the north of and extending into the Santa Cruz mountains (Leeds and Malvern). These areas experience differing rainfall conditions; the north has relatively high annual rainfall while the south experiences low annual rainfall. Farmers in the north grew mostly Scotch Bonnet for export while those in the South grow red peppers for processing.

Westmoreland

Most hot pepper farmers in this parish were planting hot pepper for the first time. The main pepper growing districts were located to the east of the parish (Belvedere and Mackfield). This area is hilly, enjoys high annual rainfall and is relatively cool. The western end of the parish is flat.

Hanover

The main hot pepper districts in this parish were Pell River and surrounding districts in the West and Haughton Grove in the east. Pell River is hilly with small swampy valleys while Haughton Grove is located in an undulating interior plateau.

St James

The main hot pepper districts were located to the south of the parish around the districts of Catadupa and Maroon Town. Both areas are in the hilly interior and experience high annual rainfall.

Farm Selection

A list of hot pepper farmers within the main hot pepper growing districts in the parishes of Westmoreland, St James, Hanover and St Elizabeth was obtained from the Rural Agricultural Development Authority (RADA). Based on the distribution of farms within the parishes, a total of thirty farmers were selected; eleven from St Elizabeth, seven each from Hanover and Westmoreland and five from St James (Table 1). North St James was not assessed because it was not identified as an important hot pepper growing area.

Production and Marketing Systems

A questionnaire was developed to determine production and marketing systems as well as farmer knowledge/ perception of the pest. The questionnaire included both open and closed qualitative and quantitative questions.

Distribution and Incidence of the midge.

On each farm, twenty plants were selected systematically. One branch on each plant was selected and the total number of fruits recorded. Fruits were separated into three size categories (button, immature green and mature) and the proportion infested in each category recorded. On farms where the pest was not detected after the assessment of 20 plants, fruits on additional plants were examined until the pest was found or all plants examined.

Data Analysis

The incidence of the midge on each farm was calculated as a percentage of the total number of fruits. The farms were grouped by parish and means and

Table 1 . Location of farms visited in the survey.

Parish	Section	District	Number of Farmers	Variety*
Hanover	West	Pell River	2	Scotch Bonnet
		Orange Bay	1	Trinidad Red
		Santoy	1	Scotch Bonnet
East	Burnt Ground	1		Scotch Bonnet
		Haughton Grove	2	Scotch Bonnet
St James	South	Horse Guards	1	Scotch Bonnet
		Garlands	1	Scotch Bonnet
		Croydon	1	Scotch Bonnet
		Seven Rivers	2	Scotch Bonnet
St Elizabeth	South	Roseberry	1	Round Red
		Roseberry	1	Goat Horn Red
		Ginger Ground	1	Goat Horn Red
		Emmaus	1	Goat Horn Red
		Emmaus	2	Wl Red
	North	Baptist	1	Scotch Bonnet
		Elderslie	1	Scotch Bonnet
		Retirement	1	Scotch Bonnet
		Maggotty	2	Scotch Bonnet
Westmoreland	West	Delveland	1	Scotch Bonnet
		Mahogany Estate	1	Scotch Bonnet
		Bath	1	Scotch Bonnet
	East	Haddo	1	Scotch Bonnet
		Happy Retreat	1	Scotch Bonnet
		Belvedere	2	Scotch Bonnet
Total			30	

** Variety name as supplied by farmer*

standard errors calculated. Analysis of variance was used to compare the incidence of the midge among fruit size categories. Analyses were done using JMP statistical software.

RESULTS

Production and Marketing Systems.

Forty six percent of farmers reported that they were growing hot peppers for the first time. The median years of experience was 15 months.

Thirteen percent of the pepper farms visited were mixed stands; intercropped with either coffee or corn. The

remaining 87% of the farms visited were pure stand. Crop ages ranged from 3 to 16 months with the median age being 7 months.

One of the farmers had not reaped for two weeks because his peppers had been rejected due to infestation with the pest. He reported that levels of the pest increased after he stopped reaping.

Pest and Pest Management

Seventy nine percent indicated that they had seen the pest damage ("scarring") before and 50% referred to it as "Blackstem". Only two of the farmers interviewed were aware of the pest associated with the damage. They had been visited by personnel from the Plant Quarantine Unit. In relation to management tactics employed, although most of the farmers used chemicals to manage pests on the peppers none were directed to the midge.

Distribution and Incidence of the midge

The midge was present in all parishes visited; however, interparish differences were observed. The midge was detected on 100% of farms in Hanover and St James, 86% in Westmoreland and 27% of farms in St Elizabeth. It should be noted that South St Elizabeth, was the only area where the midge was not detected.

Incidence on farms.

The incidence of the midge on all fruits on farms across parishes was 2.8% while the incidence on mature fruits was 16.5%. The highest incidence on mature fruit (57%) was observed in Hanover (Table 2). No fruits were infested on 50% of farms. Thirty percent of farms had incidence >0-5%, whereas 7% of farms had gall midge incidence between 5 and 10% and 13% had >10% (Table 3).

Table 2. Incidence of the gall midge across parishes.

Parish	No. of farms	Infestation levels (%)			
		All fruits		Mature fruits	
		Mean	Range	Mean	Range
St Elizabeth	11	0.27	0-1.5	0.29	0-1.7
Westmoreland	7	2.2	0-10	4.02	0.20
Hanover	7	4.6	0-16	57	0-100
St James	5	6.4	0-18	13	0.32
Overall	30	2.8	0-18	16.5	0-100

Table 3. Incidence of the gall midge on three stages of hot pepper fruit development.

Category	Incidence of the gall midge on stages of the hot pepper fruit (%)			
	All fruits	Button	Immature green	Mature fruits
0%	50%)	(100%)	(93.3%)	(57%)
0-5%	(30%)	(0%)	(3.3%)	(17%)
5-10%	(7%)	(0%)	(0%)	(3%)
>10%	(13%)	(0%)	(3.3%)	(23%)
Overall	(100%)	(100%)	(100%)	(100%)

Significant differences in infestation were observed among the various stages of the fruit. The highest level was in mature fruits (17%; Table 4). No infestation was detected in button fruits.

Table 4. Gall midge infestation of three development stages of the hot pepper fruit.

Development stage of fruits	Mean No. of infested fruits	% infested
Button	11.7	0.00
Immature Green	39.9	3.36
Mature	51.3	16.5
SE (87 df)	5.73	4.09
P	<0.001	0.0133

DISCUSSION

Based on farmer reports and the widespread distribution of the pest, it appears that the midge is not a new pest. Although infestation levels on the majority of farms were below 5%, the pest was detected in all parishes. The zero tolerance ruling by USDA/APHIS meant that shipments were rejected on detection of one pepper with the midge. As a result of this some farmers were avoided by exporters when the pest was detected on their farm. Based on farmer reports, yield per week per 1000 plants range from 18 to 360 kg. Those farmers who were prevented from selling their crops because of the pest, lost between J$1260 and J$25,000 per 1000 plants per week at $70 per kg.

Current practices characterised by poor field sanitation favour the pest. Twenty-three percent of farms had mature fruit with incidence greater than 10%. Some of these farmers had not reaped for some time. This condition may have in part, facilitated the increased levels observed. One of the farmers with high levels had not reaped for two weeks because his peppers had been rejected due to infestation with the pest. He reported that the levels increased after he stopped reaping. The use of cultural practices such as removal and destruction of all infested fruit at harvest, close monitoring of the crop especially in areas which are conducive for the pest (shaded areas where the soil is likely to retain moisture) may therefore assist in keeping the pest at manageable levels. Poor post harvest procedures and the lack of adherence to quality standards observed in the districts visited may have also contributed to the interception levels within the western region. Sensitisation of farmers within the major pepper growing communities to the pest, the associated damage, field sanitation and the market requirement is critical in the control of the pest. In addition, a rigid inspection and sorting programme at packing houses would also be useful in reducing the number of interceptions. However, post harvest protocols need to be developed which outline more stringent sorting procedures. Training of packing house staff will also be vital.

Very little information is known locally on the behaviour of the pest. Confirmation of the identity of the pest, symptomology, as well as further studies to determine the relationship between crop phenology and infestation levels are therefore critical. These studies will assist in developing an Integrated Pest Management (IPM) strategy for the control of the pest.

ACKNOWLEDGEMENTS

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INTEGRATED PEST MANAGEMENT of the SWEETPOTATO WEEVIL: A Pilot study in South Central Jamaica

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ABSTRACT

The sweetpotato Weevil, *Cylas formicarius* (Coleoptera: Apinoidae) is one of the most yield limiting pests affecting sweetpotato, *Ipomoea batatas* (Family: Convolulaceae) production in Jamaica. Losses as high as 50 percent of total yield have been reported. Effective low resource biologically based technologies which are readily adaptable including the use of selected cultural practices and mass trapping with high doses of sweetpotato weevil sex pheromones, have been successfully used in Asia to manage the weevil. Under the CARDI/CRSP IPM research programme, six farmers in three districts in South Central Jamaica were selected to demonstrate the effectiveness of this sweetpotato weevil IPM technology under local growing conditions. An initial baseline survey was conducted to determine the farmer's perception of the pest and the production practices being utilised. A modified farmer field school approach was used to disseminate the IPM technology to the pilot farmers. At harvest, weevil populations were estimated traps baited with low doses (10 ug) of weevil sex pheromones and crop loss assessments executed on IPM pilot farms and neighbouring farms within the target districts. Depending on the socio-economic factors, pilot farmers utilised the IPM technology to varying degrees. In comparison to neighbouring farms, IPM pilot farmers had significantly less weevil infestations and root damage ($P<0.050$). Marketable yields were also higher on the majority of IPM farms but, overall this was not significant ($P>0.05$). With special considerations to the socio-economic factors identified, refinement of the IPM practices currently being recommended are discussed. Also, the observations on the improvements in the knowledge base and competence of the pilot farmers in IPM are examined in relation to the principle based approach used to transfer the technology.

INTRODUCTION

As far back as 1669, the sweetpotato weevil, *Cylas formicarius* (Coleoptera: Apionidae) was identified as a yield limiting pest of sweetpotato in Jamaica (Fielding and Crowder 1993). Today, the weevil is still one of the most destructive pests affecting sweetpotato production, reducing marketable yields by more than 60 percent in some areas. Damage occurs when female weevil lay eggs within the vines as well s the surface of the roots and developing larvae tunnel and feed within the roots. In response to the presence of the weevil, roots produce terpenoids which render them unpalatable (Sata et al 1983).

A review of the research report over the past 100 years describe several control methods to manage the weevil; including cultural practices, resistant varieties, chemicals, charcoal, and wood ash. Yet the weevil has not been successfully managed after all these years. Non-adoption of the recommended tactics by farmers due to socio-economic factors (labour, marketing, lack of knowledge and/or understanding by farmers of the problem and the recommended practices) have been cited by several authors as possible reasons (Payne 1983), Fielding and Van Crowder 1993).

Farmer-participation should therefore be integral in the development or refinement of any technology for the weevil so that socio-economic factors which may constrain adoption are identified and addressed before implementation. In addition, it is critical that the knowledge base of farmers be improved such that they can actively make decisions on the management of pests. The Farmer Field School (FFS) method of technology transfer which focuses on the transfer of a system of principles and decision-making tools rather than pre set

recommendations can assist greatly in the empowering of farmers.

During the past four years, CARDI, under the Integrated Pest Management Collaborative Support Programme (IPM CRSP), evaluated the potential of a sweetpotato weevil IPM technology, which has been successfully used in Asia to manage the pest. The weevil IPM technology combines low input biologically based technologies with traditional cultural practices.

The objective of the study described herein was to determine the potential this IPM technology under Jamaican conditions. Specifically the study investigated the impact of cultural methods and mass trapping with female sweetpotato weevil sex pheromone on weevil infestations and root quality.

METHODOLOGY

Baseline Survey: An initial baseline survey was conducted in three sweetpotato growing districts (Ebony Park, Heifers Run, Prospect) in South Central Jamaica to determine production practices, pest composition and management practices being utilized by farmers. Based on the survey findings, six farmers were selected to evaluate the utilizing and integrated approach to reduce root damage.

Technology Transfer of Sweetpotato Weevil IPM Technology: The integrated approach to manage the sweetpotato weevil recommended a set of options including cultural practices (field sanitation(removal of abandoned-crop residues and alternate hosts e.g. - *Ipomoea sp* "wild slip"), irrigation, quick harvesting, clean planting material) and mass trapping weevils with high doses of sweetpotato weevil female sex pheromone (Z)-3-dodecen-1-o1(e)-2-butenoate).

Farmers were exposed to the technology through a modified approach involving interactive seminars which included discussions on sweetpotato weevil biology, economic importance of the pest, current management practices and the principles of sweetpotato weevil IPM. Field demonstrations where farmers participated in the implementation of the technology were also conducted as further reinforcement. During demonstrations, farmers were shown how to use, construct pheromone traps from local materials including plastic bottles, sticks and bamboo, and maintain traps.

Impact Assessment: Two to four seasons after the farmers were introduced to the technology, weevil infestations and root damage were assessed on the 6 ilot farms. Similar parameters were assessed on 8 neighbouring farms where farmers utilised limited cultural practices only (Non-IPM).

Sweetpotato Weevil Infestation Assessment: Immediately before harvest (approximately 4 months after planting), traps were baited with 10 ug of female sex pheromone (Z-3-dodecen-1-o1(E)-2-butenoate) were placed in the sweetpotato fields for 48 hours. The numbers of weevil caught were recorded. Weevil catch was estimated by counting 5 sub-samples of 500 weevils, determining the average weights of the samples and extrapolating the weights to the total catch.

Yield Quality: At harvest, losses due to the weevil were determined. Total harvest was weighed and sorted into marketable and unmarketable yields. The weight of each category was recorded and unmarketable yields sorted further with respect to various categories of damage (weevil, white grub, rat, cracks, immature, bruising, other). Each category was then weighed.

Analyses: Restricted Maximum Likelihood Estimation (REML) using the GENSTAT statistical package was used to compare root damage on IPM and Non-IPM farms. Adjustments were made for district effects. Weighed analyses were utilized with total yield being used as the weighting actor. Weevil counts were analysed by Analysis of Variance (ANOVA) using the IMP statistical package.

RESULTS AND DISCUSSION

Significantly lower numbers of weevils were caught on IPM pilot farms when compared to NON-IPM farms; mean weevil catch per hectare of sweetpotato after 48 hours was 187 (SE 57) and 8266 (SE 1675), respectively. Similar trends were observed for losses in yield due to the weevil. Those farmers exposed to the IPM technology experienced significantly lower weevil damage than Non-IPM farmers (P=0.007); weevil damage averaged 1 percent (SE 3%) and 16 percent (SE 3.4%) of total harvested yields respectively.

In relation to productivity, IPM farmers had significantly higher yields than Non-IPM farmers (P=0.01), yields were 8,556 kg/ha (SE 1121) and 2,607 kg/ha (SE 1,303) respectively.

No significant difference was observed in marketable yields between the groups (P= 0.9). Perusal of the crop loss profile indicated that significantly higher levels of damage resulting from immatures of the sweetpotato leaf beetle (16%) were observed on IPM farms when compared to Non-IPM (3%) (SED 4.45%) (P>0.005). No significant differences were therefore observed in marketable yields between the groups. Overall, marketable yield was 78.4 % of total harvest.

The findings of the study indicate that the IPM measures adopted by farmers were in part responsible for the reduction in weevil populations and the reduced levels of weevil damage observed. However, in order to ensure sustainability of the approach, it is critical that the socio-economic factors identified for non-adoption by IPM farmers, be considered in the further development and refinement of sweetpotato weevil IPM. For example, in order to accommodate farmer practice of allowing animals to graze in old fields, pheromone traps may have to be used to hold populations down until these fields are ploughed under. Additional training sessions need to be conducted to reinforce the relationship between trap maintenance and trapping efficiency. On 30 % of pilot farms, traps were not frequently rotated and/or had debris in the catchment container.

Moreover, it is critical that other tactics are investigated so as to optimize the number of components available for farmers. Ideally, these tactics should be effective against the weevil and other major pests such as the larvae of the sweetpotato leaf beetle, *Typhorous sp.* Which caused high levels of damage on IPM farms. Joint investigations between CARDI and USDA under the IPM CRSP programme, have demonstrated the potential of USDA multiple pest resistant lines as a pest management option under Jamaican conditions (Lawrence et al 1998). Several of these lines showed moderate resistance to the weevil as well as the leaf beetle larva. Lines which meet market standards and consumer acceptability will be integrated into the current pest management programme. Based on the cross cutting nature of these resistant lines, they will be able to be utilized , not only within a management programme for the sweetpotato weevil, but also other soil pests which limit sweetpotato potato production.

Another dimension to the study which should be highlighted was the improvement observed in the competence and knowledge base of farmers who were trained in the management of sweetpotato weevil. Indicators of farmer improvement were reflected by:

Improved execution of the recommended tactics: The type of cultural practices as well as the number of practices did not differ between pilot IPM farmers and non-IPM farmers. However, IPM pilot farmers conducted the cultural practices more thoroughly and this may be attributed to the farmers gaining a better understanding of the biology (relationship between weevil life stages) and behaviour and thus the rationale behind the tactics recommended.

Diffusion of knowledge from pilot farmers to other farmers within the districts: Farmers established pheromone traps within friends fields and in some cases farmers from neighbouring parishes came to observe fields in which IPM was being conducted.

More structured experiment: Testing cóntrol strategies is not novel to farmers; however, farmers appeared more stimulated to conduct more structured experiments independent of the researcher.
Improved decision-making in relation to when and how to apply control practices was also observed.

In summary, the study identified that an integrated approach can effectively reduce sweetpotato weevil populations. Empowerment of farmers and their continued participation in the building of integrated pest management programmes for the control of the weevil will enhance the programme in the future.

APPROACHES TO MANAGING CITRUS TRISTEZA VIRUS (CTV) DISEASE IN JAMAICA.

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ABSTRACT

Although the citrus tristeza disease has been reported in Jamaica from 1959, severe strains of the virus was only confirmed in 1992 when a survey was conducted. Mild strains were widespread while severe ones were present in the two major citrus growing parishes, Manchester and St. Catherine. The discovery of the Brown Citrus Aphid (BrCA) in Jamaica and Cuba in 1993 resulted from a northward movement of the pest from Venezuela in 1976 into the Caribbean region in 1989. Over 90% of Jamaica's citrus orchards are established on sour orange rootstock, a cultivar which is highly susceptible to CTV. The presence of all three factors- severe strains of the virus; BrCA an efficient vector of the virus, and highly susceptible cultivars as rootstock, makes an effective disease management system urgent and critieal. This paper discuss the programmes being considered.

INTRODUCTION

The failure to establish sweet orange and mandarin on sour orange rootstock in South Africa in the late 1890's was due to the presence of CTV, and not because of incompatibility between scions/rootstock. This was supported by the fact that these scions/rootstock combination grew successfully in California and elsewhere as reported by Webber (1925). The involvement of the virus in the failure of Satsuma grafted on sour orange in Florida was also proposed by Swingle (1909). The resultant plants grew slowly and were mere "dwarfed bush".

Zeman (1931) and Carrera (1933) described symptoms of a disease observed in Argentina in 1930, while Topopeus (1937) working in Java observed symptoms which he believed to be the same disease and advanced the theory that the sweet orange top developed some substance which was lethal to the sour orange rootstock.

Fawcett and Bitancourt were the first to suggest that the disease was caused by a virus following a visit to infected orchards in Argentina in 1937 (Bitancourt 1940). Subsequent to intensive research, Fawcett and Wallace (1946) confirmed that the disorder was caused by a virus. Meneghini (1946) working in Brazil simultaneously reported that tristeza was caused by a virus and the brown citrus aphid, *Toxoptera citricidus* Kirk., was a vector of the virus.

Moreira (1942), however was the first to use the name "tristeza" a Portuguese word meaning "sadness" or "melancholy". This has become the accepted name as the various disorders were determined to be identical or at least elosely related.

The discovery by Hughes and Lister (1949) that an aphid transmissible disease of lime trees induced veinal flecks and stem pitting, followed by studies by McClean (1950) in South Africa, Costa, Grant and Moreira (1950) in Brazil and Wallace and Drake (1951) in California resulted in the "lime test" being use as a diagnostic tool for tristeza. It was also observed that seedlings of West Indian (Mexican) lime (C. auranlifolia Swing) developed a specific kind of vein clearing and other diagnostic symptoms after infection with tristeza virus which led to the conclusion that lime disease, stem pitting of grapefruit, tristeza and quick decline are caused by the same virus.

BrCA was first observed in Brazil and Argentina in the 1930's resulting in the loss of 30 million citrus trees on sour orange rootstock by the subsequent spread of CTV. It was next detected in Venezuela in 1976 where 6 million trees on sour orange rootstock was reported killed by CTV by 1987.

The movement of the BrCA continued, reaching Costa Rica in 1989, Dominican Republic, Puerto Rico the Southern Caribbean island and Nicaraqua in 1992, Cuba and Jamaica in 1993, Florida 1995, the Bahamas and Belize in 1996.

The progressive spread of the BrCA in the region, the presence of CTV and over 200 million trees establish on the highly susceptible CTV, rootstock - sour orange put these orchards at tremendous risk. Moreover, this vector specie spreads CTV 25 times more efficiently than other and within five years after its introduction into an area epidemic losses can be expected.

Economic Importance

In Jamaica, Approximately 400 farmers produce citrus on 15,000 acres (6.073 hectares)of land. Some 10,000 persons are employed on farm and another 13,000 involved in marketing and processing. The industry is serviced by approximately 50 nurseries which produce over 90% of the plants grafted on sour orange rootstock. The production of citrus in 1996 was 180,200 tonnes with 10,023 tonnes being exported and realizing US$5.69 million. About 90% of citrus produced is consumed locally at a value of J$500 million.

The citrus industry of Jamaica though relatively small in absolute trade and production volume, plays an important role in the nation's socio economy. It generates labour and has a special niche in the international market.

Although CTV and psorosis were reported in the island since 1959 by Dr. L.C. Knorr a Pathologist from Florida, and confirmed by Dr. W.C. Price a Virologist from Lake Alfred Experiment Station (Tristeza on grapefruit at Wakefield and Bodles, St. Catherine, on sweet orange at Irwin, St. James, and Psorosis on grapefruit at Bodles, St. Catherine,) it did not pose a problem. However, with the presence of the BrCA in 1993 its colonization and rapid spread, the scenario has drastically changed.

Certification Programme

The presence of the virus, its efficient vector BrCA, and the susceptible rootstock makes citrus very vulnerable to CTV. This will necessitate the change to CTV tolerant rootstocks so as to combat the threat.

It poses another problem as these rootstocks are susceptible to other graft-transmissible viruses and viroids. For example, *Exocortis* and other viroid will limit growth and productivity on citrange citrumelo and sweet lime rootstock, *Cachexia* on mandarin and Macrophylla rootstock, Citrus tatterleaf on most citrange, citrumelo, trifoliate and lemon rootstock as well as lemon and limes grown on other rootstocks. By using only certified citrus plants any CTV tolerant rootstock may be considered as the certified scion budwood will be free of other viruses.

The FAO at the request of the Government of Jamaica provided technical and legal experts in establishing the frame work for a Citrus Certification Programme. The Jamaica Government through the Ministry of Agrieulture has delegated the implementation of the programme to the Jamaica Citrus Protection Agency (JCPA). The JCPA will be a registered liability company be financed through membership fees, acreage fees, and service fees. There will be a board of management supported by a technical advisory council.

Technical Aspect

The technical aspects of the programme will involve all the biological phases, i.e selection of parent material, rootstock, indexing, cultural practices etc. in the production of certified disease free planting material.

Parent trees will be established by importing pathogen free budwood from a elean stock programme that implement or complies with the FAO/IPGRI guidelines for the safe movement of Citrus Germplasm or local clones based on documented evidence of desirable traits, such as yield and/or fruit quality data. Local clone selections

will be sent to an institution where a recognised clean stock programme is practiced and undergo shoot tip graft transmissible diseases.

All prospective parental accessions will be indexed as follows:

* **Short term indexes for CTV (conducted by ELISA), citrus viroids (except cachexia), and psorosis complex of viruses.**

  Freedom from viroids will be done by biological indexing using citron scions maintained under warm temperature, followed by extraction and analysis on polyacrylamide gels if no symptoms are expressed citron.

  Freedom from cachexia may be tested from the inoculated citron by use of polyacrylamide gels and/or reverse transcriptase polymerase chain reaction assays with the use of proper positive and negative controls.

  Freedom from psorosis complex of viruses may be tested by graft inoculating a nursery plant, such as rough lemon or sweet orange, and top-working with a live bud of Rusk citrange.

* **Long term indexes for freedom from citrus cachexia viroid and citrus tatterleaf virus.**

  These three should be observed for two years for symptoms expressions. These long term indexes should be completed by the time the trueness of type of the fruit has been verified.

  Cachexia viroid is long term indexed by planting two trees propagated from the prospective parent trees on either Orlando tangelo or Clemelin root stock.

  Citrus tatterleaf virus is long term indexed by planting two trees propagated from the perspective parent trees on Poncirus trifoliata rootstock.

* Budwood from the prospective parent trees may be conditionally released upon negative indexing results for the short term indexes, but the subsequent budwood propagations will be subject to recall if cachexia, citrus tatterleaf virus, or other virus is indicated by the long term indexes.

Administration

The Jamaica Citrus Protection Agency (JCPA) will be responsible for administering the programme. It comprise a Board of Directors which will oversee the legal and financial aspects, with a council which is responsible for the technical matters. Registration of nurseries, certification of scions, seed source trees, local clone accessions, variety trial, budwood cutting and service fees will be the responsibility of JCPA.

- **Seed Source Trees**

These will be trees established for the production of certified seeds which will be used for indicator plants (indexing) and rootstock for citrus propagation. These will undergo test for psorosis complex (the only virus known to be seed transmitted in citrus) and if found negative will be certified and registered. Certification will be for a period of four years and the trees and those immediately surrounding them will be inspected visually on an annual basis for freedom from bark and leaf symptoms of the psorosis complex, citrus blight citrus viroids, decline, gummosis or other recognisable disease symptoms as well as fruit or foliage mutation

Physical

The physical structures required for operating the programme are:

1. A large insect proof screenhouse with double door for the production of indicator plants for indexing.
2. Two glasshouses with controlled temperatures

   (a) A cool room with temperatures of 24°C-30°C in the day and 18-20°C at night for viruses which require cool temperature for best symptom expressions.
   (b) Warm room with temperature 30-35°C in the day and 20-24°C at night for viruses which require warm conditions for symptom expression.
   (c) Hot room with temperature of 32-40°C in the day and 24-27°C at night for preconditioning of budwood prior to thermo-therapy.

REGIONAL ASPECT

Jamaica is in the process of establishing a citrus certification programme like its neighbours Belize, Cuba and others in the Caribbean basin.

The Inter-American Citrus Network has already undertaken a survey on the distribution of the BrCA in the region. Two projects are being developed.

- To challenge the advance of BrCA/CTV in the region and subsequent development of virulent strains of CTV.
- The production and distribution of certified planting material (disease-free with high productive potential and quality) in all countries of the region.
- A meeting to standardize the indexing procedure tool place in June of this year.

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THE SCREWWORM AS A PEST IN THE CARIBBEAN AND PLANS FOR ITS ERADICATION FROM JAMAICA AND THE OTHER INFESTED ISLANDS USING THE STERILE INSECT TECHNIQUE (SIT)

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ABSTRACT

The New World Screwworm (NWS), *Cochliomyia hominivorax* (Coquerel) has been shown to be of widespread occurrence and distribution in the majority of countries in the Caribbean Region. Its occurrence is without regard to seasonal variations, type of ecological community and altitude. This pest currently presents a serious problem for these countries making for significant economic losses to the livestock industry in addition to posing potential public health risks.

A programme for the eradication of this insect pest has been initiated in Jamaica. Annual losses due to NWS infestation in this particular country are estimated to range from US$5.5 B 7.7 million. The eradication of this pest should serve to eliminate the current losses while greatly contributing improvement of the expansion of the Jamaican livestock industry. It is expected that a successful Jamaican programme will serve as a model for future programmes in the other Caribbean countries namely, Cuba, Haiti and the Dominican Republic which have also been confirmed as being NWS infested.

Eventually the entire Caribbean should be screwworm free with the exception of Trinidad and Tobago which will have to be eradicated in association with South America. This paper will discuss the current status of the NWS eradication efforts in Jamaica and the rest of the Caribbean.

INTRODUCTION

The screwworm, ***Cochliomyia hominivorax*** (coquerel), was eradicated from the Caribbean island of Curacao in 1964 (Baumhover et al, 1955) with that programme being considered a test of the SIT principle. In 1959, the pest was eradicated from Florida and with the concept fully established as a sound and novel entomological principle (Baumhover 1966). In 1962, a similar programme was initiated in the Southeastern United States with a barrier established along the Mexican-US Border (Bushland 1975). In 1975, the pest was eradicated from the island of Puerto Rico, the US and the British Virgin Islands (Williams et al 1977). By 1981, the pest was totally eradicated from the United States and from all of Mexico in 1986.

It has since been eradicated from Belize, Guatemala, Honduras, El Salvador and Nicaragua. The eventual goal of the programme is to eradicate the pest from Costa Rica and Panama down to the Darien Gap where a sterile fly barrier will be maintained.

In the Caribbean Jamaica, Hispaniola, Cuba, Trinidad & Tobago are the only countries infested. Despite this fact, no comprehensive eradication plans have ever been made for these countries. However, based on the great success of the programme elsewhere and recent interest shown by various international organizations and governments in countries which are infested, the situation is changing rapidly. Currently, the country which is most prepared for an eradication programme is Jamaica where government officials have long shown an interest.

For example, in 1959, a group of Jamaican livestoek owners visited with officials associated with the Florida eradication programme. Since this date serious consideration has been given and several attempts made by Jamaica to implement an eradication programme but without success. Real progress was made in 1997 based principally on efforts of the Jamaica Veterinary Services Division (VSD) when cooperation was established with the International Atomic Energy Agency (IAEA), Food and Agriculture Organization (FAO) and Animal and Plant Health Information Service of the United States Department of Agriculture (APHIS/APHIS/ARS) with respect to the preparation for an eradication programme. Preliminary organizational activities for this programme have been started with the expectation that the first sterile fly releases will be made in January, 1999 to initiate what is projected to be a 3-year eradication campaign.

With respect to the rest of the Caribbean, the FAO currently has a project in Cuba which is aimed at a determination of the extent of the problem and its economic impact.

Concurrently, the IAEA is developing a "thematic" plan for the entire Caribbean and South America.

Cuba

This is the largest New World Screwworm (NWS) infested country in the Caribbean with a landmass of approximately 114,525 km^2 and a human population of 10,870,000. (Table 1). An eradication programme for Cuba will require about 150 million sterile flies per week for two (2) years, a full year to organize the programme, two (2) years for actual eradieation and about one (1) year for verification of results. It is possible that the country could also be eradicated in two sections which would take longer but fewer sterile flies at one time. The cost of eradication would likely to be in the region of US$54 million (Table 2), with the costs somewhat higher if the 2-phased approach were to be selected. A one step approach would add cost based on the need for more emergence chamber space for flies. On the other hand, it would reduce the time needed for the eradication as well as eliminating the need for quarantine and a buffer zone. The cost-benefits from eradication have not yet been determined for Cuba but this work is currently being undertaken through the sponsorship of the FAO. The current data collected have indicated that the NWS is a serious problem in the country and that the insect is widely distributed throughout and affects all warm blooded species while being active at all seasons of the year

Table 1. Comparison of Size (Miles^2/km^2) and Human Population of Caribbean Countries Where the Screwworm is or was Endemic.

COUNTRY	SQ. MILES	SQ. KM	POPULATION
CUBA	44,205	114,525	10,870,000
HAITI	10,710	27,750	6,764,000
DOMINICAN REPUBLIC	18,700	48,440	7,471,000
JAMAICA	4,410	11,425	2,469,000
PUERTO RICO	3,640	8,960	3,580,000
TRINIDAD & TOBAGO	1,980	5,130	1,265,000

Table 2. Estimated Cost of Eradicating NWS from Cuba.

Item	Estimated Cost
Sterile Flies (estimated at 1,700/million for 2 years)	26,000,000
Chilled Fly Chambers for Fly Emergence	3,000,000
Information Campaign	4,000,000
Quarantine Campaign	3,000,000
Administration	3,000,000
Dispersal Centre Operation	12,000,000
Miscellaneous Costs	4,000,000
Field Operations	7,000,000
TOTAL	**54,000,000**

Hispaniola

Hispaniola which comprises both Haiti and the Dominican Republic is considered an infested area. Both countries occupy equivalent landmass of 10,710 km^2 each and with human populations of 6,764,000 (Haiti) and 7,471,000 (Dominican Republic) (Table 1). The population of both countries is fast growing with an expected increase of 1.5 million within the next 10 years. The best estimates of NWS damage at this time (FAO) is US$16.0 million and US$10.0 million annually in the Dominica Republic and Haiti respectively. In both countries there is currently no organized effort to control the pest although NWS is well known by local people. The problem is believed to be either ignored or neglected by the local authorities. It is suspected that the greatest losses to the livestock industry and the biggest human health problem resulting from NWS infestation anywhere may well be found in these two countries once the relevant impact studies are conducted.

Despite the current situation these two countries may well be the most important ones for eradication to take place at this time in the region. It is being suggested that the best approach to the implementation of an eradication programme for them is a combined programme which utilizes a single distribution centre for both.

The estimated requirements for such a programme is about 95 million sterile flies weekly at a total cost of US$36,000,000 million. (Table 3). The time frame would be similar to that for Cuba.

Table 3. Estimated Cost of Eradicating the NWS from Hipaniola.

Item	Estimated Cost
Sterile Flies (estimated at 1,700/million for 2 years)	17,000,000
Chilled Fly Chambers for Fly Emergence	1,000,000
Information Campaign	2,000,000
Quarantine Campaign	1,000,000
Administration	1,500,000
Dispersal Centre Operation	9,050,000
Miscellaneous Costs	1,000,000
Field Operations	3,000,000
TOTAL	**35,550,000**

South America and Trinidad and Tobago

The landmass associated with the NWS in South America is very large. The literature contains numerous reports of infestations in Columbia, Venezuela, Suriname, Guyana, French Guiana, Ecuador and Paraguay. There are reports of human infestations in Uruguay, Peru and Bolivia. The temperatures in the southern regions of Argentina and Chile, as well as, high elevations of the Andes Mountains are notably too cold for the survival of the NWS. The situation is similar for parts of the Brazilian and Guiana highlands. An estimate of the areas of South America which is continuously NWS infested is placed at 50% with another 30% of the land area invaded each year but only to be eliminated by cold weather at the end of the warm season. This is only an estimate of the situation and data need to be collected in all of the countries in order to determine the true situation.

The Twin Island state of Trinidad and Tobago is also NWS infested. Given their geographical location with and almost contiguous border with South America an eradication effort at this time would best be considered in association with this area rather than as a part of the Caribbean. This may well be so unless new information pointing to the contrary becomes available.

Jamaica

Jamaica lies in the Caribbean Sea 145 km south of the southern most extremity of Cuba. The greatest length of the island is 235 km and with its greatest width being 82 km. The topography consists mainly of coastal plains

around the island separated by a central mountain range running from the east and with hills and a limestone plateau occupying the central and western areas of the interior. The land area is 11,422 km^2. The island has a tropical climate which is modified by the influence of the sea, the trade winds and to a lesser extent, by land and sea breezes. There are four (4) seasons distinguished mainly by the differences in rainfall but conditions are not uniform over the island and vary considerably according to altitude and location.

Usually, the major rainy season starts in August and reaches a peak in May. However, periods of heavy rainfall and drought may occur at any time during the year. The lowest temperature occurs in January or February the peak temperature usually occurs in July or August. In coastal areas, the average daily temperature ranges from about 23 - 28 °C. However, the temperature often rises to about 30°C during the afternoon and may fall as low as 18°C. in the early mornings during the cool season.

Screwworm infestation is widespread in Jamaica and without regards to seasonal variations, altitude or ecological conditions. All types of livestock operations are affected irrespective of size and management practice. Trang (1998 unpublished study) estimated that the annual benefits from eradication would be between US$5.5 and 7.7 million. Benefits were defined as losses avoided due to (1) mortality and (2) additional expenses for labour associated with surveillance, prevention and treatment of infested wounds, and (3) loss in productivity of infested animals. Assuming an eradication cost of US$9.0 million, she calculated net savings after 3 years as ranging from US$4.2 million to US$13.5 million. It was further estimated net benefits to be between US$25 and 43 million after 10 years.

Active infestations are likely to occur in any season but appear to be related to the wetter periods. However, this pattern is modified by traditional production schemes for calving, branding etc. In most instances wounds are treated by the owner and not reported to veterinarians. Snow et al (1976) reported that peak occurrence was in October during the major rainy season, and that there was a smaller peak in February, several months before the minor rainy season. They reported 210 cases in their paper as cattle, 151; swine 20; sheep 11; goats23 and horses 5.

Cattle were by far the principal economic host, followed by swine and goats. They reported dogs were more likely to be the single most important host of the screwworm in Jamaica. Private veterinarians have reported to the senior author that from 15-30% of clinically treated dogs were for screwwom infestation. Dogs are most heavily infested during the mating seasons when they stray from home for days at a time and become wounded while fighting.

Unlike cattle, dogs are rarely treated until after infestation. Rawlins and Sang (1984) reported pigs as the most important host in Jamaica and that screwworm occurred in all parishes. Table 4 presents data taken from this paper where they reported that infestation was the most prevalent in the umbilicus of neonates, bites and barbed wire cuts. Tick bites, castration wounds and branding scars were of lesser significance.

TABLE 4: NWS Infestations of Five-Types of Wounds Seen in NWS Infestation in Jamaica in 1981.

Animals	Branding Scars	Accidental Cuts	Tick Bites	Neonate Umbilicus	Castration Wounds
Beef Cattle	7	43	10	54	7
Dairy Cattle	1	27	2	19	8
Pigs	1	4	3	15	24
Goats	2	5	2	18	5
Sheep	0	0	1	2	0
Horses	0	5	1	1	1
Dogs	5	3	2	0	6
Donkeys and Mules	2	1	1	-	0
Cats	0	1	0	0	1

The occurrence of screwworm infestation in Jamaica is as such that potentially all wounds occurring at any time of the year can be infested. It is estimated that 80% or more of all untreated wounds are likely to become infested. Most producers have become so accustomed to living with the screwworm that they take prophylactic actions without considering the cost involved.

The livestock operations range from large seale to medium size commercial and smaller backyard and "down-the-road" type operations. Cattle production comprises the largest and most important component of livestock industry in Jamaica with approximately (350,000 heads) and with beef (67%), dairy (15%) and dual purpose and draft animals the other (18%). Currently Jamaica is not self-efficient in beef production but hopes to attain this goal within the next 10 years. The other livestock of importance include goats (440,000), pigs (210,000), equines (33,000), and sheep (4,000). Most of these animals, particularly goats are found in small-type operations of fewer than 5 animals. However, all operations regardless of size have some methods of controlling screwworm infestation.

No wild animals capable of supporting infestations such as the white-tailed deer, rabbits, opossum or peccaries are present in Jamaica. The only likely candidates are a few wild pigs in the eastern region of the island and the mongoose, an animal introduced in the last century to destroy rats and snakes in the sugar plantations. It has not been determined if the mongoose serves as a reservoir host for NWS.

Reports of human myiasis have been made by both public and hospital officials who considered this a minor problem. However, anecdotal information suggests that NWS myiasis in human is a significant problem on the island. It should be noted that a major problem in terms of determining true prevalent rate is that of reporting non or underreporting of cases, The cases reported are for the most part have been observed in children, the senile, the mentally retarded and individuals not receiving adequate medical attention or those experiencing substandard levels of personal hygiene. Usually, infestations are found in the legs, toes, facial sores and nasal cavities.

The Eradication Programme

The plan is to eradicate the NWS from Jamaica by the use of the Sterile Insect Technique (SIT) which involves the sequential aerial dispersion of adequate numbers of radiation-sterilized NWS over the entire island. An estimated twenty million pupae per week will be obtained from the Mexican-US Screwworm Commission in Mexico. These pupae will be flown weekly to emergence facilities in Jamaica. Once emerged, these pupae will be subjected to aerial release 4 days of each week. An estimated 15 million sterile flies are expected to emerge from the 20 million pupae each week thereby making for a 1,200 sterile flies sq./km aerial release over the entire country.

It is estimated that this eradication programme will require three (3) years for completion. This includes (6) months for the programme organization, two (2) years of sterile fly releases and another (6) months for free-status verification. The cost of the programme will be approximately US$9.0 million dollars (Table 5).

Table 5. Estimated Cost of Eradicating the NWS from Jamaica.

Item	Estimated Cost
Sterile Flies (estimated at 1,700/million for 2 years)	3,536,000
Chilled Fly Chambers for Fly Emergence	500,000
Information Campaign	800,000
Quarantine Campaign	50,000
Administration	1,214,000
Dispersal Centre Operation	1,500,000
Miscellaneous Costs	300,000
Field Operations	1,100,000
TOTAL	**9,000,000**

Most of these funds will be used for the purchasing of flies and aerial release component of the programme. The necessary funds for implementation has been secured through budgetary allocations by the Jamaican Government and with financial assistance from the International Atomic Energy Agency (IAEA). Additional support will be that given through a "cess" on slaughter cattle agreed to by the local livestock association. Technical and "in kind" assistance will also be provided by the USDA/ARS and the US-Mexican Screwworm Eradication Commission.

To facilitate the economic and effective use of the SIT and to ensure an early positive impact, implementation will be supported by ground-based activities aimed at reducing the local wild fly population. Intensive animal inspection measures and wound treatment regimes will be initiated in collaboration with lqcal livestock owners. These activities will involve the regular inspection of all domestic animals throughout the island and will include prophylactic and curative treatment with selected insecticides. Larvae found in wounds will be collected, recorded, preserved and identified. The data obtained will be used as the basis for estimating the density and distribution of the screwworm and for monitoring the progress being made towards final eradication.

Finally, to prevent the spread of infestation, all livestock movement will be effectively controlled through the strengthening of quarantine and other existing regulatory measures. Similarly, all animals will be inspected and treated prior to leaving the country and with strict import entry for all animals with respect to screwworm free-status. Animals with infested wounds or with abrasions susceptible to infestation will be quarantined and treated. At some point in the future, following a successful Jamaican programme similar eradication programmes will be planned and be implemented for the other Caribbean islands with the Jamaican programme serving as the model.

In summary, the available information suggests that NWS myiasis is well recognized and acknowledged to be economically devastating to the livestock sub-sector of the Caribbean Region. Despite this fact, in most of these countries competing national priorities for scarce budgetary allocations may suggest that such eradication programmes may not be seen as being expedient. However, based on unknown experience the immediate and long-term returns from an NWS free-status will more than offset the cost of any eradication programme. More importantly, the eradication of NWS have repeatedly been shown to contribute greatly to the alleviation of rural poverty and the promotion of an orderly development of integrated crop and livestock production systems in those countries which have undertaken such a programme

A successful Jamaican eradication programme would not only serve as a model for future eradication efforts in the other countries of the Caribbean but should also serve as an important barrier against re-infestation of already free areas of both the Caribbean and mainland America.

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