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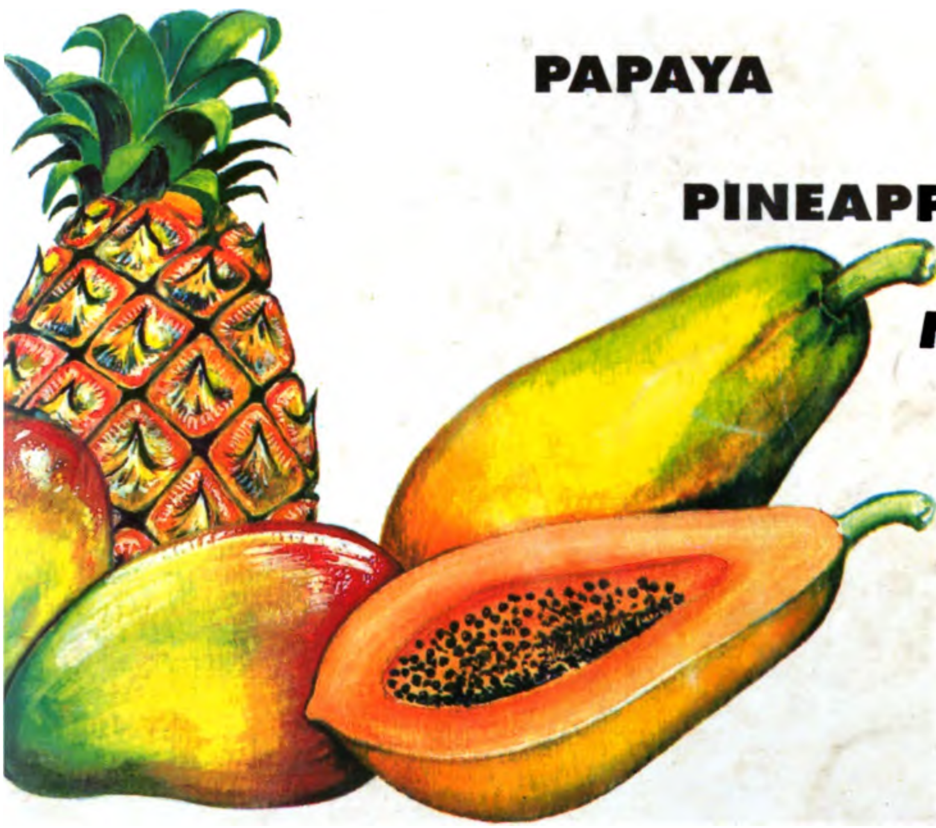
INTER-AMERICAN INSTITUTE FOR COOPERATION ON AGRICULTURE
OAS

OND REGIONAL WORKSHOP N TROPICAL FRUIT CROPS

Beach, Antigua, December 1-6, 1991



PAPAYA

PINEAPPLE

MANGO

ADCU
OECS
AGRICULTURE DIVERSIFICATION
CO-ORDINATING UNIT

CARDI
CARIBBEAN AGRICULTURAL RESEARCH
AND DEVELOPMENT INSTITUTE

RICULTURE
IGUA & BARBUDA

"WHAT IS IICA?"

The Inter-American Institute for Cooperation on Agriculture (IICA) is the specialized agency for agriculture of the inter-American system. The Institute was founded on October 7, 1942 when the Council of Directors of the Pan American Union approved the creation of the Inter-American Institute of Agricultural Sciences.

IICA was founded as an institution for agricultural research and graduate training in tropical agriculture. In response to changing needs in the hemisphere, the Institute gradually evolved into an agency for technical cooperation and institutional strengthening in the field of agriculture. These changes were officially recognized through the ratification of a new Convention on December 8, 1980. The Institute's purposes under the new Convention are to encourage, facilitate and support cooperation among its 32 Member States, so as to better promote agricultural development and rural wellbeing.

With its broader and more flexible mandate and new structure to facilitate direct participation by the Member States in the activities of the Inter-American Board of Agriculture (IABA) and the Executive Committee, the Institute now has a geographic reach that allows it to respond to needs for technical cooperation in all of its member states.

The contributions provided by the Member States and the ties IICA maintains with its 13 Permanent Observer Countries and numerous international organizations provide the Institute with channels to direct its human and financial resources in support of agricultural development throughout the Americas.

The 1987-1993 Medium Term Plan, the policy document that sets IICA's priorities, stresses the reactivation of the agricultural sector as the key to economic growth. In support of this policy, the Institute is placing special emphasis on the support and promotion of actions to modernize agricultural technology and strengthen the processes of regional and subregional integration. In order to attain these goals, the Institute is concentrating its actions on the following five Programs: Agricultural Policy Analysis and Planning; Technology Generation and Transfer; Organization and Management for Rural Development; Trade and Agroindustry; and Agricultural Health.

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SECOND REGIONAL WORKSHOP ON TROPICAL FRUIT CROPS

Jolly Beach, Antigua, December 1-6, 1991

PAPAYA, PINEAPPLE AND MANGO

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Contents

List of Acronyms

ADCU	Agricultural Diversification Coordinating Unit
AIDB	Agricultural Industrial and Development Bank
APHIS	Animal and Plant Health Inspection Service
ARCD	Agricultural Rehabilitation and Crop Diversification Project
AREP	Agricultural Research and Extension Project
AVT	Agricultural Venture Trust
BDDC	British Development Division in the Caribbean
BWIA	British West Indian Airways
CAB	Commonwealth Agricultural Bureau International
CARDI	Caribbean Agricultural Research and Development Institute
CARICOM	Caribbean Community
CARIRI	Caribbean Industrial Research Institute
CATCO	Caribbean Agricultural Trading Company
CBI	Caribbean Basin Initiative (USA)
CCGA	Co-operative Citrus Growers' Association
CDB	Caribbean Development Bank
CEMACO	Central Marketing Corporation
CEPAT	Continuing Education Programme in Agricultural Technology
CIDA	Canadian International Development Agency
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
DAI	Dominica Agro Industry
EDF	European Development Fund
EEC	Economic European Community
FAO	Food and Agriculture Organization
HIAMP	High Impact Agriculture Marketing Project
IICA	Inter-American Institute for Cooperation on Agriculture
INRA- AG	Institut National de la Recherche Agronomique-Antilles-Guyane
IRAT	Institut de Recherches Agronomiques Tropicales et des cultures vivrières
IRFA	Institut de Recherches sur les Fruits et Agrumes
JAMPRO	Jamaican Promotion Corporation
MAIL	Ministry of Agriculture, Industry and Labour (St. Vincent and the Grenadines)
MNIB	Marketing and National Importing Board
MoA	Ministry of Agriculture
NDF	National Development Foundation
NRI	Natural Resources Institute
OAS	Organisation of American States
OECS	Organisation of Eastern Caribbean States
PFU	Productive Farmers' Union
PROCACAO	Regional Network for Cocoa Technology Generation and Transfer
PROCIANDINO	Cooperative Agricultural Research and Technology Transfer Programme for the Andean Sub Region
PROCISUR	Cooperative Programme for the Development of Agricultural Technology in the Southern Cone
PROMECAFE	Cooperative Programme for the Protection and Modernization of Coffee Cultivation in Mexico, Central America, Panama and the Dominican Republic
ROC	Republic of China
SPV	Service de la Protection des Végétaux
SLDB	St. Lucia Development Bank
SSMC	St. Kitts Sugar Manufacturing Corporation
TROPRO	Tropical Products Support Project
UNDP	United Nations Development Program
USAID	United States Agency for International Development
UWI	University of the West Indies

FOREWORD

Given the market uncertainties and depressed prices for the traditional export crops, within recent times Caribbean countries have been making concerted efforts to diversify the agricultural base of their economies and foster inter-sectorial linkages, particularly with tourism and agro-industries. Fruits are among the main agricultural commodities targeted for the diversification thrust.

Accordingly, in 1989, technicians from the Caribbean Agricultural Research and Development Institute (CARDI), the Agricultural Diversification Coordinating Unit of the Organization of Eastern Caribbean States (ADCU/OECS) and the Inter-American Institute for Cooperation on Agriculture (IICA) agreed to implement a series of workshops to address some of the main constraints to the development of the fruit sub-sector emphasizing in particular, those commodities that appear to have export potential.

The first workshop, which dealt with passion fruit, avocado and citrus, was hosted by the Ministry of Agriculture in Dominica and this second workshop in Antigua and Barbuda dealt with papaya, pineapple and mango. It is proposed to hold a third workshop in the near future, to focus on golden apple, soursop, breadfruit, carambola and other exotic fruits.

In the second workshop, there were some 65 participants from 14 countries in the region, a fact which illustrated the widespread interest in the selected commodities.

The workshop also brought together representatives from a number of regional agencies (CARDI, ADCU, UWI, CATCO) in a collaborative effort to address some of the many problems. It was particularly gratifying to have had the support of our French colleagues from INRA and IRFA. IICA is fully supportive of such collaborative initiatives which bring together a wide range of expertise and experiences to identify and resolve constraints in a cost effective manner. We at IICA look forward to the continued collaboration of these agencies in support of the efforts of Member States to develop a diversified, modern and competitive agricultural sector.

Reginald E. Pierre

Director of Operations (Caribbean) and
Representative in the Eastern Caribbean States (Acting)

ACKNOWLEDGEMENT

The organizers of this Regional Workshop would like to acknowledge the support received from persons and institutions without whose assistance the organisation of the workshop would not have been possible.

First we would like to recognize and acknowledge the outstanding participation of all delegates and speakers from the 14 Caribbean countries participating in the Workshop. Without their inputs this effort would have been meaningless.

Our special thanks to the Ministry of Agriculture of Antigua and Barbuda for hosting the workshop and for the special attention each of us, including orgainzers, participants and speakers received during the workshop. Our appreciation is extended to the OECS/ADCU, CARDI and IICA for sponsoring this Second Regional Workshop.

A very special thanks to the French Inter-Ministerial Fund for the Caribbean (FIC), the French Ministry of Foreign Affairs (MAE), IICA, and ADCU for financing the participants and the speakers, as well as providing funds for the publication of these proceedings. Our gratitude is extended to UWI, CARDI, CATCO, and the TROPRO project for allowing staff members to be main speakers in the Workshop.

We acknowledge the logistic support of the IICA staff in the Trinidad and Tobago and Antigua offices for their continued assistance before, during and after the Workshop. Our appreciation is also extended to F.A.S.T.E.R. Publishing Services for the production of this publication.

Rafael Marte
Workshop Coordinator.

SECTION 1

COUNTRY PAPERS

ANTIGUA/BARBUDA

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I. Generalities

1.1. Projects

In Antigua/Barbuda there are six major tree crop projects which are currently undertaken.

(i) *Greencastle Agricultural Station* — This project was commissioned in 1932 with an objective to propagate tree crops and to produce vegetable seedlings to meet the needs of farmers, backyard gardeners, etc. In addition, experiments/crop investagtions were also conducted. The objectives of the station have not varied significantly; Greencastle remains a centre where farmers, house-owners, etc. can obtain potted fruit plants, ornamentals, and vegetable seedlings.

The project is approximately 12 ha (30 acres) and consists of the following:

Mango orchard	3.2 ha	(8 ac)
Citrus orchard (bearing)	1.2 ha	(3 ac)
Banana orchard	1.2 ha	(3 ac)
Vegetables & food crops	4.0 ha	(10 ac)
Young citrus orchard	2.4 ha	(6 ac)

The technology in terms of tree crop propagation is obsolete but effective in terms of the project's initial objective and its socio-economic spinoff or benefits in the community. Greencastle has the capacity to produce 1,500 potted plants and 30,000 vegetable seedlings annually.

(ii) *Christian Valley Plant Propagation Station* — This project began operations in 1976. Total size of the project is 28.3 ha (70 acres) which consists of the following:

Citrus orchard	6.1 ha	(15 ac)
Mango orchard	6.1 ha	(15 ac)
Avocado orchard	2.4 ha	(6 ac)
Cashew orchard	2.4 ha	(6 ac)
Guava orchard	2.4 ha	(6 ac)
Uncultivated (to be cleared)	8.9 ha	(22 ac)

The project is equipped with machinery (sterilizers, soil-mixing equipment, propagation bins/sheds, mist facilities) along with ancillary tools and equipment. In addition, Christian Valley has become the main centre for tree crop production in Antigua/Barbuda.

The project is administered on a day-to-day basis by a project co-ordinator who reports to the Director of Agriculture, along with a station manager and office and field staff. Christian Valley is reputed to have the widest collection of germplasm material within the OECS countries.

(iii) *Cades Bay Pineapple Project* — Cades Bay Pineapple Project began operations in 1960. Total area of the project is 14.4 ha (36 acres) with some 10 ha presently under cultivation. The project is equipped with one MF 265 tractor, equipment and ancillary spraying machinery specific to pineapple production. The primary objective of this project is crop research and development with a view to select and provide high yielding planting material to farmers. The pineapple cultivar grown at Cades Bay is the Antigua Black. Total acreage of pineapple is shown in Table 1.

(iv) *Agricultural Extension Tree Crop Project* — The Agricultural Extension Division embarked on a Tree Crop Development Programme for the south-western agricultural districts. The programme began in 1978 and involves 25 farmers. Farmers are currently being taught techniques in budwood selection, grafting, pruning, topworking in mango and management of tree crop orchards. Crops involved in the project are mango, citrus, and avocado. This project is most opportune because of the need to encourage farmers to invest in tree crop projects and development.

Table 1: Distribution/size of pineapple farms

Farmer	Location	Area(ha)	Plant crop	1st Ratoon	2nd Ratoon	3rd Ratoon	Fallow
Don Brown	Claremont	24.00	10.00	10.00			4.00
Dalma Browne	Claremont	2.36	1.48	0.88			
Theophelus Jacobs	Orange Valley	1.21	0.60	0.40		0.21	
Olive Humphrey	"	0.84	0.63	0.05		0.16	
Carlton Hampson	"	0.63	—	0.20	0.20	0.23	
Juliana Hampson	"	0.46	0.30	0.16			
Everett Joseph	"	0.39	0.10	0.20	0.09		
Gwendolyn George	"	0.32	0.15	0.17			
Edmund Farrel	Paterson	1.40					
Government	Cades Bay	12.88	3.52	1.94	1.16		6.26
Goodwin	"	0.20			0.20		
Others		0.80					
Total		45.47					

(v) *Papaya Project* — The Papaya Project began in 1989 and involved personnel from the Ministry of Agriculture, Lands, Fisheries and Housing, CARDI and IICA. The main objectives of this project were to introduce, select and establish papaya orchards primarily of Solo accessions as well as the transfer of technology. The project was badly affected by Hurricane Hugo in 1989, but has been revitalized with more accessions of the RM Pink and RM Yellow Solo. There are four farmers currently engaged in this pilot study.

(vi) *Tree Crop Development Project* — Recently, the Government of Antigua/Barbuda through the Ministry of Agriculture had developed a Tree Crop Development Project for the entire south-western agricultural districts. The project is not yet in the implementation phase; however, it will consist of the development of 120 ha (300 acres) of tree crop orchards. Farmers will be allocated 4 ha (10 acres) each with the primary objective to grow and develop fruit orchards. The project costs approximately EC $2.1 million and it is expected that the Agriculture Bank, that is, Antigua and Barbuda Development Bank, will execute the credit arrangements for the project.

Within the project, it is envisaged that the propagation and nursery facilities at both Greencastle and Christian Valley Plant Propagation Stations will be upgraded along modern lines. Also, an optimistic view of the project suggests that it will certainly meet the growing demand for fruits and related products within the vital tourism industry.

1.2 Ecological Problems

The major problem under which tree crops are grown and developed in Antigua/Barbuda is that of rainfall. Appendix A shows the distribution of rainfall within the south-western agricultural districts, which averages 1270 mm (50 in.) per annum. In addition, Appendix A also reflects a marked pattern from August to December each year where rainfall is highest. Obviously, the pattern or seasonality of production is related to the rainfall pattern (see Appendix A for details).

1.3 Limiting Factors

The major limiting factors for expansion in tree crop development include the following:

(i) Land tenure/lease agreements.

(ii) Lack of incentives to invest in irrigation facilities.

(iii) Competition from other agricultural sectors, e.g. vegetable crops, that are more lucrative over a short time span.

(iv) Seasonality of rainfall.

(v) Market uncertainty.

(vi) Soil type to some extent for pineapple production

1.4 Cost of Production

Cost of production and return for papaya, pineapple and mango are shown in Appendices B, C, and D.

1.5 Seasonality of Production

The seasonal variations of the rainfall in Antigua/Barbuda have a marked effect on the bearing season for tree crop production. For example, the various cultivars of mango normally begin to bear as shown in Tables 2 and 3, respectively.

Table 2: Seasonality of production for mango in Antigua/Barbuda

Cultivar	Season
Julie	April–June
Early Gold	April–June
Yellow Haden	April–June
Julie	June–August
Edward	June–August
Ruby	June–August
Tommy Atkins	June–August
Pinero	June–August
Bombay	June–August
Haden	June–August
Palmer	June–August
Eldon	June–August
Francique	June–August
Sensation	June–August
Erwin	June–August
Julie	August–October
Kent	August–October
Keitt	August–October

Source: Crop Research Unit, Department of Agriculture

Table 3: Seasonality of production for papaya and pineapple in Antigua/Barbuda

Crop	Cultivar	Season
Papaya	Solo accessions	All-year-round
	Known You	All-year-round
	Local selections	All-year-round
Pineapple	Antigua Black	All-year-round

Source: Crop Research Unit, Department of Agriculture

1.6 Main Markets

The main markets for locally produced fruits are hotels, restaurants, the Central Marketing Corporation (CMC) and the St John's vegetable market. Domestic production of the fruit crops is at least 70% of the quantity supplied, particularly mango and pineapple. Demand for these products, is met by importation of canned pineapple and to a lesser extent of mango and papaya.

It is important to note that the mango seed weevil problem in some neighbouring mango exporting countries has further eroded the demand/supply situation in net-importer countries such as Antigua/Barbuda and other drier Leeward Islands. Hence, there is need to expand the current production area to capitalize on the existing demand for those commodities.

II. Pre-production

2.1 Cultivar Selection

2.1.1 Papaya

Cultivar	Bearing season
Solo accessions (Pink & Yellow)	All-year-round
Known You	All-year-round
Local selections	All-year-round

The Solo accessions (Pink and Yellow) have been recently introduced in Antigua/Barbuda. In spite of their high yield and good fruit quality, both cultivars are highly susceptible to the bacterium *Erwina* sp. On the other hand, local selections possess drought-tolerant characteristics.

A well-managed papaya orchard crop has good market potential in view of the demand for the product in the US and UK.

2.1.2 Pineapple

Cultivar	Bearing season
Antigua Black	All-year-round

The Antigua Black pineapple is the only cultivar grown in Antigua/Barbuda. However, within that cultivar of the Queen family of pineapples there are two selections of the Antigua Black — the cylindrical shaped and the globose or rounded type.

This cultivar possesses some drought-tolerant characteristics and has yielded 20,000 kg/ha under Antigua/Barbadua soil and climatic conditions. Pineapple is grown all-year-round.

2.1.3 Mango

Cultivar	Bearing season
Julie	Early
Early Gold	Early
Yellow Haden	Early
Julie	Mid-season
Edward	Mid-season
Ruby	Mid-Season
Tommy Atkins	Mid-season
Pinero	Mid-season
Bombay	Mid-season
Haden	Mid-season
Palmer	Mid-season
Eldon	Mid-season
Francique	Mid-season
Sensation	Mid-season
Erwin	Mid-season
Julie	Late
Kent	Late
Keitt	Late

The selection of the mango cultivars (above) will enable the spread of production over a longer period of harvest. This is most opportune in the Antiguan context since these cultivars mature prior and after the annual Carnival festivities when demand for mango is highest.

2.2 Propagation

2.2.1 Papaya

Papaya is propagated by seed. However, prior to this procedure plants are selected on the basis of a number of characteristics (yield, early bearing, space between leaf axil and stem, hermaphroditic etc.), then immature flower buds are selfed to maintain the line (accessions).

2.2.2 Pineapple

Pineapple is propagated vegetatively — both side and basal suckers are used.

2.2.3 Mango

The rootstock used is Local Kidney and the major problems encountered is the incompatibility of the rootstock and scion, i.e. Local Kidney rootstock grows faster than the scion Julie, which results in a bottleneck effect around the graft area. Tip die back is now occurring in mango seedlings that have been recently potted at Christian Valley. No inference has been made since it is still in the investigation stage. The wedge graft is the main type of graft used.

2.3 Plant Demand and Supply

2.3.1 Papaya

Because papaya is primarily propagated by seed, most farmers produce their own plants; however, there is a growing demand for the higher yielding cultivars, Solo and the Known You.

2.3.2 Pineapple

In spite of the area of pineapples planted being approximately 45 ha there is the usual problem of planting material. Management problems include the removal of suckers at the correct stage. There is also the problem of the number of ratoons. These factors, or a combination of factors results in the recurrent shortage of planting material.

2.3.3 Mango

In view of the rainfall distribution shown in Appendix A, there is usually a high demand for plants at the onset of the rains. This obviously can lead to stressful conditions within the propagation unit to meet the demand. The quantity of plants demanded is higher than can be supplied. Present production is 3,000 plants per annum.

III. Production Systems

3.1 Planting

The planting of tree crop orchards (mango and papaya) conforms to the normal practices of land clearing, levelling, lining and preparation of planting holes with the incorporation of both organic and inorganic fertilizers. Holes are normally prepared in the dry season (in the case of mango) with dimensions 46 cm × 46 cm × 46 cm (18 in × 18 in × 18 in). About 60–90 g (2–3 oz) of inorganic fertilizer (NPK) and pen manure are mixed thoroughly prior to planting. In the case of pineapple the beds are prepared (ploughed, reploughed, harrowed/rotavated and ridged) and prior the last operation triple superphosphate is broadcast and incorporated at a rate of 200 kg/ha. This operation is done as required or when weather permits. Beds are spaced 1.5 m (5 ft) centre to centre.

3.2 Planting Distance

Planting distances within the orchards are as follows:

Julie mango	8 m × 8 m	(25 ft × 25 ft)
Large cv. mango	9 m × 9 m	(30 ft × 30 ft)
Pineapple	30 cm × 45 cm	(12 in × 18 in)
Papaya	1.8 m × 2.4 m	(6 ft × 8 ft)
	2.4 m × 2.4 m	(8 ft × 8 ft)

3.3 Crop Husbandry

3.3.1 Fertilization

(a) Papaya—For papaya, a week before planting 60–90 g (2–3 oz) of NPK is incorporated in the planting holes. Fertilization is done every 6 weeks at a rate of 115 g (4 oz) per application, until each plant obtains an annual application of 2.25 kg (5 lb) per plant per annum. Prior to fruit induction a foliar application is given every 2 weeks.

(b) Pineapple—For pineapple fertilizer (triple superphosphate) is broadcast at a rate of 100–200 kg/ha (1-2 cwt/ac) prior to the last land preparation operation. Potassium nitrate and urea are applied at rates of 200 and 100 kg/ha (200 and 100 lb/ac) in split applications in the first year of crop life.

At 9 months a mixture of boron, Ethrel and urea is applied to induce flowering and to correct boron deficiencies. Subsequent application is made at 17-day intervals. This is not a general practice since optimum results are obtained from the use of Ethrel.

(c) Mango—For non-bearing mango trees the frequency of application of NPK is three times per year at a rate of 113–227 g (G–H lb) per tree per application. As the tree approaches 5 years, the frequency of application is reduced and the amount of NPK increased to approximately 0.5–1.0 kg (1–2 lb) per tree.

For bearing trees fertilization is normally done after harvest and at fruit setting. Bearing trees are usually fertilized twice per year at a rate of 4.5 kg (10 lb) per tree or (5 lb per application of NPK). Muriate of potash and potassium nitrate are used for fruit development.

3.3.2 Crop Protection

(a) Papaya—The major problem affecting papaya in Antigua/Barbuda is the bacterium *Erwinia* sp.

Fungicides used are Ridomil, Benlate, Dithane M45, Manzate 200. Insecticides used are Perfekthion, malathion, diazinon, Decis, etc.

(b) Pineapple—To control the syphilids, Furadan or D.D. is incorporated during the final operation (ridging). Other chemicals used are malathion and diazinon to control the mealy bug which is the major pest in the dry season.

Weed control is done by manual, mechanical and chemical means. Chemicals used are Hyvar X or a Hyvar X/Karmex combination known as Krovar I or II depending on concentration, i.e. 1 or 2 kg/ha (1 or 2 lb/ac).

Chemical is applied after planting with good soil moisture. A subsequent application is used to control nutsedge (*Cyperus* sp). Evik (ametryne) is used post-emergence as a directed spray to control broadleaf weeds during fruiting.

(c) Mango—The major problems within the mango orchards are powdery mildew and anthracnose. Sulfur (elemental) is used to control powdery mildew and is usually applied after a heavy dew. Other fungicides used are Tri-Miltox Forte and Benlate (benomyl). Insecticides used are Malathion and Perfekthion.

Weed control is accomplished by manual, mechanical, and chemical means. Chemicals used are Reglone/Gramoxone and Roundup.

3.3.3 Pruning

For mango, pruning is done regularly with the available labour. However, in view of the demography and the low output of workers, it is envisaged that labour-saving devices, e.g. small tools, could increase productivity at the station. Pruning of trees is usually done after harvest.

3.3.4 Mulching

Mulching and other soil and water conservation measures are done.

3.4 Yields

Mango	10–12 dozen/tree
Pineapple	15,000 kg/ha (lb/ac)
Papaya	100–120 fruits/tree

3.5 Causes, Effects and Control of Factors Affecting Production

3.5.1 Rainfall

Appendix D shows an average distribution of rainfall in the southern agricultural districts. More than 50% of the annual precipitation occurs between August and December.

3.5.2 Management

Management of orchards is to optimize production — regular pruning, fertilizing, removal of suckers, crop logging.

3.5.3 Soil Type

To some extent soil type in pineapple expansion is a major limiting factor since it grows well in neutral to medium-acid soils.

3.5.4 Working Capital

Timely procurement of the working capital is necessary to carry out essential management practices, procurement of inputs, etc.

IV. Harvesting

4.1 Methods

Harvesting of orchard crops is still done manually. However, a 3.7 m × 5.5 m (12 ft × 18 ft) fruit-picker along with a stepladder have been locally fabricated to improve harvesting efficiency.

4.2 Maturity Indices

At Christian Valley, problems are experienced in determining the correct stage to harvest mango. The current technology is done by computation, fruit set to fruit maturity. This principle has not worked out for all mango cultivars.

V. Post-harvest Handling

5.1 Transportation from Field to Packhouse

Fruits are collected in field crates 30 cm × 45 cm × 90 cm (12 in × 18 in × 36 in) with holes 1.25 cm (0.5 in) in diameter, then transported by pick-up or tractor cart to the field shed or office where they are sold.

VI. Marketing

6.1 Prices

The selling prices for mango, pineapple and papaya are as follows:

Papaya (green)	EC $0.50/lb (0.5 kg)
Papaya (ripe)	EC $1.50/lb (0.5 kg)
Pineapple	EC#2.60/lb (0.5 kg)
Mango	EC $10.00/dozen

6.2 Supply/Demand

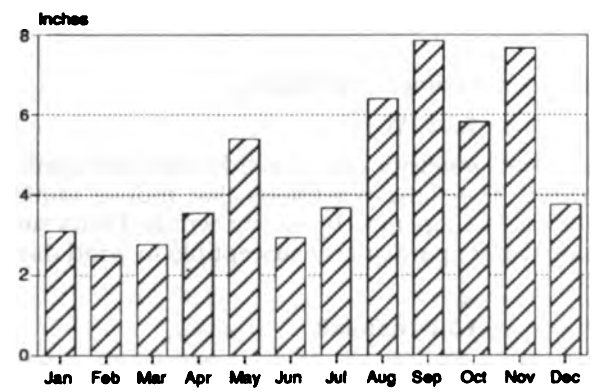
Appendices E, F and G show in detail the production of mango at Christian Valley and Greencastle and pineapple production at Cades Bay.

Antigua/Barbuda is a net importer of canned pineapple products and to a lesser extent of mango and papaya nectar in order to meet local demand.

In view of the proposed development of the tree crop industry in Antigua/Barbuda, it is envisaged that fruits will be sold within the domestic fruit trade along with prospects to develop cottage industries. Industrial processing may be possible once production can justify it.

Appendix A

Average monthly rainfall, 1986–1990
for the Southern District, Antigua/Barbuda



Appendix B

Cost of production and returns for papaya per 0.4 ha (1 acre) in Antigua/Barbuda

Activity	Year 1	Year 2	Year 3
Establishment cost	1,600	—	—
Labour	400	450	450
Fertilizer	450	450	450
Chemicals	300	300	300
Transport (pick-up)	150	200	200
Maintenance cost	400	400	400
Total variable cost	3,300	1,800	1,800
Revenue	5,000	10,000	10,000
Gross margin	1700	8200	8200

Source: Crop Research Unit, Department of Agriculture

Appendix C

Cost of production and returns for pineapple per 0.4 ha (1 acre) in Antigua/Barbuda

Activity	Year 1	Year 2	Year 3
Establishment cost	2,000	—	—
Labour	500	600	600
Fertilizer	450	500	500
Chemicals	300	350	350
Transport (pick-up)	200	300	300
Maintenance cost	450	450	450
Total variable cost	3,500	2,200	2,200
Revenue	—	20,000	10,000
Gross margin	–3,500	12,800	7,800

Source: Crop Research Unit, Department of Agriculture

Appendix D

Cost of production and returns for mango per 0.4 ha (1 acre) in Antigua/Barbuda

Activity	Year 1	Year 2	Year 3	Year 4	Year 5
Establishment cost	1,942	52	—	—	—
Labour	540	630	660	870	960
Fertilizer	29	61	117	174	220
Chemicals	157	157	135	135	135
Transport (pick-up)	—	—	—	84	126
Maintenance cost	726	848	912	1,263	1,449
Total variable cost	2,668	900	912	1,263	1,449
Revenue	—	—	—	1,050	1,575
Gross margin	–2,668	–900	–912	–213	126

Source: Crop Research Unit, Department of Agriculture.
NOTE: Spacing: 8 m × 8 m (25 ft × 25 ft); Density: 175 trees/ha (70/ac).

Appendix E

Mango production (kg) at the Christian Valley and Green Castle propagation projects

Year	Christian Valley	Greencastle
1986	1,448	2,225
1987	4,545	1,112
1988	1,293	2,482
1989	1,909	2,454
1990	3,495	2,454

SOURCE: Crop Research Unit, Dunbars

Appendix F

Pineapple production (kg) at the Cades Bay project

Year	No. of fruit	Production	Av. Fruit weight
1987	55,870	33,099	0.59
1988	92,248	47,584	0.51
1989	95,070	48,018	0.51
1990	59,929	27,719	0.46

SOURCE: Crop Research Unit, Dunbars
Note: Higher hectarage of ratoons

Appendix G

Distribution (ha) of the pineapple crop at the Cades Bay project

Year	Plant crop	1st Ratoon	Subsequent ratoons	Total
1987	2.80	2.24	2.95	8.00
1988	1.93	2.80	3.26	8.00
1989	2.80	2.40	2.80	8.00
1990	2.40	1.20	3.20	6.80

SOURCE: Crop Research Unit, Dunbars

BARBADOS

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I. Generalities

Barbados lies within the humid tropics, its climate being influenced by the north-east trade winds. Precipitation, the most variable climatic factor, fluctuates annually, seasonally, as well as within the island.

Soils in Barbados are mainly limestone-derived and many of them display vertisol properties. However, in one area which is called the Scotland District, the soils have a distinctly non-calcareous nature. These silty clays are often slightly acid, but contamination by coral colluvium often raises the pH above 7.

The main export crop of Barbados is sugar cane, but recent problems in marketing of this crop have spurred a drive towards a diversification programme. Fruit production has been cited as one of the sub-sectors for increased development.

1.1 Projects

The only formal programme which is being expedited at the moment is the Fruit Development Programme. This programme is funded primarily by the Government of Barbados with only a few external inputs in the area of marketing.

1.2 Ecological Problems

1.2.1 Wind

High wind intensity affects production and quality of fruits. The same conditions that induce rainfall are often accompanied by strong winds. Fruits such as papaya are particularly susceptible to wind damage.

1.2.2 Rainfall

Few areas on the island offer possibilities for rainfed production, so complementary water is required for good productivity. Whereas rainfall figures may seem adequate when an annual total is quoted, the distribution is often where the problem lies. During the dry months the rainfall drops below the level required for nearly all of the crops. This combines with high solar radiation and steady winds to place trees under a lot of stress. Mango in deep soils remains "evergreen" even in the peak dry season but numerous young plants are lost due to wind/drought stress. Even pineapple plants do not perform well in drier areas without strategic irrigation. Drought stress also predisposes papaya to bunchy top attack. Other effects of rainfed planting have been reduced growth and yield and poor quality fruit.

1.2.3 Soils

The calcareous nature of our soils poses a problem for most fruit species but the appropriate chemicals can be used to manage orchards under these conditions. The main problem is the availability of these chemicals. The inputs may also prove to be expensive to growers.

The fact that many of our soils are vertisols complicates the estimation of irrigation requirements. The strong water retention tendency of such soils has its implications in terms of the type and frequency of irrigation that is desirable. It is also likely that a large portion of the moisture that enters the soil in the drier months is not available to fruit trees. The cracking nature of these soils may also be damaging the roots of trees and making them further unable to extract water from the soil. This is an area which seems worthy of some research.

1.3 Limiting Factors

1.3.1 Pests and Diseases

A range of pests and diseases affect fruit in Barbados. Table 1 shows the main problems affecting the major species. These pre-harvest problems have been found to seriously affect the quality of fruit and, so, the marketing. The variations in quality that result are particularly limiting to export-oriented production.

The problem in controlling these biological invaders is often the lack of adequate spraying equipment. Critical in solving this problem for commercial orchards, is the development of private spraying units. The government provides this facility only on a very limited basis.

Of the internationally important pests, mango seed weevil (*Strenochetus mangiferae*) is the only one which has been recorded. This precludes the export of mangoes to some countries.

1.3.2 Monkeys and Birds

These larger pests are a serious problem and are very difficult to control. Susceptibility of fruit varies depending on species, location and time of year. Electrical fencing seems like the only practical way of controlling monkeys. The measures that control birds in the orchard situation tend to be very expensive. Mangoes and papayas are particularly susceptible to these pests.

1.3.3 Livestock Damage

This problem has been a serious constraint to fruit production, especially in the establishment phase. The trampling and chewing of young plants can be devastating, especially in the dry season when fruit trees may be the only green plant in the field. Although legislation is in place to deal with this problem in the Scotland District the control of farm animals remains extremely difficult as it has a deep socio-economic rooting.

1.3.4 Praedial Larceny

This is another problem which is escalating in its impact, and has caused many growers to delay

Table 1: Main problems affecting production

Crop	Factor	Effect	Control
Papaya	Bunchy top	Eventual death of tree	Variety selection; control of vector
	Phytophthora	Death of plant; Fruit rot	Site selection (adequate drainage); Post-harvest hot water treatment
	Anthracnose	Post-harvest rot	Pre-harvest chemical treatment; Post-harvest hot water treatment
	Mites	Leaf defoliation; Fruit bronzing	Chemical control
	Thrips	Predisposes fruit to secondary infection	Chemical control
	Aphids	Predisposes fruit to secondary infection	Chemical control
	Leaf hopper	Vector for bunchy top	Chemical control
	Birds & monkeys	Loss of yield	Early harvesting
Pineapple	Scales	Reduced plant growth	Chemical control
	Mealy bugs	Reduced plant growth; Lower fruit quality	Chemical control
	Crown rot	Death of plant	Pre-plant chemical treatment; adequate crop husbandry (weeding)
Mango	Anthracnose	Fruit drop; Post-harvest rot	Chemical control; varietal selection; Hot water treatment
	Seed weevil	Loss of seedling material	
	Snow scale	Poor aspect of fruit Death of young plants	Chemical control
	Sooty mold complex	Lower fruit quality; Reduced tree growth	Chemical control
	Mealy bugs	Reduced growth of young trees	Chemical control
	Shoot borer	Shoot die back	Routine chemical control
	Mites	Fruit bronzing	Chemical control
	Birds	Fruit damage	Netting or small scale; Early harvesting

expansion or to discourage others from planting orchards. Pineapples and mangoes seem to be "highly prized" by thieves. The current economic crisis is likely to increase the incidence of this problem.

It must be noted as well that research efforts have been affected by the theft of produce. At Codrington Agricultural Station a lot of the yield data has been unobtainable due to persistent larceny. The Florida types of mango are often stolen long before maturity because they develop a "blush" from early.

1.3.5 Herbicide Damage

Because of the widespread growing of sugar cane, 2, 4–D damage often affects certain fruit and vegetables. Papaya is particularly susceptible to this chemical. High levels of drift have caused decline while lower levels led to flower abortion. The chemical also weakens the trees and makes them more susceptible to bunchy top. Mango and pineapple seem to be more tolerant to this problem.

1.4 Area Planted

During the past decade there has been a steady increase in the planting of mango orchards. So far the most popular size seems to be 0.5–1 ha. Papaya planting has fluctuated from time to time, the current crop area has not been assessed recently. However government has recently established about 1 ha of farm plots. Pineapple plots fluctuate as well, but at the moment about 7 ha are recorded.

Table 2: Current status of fruit planting in Barbados (ha)

Crop	Commercial	Backyard	Goverment
Mango	44.8	133.2	5
Pineapple	7.0	*	*
Papaya	*	*	1

* Figures unknown at time of preparation of paper.

1.5 Cost of Production

Returns from fruit production seem favourable. However, labour costs in Barbados are high compared to most other countries in the region. Table 3 compares these differences.

Table 3: Comparision of labour costs in countries of the region

Country	Labour cost (US$/day)
Dominica	7–9
Grenada	4–5
St. Lucia	7–9
St. Vincent	4–6
Dominican Republic	2–3
Barbados	19

Source: Estefanell et al. (1987)

1.6 Seasonality of Production

Most of the fruits growing in Barbados are characterized by a short period of availability (3–4 months of the year). Mangoes and pineapples show a high seasonality. Local mangoes are available from June to August.

For mangoes the approach has been to introduce "off season" varieties. These early and late season cultivars have been introduced and, in trials, have proved their ability to extend the bearing season. Cultivars of mango such as Julie. Perelouis, also give three or four bearings throughout the year and so extend the season of availability.

1.7 Markets

Apart from the large amount of fruit which goes directly from producer to consumer, the marketing system consists of the following channels: hawkers (hucksters), 40% of the market; wholesalers; supermarkets; hotels and restaurants.

There are three main marketing organizations involved in fruit marketing. These are the Barbados Marketing Corporation (BMC), the Agricultural Commodity Trading Company (ACTCO) and the Caribbean Agricultural Commodity Trading Company (CATCO).

The BMC, a statutory board, typically handles very little of the market (less than 10%) but has played a major role in cherry exports. ACTO, which is the marketing arm of the Barbados Agricultural Society, has been active in purchasing and distributing non-sugar commodities. Papaya and breadfruit have been exported to the United Kingdom through CATCO on a significant scale.

The handling of export produce through the BMC has been greatly enhanced by the introduction of the Export Packaging Unit. This facility, which operates as a pilot unit provides containers to farmers for proper handling and uses a refigerated truck for storage and transportation of perishable export produce to the airport.

A new processing plant began operation in the late 1980s and has been set up to process cherry, guava and passion fruit among other produce. There are also some 16 processing companies operating, three of which are making products from bananas and plantains.

For ease of analysis and presentation a number of markets are differentiated in this paper as each one of these demands a specific treatment. The distinction is as follows:

(i) From farm to:

(a) Packing and Processing
There is little information on the volume of fruit handled by processors and on the whole these facilities are limited. The main problem at this stage is a vicious circle which prevents the development of agro-processing, i.e. insufficient fruit production causes processors to be unable to develop and this precludes them from offering

contracts to farmers for the development of fruit crops.

(b) Fresh Fruit Market

Little information on volumes is available. There are imperfections in the market at the farm gate as well as at the retail point. Buyers set the price at the farm and again at the retail market. Bargaining in the market place is almost unheard of, perhaps due to a limited amount of fruit being available or maybe because sellers are not close together in one market building. This situation however, gives way to more competitive pricing when fruit are plentiful.

Public markets do not play a very significant role in the market system of fresh produce. Very little produce is sold from within these buildings. This maybe because many of the vendors, especially of imported fruit, practice more aggressive marketing in high traffic areas such as bus-stands and main streets. Consumers often have no need to go to the market building. Within recent times, also a larger amount of local fruits is being sold in the bigger supermarkets.

The problem of praedial larceny tends to complicate the marketing process since stolen fruits are sold at prices which bear no relation to normal market prices. Another source of competition for fruit vendors who concentrate on local fruit is the trend towards the sale of imported fruit such as grapes and apples. While this activity has generated income to the persons who sell them, the share of the consumer's income which is spent on these fruits is no longer available for purchasing local fruit.

(ii) From Packing and Processing to:

(a) Export

Exports of processed fruits are very small and consist mainly of fruit flavourings and preserves. Many of these exports are to CARICOM countries.

Export of papaya has been done on a significant scale. The biggest problem facing these export ventures has been in maintaining a volume of homogenous quality. A high rejection rate was obtained for papaya on the export market because of variation in size and bruising of the fruit. In this situation many of the papayas ended up on the local market. With these volumes of fruit being channeled to the local market, many smaller papaya growers withdrew from the market.

(b) Local Consumption

Most of the processed fruit is consumed locally. The potential for the use of local fruit in flavouring ice cream and beverages seems to be under-exploited since imported concentrate is still widely used. This maybe because the supply of local produce is unreliable. The prices of local produce may also not be sufficiently competitive to offset the use of imported concentrate.

(iii) Imports

There seems to be little information on volumes of intra-regional trade. However, because of the mode of operation (transportation, handling, storage) it is likely that there are many losses incurred. This trade, which is mostly handled by hawkers (hucksters), has however been able to supply adequate amounts of fruit to consumers in Barbados over the years. Mangoes are imported from neighbouring islands at some times of the year. A large amount of pineapple is also being imported from Guyana at the moment.

It has been noted previously that imported fruit such as apples and grapes offer competition to local fruit. Local production and import trends show no clear relationship. In fact the imports appear to be more closely related to the production season of the exporting country (mainly USA) and the peak consumption periods of Christmas and the tourist season.

II. Pre-production

2.1 Cultivar Selection

2.1.1 Papaya

Over a period of time a number of lines have been developed. The two main selections are Barbados Yellow and Barbados Pink. Both are tolerant to bunchy top. Fruit size for Barbados Yellow is 300–600 g and for Barbados Pink, 650–1200 g. The problem in papaya propagation has been to maintain the selected lines in the long run. The limited storage life of seeds also makes it difficult to keep planting material.

2.1.2 Pineapple

Two cultivars of pineapple are grown; the Antigua Black and the Smooth Cayenne with fruit sizes of 2 and 1 kg respectively. Antigua Black has a long shelf-life whereas Smooth Cayenne has a short shelf-life but a high brix.

2.1.3 Mango

A range of mango cultivars is available from the plant nursery.

2.2 Propagation

2.2.1 Pineapple

The problem in propagation is still the supply of plant material. Propagules of Smooth Cayenne have been introduced and were distributed to farmers with the intention of operating a revolving scheme. Poor maintenance of these plots has led to a low generation of plant material.

2.2.2 Mango

Propagation is mainly by wedge and side veneer grafts. The biggest problem is in getting seedlings for rootstock. High infestation by the mango seed weevil has made it necessary to check seed first for the weevil and pay suppliers on the basis of the percentage of good seed.

The main rootstocks used are Mango Long and Thousands.

2.3 Plant Demand and Supply

The biggest problem at the plant nursery lies in supplying plant material for commercial plantings in the time frame that is usually required. This has a number of aspects.

First of all there is the plant propagation lag time. This requires that a grower who plans to plant a larger orchard may need to approach the nursery one year before, depending on the species. In addition, timing of production at the nursery is made difficult when rainfed planting is done. This creates a heavy demand at the beginning of the rainy season while at other times of the year plants may be in storage for a long time. Introduction of irrigation in orchards should help to reduce this peak demand period. Some private nurseries are also showing interest in propagating fruit trees for commercial orchards.

In terms of availability of specific cultivars, a range of material is available for different purposes. However, for some of these the volumes of plant material is limited.

Short term supply of papaya planting material is adequate for small plots. However, in the long term there is a need to develop measures to preserve the genotypes which are selected. Micropropagation methods have been developed for this purpose and it is expected that these will be applied as soon as the tissue culture laboratory becomes functional.

Provision of pineapple plant material has also been difficult. The revolving scheme for propagules has failed to a large extent because of the inadequate maintenance of the private plots. Therefore only a limited amount of plant material is currently available.

III. Production Systems

3.1 Planting Distance

3.1.1 Papaya

Spacing is usually 2.5 m × 2.5 m. Some smaller plots use a system where plants are planted on the top of 2 m beds. Adjacent rows of plants are then staggered in this system.

3.1.2 Pineapple

This crop is grown on a ridge and furrow system. Ridges are 1 m apart and planting consists of a staggered double row on the ridge. The distance between rows is 0.3 m while intra-row spacing is 0.35 m.

3.1.3 Mango

Spacing is generally 8 m × 8 m though smaller trees like Julie can be planted at 6 m × 8 m. Some plantings of larger trees may be extended to 8 m × 10 m. Planting is usually done on a square grid.

3.2 Crop Husbandry

3.2.1 Papaya

The problem is sometimes low fertilizer application although residual high levels of fertility have caused problems as well. Weed control is perhaps the biggest problem in larger plots. Herbicide damage to the lower trunk has been a persistent problem. Hand-weeding of larger plots is expensive.

Spray programmes have been designed to control the vector of bunchy top. It has been difficult to control mites which tend to predominate after control of insect pests is achieved. Phytotoxic responses have occured in response to some products such as diazinon and Comite.

3.2.2 Pineapple

The main problem occurs in weed control, especially for difficult grasses such as nut grass. Manual weeding is difficult. It also leads to rotting of plants when soil is thrown into the apical point and some plants are dislodged. While there are chemical control methods, the timing of application often makes the programme ineffective. The high pH of the soils also necessitates the use of more expensive fertilizers. For example, rather than using ammonium sulphate it would be better to use potassium nitrate but this would cost at least 500% as much.

Impeded drainage has been a problem in many of the heavy clay soils.

3.2.3 Mango

Little research has been done on fertilizer programmes specific to Barbados. Few plots are irrigated. Survival is low in the establishment phase. Sometimes in backyard plants constant moisture leads to low flowering and fruiting. The problem of many of the large plots is the difficulty in spraying large trees.

3.3 Yields

3.3.1 Pineapple

The average weight of the Smooth Cayenne is 2 kg (4.5 lb) but fruit size has been variable, ranging from 1 to 3.5 kg (2.5–8 lb). Fruit of Antigua Black are on average 1 kg (2.5 lb).

3.4 Causes, Effects and Control of Factors Affecting Production and Fruit Quality

The main problems affecting the production of quality of fruit in Barbados are listed in Table 1.

IV. Harvesting

There are no mechanized harvesting systems in use. Harvesting is done either by climbing and throwing or by using a pole from the ground. Many persons do not attach bags to the poles and fruits often get damaged when they drop.

Maturity is usually detected by personal judgement based on experience. This has caused premature harvest of the Floridian types, usually by praedial thieves.

In the case of papaya, harvesting is done at the sight of the first yellow streak. Some people still wait for full ripening on the tree.

V. Post-harvest Handling

5.1 Transportation from Field to Pack-house

Containers are often nothing more than the commonly available utensils such as buckets and bags. Many of the export-oriented fruits, however, are handled in appropriate crates.

Vehicles are often the same as those used for vegetables and other crops. One farm which exported papayas used all-terrain vehicles to transport produce from the field. The uneveness of most roads on bigger farms most likely contributes to bruising of fruit.

5.2 Pack-house Operations

Since much of the production is for local markets most persons have not invested in any special packing facilities. Growers usually use the same facilities that are used for vegetables. These facilities range from garages and tall cellars to specially built sheds. Many fruits even go directly from the field to the market place, with only a grading and weighing.

Papayas for export have, however, been handled in a packing house. The facility includes equipment for washing and chemical treatment as well as grading and cold storage facilities.

5.3 Rejection Rate and Causes

Figures could not be obtained within the time-frame in which this paper was prepared to allow for a numerical classification.

Brusing, cuts, spray damage, smashing and pest infestation have all been observed to play a part in making fruit unsuitable for the local market. Bird damage on mangoes and papayas is also relatively high but usually these fruits are not harvested.

Bruising seems to account for a large share of the losses; in the case of exported papaya as high as 55% (Marte, unpublished paper)

VI. Processing

Very little processing of these fruits is done. A few cottage industries have utilized small quantities of mango and papaya.

VII. Marketing

7.1 Markets, Demand, Supply, Potential, Channels

7.1.1 Papaya

There is a local demand for fresh fruit but this has an upper limit and production has to be regulated to avoid gluts. There are also good prospects for local processing.

There is a rising demand for fruit on markets in the UK, Holland, USA and Canada. As an export crop it is not suitable for small farmers since the market requires a reliable volume of suitable quality. High investment in infrastructure is needed to satisfy these requirements.

7.1.2 Pineapple

Based on the imports there seems to be a strong local demand. Barbados in 1989 consumed 95% of Guyanese exports of this fruit which amounts to 576 tonnes. With careful management this crop could offer good returns on the local market but production systems need to be developed.

7.1.3 Mango

There is a heavy demand for mangoes on the local market and virtually any cultivar is acceptable. Late varieties will be used to extend the season and fetch good prices.

The export market continues to increase with a rising demand for the Floridian types. The presence of seed weevil precludes exports to the USA but markets may still be open in the UK, Holland and Canada. The competition is very tough for Floridian types but West Indian types with careful marketing might have more potential in the future.

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BRITISH VIRGIN ISLANDS

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I. Generalities

1.1 Projects

The objective of the fruit tree project is to establish 40 ha (100 acres) over a 4-year period with various tropical fruits. This project originated in 1990 with the participation of 17 farmers each planting 0.1–0.2 ha (¼–½ acre) of trees. Thus far, between 1990 and1991, a combine total of 8 ha (20 acres) has been planted.

1.2 Ecological Problems

The ecological factors affecting papaya, pineapple, mango are: poor rainfall; erosion when rains do occur and wind blowing leaf and blossoms off the trees.

1.3 Area Planted

1.3.1 Papaya

The area of planting papaya is not known.

1.3.2 Pineapple

There are 1.2 ha (3 ac) of pineapple planted.

1.3.3 Mango

There are approximately 4 ha (10 ac) acres of mango planted.

1.4 Limiting Factors for Expansion

Factors limiting expansion are: land location; uncertainty of market and high cost of land clearing.

1.5 Seasonality

1.5.1 Papaya

These can be produced all-year-round.

1.5.2 Pineapple

The main season is June to September but small quantities are produced year-round.

1.5.3 Mango

The mango season is from June to August.

1.6 Markets

These fruits are marketed locally to supermarkets and hotels. Usually the peak demand far outweights the supply.

II. Pre-production

2.1 Cultivar Selection

Papaya	Hawaiian Solo
Pineapple	Antigua Black; Local
Mango	Local Julie; Imperial; Keitt; Kent

2.2 Propagation

Papaya is propagated by seed then transplanted to potting bags. Pineapples are propagated by suckers, while mango seed and seedlings are used; there are no problems with the rootstock.

2.3 Plant Demand and Supply

Mangoes, especially the local grown variety Julie, are in great demand but the supply is limited due to the lack of labour. There are no distribution problems.

III. Production Systems

3.1 Planting Methods and Planting Distances

The clearing of the land is done by a backhoe or manually. Planting holes are dug by backhoe or pickaxe. Peatmoss or Promix is incorporated and mixed in the soil before planting.

Spacing for planting depends on the type of soil and the cultivar grown. The spacing for mango is 8 m × 8 m (25 ft × 25 ft) with one plant per hole, while two seedlings per hole is used for papaya. Pineapple is planted 1 m (3 ft) apart with only a single sucker or slip to a hole.

3.2 Crop Husbandry

3.2.1 Fertilization

Fertilizer is given at planting.

3.2.2 Weed Control

Monthly manual cutlassing of drip circle area to keep it weed-free.

3.2.3 Pest Control

Spraying insecticides etc. is done on a monthly cycle by the Agriculture Department.

3.2.4 Irrigation

A drip system for irrigation purposes has been set up by the Agriculture Department.

3.3 Yields

Estimated average of yield per tree per year for papaya is 57 kg (125 lb); pineapple yield is 9,000 kg/ha (9,000 lb/ac) while mango yield per tree is 500 fruits.

3.4 Causes, Effects and Control of Factors Affecting Production

Inadequate pruning of mango trees. Poor field sanitation results in increased diseases and pests which readily destroys the crop.

IV. Harvesting

Fruits are harvested manually.

The main techniques used to determine the maturity of the fruit are firmness of the fruit, feeling, stem judgement and sight.

V. Marketing

Because of the few fruit trees in the British Virgin Islands, fruits are not exported. They are used and sold locally. No processing is being done at the present time.

5.1 Prices

Price competition is common when supply is greater than demand. Locally grown fruits or vegetables could have great potential, if there were a steady supply. By forming a farmers association the competition could be reduced.

DOMINICA

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I. Generalities

1.1 Projects

1.1.1 Papaya

The growing of papaya has not taken any significant place in the diversification effort of the Ministry of Argiculture. It is not a component of any fruit development project. Papaya, however, has been grown and is still being produced throughout the island. It is estimated that there are about 12–16 ha (30–40 ac) established throughout the island. In most cases, it is considered as a backyard crop. However, there are a few scattered pure-stand plots. To date, no work has been done on production costs.

1.1.2 Pineapple

Pineapple production has not got a high rating in the Agricultural Development Programme. It does not form part of any programme diversifying away from bananas. It is however, grown and produced by many farmers on a fairly small scale. The area under production can be estimated at 8 ha (20 ac).

1.1.3 Mango

Dominica in its crop diversification thrust has identified mango as one of the crops for expansion and increased exports to the regional and extra-regional markets, mainly the United Kingdom.

In an effort to increase mango acreage in Dominica, the Tree Crop Diversification Project (TCDP) funded by the British Development Division for the Caribbean (BDDC) established 124 ha (310 ac) of mango (predominantly Julie cultivars) mostly in the dry coastal areas of the north-west and north-east agricultural districts of Dominica. The Tree Crop Diversification Project which started in 1978 ended in 1987.

CARDI/BDDC Exportable Fruit Crop Project (EFCT commenced in 1989. Under this project, an integrated and multidisciplinary approach has been taken to increase the production of quality mangoes from Dominica to both regional and extra-regional markets. Through agronomic, pathological, entomological and post-harvest research work being conducted in mango, it is hoped that some of the problems associated with mango production in Dominica, such as poor flowering and fruit set, anthracnose, fruit fly and gall midge, can eventually be solved.

1.2 Ecological Problems

1.2.1 Pineapple

Early in the 1980s a research station — the Wet Experimental Station — located in the interior of the island, with average rainfall of well over 7,500 mm (300 in) annually, tested pineapples under these conditions. This proved successful and a tech-pack was developed. This tech-pack was not fully adapted by farmers and this led to numerous managerial problems, particularly that of weed control. The success of this crop has led to the establishment of small plots in that area.

1.2.2 Mango

High Rainfall — Mango orchards established in areas with high rainfall regimes tend to produce a lot of vegetative growth at the expense of fruiting.

Heavy rains at flowering are highly injurious and sometimes cause a total crop failure. The mango flower is very delicate and during heavy rains, pollen grains are easily washed away.

Heavy rainfall also reduces the activity of pollinating insects and effective pollination cannot occur.

In the wet areas in Dominica where mangoes are cultivated, the incidence of anthracnose tends to be higher. The dry western coast which stretches from Soufriere in the south to Portsmouth in the north-west, characterized by a pronounced dry season and an annual rainfall of 1,750 mm (70 in), constitutes the most suitable area for cultivation of mangoes in Dominica. Here the incidence of anthracnose is lower, fruits tend to be cleaner and yields are also higher.

It is recommended that zoning should be implemented in the establishment of future orchards so as to concentrate on production in areas with the best environmental conditions.

1.3 Limiting Factors

1.3.1 Papaya

During the early 1980s to 1990s, there has been a steady decline in the areas planted; a disease destroys large numbers of trees. This disease has been the limiting factor towards expansion.

1.3.2 Mango

(i) The presence of mango seed weevil (*Sternochetus mangiferae*) has led to reduced market alternatives in the USA, Virgin Islands, Martinique, Guadeloupe and Barbados.

(ii) The presence of the fruit fly (*Anastrepha obliqua*) was confirmed in the fruit fly survey completed in 1990 in Dominica. Dominican mangoes, therefore, cannot enter the United States, US Virgin Islands and many other Caribbean islands.

1.4 Area Planted

1.4.1 Pineapple

Production is scattered throughout the island with concentrations in the north-east and east of the island. The plots size ranges from a few beds to 0.5 ha (1acre). The main varieties grown are the Black Antigua, Smooth Cayenne and some local cultivars.

1.4.2 Mango

Most of the mangoes in Dominica are grown in scattered zones and on scattered trees — 332 ha (830 ac) — with little or no attention being paid to tree or orchard management. In addition, the Dominica Tree Crop Diversification Project (TCDP) established about 124 ha (310 ac), mostly in pure-stand orchards in the drier coastal areas of the north-west and north-east agricultural districts of Dominica.

1.5 Cost of Production and Returns

1.5.1 Mango

From an economical analysis made for Julie mango on an acre basis by the Ministry of Agriculture, a farmer with an acre of well managed Julie mangoes at the full production stage yielding 500 fruits per tree can obtain a total revenue of EC$9,000; total production cost amounts to EC$1,677; thus potential returns appear to be very good with a potential profit at EC$7,323 and a return to labour of EC$177 per man-day. (See Appendix A)

1.6 Seasonality of Production

The main flowering season for mangoes in Dominica occurs between January and March; the production season lasts from May to August. (See Appendix A)

1.7 Markets for Mangoes

Julie is the main cultivar used for export to the United Kingdom and regional markets. Mango Long (Kidney) also has a good regional export market. In 1985, 1,900 tonnes of Julie and Kidney mangoes were produced, of which 178 tonnes were exported, mainly to the regional market. Export figures for mangoes from 1983 to 1989 are shown in Table 1.

Table 1: Exports of mangoes by general destination from Dominica (t)

Year	OECS	Rest of CARICOM	Rest of Caribbean	EEC	Total
1983	13.60	4.10	40.10	19.50	77.30
1984	37.27	46.26	68.75	2.06	154.34
1985	55.27	43.70	72.09	6.81	177.87
1986	43.45	16.87	50.88	0.85	112.05
1987	8.48	—	59.97	37.10	105.55
1988	3.81	—	64.84	12.53	81.18
1989	0.99	—	50.91	0.37	52.27

Source: Central Statistics Office, Dominica

The major demand for mangoes on the extra-regional markets is for fresh fruits but occasionally, small quantities of immature (green) mangoes are demanded by the European and North American markets. The demand for fresh mature mangoes in Europe (FRG, France, Netherlands and UK) has grown considerably in the last 5 years increasing from 8,000 tonnes in 1980 to 22,500 tonnes in 1986.

Julie mangoes shipped from Dominica are exported mainly to the UK where there are no quarantine restrictions. Because of the presence of the seed weevil and fruit fly a number of markets are now "off-limits" to Dominican mangoes. Discovery of these two pests has resulted in a decrease in supply of mangoes in Dominica. It is hoped that with the establishment of a hot water plant in Dominica the supply of mangoes will increase significantly, and the American market will be opened once again to our mangoes.

II. Pre-production

2.1 Cultivars

2.1.1 Mango

The characteristics of the main mango varieties grown in Dominica are given in Table 2.

2.2 Propagation, Rootstocks and Related Problems

2.2.1 Papaya

Production of papaya seedlings does not form part of the Ministry's propagation programme. There has been some interest by a few for desired planting material, but this has been too small to demand special attention. Farmers usually prepare their own planting material.

2.2.2 Pineapple

Planting materials are derived from basal shoots but

Table 2: Characteristics of the main mango varieties grown in Dominica

Variety	Colour when ripe	Average weight (g)	Fibre level	Turpentine flavour	Sweetness	Proportion of production[(a)]
Babb	Yellow	100	High	No	Extremely sweet	2%
Bitter skin	Yellow	100	Moderate	Yes	Sweet acid	5%
Graham	Yellow	450	Low	No	Sweet	0.5%
Julie	Yellow/red blush	300	Low	No	Very sweet	30%
Lieka	Yellow/red blush	90	High	Slight	Very sweet	5%
Long	Yellow	210	Medium high	No	Sweet	50%
Rose	Pink	225	Low	Slight	Sweet	1%
Tommy Atkins	Yellow/red blush	530	Low	No	Medium sweet	0.05%

[(a)] The other 6.45% of production is made up of the other minor varieties

with shortage of planting material, most plants are used.

2.2.3 Mango

The main mango variety propagated is the Julie cultivar, this is done on government propagation stations strategically located for distribution purposes. Other varieties propagated and usually on request include Tommy Atkins, Graham and some local varieties. The predominant variety used as rootstock material is the Mango Long (Kidney).

At propagation stations seeds are sown on well prepared beds. After germination, seedlings are selected and transplanted into large polythene bags with rich potting mixture. When seedlings are 30–45 cm (12–18 in) in height, grafting is done.

The propagation targets for the last 5 years projected an increase of 255 ha (637 acres). Out of this total 160 ha (400 acres) were actually established. The demand for planting material still remains high.

III. Production Systems

3.1 Crop husbandry

3.1.1 Papaya

Papayas are planted on backyard plots in well prepared holes, average 45 cm × 45 cm (18 in × 18 in). These are filled with well-rotted pen manure. In fairly large plots, they are scattered and inter-cropped with other crops.

The general management of the crop fits in with the ongoing practices. Weed control is usually done by hand in order to protect the intercrop and the commercially available NPK fertilizers are used. There has been no need for irrigation.

3.1.2 Pineapple

Pineapples are either planted on 1.2 m (4 ft) beds or on flat or gently sloping land. They are spaced 60 cm × 90 cm (2 ft × 3 ft). They mature in about 18 months.

Limited use is made of selected weed-killers mainly because of unavailability. Commercial fertilizers usually the banana type (16:8:24) are applied frequently. Fruit initiation is seldom used.

There has been a slight increase in production over the years.

This crop has great potential for export. With the recently constructed Packing house adjoining the Melville Hall airport, farmers in that area can expand cultivations.

3.1.3 Mango

In Dominica mangoes, primarily Julie, are established in pure stands, in backyard gardens or in multi-cropping combinations.

On sloping or steep land, Julie mangoes are planted at a distance of 8 m × 8 m (25 ft × 25 ft) for conservation purposes. On flat or gently sloping land, a distance of 12 m × 12 m (40 ft × 40 ft) is used so as to accomodate inter-cropping. For establishment in the field, 60 cm × 60 cm (2 ft × 2 ft) holes are dug. The plastic bags are removed without disturbing the soil around roots of the mango seedlings, which are then planted into the holes.

When mango seedlings are established in the field, weed contol is usually done manually or by using the herbicide Gramoxone.

Irrigation and spray programmes are non-existent in Dominica; mango orchards are grown under rain-fed conditions.

Farmers do not spray young orchards for control of pests and diseases. Even pruning which is an important agronomic practice which should begin in the early years of crop establishment, is not commonly practised by farmers.

It is recommended that mango seedlings about 1 year old should receive 0.5 kg (1 lb) of sulphate of ammonia. At 3 years old, trees should receive 1.5 kg (3 lb) of a compound fertilizer, usually 16:8:24 (banana fertilizer). At 4 and 5 years old, young plants should receive 2 and 2.5 kg (4 and 5 lb) of NPK fertilizer respectively.

When mango trees are about 6 years old, dense canopies start developing; it is important that pruning be done to allow for proper aeration and sunlight penetration. This also reduces humidity within the canopy.

Bagging of fruits is not done in Dominica.

3.2 Yields

Yield per mango tree varies accordingly to age and location in Dominica.

From phenololgical studies conducted by CARDI in Dominica, the average yield (full production stage) in the southern part of the island (dry area) is about 250 fruits per tree. In the west and north-western coastal areas, it is about 500 fruits per tree. In the coastal areas of the North East District, which is wetter than the south and west coastal areas, it is about 200 fruits per tree.

3.3 Causes, Effects and Control of Factors Affecting Production and Fruit Quality in the Field

3.3.1 Mango

Some of the production practices affecting quality of mangoes in Dominica include:

Locality — The effect of locality on post-harvest quality acts through the occurence of a fungal disease which is more prevalent in areas of high rainfall and high humidity. The fungus causes mango anthracnose, which attacks both flowers and developing fruits causing black spotting of ripening fruits.

In Dominica, the disease is more serious on the east coast and north of the island and in the interior. The west coastal regions between Colihaut in the northwest and Morne Patates in the south are less affected.

No practical field control programme can be recommended at this time for Dominica.

Tree spacing — Over-crowded trees produce low yields of poor quality, diseased fruit.

Pruning of mangoes is not commonly practiced in Dominica; it would allow for greater flow of air through and under the tree, and sunlight penetration. Through this practice, disease severity particularly anthracnose can be reduced, and a better quality fruit is obtained.

Inadequate nutrition — Mango trees in Dominica are not normally fertilized and almost certainly do not attain their full potential yield. Post-harvest quality is affected by fertilizer application. Nitrogen is particularly required for development of good sized fruits and potassium is needed for good colour and flower development. The application of an NPK compound fertilizer is recommended.

IV. Harvesting

4.1 Methods and Tools

4.1.1 Papaya

Papaya are harvested by hand. Fruits are reached by climbing or with the use of a ladder. A sharp knife or clipper is used to cut the stem at approximately 1 cm. Plastic field crates are used for field transport.

4.1.2 Mango

Mangoes are harvested by hand or picking pole (khali) operated from the ground and by climbing on to the tree. A number of picking poles using a moveable cutting blade have recently been introduced for evaluation by CARDI/TROPRO.

Field crates and baskets are used for harvesting and field transport of fruits.

4.2 Maturity Indices

4.2.1 Papaya

For the domestic market, fruits are harvested at the first signs of yellowing, which is usually between the lobes at the distant end of the fruit.

4.2.2 Mango

Harvest maturity of fruits is determined by growth of shoulders, colour and size.

4.3 Main Problems

4.3.1 Papaya

Difficulty in harvesting and height of trees.

4.3.2 Mango

Determination of correct harvest maturity poses a problem to some pickers. This is due to the inability of some pickers to separate mature and immature fruits often found at the same time.

Latex stains are a problem in fruits that are not washed soon after harvest or in immature fruits that are harvested.

Traditional "khalis" cause physical damage to fruits resulting in rejects and eventual decay. Tall trees make harvesting difficult and costly.

CARDI/MoA/TROPRO have recently conducted a Harvesting Workshop which trained extension officers and the main mango farmers on harvesting techniques. Also, the Post-harvest Group in Dominica has produced a booklet on post-harvest handling of mangoes for export, *Make more of mangoes* which has been distributed to extension officers and is currently used to improved production management practices.

V. Post-harvest Handling

5.1 Transportation

5.1.1 Papaya

Transportation vehicles are mainly pick-ups; containers are plastic field crates.

5.1.2 Mango

Transportation vehicles are mainly pick-ups; containers are plastic field crates.

The main problems are (i) overfilled crates, which causes damage to fruits when stacking; (ii) spread of latex.

5.2 Packhouse operations

5.2.1 Papaya

Post-harvest treatment: None.

Packing:
Fruits are packed in cardboard cartons similar in size and shape to banana and citrus cartons.

Storage:
Ambient storage conditions for local and regional markets and 13°C for extra-regional markets (United Kingdom).

5.2.2 Mango

Sorting:
Fruits are rejected for maturity, size, blemishes and mechanical damage.

Washing:
Fruits are washed in tap water with a soft sponge to remove debris and latex.

Post-harvest treatment:
Fruits for the United Kingdom are treated in hot water at 46°C for 45 mins to control fruit fly and reduce anthracnose development.

Packing:
Cardboard cartons are used for the United Kingdom market. Each carton contains 16 fruits (Julie mango) held separately by cardboard dividers. For regional markets, fruits are packaged into larger boxes (banana or citrus box), containing 40 – 60 fruits.

Storage:
Storage for the United Kingdom is at least 13°C and at ambient temperature for local and regional markets.

5.3 Causes for Rejection

5.3.1 Mango

Rejection rate (1 = most common, 5 = least common) is as follows:

- cuts and bruises 3
- smashing 4
- pests and diseases 1
- maturity and size 2

VI. Shipping and Distribution

6.1 Papaya

Dominica does not have bunchy top found in many Caribbean islands. No regulations exist on the export of papaya from Dominica. In the latter part of the 1980s, most papaya exports went to the United Kingdom. However, in the 1990, 52.4% went to Antigua while 19.76% went to Guadeloupe and St. Maarten.

6.2 Mango

Mangoes are restricted from entry to the United States and some Caribbean islands due to the presence of the mango seed weevil and the fruit fly. Mangoes are shipped from Dominica by sea (either refrigerated or unrefrigerated) and by air.

Refrigerated sea shipment is mainly used for export to extra-regional markets. The cool conditions slows down the rate at which fruit ripens.

Unrefrigerated sea shipment is a major route for export to neighbouring islands.

Air shipment is expensive and is not generally used for shipping mangoes.

Mangoes shipped to the United Kingdom are transported via Geest Line.

VII. Processing

7.1 Papaya

Papaya is used in processed products as an ingredient and also as a final product. Young green papaya is used as a filler in the manufacture of hot pepper sauce. Approximately 500 kg (1,000 lb) of green papaya is used on a weekly basis in this manner.

Papaya is also used to produce crystalized fruit on a small scale. The product is used in confectionery, cakes and desserts. About 200 kg (400 lb) of mature papaya is used weekly in this operation. The products are sold locally.

7.2 Pineapple

Pineapples are processed into pineapple jam by a small-scale processing operation. Approximately 50 kg (100 lb) of pineapple is processed on a weekly basis during the pineapple season. The product is sold on the local market in 225 g (8 oz) jars and is also exported to St. Lucia, St. Marteen, Antigua and St. Kitts.

7.3 Mango

There is no commercial processing of mango in Dominica. However, product development work in the Produce Chemist Laboratory of the Division of Agriculture has been conducted on mangoes bottled in syrup, dried mango, mango jam and mango chutney.

VIII. Marketing

8.1 Papaya

Papaya is normally in high demand. However, supply has been limited due to disease problems associated with high rainfall and humidity.

Under proper management and with suitable cultivars it is a crop which has considerable potential for export.

Papaya is sold at EC$1.61/kg (EC$0.73/lb) according to Dexia's Agricultural Trade information booklet, 1991.

Most of the export figures for the last 2 years represent papaya in the green stage, as can be seen in Table 3.

Table 3: Export of fresh papaya (kg)

Market Destination	1984	1985	1986	1987	1988	1989	1990
CARICOM							
Antigua	0	0	219	546	649	1,436	3,106
Barbados	0	0	0	0	0	0	154
Montserrat	0	0	0	0	0	0	87
Other regional							
British Virgin Islands	0	0	0	0	23	104	674
Guadeloupe	0	0	102	120	15	120	1,170
Martinique	0	0	15	0	0	23	0
Neth. Antilles	0	0	408	95	118	0	232
US Virgin Islands	0	0	891	50	210	3,045	54
Extra-regional							
UK	0	0	50	979	1,762	1,164	444
France	0	0	0	0	18	0	0
Total	0	0	1,685	2,020	2,795	5,892	5,921

8.2 Pineapple

Table 4 shows the export of fresh pineapple to different countries.

Table 4: Export of fresh pineapple (kg)

Market destination	1984	1985	1986	1987	1988	1989	1990
CARICOM							
Antigua	136	317	0	0	0	0	0
Barbados	0	0	240	0	34	418	0
St. Lucia	0	0	0	76	1,408	0	0
Montserrat	0	0	0	0	0	0	98
Other regional							
British Virgin Islands	0	0	0	13	0	0	0
Guadeloupe	0	115	96	19	36	41	15
Neth. Antilles	0	0	0	109	446	0	0
US Virgin Islands	0	0	758	0	0	0	0
Total	136	432	1,094	217	1,924	459	113

8.3 Mango

Over the last 5 years, most of Dominica's mango export went to the United Kingdom and the Netherland Antilles. A limited quantity went to Guadeloupe and St. Maarten (Table 5).

There is potential for Dominica to increase its mango exports to the United Kingdom as a result of post-harvest treatments developed by CARDI.

The price of mangoes is EC$1.41–1.94/kg ($0.64–0.83/lb). (DEXIA's Agricultural Trade information booklet, 1991).

Wholesale prices in 1986/1987, ranged between £1.05 and 2.5/kg in the United Kingdom and between DM2.90 and 7.00/kg in the Federal Republic of Germany.

If the problem of fruit fly is addressed in Dominica and quarantine restrictions are uplifted, there is potential for increased sales of fresh mangoes to Barbados, Trinidad and the French and Dutch islands.

The greater potential increases in mango production in Dominica will be by export to extra-regional markets.

Cultivar preference in the extra-regional markets varies with the origin of the consumer groups. West Indian ethnic groups prefer "West Indian" mangoes of which Julie is by far the most popular.

There is a need for advertising the Julie cultivar on the extra-regional markets. Although it is recognized as a good eating variety, it is still not well known by consumers in the United Kingdom and Europe. Advertising and trade promotions are required if Julie is to become popular in the United Kingdom and Europe.

Table 5: Export of fresh mango (kg)

Market destination	1984	1985	1986	1987	1988	1989	1990
CARICOM							
Antigua	34,331	52,400	39,573	1,392	1,454	644	740
Barbados	4,501	34,415	15,780	0	0	0	65
Montserrat	0	0	0	0	136	29	451
St. Kitts	2,940	2,873	3,876	7,084	2,221	318	7,277
Trinidad	41,761	9,288	1,091	0	0	0	0
Other regional							
British Virgin Islands	601	2,069	10,011	30,474	6,639	1,978	2,393
Guadeloupe	52,214	26,781	13,545	18,105	9,282	6,416	32,668
Martinique	0	134	201	0	0	0	0
Neth. Antilles	1,966	33,554	21,159	10,536	48,871	40,155	66,161
US Virgin Islands	13,967	9,557	5,965	856	45	0	318
Extra-regional							
UK	2,055	6,814	852	12,526	2,621	5,200	
Holland	0	0	0	0	0	110	0
Total	154,336	177,885	112,053	105,550	81,174	52,271	115,273

Appendix A

Productivity Profile of Julie Mango

(A) SEASONALITY

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total Mandays
Mandays Requirements				3	2	16	19	4	1	2			47
Harvesting Months:				>>>	»»»»»	»»»»»	»»»»»	>>>		>>>	>>>		PRICE:
Monthly Prices (per fruit):					$0.45	$0.35	$0.35	$0.40	$0.45	$0.50	$0.50		$0.36

Key: »»»»» Main harvest
>>> Light harvest

(B) YIELD PROFILE

Year	1	2	3	4	5	6	7	8	— yr → 20	— — yr → 30
Fruits per tree			25	50	100	300	350	500	500	500
Tons per acre			0.4	0.7	1.4	4.3	5.0	7.1	7.1	7.1

(C) COST OF PRODUCTION OF ONE POUND OF JULIE MANGO

		EC cents	
Maintenance			
	Labour	1.0	
	Materials	0.9	17%
Harvesting			
	Picking	3.4	
	Heading	1.9	50%
Transport		3.5	33%
Total Cost		10.6	100%

NOTE: ASSUMPTION USED IN MODEL

Economic life of trees:	40 years
Number of trees per acre:	50 trees
Average weight of fruit:	0.63 lb
Average price of fruit:	35 cents
Average price per pound:	57 cents
Quantity picked per manday:	625 lb
Access time to plot:	10 min

GRENADA

CECIL WINSBORROW
Ministry of Agriculture, Grenada

I. Generalities

1.1 Projects

1.1.1 Papaya

In 1988 a pilot project for papaya was implemented by a technical committee comprising individuals from PFU, IICA, MoA, CARDI and HIAMP. A US $10,000.00 commercialization grant was obtained from HIAMP and seeds of Barbados Pink and Barbados Yellow varieties were obtained from IICA.

Under this project 10 plots were established in various agroecological zones. Each farmer was given 400 plants (0.1 ha; 0.25 ac) of either Pink or Yellow and all the inputs and technical support. A system was set up by the Pest Management Unit of the Ministry of Agriculture to check for *Empoasca* and other pests and for spraying by the Productive Farmers Union (PFU). Several training sessions were held for farmers and extension officers. A system was also set up for selection of high-yielding, disease-tolerant trees which were used for seed production. From the 10 plots profitable yields were obtained by five farmers. Three of the farms were devastated by disease, one by bunchy top, one by *Erwinia* and one by fungal spotting. One farmer dropped out of the programme, and all the plots, except one, showed rapid decline after the first picking due to increased incidence of bunchy top. As a result of the project the supply of papaya increased from 1,350 to 24,000 kg (3,000 to 53,000 lb) of which 14,750 kg (32,443 lb) were exported.

1.1.2 Pineapple

The Pineapple Project began in June 1986 by the French Agricultural Mission. At that time the Marketing and National Importing Board listed seven farmers as selling approximately 135 kg (300 lb) of fruit per annum between April and June. The fruits were from local types which are very small, seedy and spiny. Two sets of planting material of 10,000 plants each of Smooth Cayenne (crowns) were introduced from Martinique in June 1986 and November 1987. A nursery was established and plant distribution began in 1987. Over the period 1987 to 1990 a total of 31, 538 plants were distributed to 33 farmers and 79 persons were trained to grow pineapples. Fruits reaching the market from the project were estimated to be 340 kg (750 lb) in 1988, 9,000 kg (20,000 lb) in 1989 and 13,600 kg (30,000 lb) in 1990. Many farmers have not expanded as expected but have remained at a low level or have gone out of production.

1.1.3 Mango

Presently there are no projects being implemented in mango in Grenada. Activities like propagation and organized plantings are being done to support the export programme.

1.2 Ecological Problems

1.2.1 Papaya

Rainfall can be a major ecological problem. If insufficient there is poor fruit set and if too much then fungal spotting and root rot can result.

1.2.2 Pineapple

Planting on the slope can cause erosion; otherwise no major ecological problems.

1.2.3 Mango

The major ecological problem is that of rainfall. High rainfall encourages the development of anthracnose and many of the mango trees are planted in areas of high rainfall.

1.3 Area Planted

1.3.1 Papaya

The area planted is approximately 2.5 ha (6 acres). The major limiting factor is disease.

1.3.2 Pineapple

Present effective area is about 2 ha (5 ac). Limiting factors for expansion are: lack of planting material; weed control; pests and diseases, especially mealy bug wilt; possible maturation period of the crop; and the small-farmer approach that was taken by the project.

1.3.3 Mango

The area planted is very difficult to determine. The Marketing and National Importing Board (MNIB) bought mangoes from over 500 growers in 1991 each of whom had from one to five trees. An estimate would put the area of table mangoes at about 40 ha (100 acres) and that under seedling mangoes at about 160 ha (400 acres). The major factors limiting expansion are lack of planting material, post-planting care and the long maturation period.

1.4 Production Costs and Returns

1.4.1 Papaya

Approximate cost of a 0.1 ha plot was EC$700–1,000. Approximately revenue was EC$3,000–4,000 for 0.1 ha, at a price of $1.10/kg ($0.50/lb).

1.4.2 Pineapple

Production costs estimated on a 500-plant plot were put at EC $592.55. Total return on a 500-plant plot was put at $3,330.00. Harvest from the 500-plant plot was 805 kg (1,775 lb) with average fruit weight of 1.7 kg (3.8 lb).

1.4.3 Mango

Total production cost is put at EC$18,036/ha (EC$7,299/ac) over a 5-year period and gross returns by Year 5 are about 1,350 kg (3,000 lb) at $1.00/kg ($0.45/lb) giving a total of $1,350 for Julie.

1.5 Seasonality

1.5.1 Papaya

Production is year-round.

1.5.2 Pineapple

The main season is from April to June. However, small harvests are made between November to March.

1.5.3 Mango

Variety	Main Season
Julie	May–August
Peach	May–August
Graham	July–September
Ceylon	July–September
Long	August–October
Other types	August–December

1.6 Main Market, Demand and Supply

1.6.1 Papaya

The local market is well supplied but the export market receives only small amounts of fruit presently.

1.6.2 Mango

The UK, Holland and USA are the main markets. The local market is very small. The demand for Julie is much higher than supply. The extra-regional market in 1989 was 18,000 kg (40,000 lb) for table mangoes and 13,500 kg (30,000 lb) for common mangoes. In 1990 the market was 135,000 kg (300,000 lb) for table, and 90,000 kg (200,000 lb) for common. Some Julie mangoes are also still exported to Trinidad.

II. Pre-production

2.1 Cultivar Selection

2.1.1 Papaya

Main cultivars are Barbados Pink and Barbados Yellow. Fruits are generally small (0.25–0.75 kg; 0.5–1.5 lb), thick-fleshed, sweet and tough-skinned.

2.1.2 Pineapple

The main cultivar is Smooth Cayenne with smaller amounts of Sugar Loaf and other local types.

2.1.3 Mango

The main cultivars are Julie, Peach, Graham and Ceylon with Julie becoming more important recently. Many other seedling types are exported. These include: Rose, Spice, Long Tasty, Cheese, Sherry, Shenda, Rosie, Shelly, Flavour, Cheese King, Girley, Pa Louis, Judy, Sweet, Jill, Red Face, Spike.

2.2 Propagation

2.2.1 Papaya

Propagation is from seed. These are placed in 15 cm (6 in) bags with soil, manure, sand mixture. Plants are normally ready for distribution 5 weeks after sowing.

2.2.2 Pineapple

Propagation is done by flower induction, removal of fruits and harvesting of suckers. Problems are the temptation to leave the fruit thus hampering shoot development, and the long period from planting to shoot distribution.

2.2.3 Mango

The procedure for propagation of mango is as follows:

- seeds or seedlings of Long or Rose mango are collected and sown in bags containing a medium of soil, manure and sand
- plants are left under the saran shade until a new flush appears then they are transferred to the open
- seedlings are left for 6–8 months or until of pencil thickness
- the scion is prepared 7 to 8 days before its removal by removing leaves
- a side veneer graft is used and plants are covered with diothene bags.
- the bags are loosened after 1 month and once the graft has taken the bag is removed and the stock cut back.
- plants are distributed about 5 months after cutting back; about 80% take is achieved.

Problems exist with getting adequate amounts of scion during the flowering period and there is a lower percentage take during the rainy season.

2.3 Plant Demand and Supply

2.3.1 Papaya

Presently plant supply is more than demand.

2.3.2 Pineapple

Plant demand is far greater than supply.

2.3.3 Mango

Plant demand is much greater than supply. About 2,000 grafted plants are produced for distribution every year.

III. Production Systems

3.1 Papaya

Spacing is 2.4 m × 3 m (8 ft × 10 ft), with two seedlings per site, later thinned to one per site leaving the hermaphrodite plants.

Fertilizer is applied as follows: 15 g (½ oz) triple superphosphate at planting; 110 g (4 oz) of sulphate of ammonia 1 week after planting; and at 6 weeks intervals, 12:12:17:2 at 110 g (4 oz)/plant.

Spraying is done fortnightly with insecticide and fungicide to control leaf hopper and weed control is done manually or by careful use of Gramoxone.

Site selection is critical since continuous rain even in well-drained areas can result in losses.

With irrigation and a proper level of fertilizers, trees can yield over 35 kg (80 lb).

The major factors affecting production and fruit quality are diseases. Bunchy top and to a lesser extent *Erwinia* can completely destroy a field in a very shot space of time. A system of monitoring, determination of threshold levels and spraying was used but this was not effective in all cases.

3.2 Pineapple

Planting is done on beds with two or three rows to the bed, spaced 45 cm× 45 cm (18 in × 18 in) with a walk of 1 m (3 ft) between beds.

Fertilizing is done with incorporation of triple superphosphate at planting and surface dressings of 12:8:24 at 3, 5, 8 and 10 months after replanting.

Weed control is done either manually or using Gesatop and Karmex. Malathion and Ridomil or Aliette is used to control mealy bugs and heart and bud rot respectively.

The average fruit weight is about 2 kg (4 lb).

The main factors affecting production are weed control and mealy bug wilt.

3.3 Mango

Plants are spaced 8 m × 8 m (25 ft × 25 ft) for Julie and 9 m × 9 m (30 ft × 30 ft) for other varieties.

Fertilizing is done using NPK three times per year: 110 g (4 oz)/plant during the rainy season.

Weed control is done either manually or using Gramoxone.

No irrigation is practised.

A spray programme was practised for a period in an attempt to control anthracnose: 717 trees were sprayed owned by 27 farmers on 32 different holdings. Three cycles were done in February, March and April. Cupravit blue, Dithane M45, Trimiltox Forte, Triona LME, and Torque were used. It was felt that there was an improvement in quality.

Accurate yield figures do not exist but the experience of the Marketing and National Importing Board for Julie is about 135 kg (300 lb) and about 225 kg (500 lb) for other cultivars, for full-bearing trees.

The major problems affecting production is the scattered nature of the plantings and anthracnose. Trees are very big and difficult to spray. Most of the varieties are also planted in areas where the rainfall is too high.

IV. Harvesting

4.1 Papaya

For the local market fruits are harvested at one-half to three-quarters ripe; for export in summer one-fifth ripe and in winter three-fifths ripe. Recently there were requests for small amounts of green papaya.

Fruits are picked using a sharp knife or secateurs. Fruits are handled very carefully since the slightest bruising results in dull, listless fruits.

4.2 Pineapple

Harvesting is done based on colour change. Harvesting of immature fruit is sometimes a problem because of praedial larceny.

4.3 Mango

Harvesting is done by climbing and using a picking bag and pole.

The main maturity index used is development of shoulders, size, age, and development of internal and external colour. Harvesting of immature fruits is a problem, especially for Julie mangoes.

V. Post-harvest Handling

5.1 Papaya

For the local market, fruits are packed in open crates for transporting. For export fruits are washed, stem end clipped, dipped in a solution of benomyl, dried, individually wrapped in paper and packed one layer per box.

The main rejection is from bruising.

5.2 Pineapple

There are some problems of reduced shelf-life because of removal of the crowns.

5.3 Mango

Transportation from field to packhouse is in crates on trucks. Once received in the packhouse, fruit is stored in a cool room at 13°C until next day when it is washed in clean water, dipped in Benlate solution, wiped dry, packed and left in an air-conditioned room until shipment.

The main causes of rejection are anthracnose, bruising and immaturity.

VI. Processing

6.1 Papaya

Some local processing is done using green papaya for filler in hot sauces or for candied papaya. This is for very small amounts.

6.2 Pineapple

Processing is not done.

6.3 Mango

Processing is not done.

VII. Marketing

7.1 Papaya

Locally farmers receive EC$1.25/kg ($0.75/lb). Export farmers receive EC$0.88–1.10/kg ($0.40–0.50/lb).

7.2 Pineapple

All fruits are sold locally, 80% to hotels and 20% to supermarkets. Prices range from EC$6.60–7.70/kg ($3.00–3.50/lb) for hotels to EC$2.20–4.40/kg ($1.00–2.00/lb) for supermarkets.

7.3 Mango

The main markets are UK, US, Holland and Canada. A small amount of Julie mango is still shipped to Trindad. The potential seems to be good for Julie mangoes. The price offered to farmers is EC$1.00/kg ($0.45/lb) for Julie and EC$0.66/kg ($0.30/lb) for other varieties. Shipping is done by air.

GUADELOUPE

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The agricultural development of Guadeloupe still relies on two monocultures (sugar cane and banana) and our stock farming.

Fruit growing other than banana represents only 1% of the agricultural area (580 ha).

Available areas in Guadeloupe are too limited to consider fruit export. Moreover, the local demand is no way near supplied. Though the situation is evolving, only a few farmers are very interested in fruit growing:

- Heavy investments as compared to long-term returns (3 or 5 years between planting and cropping).
- High labour costs (more than 33 FF per hour).

The most cultived fruit crops are lime, other citrus, and mango in that order. Avocado growing, as profitable as it is, attracts only a few farmers. There is no real fruit-growing tradition in Guadeloupe, and orchards are rarely intensified and often consist of scattered trees.

Five years ago, IRFA started a fruit research programme, located at Vieux-Habitants Experimental Station, on the leeward coast. The purpose is to promote fruit diversification by:

- The introduction and evaluation of new species and varieties.
- Phytotechnical studies.
- Studying in greater detail certain specific limiting factors.

I. Generalities

1.1 Fruit Project

Since 1981 there has been no project involving mango culture in Guadeloupe. From 1979 to 1981 there was a subsidized project with a 41 ha mango plantation (especially Floridian varieties associated with 'Julie').

1.2 Ecological Problems

The main limiting factors in the island are the climatic conditions. Above a total annual rainfall of 1,500 mm, associated with a very short dry season, flowering is erratic for Floridian varieties and parasitism is increased.

1.3 Planted Area and Value of the Production

The latest agricultural statistics (1990) estimate the total area of grafted mango to be 100 ha — 70 ha in pure-stand and 30 ha mixed.

In 1990 mango production was 950 tonnes. The factors adverse to mango culture development are: high investment and long delay before cropping; credit terms inappropriate (need for a delayed reimbursement); commercialization is unsufficiently organized.

1.4 Production Costs and Returns

Table 1 gives an estimate of costs and returns per hectare for a properly maintained orchard. The average price for 1990 was 6.5 FF/kg.

Table 1: Estimated Production Costs and Returns for Mango (ha)

Item	Year							
	1	2	3	4	5	6	7	8
Land preparation	4550							
Planting	14925							
Plants	6000							
Fertilizer	4105							
Labour	4800							
Fertilizer	610	857	945	1201	1714	2424	2897	3354
Material	460	557	645	751	1114	1524	1847	2145
Labour	150	300	300	450	600	900	1050	1200
Disease and pests control	392	633	1768	2917	4146	5375	5375	5375
Material	92	183	868	1317	2146	2975	2975	2975
Labour	300	450	900	1600	2000	2400	2400	2400
Weeding	7500	5500	6700	6700	6900	6900	5700	5700
Pruning	—	—	300	600	1200	1200	1200	1200
Harvesting	—	—	—	1800	6000	9900	12000	15900
Total Cost	27977	6990	9713	13218	19960	25799	27172	31529
Production return (FF) (4,5 FF/kg)	—	—	—	13000	39000	65000	78000	104000

1.5 Seasonality

In a normal year, mango production is from mid-May to mid-September according to the variety:

Variety	Season
Haden, Zill, Irwin	mid-May-July
Carrie, Eldon	June-July
Fascell	end June-July
Smith	July-August
Palmer	July-August or September
Keitt	August-September

1.6 Main Markets, Demand and Supply

The whole production is locally commercialized, except for small export initiatives, never more than 10 tonnes.

The gap between the supply and demand might vary during the cropping season, but it is obvious that the potential consumption is much higher than the actual level: expanded tourism; improved commercialization; retail prices are artifically high.

Floridian varieties are becoming more and more attractive, even more so to West Indian customers.

II. Pre-production

2.1 Varieties

Varieties available or just introduced from our germplasm collection on the Ivory Coast are listed in Table 2. All these varieties should be available in 1993.

At the moment, varieties being multiplied are Irwin, Zill, Haden, Keith, Smith, and especially Julie which is very much appreciated by West Indians.

An increasing demand is observed for Floridian varieties such as Irwin (regularity, abundance and quality of the production) or Keitt and Smith (production is less regular and abundant but the latest).

2.2 Propagation Methods and Techniques

The grafting method currently employed is side cleft grafting using seedlings of wild mango (Mango fil) as rootstock.

If grafting is not a problem, anthracnose disease frequent causes damage in the nursery.

This particular susceptibility to anthracnose is also noticeable on the young plants one year during and after planting.

2.3 Plant Demand and Supply

Main plant demand is from private individuals and not from proper growers.

IRFA's nursery in Neufchateau supplies almost all of our local market. Other local small nurseries are not sufficiently trained to deliver good quality and certified plants.

In 1991, about 1,500 plants were produced and sold by IRFA, but we can estimate that the actual demand is double that.

III. Production Systems

3.1 Planting

Planting distances from 7 to 10 m on square, rectangular or diamond patterns have been common.

Table 2: Varieties of mango at IRFA, Guadeloupe

Available	
Adams	Am. Du Cameroun
Carrie	Early Gold
Edward	Eldon
Fascell	Haden
Irwin	Julie (Guadeloupe)
Keitt	Kent
Palmer	Pomme
Ruby	Sensation
Smith	Tommy Atkins
Van Dyke	Zill
Just introduced	
9 C	Aeromanis
Ah Pingh	Alphonse De Goh
Alphonse Hawai	Alphonse Paheri
Ameeri	Amelie
Amelie Guine	Anderson
Auguste	Bedami Roug
Bedami Vert	Beverly
Big Yellow	Black
Bombay	Bombay
Boy Toy 15	Broocks
Camayenne	Cambodiana
Candaha	Candaha
Carmen	Crazou
Coq's Hall	Dabsha Drahnet
D'or	Diego
Davis Haden	Dixon
Divine	Djibelor Casamance
Djibelor	Egypte A
Egypte B	Egypte C
Egypte D	Egypte E
Egypte F	Eldon Ferke
Florigon	Fraissinette
Just introduced (continued)	
Francis	Gabriel
Galerie	Glazier
Glenn	Gomera A
Gomera II	Gomera III
Gordon	Green Ferke
Grosse Rouge	Haden Carabao
Hindibi Sinara	Ifac I
Jacqueline	Je 4
Julie Kasowa	Julie Lataha
Julie Nyombe	Kensington
Linzolo	Lippens
Longo Diego	M. Laurina
M. Pelipisan	Mabroka
Mabrouk	Maison Rouge
Malembe	Man
Mangotine	Martin
Maya	Metchouang
Miami Late	Mulgo Round
Nimrod	Obette
Osteen	Paheri
Paris	Passy Hatine
Peche	Peter Passand
Petit Greew	Philipino
Pico	Pirie
Pope	Punta De La Muna
Rachel	Romania
Sabot	Sabre
Sacabi	Sandeshi
Sans Pareil	Soudan II
Springfield	Sybil
Taymour	Tolbert
Valencia	Valencia Pride
Whitney	Wooton
Xoi Cai Mitho	

The planting hole size ranges from 50 cm × 50 cm × 50 cm to 80 cm × 80 cm × 80 cm. When plantings exceed a certain number of trees, holes are often made with a mechanical shovel.

3.2 Cultural Practices

3.2.1 Fertilization

Rate of fertilizer applied per tree and per year is indicated in Table 3. Before the first fruit onset, the annual amount is supplied in four doses. After the first fruiting, half of the annual amount of nitrogen and potassium is supplied in July, a quarter of this amount and the total phosphorus fertilizer are supplied when the floral panicles are expanding; the remaining quarter is supplied at fruit onset.

Table 3: Mango fertilization (kg per tree per year)

		Year					
Age of plant	Planting	1	2	3	4–6	6–12	13 +
N	0.1	0.3	0.35	0.4	0.5	1	1.4
K_2O	1	0.3	0.35	0.4	0.5	1	1.4
P_2O_5	0.6		0.1	0.25	0.25	0.35	

3.2.2 Weed Control

Weeds between tree rows are removed by machine. Herbicides are used to control weeds around young trees or in strips as trees become larger; glyphosate is commonly used as the herbicide.

3.2.3 Irrigation

Generally irrigation is advisable after planting. The year following planting, an occasional irrigation would be necessary to enable good establishment of the tap-root of the plant. The plant is then considered to be hardy enough to grow without irrigation, at least under Guadeloupe conditions. Some years, climatic accidents make an occasional irrigation necessary, especially at flowering/fruit onset.

3.2.4 Spray Programme

The two main diseases are :

- Anthracnose (*Colletotrichum gloesporioides*) attacking leaves, panicles (blossom blight) and fruits (post-harvest diseases).
- *Oidium* (*Oidium mangiferae*) attacking panicles and young fruits.

For anthracnose control :
- from flowering to fruit onset: every 10 days alternate Mancozeb, copper products and benomyl.
- from fruit onset to harvest: same treatments every month.

For *Oidium* control:
- benomyl treatment is followed by misting with sulphur (1 kg/ 100 l of water).

As resistant strains of C. *gloesporioides* to benzimidazole products have now been observed in Florida, it should be useful to try other products such as prochloraz or propiconazole.

The main pests are:

- Scales (*Ferrisia virgata* Cock) can lower the quality of fruit: two to three methidathion treatments before harvest enable a good control.
- Thrips (*Selenothrips rubrocinctus*) attacks are irregular but might become very damaging; pyrethroid treatments (not repeated) allow a good control.

3.2.5 Pruning

Young mango trees of most varieties ordinarily require little pruning since they normally assume a desirable symmetrical form.

Training by pruning is desirable with certain varieties such as Keitt and Palmer, which tend to spread irregularly with long branch growth.

The only pruning usually given until bearing trees start to crowd each other is the removal of dead wood and branches weakened by disease, wind or heavy equipment.

If overcrowding occurs, we have to prune to fit the available space.

3.2.6 Flower-inducing Chemicals

Two experiments have been carried out this year at Vieux-Habitants:

Experiment 1:

Comparision of two flower-inducing products on Eldon mango.

Both products were tested on 16 January1991 for mango trees of the Eldon variety, 10 years old and grafted on Local mango.

Flowerset (240 g KNO_3/1): 15 ml/l in a foliar spray (14 l per tree);
Miracle Blum powder: 15 g/l in a foliar spray (14 l per tree).

After the natural flowering (T + 15) on treated and untreated plants, we noticed an increased flowering (T + 35) on treated plants.

Flower-inducing chemicals had a significant effect on the number and the weight of fruits per tree:

Flowerset: 42.6 fruits; 22.9 kg
Miracle Blum: 56.3 fruits, 26.5 kg
Control: 6.14 fruits, 2.87 kg.

There was no significant difference between the two products and the fruit size was not affected.

Experiment 2:

Comparison of three flower-inducing chemicals on Haden mango.

The three products were tested on 19 March 1991 for mango trees of the Haden variety, 3 years old and grafted on Local mango:

Paclobutrazol: 60 ml of Cultar in 20 l of water poured around the tree.

KNO_3: 10 and 40 g/l in a foliar spray (10 l per tree)

Flowerset: (240 g KNO_3/l): 15 ml/l in a foliar spray (10 l/tree).

On all plants (treated and untreated) terminal buds were swollen and dormant.

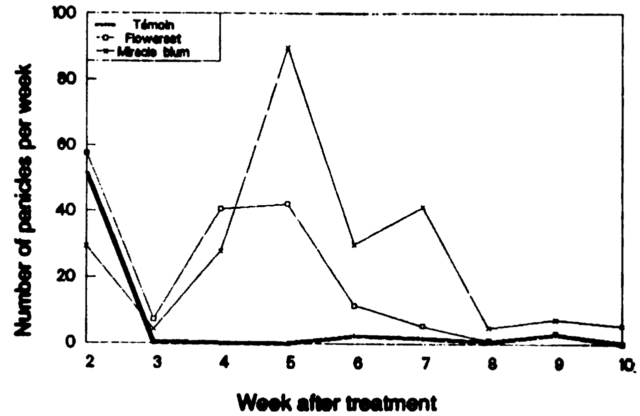
The three treatments containing KNO_3 had a significant effect on the number and the weight of fruit per tree. No effect was observed with Cultar:

KNO_3 10g/l: 25 fruits, 7.16 kg
KNO_3 40 g/l: 14 fruits, 4.30 kg
Flowerset: 32 fruits, 10.76 kg
Cultar: 0 fruits
Control: 0.14 fruits, 0.37 kg.

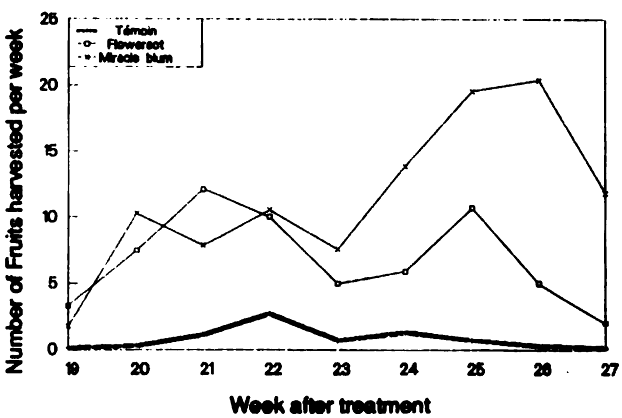
The relatively low production was because of the youth of the plants (3 years).

It is important to do more work on ways to induce flowering in certain limiting climatic conditions. Another interest is in grouping the production and out-of-season production.

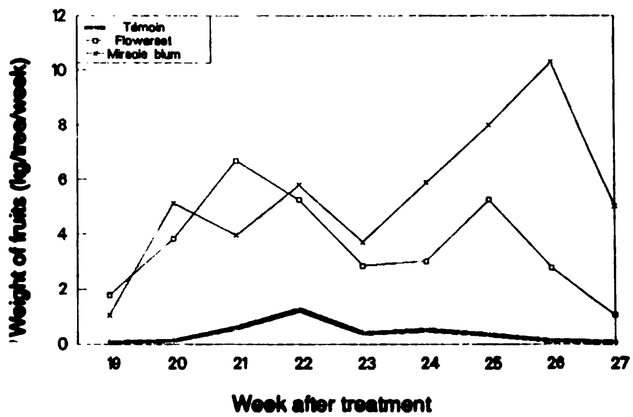
Flower inducing test on mango tree
Average number of inflorescences per tree



Flower inducing test on mango tree
Average number of fruits per tree



Flower inducing test on mango tree
Weight of harvested fruits



GUYANA

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A wide variety of tropical fruits are grown in Guyana. The Ministry of Agriculture and IICA have identified and characterised more than 40 species of fruit crops being cultivated in Guyana. However, very few are cultivated in any organized system nor has there been any concerted focus on agronomy, harvesting techniques, post-harvest handling, fruit quality and marketing as part of a system. Hence there is wide variability in quality and quantity of fruit produced.

The National Agricultural Diversification Programme has focused on the export of non-traditional crops. It is my considered opinion that the combination of the availability of lucrative regional markets and the favorable investment provisions provided under the Government's Economic Recovery Programme has allowed pineapples to emerge as the third highest agricultural export crop behind sugar and rice. Pineapple is primarily for the fresh fruit market but some amount of processing into chunks, juices and jams is done locally and possibly for imminent export.

However, if the currently lucrative markets are to be retained and expanded several constraints will have to be addressed not the least amongst which is the lack of an appropriate technological package to effectively deal with problems associated with the ecology, technology (production) and marketing.

Commercial pineapple production commenced in the early 1970 in Region 4. The main area of production is now in Region 3 and to a lesser extent in Region 2. The variety Montserrat is mainly cultivated and yields an average of 17 tonnes/ha/year. Production is year-round since NAA tablets are used to induce flowering. The pineapple industry is serviced by the Regional Democratic Councils' Agricultural Department, NARI, the New Guyana Marketing Corporation (NGMC), Seals and Packaging Industry (SAPIL) and CARICARGO (air transport).

I. Generalities

The potential of the fruit sub-sector in Guyana has been recognized for some time now as being potentially important to the national and farming economy. However, as assessed by the allocation of resources to the development of the sub-sector one can say that the sector has a low priority for the Government. It is also important to recognize the low absorptive capacity of the local economy both in terms of the size of the market and consumer purchasing power especially for non-essential food items. Additionally, in the short-term there is little possibility for fresh produce marketing out of Guyana, given the extreme deficiencies of production, e.g. farm to market roads, and marketing, e.g. holding and storage facilities, sea and airport load capacities, infrastructure.

1.1 Projects

Two projects are currently being implemented and impact in a general way on development in the fruit sub-sector:

- MoA/IICA Project — Supporting the Development of Tropical Fruits in the Caribbean.
- GoG/FAO — Institutional Strengthening of the "New" GMC.

1.2 Ecological Factors

1.2.1 Papaya and Mango

In respect of papaya and mangoes two important areas of influence are related to soil and weather conditions. For the coastal areas, seasonal flooding of the heavy clays and lower humidity than in the savannah areas (sandy, free-draining and infertile) differentiate these two important ecozones. In the case of mangoes, plants may develop extensive canopies and grow into large sized (>7 m; 20 ft) trees in both ecozones, however, it is only in the areas with relatively lower humidity that mango trees are able to consistently produce fruit.

1.2.2 Pineapple

Climate

Rainfall is the major limiting climatic factor to production. In the low areas with poor drainage there is a high possibility of flooding which while reducing the oxidation of valuable organic matter predisposes the plant to root rot. During the dry period soil acidity increases.

Soil

From a chemical point of view, soil acidity is the most relevant characteristic in connection with pineapple cultivation. The pH range for optimum growth and desirable fruit quality is between 4.5 and 5.5. In Guyana, pineapples are grown mainly in Region 3 in three areas, namely Parika/Ruby Backdam, Canal Polder Nos 1 and 2 and Boeraseri. The soils of these areas are classified as Mara Clay (Typic sulphaquent).

Mara clay is a very poorly drained soil developed from brackish alluvium and deposited from tidewater sediments. The soil is characterized by a shallow peat deposit over a black to very grey clay. The soil is extremely acid, slowly permeable and difficult to drain. It has a fairly high clay content and is low in plant nutrients. Pineapple yields decrease rapidly with an increase in acidification. Current cultivation practices do not help this acid condition.

Nutrition

Currently the fertilizer regime employed is almost always confined to the application of elemental nitrogen in the form of sulphate of ammonia or urea. Substantial applications of limestone and complete fertilizers would be required for satisfactory yield. The indiscriminate use of sulphate of ammonia contributes to increasing acidification and reduced land and crop productivity.

1.3 Area Planted

1.3.1 Papaya and Mango

No information is available on acreage occupied by these two crops and since only a small fraction of the production enters the formal market system the value of the production is also unknown. There is a significant, widely spread population of mainly seedling mango trees. In the case of papaya the areas are not as extensive and widespread. In a general way, the main limiting factor to production may be related to the absence of programmes for identifying varieties that are adapted to the local growing environment.

1.4 Cost of production

1.4.1 Papaya and Mango

Production costs are not available.

1.4.2 Pineapple

The cost of production is given in Table 1.

1.5 Seasonality

1.5.1 Mango

For mangoes on the coast the main bearing periods

Table 1: Cost of production of pineapple and returns per acre (0.4 ha) in Guyana dollars

Revenue	Weight (kg)	Unit price	Total price
Harvest #1 (14 months)	19,000	$20	380,000
Harvest #2 (26 months)	16,500	$20	330,000
Harvest #3 (38 months)	13,500	$20	270,000
Total			980,000
Operating expenses			
Land preparation			4,000
Plants	12,000	$3	36,000
Fertilizer:			
Limestone	1,000	$37/kg	37,000
12-12-17-2	545	$46/kg	25,070
Chemical			
Pre-plant Dip			688
Weed			6,581
Pests			3,445
Post-harvest			7,187
ANA			1,500
Labour	135	$150	20,250
Marketing			3,600
Subtotal			145,321
Misc. 15% of operating costs		21,798	
Total operating costs			167,119
Fixed			
Land			7,500
Total costs			174,619
Cost per kg			3.41
Return over costs per kg			16.59

are from July to September and from December to January. However, mangoes may be found in the local markets throughout the year. This pattern of bearing is related to the occurrence of the main rainy seasons (bi-modal for most of the country except for the Rupunui Savannahs where the distribution is uni-modal) which occur in May/June and Nov/December.

1.6 Main Markets

1.6.1 Papaya and Mango

The main market is local and this is satisfied on a seasonal basis.

1.6.2 Pineapple

The main markets are Trinidad and Barbados.

II. Pre-production

2.1 Cultivars

2.1.1 Pineapple

In Guyana, four varieties are found, they are Montserrat, Smooth Cayenne, Sugar Loaf and Tiger Head.

Montserrat is the variety of choice for the fresh fruit market as the fruit is delicious, firm and of excellent quality. The fruit is conical in shape and averages 2.5 kg in weight. The variety is believed to be a mutant.

The other varieties are not cultivated on a large enough scale to warrant description. Except that the Smooth Cayenne has potential for a canning industry due to its high sugar content.

2.1.2 Mango

Although introduced into the country several times over the last 40–50 years the Floridian mangoes are not well-known and the local Buxton Spice is the dominant variety. Julie is not widely known but highly appreciated by those who have tasted it. Several other introductions from India and other parts of South East Asia were made previously and two are still recognizable — Bombay and Primrose (thought to have been introduced as Cambodiana from South East Asia).

2.2 Propagation

2.2.1 Pineapple

Pineapple is vegetatively propagated. Slips and ratoon suckers are used as planting materials. The material is usually treated with a solution of Basudin 63 EC or Malathion 60 EC and planted. Little or no selection for quality of planting material is done since there is always a great pressure on the supply and in satisfying demand.

The advent of the plant tissue culture facility at NARI has seen the successful micropropagation of pineapple plant material. This has already been released to innovative pineapple farmers for multiplication and on-farm assessment.

2.2.2 Mango

The rootstock used almost exclusively for nursery propagation is Long Mango. No propagation-related problems are known.

There is low demand for this species and the supply of grafted mango plants is generally adequate.

The main problems at the pre-production stage lie mainly with the organization and management of the government nurseries, which predominate. Newly established, privately-owned nurseries tend to produce nursery plants for the specific production operations with which they are associated.

III. Production Systems

3.1 Planting Methods and Distances

3.1.1 Pineapple

Two methods of tillage are used. On new lands in the Upland sandy zones the slash and burn method of land clearing followed by minimum tillage is practiced. On the heavier riverain soils the land is ploughed in the dry season, left to weather for 3–4 weeks and then harrowed.

On riverain and acid sandy soil, planting is done on ridges with drains at 3 m intervals for planting in single row spacing (inter-row = 1.5 m; intra-row = 0.6 m) and at 4.5 m for the double row spacing (inter-row for single row = 0.75 m; intra-row for double row = 0.5 m, inter-row for double row = 1.5 m).

3.2 Crop Husbandry

3.2.1 Pineapple

Fertilizer
Only elemental nitrogen in the form of sulphate of ammonia (100 kg/ha) or urea (50 kg/ha) is applied at final land preparation, at planting and during the crop. Although it is recognized that apart from potassium, absorption of mineral elements usually stops during fruit development, nitrogen fertilizers are still added.

Plant Protection
Weeds are controlled using paraquat (1–4 kg/ha). Hand pulling is practised depending on labour availability.

For the control of mealy bugs and ants, slips are treated with a 0.04% solution of Basudin and the ant baits (containing Mirex) are set at nest locations. Sanitation and routine monitoring of ant nests and subsequent treatment are practised.

Gummosis is controlled somewhat by eliminating the ants and so destroying the ant/mealy bug complex. It is hoped that the supply of virus-free planting materials will eliminate pineapple wilt.

These management strategies for the control of weeds, other pests and diseases follow recommendations provided by the Integrated Pest Management Section of NARI.

Artificial Floral Induction
Napthyl acetic acid (NAA) tablets are inserted in the heart of each plant to facilitate artificial flower induction. However, best results are obtained if this practice is done at night when ambient temperatures are 26°C. This feature allows for all-year-round production.

3.3 Causes, Effects and Control of Factors Affecting Production

3.3.1 Pineapple

Pests
The main pest problem is the ant/mealy bug complex. The mealy bug, *Dysmicoccus brevipes* (Cockerell), is the vector of two diseases of pineapple in Guyana, namely pineapple wilt and gummosis. The mealy bug is tended and protected by the ant, principally *Solenopsis* spp. The ants build nests in the soil for themselves and earthern shelters for the mealy bug at bases of pineapple plants. According to Rohrbach *et al.* (1988), the caretaking behaviour of the ants allows the mealy bug to flourish.

The unavailability of traditional insecticides, Omethoate and Heptachlor, recommended by Rai and Sinha (1980) to kill mealy bugs and ants respectively, has necessitated the search for new approaches.

Diseases
The major diseases are gummosis and pineapple wilt. Gummosis is caused by a yeast fungus, *Saccharomyces* sp. Pineapple wilt is strongly believed to be caused by a virus (Rohrbach *et al.*, 1988). Gummosis is characterized by internal browning and fruit rot. Exudates of gum may occur. Pineapple wilt is characterized by straight stiff brown leaves of reduced function (McDonald and Muller, 1977).

Reduced yields and undesirable fruit quality are the attendant results of infection by the yeast fungus and the virus. Farmers do not practise desirable disease prevention measures.

Weeds
Pineapple plants are slow-growing and coupled with the spacing regime, allow for ground exposure and the development of weeds. The major weeds species include *Imperata cylindrica*, *Digitaria* spp., *Panicum ripens*, *Paspalum conjugatum* and *Caladium bicolor*.

Farmers practise hand-pulling combined with the indiscriminate use of paraquat which often contributes to soil fertility degradation.

While the NGMC has succeeded in faciliting and coordinating the development and export of pineapples there still remains a lot more to do to build a viable pineapple industry. Some researchable areas include:

(a) The development of an appropriate farming system to maximize land and crop productivity with minimum soil degradation.
(b) Germplasm collection and evaluation to develop a critical mass of diverse genotypes.
(c) The development of an appropriate production technology that will produce an abundance of good quality pineapple to take advantage of the existing marketing arrangements
(d) The appropriation of sound post-harvest technology to preserve fruit quality.

These is a great future for pineapples both fresh and processed. The multi-institutional approach involving the NGMC, IICA, NARI RDC and the MoA is a necessary strategy.

3.3.2 Mango

The unavailability of appropriate spray application equipment hinders initiatives for effecting control of anthracnose. Previously, a bucket and stirrup pump method was used for this operation.

3.4 Yields

3.4.1 Mango

Mango is found mainly in backyards and in volunteer stands. It is estimated that a 5–10 year-old seedling Buxton Spice would bear about 700–800 fruit with a fruit weight of 140–225 g (5–8 oz).

IV. Harvesting

4.1 Methods and Tools

4.1.1 Papaya and Mango

Fruits are harvested mainly by climbing and picking. Long poles with wire hooks may be used occasionally, especially for mangoes.

4.1.2 Pineapple

Hand-harvesting is practiced. This activity is very labour intensive. The growing phenomenon of organized labour (contract) puts a heavy cost on harvesting.

Since crop husbandry is somewhat poor, especially lack of potassium, fruit quality at harvest may not meet acceptable standards. Mature fruits are however, harvested by cutting the stalk with a sharp knife or by breaking it off the stalk by hand.

4.2 Maturity Indexes

4.2.1 Papaya and Mango

Maturity at harvest depends on the use to which the fruits are to be put — as a snack food or for the preparation of chutneys, curries, etc. (unripe and green in the case of mango). For medicinal and culinary purposes, papaya may also be harvested when immature.

4.2.2 Pineapple

The appearance of the fruit is the main index. If the fruit is for export it is harvested when mature, that is when a yellowish color appears at the base of the fruit. For local consumption, the fruit is harvested ripe, that is when half to three-quarters yellow.

The ease with which a leaflet can be jerked from the crown is also an induction of maturity. Last but not least, time (age) is a useful indicator.

V. Post-harvest Handling

5.1 Transportation

5.1.1 Papaya and Mango

Transportation from fields to market is by cart, boat and/or motorized transport. Crates, polypropylene bags or baskets are the containers used.

5.1.2 Pineapple

From the field pineapples are packed in bags (jute and/or polypropylene) and loaded into vans, boats or dray carts. Enough care is not exercised and fruits become easily damaged. Also dams may become impassable during the rains thus rendering the task of transporting an often difficult and laborious one.

The number of pineapples packed into a bag and the number of tiers determine the possible quantum of fruits likely to suffer damage.

5.2 Pack-house Operations

5.2.1 Pineapple

Fruits are normally placed on earthern or concrete floors for sorting and treatment. Washing is seldom done. Some producers treat the fruits with Benlate and wax to prevent fungal infection and to increase the shelf-life. Most avoid these necessary costs by simple sorting, brushing and packing.

Special boxes are designed by SAPIL for the packaging of pineapples. Usually brand names allow for product differentiation.

5.3 Rejection

5.3.1 Papaya and Mango

Harvested fruit suffer from serious post-harvest damage, mainly due to of bruising and smashing, because of rudimentary practices.

5.3.2 Pineapple

About 20% of harvested fruits are rejected because of: bruising, smashing, cuts, pests and the size.

5.4 Processing

5.4.1 Papaya and Mango

Green mangoes are processed into chutneys, achars, hot sauces, etc. in cottage-type operations. Recent initiatives by one entrepreneur — Organic Juices Ltd. — to promote dehydrated products of both these fruits have not as yet yielded their potential. A shortage of suitable containers and processing equipment may be a problem even at the cottage industry level.

5.4.2 Pineapple

At the moment two companies are processing pineapples:

Companies	Processed product(s)	Country exported to
Adventure Manufacturing	Pineapple chunks; pineapple jam	Trinidad
Quality Foods Ltd	Pineapple juice (fresh)	Local

VI. Marketing

6.1 Papaya and Mango

In the local fresh markets prices for papaya and mango are currently about G$12.00 each and G$88.00/kg (US$1,00– G$120.00) respectively. This represents a twelve-fold increase over 1989/1990 retail prices. This does not necessarily reflect higher farm-gate prices but the much higher cost of farm to market transportation.

6.2 Pineapple

Prior to the advent of the NGMC the export of pineapple was at a bare minimum. Potential exporters had no clue as to the preparation of the product to meet the regional and international market requirements. Also, securing a channel for export was problematic. These exporters were further thwarted in their efforts since to effectively deal with the stringent government regulations which offered huge bottlenecks, required patience and ingenuity. Thus frustration and low returns to investments characterized the export trade in pineapples.

The establishment of NGMC in 1985 was as a result of government's realization that economic recovery of Guyana can be made possible through the adoption of an investment policy which offers, among other things, liberal trading regimes, free market enterprise and which encourages greater private sector investment. Thus the NGMC was mandated to facilitate and coordinate the development of quality non-traditional agricultural products for export. The results of this are now history.

The NGMC in collaboration with the Inter-American Institute for Cooperation on Agriculture (IICA) sought to realize its mandate. A bifurcated strategy was adopted. Firstly, a market intelligence unit was set up to gather information on demand and supply, prices, seasonality of production, costs of production, returns to investment and the factors affecting expansion and quality of output. Secondly, a Commercial/Marketing Policy Unit dealt with government regulations, channels, product presentation and differentiation and securing foreign markets.

Pineapple soon emerged as the crop with the best potential to provide greater returns to investment as there existed a lucrative fresh fruit market. Trinidad and Barbados absorbed most of the exported pineapples. Production increased from 1,800 t in 1980 to an all time high of 11,000 t in 1989.

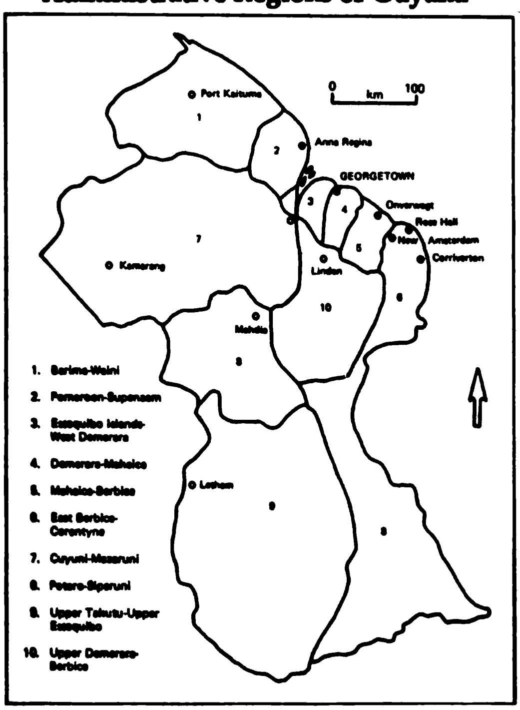
Demand for pineapples increased and for the first time pineapple producers were able to smile all the way to the bank. At the moment pineapple is exported to 11 countries including (in order of decreasing volume) Trinidad, Barbados, Antigua, USA, Canada. Sample shipments have been sent to Jamaica, Great Britain, West Germany, Holland and Japan. Air and see transport service the export of pineapples. (see Table 2).

Table 2: Volume of produce exported by air and sea by country as a percentage of total quantity exported, volume of pineapple in relation to total quantity of all produce and volume of pineapple as a percentage of all produce exported to each country

Country	Total quantity of all produce exported 1990 (t)	Volume of produce exported by country as % of total quantity	Volume of pineapple in relation to total quantity of all produce (t)	Volume pineapple as a % of total quantity of all produce exported to each country
Antigua	4.35	0.36	0.61	0.09
Barbados	365.02	30.30	332.34	49.95
Canada	10.29	0.85	0.22	0.03
Grenada	0.20	0.02	0.00	0.00
Great Britain (UK)	0.08	0.01	0.00	0.00
Jamaica	0.00	0.00	0.00	0.00
Japan	180.31	14.97	0.00	0.00
Trinidad	616.31	51.16	331.58	49.84
USA	22.30	1.85	0.58	0.09
West Germany	1.34	0.11	0.00	0.00
Holland	4.55	0.38	0.00	0.00
Total	1204.75	100	665.33	

However, the preservation of these markets and the expansion into others will depend heavily on a continued adequate supply of quality pineapples.

Administrative Regions of Guyana



MARTINIQUE

F. Marie
IRFA/CIRAD, Martinique, French West Indies

I. Generalities

1.1 Pineapple Production

Traditionally, pineapple has been cultivated in Martinique for a very long time. Today, it is still present in all the island gardens.

The first cannery was built a the beginning of this century. Now pineapple cultivation is very intensive; most of the production is processed by two factories; only a small part is sold on the fresh local market.

In 1990, pineapple production was about 17,000 t: 15,000 t were processed (canned, juice, jam) and most of these products were exported to France; 2,000 t were sold on the local fresh market; and 124 t of fresh fruit were exported to St Lucia, Guadeloupe and France.

From 1985 to 1988, production decreased very severely but today it is stabilized. Three factors explain the decline and the stagnation of production: the exchange rate of the US dollar; competition on the international market (Thailand, Philippines); and impact of black core rot and leathery pocket diseases. This can be seen in Figure 1. Local fresh fruit demand is increasing (tourism) while exportation is decreasing very quickly.

The main production area is located in the north of Martinique, around the SOCOMOR factory, which is the most important processing unit (14,000 t/year). This production area is about 450 ha. The other area is less extensive, 30 ha, and it is situated in the center of the island around the ROYAL cannery.

Three kinds of farms can be distinguished, according to their area: one very big farm (200 ha); six middle-sized farms (20–40 ha); 40 small farms (0.5–10 ha). The middle-sized and big farms are mechanized and use an intensive monoculture system (high technology) while a very large diversity of situations (rotations, level of technology) is found in small farms.

1.2 Ecological Problems

1.2.1 Pests and Diseases

Three types of parasites may cause severe losses:

— Black rot and leathery pocket diseases. These two disorders are due to the fungi *Penicillium funiculosum* and *Fusarium moniliforme*. Fruit infection takes place after forcing as the inflorescence is rising in the heart of the plant and then during the flowering period. The rot develops during fruit maturation. Cayenne fruits show no external symptoms of black spot. These disorders can be very important; the infection rate may reach about 40% in Martinique. Till now, control of this disease has not been effective.

— Symphyllids (*Hanseniella* sp.) are small white myriapods which feed on the roots tips. The absorption of nutrients is disturbed, so the growth is badly affected. Symphyllids like moist soils with aeration, and soils with a high organic matter content. As symphyllids are extremely profilic, these factors provoke "demographic explosions". In Martinique, the problem is particularly important in the high areas (200 m).

— Wilt disease which is due to a virus propagated by mealy bugs, *Dysmicoccus brevipes*. Without treatment, the number of plants affected can reach 50%, and yields decreased very severly. In Martinique, systematic treatments are done for controlling this disease.

1.2.2 Control of Natural Flowering

Pineapple flowering is favoured by short and cloudy days and cool temperatures (i.e. during the months from November to January). High frequencies of natural flowers in a field prevent harvesting fruits at the same time and greatly decrease the yield of the second cycle.

1.3 Production Costs and Returns

Production costs depend very much on the type of production: size of farm, level of mechanization and technology, degree of investments, and origin of planting material. The price of pineapple bought by factories is 2.50 FF/kg; the price for the fresh market is between 4 and 7 FF/kg, depending on the season. First crop yields are between 60 and 80 t/ha.

1.4 Seasonality

Control of flowering allows the production of pineapple all-year-round for the local fresh market. The most important factory, SOCOMOR, only runs for two periods, that is from May to July and from October to January. So the majority of the producers have to control their production cycles.

II. Pre-production

2.1 Cultivars

The cultivated clones belong to the Smooth Cayenne group which is the most widely cultivated for canning as well as for fresh fruit export.

A mutation suppressing most of the spines has been selected. The fruit weight ranges from light (0.5 kg) to very heavy (4 kg), according to the length of the cultivation cycle and inputs (high potential). Slips may be present in variable numbers. The flesh is soft, pale yellow, juicy, slightly acidic, and sweet (brix usually higher than 14).

2.1 Planting Material

The usual planting material is the crown (majority of fruits are processed). If needed, ratoons are used. Medium and big farms supply plants to the other farmers. The price is about 0.50 FF/plant. Demand for planting material is important; that is why IRFA/ CIRAD Martinique is developing a research programme on multiplication techniques (use of hormone, cutting of old stems).

III. Production

3.1 Planting

Spacing is 40 cm between the 2 rows of a bank, and 30 cm in the row, resulting in a density of 55,000 plants per ha. Before planting, sorting of material is necessary to get homogeneous plots.

3.2 Crop Cycle

Since flowering can be induced artificially, pineapple is actually a programmable crop. The main advantages of such crop cycle planning are: the choice of production time; maximum homogeneity in maturity and fruit size; and it allows a better management of cultural operations.

The pineapple cultivation cycle is divided into two phases: the vegetative phase from planting to floral induction, and the fruiting phase from floral induction to harvest.

The length of the vegetative phase depends on planting material (suckers grow faster than crowns), climate, fertilization and size of the fruit to be cropped.

In Martinique, plants from crowns are treated for flowering at 10 months at sea level and plants from suckers at 9 months. At an altitude of 400 m, the vegetative phase is 1 month longer.

The fruiting phase lasts 5 to 5.5 months (depending on season) at the sea level and 2 weeks more at 400 m. Fruit production from a ratoon crop (second cycle) implies a rigorous homogeneity and a good yield of the first crop because fruit size and field homogeneity decrease from the first to the second cycle. These reduced yields are balanced by shorter duration and lower costs of production. The ratoon crop vegetative phase is terminated 6 months after first harvest. Its yield is generally about 50–60% of the first crop cycle.

3.3 Cultural Practices

Level of mechanization is generally increased with area; big farms have tractors, trucks, boom sprayers, equipment for soil preparation and harvesting.

3.3.1 Soil Preparation

Pineapples like acid, light and well-drained soils. The roots are very fragile. The aim in soil preparation is to get a soft and homogeneous soil.

The first operation is a complete crushing of the preceding crop residues. Then the material is incorporated into the soil with light discs. This can be done three or four times to stimulate decomposition. Before or after tillage (depth about 40 cm), lime is applied (about 1 t/ha) in order to stabilize the acidity of the soil at a good level (between pH 5 and 5.5). Surface finishing is done with light discs and rotovator (with incorporation of a nematicide-symphillicide). The next operation is banking. Banks are at least 20 cm high and 60 cm wide. After that, drains are dug. Their number depends on the slope.

The drainage system must be carefully designed to efficiently remove excess water. In certain cases of steep slopes, planting in the direction of maximal slope may be a good compromise to improve drainage and lessen the risk of severe erosion.

3.3.2 Fertilization

The needs of pineapple during the cycle are:

	1st Cycle	2nd Cycle
N (g/plt)	10.15	6.9
P_2O_5 (g/plt)	1.6	
K_2O (g/plt)	18.35	10
M_gO (g/plt)	1.6	

Nitrogen is essential for vegetative growth and K for fruiting. They are applied in an increasing K/N ratio (about 2 on the whole cycle). Solid fertilizer (20 g/ plant of 12.4.24 + 6 M_gO) is given after root formation and at 3 and 6 months; liquid fertilizer (urea and sulphate of potash) is sprayed once a month.

Fertilization is stopped at floral induction, till the end of the fruiting phase. In the following sucker production phase or ratoon cycle, the rate is also one spray per month (only liquid fertilization).

3.3.3 Weed Control

Pineapple growth is slow in the first months. By competing for water, mineral elements and light, weeds severely reduce pineapple growth.

For controlling weeds, prevention is better and pre-emergent herbicides must always be preferred. Karmex (diuron) is used directly at planting, preferably just after planting to avoid disruption of the herbicide film on the soil, at a dose of 2 kg/ha. Hyvar (bromacil) also can be used at planting (2 kg/ha) and is efficient against *Cyperus*, but it is dangerous because of its high retention in the soil (4 years). As a post-emergent, Gesapax (ametryn) can be used between banks at a rate of 6 1/ha. This rate must be reduced when treating the whole field (2 1/ha).

When treating between banks, diuron and ametryn may be mixed to get a synergy in their effects. Fusilade (fluazifopbutyl) is very efficient against grasses (at 1.5 1/ha) and is never dangerous for pineapple growth.

Herbicides are always more efficient when applied on young weeds. Herbicide excess provokes a yellowing of the eaves and disturbs the growth of pineapple plants.

3.3.4 Parasite Control

Wilt and mealy bugs — Wilt is the most common disease of pineapple, it is a viral disease propagated by the mealy bug *Dysmicoccus brevipes*. This insect is generally found at the base of old leaves, fruits and suckers and on the roots. The presence of mealy bug colonies is necessary for the expression of the disease. The symptoms are successively a reddening of the leaf tips which begin to bend, and a loss of turgor. In the final stage, leaves dry and curl back and the root system is destroyed. Late wilted plants give small fruits with sharp eyes (decrease of yield may reach 50%) To control wilt, the farmer must control both the mealy bugs and the ants which carry and protect them. This control must be constant throughout the crop cycle. For instance, when preparing the soil, all residues from the preceding crop should be destroyed and incorporated to elimate potential sources of infestation.

In Martinique, disinfestation of planting material is not done because of its cost.

To control wilt, the systemic insecticide disulfoton is applied at the base of old leaves at rates of 1 g per plant. It may be applied twice (at 2.5 and 5 months) or thrice (at 2.5, 5 and 7 months). The contact insecticide methyl parathion is sprayed once a month (at 6 l/ha), mixed with a liquid fertilizer.

Symphillids and nematodes — The main parasites of the roots are the symphillids and the nematodes *Meloidogyne* spp. and *Rotylenchus reniformis*.

The external symptoms are classical symptoms of root disfunctions, i.e small plants with thin and reddish leaves. For controlling symphillids and nematodes, Mocap (ethoprophos) is incorporated in the bank before planting at a doses of 200 kg/ha. Two other applications at 100 kg/ha are done at 3 and 6 months.

Phytophthora — The fungus *Phyrophthora parasitica* is the causal agent of heart rot. It is present in the soil and its spores are dispersed by surface water. They are projected by rain drop impact into the plant heart. High soil pH above 5 and humidity increase the risk of heart rot. In these conditions, it is necessary to treat with Aliette (phosethyl Al) just after planting, at doses of 7 kg/ha.

3.3.5 Artificial Floral Induction

Floral induction time is very important. The fruit weight depends on plant weight and growth rate at forcing time. The better the plant development and the faster the growth and the heavier the fruit.

Plant weight is estimated through the D leaf weight, i.e. the weight of the leaves which have finished their growth. At forcing time, D leaf weight must be between 80 and 100 g.

The success of the floral induction is essential as it allows the harvest of all the fruits at the same time and enables a good homogeneity in the 2nd cycle (ratoon cycle).

Flowering is induced artificially by nocturnal spraying of an aqueous solution of ethylene (800 g/ha in 6–8,000 l of water) or Ethrel (ethephon) at 3 l/ha in 2,000 l of water. Ethrel is usually sprayed with 50 kg/ha of urea, which improves the efficiency of the treatment. Because of the economic importance of successful induction, the field is treated twice at a 4–7 days interval.

IV. Harvesting

Fruits are harvested when the base of the fruit is yellow or orange while the upper half is green. The crowns are left in the field. Fruits are transported to the factories by trucks or pick-up cars. The fruits are processed on the harvest day. Fruits for the local market are harvested with special care because pineapples are very susceptible to bruising during transportation and before sale.

The most appreciated fruits have a brix over 15 and an acidity of 10–12 meq/100 ml of juice. Sugar content and acidity depend on the stage of ripeness of the fruit at harvest time. Sugar content increases very quickly during the last stages of ripening while acidity is going down. Both vary with the climate: temperature, water consumption and solar radiation. They can be controlled by fertilization, particularly by potash.

V. Conclusion

The main problem of pineapple production in Martinique is due to black rot and leathery pocket diseases. For canning, pineapple slices must be sorted and rotten slices are eliminated. That means losses both for the farmer and the cannery.

The only way to limit these losses is in harvesting early (since rots develop with maturity), but with negative consequences on fruit quality (high acitidy).

ST. KITTS AND NEVIS

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The Ministry of Agriculture (MoA) in St. Kitts and Nevis has identified a number of potential tree or fruit crops for cultivation in the twin-island federation. The MoA priority tree or fruit crops as outlined in the Organization of Eastern Caribbean States (OECS) Diversification Plan are mango, breadfruit and pineapple. Recently papaya was added to the list. Limited information is available on the cultivation, areas of production and marketing of these crops.

Due to the land tenure situation in St. Kitts and Nevis the area under permanent non-sugar cropping is very small. In St. Kitts only 36.4% of land farmed is privately owned whilst in Nevis only 65.1% of the parcels operated are legally owned by the farmer. Farm size and distribution are similar in both islands — 91.9% and 84.6% of all holders operate land ranging in size between 0.04 ha and 1.2 ha (0.1 and 3.0 acre) and more holdings are planted to permanent crops in Nevis than in St. Kitts (1987 Agricultural Census).

I. Generalities

1.1 Projects

1.1.1 Papaya

Papaya production in St. Kitts and Nevis has always been a backyard (one or two trees) operation. However with the new emphasis placed on fruit tree production in the Federation, attempts are being made to commercialize the papaya. The Department of Agriculture and CARDI have been looking at cultivars that would be suited to the ecology and market in St. Kitts and Nevis.

1.1.2 Pineapple

There are currently eight production plots on Nevis and two on St. Kitts. Most of these plots have been initiated or revitalized by CARDI with the support of the extension staff. Moreover in all cases of production CARDI has been instrumental in assisting farmers to increase their production. At present CARDI has two on-station plots which are used as observation plots and as a source of planting material for further expansion of the pineapple project. Recently two other plots of about 0.05 ha (0.125 acre) have been planted.

1.1.3 Mango

In St. Kitts and Nevis mango shows a compact distribution in holdings bordering ghauts or old orchards abandoned by estates. This crop was established years ago and is growing in a somewhat wild state. In essence these holdings are operated by landless farmers.

1.2 Ecological Problems

1.2.1 Papaya

Solo cultivars were obtained from Barbados and Trinidad and planted on the Department of Agriculture and CARDI stations. The results have been the loss of the majority of plants due to bunchy top and other unspecified diseases.

1.2.2 Pineapple

There are no ecological problems and plots thrive well under local conditions.

1.3 Area Planted

1.3.1 Papaya

The total area under organized papaya production is 0.6 ha (1.5 acres): 0.4 ha (1 ac) in St. Kitts (at three locations) and 0.2 ha (0.5 acre) in Nevis (at two locations). In St. Kitts the trees are under a rainfed system while in Nevis the trees are under drip irrigation.

1.3.2 Pineapple

The total area planted for pineapple is approximately 1.6 ha comprising of 0.6 ha on Nevis and 1 ha on St. Kitts. The value of the crop is to supply the local demand for hotels, restaurants and domestic purposes thereby reducing the importation of the commodity and enabling the Federation to become self-sufficient. Farmers also use it as a source of income.

The major limiting factors are: the shortage of planting material; farmers attitude to the production of the crop (management); and the high incidence of praedial larceny.

1.4 Cost of Production

1.4.1 Pineapple

The preliminary costs of production and returns are currently being complied by CARDI and will be made available in the near future.

1.5 Seasonality

1.5.1 Pineapple

Prior to 1990 the fruiting season for pineapple was from May to August. However due to artificial flower induction with the use of Ethrel these plants have been synchronized to produce fruit on a monthly basis thereby eliminating the problem of seasonality.

1.6 Main Markets

1.6.1 Pineapple

The main markets are hotels, restaurants, and the

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local domestic market. There is always a great demand for the fruit but the supply is limited as the area planted is insufficient and the price of imported pineapple too high.

1.6.2 Mango

Very small quantities leave the Federation; no mango fruits are allowed into the United States and its territories due to fruit fly infestation.

II. Pre-production

2.1 Cultivar Selection

2.1.1 Papaya

In 1990 the Republic of China (ROC) Technical Mission introduced three varieties for promotion of commercial papaya production. The cultivars included Sunrise, Solomon and Tainong #2 which was sown in September 1990 and planted out in October/November at five locations: Fountain, Greenhill and Fahies in St. Kitts, and Prospect and Cades Bay in Nevis.

2.1.2 Pineapple

The varieties being propagated are Antigua Black, Montserrat and Local which resembles Sugar Loaf.

2.2 Propagation

2.2.1 Pineapple

Due to a lack of propagation facilities in some cases quite a high percentage of suckers are lost in the nursery. Stock used are side suckers, basal suckers and crowns.

There is a great demand for planting material. However, due to the small plots used for procuring planting material and the difficulty in identifying an alternative source the demand is also greater than the supply.

III. Production Systems

3.1 Planting

3.1.1 Pineapple

Planting is done manually in a double-row system using various spacings. The most common being 45 cm × 60 cm, and 60 cm × 60 cm.

3.2 Crop Husbandry

3.2.1 Pineapple

Plants are fertilized once monthly with NPK, 60 g per plant and weed control is done either manually or with Hyvar X at 115 ml in 22.5 l. A rainfed systems. The major pests are mealy bugs found in association with ants; control is by Diazinon.

3.3 Yields

3.3.1 Pineapple

Average yield is 16,500 kg/ha. Because of the attempt to establish year-round production plants were treated with Ethrel to induce flowering. This has resulted in a certain quantity of fruit being produced monthly for the local demand. There were no changes found in fruit quality.

3.4 Factors Affecting Production

3.4.1 Papaya

In July/August the plants located at Fountain in St. Kitts began dying quite suddenly. The plants started dying from the top down with stems getting water soaked spots and progressed rapidly into rotting of terminal end of plant. The field at Greenhill was examined and the problem existed but less severe. Also less severe at Fahies. There has been no outbreak in Nevis to date.

Dr. O. Liburd of St. Kitts, Mr. F. Jones of CARDI and Dr. A. Hernandez of FAO visited two infected areas and diagnosed the problem to be *Erwinia*. This has become a major concern for the Ministry of Agriculture.

3.4.2 Mango

Commercial mango production will be difficult to develop due to the land tenure situation in the Federation, difficulty in the collection of fruits from widely distributed small plots, praedial larceny and maintenance of strict quality guidelines.

IV. Harvesting

4.1 Papaya

Fruits are harvested by cutting the stems with a knife. Fruits are packed in cardboard boxes, buckets and baskets and sent to market. Market acceptance was slow at first but picked up very fast. At present the hotels, in particular, are asking for more papaya. The varieties Sunrise, Solomon and Tainong #2 are very sweet with good texture and colour. These have the potential to become very important varieties in St. Kitts and Nevis to meet the domestic demand.

4.2 Pineapple

Fruits are removed from the plant by breaking them off the stalk or by cutting from the stalk. The tools used are knives and secateurs.

The maturity index used is the change in colour of fruit. There are no major problems at harvest.

V. Post-harvest Handling

5.1 Pineapple

Harvested fruits are transported in plastic crates, boxes and buckets to the market place.

VI. Marketing

6.1 Pineapple

Fruits are sold to hotels and the local domestic market. There is often a great demand for the fruit — the quantity of fruit used in the Federation is in excess 9,000 kg per annum.

The price for local pineapples is $6.60–9.90/kg. That for imported pineapples is $9.90–11.00/kg. During the summer months pineapples have to compete with mangoes thus the sales of pineapples are reduced.

ST. LUCIA

COLIN PAUL
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I. Generalities

1.1 Projects

The fruit projects currently being implemented in St. Lucia fall under two broad categories: The Tree Crop Programme (includes mangoes) and aims at increasing non-traditional exports, and The Import Substitution/Replacement Programme aimed primarily at local marketing and includes pineapple, papaya and mango. The main activities of these two programmes centre around production enhancement and technological improvements.

A number of institutions are engaged in activities related to mangoes, pineapples, papaya and fruit crops generally. In particular, IICA and CARDI are deeply involved in fruit projects. In St. Lucia, the CARDI team is at the forefront of technology generation and both IICA and CARDI are involved in the transfer of technologies in collaboration with the Department of Agriculture. CARDI is also involved in agronomic studies on mango and pineapple, as well as in the introduction and evaluation of germplasm of papaya and mango. Adapted technologies of topworking have also been introduced and currently mangoes especially and other fruit trees are topworked into more marketable varieties. The co-ordination of these activities locally is done through Quarterly Review meetings. IICA, CARDI, The French Technical Mission, the Chinese Mission, and the Ministry of Agriculture Extension and Research Divisions are all involved in these meetings. Monthly monitoring meetings are held at the ministerial level.

1.2 Ecological Problems

There are no major problems associated with the ecology under which these crops are grown. Soil conditions, humidity, and temperature are favourable but in limited acreages, suggesting the need for zoning and prioritization of crops generally. Supplementary water (irrigation) during the dry season and in dry areas is necessary for increased yields and improved quality, while wind problems are normally area-specific.

1.3 Planted Area

The area listed in Table 1 was taken from the Final Report on the 1986 Census of Agriculture in St. Lucia, published in June 1987.

Table 1: Area planted (ha), exports, recorded local purchases, and production estimates (tonnes) of selected fruit crops.

Crop (ha)	Av. exports (tonnes)	Av. recorded purchases (tonnes)	Total (tonnes)	Inflation factor	Est. prod. (tonnes)
Papaya (NA)	0.8	1.9	2.7	10%	3
Pineapple (NA)	7.4	4.8	12.2	10%	13
Mango (480)	444	27	471	10%	518

Other data in Table 1 are based on 1988 to 1990 information extracted from "Prix Produit" except exports of mango and papaya which are based on 1985–1990 figures. An inflation factor of 10% was used to give a conservative estimate of production.

Estimated production and value are given in Table 2

Table 2: Estimated production and value of papaya, pineapple and mango

Crop	Est. prod. (tonnes)	Av. price EC$/kg (1989)	Value EC$
Papaya	3	1.59	4,770
Pineapple	13	4.00	52,000
Mango	518	0.59	305,620
Total	534		362,390

The estimated production was taken from Table 1, while the average price represents average local wholesale prices recorded in 1990. These have been used to estimate the value of the production, which totals EC $362,390 for 534 tonnes of these crops.

1.4 Factors Limiting Production Expansion

Some of the more important factors mitigating against production expansion include:

(i) Low availability of suitable land; competition with other crops and uses. This is so for all crops.
(ii) Lack of organized production and marketing.
(iii) Lack of quantity of exportable cultivars.
(iv) Low cultural/management practices.
(v) Low quality.
(vi) Minimal agro-processing.

(vii) Pests and diseases.
(viii) High labour costs.

1.5 Seasonality

Crop	Availability period	Peak period
Papaya	Jan-Dec	Jan/Feb and Jun/Jul
Pineapple	Oct-Jul	Mar and Jun
Mango	Mar-Oct	May-Aug

1.6 Main Markets

Average yearly exports and local purchases (tonnes) are:

Year	Papaya Export	Papaya Local	Pineapple Export	Pineapple Local	Mango Export	Mango Local
1990	0.6	2.2	2.5	7.4	433.2	32.0
1989	0	1.4	13.4	4.8	448.8	27.4
1988	0.1	2.2	6.2	2.2	604.2	23.8
Ave.	0.2	1.9	7.3	4.8	495.4	27.7

The average yearly exports and local purchases (leading supermarkets and the St. Lucia Marketing Board), are based on 1988 to 1990 data extracted from the yearly Prix Produit Reviews. These figures reveal the importance of mango as an export crop while pineapple and papaya appear to be more important on the local market, as the quantities exported are very low.

1.6.1 Papaya

Papaya is more important in domestic marketing than in exporting. The small volume recorded as well as those sold at the local central markets (unrecorded) perhaps indicate a potential for expansion.

1.6.2 Pineapple

Pineapple is more important in domestic marketing than in exporting although average exports for pineapples are higher than the recorded local purchases. The small volume recorded as well as those sold at the local central markets (unrecorded) perhaps indicate a potential for expansion.

1.6.3 Mango

The main markets for mango are the international markets with the UK and Canada as prime destinations. Recent exports reveal the following:

Export market	Percentage
UK	79
Canada	11
St. Maarten	4
Netherlands	4
USA	2

Locally, the central markets and supermarkets are major outlets. Hotels and restaurants are important outlets as well.

II. Pre-production

2.1 Cultivars

2.1.1 Papaya

With respect to papaya, the local variety is normally grown in scattered plantings and near to farm houses. Some improved Solo varieties introduced for testing by IICA showed some initial success but problems with collar rot (*Erwinia* sp.) were overwhelming.

2.1.2 Pineapple

The main variety of pineapple grown is the Smooth Cayenne, but there is some production of local types. The bulk of the production is done by two large estates in the southern part of the island.

2.1.3 Mango

Many varieties are found in St. Lucia. They are mostly seedlings, but some improvements and introductions have been made. The popular types include Graham (introduced by the BDD Tree Crops Project) while Julie, Long and Pierre Louis have assumed an increased importance.

Local purchases recorded (t) are:

Variety	1988	1989	1990
Julie	6.7	6.0	5.7
Graham	12.4	11.2	11.3
Others	4.6	10.0	15.0

Graham tends to have medium to large fruit with a smooth skin which ripens yellow. The flesh is smooth, firm and the fibres are very soft. It tends to be susceptible to anthracnose in wet areas or where pruning is not adequate. Julie and the other local varieties tend to have smaller fruit and are more prone to mechanical damage. The Pierre Louis (Pal we) variety tends to have firm fruit while the Long is very fibrous. The mango seed weevil has been found in most varieties on the island and this has serious implications for the propagation of mango plants.

2.2 Propagation, Rootstock, and Related Problems

2.2.1 Papaya

Papaya seeds are collected from fruit, sown and transplanted in available spots randomly. Production is neither systematic or organized.

2.2.2 Pineapple

Pineapple slips are graded and planted according to size in intensive production (large estates), while crown and slips are used by producers of the local variety.

2.2.3 Mango

The propagation of Graham and Julie mango is done by terminal wedge or side grafting onto seedlings of the Long variety mainly and the Pierre Louis to a lesser extent. Scions are obtained from the agricultural stations, while fruit and seeds from any source are used for rootstocks. There is a problem related to the seed weevil which can drastically reduce the quantity of viable seeds.

2.3 Plant Demand and Supply

In general, there are no properly organized and maintained fruit germplasm collections. Also there are problems related to the system of plant propagation and distribution generally.

An average of about 4,000 mango plants are distributed annually. Transportation cost is usually high, while farmers have the expectation that plants should be available on a year-round basis.

III. Production Systems

3.1 Planting

3.1.1 Mango

The production system for mango is characterized by scattered plantings usually widely spaced and intercropped, with bananas as the main crop. Mango plants are often used as boundary markers, along river banks and for soil conservation purposes.

3.2 Crop Husbandry

3.2.1 Papaya

Papaya production is characterized by scattered plants usually of the local types.

3.2.2 Pineapple

Systematic and intensive production is done on two large estates in the southern part of the country. Experiments are being conducted by CARDI on flower induction as well as on plant density with a view to controlling fruit size.

3.2.3 Mango

Fertilization and weed control is usually practiced for non-bearing trees especially in the early part of establishment. In older and bearing trees, fertilization tends to be incidental — when bananas are fertilized and sprayed, other crops in the system also benefit.

3.3 Factors Affecting Production

Factors affecting production and quality in the field include:

(i) Low quantity of improved varieties.

(ii) Poor cultural practices.

(iii) Poor management practices.

(iv) Pest and disease problems which tend to be handled by corrective rather than by preventative measures.

IV. Harvesting

4.1 Tools and Methods

Mango trees are commonly climbed, the fruits picked by hand or shaken to the ground by shaking branches. Also V-poles with sacks attached (kali) are commonly used. Fruits are then collected, cleaned and selected for marketing. Improved varieties like Julie and Graham are commonly harvested with kalis. A fruit picker is currently being tested and modified by CARDI and the Engineering Division of the Ministry of Agriculture.

Pineapples and papayas are picked exclusively by hand.

Fruits which have fallen to the ground can suffer from bruising, splitting and or internal damage. A general problem is related to collection of fruit from scattered trees. This tends to increase the cost of harvesting, handling and transportation.

4.2 Maturity Indices

The most common index used is colour change. Mangoes are more often harvested at the green mature stage, especially for export trading. On the local market, all stages can be obtained.

Pineapples and papaya are usually harvested when early signs of ripening are detected. Size is also used as an indicator of maturiy, usually in combination with colour change.

The main problem is related to marketing, where early in the market period, immature fruit may be sold as green mature.

V. Post-harvest Handling

5.1 Transportation from Field to Packhouse

The main type of vehicle used in the transportation from field to packhouse is the pick-up van. Small trucks (2–3 t) are also frequently used by exporters and large estates. Mango and papaya are usually packed in boxes or baskets. Pineapples are usually placed directly in the tray of vehicles. Improper packing in vehicles leads to shaking which results in bruising, splitting and internal damage.

The main reasons for rejection of fruit in the packhouse are bruising from inadequate packing and signs of squeezing and compaction from too dense packing. Fruits showing noticeable signs of pest and disease damage are rejected in the field or during the selection process.

VI. Shipping and Distribution

Regulations relate to general sanitation, phytosanitation, and condition of the packing materials.

Costs are not standard and vary depending on the carrier and the volume of the consignment. In general air freighting is very expensive and should be reserved for high value crops.

The alternatives appear to be joint marketing, increased regional trading and processing which can add value to the product.

VII. Processing

There is no major processing of mango, pineapple and papaya in St. Lucia. These fruits are used primarily in the fresh state although some processing is done by cottage-type operations. Jams, jellies, marmalades and juices are used in restaurants and hotels, but the major use is in fruit salads and juices.

The main drawback to processing is the relatively high cost of fruit and insufficient quantity of supplies.

VIII. Marketing

The main marketing channel for mangoes is the export market and in particular the UK which accounts for more than 75% of exports. The fruits are sold on the fresh fruit market and the main consumers tend to be ethnic in origin. Mangoes are also very important in local marketing and although complete data are not available, estimations indicate its significance.

Pineapple and papaya are marketed almost exclusively on the local market. They are disposed of through the supermarket, central markets and hotels.

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ST. VINCENT AND THE GRENADINES

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I. Generalities

1.1 Projects

1.1.1 Papaya

There is no organized production of papaya in St. Vincent and the Grenadines. Fruit is obtained mainly from scattered trees grown in a backyard farming system. Local demand is quite limited. Medium sized fruits are sold at a price of $1.00–1.50 per fruit. No selection has been done, most of the fruits in the market are round shaped (from female flowers).

1.1.2 Pineapple

There is little or no commercial production of pineapples in St. Vincent and the Grenadines. Pineapple is almost absent in the local markets and the few that sporadically appear are sold at approximately EC$5.00/kg. There is a ready market for pineapples for local consumption and for the tourist trade in the Grenadines. There are two research activities currently underway in St. Vincent: flower induction to achieve year-round production, conducted by CARDI; and introduction of new varieties by the French Technical Mission.

1.1.3 Mango

The Mango Topworking project funded by BDDC ended in March 1991 — 4,000 trees have been topworked. The Ministry of Agriculture, Industry and Labour propagates and distributes plants at a subsidized rate of $1.00 per plant. CARDI has a project for orchard management.

1.2 Ecological Problems

For mango the problems are: poor fruit set due to high rainfall during flowering (November to February); an indefinite flower induction period; anthracnose related to high humidity and rainfall; conditions for vegetative growth are very favorable — there are a few months of a marked dry season.

1.3 Limiting Factors

1.3.1 Pineapple

The limiting factors for the expansion of this crop are:

(i) Unavailability of planting material.
(ii) High cost of production
(iii) Limited land space

1.3.2 Mango

Relatively small yield per tree.

1.4 Area Planted

1.4.1 Papaya

The Chinese Technical Mission of Taiwan cultivates approximately 0.4–0.8 ha (1–2 ac) annually. They test the adaptability of the Chinese cultivars to local conditions. The main constraint is the bunchy top disease.

1.4.2 Pineapple

Introduction of new varieties and the expansion of production is carried out by the French Technical Mission. So far, 2 ha (5 acres) have been planted, valued at $30–40,000.

1.4.3 Mango

There are 12,000 trees planted, mainly in scattered locations.

1.5 Production Costs and Returns

1.5.1 Pineapple

Production costs for the first year are $12,400 with returns of 10,000 kg (20,000 lb).

1.5.2 Mango

Value of production is $440,839.

1.6 Seasonality

Pineapple: August to October

1.7 Main Markets, Demands and Supply

Pineapple: Local market
Mango: Regional (Barbados and Trinidad) and extra-regional (England, Canada and USA).

II. Pre-production

2.1 Cultivars

2.1.1 Pineapple

Smooth Cayenne, Antigua Black, Monsterrat and Sugar Loaf. The Antigua Black is the most important.

2.1.2 Mango

Julie, Imperial, Horse, Palawee, Bombay. Julie is the most important; it has good taste, very much appreciated by locals. It is fairly resistant to anthracnose. The trees are semi-dwaft.

Imperial has big strong trees, low yields, big fruits (0.5–0.7 kg) with skin colour yellow with red check and pale yellow flesh with no fibre. It is susceptible to anthracnose.

2.2 Propagation, Rootstocks and Related Problems

2.2.1 Pineapple

Propagation is by suckers and crowns. The main problem is the limited planting material.

2.2.2 Mango

Propagation is by seeds, which are planted directly in bags. Rootstocks are from seeds collected from local varieties. The problem related to propagation is the low number which catch after grafting.

2.3 Plant Demand and Supply

2.3.1 Pineapple

Supply does not meet demand.

2.3.2 Mango

Demand is higher than supply. However, it is projected that supply will satisfy demand for the 1992 planting season.

III. Production Systems

3.1 Planting

3.1.1 Pineapple

Planting is on beds and terraces. Planting distances are 30 cm × 30 cm × 1.8 m (1 ft × 1 ft × 6 ft) in double rows.

3.1.2 Mango

Scattered trees, used as boundary marks, intercropped with root crops is the method of planting used. Planting distance is 8 m × 8 m (25 ft × 25 ft) for Julie and 9 m × 9 m (30 ft × 30 ft) for Imperial.

3.2 Crop Husbandry

3.2.1 Pineapple

NPK (banana fertilizer) is given at 30 g (1 oz) per plant after one month. Then 30 g (1 oz) are given every 6 weeks thereafter.

Pre-emergent herbicide (Gesagard) is used and then hand-weeding. No irrigation is done.

Spraying is done using Primicid and Mocap. Ethrel is used at 15 ml in 15 l of 2% urea solution. Sometimes leaves are pulled over the fruits to prevent sunburn.

3.2.2 Mango

Fertilization for non-bearing trees (1–4 yrs), is the NPK banana fertilizer — 110–225 g (¼–½ lb) four times per year in increasing quantities. For bearing trees, nitrogen fertilizer is given twice per year (avoiding application 2 months before fruits mature) at the rate of 110 g (¼ lb) per 25 kg of fruits produced.

Controlling weeds is done by cutlassing and herbicide application (Gramoxone). There is no irrigation programme.

The Ministry of Agriculture, Industry and Labour has a spray programme for fruit crops against anthracnose and pests.

Pruning of trees is done to control light and to open the compact canopy.

3.3 Yields

3.3.1 Pineapple

Pineapple yields 20–30,000 kg/ha (lb/ac).

3.3.2 Mango

Julie, 500–1000 fruits; Imperial, 250–500 fruits. Local varieties can yield up to 5,000 fruits.

IV. Harvesting

4.1 Methods

4.1.1 Pineapple

A knive or cutlass is used to cut the stems of fruit.

4.1.2 Mango

A pole-picker and also hand picking is used.

4.2 Maturity Indices

4.2.1 Pineapple

Colour of fruit.

4.2.2 Mango

Fruit size and colour.

4.3 Main Problems

4.3.1 Pineapple

Thorns on plants inhibit harvesting.

4.3.2 Mango

Picking fruits from tall trees.

V. Post-harvest Handling

5.1 Transportation from Field

5.1.1 Pineapple

Fruits are transported by head or pick-up trucks. The main problem is sunburn.

5.1.1 Mango

Fruits are placed in sacks and boxes then transported by pick-up trucks

5.2 Packhouse Operations

5.2.1 Mango

Fruits are received, sorted, washed, and then packed in cardboard boxes.

VI. Shipping and Distribution

6.1 Mango

St. Vincent and the Grenadines has a fruit fly free status. Transportation to regional areas is by sea and to extra-regional by air.

VII. Processing

Chase Food Limited processes a very limited amount of mango, an incentive to agro-industry. The price to farmers is $0.25–0.40 per fruit.

SURINAME

D. RESIDA
IICA, Suriname

Fruit crops have had, and still have, a moderate position in Surinamese agriculture, which has a historical and cultural background. In general, Surinamese have a lifestyle where every family has a house and a garden. It is in our culture to plant fruit trees in the backyard. Fruits harvested take an important part in the diets and are shared with relatives and friends. The surplus is sold from stands or goes to the market.

Within the agricultural sector, farmers usually do not cultivate extensive areas with fruit crops. Fruits are not considered to be the main crop and occupy a relatively small part of the land, mixed with other crops like vegetables or livestock. An exception in this situation is that of bananas and citrus which cover 2,000 and 1,800 ha respectively. Until recently, the idea of extensive orchards had not existed within fruit production.

Looking at the status of fruit crops in Surinamese agriculture, one should also consider the soil and climatological conditions. Suriname, from a geomorphological point of view, can be divided into four parts:

Young Coastal Plain
This area mainly consists of heavy marine clay with a surface peat layer. Scattered are sandy ridges. The total area covers about 10,000 km^2. About 200,000 ha is suitable and accessible for agriculture. Most agricultural activities take place in this part of the country.

Old Coastal Plain
This area is characterized by higher plateaux and in between depressions. The soil can be described as silty loam, with moderate to low fertility. The area covers about 10,000 km^2.

Savannah Belt
This belt is characterized by different soil types, from white coarse sands to yellow-brown loamy sands. These soils are well-drained with low fertility. In total this area covers 5,000 km^2.

The Interior
The soils are diverse and originate from old rock formations. Fertility is low. The area is mainly covered by tropical rain forest.

Suriname has typically an equatorial climate. The annual mean temperature is 27°C. The annual precipitation is about 2,250 mm.

Four seasons can be distinguished.

Minor dry season	— mid February to mid April
Main rainy season	— mid April to mid August
Main dry season	— mid August to November
Minor rainy season	— December to mid February

Pronounced differences may occur in length of seasons and mean precipitation.

Following the seasonal pattern, periods of flooding and drought occur regularly. To develop agricultural infrastructure, drainage and irrigation are indispensable. As this infrastructure is not in an up-to-date condition this creates a serious constraint in agriculture.

Another aspect which characterizes the agricultural sector is the farmer. Most farmers are part-timers having a job with the government or another institution/company. Farm activities have been mostly restricted to those with the highest net returns in the shortest possible time, which are vegetables and rice crops.

Recently a new development in the area of fruit production has started, mostly in passion fruit, West Indian cherry and carambola, all for fruit processing. This development is taking place mostly in the districts of Commewyne and Saramacca. The planning of this development differs completely from our traditional backyard fruit tree farming and fruits as a minor crop. Larger areas have come into production for one fruit crop with specific cultural conditions and management. This new direction in agriculture originates from the initiatives of private companies, government companies and foundations.

The government has recognized the importance of this new development in agriculture and approached IICA for support to guide and develop this area to its full potential.

Within the recent developments in the fruit area, no new activities have been implemented for papaya, mango and pineapple. Although the Ministry of Agriculture has published information leaflets on cultivation methods of these crops no extensive production areas exist.

I. Papaya

Papaya has had and still receives considerable attention from the Ministry of Agriculture. Experiments with papaya started about 20 years ago. Attention has been paid to:

— selection of local varieties
— production methods for local and foreign selections
— studies on fruit quality
— studies on pollination, fruit bearing and production
— studies on flowering, pests and diseases

Currently, a study is being done on cultivation aspects of papaya on heavy clay soils of the Young Coastal Plain with emphasis on agrohydrological aspects in relation to soil fertilizers and liming.

Even though papaya has received considerable attention from the Ministry of Agriculture, no extensive production areas exist. The main limitations within this crop lie in its sensitivity to flooding and drought. The main agricultural areas do not have proper drainage and irrigation facilities. Furthermore growing this crop is limited by the incidence of compacted clay soils causing shallow rooting, almost entirely in the upper peat layer.

II. Pineapple

Pineapple is mostly cultivated in specific areas; the high silty loam soils in the Old Coastal Plain, specifically in the District of Para, and by Indians in certain locations of the Savannah Belt. Traditional methods of shifting cultivation are still applied and production areas are relatively small. In Coebiti, an experimental station of the Ministry of Agriculture, trials on pineapple cultivation were carried out until 3 years ago, when illegal armed troops occupied the area. Little pineapple production takes place in the Young Coastal Plain because of the previously mentioned drainage problem.

III. Mango

Although Mango is a popular fruit crop in Suriname and about 250 ha is in production (backyard system) little attention is paid to this crop. The reason for this is that the climatological conditions are not suitable for commercial mango production. The main limitations identified are:

— too much precipitation causing flower and premature fruit drop.
— irregular bearing caused by unknown factors.
— non-bearing trees.

TOBAGO

REGINALD PHILLIPS
Division of Agriculture, Forestry and Marine Affairs, Tobago

Tobago, the smaller of the twin-island state of Trinidad and Tobago, lies just north of the 11°N latitudinal line, enjoying therefore the climate associated with that position. Its 300 km² size allows the land and sea breezes to have a moderating effect on this climate.

Tobago has a single backbone of highlands peaking at Pigeon Hill and the lowland areas predominate around the coastline, in the south-west, and in river valleys throughout the island.

The soils are rich and varied ranging from a neutral pH in the calcareous south-west, to acid in the north-east. The island enjoys a dry season from January to May and a rainy season from June to December, most rains falling in the June–July and October–November periods.

Tobago's economy is tourist-oriented and while the tendency is towards hotels, resorts and other non-agricultural activities on the island, a large number of abandoned agricultural holdings are now stationed and are available for planned agricultural development.

The Tobago House of Assembly has embarked on a stateland distribution programme aimed at leasing to farmers parcels of stateland for agricultural purposes. The island climate its soil and its topography allow for the pursuit of a wide range of tropical and subtropical agricultural activities.

I. Generalities

1.1 Projects

Like most Caribbean islands, Tobago has traditionally produced fruits mainly for its domestic fruit sector. This is now one area of the agricultural programme of the Division of Agriculture, Forestry and Marine Affairs and the intense interest in this area is reflected in the fact that a team of officials has recently been looking at the fruit production and marketing aspects of agriculture in Dominica (citrus) and the Tobago House of Assembly has seen it fit to finance, out of its limited budget, a full team of officals to this workshop in Antigua. We know what Trinidad is doing. We are now comparing our programme with that of other Caribbean islands.

Tobago is currently not targeting the export market although individual farmers have outlets in Canada and Europe, particularly for Julie mangoes. The Division's interest is fuelled by its desire to satisfy the domestic demand for fresh fruits, a demand which is growing with a growing tourism sector and an intensification of the government's School Nutrition Programme.

Our current emphasis is in the following areas:

— Improvement in the island's nursery capability.
— Upgrading the quality of its extension service.
— Forging a closer linkage with our forestry programme, our tourism sector and with other major markets.
— Targeting specific crops for special attention.

II. Pre-production

2.1 Nursery Capability

The Division of Agriculture, Forestry and Marine Affairs has no current plans for expansion on its nursery capability however, it has undertaken the following activities:

— It is seeking to be self-sufficient in stock and scion material and has recently widened the range of its scion bank at Louis D'Or to include varieties which are in current demand internationally.
— It is currently upgrading all aspects of its propagation techniques paying special attention to sterilization of its shredded medium, improvement of irrigation in the nursery sheds, retaining of nursery personnel, etc. The Division is evaluating the need to produce plants in larger bags or in the barefoot fashion, the ultimate aim being to offer the farmer a disease-free plant of reasonable size in a manner which will reduce his field transport problems and yet not interfere with the survivability of the plant in the field.

2.2 Extension Service

Refresher courses for out-field extension staff have been limited to classroom training. The Division has now embarked on field visits to other islands to capture differences in the approach to extension work, exchanging ideas with colleagues elsewhere and broadening horizons in a very general sense.

Specialist training is also earmarked for extension personnel following the Division's narrowing of its area of focus re fruit development.

Two additional areas requiring urgent attention are the provision of modern teaching aids for farmers' meetings and the provision of more appropriate farmers' bulletins on specific crops.

The Division is currently in search of sponsorship for this aspect of its fruit programme.

2.3 Linkage of Fruit Sector with other Sectors

This linkage is being forged mainly from a marketing standpoint but is extended into areas of forestry that bear on pest control and wildlife support.

2.4 Emphasis for 1992

The Division has an ongoing programme of orchard plant production for sale to its farmers and homeowners. As of 1991, however, we have begun to zero in on four fruit types including papaya and pineapple. A three-man committee has been appointed to supervise the development of these crops over the 1992-1993 period. The committee is looking at all aspects of crop development, nursery development, training of staff and farmers, collection, printing and distribution of farmers bulletins, follow-up field work prior to and after plant distribution.

III. Production Systems

3.1 Papaya

Papaya is currently grown on small plots but is plagued by bunchy top yellows. Our farmers are encouraged to use the 2 m × 3 m spacing and intercrop their papaya with ginger, aloa vera and hot pepper.

We are encouraging our farmers to utilize the disease resistant/tolerant varieties grown from imported seeds but the widespread practice is to constantly replant and salvage the most from any crop.

Some farmers have reported success with fortnightly spraying of Perfekthion into the heart or growing point of the plant.

3.2 Pineapple

Pineapple, like other fruits, is aimed at the fresh market. The Tobago variety grows wild in parts of the island, but the cultivated varieties are the Cedros Deltada, crosses of Antiguan Black and small quantities of Mundo Nuevo Red. One of the original Smith crosses seems to be performing best under Tobago conditions and also seems to have a favourable taste advantage over other varieties.

The Tobago delegation is prepared to pool some of its spending money to purchase some original Antiguan Black suckers if at all these could be sourced in Antigua at an affordable price.

3.3 Mango

There is a total of about 12 ha (30 acres) of mango throughout Tobago. Most of this is backyard cultivation to satisfy family needs. There are however significant plots of pure-stand cultivation on statelands and private holdings in Scarborough, Kendal, Richmond, and Patience Hill. There are also mixed fruit plots including mangoes in recently planted areas of Buccoo, Studley Park and Mason Hall.

The main varieties are Julie, Ice Cream and Graham but our newly established scion bank is cultivated with Tommy Atkins, Haden, Buxton Spice and other desirable varieties. The Vert, the Little Pa, and Doux-Doux are also grown.

3.4 Constraints to Production

The major constraint to our fruit programme in Tobago is the prevalence of bird pests. The green parrot, the parakeet, the cocorico and the woodpecker are wreaking havoc in some parts of the island.

Tobago is willing to accept any regional or international assistance in the area of pest control, particularly the control of bird pests.

IV. Conclusion

All major research is done at the central government level in Trinidad. Specific field trials and on-farm validation exercises relevant to Tobago are done in Tobago.

Production, export and import statistics for Trinidad and Tobago are normally lumped together and are not easily disaggregated. Tobago is however in an advanced stage of planning to establish its own data base.

TRINIDAD

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The twin-island state of Trinidad and Tobago is found at the southernmost end of the Caribbean island chain. Trinidad lies approximately 11°N and has an area of 4,828 km². Soils of the Northern Range are free-draining, low in fertility and tend to be acidic. Erosion control on the slopes, contour planting, use of a complete fertilizer and pulverized limestone are some of the management practices employed to allow for good crop growth. In the northern valleys the soils are alluvial, free-draining with moderate nutrient and acidity levels. Cambered beds with graded drains are necessary to remove excess water from around roots. In the central plains, the terrain is undulating. The soil varies from non-calcareous to calcareous, heavy clays to sandy loams with drainage ranging from free to impeded. The soils of the south are developed from marl and limestone while the Cedros Peninsula is more sandy. Forest and tree crops occupy two thirds of the east part of Trinidad while sugar and rice occupy the western part. Approximately 15% of the total land area is planted in tree crops. The eastern area has a mean annual rainfall of 2,000 mm.

The island enjoys a humid climate with a dry season from January to May and rainy season from June to December with most rains in June and July, October and November. The mean minimum and maximum temperatures are 22 and 31°C respectively.

In domestic agriculture, fruit crop farming has low priority with the exception of citrus. However with a high expenditure on imported fresh and processed fruit, there is a clear indication of an increasing popularity of local fruit (Table 1).

Recently there has been a major development in the fruit industry. Besides the diversification programme at Caroni (1975) Limited, some farmers have embarked on planting small (half-hectare) plots of various fruit crops including papaya, mango and pineapple. These fruits are either suppled to the fresh fruit market or they are sold to the large fruit processors in the country, e.g. National Canners, Chase Foods or to small cottage industry processors.

Some of these processed products are then exported (Table 2).

I. Generalities

1.1 Fruit Projects

For a long time now, papaya, mango and pineapple have been commercially produced. However in the Ministry of Food Production and Marine Exploitation, pineapple is one of the priority crops of particular interest, while papaya and mango rank only as secondary projects.

1.1.1 Pineapple

The research programme of the Ministry of Food Production and Marine Exploitation seeks (a) to characterize local germplasm; (b) select suitable types for the processing and fresh fruit markets; (c) assess propagation techniques; and (d) produce planting material through the tissue culture method.

Table 1: Import values (TT$) for fruit and fruit products for 1990

Commodity	Exporting country	Quantity (kg)	Value ($CIF)
Pineapple			
Fresh	Guyana, USA, Venezuela	134,125	100,159
Jams, jellies marmalades	USA, China, Guyana, Canada	165,487	1,906,523
Juice	Costa Rica, Puerto Rico	110,521	641,919
Frozen	Guyana	4,303	6,423
Preserved canned	Guyana, Canada, USA China, Thailand	175,932	998,212
Mango			
Fresh	Grenada, St. Vincent	35,347	40,012
Preserved	Hong Kong	4,608	57,650

Source: Central Statistical Office, Trinidad and Tobago, 1990

Table 2: Export values for fruit and fruit products in 1990

Commodity	Country	Quantity (kg)	Value ($FOB)
Pineapple			
Fresh	Guyana, CARICOM Greece	3,735	21,269
Jams, jellies marmalades	CARICOM, UK, Canada, Guyana, USA, Sweden, Aruba	65,498	564,210
Juice	UK Canada, CARICOM	14,496	71,658
Preserved	USA	13,569	140,211
Mango			
Fresh	UK, Canada, USA	38,519	39,419
Preserved	UK, Canada, USA Sweden	15,553	139,671

Source: Central Statistical Office, Trinidad and Tobago, 1990.

II. Pre-production

2.1 Cultivars

2.1.1 Pineapple

The local germplasm has already been characterized and six cultivars were selected for further evaluation. These selections are well suited for both the fresh fruit market as well as for processing into juices, jams and other preserves. Table 3 shows these different cultivars. Assistance is sought in having the local types properly identified and so we are in close contact with our fellow researchers in Martinique.

Table 3: Cultivars of pineapple found presently in Trinidad

Cultivar	Brix (degrees)	Weight (kg)	Leaf & fruit characteristics	Utilization
Black Antigua	12.4	1.2	sweet; soft, bright yellow; spines	fresh fruit market
Deltada	9.6	0.7	semi-sweet; fibrous; whitish; spines	Jam, jellies marmalades, etc
Hybrid #6	16.0	1.9	sweet; soft; deep yellow; spines on tips tips of leaves only	fresh fruit market
Sugar Loaf (Green Pine)	12.2	1.4	soft; sweet; (extremely) whitish yellow; spines	fresh fruit
Mundo Nuevo Red	10.1	3.0	semi-sweet; soft creamy; large spines	pizza
Mundo Nuevo Green	13.0	1.6	sweet; soft; yellow; large spines	fresh fruit

2.1.2 Mango

The main cultivars are Julie, Starch and Doux Douce (Table 4). Graham and the Florida varieties are not produced to any large extent due to local consumer preference for those cultivars propagated in large numbers. Most mangoes are consumed on the local market. It is only from 1991 that there was some choice of varieties for processing, e.g. Graham for fruit cocktails; Rose and Vert/Long for condiments. Requests are for 2,500 for each cultivar.

2.2 Propagation

2.2.3 Mango

The rootstock used is mainly Rose with some Vert/Long. Approximately 50% of the rootstocks are col-

Table 4: Characteristics of mango varieties grown in Trinidad

Variety	Fruit characteristics	Other information
Julie	Weight 424 g; non-fibrous; excellent flavour ripens orange/green with slight blush.	Small tree; highly susceptible to anthracnose disease; monoembryonic.
Buxton Spice	Weight 295 g; non-fibrous; excellent flavour; ripens orange/green with slight blush; highly aromatic; some stem-end breakdown; originally from Guyana.	Small-medium tree size, Tolerant to anthracnose.
Zabricot	Weight 175 g; few fibres; good flavour; ripens yellow/green; tendency to fruit cracking.	Medium to large tree
Starch	Weight 175 g; fibrous; starchy texture; good flavour; ripens yellow.	Tall tree; highly susceptible to anthracnose; bark silvery white.
Doux Douce	Weight 183 g; fibrous; good flavour; ripens orange with red blush	Medium sized tree; prolific bearer.
Calabash	Weight 280 g; non-fibrous; flavour good when fully ripe; ripens green/yellow	Tree size large.
Graham	Weight 460 g; non-fibrous; flavour good when fully ripe; ripens yellow/orange, slight blush.	Tree size large
Vert (Long)	Weight 266 g; fibrous; flavour good; ripens yellow/green	Tree size large; fruit sold green for home processing; polyembryonic (i.e. usually true to type from seed)
Rose	Weight 175 g; fibrous, bland flavour; ripens with a pink to purple blush	Tree size large; fruit sold green for home processing; polyembryonic

lected from nurseries within the Ministry of Food Production and Marine Exploitation. The balance is purchased from private farmers.

The sales from government propagation stations are given in Table 5.

Problems in plant production include:

(i) Seed collected from private farmers are sometimes non-viable; either it is immature or lacking in embryo. Germination averages 50%.

(ii) Praedial larceny of fruits from the Ministry of Food Production and Marine Exploitation nurseries.

(iii) Seeds are usually set in cool, shaded areas under trees and covered with a mixture of bagasse/fibrebast and soil. When germinated they are transplanted into individual bags.

Seeds sometimes die from desiccation (if irrigation problems exist) or from flooding in areas prone to overflow of rivers/water sources. It would be preferable to set them in bins under more controlled conditions, but breakdown of pulp takes approximately 1 month and the large quantities of seeds that must be collected are difficult to handle.

(iv) Because of the large quantities being handled, transplanting may be delayed and plants die due to damage of their root systems.

(v) Although chemical control of pests and diseases is exercised at all times, some anthracnose and scale insects occur.

Table 5: Sale of mango plants by type 1987; number sold by station

Cultivar	St. Augustine Nurseries	La Pastora	La Reunion	Marper Farm	Total
Julie	9,826	4,900	9,121	4,109	27,956
Starch	1,014	1,233	2,971	1,051	5,367
Buxton Spice	195	864	1,489	891	3,439
Graham	—	544	—	96	640
Doux Douce	280	549	691	84	1,604
Zabricot	15	377	—	48	440
Vert	—	40	59	63	162
Kandahar	—	12	—	2	14
Calabash	174	22	194	118	508
Tommy Atkins	—	3	—	31	34
Sensation	—	—	84	23	107
Peter	1	—	72	—	73
Bombay	—	—	—	4	4
St. Clair	—	2	—	—	2
	11,505	8,546	13,781	6,520	40,352

Source: Sub-division of Horticulture, Ministry of Food Production, Trinidad and Tobago

2.3 Plant Demand and Supply

2.3.1 Papaya

Plants are produced directly by farmers through purchase of imported seeds of Taiwanese varieties from the agricutural companies.

Information from the hybrid seed supplier, Caribbean Chemicals, is that the seed sold can plant 150 ha/year, this can be seen in Table 6. Plants producted by the Ministry are indicate in Table 7.

2.3.2 Pineapple

Plants are purchased directly from other farmers, due to the more advantageous price and larger quantities available from fruit producing farmers.

Plants are also propagated by the Ministry of Food Production and Marine Exploitation for sale to homeowners in the numbers shown in Table 7.

2.3.3 Mango

Plant orders are collected by the Extension Services Division and forwarded to the Horticulture Sub-division. Usually larger numbers are ordered than actual requirements. For example, 1981–1986 plant orders were in the vicinity of 300,000; orders from 1987 to 1990 were more realistic (due to the downturn of the economy) ranging from 40,000 to 80,000.

Production capacity is presently 50,000 plants per annum. Since sales have been averaging 40,000 plants for the past 5 years, this production target is selected unless other factors indicate need for a review. Table 8 shows production and sales over a 10-year period.

III. Production Systems

The production systems for papaya, pineapple and mango are summarized in Table 9.

3.1 Papaya

Papaya is currently grown on small plots but is plagued by bunchy top yellows. At present, in Trinidad there are about 50 ha of land under cultivation. Farmers' holdings are found on the north eastern and the west part of the Southern Range with the majority of farmers found in central and north Trinidad, especially in the valleys of Caura, Diego Martin, Maracas, Santa Cruz and St. Joseph. Papaya plants can be found throughout the island growing in backyards, scattered or intermixed with other fruit trees, in commercial, pure-stand plantings or growing isolated in the wild. The amount of high-quality papaya produced is insufficient though for the successful penetrating of the export market. Pests and diseases, as well as poor quality and susceptibilities of the varieties being cultivated, are the major constraints to this poor commercial development. Virus and virus-like diseases limit papaya production. Bunchy top caused by a mycoplasma is the most important followed by distortion ringspot which is caused by a virus. Therefore resistant lines must be found. The ripe fruits supply the fresh fruit market and some are processed into cocktails while some green fruits are processed into candies and/or used as a filler for sauces.

Table 6: Hybrid varieties of papaya grown in Trinidad and Tobago

Variety	Maturity	Weight (kg)	Yield (ha/yr)	Shape	Flesh	Brix (°)	Features
Tainung No. 1	Medium early	1.1	60,000	near round to oblong	red	11–12	medium dwarf
Tainung No. 2	Early	1.1	60,000	—	—	13–14	good flavour
Tainung No. 3	Early	1.3	60,000	—	salmon	11–12	dward; productive
Known You No. 1	Early	1.6	60,000	oblong	yellow	12	virus tolerant; productive
Sunrise	Early	0.4	30,000	pear-shaped	red	15	dwarf; excellent flavour

Table 7: Production and sales of papaya and pineapple plants

Crop	Year	Production	Sales
Papaya	1986	1,305	1,300
	1987	1,280	1,039
	1988	1,548	1,517
	1989	699	609
	1990	1,399	406
Pineapple	1986	8,289	5,107
	1987	11,363	5,778
	1988	11,706	3,805
	1989	1,768	6,960
	1990	6,265	2,838

Source: St. Augustine Nurseries, Sub-division of Horticulture Ministry of Food Production, Trinidad and Tobago

Table 8: Production of mango plants 1981-1990

Year	Production	Sales	Percentage sold
1981	78,781	59,223	75
1982	57,436	57,436	90
1983	53,275	43,000	82
1984	60,588	46,585	77
1985	75,502	36,862	49
1986	79,669	47,801	60
1987	38,650	40,352	100
1988	42,755	25,792	60
1989	37,034	32,641	88
1990	39,181	34,318	88

Table 9: Production system of papaya, pineapple and mango in Trinidad and Tobago.

Crop	Cultivar	Season	Spacing	Pests	Diseases
Mango, *Mangifera indica*	Julie, Starch, Rose, Doux Douce Graham, Vert	Jun-Sep. Jun-Aug	6 × 8 8 × 10		Anthracnose; soft nose; gallings; sooty mold, Nematodes, thread blight
Papaya, *Carica papaya*	Solo, Sunrise, Scott Hybrid varieties	all year	2 × 3	Fruit fly Scale insects;	Anthracnose; Internal blight, Stem canker bunchy top; ring spot virus, Nematodes
Pineapple, *Ananas comosus*	Black Antigua, Deltada Mundo Nuevo Red Mundo Nuevo Green Hybrid #6, Green pine	all year	0.45 × 0.60	Mealy bug; Butterfly Rhinoceros beetle	nematodes Heart and root rot bud rot

Farmers are encouraged to plant 2 m × 2 m or 2 m × 3 m when using imported seeds of disease-tolerant/ resistant varieties. Also, regular dressings of minor elements help the plant to produce large quantities of fruits.

3.2 Pineapple

At present there are about 50 ha of land under pineapple cultivation. There are two farmers (Princes Town and Mausica) each with approximately 18 ha under cultivation. Farmers are encouraged to plant at 45–60 cm apart and to practice weed control.

3.3 Mango

Mango cultivation, though never found in a pure stand, is assuming greater importance in Trinidad, although it is still considered a minor crop. Mango can be satisfactorily cultivated on all types of soil from well-drained fertile soils to very heavy clays. Some mango growing areas are Cascade, St. Anns, Las Cuevas, Maracas in the Northern Range; Vega de Oropouche, Plum Mitan in the Northern Plain; Claxton Bay, Mayaro in the Southern Plain; La Brea, Cedros in the Cedros Peninsular; and Les Couteaux, Spring Garden in Tobago. The rainfall in the Northern Plain is very high so mango production suffers from anthracnose whereas in the Cedros Peninsula mango production yields are much better because of the climatic conditions.

Julie is the most popular variety, because of its excellent flavour and small tree size. Buxton Spice has outstanding fruit flavour, good fresh colour and a tree size, slightly larger than that of Julie. It yields better than Julie under very wet conditions. About 28 ha of land are under mango production. However mango production is affected by the following problems: yield of the major variety Julie is low only (0–150 fruits/tree); many varieties including Julie are subject to anthracnose disease, causing blossom blight and fruit blemish; and production is limited generally to the period May – September. Buxton Spice shows good tolerance to anthracnose (therefore yields better) and shows a tendency to off-season cropping. Thus an important factor in the successful production of mangoes for the fresh fruit market is the effective mangement of anthracnose disease. This disease is very severe in the rainy season and is caused by the fungus *Colletotrichum gloeosporioides*. Death of young leaves and stems may result. A severe flower blight leads to reduced fruit set. Young fruit and also mature fruit are heavily blemished. This disease leads to low fruit yield and to fruit of poor quality.

3.4 Factors Affecting Fruit Production

The following four factors affect fruit production:

Low yields — maybe associated with local ecological conditions, e.g. shallow soils, uneven rainfall distribution, or lack of knowledge of proper fruit husbandry.

Poor quality fruit — maybe associated with the varieties; lack of water; shade; high incidence of pests and diseases; other production techniques, poor harvesting methods where fruit are usually collected after falling to the ground; lack of grading and other marketing functions.

Scattered production — fruit trees are scattered and this makes marketing difficult.

Seasonality of production — flowering occurs in response to the stress of a dry spell so that production coincides with the wet season. Some tree crops however flower twice per year, e.g. some mango varieties, while other crops produce all-year-round depending upon the availability of water, e.g. papaya.

IV. Harvesting

A major thrust in fruit production requires improvement in the harvesting management. Farmers must be advised on the improvement of methods to handle perishable produce. The harvest operation aims to gather the fruit from the field at the desired stage of maturity, with minimum damage/loss, rapidly and economically.

V. Post-harvest

The following are the major post-harvest problems.

- high incidence of diseases such as anthracnose in papaya and mango.
- absence of maturity indices which are crucial in the mangaement of orchard production systems.
- the lack of application of adequate handling techniques, especially in the case of soft fruit. The result is early deterioration and other associated problems.
- insufficient information on appropriate storage conditions for local cultivars.
- inadequate transportation units for export marketing.

VI. Processing

When faced with the prospects of excess production and no markets, farmers are told to take their produce to the processors. Processors want cheap raw materials, but should farmers accept lower prices which are sometimes below the cost of production? There are five large processors of fruit: National Canners, Superior Foods, Chase Foods, Nestlé and Cannings. With the increased awareness of the processing ability of some fruits there are many householders forming small cottage processing industries (Table 10).

National Canners — Under the labels of Matouks, Mabel and MP: pineapple slices, chunks and jams are made. 100,000 kg/year of the Graham variety are processed into jams, while 20,000–30,000 kg/year of the Green Graham and/or Rose, Vert are processed into kuchela and amchar. Green papayas are used at 100,000 kg/year as a filler in pepper sauce.

Table 10: Update of Processors and Processed Products

	National Canners	Chase Foods	Superior Foods	Nestlé	Cannings	Cottage Industries
Pineapple ripe	Slices, drinks, jams	Slices, chunks, jams juices, cocktails candied, raisins	pulp	juice	juice	Candied james
Mangoes ripe	—	juices, nectars, slices, jams				candied jam
green	chutney, kuchela, amchar	chutney, kuchela, amchar				kuchela, amchar, peppered and sweet preserved mango slices
Papaya ripe	—	nectar jams				jam
green	filler for sauce	filler for sauce	filler for sauce			candied, raisins, coloured, candied slices

Superior Foods — This processor has not done work with mango but 70,000 kg of pineapple came into Trinidad from Guyana. The machine can produce 2,000 kg/day of pineapple pulp. Papaya also is processed at a rate of 4,000 kg/day.

Chase Foods — Under the label of Sun Pick Products: 15,000 kg/month of pineapple is imported from Guyana to be processed into slices, chunks, juices, cocktails and jams. Sometimes the local pineapples are used to complement this if there is a large request for the processed product to be exported. Local pineapples though have low quality, large crowns and small fruits. Candied pineapple and pineapple raisins are also produced. Graham and Rose varieties of mangoes are used to produce juices, nectars slices and jams. Papaya is processed at 1,500 kg/month into nectars, jams and slices.

All the above processors supplement their imported raw materials by using some fruit from farmers. Their products are then exported to CARICOM countries, UK, Canada, USA and Holland.

The other two processors Nestlé and Cannings import their raw material but sell their products on the local market.

Nestlé imports pineapple concentrate from Thailand, Indonesia, Brazil in very large quantities 17–18 t every 2–3months. They sell locally 100 cases (8 × 1 l packs) per month. They export to CARICOM 160-180 cases/month.

Cannings on the other hand import the concentrate and package the pineapple juice under a Motts label.

VII. Marketing

The local market for the fresh fruit is somewhat under-developed whereas the processed fruit is marketed both locally and abroad. A great deal of fresh fruit mango (35,347 kg) is imported from Grenada and St. Vincent. The majority of the fruit produced locally reaches retail vendors via middle men or directly from farmers. Some producers market directly to the supermarkets.

There are two sources of market data appearing in the daily newspaper. The Agricultural Development Bank advertises demand and supply information for its clients and publishes wholesale and retail prices as they occur in the central and municipal markets. General market information is also collected by the Planning Division of Ministry of Food Production and Marine Exploitation, the NAMDEVCO, the Central Statistical Office and the Export Development Corporation.

VIII. Conclusion

Production of papaya, mango and pineapple is at present an attractive proposition in Trinidad and Tobago. Unfortunately farmers do not recognize the possibilities for greatly increased yields and profits through giving adequate care to the production practices of the various fruit crops.

SECTION 2

TECHNICAL PAPERS

Production of Papaya

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INTRODUCTION

The papaya (*Carica papaya* L.) is a popular fruit in all Caribbean countries. In this region papayas can be found growing in pure-stand commercial orchards, as a backyard crop, scattered and intermixed with other fruit trees, and in some places (e.g., Guyana) as a wild plant. Although the origin of the papaya was in the Tropical Americas, the Spanish and Portuguese sailors quickly disseminated plants to many tropical and sub-tropical areas around the world.

Despite the popularity of papayas in the Caribbean, commercial development of this crop has been relativcly slow. Only a few countries have developed commercial-scale plantings and even in those the total acreage planted has been up and down in a relatively short period of time. Among these the Bahamas, Barbados, Belize, Cuba, the Dominican Republic, Jamaica, Puerto Rico, and Trinidad and Tobago have developed commercial production and exported to extra-regional markets. More recently, efforts are being made to expand the commercial acreage to other countries such as Antigua, Grenada, St. Lucia and St. Vincent. Susceptibility to pests and diseases has been blamed as one of the most important constraints to the poor development of this crop in the region. Nevertheless, efforts have and are still being made to overcome these constraints and explore the potential of papaya as an income generator and as one of the alternatives for agricultural diversification in the region.

I. Botany and General Aspects of the Papaya Plant

1.1 Taxonomy

The papaya (*Carica papaya* L.) belongs to the Caricaceae family which contains four different genera:

— Carica
— Cylicomorpha
— Jacaratia
— Jarilla.

Of these, only the genus *Carica* contains species that are cultivated for their fruits. This genus contains about 21 species of which *C. papaya* L., *C. candamarcensis* Hook., *C. monoica* Desf., *C. pentagona* Heilborn, *C. erythrocarpa* Heilborn, *C. goudotiana* Solms-Laubach, and *C. quercifolia* Benth and Hook produce fruits which are edible. However, all except *C. papaya* lack the palatability for eating as a fresh fruit and therefore are seldom eaten as such.

1.2 The Plant

The papaya is a giant herbaceous dicotyledonous plant with a soft-wooded hollow stem. Initially, the plant normally has a simple trunk. However, lateral branches may be easily induced, mainly at the top, by injuries (physical or biological) or these may naturally develop as the plant becomes older. Although the plant will normally grow 2–3 m high before it needs to be removed, it can grow up to 6 m or more depending on the ecology where it is grown and how effective the control of pests and diseases is. Commercial life in the Caribbean ranges from 1.5–3 years, but some plants can grow and produce for over 20 years if the conditions are favorable. The hollow stem bears large, deeply-lobed leaves bunched together near the apex on long, hollow, soft petioles. The papaya plant develops a tap root system and in most cases it is soon atrophied and lateral roots are induced. Studies conducted in Brazil (Inforsato and Carvalho 1967) found that on plants 4–12 months old the increase in total root area was 222%. They also found that 76% (4 months) and 68% (12 months) of the roots were found in the first 30 cm. The same authors found that from 30 cm to 2.5 m the root system was quite uniform. The papaya root system is very susceptible to waterlogging.

1.3 The Flowers and Fruits

Papaya is a polygamous species. Plants can be male (staminate), female (pistillate) or hermaphroditic (bisexual). Some plants can produce flowers which exhibit different degrees of maleness and femaleness. Plants showing this kind of behavior are referred to as "crazy sex plants". Climatic factors such as drought and sudden change in temperature have been related to these changes in sexual expression. In fact, the production of male flowers is facilitated by high temperature.

Depending on the variety and the climate where it is grown, the papaya plant begins to flower 3.5–9 months after germination or 2.5–8 months after transplanting in the field. Flowers are borne in each leaf axil for as long as the conditions are favorable. Plants producing hermaphroditic (bisexual) flowers are preferred because they produce the pear shaped fruits looked for by the extra-regional markets.

Fruit set occurs 4.5–10 months after germination or 3.5–9 months after transplanting. The sex of the flowers determines the shape of the fruit; round or oval for female flowers and elongated or pear-shaped for hermaphroditic flowers. The size of the fruit varies from less than 5 cm in length and diameter (weighing less than 50 g) in some strains, to 50 cm or more (over 10 kg in weight) for others. Small pear-shaped papayas weighing 450 g are preferred for the export market.

It takes 8.5–14 months from seed germination to fruit maturity. That is an average of 120 days from the appearance of the flower bud.

II. Varieties

The complex genetic make-up of papayas makes it difficult to talk about true varieties. Most of the existing papaya 'types' fit better into the category of 'strains' or 'lines.' However, there are a few which continue to present uniformity in horticultural characteristics when seeds are produced under closely controlled pollination. Among these, the most popular are undoubtedly those within the 'Solo' group. Others include 'Bush' from Hawaii and the 'Hortus Gold' of South Africa. All these 'varieties' were originated as intra-specific hybrids between different 'strains.'

The 'Solo' papayas, e.g. Line 5, Line 8, Kapoho, Sunrise, and Waimanalo, originated from seeds collected from a fruit purchased by Gerrit P. Wilder in a Barbados market in 1910. The 'Solo' papayas are today comprised of a group of 'varieties' characterized by their bisexual flowers, a high degree of self-pollination, and small uniform pear-shaped fruits. Color of the pulp ranges from yellow to a deep pink. Among this group of varieties, 'Sunrise' and 'Kapoho' are the most popular and are being cultivated by most papaya producing countries.

More recently the Fengshan Tropical Horticultural Experiment Station in Taiwan, developed and released three F1 hybrids: Tainung no.1, Tainung no. 2 and Tainung no.3. Also, the 'Known-You' company developed the F1 hybrid 'Known-You no. 1', which is claimed to be tolerant to the papaya ringspot virus.

Many other 'strains' were developed in producing countries and cultivated on a commercial scale. Some of these still continue to be important for local marketing. The most popular are summarized in Table 1.

When selecting a given variety to grow, several factors should be taken into consideration by the grower. Among these, the most important are those related to adaptability to local conditions and to the intended market. Some of the characteristics a grower should look for in selecting a variety are the following:

- The product should correspond to the standards demanded by the intended market, e.g. size, shape, color, brix, appeal etc.
- The plant should be tolerant to existing growing constraints, e.g. physical, chemical or biological.
- High yield, precocity and low stature.
- Low or no segregation.

Table 1: Local papaya 'strains' and countries where cultivation has been reported.

Strain	Country
Betty, Homestead, Fairchild	
Califlora	Florida (USA)
Graham	Texas (USA)
Cartagena, Ombligua	Dominican Republic
Hortus Gold, Coorg Honey	South Africa
Barbados Yellow, Barbados Pink RM-Pink, RM-1, RM-2, CP-5	Barbados
Petersen, Guinea Gold,Sunny Bank	Australia
PR 10-65, PR 7-65, PR 6-55	Puerto Rico
Madhu Bindu, Honey Dew	India
Santa Cruz Giant, Cedros, Singapore Pink	Trinidad
Verde, Gialla, Cera, Mamey, Chichona	Mexico
Maradol	Cuba
Singapore	Malaysia
Red Panama	Cameroon
Thailandia	Brazil
Guayas	Colombia
Cubana, Paraguanera, Cartagena Roja	Venezuela

Source: Marte (1986)

A given variety, e.g. Sunrise, may have all the necessary characteristics demanded by the export market of a papaya fruit, but if that variety is susceptible to local existing constraints, e.g. bunchy top, the grower may have to discard it from the list. Table 2 summarizes some important characteristics for the most used 'varieties' in the Caribbean.

III. Propagation and Seed Production

Papaya seeds are produced abundantly and germinate readily in a short period of time (8–15 days). Therefore, seeds have been the preferred method of propagation for papaya. Nevertheless, the papaya

Table 2: Main characteristics of the most important varieties of papaya cultivated in the Caribbean

	Plant		Fruit					
Strain or variety	Size	Maturity	Weight (kg)	Size	Shape	Flesh colour	Brix (%)	Market
Sunrise	small	early	0.4	sm	pear	red	15%	ext. reg
Kapoho	small	early	0.4	sm	pear	yellow	14	ext. reg.
Barbados yellow (CP-5) ***	small-medium	med-early	0.6	med	pear	yellow	14	local & ext. reg.
RM-1 **	small	early	0.4	sm	pear	pink	15	ext. reg.
RM-2 *	small	early	0.4	sm	pear	red	15	ext. reg.
Tainung #1	medium	med-ea	1.1	m-lg	oblong	red	12	loc. reg.
Tainung #2	medium	early	1.1	m-lg	oblong	red	13	loc. reg.
Tainung #3	small	early	1.3	larg	oblong	pink	12	loc. reg.
Known You #1+	med-Large	early	1.6	large	long	yellow	12	local

Tolerance to bunchy top: *** High, ** Medium, * Some
+ Tolerance to papaya ringspot virus.

plant can be propagated vegetatively by cuttings, grafting and tissue culture. Although the first two asexual methods are too laborious to justify their commercial use they, as well as propagation by tissue culture, have the advantages of allowing 'true to type' propagation of promising heterozygous lines. Tissue culture propagation of papaya, although still used on a reduced scale, will become a more widely used propagation method for papaya because of the potential for direct selection-propagation of outstanding clones and the potential to obtain homozygous hermaphroditic plants through 'anther culture'.

3.1 Sexual Propagation

Seeds should be collected from a well known source otherwise yield and quality of the fruit may not only be poor but also be lacking in the required uniformity. Unfortunately there are few 'true-breeding' varieties or strains of papaya available. This situation has arisen mainly because of the traditional propagation of papaya, using seeds from fruit coming from open-pollinated flowers with no control of the pollen sources.

If the flowers are hand-pollinated from known pollen sources the progeny of papaya can be predicted:

Female (pistillate) flowers pollinated by male (staminate):
- 50% male
- 50% female

Female pollinated by hermaphroditic (bisexual):
- 50% female
- 50% hermaphroditic

Hermaphroditic self-pollinated or cross-pollinated by hermaphroditic:
- 33% female
- 67% hermaphroditic

Hermaphroditic pollinated by male:
- 33% male
- 33% female
- 33% hermaphroditic

The following are some hints useful in the production of seeds for improved varieties:

- Select the most outstanding bisexual plants in the grove showing desirable characteristics of yield, quality and tolerance to problems.
- Cover the flowers with small paper bags just before they open. Ensure the flowers are mature; this is easily recognized by a change in the color of petals from a pale to a deeper yellow color.

  In covering the flowers be sure that:
  - The bag is tied so no insects will penetrate
  - The tie will not strangle the peduncle causing the flower to abort.
  - The inside of the bag does not touch the flower.
  - The bag is secure enough not to wave with the wind
- Remove the bag 12 days after bagging the flower.
- Gently mark the fruit to ensure that this can be identified up to the date of harvesting. This can be done with permanent markers at the base of the fruit peduncle or by tying colored cotton strings on the peduncle.

Selfing of bisexual flowers over two generations eliminates completely the possibility of the appearance of male plants thus saving effort for commercial growers.

Seeds for propagation of papayas are collected from ripe fruits. The gelatinous substance (aril) is removed since it contains inhibitors that delay or prevent seed germination.

Depending on the viability of the seeds one, two or three seeds are planted in small (10 cm × 15 cm) plastic bags filled with a soil-based mixture to provide good drainage. Alternative methods are the use of Speeding trays, leach tubes, peat pots, Jiffy pots, etc. The container recommended depends basically on the cost and type of orchard to be established. Although some growers still use them, seed-beds are cumbersome for the propagation of papaya. Direct planting usually requires too many seeds and it is not usually recommended in our region. Germination occurs within 8–15 days. The time required before transplanting in the field depends basically on the type of container used, the type of irrigation (if any) and the transplanting system. This period usually ranges from 6 weeks (plants should be 12–18 cm tall) for most containers going to fields with drip irrigation, to 12 weeks (plants should be no more than 30 cm tall) for plastic bags to be transplanted under rainfed or overhead irrigation systems. It is important when transplanting, that the plants are not too tender or too tall and have a strong stem to avoid bending.

The use of fresh seeds is always recommended. However, seed storage is usually required. When storing seeds it is important to ensure that they are properly dried and packed in plastic bags. The seeds can then be placed in the vegetable compartment of a refrigerator. A drop in the viability will be noticeable after 5–6 months but seeds under these conditions should last for 12 months, maintaining at least 80% germination.

IV. Ecological Factors

The papaya plant prefers fertile soils with good drainage, an abundant well distributed rainfall (800–2000 mm) and warm temperatures of 25–30°C. The plant does not tolerate strong winds, flooding or prolonged dry periods. However, the plant is adapted to a wide variety of soil types as long as they have good drainage and salt content levels are normal. Therefore, heavy clay soils and saline plots should be avoided. It does better on soils with a pH near neutrality (6.5).

At high elevations or cooler temperatures, plants are late in flowering, fruit maturity is slow and the fruits normally develop with a lower brix. High air humidity facilitates development of fungal diseases while very low air humidity usually means a need for more frequent irrigation. Plants subjected to waterlogging, shed their leaves, flowers and fruits and may die if the root system is badly affected. Under a prolonged dry spell leaves wither and flowers and fruits are shed. Fruit size and fruit quality are also affected by the amount of water available. A fruit growing under high soil moisture is larger and develops a watery pulp which is easily damaged during transportation. A plant growing under dry conditions bears fruits which are smaller and hard to eat.

V. Planting

5.1 Land Preparation

Land preparation depends on the type of soil, area to be planted, purpose of the orchard, and the equipment and labor available. For example, clearing can be done with machinery or by hand, the soil can be harrowed throughout or only partially. Sometimes only the spot where the plants are to be located is manually worked out with a hoe. Large contour terraces may be necessary or 'eye-brow' terraces individually constructed. In general, for flat land on a moderate acreage, the plot is cleared and harrowed once or twice. Depending on the drainage and the topography of the plot, the construction of a drainage system may be necessary. In some cases the soil may need to be chiselled and beds of various widths and heights constructed.

5.2 Layout

For good yield and high fruit quality it is important to orient the orchard to favor wind direction and maximize the use of sunlight, but it is also important to orient the orchard to prevent soil erosion. The selection of a suitable planting system depends on many factors including the variety to be grown, the topography of the plot, the scale of the operation and the machinery available for all operations within the future orchard.

As with other fruit plants, papaya can be planted under three basic systems: Square, rectangular and triangular. A combination of these systems is also possible, e.g. a double-row system. The square system is more common on small plots with limited mechanization of operations. The triangular system is used on soils with pronounced slopes. The rectangular system is the most common and mainly used where some mechanization is needed, e.g. for weed control. Recommended plant spacing varies from 1 to 3 m between plants within the rows and 2 to 5 m between rows. Plant density varies from 1000 to 3000 plants/ha. Some varieties support a higher plant density than others e.g. Barbados Yellow CP-5, Kapoho and Sunrise produce a lot of rejected under-sized fruits when planted at more than 2000 plants/ha while Barbados Pink and the Tainung hybrids can support as much as 3000 plants/ha. The distance between rows may be increased to accommodate cultivation or harvesting equipment or simply for inter-cropping systems.

5.3 Establishment

Papaya is not the only plant to be established in a papaya orchard. Windbreaks, as well as inter-crops are frequently part of the orchard and need to be established as well.

5.3.1 The papaya plant

The size of the planting hole is directly related to the container in which the plants have been growing. In general, the hole should be twice the width, height and diameter of the container. It is always convenient to apply well decomposed manure mixed with top soil at the bottom of the hole. The container should be completely removed and plants with physical damage to the root system should be avoided. Three plants are normally planted in a triangle, each separated by at least 15 cm. The three plants are used to compensate for plant losses and will allow for selection of one hermaphroditic plant in most cases. When setting the plant in the hole, ensure that the level of the soil in the container is about the same level as the surface of the soil where it is planted. If necessary, a small basin is constructed around the plants to facilitate irrigation. Where irrigation is by furrow, small cambered beds are recommended and planting should be done in the middle between the top of the bed and the bottom of the furrow.

5.3.2 The windbreak

Papaya plants are very susceptible to strong winds therefore, protection should be provided whenever there is the hazard for wind damage to occur. Rows of sugar cane, banana, plantain and pigeon pea make excellent, temporary, live windbreaks for papaya. More permanent crops such as jamoon, cassuarina, etc. can also be used. In all cases live windbreaks should be established long before planting the papaya plants. Physical barriers can also be constructed with saran netting and polypropylene sacks.

5.3.3 The inter-crop

Inter-cropping with papaya is possible in two ways: (*a*) Using papaya as the main crop, and (*b*) using papaya as a temporary crop, e.g. within perennial plants such as citrus, mango etc. In the first case a quick-growing crop is selected. Peas, peppers and beans are among the most commonly used. Tubers and root crops such as yam, potato, sweet potato and cassava should be avoided since their cultivation and harvesting may damage the papaya root system. Species within the Cucurbitaceae family, e.g. cucumber, squash and other vine crops should also be avoided because their vines are difficult to keep away from the plant and normally will cause physical damage to the papaya fruits.

VI. Cultural Practices

6.1 Sexing

This term refers to the selection of hermaphroditic plants and the removal of male and female plants from the plot. However, the term has been extended to cover the removal of poor growing seedlings and plants affected by diseases prior to or at the time when the sex of the first flower can be identified. Thinning to only one plant per hole is done soon after hermaphroditic flowers can be identified. Since the female plants are more precocious than the bisexual, in most cases these are eliminated first facilitating the development of the other two plants. However, for small-scale operations, if only two plants remain per hole and the first flower to set is a female, this plant should not be removed until the other proves to be a bisexual plant.

Delays in sexing the plants may result in slender plants. In this case the first flowers are borne high on the stem losing productive space and time and making harvesting a more difficult operation.

6.2 Weed Control

No different from other crops, weeds on papaya fields must be controlled early in order to avoid competition and eliminate chances that these may become hosts for vectors and other insects. A rapid cleaning of the field will prevent the weeds having a chance to seed, making the future maintenance of the plot easier. It is advisable to clean the whole area of weeds except in cases of steep slopes where the weeds are maintained as a cover crop to reduce erosion and only mowed. Even in these cases it is advisable to maintain an area of about 1 m all around the trunk free of weeds. This area is usually referred to as the 'drip area'.

Most contact herbicides, e.g. paraquat, can be used on papaya fields as long as they do not touch the leaves or the stem while the latter is still green. The same applies for some systemic products such as Roundup. Grass killers such as Fusilade, Daconate, and Asulox are quite useful but some side-effects such as cracking of the stem were noticed in Barbados when using Daconate.

Pre-emergent herbicides are being used by several producing countries. Among these are Diuron, Dalapon and Goal. However, based on experiences in Barbados, the Dominican Republic, Antigua, Grenada and St. Vincent where application of Diuron and Dalapon caused flower abortion, fruit shedding and reduction of yield, the recommendation is that the product should be tried on a few plants before doing the application orchard-wide. Application of Diuron on heavy soils is not recommended.

Burning the stem with herbicide facilitates the entrance of *Phytophthora* and speeds up the decline of the plant even if this occurred in the early stages of development. This damage is commonly found when the herbicide is applied carelessly or without protecting the stem of the young plant.

It is difficult to prevent some drift of the herbicide during application and avoid touching the stem, even when a shield is used. This happens especially where winds are strong and frequent. The use of large buckets to cover individual plants in two or three rows at a time is a good practice to protect young plants. These buckets are systematically moved to other rows and weeds too near to the plant are manually removed. A similar practice is the one using a large plastic bag from the moment the papaya plant is transplanted. This bag is unfolded to cover the stem as the plant grows. The bag remains covering the stem at least for the critical period during which herbicide drift may affect the stem. The bag is supported by staples.

When the weeds are tall, the use of a 'chemi-hoe' is useful to prevent drift damage.

The papaya plant is very susceptible to 2, 4-D sprays used in plots nearby. Mature and young leaves normally curl and young leaves may be distorted, resembling leaves from plants affected by virus.

6.3 Fertilizer Application

This cultural practice if not the most critical, is undoubtedly one of the most important practices to obtain a good yield and high quality fruits. The papaya, unlike other fruit crops, is growing and bearing continuously. Therefore, to obtain good yields and to expand the tree life, water and nutrients must be continuously available.

Our region is characterized by a shortage of reliable laboratories where soil analysis and recommendations can be obtained to advise the grower of what and when to apply in a short but reasonable time. Due to this, empirical recommendations based on country experiences are useful.

A usual practice in most producing countries is to recommend a pre-planting application of $N:P_2O_5:K_2O$ at a ratio of 1:3:1, to the hole and the area immediately surrounding it.

In the particular case of papaya, phosphorus is particularly important for young plants, while potassium is needed after flowering. Nitrogen availability is critical at all stages from growth to flower and from fruit setting to fruit maturity.

Foliar analysis is useful in determining whether the contents of macro and micronutrients are adequate or deficient for a good yield and fruit quality. Studies conducted at the University of Hawaii showed optimal levels of nutrients in papaya leaves collected during the flowering period and related them to a very high production on soils with pH 5.9. These results are presented in Table 3.

Table 3: Percentage of macronutrients found in papaya leaves and petioles after flowering period related to a very high production in Hawaii.

	N (%)	P_2O_5 (%)	K_2O (%)
Leaves	1.15	0.185	2.78
Petioles	1.3	0.164	5.2

Cunha (1979) in Brazil determined the concentration of micronutrients and related them to the absorption by stems, leaves, flowers and fruits of 1650 plants/ha at different ages. The results are shown in Table 4.

In the same study Cunha (1979) also determined concentrations of macronutrients in dry matter and related those to the absorption by stems, leaves, flowers and fruits. These results are shown in Table 5.

Most producing countries have given general recommendations in terms of total or monthly applications for commercial production of papaya. Following are some of these recommendations with their respective reference.

HAWAII:
Ito et al.
225-450 g of 10-10-10 per tree per month.

University of Hawaii (1970)
- At planting: 10-10-10; 62–144 g around the plant
- From 3–5 month: 10-10-10; 80 kg/ha
- After 5 months: every month 10-10-10; 320 kg/ha
- After harvesting: every month 10-10-10; 454 g/plant

BRAZIL:
Anda (1971)
90 g N, 90 g P_2O_5 and 90 g K_2O per plant in three applications.

Pipaemg (1972).
- Before planting: 20 l of pen manure, 60 g P_2O_5 and 30 g K_2O.
- After planting: Two applications of 20 g N, one application of 20 g N, 40 g P_2O_5, and 60 g K_2O.

ANGOLA:
Xabregas and Santos (1967)
- Before planting: 10-10-10; 50 g/hole
- 3-4 months after: 10-10-10; 250 g/plant
- Second year: 10-10-10; 500 g/plant when rains start and repeat at middle of rainy season.

INDIA:
Rao and Shanmugavell (1971)
50 g N, P and K every 2 months, until the seventh month.

SOUTH AFRICA:
Malan (1964)
- At planting: 454 – 667 g/hole of superphosphate
- Before harvesting: 56 g of a 20% nitrogen fertilizer; repeat every 6 weeks until plants are 1 year old.
- After first harvest: 450 g superphosphate/plant/year during the Spring. NPK with ratio 2:1:2 or 2:1:3 for more potash deficient soils.

AUSTRALIA:
Cann (1966)
675 g/plant for the first year and 900-1350 g for older trees of NPK (8-12-6)

VENEZUELA:
Millan (1978)

	(g/plant)		
	N	P_2O_5	K_2O
Less than 6 months	10	10	15
6-12 months	40	40	60
More than a year	100*	100*	150*

*In two different applications.

BARBADOS:
Marte (1986)
12-12-17-2 at the following rates:
- Planting: 110 g/plant
- 1-3 months: 110 g/plant/month
- 3-7 months: 335 g/plant/ month
- after: 450 g/month

Complement with chelated micronutrient mixture (Mg, 2%; Mn, 3%; Fe, 1.5%; Zn, 0.5%; S, 4%) as follows:
- 4.5 l/ha at 2.5 months after planting
- 11.9 l/ha at 7 months after planting
- 11.9 l/ha at 11 months after planting
- 9.5 l/ha at 15 months after planting

Different studies on papaya have shown that applications of N, P and K can block or increase the absorption of other nutrients. For example application of N can induce a decrease in the concentration of K, P and Ca and/or increase the percentage of Mg, S, Mn, Zn and Cu. Applications of P can induce increases in the levels of Ca, S and Cu, while K can decrease the percentage of N, Ca and Mg. Studies conducted in Barbados by the author (Marte 1990, Unpub.) showed that deficiencies of Mn, Fe and Zn cause papaya plants to take up chlorine. This normally causes a severe chlorosis and decline of the plant which affects yield and may eventually kill it.

6.4 Irrigation

Unlike other crops, e.g. mango, papaya does not need a rest period in order to flower and set fruits. These are set on a continuous basis and therefore the papaya plant requires available water to grow and bear continuously. In general, the amount of water needed is influenced by the stage of development, spacing,

Table 4: Mean concentrations of micronutrients in dry matter and average absorption by the aerial parts of the papaya plant at different ages.

		Concentration (ppm)			Absorption (g/ha)			
Micronutrient	Days from planting	Stem	Leaves	Flowers & fruits	Stem	Leaves	Flowers & fruits	Total
	120	32.5	52.2		0.3	0.6		0.9
Boron	240	26.0	23.0		13.4	23.8	6.1	43.3
	360	23.5	38.0		39.1	42.8	19.6	101.5
	120	5.5	9.2			0.1		0.2
Copper	240	8.0	8.7	6.0	4.1	4.9	1.3	10.2
	360	9.0	7.0	6.7	15.8	8.0	6.0	29.7
	120	105.2	192.7		0.9	2.5		3.4
Iron	240	49.5	72.2	52.2	25.8	43.3	11.3	80.4
	360	85.0	123.2	62.7	147.8	136.7	53.6	338.1
	120	47.2	109.5		0.4	1.4		1.8
Manganese	240	49.5	77.2	66.7	25.8	43.3	14.2	83.3
	360	39.2	99.2	33.2	69.2	112.7	29.4	211.0
	120	0.05	0.215		0.0005	0.0025		0.0030
Molybdenum	240	0.03	0.095	0.165	0.0157	0.0538	0.0353	0.1048
	360	0.043	0.083	0.103	0.0718	0.0926	0.0899	0.2543
	120	24.25	19.5		0.21	0.25		0.46
Zinc	240	31.25	17.2	51.2	15.5	21.1	10.99	47.58
	360	32.50	19.7	26.0	56.2	27.8	22.3	106.4

Source: Cunha

Table 5: Mean concentrations of macronutrients in dry matter and average absorption by the aerial part of the papaya plant at different ages.

		Concentration (ppm)			Absorption (g/ha)			
Micronutrient	Days from planting	Stem	Leaves	Flowers & fruits	Stem	Leaves	Flowers & fruits	Total
	120	0.9	3.2		0.1	0.4		0.5
Nitrogen	240	1.2	3.6	2.0	6.1	20.0	4.44	30.8
	360	1.8	4.2	2.9	30.8	47.9	24.9	103.6
	120	0.2	0.3		0.0	0.0		0.1
Phosphorus	240	0.1	0.3	0.4	0.7	2.0	0.8	3.5
	360	0.2	0.3	0.3	3.4	3.4	2.9	9.7
	120	2.8	2.3		0.3	0.3		0.6
Potassium	240	2.1	2.6	2.8	10.8	14.8	6.1	31.7
	360	2.6	3.2	3.1	44.7	36.4	27.3	108.3
	120	0.9	1.4		0.1	0.2		0.3
Calcuim	240	0.9	1.2	1.1	4.6	7.0	2.4	13.9
	360	0.9	1.5	0.6	14.7	16.8	5.4	37.0
	120	0.4	0.5		0.0	0.1		0.1
Magnesium	240	0.4	0.4	0.4	2.1	2.3	0.9	5.3
	360	0.5	0.5	0.5	7.9	5.3	2.4	15.7
	120	0.3	0.5		0.0	0.0		0.1
Sulphur	240	0.3	0.3	0.4	1.7	1.9	0.9	4.6
	360	0.3	0.3	0.3	5.3	4.0	2.6	11.9

Source: Cunha (1979)

soil water retention capability, the topography, the temperature, the wind intensity, and cloudiness. General estimates suggest that papaya in its productive stage requires an average of 25 mm/week. Prolonged periods of drought affect yield and fruit quality. Leaves and flowers, as well as young fruits are shed under these conditions. Fruits developed under water stress are smaller and have a hard pulp which is difficult to eat. In general, young plants are more tolerant to dry spells than mature plants.

There are different systems in use today for irrigation of papaya. Each of them offers comparative advantages and disadvantages in terms of costs and effects; growers should analyze these before making an investment. Some of these are presented in Table 6.

Although at the initial stage one dripper per hole may be sufficient to supply the amount of water required, the number should be increased as the plant grows. Otherwise the papaya plants have a tendency to concentrate roots only on the side where the water is being applied, limiting its absorption area and its anchorage ability. This is one of the several advantages of microsprinklers over the drippers since there is a better distribution of water in the 'drip' area.

6.5 Removal of Lateral Branches

Some cultivars have a tendency to produce many axillary suckers. These should be removed early since they are borne at the same site where flowers and fruits are set, bruising the fruits in their early stage of development. Moreover, studies have shown that these shoots are preferred by mites where they hide from the effects of contact with miticide. A high concentration of N normally induces an increase in the production of these lateral branches.

6.6 Pesticide Spraying

The equipment used to spray chemicals in the grove depends largely on the scale of the operation, the topography of the terrain, the type of soil and the age of the plants. Large-scale planting requires large equipment such as power mist-blowers. In most cases however, knapsack sprayers are used for young plants. In cases where the soil is heavy it is important to avoid soil compaction. Therefore the use of heavy equipment such as ordinary tractors should be avoided. In those cases low pressure tyres and light vehicles, e.g. ATV, are useful.

Papaya plants are very susceptible to phyto-toxicity which can be easily induced by a high application pressure. Therefore calibration of the equipment prior to each application is important in order to avoid heavy stresses, fruit damages and burning of leaves.

In particular two products have been shown to be phytotoxic to papaya at any rate: Diazinon and Omite (also sold as Comite). However, phytotoxicity only occurs when a liquid formulation is used, not for the WP formulations.

Table 6: Advantages and disadvantages of different irrigation systems for papaya.

System	Main advantages	Main disadvantages
Furrow	Inexpensive initial investment	Waste of water. Not adapted to slopes. Facilitates soil erosion, leaching of nutrients and root diseases
Drip and micro sprinklers	Saves water Minimizes nutrient losses Facilitates fertilization by fertigation	High initial investments
Overhead	System can be used for other crops or plots	High initial investment. Impact of water may damage flowers and fruits

VII. Harvesting

The time from planting to fruit maturity varies mainly with the cultivar used and the temperature under which the papaya is planted. In tropical climates, fruits maturing during the summer take an average of 7 months from transplanting while fruits maturing during the winter usually take 8–9 months to mature. Those maturing during the autumn are intermediate (8 months). However, in sub-tropical climates, e.g. Hawaii, the plants take a longer period, usually 12-14 months, to mature the first fruit. Additionally, under tropical conditions harvesting is done three times a week while under sub-tropical conditions it is done once or twice per week.

Harvesting is done at the first change of color from green to yellow. This operation is first done manually or with the help of a knife. However as the tree continues to grow, additional help is required. When the fruit cannot be reached from the ground harvesting tools are useful. The use of a ladder (step or one flight) is common but cumbersome since the person harvesting has to move it for every individual plant being harvested. The Thailand harvester is an ideal tool but the harvest crew must be trained to hold not more than two fruits at the same time. The use of mechanical platforms although more expensive, is justified for large-scale orchards in flat or gently sloping terrain. There are many modifications, from pneumatic to interchangeable platforms.

In most cases the economical life of a papaya plant in the Caribbean is 18 months, after which it is preferable to replace it. This represents 9-11 months of harvesting. Yield is highly variable but a good production should average 90,000 kg/ha (80,000 lb/ac) of total fruits over the 18-month period.

VIII. Main Constraints to Production

Undoubtedly, the main constraints to the production of papaya in the Caribbean are those related to pests and diseases. Among these bunchy top, *Erwinia* and distortion ringspot virus head the list. Unfortunately, the only papaya improvement programme in the Caribbean, initiated in Barbados in 1983, is no longer active. An exception is the effort being made by INRA and IRFA in looking for tolerance or resistance to *Erwinia*. However, any serious attempt to develop the papaya industry in this region will have to address these and other problems as a package and not in piecemeal fashion. Following is a list of the most important needs.

8.1 A Papaya Improvement Programme

The most important role of this programme would be the development of new lines or improvement of the existing ones looking for:

— Tolerance or resistance to bunchy top, *Erwinia* and distortion ringspot. The final product should be a homozygous hermaphrodite variety.

— Elimination of the Carpellody condition.
— Reduction of the ovarian cavity.
— Elimination of 'crazy sex' (sterile hermaphrodites).
— Tolerance to drought.
— Tolerance to mites, thrips and other pests.
— Tolerance to waterlogging.
— High efficiency under low input management.

8.2 An IPM Programme Adapted to Local Condition

Such a programme would involve:
— Study of local natural enemies of main pests; if necessary introduction of others.
— Testing with less harmful chemical products.
— Determination of the level of pest population needed before recommending spraying.

8.3 An Applied Research Programme

The following should be addressed in this programme:
— Cultural practices, e.g. amount, kind and frequency of fertilizers, chemical weed control, etc.
— Spacing.
— Inter-cropping.
— Post-harvest, e.g. treatments, chemical residue studies, packaging, shipment by sea, etc.
— Cross-protection studies.

8.4. Promotion in the Market.

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A Guideline for Mango Production in the Caribbean

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INTRODUCTION

Mango has been identified by the Organization of Eastern Caribbean States (OECS) as one of the major crops of the region with a potential for export and diversification from traditional commodities, e.g. bananas.

Most of the potential increases in regional mango production will be for export to extra-regional markets. There is however, limited potential for increased sales of fresh mangoes to domestic markets and consumption by tourists.

Mango imports into Europe increased from 3,200 t in 1977 to 26,000 t in 1987. The largest exporters to the European market are Mexico, Mali, Brazil and Puerto Rico. However, with increased demand for mango it is likely that there will be room for exported fruit from the Caribbean islands.

The purpose of this guideline is to highlight the technologies and agricultural practices which will allow reliable production of fresh fruit of high quality for export.

I. Selection of Planting Site

The mango is able to grow on a wide variety of soils but does best at a pH of 5.5–7.5. On acid soils, dolomitic limestone should be applied to bring the pH as close as possible to the optimum of 6.8. Water-logged areas are not recommended. Mango may grow at elevations from sea level to 1,330 m (4,000 ft) in the tropics but does best below 665 m (2,000 ft).

A large taproot allows the plant to thrive by utilizing nutrients far beneath the surface and anchors the plant firmly. The trees will stand strong winds but it is not advisable to plant close to the sea with a constant wind (windward side).

Annual rainfall of 750–2,500 mm is required. Rain distribution is very important; mango grows best when at least 4 months of dry weather occur from flowering to harvest. Rainfall during flowering encourages flower drop, prevents pollination by insects and promotes flower disease (anthracnose).

Mango fruits develop better in conditions of low humidity which discourages diseases caused by fungus and bacteria.

II. Pre-planting Operations

It is advisable in poorly drained areas to construct a drainage system of ditches between the rows of trees. Ploughing should be done when possible on levelled ground and weeds should be controlled by disking or using herbicides. Strong constant winds may cause damage and reduce yield; planting of wind-breaks is recommended under such conditions.

III. Varieties/Cultivars

3.1 Commercial Production

Criteria for judging a mango variety for commercial possibilities are:

— It should bear good crops every year under favourable conditions.

— A high percentage of flowers should be perfect and there should be little tendency to produce fruits without an embryo.

— Fruit should be attractively colored with a good blush.

— Fruit should be free of physiological breakdown in the flesh.

— Fruit should ripen with a good quality as much as 10–14 days after harvest.

— The cultivar should be sufficiently tolerant to anthracnose that the usual commercial control methods would be practical.

— Flavor should be satisfactory with flesh free of objectionable fibers and the stone should not be more than 10% of the weight of whole fruit.

3.2 Cultivars

There are two groups of mango cultivars, the 'Indian' types producing one seedling per seed (monoembryonic) and the 'Indo-Chinese' producing more than one seedling per seed (poly-embryonic). The important commercial cultivars of the Windward Islands are:

3.2.1 Julie (St. Julian)

Julie is probably the most important cultivar grown in the West Indies. The tree is semi-dwarf and is the smallest of the commercial cultivars. Bearing is somewhat irregular and in certain areas it bears twice a year. The fruit weighs 200–300 g, has a good flavor, little fiber and is green to yellowish in color.

3.2.2 Graham

Graham has a strong and massive tree. The fruit is large (400–500 g), fiberless, of reasonable taste, travels well, and is green to yellowish in color with potential to develop a red cheek when exposed to sunshine. The main crop is during July - August. This cultivar is susceptible to anthracnose, fruit fly and seed weevil.

3.2.3 Imperial

The tree is large. Fruits are 500–700 g in weight, of good color when exposed to sunshine, with a fair flavor and fiberless. However they are susceptible to anthracnose and bruise easily.

3.2.4 Mango Long

Mango Long has a large and massive tree. It is polyembryonic and is commonly used as rootstock. The fruit is small (150 g), of poor quality, fibrous and susceptible to anthracnose, but the trees bear well

3.2.5 Mango Palai

With a medium size tree and poly-embryonic, this cultivar is commonly used as rootstock. The fruit is small (200 g), of poor quality, fibrous and very susceptible to anthracnose. However this is a good bearing cultivar.

3.2.6 Florida cultivars

Florida cultivars includes Tommy Atkins, Haden, Keitt, Kent and Palmer. These cultivars grow and bear well in some islands with similar climatic conditions to Florida (Puerto Rico, Jamaica). They are still to be fully evaluated in the West Indies and are not recommended for planting on a large scale.

IV. Orchard Planning

Fruit production on mango trees is mostly on the outside of the canopy. Over-crowding creates low fruit production, poor color due to lack of sunshine and conditions favorable for diseases caused by poor ventilation. Trees must be allowed to reach their full potential size for maximum yield. Tall trees present harvesting problems.

Since wide spacing results in a low yield per unit area in the early life of the plantation, it is advisable to plant the trees at a close distance and remove alternate trees later on when over-crowding occurs. Semi-dwarf varieties, e.g. Julie, should be planted 4.5–5 m (15 ft) apart and strong growing varieties should be planted 6–6.5 m (20 ft) apart.

Spacing should be closer in dry conditions as well as on shallow soils. In fertile and deep soils as well as on slopes spacing should be greater. Planting patterns can be square, diamond or rectangular.

V. Planting

A supply of well developed nursery-grown mango plants is the first requirement for a successful orchard. The criteria for mango plants are:

— The rootstock-scion union must be perfect (smooth and full with no dry tissue).

— Plants should be 10 mm thick at 10 cm above the union.

— Foliage should be green-flushed and healthy.

— The root system should be well developed with the main root straight and unbanded at the base of the plant.

— Plants should be well established in bags.

— Plants should be free from pests and diseases.

Planting time should be at the beginning of the rainy season. Trees planted during this period have a longer time to become well established. Planting holes must be prepared large enough to accommodate the root system. The root system should not be any deeper in the soil than it was in the nursery plant container. Soil should be firmly packed around the roots and water used to avoid air pockets. The ground around the plant should be covered with a mulch made of weeds which will keep the soil surface moist and cool.

VI. Care of the Young Orchard

Young trees should be allowed to develop a trunk no taller than 60 cm (2 ft). Training by pruning is desirable to promote a strong framework. Systematic thinning out of central branches and topping of strong branches is recommended to facilitate a short and wide tree canopy with an open centre and plenty of lateral branches which will fit into the available space between trees. Pruning should be carried out according to tree development.

The framework of a well-developed tree should include a 50–60 cm (2 ft) trunk with three to five main branches no longer than 60 cm (2 ft). It is recommended that the main branches should not grow from the same spot.

VII. Care of the Bearing Orchard

Mango trees start bearing after 3–5 years from planting. After that they should continue to bear good crops. Trees should be allowed to expand and fill the space available to them. When trees start to grow into each other it is necessary to remove alternate trees. Systematic pruning and removal of dead wood and weak branches should be done routinely. In addition, the height should be controlled by topping and removing the central branch. This action allows light penetration and facilitates the achievement good colored fruit.

VIII. Nutrition

Young mango trees require several applications during the rainy season (once a month) of a balanced fertilizer, e.g. 10:10:10, from planting to bearing. The total amount of fertilizer given in the first year should be 0.5 kg/tree. This quantity should be increased by 1 kg/tree per year until bearing (5 years).

According to Florida sources, trees just coming into bearing should receive fertilizer proportionate to their yield — 0.5 kg N per 25 kg of fruit should be given. Between 90 and 125 g N should be given per 25 kg of fruit to a mature tree. Next to N, K is the fertilizer element most often controlling growth and yield. It should be applied on acid soil in the same quantities as N. Application of potash improves the color and flavor of fruit. Potash deficiency gives rise to small fruit and poor quality. Excess K causes Ca deficiency and physiological breakdown of fruit (especially on acid soil). Phosphorus requirements of the plant are about one-quarter of the amount of N used.

Of the microelements, Mg is required the most. It should be included in the fertilizer mix at about 10% of the potash content; Cu and Zn are needed in trace amounts.

The time of fertilizer application to mature mango trees should be mainly from the end of harvesting to 2 months before the following harvest. Applications of fertilizers should be arranged so that they are likely to be followed by rain if possible. Heavy applications before fruit maturity should be avoided on acid soil because this would tend to increase Ca deficiency. Leaching may be reduced by dividing the yearly requirements evenly amongst applications. Split applications are especially important on poorly drained soils where the root system is shallow — leaching losses are not great on deep well-drained soils where rooting is deep.

IX. Harvesting

Fruits for fresh consumption and processing are usually harvested in a physiologically mature but unripe stage (green mature stage). Unless fruit is to be consumed shortly after picking it should not be allowed to ripen on the tree; the shelf-life of such fruits is inferior.

9.1 Harvesting Checklist

- Select fruit at the correct maturity stage for the post-harvest handling period to follow.
- Harvest fruit in the cool of the day between 6:00 A.M. and 9:00 A.M. Avoid harvesting in rain which can increase the likelihood of skin blemishes and disease.
- Clip or pick the mangoes from the tree. When harvesting by hand snap the fruit stalk with a sharp rapid twisting action. Immediately after picking the stalk should be trimmed to 10 mm with a sharp clipper. Fruit picked with a pole-picker (cali) should also have their stalks clipped before further handling.
- Ensure that the pole-picker is not causing damage to the fruit. No more than three or four fruits should be harvested with a pole-picker before emptying the bag.
- Keep finger nails short and remove rings to prevent damage to the fruit.
- Never allow mangoes to touch the ground.
- Use clean harvesting crates. Do not overfill field crates. Stack them carefully.
- Keep harvested fruit in the shade.
- Remove latex by washing as soon as possible (within an hour) after harvest, preferably in the field.

X. Major Pests and Diseases

10.1 Fruit Flies

Fruit flies infest mango fruit and cause losses. The Julie cultivar is somewhat tolerant. Control measures against fruit fly involve spraying with Rogor 40 or Lebaycid. Fruits should be sprayed from the time they are half mature until 2 weeks before harvesting.

10.2 Mango Seed Weevil

The adult weevil lays eggs on the skin of newly set mango fruits. The grub which emerges from the egg settles in the seed inside the mango stone. When the fruit ripens the weevil burrows its way out of the stone. Infested fruits may fall. Since most of the cycle of the weevisl within the fruit, chemical control should be done at the early stage of fruit setting by spraying with Basudin or Sevin. However the effect of these on the mango seed weevil is not yet known.

10.3 Scale Insects

Scale insects attack leaves, twigs and young shoots. These insects sucks the sap of the plant and exude honeydew on which black sooty mold fungus develops and covers leaves and fruits. Scale insects can be controlled by spraying with an oil emulsion.

10.4 Slugs

Slugs attack and feed on young shoots and leaves. Young trees can be severely damaged by defoliation which results in die-back of twigs. Control can be achieved by keeping the orchard clean of weeds and bush and by use of bait containing metaldehyde.

10.5 Mealy Bugs

These sucking insects reduce the plant vigour due the sap loss. In addition sooty mold fungus develops on their honeydew excretion and contaminates the fruit and foliage. Mealy bugs can be controlled by spraying with Basudin, Chlordane, Lannate or Malathion.

10.6 Thrips

The commonly known red-banded or cocoa thrip attacks mango leaves, fruits and flowers by scraping and sucking the exuding sap. Leaves turn yellow-brown and the fruit skin becomes brown which makes it unmarketable. When heavy infestations occur pesticide spraying with the following chemicals is recommended: Lannate, Malathion, Sevin, Sweecide or Supracide.

10.7 Anthracnose

Anthracnose is the most severe mango disease in the Caribbean. It is caused by a fungus which attacks leaves, flowers and fruits. Infection is increased by high humidity and rainfall. It appears on young leaves as small dark spots which sometimes develop into large necrotic areas; spots remain small (6 mm) on old leaves.

When young fruits are infected the fungus remains latent and causes decay on mature fruits. Mature fruits infected by this fungus will show extensive rot with some tears remaining on the surface. The disease can be controlled by spraying (from 2 weeks before flowering up to harvesting) with Benlate or copper fungicides. Spraying should be done routinely — up to once a week if necessary. Preventative measures are also recommended, e.g. pruning, site selection (low humidity), tolerant cultivars such as Julie.

Bacterial Canker of Papaya Caused by *Erwinia* sp.

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INTRODUCTION
In the French West Indies (FWI), as in other Caribbean countries, attempts to develop papaya production has been hampered by the extensive development of declining trees. This disorder was different from well-known fungal, viral and mycoplasmal diseases or unusual tropical fruit diseases with extended latent periods, such as purple-stain of papaya (*Erwinia herbicola*) or internal yellowing (*Enterobacter cloacae*).

This decline disease was particularly damaging on introduced Hawaian cultivars from the 'Solo' group, like 'Sunrise Solo' and 'Kapoho Solo' which were selected for their agronomic properties.

This disease rapidly became a limiting factor, especially in Guadeloupe and Martinique which are free of other world-wide viral diseases (mosaic virus, ringspot virus and apical necrosis virus). As a result papaya production has been extensively abandoned. However it is still considered a very attractive fruit for local and export markets because:

- it gives high agricultural yields and marginal income
- it is a short-cycle crop
- it is a hardy plant.

The purposes of this communication are:

— to review knowledge on this bacterial disease called bacterial canker of papaya
— to present actual and expected research programmes
— to propose the constitution of a Caribbean working group to identify the needs for collaborative links in research, training and information exchange.

I. Geographical Distribution of the Disease

Most of diseases of economic importance on papaya trees have been associated with fungus, virus or mycoplasm, but few diseases have been associated with bacteria. During the 1960s in the FWI, phytobacteriologists from INRA (M. Bereau and B. Rat) were the first to observe an outbreak which caused the complete decline and death of papaya. Isolations from diseased material resulted in diagnosis of a bacterial disease attributed to *Erwinia* sp.

A search in the literature showed that similar bacterial diseases had been reported from 1931 up to 1985 (Table 1).

Table 1: Distribution of *Erwinia* sp. disease of papaya

Location date & author(s)	Bacteria	Disease
Java, 1931, Von Rant	*Bacillus papayae*	Bakterient-krankheit
1937, Magrou	'*Erwinia*' (?)	
Trinidad, 1978, Persad	*Erwinia* sp.	Stem canker
Formosa, 1980, Leu, Lee & Huang	'*E. cypripedii*'	Papaya black rot
Mariana Islands 1982, Trujillo & Schroth	*Erwinia* sp. type MC *Erwinia* sp. type D	Mushy canker *Erwinia* decline
Philippines, recent, Pordesimo	*E. carotovora* (?)	Bacterical soft rot

In the Caribbean, declining trees have been reported from different locations (Table 2).

The question of similarity of all those *Erwinia* diseases is interesting from taxonomical considerations, and this will be discussed later. Another interesting question is whether the disease is associated with the introduction of new papaya cultivars in tropical islands where diversification is of economical importance.

This restricted distribution resulted in different enquiries.

II. Questions and Remarks on Distribution of Bacterial Diseases

Are they similar diseases? The answer will be provided from symptom and strain comparisons.

Is there an island status for bacterial canker epidemics? As far as we know, the disease has been reported

Table 2: Distribution of *Erwinia* sp. disease of papaya in the Caribbean

Location, date & author(s)	Bacteria	Disease
Virgin Islands 1985, Webb	*Erwinia* sp.	Bacterial canker
French West Indies 1985, Forossard, Hugon & Vernière	*E. amylovora*	Dépérissement
1985, Prior, Béramis and Rousseau	*Erwinia* sp.	Dépérissement
Grenada* 1991, Hunt & Ferguson	*Erwinia* sp.	
Saddler (CMI, UK)	*Erwinia* like, or anomalous *Erwinia* ?	
Kew and Stead (MAFF, UK)	*Enterobacter* ?	
Venezuela* 1980s Guevara	*Erwinia* sp.	
St. Lucia* CARDI		
Dominica* CARDI		

*Personnal communication

from Venezuela. Are there any other reports from the mainland?

This restricted distribution may not reflect reality because bacterial canker exists at undetectable levels in local papaya populations, or may not cause much damage. The introduction of the highly susceptible cv. 'Solo' has been the detector.

Bacterial canker may be misdiagnosed in locations were viral or other diseases are prevalent.

III. Field Diagnosis Based on Observation of Symptons

Reports from the French West Indies (Guadeloupe and Martinique) and the US Virgin Islands (St. Croix) will be considered here as reference symptoms for subsequent comparison with other reports on expression of the disease in relation to a particular environment.

In the field, typical bacterial canker symptoms are: greasy, regular and water-soaked spots at the petiole insertion of the damaged leaf and also on the pseudostem. Characteristic foliar symptoms are: translucent, greasy spots located along mid-veins. Finally, *Erwinia* sp. caused death of papaya with a general 'pencil point' pattern.

The disease is associated with latex exudating from fruits. After artificial inoculation with the bacterium, systemic invasion developed on juvenile tips with vascular colonization and associated greasy spots.

Typical soil-borne infection may occur. The bacterium enters the root causing necrosis. Xylem colonization may be seen by removing the bark. Greasy spots have not yet appeared at collar level, but are already apparent at the apex. Webb (1985) has pointed out possible sources for misdiagnosis:

— greasy spots may also be caused by viral infection
— premature absission of leaves and cessation of apical growth (a symptom called 'pencil-point') are caused by a number of adverse conditions including:
  — root rot, *Pythium butleri*
  — water stress, nutrient deficiencies or imbalance
— bacterial canker.

In conclusion, symptoms which characterize bacterial canker on Solo cv. are:

— greasy, water-soaked spots on the pseudostem
— associated foliar symptoms.

IV. Comparison with Other Diseases

The disease observed in the Caribbean (FWI, Trinidad, Virgin Islands and maybe others) appears similar to diseases reported from Formosa, the Mariana Islands and the Philippines.

But it is difficult to compare different diseases based only on a description of their symptoms. Laboratory diagonostic studies are needed including cultural characteristics required for subsequent identification tests, biochemical characteristics, serological diagnosis and pathogenicity tests.

4.1 Cultural Characteristics of *Erwinia* sp.

This *Erwinia* sp. is a slow-growing organism compared with generally fast-growing *Erwinia* species, i.e. colonies were visible after 28-40 h at 27°C.

When visible, small colonies are hyaline on LPGA or King's medium B. They rapidly turn mucoid. After 2-3 days colonies are white/creamy-white and they join, resulting in a homogeneous fluidal sheet on LPGA, but not on buffered King B medium. A blue, non-diffusible pigment may be observed on King B under transmitted daylight.

4.2 Biochemical Characteristics

Table 3 summarizes the principal characteristics of the bacterium reported from the Virgin Islands, FWI and the Mariana Islands. They are compared with the general characteristics of *E. amylovora* (EA) and *E. carotovora carotovora* (ECC). Based on these laboratory studies, it appears that the symptoms of bacterial diseases are similar for the Antilles and Formosa and the Mariana Islands, whereas the bacterial pathogens are different. The *Erwinia* sp. described in the Antilles is close to *E. amylovora*, but the absence of flagella (as for *E. stewartii*) does not fit in with the pathovar system and makes this bacterium of original species ranking. *Erwinia* type D from the Mariana Islands is related to *E. chysanthemi*, and type MC is close to ECC.

4.3 Sterological Diagnosis

Another strategy used was serological diagnosis of this *Erwinia*. However complementary studies are needed to provide specific antisera. Preliminary work indicated cross-reactions with somatic and soluble antigens of *E. amylovora* strains. Further studies are needed in this approach. Some antisera will soon be available from INRA-CRAAG — the first use for it will be for taxonomical purposes.

Table 3: Principal biochemical characteristics of bacteria reported from the Virgin Islands, French West Indies and the Mariana Islands compared with *E. amylovora* and *E. carotovora carotovora*

Test	Virgin Islands	FWI		Mariana Islands	*E. amylovora*	*E. carotovora carotovora*
Gram	—	—	—	—	—	—
Urease	—	—	—	—	—	—
Flagella	—	p*	—	p	p	p
Nitrate reduction	ni	—	—	ni	—	+
Growth factors	+	+	+	+	+	—
Growth - 36°C	+	+	—	+	—	+
NaCl (5%)	+	+	—	v	ni	t
Pectate degr.	—	—	—	+	—	+
Blue pigment	+	+	ni	+	—	—
Gelatin liquef.	—	v	—	—	+	+

* two types of colony were observed on Kelman's medium with TTC. Rough, avirulent type was motile whereas fludial, virulent type was not.

4.4 Pathogenicity Test

The most reliable diagnosis was from a pathogenicity test on the susceptible Solo cultivar.

Standard inoculation for diagnosis may be performed with a suspension of 10 cfu.ml. Contamination of papaya was achieved through wound inoculation at the apex of young seedlings. Positive isolates produced water-soaked spots around the point of inoculation 5-7 days after inoculation. Death occured after 3 weeks.

This test has to be done on Solo because variability may occur in disease expression related to unknown host genotype-bacterial strain and environmental factor interactions. The most notable difference was the type of bacterial spread in tissues. In most cases the bacterium was reported to be systemic, except in Grenada (Hunt, personal communication).

V. Epidemiology and Survival

Knowledge of the epidemiology and survival of the bacterium is fragmentary but some particular points have been demonstrated. Researchers have reported a seasonal pattern of epidemics related to rainfall. This aspect needs complementary investigations because some aspects of the development of the disease remain unexplained. The air-borne dissemination of bacteria from infected trees to healthy ones by wind has been demonstrated (Persad 1978). Today insect transmission is still not proven. In addition, soil-borne infections have been observed and confirmed in the field.

An important point is that bacterial canker of papaya is not seed-borne. Although young papaya appears more receptive to the disease under artificial infection, there is no evidence for a particularly susceptible physiological period in the field. Survival and persistence of bacteria within papaya roots and decaying and diseased materials was low under the semi-arid climate of St.Croix (Webb 1985). This may indicate that *Erwinia* sp. is a transient soil inhabitant.

The host range of *Erwinia* sp. is still unknown. Epiphytic survival of the bacterium on cowpea (*Vigna sinensis*), cantaloupe (*Cucumis melo*) and tomato (*Lycopersicon esculentum*) is possible as Webb (1985) has demonstrated.

The effects of climatic factors on epidemic onsets are still unknown — this is a key problem which needs experimentation.

VI. Disease Control

Control of bacterial canker of papaya has not been the subject of intensive research. As for other phytobacterial diseases, use of chemicals (bactericides, antibiotics and fungicides) has not been effective and the development of resistant cultivars is the most promising strategy. Resistance or tolerance properties in commercial cultivars have not been identified as yet. Although 'Saipan Red' appears very tolerant in the Mariana Islands and 'Barbados Dwarf' in the Virgin Islands, those cultivars were found to be susceptible in the FWI. Prophylactic measures are recommended, i.e. survey and elimination of the first diseased trees in the field. Unfortunately, although this may limit explosive epidemics, it is inadequate for controlling the disease.

In the absence of resistant cultivars, planting of suitable 'barrier crops' that do not support epiphytic populations of the pathogen — cassava (*Mahihot esculenta*), banana (*Musa* sp.) and pigeon pea (*Cajanus cajan*) — has been recommended (Webb 1985) in the US Virgin Islands. This strategy has been used to make the crop environment healthier and is recommended as an alternative to avoid monoculture and to develop intercropping with fruits or vegetables, except cantaloupe, tomato and cowpea. This strategy needs further experimentation.

Today, programs at IRFA, Guadeloupe are focusing on identification of tolerant or resistant papaya ecotypes. A pathogenicity test in the nursery was developed and applied to a papaya collection from different countries. The objective was to identify tolerant sources by nursery screening. The method which was used involves two steps:

- twelve seeds are taken at random from a packet and tested for bacterial canker tolerance. The other seeds are stored.
- when tolerance is identified, stored seeds from the fruits are tested under natural field contamination conditions and compared with the susceptible Solo. This is a validation of nursery screening for tolerance.

Greenhouse inoculation with the bacterium resulted in typical symptoms consisting of a collapsus, water-soaked disease of the apex from and at the inoculation point. This evolved into a typical canker pattern.

From this nursery test, typical tolerant ecotypes showed axillar shooting after cicatrization at the inoculation point. On the contrary, susceptible cultivars showed a complete rotting of the pseudostem. This differential reaction was obtained with a homogeneous response within tolerant or suseptible plots.

Tolerant host response may evolve, and new infections can occur after regrowth of axillar shoots. This observation led to abandoning the plot.

In experiments under high natural bacterial infestation with tolerant inoculated plants, they showed perfect growth. A detailed observation of the collar showed a grafting pattern resulting from cicatrization at the inoculation point.

VII. Conclusions from this Preliminary Evaluation

(1) Sources of tolerance are available from the local papaya population in Guadeloupe. No tolerant cultivar was identified from other geographical origins.

(2) The reliability of the screening test done in the nursery permitted identification of tolerant ecotypes for subsequent introduction into a breeding program for genetic improvement.

Most important is the identification of tolerant ecotypes in local ecotype populations, but not in others of international origin. This may indicate that we are studying this disease in its geographical origin basin. The consequence is that tolerance sources have to be found in this area where selection pressure by *Erwinia* sp. has been acting for a long time. As previously indicated the control of bacterial canker of papaya implies a genetic improvement with two important objectives:

— Short-term mass selection to select papaya for local food.
— Long-term breeding to select a variety which conforms to standard commercial fruit quality.

VIII. Expected Cooperation at the Caribbean Level

A Caribbean research working group is needed to:

— identify collaboration and constitute a work team
— collect *Erwinia* sp. isolates to make a full

taxonomical study (L. Gardan, INRA, Angers, France) and to determine variability in aggressiveness. A genetic improvement program must rely on this knowledge
— help with diagnosis
— collect papaya seeds from different ecotypes and introduce them into the same inoculation screening program.
— identify grants for Caribbean research programs.

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Major Arthropod Pests of Mango in the Caribbean

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INTRODUCTION

Of the over 60 arthropod pests of mango listed by Hill (1987), only about 10 are considered to be major pests. In the Caribbean, of the more than 80 recorded pests, only about 12 are for mango (FAO 1990; Appendix 1). All parts of the mango plant are prone to attack by pests which in some cases, can be a major constraint to production and marketing of the crop.

This is a brief account of the most frequently encountered and the most economically important arthropod pests of mango in the Anglophone Caribbean.

I. Root Pests

The Curculionid weevils, *Diaprepes abbreviatus*, *D. famelicus* and *Pachnaeus* sp., are potentially the most serious pests of mango roots. *D. abbreviatus* is primarily a pest of sugar cane and citrus whereas *D. famelicus* and *Pachnaeus* are pests of citrus. Adult females of all three species oviposit on the leaves of the plant. On hatching, the larvae fall to the ground and enter the soil where they feed on the roots. Larvae remain in the soil for 9-10 months and pupate; adults tend to emerge en masse during prolonged rainy spells.

Larval feeding can inflict severe damage to the root system of the plant producing symptoms of nutrient deficiency, debilitation and eventual death. Although these weevils are common pests of citrus throughout the region, infestation in mango (and other tree crops) is sporadic. Such an infestation of young mango plants by these three species has recently occurred in Montserrat.

Root weevil eggs are often heavily parasitized by the parasitic wasp *Tetrastichus haitiensis*. Large numbers of first instar larvae can be desiccated or be eaten by ants and other predators when they fall to the ground. Larvae can also be killed by entomogenous nematodes, e.g. *Neoaplectana carpocapsae*, applied to the soil.

Management options for these weevils include the use of these natural enemies, physical barriers to prevent larval entry into the soil and application of insecticides to the soil and foliage.

II. Pests of Trunks and Stems

Various Scolytid beetles can infest the trunks and branches of mango trees. *Hypocryphalus mangiferae* and *Hypothenemus* sp. (bark beetles) and *Xyleborus* spp. (Ambrosia beetles) tunnel into the branches and twigs, creating galleries which may ramify throughout the bark. Females excavate new galleries into which they lay their eggs. The larvae of bark beetles may continue the excavation while feeding on the plant tissue while Ambrosia beetles feed on the conidia of fungi which grow in association with them in the galleries.

The Bostrichid twig borer, *Apate monachus*, can also infest the stems of mango trees. The adult females make galleries in the trunk into which eggs are deposited. All subsequent development occurs within the wood. The tunnelling activity can kill the plant directly or render the branches liable to wind damage.

The termite, *Neotermes* sp., has also been recorded attacking the trunks of live mango trees in Grenada.

Both these beetles and the termite are more successful in attacking weakened or stressed trees and are generally of little economic importance in well-managed orchards.

III. Pests of Buds

The mango bud mite is frequently encountered infesting the leaf and inflorescence buds. All life stages are passed beneath the bud scales which may become distorted or may die from the effects of the mite's feeding.

The economic importance of this mite is unknown and no specific management techniques have been developed for it.

IV. Foliage Pests

A wide array of arthropods is associated with the foliage of mango trees but no specific pests have been recorded in the region.

Adults of the root weevils previously discussed, feed on mango leaves. The characteristic feeding damage is a scalloping along the edges of the leaves. Except in very heavy infestations, leaf feeding is rarely serious and hand picking of the adults may be enough to prevent damage during light infestations. It should be noted that the adults of *D. famelicus* are nocturnal and are rarely encountered in the day.

Leaf-cutting ants, *Atta* spp. and *Acromyrmex* spp., can remove large amounts of mango leaves to their nests for the cultivation of their fungus gardens. These insects are considered to be very destructive, considering their wide host range and the quantity of leaves they destroy. Much research has been conducted on the management of these pests with various formulations of poisoned bait.

Twenty-one species of scale insects and mealy bugs have been recorded from mango foliage in the region. Of these, two species are considered as major pests:

Coccus mangiferae — Mango scale; scales may cover buds and young leaves causing buds not to open.

Insulapsis insularis — Snow scale; infests both foliage and fruit; causes bronzing of fruit and is considered to be a serious pest in Barbados.

Ceroplastes floridensis (soft scale), *Coccus viridis* (green scale) *Pulvinaria psidii* (green shield scale), *Vinsonia stellifera* (star scale), *Ischnaspis longirostris* (black thread scale) and *Planococcus citri* (citrus mealy bug) are widespread but rarely of economic importance. They are usually kept under biological control by various natural enemies.

The red-banded thrip, *Selenothrips rubrocinctus*, is a widespread and serious foliage pest throughout the region. All life stages occur on the leaf; eggs hatch into nymphs which bear a characteristic red band around the middle; adults are black. All stages feed together on the underside of the leaf, depositing excreta which dries into shiny tar-like spots. Leaves become bronzed and appear to be scorched when severely infested. Defoliation often results. Treatment with systemic insecticides are usually required to control such infestations.

A white fly, *Dialeurodes* sp., has been reported as a serious pest in some parts of Barbados. This insect is also associated with premature defoliation.

V. Inflorescence Pests

A wide diversity of insects visit mango inflorescences. Many of these are important as pollinators since this plant does not rely on honeybees or any other specialized pollinator. Fifteen species of Lepidoptera, two each of Thysanoptera and Hemiptera, two species of Cecidomyiid flies, two Chrysomelid and one Scarabid beetle are consistently associated with mango inflorescences in Dominica. Of these, the beetle, *Macraspis tristis*, and the Cecidomyiid midge, *Erosomyia mangiferae*, are potentially the most serious pests.

Macraspis tristis is a large beetle, commonly referred to as a June bug. The larvae are soil dwelling. Damage is done by the adults which feed on the ovarioles of the flowers. Heavy infestations have been reported to result in the destruction of all flowers within 2 days. Generally however, it occurs only sporadically and in low numbers and is not yet a cause for serious concern.

The mango gall midge, *E. mangiferae*, has long been recognized as a pest of mango inflorescences but has not been studied until very recently. Eggs are laid on the scales of inflorescence buds or on young inflorescences. On hatching, the larvae bore into the tissue, often inducing the formation of galls. At maturity, larvae exit the inflorescence to pupate in the soil. Secondary organisms then enter through the exit lesions causing the eventual destruction of the inflorescence.

A consideration of the relationship between the midge and inflorescences in various stages of development is of critical importance in determining the economic status of this insect. The relationship between infestation levels and environmental conditions must also be considered as these conditions affect flowering as well as the life processes of the insect.

Detailed investigations of the infestation dynamics of *E. mangiferae* have recently been conducted in Dominica (Rhodes, 1991). These investigations were to determine the infestation levels in inflorescences in various stages of development, to determine the distribution of exit lesions in mature inflorescences and to relate these parameters to flower loss in orchards located in relatively wet and dry locations.

Six developmental stages of mango inflorescences can be defined:

1. Buds completely covered with enlarged scales.
2. Buds with 1-2 differentiated inflorescences apparent.
3. Bud scales begin to abscise, and spikelets become apparent.
4. Bud scales have all abscissed and the spike is elongating slightly.
5. Spike is greatly extended but flowers are unopened.
6. Spike is fully extended. Flowers are fully opened.

Galling and the exudation of latex are the main symptoms of infestation in the early stages of inflorescence development (Stages 1-4). In the later stages, exit lesions are the main manifestation of infestation. A large proportion of young inflorescences may contain larvae without displaying any symptom and by the time symptoms are observed in the older stages, the larvae have already left.

Inflorescences in Stages 4 and 5 had the highest proportion with midge larvae. The highest larval population density also occured in these two stages. Infestation is therefore synchronized with inflorescence development; eggs are laid in Stages 1 and 2, larvae develop in Stages 4 and 5 and exit from Stage 6 for pupation.

Mortality in the larval stage hardly exceeds 30%, particularly in humid conditions. Larvae can survive for long periods and even pupate while submerged in water. Heavy mortality is inflicted on the pupae by the parasitic wasp *Platygaster* sp.

Exit lesions can occur at any position on mature inflorescences (See Figure 1). These lesions are discrete round spots about 0.5 cm in diameter, necrotic and black. Coalescence between lesions can result in a generalized necrotic area. Lesions occurring on the primary or secondary axes are not very destructive except at high density since individual lesions do not destroy much vascular tissue. Axillary lesions are much more destructive since their presence induces the abscission of the affected axis. The distribution of the lesions within the proximal, medial and distal portions of the inflorescence also influences the severity of the damage since more flowers are borne in the proximal and medial sections. Lesions located at the secondary axils in the proximal and medial sections are the most destructive since each of the affected axes bears about 5% of the total flowers on the inflorescence.

The main cause of inflorescence death is the invasion of secondary organisms into the entrance holes (Stages 1 and 2) or exit lesions (Stages 5 and 6) made by the larvae. Two fungi, *Botrydiplodia theobromae* and *Phomopsis mangiferae* and a gram negative bacterium have been isolated from these exit lesions. These organisms are known to cause rotting of plant tissue.

Julie mango has a flowering habit in which trees replace inflorescences which are killed by producing

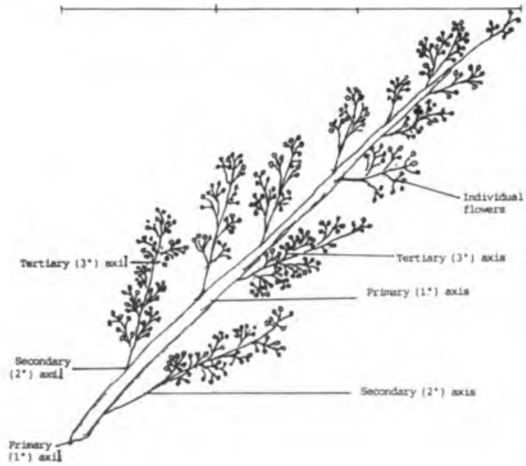

Figure 1. **Diagrammatic representation of a typical mango inflorescence showing principal morphological features.**

one or more new ones laterally on the same terminals as those destroyed. This tendency decreases as the flowering season progresses.

All parameters of inflorescence infestation and mortality are more severe in orchards located in areas of high rainfall and humidity. This must be related to the biological requirements of the larvae for wet conditions to successfully pupate and complete development. Pupae of similar midges are known to suspend development and enter into diapause during dry periods.

In cases where gall midge causes economic loss, management options may include the application of soil insecticides or soil cultivation to destroy mature larvae, or the application of systemic insecticides against larvae within the inflorescences. This is particularly risky, since most insecticides threaten the survival of pollinating insects. The insecticide cyromazine (Trigard), a systemic growth regulator which is active only against Dipteran larvae is being evaluated in Dominica. Timing of application is crucial since this must coincide with the presence of inflorescences of the appropriate stages in individual orchards. Biological control with the existing natural enemies does not appear to be promising since the mortality is inflicted on the pupal stage, after the damage has been done.

In India related species of gall midge cause serious losses by damaging fruit just set. However, mango trees produce many times more flowers than fruits set and given dry environmental conditions and good cultural management, mango gall midge may not be a serious pest.

VI. Fruit Pests

While there are many general feeders which may infest mango fruits (scale insects etc.), by far the most important pests are Tephritid fruit flies of the genus *Anastrepha*. *A. obliqua* is a pest of mango and many other soft fruit in most Caribbean countries (except Grenada and St. Vincent and the Grenadines). *A. ludens* is a serious pest in Belize; *A. serpentina* and *A. striata* occur in Guyana and Trinidad and Tobago; *A. ocresia* and *A. suspensa* occur in Jamaica.

The adults of *A. obliqua* are moderately sized flies with conspicuous bands and markings on their wings and thorax. Female flies lay eggs beneath the skin of mango fruits. On hatching, the larvae bore into the pulp on which they feed. At maturity, the larvae bore exit holes in the skin of the fruit and fall to the ground for pupation in the soil. Feeding damage and the invasion of secondary organisms results in the decay of the fruit. These fruit flies are very serious pests and are of quarantine importance.

While fruit flies may show a preference for infesting ripening or ripe fruit, hard mature fruit may also be attacked. The factors governing the host selection behaviour of these flies is unclear. There are reports of wide divergence in host preference of *A. obliqua* in different countries in the region. Also,there are noticeable differences in the susceptibility of various varieties of mango to infestation. In Israel, Joel (1980) showed that the size, density and distribution of resin ducts in the peel of mango fruit influenced the susceptibility of 15 varieties to infestation by the Mediterranean fruit fly. In Colombia, Zapata and Guitierrez (1986) found little relationship between peel texture of 53 varieties and infestation by *A. fraterculus*. Chemical characteristics, particularly brix, were found to be more important influences.

Many approaches have been taken to the management of fruit flies. Cultural methods include the removal of infested and fallen fruit, and pruning of trees to allow light penetration. Destruction of wild hosts is also an important option. Spraying with insecticide (malathion) mixed with an attractive bait is also widely practiced.

Various trapping systems have been developed for the capture and management of fruit flies. The McPhail trap is an efficient tool for the capture of *A. obliqua*. The traditional glass trap is however too bulky and fragile for routine use by farmers for fruit fly control and is difficult to transport and store. Plastic traps are available which overcome these problems. These traps can be placed at high density in orchards where they can significantly reduce fly populations (Figure 2). The number of traps required depends on the type of bait used. Pellets made of a mixture of yeast and borax will attract flies over a radius of 12 m (40 ft), while studies in Venezuela have shown that with hydrolyzed protein bait the optimal inter-trap distance was 48 m (Boscan de Martinez and Godoy (1990). In Dominica the experimental use of

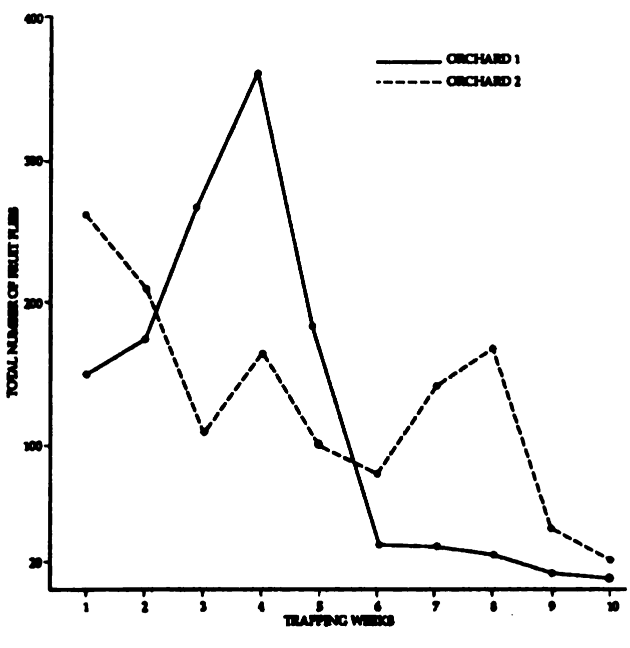

Figure 2. Total number of *A. obliqua* taken per week in 36 Mc Phail traps arrayed throughout two mango orchards.

McPhail traps in two orchards significantly increased the number of marketable fruit.

The sterile male technique has been employed against other species of fruit flies. This involves releasing large numbers of sterilized male flies to mate with the wild female flies which then produce inviable offspring. Populations can be eradicated with this technique, but it is extremely costly and technically sophisticated.

Dipping of harvested fruit in hot water at various temperatures and times has gained international acceptability as a post-harvest quarantine treatment for the control of fruit flies. Treatment parameters must be carefully researched to ensure complete kill of the larvae, while avoiding deleterious effects on the fruit. While considerable research has been conducted on these treatments for Florida type mangoes, similar work is just now being done on Julie mango in Dominica.

VII. Seed Pests

The only pest of mango seeds recorded in the region is the mango seed weevil *Sternochetus mangiferae*. This insect is known from Dominica, St. Lucia and the French West Indies.

The adult is a short, compact weevil about 8 mm in length, colored grayish to dark brown and patterned with lighter patches. Eggs are laid on the skin of green or ripe fruit and the larvae bore through the pulp and into the seed immediately after hatching. Healing of the fruit tissues conceals all evidence of the insects' presence within. Larvae tunnel and feed within the seed followed by pupation and adult emergence. Adults remain in the seed until the fruit is consumed or decays. They are nocturnal and tend to hide in the crevices under the bark of trees and in other debris. They may live for over a year.

Since all feeding is confined to the seed, the insect is of no direct importance in production except in a few late-maturing varieties in which the adult may emerge from the seed and tunnel through the pulp on its way out, thereby creating a post-harvest marketing problem. Direct feeding damage is important only in those seeds intended for use as rootstocks in propagation since feeding damage can affect the embryo. Damaged seeds can still be planted as long as the embryos are intact.

Although the weevil is not considered a serious threat to mango production, it is of serious quarantine importance and its presence prevents the export of mango from affected countries to the United States. Trade in mango between individual countries in the region has also been restricted because of quarantine against it. There have been recent initiatives under the sponsorship of FAO and CARICOM to resolve the trade aspects of this intra-regional quarantine.

No satisfactory control measures exist for the mango seed weevil. There are no specific trapping devices for it. Control with insecticides is not feasible considering the protected habitat within the seed. Outside of the fruit, adults are also not very vulnerable to insecticides because they tend to be in protected crevices.

Orchard sanitation involving the removal and destruction of fallen fruit and seed has been recommended, but Hansen and Armstrong (1990) found no significant reduction in infestation level in Hawaii as a result of these practices.

No important natural enemies are known, a virus has been reported to kill larvae.

It appears that a comprehensive determination of the pest status and quarantine risk of this insect rests as much in the political realm as in the scientific; scientists themselves are divided in their opinion.

No systematic Integrated Pest Management programme has yet been designed for mango in the Caribbean. Commercial production of the crop, particularly for export is relatively recent and the key pest in the major producing countries is the fruit fly, *A. obliqua*. Management strategies must therefore be focused on this pest and a combination of field level trapping and post-harvest hot water treatment appears promising. Spraying of broad spectrum insecticides, especially during flowering and fruiting, must be carefully considered. Vigilant quarantine must be maintained by those countries currently free of infestation.

One deficiency which must be corrected is that there is no information of the relationship between infestation levels of various pests and the resulting crop loss. There is also a lack of current research information on the optimal yield of different mango varieties in the Caribbean. Until this is remedied, pest management decisions in this crop will continue to be made by 'rule-of-thumb', rather than by the application of systematic decision-making principles.

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APPENDIX 1

List of insect and mite pests recorded on mango in the Caribbean

Scientific name	Common name	Plant part affected
Diaprepes spp.	Root weevil	Roots, leaves
Pachnaeus litus	Root weevil	Roots, leaves
Hypocryphalus mangiferae	Bark beetle	Twigs, stems
Apate monachus	Black stem borer	Twigs, stems
Xyleborus spp.	Ambrosia beetles	Wood, bark
Neotermes sp.	Termite	Stems, branches
Dialeurodes sp.	White fly	Leaves
Ceroplastes sp.	Soft scale	Leaves
Coccus acuminatum	Mango shield scale	Leaves
Coccus mangiferae	Mango scale	Leaves
Coccus viridis	Green scale	Leaves
Pulvinaria psidii	Green shield scale	Leaves
Aulacaspis rosae	Mango snow scale	Leaves
Insulapsis insularis	Snow scale	Leaves, fruit
Vinsonia stellifera	Star scale	Leaves
Ischnaspis longirostris	Black thread scale	Leaves, fruits,twigs,
Planococcus citri	Citrus mealybug	Leaves, fruit
Acromyrmex octospinosus	Leaf cutting ant	Leaves
Atta spp.	Leaf cutting ant	Leaves
Polyphagotarsonemus latus	Broad mite	Leaves,fruits
Selenothrips rubrocinctus	Red-banded thrips	Leaves
Macraspis tristis	June bug	Inflorescences
Erosomyia mangiferae	Gall midge	Inflorescences
Anastrepha spp.	Fruit fly	Fruit
Gonodonta sp.	Fruit piercing moth	Fruit
Sternochaetus mangiferae	Seed weevil	Seeds

Insect and Mite Pests of Papaya, Pineapple and Mango in the Eastern Caribbean

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INTRODUCTION

Within various CARICOM countries, increased fruit production has been identified as an important aspect of any crop diversification thrust. Fruit production (exclusive of traditional cash crops like citrus or banana, for example) has remained generally a backyard enterprise, except for some small acreages of mango, papaya, avocado or pineapple in some islands. Notwithstanding this, however, entrepreneurs can and do market sufficient fruit from such smallholdings or from backyard collections to earn significant income. St. Vincent, for example, exports significant quantities of mango and avocado intra-regionally. Grenada, too continues to export large quantities of fruit (soursop, sugar apple, sapodilla, mango tamarind, for example) to Trinidad and Tobago; St. Lucia had a fairly substantial mango trade with Barbados and other neighbouring islands before this was upset because of the presence of mango seed weevil in that country.

While any system of backyard or other small-scale production is one in which pest populations will naturally tend to be kept at low levels, it is well documented (e.g. Pimentel 1977) that a shift to large monocultural systems is one mechanism which allows an insect species to achieve major pest status. Hence, it may be fairly safe to predict that any increase of fruit production in the region will result in increased pest status of existing species and even the attainment perhaps of pest status by species which previously were not pests. To prevent this, one has to ensure that adequate preventative pest management programmes are developed and implemented as one component of any scheme for increased fruit production.

This paper highlights and reviews major pests of papaya, pineapple and mango in the Caribbean.

I. Major Pests of Papaya, Pineapple and Mango

1.1 Papaya

This is one of the crops recognized as having a great potential for commercial and export production in the region with a number of countries targeting increased production (Harvey et al. 1990). However, there are many serious constraints to increased production — pests and diseases represent just one of these.

1.1.1 Leafhoppers

Leafhoppers (Homoptera: Cicadellidae) show the typical damage resulting from homopteran feeding — yellowing of leaves, followed by drying and eventual shed. In papaya, however, this damage is secondary to their role as disease vectors.

Two major leafhoppers affecting papaya are *Empoasca papayae* and *E. stevensii* (Haque and Parasram 1973; FAO 1989b). These are both vectors of bunchy top disease. In the absence of an effective pest/disease management programme, this disease is perhaps the single major constraint to commercial papaya production in the Caribbean. Resistant, or at least tolerant cultivars, good conditions for plant growth and effective vector control are the elements of any effective pest management programme for bunchy top.

1.1.2 Scale Insects and Mealy Bugs

Various scale insects and mealy bugs may be important pests of papaya. *Pseudaulacaspis pentagona* (Targ.), the white scale (Homoptera: Diaspididae), has been reported as causing serious damage in Suriname (van Dinther 1960). Young trees, up to 1-year-old are most severely attacked — leaf stalks, leaves and stems may become encrusted with the scale. As a result the stem may become thin and the bark shrivels; plant death may occur.

Planococcus citri (Risso) (Homoptera: Pseudococcidae), the citrus mealy bug, is a more important pest of papaya in the Caribbean than of citrus. Heavy infestation may lead to leaf shedding particularly in young plants; buds may also wither.

1.1.3 Papaya Fruit Fly

Toxotrypana curvicauda Gerst. (Diptera: Tephritidae) is an important pest of papaya. It is of worldwide distribution. Though all reports generally indicate that papaya is the only host (e.g., Phillips 1946), one report out of Florida indicated that mangoes were occasionally found infested (Wolfenbarger 1955). I suspect that this may have been a misidentification. The damage caused by this pest is similar to that of other fruit flies. However, apart from mature fruit, the papaya fruit fly can oviposit in the seed cavity on young unripened fruit, with the larvae feeding on the seeds. Premature ripening and early fruit drop result.

1.2 Pineapple

1.2.1 Pineapple Mealy Bug

Pineapple mealy bug, *Dysmicoccus* spp. (Homoptera: Coccidae), is considered the most serious pest of pineapple, less so because of any direct damage to the plant but more because it is the vector of a 'quick wilt disease'. This disease has been attributed to a latent virus. Two species of *Dysmicoccus* are known to cause wilt — *D. brevipes* (Ckll.) which is very widespread and *D. neobrevipes* (Beardsley) which has been originally reported only in Hawaii (Py et al. 1987). According to these authors the female of *D. brevipes* is pink in colour and easily recognizable from that of *D. neobrevipes* which is grey-coloured.

This pest lives in colonies at the basal leaves of the plant (around the collar region) or sometimes just below the soil surface or in plant residues in shelters made by ants. These ants are essential for the survival of the mealy bugs since:

(i) they feed on secreted honeydew which, if allowed to build up in volume, 'hampers' the mealy bug nymphs as well as allows for invasion by pathogens

(ii) ants also help to disperse mealy bugs from plant to plant in a field. Once a plant shows symptoms of wilt it becomes unsuitable as a host and the pest must move to a more turgid plant. This is the reason, according to Py et al. (1987), why few mealy bugs are found on wilted plants; also why the disease appears more scattered with isolated infected plants in a field in the absence of ants but with larger-sized infected patches where ants are present.

1.2.1.1 Pest Status and Economic Impact

As indicated above pineapple mealy bug is the most serious pest of pineapple. Symptoms of quick wilt disease first affect the root system, then the leaves and finally the inflorescence and fruit. Py et al. (1987) quote earlier work of Carter (1933) who described four stages in the development of quick wilt in adult plants of Smooth Cayenne cv. These stages are based on the appearance of leaf symptoms — leaves become reddish/bronze in colour, later changing to bright pink or yellow, losing their turgidity and with their tips starting to show necrosis; finally the tips of most leaves wither and turn pale brown in colour except for the youngest leaves which may remain upright but lose all turgidity. When leaf symptoms appear in plants that have just put out an inflorescence, then this dries progressively and no fruit is set. If the disease appears later (a few weeks before the fruit matures) then the fruit fails to develop fully. As a result yield losses may be serious — as much as 50% of plants attacked (Py et al. 1987) or even the entire field could be lost (Anon. 1975).

1.2.1.2 Control

Various cultural and chemical measures have given control for *Dysmicoccus*. Biocontrol methods have not proved to be effective (Cock 1985; Py et al. 1987). However, given the general success of controlling various homopteran pests by parasitoids and/or predators, *Dysmicoccus* should prove to be a good candidate for biological control.

Cultural methods involve destruction of crop residues and use of clean planting material either through disinfection treatments or by careful selection of shoots. Py et al. (1987) suggest harvesting shoots for planting just after harvesting the fruit as mealybug populations are lowest at this time.

Chemical control includes treatment of planting material as indicated, treatment of the plant at regular intervals during its life and treatment for ant control in fields. A management strategy for mealy bug control in Guyana which included these various elements has been described by Rai and Sinha (1980). Of particular interest with this strategy was the demonstration that 2 weeks after the two ant species associated with *Dysmicoccus*, *Solenopsis* sp. and *Araucomyrmex* sp., were controlled there was a 75% mortality in mealy bug population.

1.2.2 Other Mealy Bugs and Scale Insects

Apart from *Dsymicoccus* spp., other mealy bugs have been reported on pineapple, but these are generally of minor importance, e.g., *Pseudococcus longispinus*. This pest develops in the heart of the rosette of leaves when the inflorescence appears; it subsequently spoils the appearance of the fruit (Py et al. 1987).

1.2.3 Pineapple Scale

The pineapple scale, *Diaspis bromeliae* (Kerner) and *D. boiduvali* (Signoret) (Honoptera: Diaspididae), are both widespread pests of pineapple attacking both leaves and fruits. Though generally considered to be of minor importance there may arise outbreak situations where heavy leaf infestation may lead to reduced plant growth and even death to the plant (Py et al. 1987). Fruit infestation may lead to deterioration or at least detract from the appearance.

1.2.4 Mites

Py et al. (1987) have summarized the effects of various mite species found associated with pineapple and highlight the fact that the economic impact of mites is uncertain. On one hand they are said only to cause a slowing of growth while in other cases to have a major effect on growth and hence on yield. One report for north-eastern Brazil was quoted where a 16% loss was reported. Because high mite populations frequently cause leaf wilt and consequently drying of leaves, such affected fruits are not of export quality, thus causing losses. Some species have been associated with various diseases. *Stenotarsonemus ananas* has been implicated with certain diseases caused by *Penicillium* sp. and *Fusarium* sp. *Dolichotetranychus floridanus* (Bank) has been reported to be associated with plants under stress (e.g., water stress; nutrition deficiency) where such conditions cause high mite populations to flourish. This is a similar situation to the relationship between the cocoa plant and *Selenothrips rubrocinctus*. *S. ananas* attacks the inflorescence and young fruit.

1.2.5 Fruit Borers

Many insects attack the pineapple fruit either as primary or secondary pests. One of the most important of these is *Thecla basilides* (Geyer). The larvae of this species (measuring up to 22 mm when mature) bore into the fruit and may cause serious losses. This pest is not present in the Caribbean besides Trinidad, Guyana and Suriname. Apart from direct damage caused by larval tunnelling, the fruit reacts by secreting a gummy substance which hardens on exposure to air — hence the condition referred to as gummosis of the fruit. A more liquid exudate occurs when the fruit is attacked by *Fusarium moniliforme* var. *subglutinans*, a secondary pathogen resulting from borer attack (Py et al. 1987). Because of its limited distribution in the region, *T. basilides* must be considered a pest of quarantine importance for the Caribbean.

1.2.6 Minor Pests

There are a number of pests found associated with pineapple but which are generally regarded as causing minor damage or only of sporadic importance. Various white grubs, e.g. *Phyllophaga* sp., feed on roots; lepidopteran and coleopteran pests attack the fruit. Two curculionid pests, *Metamasius ritchei* Bs. and *Cholus* sp. have been reported as causing damage to pineapple in the Caribbean. They both attack the stalk which may break as a result or the fruit itself (Wyniger 1962). Other lepidopteran fruit borers cause similar damage as *T. basilides; Batachedra* sp. has been reported in Puerto Rico (Py et al. 1987) while *Tmolus echion* L. has only been reported for Trinidad in the Caribbean (FAO 1989b). Tephritid fruit flies are also known to attack pineapple in various countries. Pineapple, however, does not appear to be a major host. Larvae of other dipteran insects have also been reported attacking pineapple fruit; for example, *Atherigonia* sp. (Fam: Anthomyiidae) (Wyniger 1962) and *Melanoloma* sp. (Fam: Otitidae) in Suriname (van Dinther 1960). Py et al. (1987) list various other minor lepidopteran and coleopteran pests particularly.

1.3 Mango

1.3.1 Mango Seed Weevil

The mango seed weevil (MSW), *Sternochetus mangiferae* (F.) (Col: Curculionidae) is the latest pest of mango to have been reported in the Caribbean. This pest had previously been associated with mango, its only known host, practically everywhere mango is grown in the Old World — Africa, Asia, Australia and the Pacific region. St. Lucia first reported the presence of MSW in 1984 and by 1986 this pest was reported for Guadeloupe, Martinique, Barbados, Dominica and French Guiana.

1.3.1.1 Pest Status and Economic Impact

While MSW is generally regarded as an important economic pest of mango throughout its distribution range some workers, have expressed doubt about this and would consider MSW to be more of a pest of plant quarantine significance (see FAO 1989a).

Eggs of MSW are laid on young fruit and newly-hatched larvae make their way directly to the seed where they then go through their entire development cycle. There has been however the odd report of larvae developing in the flesh of the fruit (Balock and Kozuma 1964; Chandler 1991). Larvae feed on and eventually destroy the seed cotyledons either totally or partially. Usually there are no external signs of infestation or damage, particularly in early-maturing varieties. However, in late-maturing varieties the adult emerges from the seed and exits the fruit through the flesh only after the fruit has matured. This results in both direct damage to the pulp and in secondary infestation by various pathogenic organisms.

Infestation levels may be quite high. According to Balock and Kozuma (1964), for example, seed infestation may be 100% in some areas in Hawaii. Estimates of damage between 46 and 93% were quoted for some parts of India by Shukla et al. (1985). These figures are similar to those quoted for another seed weevil, *S. gravis*, in India where in one state with 9,600 ha under cultivation in mango, no single tree was found free of infestation; 65–85%, and at times 100%, of fruit were found to be infested. In fact Dey and Pande (1987) considered various mango nut or seed weevils (*Sternochetus* spp.) to be "... the most serious post-blossom pest of mango" in India.

Because the pest is feeding and living in the seeds, losses do occur where seeds are required for propagation purposes (Shukla et al. 1985; Mann and Ambrose 1990; Chandler 1991). A 30% seed loss was reported for Barbados by Chandler (1991) and a mean loss of 30.9% (range 23.0 to 64.0%) from three propagation stations of the Ministry of Agriculture of St. Lucia (Mann and Ambrose 1990). Despite such losses Chandler (1991) showed that seeds were still viable even with up to 66% damage but, on germination, such seedlings were significantly shorter than seedlings from undamaged seeds of comparable age.

MSW infestation is also reported to cause premature fruit fall (Sundara Babu 1969; Hill 1975; Mann and Ambrose 1990). The latter report by Mann and Ambrose is the first for the Caribbean. On one farm in St. Lucia it was found that Graham mangoes were dropping when mature but unripened. The following symptoms on such fruit were reported: "(1) the skin at the tip of the fruit was yellow; (2) black specks in this area appeared to be insect damage and (3) underlying pulp was soft and darker orange/yellow than surrounding pulp". The majority of such fruit were found to be infested with MSW late instar larvae.

Despite such serious losses as reported, other studies suggest that *S. mangiferae* should not be regarded as a pest of serious economic importance. Certainly Balock and Kozuma (1964) were of this view for Hawaii, despite high seed infestation levels; more recently Woodruff (1987) was of the same viewpoint for mango production in some Caribbean islands.

What is certain however is that whether the pest is of direct economic importance or not in the field, it is always considered a pest of major quarantine important (Balock and Kozuma 1964; Shukla et al. 1984; Pollard 1986; Dey and Pande 1987), and in fact is now listed as a pest of quarantine importance for the

Caribbean (FAO 1989a; 1989b). One implication of this is the impact on trade and the movement of fruit from infested countries.

St. Vincent and St. Lucia, for example, have been the major exporters of mango to Barbados. However, once St. Lucia had reported the presence of MSW in 1984, Barbados placed an immediate ban on the importation of mangoes from that country. St. Vincent was then able to capitalize on the shortfall caused by this embargo on St. Lucian mangoes. According to Chandler (1991), for the period 1971/1984, St. Lucia was exporting 140,000 kg of mango per annum to Barbados at a CIF value of BDS$85,340. Since the embargo in 1984 there is just one record of an import of 1,291 kg valued at BDS$355 into Barbados. Entry of St. Lucian mangoes to the US market is also affected.

1.3.1.2 Control

Chemical Control
Because of the cryptic nature of the development of MSW, it is an extremely difficult pest to control. Various chemicals have been tested but reports generally indicate that chemical control is ineffective (Balock and Kozuma 1964; Woodruff 1987) though Kok (1979) reported that spraying could reduce the adult population. Reports by Shukla and Tandon (1985) also indicated successful chemical control in Bangalore, India, where foliar sprays were applied during the oviposition period either alone or together with spot applications to target diapausing adults congregated on tree trunks. However, in terms of cost-effectiveness, these authors recommended the use of spot applications of 0.05% diazinon to tree trunks which they claimed "... takes less time, requires less labour and causes the least environmental pollution" (Shukla and Tandon 1985).

Cultural Control
Phytosanitary measures, viz. the removal and destruction of fallen fruit and seeds from under trees, have been recommended for control of MSW (Kok 1979; Dey and Pande 1987). However such field sanitation has been shown to be ineffective in reducing the incidence of MSW (Hansen and Armstrong 1990).

Biological Control
There have been no reports of biological control measures for MSW and in an extensive study in Bangalore, India, no natural enemies were reported (Shukla and Tandon 1985). However there is one report of a new baculovirus pathogen affecting MSW. This is the first such report (Shukla et al. 1984) and suggests possibilities, perhaps, for microbial control.

Quarantine Treatments
Since control of this pest is so difficult in the field, much effort has been put into quarantine control measures. However, because of the fragility of mature mango fruit many of the standard quarantine treatments, like hot or cold treatments, and the use of ethylene dibromide (EDB) or methyl bromide, while killing the pest also cause injury to the fruit (Balock and Kozuma 1964; Shukla and Tandon 1985). In any event the use of EDB is now unacceptable. While reports suggest that gamma irradiation of marketable fruit is an effective treatment for MSW (Seo et al. 1974; Kok 1979) this treatment would not be cost-effective in the Caribbean. As a recent consultant's report has indicated, the lack of facilities in the region together with the relatively small quantities of fruit produced would make irradiation procedures prohibitive (Woodruff 1987).

1.3.1.3 MSW in the Caribbean

There is a strong feeling that MSW should not be considered an economic pest particularly as far as early maturing mango cultivars are concerned. Since the fruit would be utilized and the seed discarded before the pest has had the opportunity to leave the seed no signs of damage would be observed. In the Caribbean region it is these early maturing varieties which are most commonly grown. Hence the pest status of MSW and the consequent quarantine restrictions on trade in mango currently existing in the region may need to be re-assessed (Woodruff 1987). In fact the quarantine pest significance of MSW itself may need reconsideration especially since the view has been expressed by Woodruff (1987) that it is likely that MSW would shortly be established throughout the Caribbean — an example, perhaps, of Kahn's 'inevitability-of-establishment hypothesis' (Kahn 1977). This view was expressed based on the poor state of quarantine systems in place in the Caribbean coupled with the ease and frequency of inter-island travel and trade. A similar viewpoint had been previously emphasized with recent introductions of a number of pests in the region highlighted (Pollard 1986).

1.3.2 Fruit Flies

Of all major pests of mango reported for the Eastern Caribbean, tephritid fruit flies (Diptera: Tephritidae) should be considered to be potentially the most serious. Within the wider Caribbean there are 18 *Anastrepha* spp. reported so far, in addition to the papaya fruit fly, *Toxotrypana curvicauda* (Gerst) and the carambola fruit fly *Bactrocera* sp. While mango is listed as a major host of many of these (Table 1) *A. obliqua* (Macq.), the West Indian fruit fly, is perhaps the most important pest species of mango in the Eastern Caribbean. Infestation levels may be as high as 100% in some instances with both the local and hybrid or 'grafted' cultivars attacked.

All fruit fly species affect their host fruits in the same fashion. The female adult lays her eggs usually in mature ripening fruit except for the papaya fruit fly which may oviposit on young green fruit. These eggs hatch and the larvae tunnel through and feed on the flesh of the fruit which, as a result, loses its integrity, turning 'mushy' and unfit for human consumption. By the time the fruit has ripened and falls to the ground the larvae are ready to pupate. They crawl

Table 1: Distribution of fruit flies affecting mango (and other host plants) in the Caribbean

Species	Common names	Major host plants	Distribution in the region
Anastrepha distincta	Pois-doux fruit fly	*Inga* spp.; mango	Guyana; Trinidad and Tobago
A. fraterculus	South American fruit fly	Sapodilla; grapefruit; orange; coffee; pommerac; mango; guava; hogplum	Guyana; Suriname; Trinidad and Tobago
A. ludens	Mexican fruit fly	Citrus; mango	Belize
A. obliqua	West Indian fruit fly	Various plums, e.g. hogplum; mango; pommerac; guava; almond; grapefruit; sour orange; cashew	Throughout the Greater and Lesser* Antilles; Jamaica; Trinidad and Tobago; Bahamas
A. serpentina	Sapodilla fruit fly	Star apple; sapodilla; mango; sepote; orange	Dominica; Guyana; Suriname; Trinidad and Tobago
A. striata	Guava fruit fly	Guava; mango; various plums	Guyana; Suriname; Trinidad and Tobago
A. suspensa	Caribbean fruit fly	Almond; guava; pommerac; grapefruit; sweet orange; sour orange; hogplum; star apple; custard apple	Jamaica; Greater Antilles; Bahamas
Bactrocera sp.	Carambola fruit fly	Carambola; Curacao apple; guava; mango; W.I, cherry; Suriname cherry; sapodilla; star apple; pommerac	Suriname; French Guiana
Toxotrypana curvicauda	Papaya fruit fly	Papaya	Trinidad and Tobago; Bahamas; Greater and Lesser Antilles

*Antigua, St. Vincent, Grenada and Barbados are reportedly free of fruitflies.

Sources: Stone (1942); van Wherwin (1974); Sommeijer (1975); Lawrence (1976); FAO (1989b); Huiswoud & Schotman (1990).

out of the fruit onto the soil where they burrow a centimeter or so before pupating.

1.3.2.1 Pest Status and Economic Impact

Fruit flies are considered pests of major economic importance wherever they are found and in the Caribbean this also holds true. Fruit flies cause a direct loss through fruit infestation. As far as mango is concerned the countries at risk include Guyana, Suriname, Trinidad and Tobago, St. Lucia, Guadeloupe, Martinique, Dominica, St. Kitts and Nevis, Jamaica and Belize. However, is should be noted that while the greatest number of pest species are to be found in Trinidad, mango is not considered a host for fruit flies there. Reasons for this are unknown. Within the Eastern Caribbean Antigua, St. Vincent, Grenada and Barbados are fruit fly-free. Again there is no ready explanation for this given the fact that all these islands share relatively similar climatic conditions, have similar host plants and, as well, all participate in the intra-regional traffic in people and produce.

Apart from the direct loss through fruit infestation fruit flies are considered to be pests of major quarantine importance. The USA, one of the major target markets, will not accept any fruit unless completely free of fruit fly. Even within the Caribbean intra-regional trade in mango is dependent on the fruit fly status of the exporting country. There are no quarantine restrictions with regard to fruit flies with the European and Canadian markets (Prinsley 1987).

1.3.2.2 Control

There are well-established strategies for fruit fly control. Bateman (1972) discussed the concepts of control, suppression and eradication. Such approaches depend on the objectives which are being sought. Often control is feasible within a limited production area and serves only to control a particular pest population in that particular area, such as an orchard. The use of bait sprays is frequently employed, for example, methyl-eugenol and malathion.

Suppression refers to the strategy of attempting to control an entire breeding population or a substantial part of that population in any season. The implication of this is that it must be a continual process every season as the pest reappears. Bait sprays or pheromone traps are usually employed as well as applied biological control or the sterile insect technique.

Eradication aims to get rid of all flies within some given area on a permanent or semi-permanent basis. Such action is drastic and expensive and it is only undertaken where there is every indication of success and where any re-infestations can be easily monitored and treated or even effectively prevented. Eradication, for example, may be attempted where there has been a recent introduction into an area, where this introduction is still relatively localized and where resources are in place to mount such a program. This would involve a survey program, bait spraying, sterile insect technique and perhaps a biological control strategy all combined in an integrated program.

1.3.1 Thrips

There are three species of thrips (Thysanoptera: Thripidae) which have been reported as adversely affecting mango. In the Caribbean these three species are present but only *Selenothrips rubrocinctus* (Giard.), the red-banded or cocoa thrips, and *Heliothrips haemorrhoidalis* (Bouche) are found associated with the crop. The other species, *Thrips palmi* Karny, the palm thrips or oriental thrips, is one of the more recent introductions into the Caribbean where it has caused devastating damage to various vegetable crops but so far has not been reported to affect mango.

Selenothrips rubrocinctus
This is a very important pest species in the region where it attacks various tree crops, e.g. cocoa, cashew, avocado and mango. In fact, in some countries, e.g. Grenada, the cocoa thrips is one of the major pests of cocoa requiring regular control measures. There have been comprehensive studies of the biology of this species and its relationship to its host plants (Fennah 1955; 1963; 1965).

Thrips possess rasping or sucking mouth-parts which are used to scrape or break the surface layer of cells from which they suck the expressed cell sap. This causes these superfical cells to eventually die and the leaf takes on a bronze coloration initially. With heavy infestation and in dry conditions attacked leaves will eventually die since the protective outer cell layer is destroyed. This leads to severe defoliation. This writer has seen entire cocoa fields defoliated in Grenada.

It has been reported that cocoa thrips attack is facilitated and intensified when the host plant is under stress. In the case of cocoa, the removal of shade trees and windbreaks sufficiently alters the microclimate in fields to the advantage of the pest.

Wolfenbarger (1955) reported that *S. rubrocinctus* may be found "... at all times on some mango trees" in Florida though natural enemies and unfavourable conditions would usually keep population numbers at low levels. Both larvae and adults feed on the underside of leaves. In fact the eggs are laid on the leaves where they hatch. There are two larval stages after which pupation occurs in the soil. This is a common pattern for most phytophagous Thripidae.

Thrips palmi
As indicated above that is one of the most recent pest introductions into the Caribbean. It was first reported in 1985 from Martinique and Guadeloupe and has now spread to Antigua, Barbados, Dominican Republic, St. Kitts and Trinidad with unofficial reports for Dominica, St. Lucia and Suriname. In April 1991 the USA (Florida) reported the first introduction to mainland USA.

1.3.3.1 Pest Status and Economic Impact

Since its introduction into the Caribbean this pest has caused severe losses in several vegetable crops belonging mainly to the solanaceous and curcubit groups. Estimates of losses in Trinidad over 1989 indicated an 80, 68 and 55% decline in production of melongene, hot peppers and cucumbers respectively due to *T. palmi* (Jones 1990). In 1986 in Guadeloupe eggplant production was reduced from 5,000 to 1,600 t (Etienne et al. 1990). However there have been as yet no reports of *T. palmi* affecting mango in the Caribbean. It may be that no one has looked at mango, given the devastating losses to other crops.

The one report of *T. palmi* affecting mango has come from India (Verghese et al. 1988) where the pest was first recorded in 1987 infesting the inflorescences or panicles from the pre-bloom stage. Both larvae and adults fed on the panicles to cause "... scab-like marking at the feeding sites"; retarded growth of the panicles resulted. There was no quantification of loss. Given the severe losses in other host plants, should *T. palmi* have the same effect on mango then this is certainly a major cause for concern.

1.3.4 Mango Midges

Mango midges belong to a group of insects referred to generally as gall midges (Diptera: Cecidomyiidae). This group has not been well studied locally. This may be due to their unobtrusive nature. As Ananthakishnan (1984) has described them: "Gall midges are small, fragile insects, usually unnoticed except by the specialist" but as this author continued "... the large number of species, the wide diversity of host plants they attack and their role in various ecosystems make them much more important than their appearance might suggest".

Much of the current information on gall midges in the Caribbean is based on a series of papers published 50 years ago (Callan 1940a; 1940b; 1941). Two midges attacking mango were listed as *Asynapta mangiferae* Felt, the mango shoot midge and *Erosomyia mangiferae* Felt, the mango midge. This account of these pests relies on the above reports.

Asynapta mangiferae is the lesser important of these two midges and is considered a minor pest of mango. It was, at the time, only reported for Barbados by Callan. Larvae get below the bark of small shoots and cause death of the terminal parts of the shoot, probably as a result of cambial feeding.

Erosomyia mangiferae: according to Callan (1940a; 1941) this pest is more widespread, being endemic to the Lesser Antilles with positive records for St. Vincent and St. Lucia and possibly Trinidad. This species attacks young inflorescences and young leaf buds where eggs are laid. On hatching, larvae bore into the plant tissue causing small swellings or blister galls according to Ananthakrishnan (1984). As a result of larval feeding the young flowers and leaves die. Callan (1941) also reported that secondary fungal infestation may occur at small decayed spots on the flower stalks. This perhaps may be the reason in the past for confusing such damage with anthracnose (A. Whitwell, personal communication).

Another species, *E. indica* has been reported for India, the larvae of which produce galls on flower buds (Ananthakrishnan 1984).

1.3.4.1 Control

Again because of the unavailability of published material very little information on control was seen by this writer. Callan (1940a) reviewed control methods for gall midges in general and included preventative control (plant quarantine) and various cultural measures. However these were all with regard to short-term crops and not mango, e.g. crop rotation, time of sowing to avoid the pest, post-harvest field sanitation, destruction of volunteer plants and so on. Mention was also made of various natural enemies, viz. chalcid and proctotrupoid parasitoid wasps and the potential for applied biological control. More recently a fuller taxonomic study of chalcidoid wasps associated with mango gall midges has been reported (Boucek 1986).

1.3.5 Scale Insects and Mealy Bugs

Mango is host to a variety of scale insects, mealy bugs and white flies (Table 2) with all parts of the plant subject to attack, the roots excepted. These pests are usually of minor importance but there may be instances of sporadic serious loss. Some of these pests from within the wider Caribbean are listed in Table 2 (Pollard and Alleyne 1986; FAO, 1989a).

Table2: Some homopteran pests (scales, mealy bugs, white flies) of mango in the Caribbean.

I *Diaspididae* — Hard Scales
- *Aspidiotus* destructor Sign. — coconut scale
- *Aulacaspis tubercularis* Newstead
- *Chrysomphalus aonidum* L.
- *C. personatas*
- *Insulaspis insularis* — snow scale
- *Ischnaspis Congirostris* — Black thread scale
- *Pseudaonida trilobitiformis* (Green)
- Armoured scale

II *Coccidae* — Soft scales
- *Ceroplastes floridensis* — Floride wax scale
- *C. Irubens* — red wax scale
- *Coccus viridis* — green scale
- *Protopulvinaria mangiferae* (Green)
- *Pulvinaria psidii* Mask. — Green shield scale
- *Vinsonia stellifera* (Westwood) — star scale

III *Pseudococcidae* — Mealy bug
- *Dsymiccocus brevipes* (Cockrell) — Pineapple mealy bug
- *Planococcus citri* (Risso) — Citrus mealy bug

IV *Aleyroididae* — White flies
- *Aleurocanthus woglumi* Ashby — Citrus Black Fly
- *Aleurodiscus dispersus* Russel
- *Dialeurodes* sp.

Damage caused by these insects is typical of homopteran feeding. Yellowing occurs at feeding punctures and this may lead eventually to the entire leaf becoming dry and with consequent leaf shed. If fruits are attacked soft spots and consequent deterioration occurs at the sites of attack. At times fruit development is impaired; they may fail to ripen and be permaturely shed (Wyniger 1962). Consequent on heavy scale and mealy bug attack, especially, is the growth of sooty mold fungus on the excreted honeydew.

Although the pest status of these insects is usually low as earlier indicated, *Coccus viridis* may be of major importance in Cuba at times and similarly the snow scale, *Insulaspis insularis*, and the white fly *Dialeurodes* sp. in Barbados (FAO 1989b).

Usually, natural enemies are able to exert varying levels of regulatory control on scale insects and mealy bugs particularly as reported for Pakistan to the extent that these organisms may be effectively controlled (CIBC-PARC 1986). However, this same report indicates that indiscriminate pesticide use may result in these pests increasing in pest status.

1.3.6 Mites

Very few reports of mites attacking mangoes in the Caribbean have been seen. The avocado red mite *Oligonychus yothersi* (McGregor) and the broad mite, *Polyphagotarsonemus latus* (Banks) have been reported in Cuba and Barbados respectively (FAO 1989b).

Mites generally cause superfical damage and such damage on fruits usually results in malshapen or misshapen fruit with corky sack-like regions on the surface.

II. Conclusion

The above description highlights some of the more important insect and mite pests of papaya, pineapple and mango in the Caribbean. These are summarized in Annex I. All these pests must be effectively controlled if the full potential of these crops is to be achieved. Control is not always easy. Fruit fly control, for example, is an expensive, on-going exercise which may require both pre- and post-harvest treatments. The latter is obligatory if one wishes to access the USA market. Many effective post-harvest treatments have not been adequately investigated in the Eastern Caribbean. Even those countries which are reportedly free of these pests — Grenada, Barbados, St. Vincent and Antigua — have to undertake expensive and laborious surveys to prove that they are fruit fly-free in order to gain access to US export markets. Such surveys have to be on-going.

Apart from the pests already existing in the Caribbean, this region is a target for potential pest introduction either via natural means or through deliberate, though inadvertent entry. Various factors put the region at risk: (i) the fact that the Caribbean is a major importer of agricultural products; (ii) the present agriculture diversification thrust which is partially dependent on the importation of germplasm; (iii) the fact that the Caribbean is a major tourist destination.

Many pests introductions into the Caribbean have been reported over the past few years (Pollard 1986), the most alarming and serious in the near past being *Thrips palmi*. While national regional plant quarantine services have certainly shown tremendous improvement due to the efforts of various regional, e.g. IICA, and international, e.g. FAO/UN, organizations together with national efforts from Ministries of Agriculture, there is still a greater need to make these services more functionally effective. The importance that must be attached to plant quarantine can be seen only by considering the serious losses that result from new pest introductions. Such losses for *Thrips palmi* were highlighted above. However, it appears at times that too little importance seems to be attached to intra-regional quarantine. One may recall an earlier suggestion for the free movement of agricultural produce within the region. Such a suggestion would perhaps indicate the ignorance of the distribution of some very important pests in the region. Those countries which are certified fruit fly-free at this time, for example, would wish to maintain very strict quarantine measures to guard against introduction of these pests.

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Annex I

Major insect pests of papaya, pineapple and mango in the Caribbean with notes on their distribution and damage symptoms

Crop	Pest	Distribution	Damage
Papaya	White scale: *Pseudaulacapis pentagona* (Homoptera: Diaspididae)	Antigua and Barbuda, Dominica, Suriname, Trinidad and Tobago	Attacks mainly young trees (1-year-old); stems, leak-stalk and fruits may be attacked. Plants develop small fruit; leaves turn yellow and wilt; stem may shrivel and split; death of plant flows.
	Citrus mealy bug: *Planococcus citri* (Homoptera: Diapididae)	Widespread	Heavy infestation leads to leaf shedding; buds wither.
	Papaya fruit fly *Toxotrypana curvicauda* (Diptera: Tephritidae)	Bahamas, Cuba, Haiti, Trinidad and Tobago	Females lay their eggs in the seed cavity of young fruit, feeding on seeds and then the pulp; fruit yellow prematurely and fall; mature fruit also attacked with larvae feeding and tunnelling in pulp.
	Leafhoppers of papaya: *Empoasca papayae* (Homoptera: Cicadellidae)	Antigua and Barbuda, Grenada, St. Christopher and Nevis; Montserrat, Trinidad and Tobago, St. Vincent and the Grenadines	Vectors of bunchy top disease
	E. stevensii	Trinidad and Tobago	
Pineapple	Pineapple nealy bug — *Dysmicoccus brevipes* (Homoptera: Pseudococcidae)	Antigua and Barbuda, Dominica Republic, Grenada, French Guiana, Guadeloupe, Guyana, Haiti, Jamaica, St. Lucia, Martinique, Montserrat, Trinidad and Tobago, St. Vincent and the Grenadines	Lives in colonies at the basal leaves of the plant just below the soil surface; generally associated with ants; infested plants wilt; leaves become reddish in color and/or chlorotic; root elongation ceases; plants become stunted with reduction in fruit size.
	Pineapple borers *Tmolus echion* *Tecla basilides* (Lepidoptera: Lycaenidae)	 Trinidad and Tobago, French Guiana, Guyana, Trinidad and Tobago	Larvae feed on fruit; gummosis around entry holes; fruit mis-shapen with rotting patches.
	Batachedra sp. (Ledidoptera: Cosmopterigidae)	Puerto Rico	Eggs laid on fruit lets; hatched larvae penetrate fruit; gummosis results.
	Pineapple weevil borers: *Mestamasius ritcheri* *Cholus Spinipes* *C. zonatus*(Coleoptera: Curculionidae)	 Jamaica Grenada St. Lucia, Martinique	Larvae tunnel fruit stalk and fruit; stalk may break; fruit made unfit for consumption.
	Scale insects: Pineapple scale *Diaspis bromeliae*	Antigua, British Virgin Islands, Dominica, Guyana, Haiti, Martinique, St. Lucia, St. Vincent	Larvae tunnel fruit stalk and fruit; stalk may break; fruit shows external feeding marks with gummosis; adults also feed externally.
	D. boiduvali (Homoptera: Diaspididae)	Antigua Dominica, French Guyana, Guadeloupe, Martinique	Leaves and fruits attacked; heavy infestation may lead to reduced plant growth and even death; dwarf and fibrous fruit result.

Annex I (concluded)

Major insect pests of papaya, pineapple and mango in the Caribbean with notes on their distribution and damage symptoms

Crop	Pest	Distribution	Damage
Pineapple (cont'd)	Mites: *Dolichotetranychus floridances* (Acarina: Tetranychidae)	Unknown	Associated with plants under stress; necrotic areas may be observed on leaves; when young leaves attacked reduction in growth and wilting observed.
	Stenotarsonemus ananas (Acarina: Tarsonemidae)	Unknown	Inflorescence and developing fruit attacked; has been linked with certain fungal disease.
Mango	Fruit flies: *Anastrepha* spp. (Diptera: Tephritidae)	Wide distribution in the Caribbean region, Note: Antigua, Barbados, Grenada and St. Vincent are free of fruit flies	Females lay eggs below skin of mature fruit; larvae tunnel and feed in flesh; mature fruit with rotting spots; fruit falls.
	Thrips: red-banded thrips or cocoa thrips — *Selenothrips rubrocinctus* (Thysanoptera: Thripidae)	Barbados, Bahamas, Cayman Islands, Cuba, Dominica, Dominica Republic, Grenada, Jamaica, St. Lucia, Puerto Rico, Suriname, Trinidad and Tobago, St. Vincent and the Grenadines.	Adults and nymphs feed on under-surface of young leaves particularly; leaves turn yellow or brown speckled with spots of excreta; leaf fall results.
	Oriental thrips — *Thrips palmi* (Thysanoptera: Thripidae)	Antigua, Barbados, Dominica Republic, Guadeloupe, Martinique, Puerto Rico, St. Kitts, Trinidad	Not reported on mango in the Caribbean; In India: inflorescence infested; scab-like markings at feeding sites; retarded growth.
	Midges: mango midge — *Erosomyia mangiferae* (Diptera: Cecidomyiidae)	St. Vincent, St. Lucia, Trinidad	Young inflorescences and young leaf buds attacked to give rise to small blister galls; young flowers and leaves die as a result; secondary fungal infestation may result.
	Mango shoot midge — *Asynapta mangiferae*	Barbados	New shoots attacked by larvae which get below the bark with eventual death to terminal shoots, due possible to cambial feeding.
	Various scales and mealy bugs (Homoptera)	Wide distribution in the Caribbean	Found on leaves and/or fruit may cause leaf fall; sooty mold infestations.
	Snow scale — *Insulaspis insularis* (Homoptera: Diaspididae)	Barbados	Found on leaves and fruit; causes bronzing of fruit.
	Mango seed weevil — *Sternochetus mangiferae* (Coleoptera: Curculionidae)	Barbados, Dominica, French Guiana, Guadeloupe, St. Lucia, Martinique	No external signs of damage in early maturing varieties but can cause post-harvest damage to fruit of late maturing cultivars; infested fruit may show premature fall; extensive seed damage usually.

Disease Management in Pineapple and Mango

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I. Pineapple Diseases and their Control

Pineapples are subject to some serious diseases which must be considered for successful production.

1.1 Top (heart) Rot and Root Rot

Top (heart) rot and root rot are caused by the soil fungi *Phytophthora cinnamomi* and *Phytophythora nicotianae* var. *parasitica*. In Antigua, because of warmer soil conditions *P. parasitica* may predominate. These fungi usually attack the plants only when the soil is very wet, hence they are commonly referred to as water molds.

The early symptoms of top rot consist of a change in color of the heart leaves to a yellow or light-brown, with a red tinge. The margins are recurved and the heart leaves are easily pulled from the plant. The stem apex and leaf bases are rotted. With root rot the symptoms consist of a change of colour of the leaves from a healthy green through various shades of red, pink and yellow. the outside leaves become limp and dieback from the tip. Foliage symptoms are preceded by a collapse of the root system and affected plants are easily pulled from the ground.

1.1.1 Control

1.1.1.1 Selection of soil types

Only well drained soils should be used for pineapple growing.

1.1.1.2 Plantation drainage

Planting should be on raised beds at 25 cm high. Interception drains should be constructed to intercept outside water before it reaches the plantation. Within the plantation the water should be diverted into inter-row drains. If sub-surface compaction has occurred, deep ripping is advisable: rip down the slope. On flat shallow, poorly drained land, very high beds are recommended along with mulching with polythene to prevent bed erosion.

1.1.1.3 Treatment of planting material

Captafol (Difolatan) at 0.5 kg/45 l of water is effective as a pre-plant dip treatment. Captafol pre-plant treatments also give excellent control of base rot, caused by *Ceratocystis paradoxa*. However it should be noted that some people are allergic to Difolatan. Properly applied foliar drenches of Ridomil are preferred.

1.1.1.4 Post-plant foliar drenches

Use Ridomil 25% EC at 2.5 l/ha in 1000–2000 l of water. For the first treatment a hand drench to the heart of the plant is preferred to a spray. Later applications can be sprayed. Large volumes are preferred to wash the chemical down to the root zone. Follow up is as required, usually at 8-week intervals. Spraying during dry spells may not be necessary. The withholding period on fruit is 28 days so Ridomil should not be sprayed within 1 month of harvest. Sprays on ratoons after ratoon induction will rarely be warranted.

Ridomil should be compatible with diazinon (possible lindane) and fertilizers.

Difolatan spray rates are 10 kg/ha in 1000 l of water monthly during wet weather. Difolatan is a protectant and if used must be applied before infection occurs. Ridomil is the preferred chemical and does have some curative action.

An alternate chemical is fosetyl Al (Aliette). It is an 80% wettable powder. The suggested dipping rate is 110 g Aliette in 45 l of water — the material is dipped for 2 minutes and allowed to dry before planting. The drench rate is 5 kg/ha of Aliette at 8-week intervals or as needed. Aliette may be better than Ridomil in Antigua because it appears to give superior control of *Phytophthora parasitica*.

1.1.1.5 Polythene mulching

This sheds excess water into the inter-rows drains and encourages surface rooting, thus keeping the roots out of the wet zone where they are more vulnerable to infection. Trials have shown polythene mulch to be an effective measure of control when used in conjunction with high beds. However, mulching low beds with polythene accentuates root rot.

1.1.1.6 Broad-spectrum Fumigation

Volatile broad-spectrum fumigants such as methyl bromide, chloropicrin and methyl iso-thiocyanate are very expensive. They do not have any residual activity and the fungus can re-invade from nearby infested sites. Such fumigants are not recommended for Antigua

1.2 Mealy Bug Wilt

The most characteristic symptom of mealy bug wilt is a dying back of the outer leaves and a change in color to pale green or yellow. Heart leaves remain unaffected. Roots may degenerate but not to the same extent as when a plant is affected by *Phytophthora* root rot.

The disease is transmitted by the pineapple mealy bug which is carried from plant to plant by ants.

Planting material should be taken from wilt-free parent plants and be free of mealy bugs.

1.3 Base Rot

Base rot (or butt rot) can cause serious losses of planting material soon after planting, particularly in wet weather. Crowns, slips and suckers may be infected.

It is typically a black rot of the butt of planting material. The softer tissues are destroyed and only the stringy fibers remain. Decay of the butt is followed by wilting of the foliage, and the plants may be readily broken off at ground level.

The disease is caused by the fungus *Ceratocystis paradoxa* which commonly referred to as the pineapple fungus. It is widespread in pineapple soils and is an important organism in the breakdown of pineapple residues. this fungus also causes water blister and while leaf spot.

Many outbreaks originate in storage before planting. Inconspicuous lesions form and develop further after planting out if soil conditions are suitable. In recent Queensland field trials, fruit from plants which carried sub-lethal infections of *C. paradoxa* average 1.29 kg compared with 1.87 kg for fruit from Cayenne pineapple.

1.3.1 Control

— Do not leave a portion of fruit attached to the top when picking.

— Do not plant fresh crowns unless they are first dipped in captafol (Difolatan). Use a pre-plant dip at 450 g in 45 l of water; 10 kg/ha in 1,500–2,000 l of water directed into the heart of each plant is as effective as the pre-plant dip treatment.

— Do not store planting material in heaps. Spread it out in a single layer to cure (partially dry) with the butts exposed to the sun. If protracted wet weather occurs spray up-turned butts with captafol or captan.

— Improve soil drainage. Avoid planting during very wet periods.

1.4 Water Blister

Water blister is caused by the fungus *Ceratocystis paradoxa*. Each year during the wet season, water blister causes considerable losses in fruit consigned to distant markets. It may also occur in processing fruit if there is some delay between harvesting and processing.

1.5 Yeasty Rot

Yeasty rot affects over-ripe or damaged fruit in the field, and can cause losses in fruit sent to distant markets. It is a fermentation disease and can be caused by various yeasts. Infections occur through growth cracks, injuries and sunburn damaged tissue.

1.5.1 Control

— Protect maturing fruit against sunburn.

— Follow the picking and packing processes recommended for the control of water blister.

1.6 Fruitlet Core Rot

Varieties of the Queen group (particularly Ripley Queen and MacGregor) are very susceptible to this disease. Antigua Black is a Queen group fruit. Some seasons are likely to have increased incidence.

Fruitlet core rot is caused by the fungus *Fusarium moniliforme* which grows on the decaying floral remnants in the cavities under the eyes. It requires injury to the hard lining of the cavity before it can attack the ripening fruit. Such injury may be caused by insects (mites, mealy bugs) or growth cracks. The tissues under floral caps may fracture if a dry period is followed by rain close to maturity. Recent Hawaiian research suggests most infection occurs before redheart.

Penicillium can also cause an inter-fruitlet corking symptom similar to boron deficiency symptoms and occasionally cripple eye (a distorted eye or row of eyes).

1.7 Pink Disease and Marbling

Pink disease and marbling are two bacterial diseases of minor importance. They both occur sporadically and little is known of the environmental conditions governing infection.

There are no external symptoms. Internally the tissue has a brown speckled appearance and is abnormally hard in the centre of the fruitlet.

II. Mango Diseases and their Control

2.1 Mango Anthracnose

Anthracnose, *Colletotrichum gloeosporioides*, has been reported in the tropics and sub-tropics in crops including mango, avocado and papaya. In mango, the disease causes severe problems at different stages of crop growth, i.e. anthracnose causes blossom blight and may lead to severe losses in fruit set, as well as subsequent quiescent infections of fruits (Jeffries et al. 1990). Anthracnose exhibits the phenomenon of quiescence of latency, i.e. the fungal pathogen ceases advancing after it penetrates the cuticle and progression of disease symptoms are seen only after the fruit matures and ripens.

Disease symptoms are not usually seen nor fully developed at the time of harvest. Mango is a climacteric fruit and as such the fruit matures and ripens after harvest, and the typical anthracnose symptoms then become evident.

The symptoms of *Collectotrichum* spp. are about the same for all hosts. The differences may lie in the duration of the period that the appressorium takes to germinate or in the time the fungus remains relatively restricted within living cells before causing gross tissue damage (Dodd and Jeffries 1989). In mango the process can be seen after 24 hr (Jones and F. Mc Donald, personal communication). Angular or sub-circular depressed lesions can be found in leaves, stems and immature blossoms. When the disease is manifested in blossoms it is referred to as blossom blight stage. Fruit production is then seriously affected. Severe symptoms on leaves and stems sometimes cause leaf distortion. Brown to black lesions with a distinct margin are found on leaves. Lesions may enlarge or coalesce on leaves causing destruction of large areas often beginning from the leaf margin. Later infections produce depressed lesions on young fruit drop. (F. McDonald, personal communication) On larger fruits infections usually develop further until ripening, when dark sunken lesions appear. In many cases, the eruption of pink, slimy spore masses can be seen in the centre of the lesion.

2.1.1 Management Strategies for Control of Anthracnose

2.1.1.1 Pre-harvest

The epidemiology of anthracnose causes by *Colletotrichum* has to be studied before any effective control strategy can be developed in the field. The agro-ecology of each specific location has to be taken into consideration and also the mango cultivars for which the control is being developed.

Timing of sprays is crucial in preventing disease spread. In Australia (Fitzell and Peak 1986) mancozeb is applied every 14 days between panicle emergence and fruit set in addition to copper oxychloride being applied every 3 weeks. These fungicides are alternated on a monthly basis from fruit set until harvest.

In total the crop receives around 13 spray applications (see Table 1). The treatment is especially effective in the wet Spring sessions. In Florida, Mc Millan (1973) showed that benomyl with a surfactant gave excellent control of anthracnose and was superior to the protectant fungicides when applied at monthly intervals until 30 days before harvest. Further work by Mc Millan (1984) showed that benomyl and thiophanate methyl were the most effective treatments on Irwin cv., giving an incidence of over 35% disease-free fruits. A sticker was applied to the spray mixture. Spraying began at the panicle stage of growth with applications repeated weekly until fruit set after which fortnightly sprays were then given until 2 weeks prior to harvest. It should be noted that there have been reports of benomyl tolerant strains of *C. gloeosporioides* in Florida. (Spalding, 1982).

Many of these recently devised spray programs necesitate between 10 and 15 applications during a single season even though some would be unnecessary, especially in drier years. Fitzell and Peak (1986) have developed a program of supervised spraying based on a disease forecasting model. In Dominica, CARDI plant pathology research currently on-going is also developing a model for disease forecasting and at the same time tracing disease inoculum, over the phenological growth phases of Julie mango. It is intended to finally develop data for a rationalized spray program. Dodd et al. (1990) reported the development of a rationalized spray programme for the control of anthracnose on Carabao mango cv. in the Philippines. Five fungicide applications, one prebloom, one at flowering, two post-blossom and one pre-harvest were used and a range of fungicides compared. Benomyl, captafol and mancozeb all provided adequate control in the spray program increasing fruit set per inflorescence by 55–80% compared to untreated controls (Pordesimo, 1982). In Malaysia the use of combined spray applications of mancozeb the insecticide dicrotophos and a foliar fertilizer gave excellent control of mango anthracnose and boosted final yields when used at intervals of 7–10 days from the beginning of flower bud formation (Kwee and Chong 1985).

2.1.1.2 Post-harvest

Because most post-harvest diseases begin in the field, control measures must also begin in the field (Alvarez and Nishijima 1978). It is necessary to control anthracnose in tropical fruits during transport and ripening. Post-harvest treatments along with pre-harvest spray programs are essential components of disease control measures (Eckert and Ogawa 1985).

2.1.1.3 Hot Water Dips

The use of hot water dips either alone or incorporating a fungicide have gained popularity for the control of anthracnose, particularly in mango. The objective of any hot water dip should always aim at selecting a sufficiently high temperature and the correct duration of the dip so as to destroy the pathogen without incurring obvious fruit damage. the physiological state of maturity of fruits is another factor that needs consideration. (Segarra-Carmona et al. 1990).

Mango is generally harvested in the mature green stage and can be stored for 2–3 weeks at 10–12°C before ripening. Several treatments have been researched over the years to control post-harvest development to anthracnose with varying degrees of success (Table 2; Jeffries et al. 1990). Hot water dips alone can significantly reduce anthracnose but fruit can show signs of heat damage (Spalding and Reeder 1972). Julie mango is sensitive to high temperatures and certainly loses its lustre after heat treatment (F. Mc Donald, personal communication).

A number of fungicides have been tested as dip treatments including benomyl, which was found to be more effective against quiescent infections of anthracnose in hot water than cold water. Recently, prochloraz in hot or cold dips has proved effective against anthracnose but not stem-end rot. Other fungicides used successfully with certain mango cultivars include thiophonate-methyl (Castro et al. 1985) and hot imazalil (Spalding and Reeder 1988).

Trials using gamma irradiation to control mango anthracnose have led to the conclusion that incorporation of a hot fungicide dip was necessary to improve

Table 1: Pre-harvest spray programs used in the control of anthracnose of mango

Country	Pesticides	Number of sprays	Spray timing	Reference
Australia	Mancozeb & Copper oxychloride	13	Panical emergence onwards	Fitzell and Peak (1986)
Australia	Prochloraz & Copper (applied strategically)	Variable but significantly reduced in dry years	Panicle emergence onwards	Fitzel and Peak (1986)
Malaysia	Mancozeb & insecticide (+ foliar fertilizer)	Every 10 days	Flower buds onwards	Kwee and Chong (1985)
Philippines	Mancozeb/ chlorothalonil + copper + insecticide	5	Five sprays from induction to fruit set	Pordesimo (1982)

Source: Jeffries et al. (1990)

Table 2: Post-harvest treatments used in the control of mango anthracnose

Treatment	Reference
Scrubbing with 1% NaOCl	Pordesimo and Deang (1983)
Hot water dip (50–55 °C for 3–10 min)	Thompson (1987)
Hot benomyl dip (500–1000 ppm)	Thompson (1987)
Hot/Cold prochloraz dip (400–1000 ppm)	Le Roux and Wentze (1984)
Hot imazalil (1000 ppm)	Spalding and Reeder (1986)
Hot water + 20k RAD irradiation	Spalding and Reeder (1986)
Hot water + 75k RAD irradiation + wax	Thomas (1975)
Hot benlate/iprodione (1000 ppm)	Broderick and Thord-Gray (1982)

Source: Jeffries et al. (1990)

on control afforded by irradiation alone (Thomas 1975; Broderick and Thord-Gray 1982; Pordesino et al. 1980).

These studies in post-harvest control have highlighted the varying degrees of success obtained with similar treatments on different mango cultivars (Hatton and Reeder 1965). This reinforced the view that appropriate post-harvest treatments will have to be selected for individual mango cultivars and possible even for the same cultivar in different environments.

2.2 Stem End Rot

Stem end rot, *Botryodiplodia theobromae*, on mango is primarily a post-harvest disease and arises from poor application of harvesting techniques. The disease usually occurs at the stem end, especially when the fruit peducle (stem) is cut shorter than 1 cm. However the greyish-white water soaked necrotic lesions can also be seen on parts of the fruit other than the distal end. The leakage from the stem end as a result of too close a cut to rupture the epidermis of the fruit, or from natural cracks found in the fruit, cause spread of the infection. Sometimes the anthracnose fungus and *B. theobromae* are isolated from the same lesions or necrotic spots found on the fruit. These necrotic lesions eventuate into blotches or soft rots in other parts of the fruit surface. The infected fruit stored under poor conditions can deteriorate into a mushy mess in a few days.

2.2.1 Management for Control of Stem-end or Soft Rot

Stem-end or or soft rot damage in mango can be reduced by proper methods of harvesting ensuring that the stem is not cut too close to the epidermis—not nearer than 0.5–1 cm. Prevention of any rupture of the fruit helps to avoid leakage from the stem end. A hot benomyl dip (500–1000 ppm) has been shown to be an effective means for controlling soft rot in storage.

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Diseases of Economic Importance in Papaya, Pineapple and Mango

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INTRODUCTION

The Agricultural Diversification Programme in the Organisation of the Eastern Caribbean States (OECS) has identified two categories of crops for which active attention and appropriate line of actions would be taken to promote commercial production and joint marketing. Mango, *Mangifera indica*, is placed in the first category for which active joint marketing would be pursued. Papaya (pawpaw), *Carica papaya*, and pineapple, *Ananas comosus*, are placed in the second category of commodities with good potential. Intensive agronomic and market trials were identified as areas for commodity development in the sub region.

However, in the Annex of the same document *A Programme for Agricultural Diversification in the OECS: Identification and Promotion of Non-Traditional Export Crops with Potential for Joint Marketing* it was found that diseases were high on the list of constraints to the production and productivity of mango and papaya. No economic disease has so far been reported in pineapple in the field though plant parasitic nematodes have been reported to cause economic losses in Jamaica (Hutton, 1974). Both mango and papaya production are seriously affectea by both pre- and post-harvest diseases. These diseases are caused by several group of pathogens: fungi, bacteria, viruses and mycoplasm (MPLO).

This Presentation would deal with the principles of plant pathology of the three fruit crops and highlight the Management Strategies for Control.

I. Papaya

Papaya, *Carica papaya*, is not produced in sufficient volumes nor of high enough quality in any of the OECS countries to sustain an export effort (Anon., 1988). In fact, supply is insufficient at the present time to satisfy the domestic demand in most of the countries.

The 'Solo' group (Sunrise, Kapoho, Waimanalo etc) are the recommended cultivars of papaya.

However, diseases in the field (i.e., pre-harvest) and post-harvest diseases are major limiting production problems of papaya in the sub-region. In addition though papaya botanically is known as a perennial, virus and mycoplasma diseases have reduced the effective crop life to 1–2 years in the Caribbean.

1.1 Pre-harvest (Field Diseases)

1.1.1 Bunchy top (*Mycoplasma* - MPLO)

Bunchy top disease is caused by a mycoplasma-like organism (MPLO) an amorphous mass with no definite cell wall. Not enough is known to fully understand the etiology of the disease, bunchy top, a name derived from the later stages of infection and the symptoms exhibited. The disease can occur at any stage of tree growth but seems to occur most often 9-12 months after planting.

1.1.1.1 Svmptoms

Faint mottling in the uppermost leaves which is soon followed by malformation of the fronds (leaves) with a marked reduction and yellowing of the laminae. Internodes soon become progressively shortened and petioles stiffened, nearly horizontal and shortened. Oily spots then appear along the pseudostem end of the petioles. The disease progresses with a complete cessation of apical growth which, with shortened internodes, realizing a tuft-like growth or giving a 'bunchy top' appearance. Failure of latex to exude from wounds on diseased leaves, petioles, stems and fruits is a diagnostic characteristic of this disease. Infected plants are soon killed.

The disease is transmitted by leaf hoppers, *Empoasca papayae* and *Empoasca stevensii*, or by grafting.

1.1.1.2 Management Strategies for Control

Use of tolerant or resistant cultivars — selections out of Barbados have been reported to be tolerant to bunchy top: Barbados Pink and Barbados Yellow.

An intensive spray program is still required to control and keep down the population of the insect vectors, *Empoasca* spp.

Roguing, and the use of antibiotics (chlorotetracycline or tetracycline hydrochloride) to control bunchy top have either proved ineffective or impractical in commercial production.

1.1.2 Papaya ringspot (Papaya ringspot virus)

Papaya ringspot, caused by papaya ringspot virus, has been observed in Antigua and reported in Jamaica threatening the potential for commercial production.

Disease symptoms can first be seen on seedlings in the nursery, and later on mature plants and still later on fruits.

1.1.2.1 Symptoms

Seedlings — earliest symptoms appear as yellowing and vein-clearing of younger leaves. A prominent yellow mottling of leaves follows, giving a mosaic pattern while leaves also pucker. Leaves are malformed and distorted.

Mature plants — as the leaves develop there is further malformation and they taper off in a sword shape pattern and die slowly.

Fruits - disease symptoms on fruits are striking with concentric circles and semi-circles on the skin, hence the derivation of the disease name 'ringspot'. The fruit surface is rough and the circles and semi-circles are yellowish on mature fruit. The flavor is often unpleasant.

Infected plants exhibit growth reduction, reduced fruit set, and quality. Papaya ringspot virus can be transmitted mechanically and by grafting. However, it is thought that aphids, *Aphis gossipi* and *Myzus perisic*, transmission is the most important mechanism for disease spread in the field. Plants such as cucumber, pumpkin and squash can also harbour the virus causing this disease. Infected seedlings can be the major source of bringing the disease to the farm.

1.1.2.2 Management Strategies for Control

Until recently little could be done to effectively control the disease — sanitation, use of disease-free seedlings and spraying for aphids have all proved ineffective to control ringspot.

There are some promising papaya lines resistant to the ringspot virus, which can be good sources of field resistance.

1.1.3 Erwinia blight (*Erwinia* spp.

This disease has been observed in Antigua, Dominica and St. Lucia. The disease caused by a bacterium, *Erwinia* sp., can be very destructive on papaya. The disease spreads rapidly and a whole field can be decimated within 2-3 weeks.

The bacterium attacks stem, leaves and fruits. All commercial cultivars from Hawaii, Puerto Rico, Costa Rica and Jamaica are highly susceptible to the canker disease. It must be noted that there can be confusion in the symptomatology of this disease with viral infections, water stress and nutrient deficiencies caused by low nitrogen levels and/or high soil pH. Greasy spots on papaya caused by viral infections, and mycoplasma are often misdiagnosed as bacterial cankers.

1.1.3.1 Symptoms

Initial symptoms of the disease appear as greasy water-soaked lesions along mid-veins and margins of leaves. Two to three days after leaf lesions, many infected leaves turn yellow and absciss. Infection progresses a short distance into the petiole, causing the leaf blade to wither and hang pendant. Abscission of the petiole usually occurs rapidly. Stem cankers with bacterial ooze are observed at the nodes and internodes. Fruits are eventually infected on the tree with the consequential total rot of fruits in a very short time.

At this time the tree takes on a 'pencil point' appearance followed by tree collapse.

1.1.3.2 Management Strategies for Control

At the moment the only effective control strategy for *Erwinia* sp. canker is the use of tolerant cultivars. The Barbados Dwarf cv. seems to be very promising.

Another control strategy is the use of barrier crops that do not harbour the bacterium, e.g. cassava, pigeon pea and banana.

All chemicals including bactericides and antibiotics have proven ineffective. Copper hydroxide and mancozeb have also been shown to be inadequate for controlling the disease.

1.1.4. Phytophthora blight (*Phytophthora parasitica*)

Phytophthora blight is a wet weather disease and water-logged soils are conducive factors to this disease. Phytophthora was identified in Barbados in 1987 by the author.

The fungus causes a wide range of damage, including damping-off, root rot, stem end rot and girdling, and also fruit rot.

1.1.4.1 Symptoms

Damping-off is the rapid wilting and death of very young plants. This occurs in the propagation sheds and nurseries and also in the field shortly after transplanting.

In established fields the disease may begin in the 'hot spots' where conditions of water-logging or poor drainage are much in evidence. At the soil line, spots on the stems begin as water-soaked lesions. These areas can enlarge and even girdle the tree resulting in wilt, fall over and death of plants.

Root infection can be very severe. The first indication of major root infection is a rapid browning and wilting of trees, followed by total collapse of the plants within days.

When infection begins at the top of the tree girdling can also take place and is followed by total collapse of the plants from the top.

Fruit infection is probably the most important economically because of the possibility of spreading within a whole shipment or harvest. First symptoms are water-soaked spots. Later, mass whitish fungal growth appears on fruit which while still on the tree shrivel and fall to the ground. Here an inoculum source of the pathogen is provided for root infection.

1.1.4.2 Management Strategies for Control

Effective and good drainage should be provided to prevent any water-logging of the field. Damage to the stem should be avoided during weeding and harvesting. To prevent any fruit infection or infection at branch scars copper fungicide can be applied as frequently as may be required.

Prevention of root infection requires all of the above measures to prevent fruit and branch scar infections and general infection of plant.

Aliette (fosetyl Al) has been recommended as a foliar spray and soil drench at 2–2.5 kg/ha.

Copper sulphate or Bordeaux paste can also be applied for root rot on a limited scale.

1.2 Post-harvest Diseases

The important post-harvest diseases of papaya are of two general types: fruit surface rots and stem end rots.

The common fruit surface rot in the humid tropics, including the Caribbean, is anthracnose.

1.2.1 Anthracnose (*Colletotrichum gloeosporioides*)

Infections usually are initiated in the field at early stages of fruit development, but the pathogen remains quiescent until the fruit reaches the ripening phase.

1.2.1.1 Symptoms

On fruit, ripening beads of latex are exuded on the fruit surface and small water-soaked spots appear. As the infection advances, circular sunken lesions with translucent light brown margins develop. The fungus produces light orange or pink spore masses in the central hard centre of the lesion. *C. gloeosporioides* was first considered to be a wound pathogen of papaya but direct penetration of the cuticle and establishment of latent infections have been demonstrated.

1.2.2 Stem End Rots

Stem end rots of papaya occur when fungi invade the severed peduncle after harvest. Spores may also invade through crevices between the peduncle and the papaya flesh or invade through small wounds that occur after harvest. Several fungi are associated with stem-end rot of papaya: botryodiplodia, phomopsis, ascochyta, stemphylium and mycosphaeella.

1.2.2.1 Symptoms

Infections caused by *Botryodiplodia theobromae* have a wide margin of water-soaked tissue and a rough surface caused by an irregular pattern of erumpent pycnidia. There are distinct symptoms of each fungal infection. For example S. *lycopersici* infections are characterized by a reddish-brown discoloration of the parenchyma tissue and margins between diseased and healthy tissue are bright red to purple.

Tissue infected by *Phomopsis* sp. first wrinkles, then becomes translucent and light-green to yellow. A band of water-soaked tissue advances very rapidly from the infection site toward the fruit cavity and the infected portion often can be lifted free from the rest of the fruit. Fruiting bodies of the fungus (pycnidia) usually form on the fruit surface of advanced infections.

1.2.2.2 Management Strategies for Control of Surface Rots and Stem End Rots

Pre-harvest
Control measures must begin before onset of disease in the field. Reduction of inoculum by the application of protective fungicides is the most effective approach to disease control. Recommended chemicals for papaya are mancozeb or chlorothalonil beginning first at fruit-set about 6-8 months after planting.

Sanitation in the field should be followed by the removal of all infected and discarded fruit to reduce inoculum levels of post-harvest pathogens.

Infection by fungi that cause stem end rot occurs through and around the severed peduncle sometime after picking. Field sprays substantially reduce the inoculum level but do not eliminate stem end rot infection.

Adequate control is achieved only when field sprays are combined with post-harvest hot water or fungicide treatments.

Post-harvest
Hot water immersion or spray followed by application of fungicides in wax substantially reduces post-harvest decay, even for extended storage during surface shipment. Hot water has been found to retard ripening of papaya fruit. According to USA Federal Quarantine Regulations, papaya for export to the US mainland must be less than one-fourth ripe and must be disinfested for fruit flies within 18 hours of harvest with a double hot water immersion treatment consisting of an initial 30-minute immersion at 42°C. The double-dip treatment provides excellent control of post-harvest diseases of papaya when coupled with regular field fungicide sprays.

A number of experimental chemicals have been tested as post-harvest fungicide treatments to supplement orchard sprays. Either benomyl (already banned) or thiabendazole is effective in post-harvest treatments. The most common post-harvest chemical for surface and air-shipped papaya is thiabendazole applied at 4–8 g/l with wax.

II. Pineapple

In the CARICOM countries pineapple, *Ananas comosus*, production is still mainly traded intra-regionally. Guyana probably is the largest exporter with about 500 t being exported to Barbados during 1989/90.

However, the extra-regional trade seems to prefer the 'Smooth Cayenne' and 'Antigua Black' cultivars. No serious disease on pineapple has so far been reported in the Caribbean though plant parasite nematodes have been reported in Jamaica causing economic losses.

2.1 Parasitic Nematodes

The parasitic nematodes associated with pineapple are: *Pratylenchus* sp., *Rotylenchulus* sp. and *Meloidogyne incognita*.

Symptoms are: unthrifty growth with yellowing of leaves; undeveloped plants over an extended period resulting in delayed fruiting. Small unmarketable fruits are produced. Very often the field is then left abandoned because of the uneconomic returns derived from the field.

Several nematocides are recommended: Furadan, Phenamiphos and Vydate (Hutton 1974).

2.2 Gummosis

This is a disease described on pineapple in Guyana (McDonald 1981). A yeast-like organism *Saccharomyces* sp. was shown to be associated with this disease. The infection leads to the exudation of a gum, a polysaccharide, on the fruit surface. Sometimes the gum can be restricted within the fruit. Formation of gum leads to loss of texture and flavor of the fruit.

Poor handling and packing, improper storage and transportation facilities all contribute to significant wastage due to gummosis.

III. Mango

The bulk of the mango, *Mangifera indica*, production in the OECS is derived from the Windward group in this order: St. Vincent and the Grenadines, Grenada, St. Lucia and Dominica (Anon. 1988).

The main cultivars are Julie, Graham, Imperial. The Florida types (Haden, Keitt, etc) have not done as well as was expected. Generally, they seem to be shy bearers under prevailing environmental conditions of the sub-region.

There are two severe diseases which occur in the field:

— Blossom blight; blossom stage of anthracnose.

— Foot rot (root rot); *Phytophthora parasitica*

3.1 Field Diseases (Pre-harvest)

3.1.1 Blossom blight (*Colletotrichum gloeosporioides*)

Blossom blight can lead to severe losses in fruit set causing blossom drop, and fruit abortion. It is the same fungus *Colletotrichum gloeosporioides* that causes subsequent quiescent infections of the fruit commonly known as mango anthracnose.

3.1.1.1 Symptoms

The fungus can infect leaves, stems and young inflorescences (blossoms). The symptoms are almost the same on the organs: dark brown to black lesions which are sub-circular or angular in shape. Lesions enlarge, coalesce and cause necrosis of large areas frequently beginning around the edges of leaves. Severely affected leaves often curl. Blossom blight lesions first appear on axes of flower panicles as small brown or black spots. These enlarge, coalesce and can cause the whole inflorescence to blacken and wither before fruit-set. Later infections produce depressed lesions on young fruit, which usually result in fruit drop. It is at this stage that many a time fruits at about 4–5 cm become infected and the infection becomes quiescent until fruit ripening when dark depressed lesions appear (Peterson 1986).

3.1.1.2 Management Strategies for Control

The epidemiology of the disease — blossom blight stage — has to be fully understood before any effective control strategy can be developed. Research work in Australia allowed the development of a program of supervised spraying based on a disease model to control both blossom blight and anthracnose infection on the fruit (Fitzell and Peak 1986).

In the Philippines, Dodd et al. (1990) developed a rationalized spray program for the control of anthracnose on Carabao mango cv. Five fungicide applications, one pre-bloom, one at flowering, two post-bloom and one pre-harvest were used. Benomyl, captafol and mancozeb all provided adequate control.

In Dominica, CARDI is undertaking research in order to develop a model for disease forecasting and at the same time tracing disease inoculum over the phenological growth phases of Julie mango cv. The intention is to develop a rationalized spray programme for the anthracnose on Julie cv., based on data accumulated over time: rainfall, air humidity, air-temperature, leaf humidity (wetness), time of infection, development of disease etc.

In Malaysia, the use of combined spray applications of mancozeb, the insecticide dicrotophos and a foliar fertilizer gave excellent control of mango anthracnose and boosted final yields when used at intervals of 7-10 days from the beginning of flower bud formation (Kwee and Chong 1985).

3.1.2. Root rot (*Phytophthora parasitica*)

The fungus, *Phytophthora parasitica*, thrives in waterlogged soils. It attacks most orchard crops: mango, citrus (all kinds including grapefruit), avocado, etc. In general, the symptoms of root rot (P. *parasitica*) are similar on all fruit crops.

3.1.2.1 Symptoms

Above ground symptoms: leaves turn pale or yellow-green and often wilt; the leaves droop and sometimes defoliation can occur.

At the soil line and below ground, symptoms of necrosis can be seen to begin and traced down to the main and feeder roots. The diseased roots are blackened, brittle, and dead. Unlike avocado, mango seems to succumb to the disease rapidly and eventually the tree dies.

3.1.2.2 Management Strategies for Control

Good drainage is required to avoid any water-logging. Mango thrives with 1,000–1,500 mm annual rainfall.

Copper sulphate used as paste or Bordeaux paste (copper sulphate + slaked lime) and water are a very effective control measures.

The diseased area above the soil line should be scraped clean before applying a pruning seal; even black paint or tar can be used. Then paste copper sulphate alone or the Bordeaux paste should then be applied. The treatment may need to be repeated depending on the level of rainfall of the locality, and also the severity of disease.

Ridomil (metalaxyl) as a soil drench plus Benlate should give good control.

Relatively newer compounds such as Aliette WP and an injectable formulation of the same Aliette have proven effective in the control of Phytophthora root rot in Australia and California, USA.

3.2 Post-harvest Diseases

3.2.1 Anthracnose (*Colletotrichum gloeosporioides*)

Infection on green immature fruit does not further develop until the fruit matures and ripens. This phenomenon is referred to as quiescence or latency. Mango like papaya or avocado is a climacteric fruit, i.e. the fruit matures and ripens after harvest.

3.2.1.1 Symptoms

Disease symptoms become evident as the mango fruit becomes mature or ripens. The time between infection and disease symptoms manifestation depends on the fruit. The typical symptoms, as mentioned before, are however similar despite the host or organs of the host.

Angular or sub-circular depressed lesions can be found on the fruit surface. Lesions are dark brown to black and sunken and can coalesce enveloping the entire fruit at times. Very often pink slimy spore masses can be seen erupting through the fruit epidermal surface, as the fruiting bodies (acervuli) mature. The fruit is then rendered unsuitable for marketing.

3.2.1.2 Management Strategies for Control

Because most post-harvest diseases begin in the field, control measures must also begin in the field (Alvarez and Nishijima 1978).

It is necessary to control anthracnose in tropical fruits during transport and ripening. Post-harvest treatments along with pre-harvest spray programs are essential components of disease control measures (Eckert and Ogawa, 1985).

Hot water dips — The use of hot water dips either alone or incorporating a fungicide have gained popularity for the control of anthracnose, particularly in mango. The objective of any hot water dip should always aim at selecting a sufficiently high temperature and the correct duration of the dip so as to destroy the pathogen without incurring obvious fruit damage. The physiological state of maturity of fruits is another factor that needs consideration (Segarro-Carmond et al. 1990).

Several treatments have been researched over the years to control post-harvest development of anthracnose with varying degrees of success (Jeffries et al. 1990).

Hot water dips alone can significantly reduce anthracnose but fruit can show signs of heat damage (Spalding and Reeder 1972). Julie cv. is sensitive to high temperatures and certainly loses its lustre after heat treatment as observed by the author.

3.2.2 Stem End Rot (*Botryodiplodia theobromae*)

Stem end rot of mango is primarily a post-harvest disease and arises from poor harvesting techniques. The disease usually occurs at the stem end especially when the fruit peduncle (stem) is cut shorter than 0.5 cm.

3.2.2.1 Symptoms

The greyish-white water-soaked necrotic lesions can also be seen on the parts of the fruit other than the distal end. The leakage from the stem end as a result of too close a cut to rupture the epidermis of the fruit or from natural cracks found in the fruit causes spread of infection. Sometimes the anthracnose fungus (*C. gloeosporioides*) and *B. theobromae* are isolated from the same lesions found on fruit. These necrotic lesions eventuate into blotches or soft rots in the parts of the fruit surface. The infected fruit stored under poor conditions can deteriorate into a mushy mess in a few days.

3.2.2.2 Management Strategies for Control

Stem end rot or soft rot damage in mango can be reduced by proper and careful harvesting ensuring the stem does not cut too close to the epidermis not less than 0.5 cm. Prevent rupturing of the fruit epidermis so as to cause no leakage from the stem end. Hot benomyl dip (500-1000 ppm) has shown to be an effective means for controlling stem end rot or soft rot in storage.

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Post-harvest Handling of Pineapple and Mango

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INTRODUCTION

Pineapple is a non-climacteric fruit; no major metabolic changes occur in the fruit after harvest. After harvest, fruit will degreen and tend to lose some acidity (acidity can increase slightly during refrigerated transport). Harvesting fruit at the appropriate time for the market and employing the correct post-harvest handling procedures are critical in establishing successful marketing of pineapple.

Mango is a climacteric fruit. After maturity the fruits go through major metabolic changes associated with the ripening phase, followed by rapid deterioration. Mangoes therefore have a relatively short shelf-life. However proper post-harvest handling practices can assist in preserving fruit quality to give up to a 3 weeks storage life.

Common quality problems found in the market are:

- poor color
- skin blemishes
- latex staining
- pest damage.
- bad size grading
- variable maturity
- disease

These problems can be reduced or eliminated by attention to :

- production planning and production
- harvesting
- post-harvest handling.

I. Fruit Maturity

1.1 Pineapple

The spread of flowering of the plants gives an indication of the spread of maturity of the crop likely to be found at harvest and can act as an early indicator for arranging marketing, freight space, etc.

The maturity of fruit is generally judged by the color of the skin. However, the skin color does not always reflect the internal maturity of the fruit so that cut tests should be made to determine the condition of the flesh and sugar levels.

For the Smooth Cayenne variety total soluble solids (TSS), (which acts as a measure of sugars) should be a minimum of 10-12% at harvest. Other varieties such as the Red Spanish type should have minimum TSS at harvest of 14-15%. Sugars should be tested using juice from the flesh of fruit approximately one-third of the way from the base as the values can vary quite widely within the fruit.

The fruit loses chlorophyll starting at the base. The following stages of coloration are used as maturity guides for Smooth Cayenne:

CS1: all eyes green, no traces of yellow
CS2: 5-20% of the eyes yellow
CS3: 20-40% of the eyes yellow
CS4: 40-80% of the eyes yellow
CS5: 90% of the eyes yellow, 5-20% reddish-brown
CS6: 20-100% of the eyes reddish-brown.

For the export market of Smooth Cayenne with a sea shipment of 7–14 days, fruits should normally be harvested at CS1. Harvesting at this color stage should give a storage life of 3 weeks at 8°C, or 6 days at 20°C. CS2-3 can be used for air shipment exports.

It is important to appreciate that the exact skin color change depends not only on variety, but also on fruit size and weather conditions during ripening. The larger the fruit the more marked the advance of internal ripeness over external color. The higher the average temperature as the fruit ripens the more marked the advance of internal ripeness in relation to external color, whatever the size of fruit.

Pineapples are over-ripe for export to distant markets by sea if a cross-section of the bottom third of the fruit shows the translucent areas of the pulp to exceed 50% of the surface area.

If Ethrel is used before harvest to improve skin color it is important that the timing of application does not result in fruit with color which are not ripe internally.

II. Production Planning and Production

2.1 Mango

- Find out what the markets require.
- Select the target market.
- Plan production to suit: select appropriate variety, agronomic factors, harvest maturity, handling, preparation, packaging and shipping. Alternatively identify sites/farms for procurement of fruit of suitable quality (less prone to anthracnose, fruit fly, well-managed, etc.).

III. Harvesting

3.1 Pineapple

- Harvest selectively commencing as soon as sufficient fruit are of the correct maturity to make it economical to send a harvesting team in. Select fruit by size and color, having carried out some cut tests in the field to determine the appearance of the flesh.
- Picking may extend over about 20 days if natural flowering without Ethrel is allowed:

  first picking: 5% of fruit
  3-4 days later: 10-15%
  3-4 days later: 30%
  3-4 days later: 30%
  3-4 days later: 15%
  3-4 days later: 5-10%

  In practice, harvesting dates are usually matched to shipping or marketing schedules unless cold storage is available.
- Twist fruit from the stalk. Cut the peduncle to the correct length (2 cm from the base of the fruit) where necessary with a clean sharp knife. A shorter peduncle will fail to protect the delicate base of the fruit during transit. In Smooth Cayenne the natural break point of the peduncle varies according to the maturity of the fruit so that the peduncle will snap very close to the ripe fruit. The peduncle of other types of pineapple tends to break away from the fruit even when ripe.
- Place fruits on plants ready for another picker to collect in field crates or a knapsack-type carrier. Do not allow fruits to come in contact with the ground.
- Care must be taken at all stages to avoid damage to fruit which could allow entry of pathogens.
- Fruit should be kept shaded and cool at all times after harvest.

3.2 Mango

Maturity

On any tree there may be a mixture of fruit at different stages of maturity (determined by change of size, shape, color of skin, color of flesh, latex production from cut stalk, fruit density).

Export fruit must be harvested by selecting fruit in the mature, hard, green condition.

The maturity stages of fruit similar to Julie and Graham can be described as follows:

Immature: Shoulders below the stem insertion with ridges absent, firm and green.

Just mature (Stage 1): Shoulders in line with the stem with slightly ridged edges, firm and green.

Fully mature (Stage 2): Outgrown shoulders, formation of a depression with ridges at the stem end, firm and green.

Softening (Stage 3): Fruit beginning to soften and show skin color changes.

Stage 1 fruits are most suitable for sea shipment to distant markets as they have the longest shelf-life. Stage 2 fruits are suitable for air transport to distant markets and regional shipments. Stage 3 fruits are most suitable for local markets.

- Pick fruit at the coolest time of the day.
- Pick by hand or by picking pole (cali) leaving a long stalk on the fruit.
- Trim the stalk to 5 mm with a sharp knife or clippers.
- Do not throw fruit or allow fruit to touch the ground. This results in rotten fruit.
- Shoulder bags may be useful to lower fruit from the tree if it is necessary to climb.
- Pack mangoes into plastic field crates, selecting out defective fruit.
- Keep harvested fruit shaded.
- Do not overfill the crates.
- Transport carefully, protected by a tarpaulin.

IV. Post-harvest Handling

4.1 Pineapple

- Sort fruit to eliminate defective fruit on arrival at the packing point. Select out fruits which are at the incorrect stage of ripeness; the wrong size; bruised; with damaged crowns; deformed; with broken peduncles.
- Wash and brush fruit where necessary to remove dirt, debris and mealy bugs. Use 100-150 ppm (15 g/l) sodium hypochlorite in the wash water.
- If necessary apply fungicide as a dip or spray. Some producers just dip the peduncle of the fruit in fungicide, e.g. sodium 2-phenylphenolate at 7 g/litre.
- The main disorder which may require chemical control is black rot (also known as water blister disease or soft rot) caused by the wound-invading fungus *Thielaviopsis paradoxa*. The symptoms of this disorder are localized watery rots of the flesh with a sweetish, ethereal smell. The rot spreads from the peduncle or a lateral point of injury.
- Some producers apply wax or fruit coating to prolong storage life, e.g. banana oil, Brodex wax (including TBZ), Semperfresh. This may also help

to reduce physiological disorders such as internal brown spot (IBS). Symptoms appear as brown lenses at the top of the fruit near the stele and can spread to the whole of the pulp. No external sign is visible. IBS can commonly occur in fruit after refrigerated transport. It can be more prevalent after high field temperatures during development of fruit and low nutrition levels particularly low potassium. A suggested treatment to prevent IBS is to apply dry heat at 35°C for 24 h before or after cooling.

- Pack into full telescopic cartons(30.5 cm × 45 cm × 31 cm; w × l × d) with a bursting strength of 1.9 Pa (275 psi). Dividers to prevent rubbing are commonly used. Normal package net weight is 10–15 kg (22–33 lb).

4.2 Mango

Basic facilities required are:

- Clean water, buckets or tanks, field crates, good light (natural or artificial), appropriate chemicals, a dry area for carton storage and construction, a raised surface for grading and packing, weighing scales.
- Handle fruit as little as possible.
- Select and wash fruit at the same time. Use soapy water and a soft cloth to remove latex. Reject/sort fruit for maturity, size, degree of blemish, damage. Keep water clean. Use 100 ppm sodium hypochlorite (0.15 g/l).
- Use fungicide dips or hot water dips for control of disease and fruit fly. Hot water dips can also be used to overcome quarantine restrictions for fruit fly, however specialized equipment is required and procedures must be approved by the appropriate regulatory bodies.
- Allow fruit to air dry/cool.
- Pack fruit into cartons, grading for color and size to give uniform fruit in each box.
- Single layer 4–5 kg cartons are preferable. Suggested internal dimensions : 11 cm × 34 cm × 27 cm or 10 cm × 43 cm × 28 cm. Bursting strength of the fiberboard should be 1.7 – 1.9 × 103 Pa (250–275 psi). Dividers, shredded paper, etc. can be used to limit movement of fruit in transit.
- Label each carton.
- Store cartons in a cool place prior to shipment.
- Ideal temperature for shipment is 12°C, 85-95% RH. Pre-cool if possible before loading.
- Palletize boxes if possible to minimize handling and damage to fruit. Avoid storing fruit where vehicle exhaust may affect the fruit as this can initiate early ripening.
- Ripening of fruit can be synchronized before shipment by use of a 24 hr ripening period similar to that used for bananas. Optimum conditions for this are 20–25°C and 90–95% RH. Ethylene gas at 10–100 ppm is required. This is only appropriate in the case of fruit for air shipments.

V. Shipping

5.1 Pineapple

- Do not pre-cool unless the cool chain can be maintained through shipping as condensation can seriously increase risk of fungal infection.
- Ship at 8°C by sea container or by air. Pineapple are chill-sensitive so care must be taken in temperature control.

VI. Other Disorders Found in the Fruit

6.1 Pineapple

Tables 1 and 2 list some common symptoms occuring in pineapple fruit both externally and internally with possible causes.

An internal disorder which may resemble IBS is black spot which is caused by *Penicillium funiculosum* — symptoms are not normally visible externally. The centre of the eye of the fruitlet turns black possibly extending to the heart. This symptom is most often found in the basal half of the fruit.

Yeasts can cause a problem: the fruit caves in and ferments. This can be triggered by sudden changes in water supply.

VII. Summary

7.1 Pineapple

Correct determination of maturity of fruit at harvest and careful handling and packaging to avoid damage are vital in meeting the market requirements for pineapple.

7.2 Mango

Mango field production must be tailored to the selected market. Fruit must be selectively harvested at the correct maturity stage for the handling and marketing chain to follow. Attention must be paid to temperature management of the fruit. Every effort must be made to avoid damage to the fruit after harvest. Proper post-harvest handling can help to ensure a reliable supply of quality fruit to the market, and improve business profitability.

Table 1: Identifying the cause of abnormalities observed on the fruit: Abnormalities visible externally

Abnormality observed	Probable cause	Abnormality observed	Probable cause
Very small crown or no crown at all	Ca deficiency; various pests	Cone-shaped fruit	Genetic abnormality; flower-inducing product; Nutritional deficiency (water or mineral) Excessive nitrogen
Crown leaves nibble at	Various pests		
Multiple crowns. Fasciation	Temperature too high at floral differentiation — extent depends on clones.	Corn-like cracks and crevices between the eyes	Sudden water imbalance at ripening; Boron deficiency Penicillium funiculosum 'interfruitlet corking', Toxicity of certain herbicides (Dalapon).
Slip-like outgrowth at base of fruit. Multiplication of slips	Ca and Zn deficiency?; Genetic abnormality; Function of clones and physical environment	Protuding eyes.	Wilt, Fe deficiency if fruit is red; drought; root deficiency
Lodging	Excessively long peduncle - Excess of N and other mineral imbalances; - Flower-inducing product Peduncle withered: drought	Red fruit	Fe deficiency
		Fermentation of fruit. Exudation froth	Yeast attack due to sudden return of water supply as harvesting approaches
Bracts nibbled at	Crickets; various insects	Localized rot. Deliquescent fruit Sweetish, ethereal smell	Thielaviopsis paradoxa in connection with a wound. See internal appearance — Thielaviopsis rot.
Modification of tissue. Bending of fruit	Mechanical wound, whether or not parasitic		
Localized discoloration. Yellowing bending	Sun scald	Eye depressed, at advanced stage of ripeness brown at harvesting	Penicillium funiculosum (black spot)

Source: Growing Pineapples for Export in the Ivory Coast — Grower's Institute de recherches sur les fruites Manual et agrumes (IRFA)

Table 2: Identifying the cause of abnormalities observed on the fruit: Abnormalities observed internally

Abnormality observed	Probable cause	Abnormality observed	Probable cause
Advanced translucidity of flesh in relation to skin color. Low acidity. High degree of mechanical brittleness	"Yellow"	Brown spots starting at top of the fruit at the base of the eyes	"Internal browning" after exposure to cold (in field or during refrigerated transportation).
Flesh rot. Softening with bright yellow colour, then liquefaction of affected tissue with appearance of black spores. Sweetish, ethereal smell Spreads from peduncle or a lateral point (impact)	*Thielaviopsis*	Radial dry spots at level of loculesNeighbouring tissue fails to develop	Bacteria. "Marbled fruit disease".
		Suberization of walls of carpellary locules	*Penicillium funiculosum* (Leathery pocket).
Brown/black spots, usually centred on an eye, but possible extended. Relatively dry or wet	*Penicillium funiculosum* (black spot)	Longitudinal crevices in stele. Sometimes very large	Serious water deficiency.

Source: Growing pineapples for export in the Ivory Coast Growers manual. Institut de Recherches sur les fruites manual et agrumes (IRFA)

Processing of Tropical Fruits — The Antigua Experience

HAYDEN THOMAS
Ministry of Agriculture, Antigua and Barbuda

BACKGROUND

The Chemistry and Food Technology Division of the Ministry of Agriculture, Fisheries, Lands and Housing began early this century as the Laboratory of the Government Chemist in what was then the Leeward Islands Department of Agriculture. It therefore served the needs, not only of Antigua and Barbuda, but also of St. Kitts, Nevis and Anguilla, Montserrat and the British Virgin Islands. At that time the emphasis was on chemical analyses of, for example, soil, water, fertilizers and food, As you are aware, agriculture was then the mainstay of the economy of the islands, the main crops being sugar cane in St. Kitts and Antigua with the sugar factories having their own laboratories, and sea-island cotton an important crop in Antigua, Montserrat and Nevis. The Government Chemist's Laboratory in Antigua was closed in the 1940s.

About 1953 an Industrial Development Board was established mainly to assist with the promotion and establishment of industries. Processing of arrowroot starch was identified as an industry which could be established on a commercial basis in the south-western part of the island. It was already being done as a cottage industry. The UK government then provided funds under the Colonial Development and Welfare Scheme to re-establish a laboratory and appointed a starch chemist to head it. Quality control services were also provided by the laboratory for other industries run by the Board which included factories for cotton seed oil and corn meal. These are now no longer in operation. The laboratory, however, continued to perform other functions including chemical analyses of water, soil, food plants and also a limited amount of forensic work, particularly in the area of analysis and identification of drugs of abuse.

Problems arose in the sugar industry in the late 1960s and early 70s due among other things to drought, shortage of labour and low prices. Eventually this industry was abandoned and gradually the tourism industry was developed and has now become the main foreign exchange earner. The need was however identified for agricultural activities to replace the void left by sugar and government decided to embark on an agricultural diversification program involving growing fruits and vegetables. Because, however, of the rainfall distribution pattern, most of the crops are planted during a comparatively short period and glut situation often arose leading to much waste because of the perishable nature of these crops. The Laboratory then decided to carry out research and development work in the processing and preservation of foods, hence the present name: Chemistry and Food Technology Division. Work was carried out in the processing of tomatoes into ketchup, peppers into pepper sauce, cucumbers, onion and eggplants into pickles, sweet potatoes into flour and blanching and freezing of okras among other things. In the case of fruits, we have processed guava into jelly and cheese, soursop into nectar, carambola and tamarind into drinks, cashew into jelly, limes into lime juice and pineapples into jam. Table 1 shows quantities of some raw materials processed during 1982/1990 and Table 2 the nutrient composition of some fruits.

Table 1: Some raw materials processed (kg) in the Chemistry and Food Technology Division, Antigua (1982 – 1990)

Year	Pineapple	Mango	Guava	Lime	Tomato
1982	2,112	—	—	81	—
1983	2,346			37	
1984	7,285	200	802		1,330
1985	6,389		464		17,148
1986	10,151	75	581	595	4,172
1987	5,495		1,724	218	6,449
1988	8,779		676	39	6,852
1989	6,595		1,174		11,365
1990	2,739		1,096		2,905

Table 2: Nutrient composition of some tropical fruits (composition in 100 g edible portion)

Nutrient	Pineapple	Papaya	Mango	Guava	R.D.I.*
Water	85.3	88.7	83.5	83.8	
Energy (Kcal)	52	39	59	57	2900
Carbohydrate (Total g)	13.7	10.0	15.4	15.2	
Calcium (mg)	17	20	12	20	500
Iron (mg)	0.5	0.3	0.8	0.6	10
Vitamin A (Retinol Eqv.)	5	175	210	25	750
Vitamin C (mg)	17	56	53	72	30

* Recommended daily intake from food composition tables for use in the English-speaking Caribbean; CFNI (1974)

I. Food Processing Unit

We moved from the laboratory-scale to the kitchen-scale using the old sugar factory premises. Later, government renovated an old garage next to the Central Marketing Corporation (CMC) for use as a Food Processing Unit. The CMC were mandated to purchase all of the farmers' produce. The actual situation was however that the farmers often sold their earlier crops on the open market where they were able to obtain higher prices and used the CMC as their last resort when glut situations were encountered. The Unit tried its best with pots and pans and was able after some hard work to produce products of acceptable quality as confirmed by chemical and microbiological analyses, sensory evaluations and market testing. In 1978 a project proposal was put up to the British government for a small facility that could be used to process surpluses.

Although we realized that any viable commercial food processing industry would need raw materials grown specifically for processing and not merely surpluses, we thought that using the surpluses, was a good beginning for development and demonstration purposes. We got a small pilot plant from the UK which we are still using for research and development as well as for semi-commercial work.

In 1983 the Prime Minister was invited to visit the People's Republic of China and he included the Director of Agriculture and the author to that mission. A proposal was put up by us for the upgrading of the laboratory as a result of which, equipment was donated by China, following the construction by the Antigua/Barbuda government of a new building to house the laboratory. Our analytical capability was increased significantly, especially in the area of microbiology. Donations of equipment were also made by the OAS, UNESCO, CSC, and UNIDO. These have all helped in our quality control work. Processing facilities include a steam-jacketed kettle, pulper-finisher, boiler, filler, stainless steel tables, holding tanks, deep-fat fryer, can seamer and heat sealer. Analytical instruments include atomic absorbtion, uv/visible spectrophotometers and an infra-red spectrophotometer. There is also a gas chromatograph which is defective and is in the process of being repaired. There is a staff of 22 including six graduates, one technologist, one laboratory assistant, one laboratory attendant, three food processing assistants, five processing attendants and three office support staff.

Training of human resources is an ongoing activity and members of staff have benefited from courses (e.g., in Food Processing, Food Quality Control, Microbiology, Management and Environment Science) at various institutions in the UK, USA, Jamaica, Trinidad and Tobago, India, St. Lucia and Costa Rica.

Apart from the work being done in food processing, we carry out analytical work for the recently established Bureau of Standards, work for industry and for private citizens. We also give advice to other government departments in various areas of sciences and technology and periodically perform analyses for Montserrat and Anguilla. In the final analysis it is hoped that the Division will catalyze the development of food processing on a full commercial scale in Antigua and Barbuda.

II. Fruit Processing

2.1 Pineapple

Bearing in mind that the main focus of the conference is on pineapple, papaya and mango, I consider it necessary to go into a bit more detail with their processing, in particular the processing of pineapple jam. Judging from the feedback received this is one of our best-liked products.

As you are aware the Antigua Black variety is a favorite not only in Antigua, but throughout the Caribbean and indeed in other parts of the world. It is famous for its sweetness and good texture. While the larger fruit is sold fresh for the table, there are in many cases smaller ones which may be regarded as rejects. It is these that we use for the processing of jam.

In the initial jam experiments, work was carried out on the Jamaica Red Spanish variety as well as on the Antigua Black, using various proportions of brown or white sugar, fruit crushed or diced, pectin and citric acid to bring the pH to approximately 3.3 to improve set. It should be noted that a high pH, say greater than 3.5, will prevent the jam from setting properly while a low pH (less than 3.0) will cause the jam to weep on storage.

We use a standard:

Soluble solids	68%
Fruit content	40%

The reducing sugar was kept in the range 20–40%. If reducing sugar is below 20% the sucrose will be too high and crystals of sucrose will separate out on storage. On the other hand, if the reducing sugar is greater than 40%, a honey-like mass will be formed.

Since invert sugar increases with increased acidity and boiling time, these have to be carefully controlled. The bottle and cover used have to be well-sterilized. We use a chlorine solution followed by thorough washing and rinsing with boiling water.

Bottles are filled hot, inverted periodically and then cooled in water at room temperature. These bottles are imported from Miami in 20 ft containers. We find the freight charges to be quite high.

2.2 Mango

This fruit is grown mainly as a 'backyard' crop, however there are at least two orchards in government stations. Surpluses reported to be in quantities of 30–40 t per annum are experienced in some years and requests are sometimes made for processing. To date our work which has been limited to the making of mango nectar is acceptable, a separation problem is sometimes observed in storage which means that the nectar is not always presentable in appearance. More work is therefore necessary. this is being worked on by a member of the technical team from the People's Republic of China.

Good results were obtained for the chutney and mango cheese. Most people who tried the cheese however, preferred the flavor of guava cheese.

2.3 Papaya

The work so far done in the processing of papaya has been limited. In one experiment the pulp was macerated and diluted with various proportions of water and sugar added to taste. More work is needed. The author recently observed that in Costa Rica various combinations of papaya with other foods (e.g., milk) are made and sold as a fresh drink in restaurants. This holds some prospects for Antigua and Barbuda.

In some experiments the green papaya has been used for making candied fruit. This is also done in a limited way by some persons at home as an ingredient in cakes.

By far most of the papayas used in the Food Processing Unit have been used green as a filler in hot pepper sauce. It is hoped later to do some work involving the extraction of papain for use as a meet tenderizer.

III. General Discussion

Some advantages as well as disadvantages have been identified during the period that we have been working in the processing of tropical fruits in Antigua and Barbuda.

The following are some of the advantages:

— New skills have been learnt by workers

— Some jobs have been created

- — Many people are pleased to be able to purchase products made in Antigua as gifts to send abroad for friends
- — A link, however small, has been forged with the tourist industry in that some tourists also purchase these products.
- — Wastage of raw materials has been reduced, even in a small way.

The disadvantages are:

- — The irregular supply of raw material make it difficult to plan adequately. Sometimes workers have much more work than they can cope with while on other occasions there is insufficient work for them to do.
- — The high cost demanded by some farmers for the raw materials
- — The high cost of packaging materials
- — Inappropriate size of food processing equipment
- — Difficulties in maintaining some equipment

The personal view of the author is that some food processing activity is required to assist with the development of agriculture in Antigua and Barbuda. For example in the making of pineapple jam the smaller fruits are used. As the pineapple industry expands more of the small fruits will become available. The same situation would exist if these crops reach export levels. Because of the standards which would be established more fruits would be rejected for the fresh trade but, after sorting, some of these could become available for processing. This would be in addition to quantities of fruit planted specifically for processing.

Millions of dollars leave the country every year for purchasing preserves which the work carried out to date has shown could be made right here. There is a ready market in the hotels — e.g., there is the need for portion packs of jams and jellies for serving at the breakfast table. The Food Processing Unit has demonstrated what can be done; it is now left for private entrepreneurs either on their own or in collaboration with government in joint ventures to carefully examine the situation with a view to establishing a small commercial food processing of co-operatives in which farmers themselves are involved so that they will feel committed to supplying the raw materials to the factory at a reasonable rate with the knowledge that they would subsequently reap the benefits from whatever profits accrue. Still another alternative is for farmers to set up small processing units as cottage industries. FAO is at present promoting the idea of processing on a community and family level. The laboratory would need to collaborate by giving technical advice and providing a quality control service acceptable to the Bureau of Standards.

You will observe a small exhibition of some of the products being made on a semi-commercial scale at the Government Food Processing Unit. You are invited to observe them after this presentation. It should be pointed out that there are indeed some individuals and groups who process some fruits on a small scale. Let us hope that this will continue and that further expansion of food processing activities will take place for the benefit of the country as a whole.

United States and European Markets for Papaya, Pineapple and Mango

STEVEN NEW
TROPRO-CATCO, Barbados

Papaya - United States Market Survey

World production: World production of papaya stood at 3,900 million kg in 1989, up from 2,100 million kg in 1979 and from 3,800 million kg in 1988. Brazil accounted for 43% of world production in 1989. Other major producers (with corresponding production shares) included Mexico (17%), Indonesia (9%), India (9%), Zaire (5%), and China (3%). The Food and Agricultural Organization of the United Nations reports an additional 26 countries with production over 1 million kg.

Unites States production: United States production is primarily centered in Hawaii. In 1990, US production stood at roughly 30.8 million kg, produced on 1,000 ha of land. Over the past 10 years US production has ranged from a high of 42.6 million kg to a low of 23.6 million kg. Average production levels appear to be in the range of 30–33 million kg per year. Approximately 15% of production is processed.

Imports - historical: The US imported 5.2 million kg of fresh papaya in 1990, nearly double the 1989 figure and nearly 10 times the 1981 level.

Market share: Mexico is the largest exporter to the US market with 3.0 million kg, up from 2.1 million kg in 1989 and from 0.4 million kg in 1981. The Bahamas is the next largest supplier, with the US importing 1.6 million kg in 1990, up dramatically from 0.3 million kg in 1989 (the Bahamas did not export papaya to the US in 1981). Other exporters to the US in 1990 included Belize (0.4 million kg), Thailand (0.1 million kg), the Dominican Republic and Jamaica (both under 50,000 kg).

Although Mexican exports to the US have increased from 1989 to 1990, its import market share has fallen from 76 to 57%. Bahamian import share has risen from 10 to 32% over the same period, as has Belize's import share (from 3 to 8%).

Monthly supply: The US imported papaya in every month of 1990. In January and February, imports averaged approximately 200,000 kg. The import level steadily increased, reaching over 700,000 kg in August, then declining to 341,000 kg by December. Only Mexico and the Bahamas supplied papaya to the US market in every month of 1990, although Belize supplied in every month except October.

Wholesale prices: Wholesale price statistics provided by USDA's Market News Service were evaluated for the New York, Miami, and Los Angeles markets. Hawaiian papaya averaged between $7 and $18 per carton (1 layer, 8s to 12s). New York prices were generally higher (in some cases significantly) for Hawaiian papaya during the same reporting week. Peak and trough prices generally followed the same pattern in each market for Hawaiian papayas — in April and from June to August prices were at the high range.

In Miami, the Market News Service reported wholesale prices for papaya from Jamaica, the Dominican Republic, the Bahamas, and Belize over the period 1 October 1989 to 30 September 1990. Prices were considerably less than prices quoted in New York, although more comparable to Los Angeles prices. Prices peaked in July and August at between $8 and $9 per carton (1 layer, 8s to 12s). For the remainder of the year, prices generally fluctuated between $6.25 and $7.25 per carton. All price quotes are the average of the second highest and second lowest prices for Monday or Tuesday.

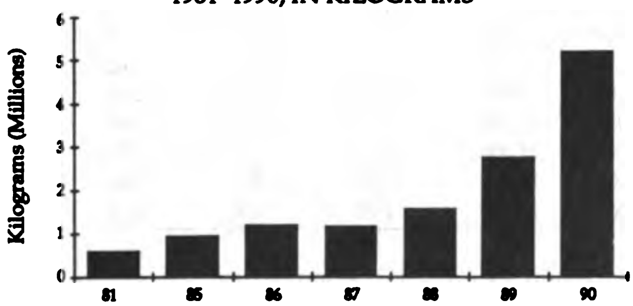
Market preference: Small (260 to 330 g) and medium (360 to 500 g) hermaphrodite fruit are preferred with 50–70% yellow coloration on arrival to the importer. small female fruit are acceptable to some importers. Certain ethnic and catering markets may require larger fruit. Hermaphrodite fruit should be pear-shaped and female fruit uniformly round. there should be no shrivelling, discoloration, or non-uniform ripening.

U.S. Imports of Fresh Papayas, 1981-1990, kilograms

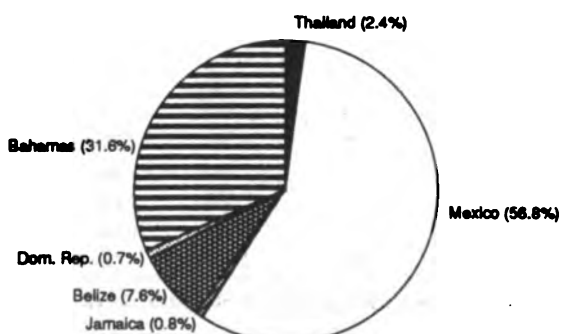
Country	81	85	86	87	88	89	90
Bahamas		700,009	362,022	91,349		264,914	1,646,910
Belgium	3,874	9,534		552		3,060	
Belize				149,910	20,431	82,331	395,873
Bermuda		23,835					
Brazil	99,655						
Chile					1,039		
China					336		
Colombia				14,660			
Costa Rica	2,275			16,734	47,352	2,970	
Dom Rep	15,508	38,438	4,358	61,572	38,262	205,159	37,354
El Salvador							
Guatemala		6,561	862				
Haiti					7,598	6,630	
Hong Kong		908					
Jamaica		21,944	16,605	145,333	312,251	40,835	43,378
Mexico		131,011	808,002	676,855	1,126,936	2,070,813	2,958,351
New Zealand				2,452			
Philippines	409						
Spain		7,627					
Taiwan							
Thailand						64,008	126,903
United Kingdom							
TOTAL	620,147	939,866	1,191,849	1,159,417	1,554,205	2,740,720	5,208,769

Source: U.S. Bureau of the Census

U.S IMPORTS OF FRESH PAPAYAS
1981–1990, IN KILOGRAMS



U.S IMPORTS SHARE OF FRESH PAPAYAS
1990 IN KILOGRAMS

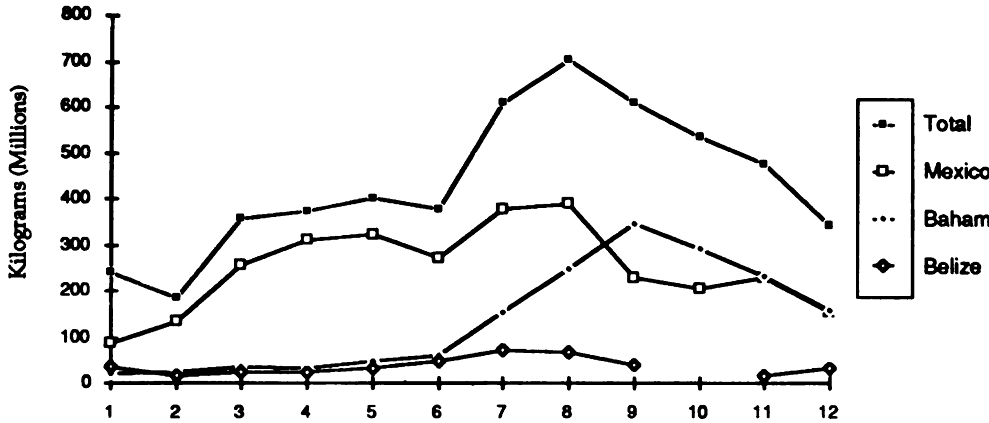


U.S. Imports of Fresh Papayas, 1990, by month in kilograms

Country	1	2	3	4	5	6	7	8	9	10	11	12	Total
Bahamas	20,531	23,041	34,817	30,944	48,434	59,024	154,388	248,716	345,094	291,717	232,787	157,417	1,646,910
Belize	34,202	16,530	23,373	25,317	29,700	48,347	70,187	66,951	37,419		14,321	29,526	395,873
Dom Rep	9,680	10,577	10,972	2,722					1,745		959	699	37,354
Jamaica	1,824		33,247	1,530	2,200		4,577						43,378
Mexico	85,008	134,373	254,523	312,277	322,508	270,822	379,159	387,936	226,440	203,622	228,407	153,276	2,958,351
Thailand	87,661									39,242			126,903
TOTAL	238,906	184,521	356,932	372,790	402,842	378,193	608,311	703,603	610,698	534,581	476,474	340,918	5,208,769

Source: U.S. Bureau of the Census

U.S IMPORTS OF FRESH PAPAYAS 1990
BY MONTH IN KILOGRAMS



Papaya: U.S. Commercial Production Statistics 1970-1990

	Commercial Production 1000ST	Acreage Harvested Acres	Yield per Acre Pounds	Total	Utilization Fresh 1,000 Pounds	Processed	Fresh	Grower Price Processed Cents/Pound	All
1970	12	1,040	23.3	24,960	23,938	1,022	10.0	3.9	9.8
1971	10	970	21.4	20,725	19,172	1,553	14.0	3.3	13.2
1972	13	985	26.1	25,735	21,959	3,776	15.1	2.9	13.3
1973	16	1,430	23.0	32,824	28,848	3,976	14.0	3.5	12.7
1974	19	1,690	22.0	37,224	34,529	2,695	13.9	3.1	13.1
1975	20	1,840	21.7	39,896	34,952	4,944	15.8	3.0	14.2
1976	25	1,930	25.9	50,037	43,588	6,449	13.5	3.8	12.3
1977	32	2,155	29.5	63,548	53,987	9,561	13.2	4.7	11.9
1978	45	2,190	40.6	64,000	54,624	9,376	14.4	4.6	13.0
1979	30	2,210	29.7	41,015	36,446	4,569	25.6	4.0	23.2
1980	37	1,950	37.9	48,916	45,360	3,556	21.7	3.4	20.4
1981	47	2,110	44.5	66,390	58,170	8,220	20.9	3.1	18.7
1982	26	2,170	38.7	52,750	44,770	7,980	25.1	3.1	21.8
1983	31	2,120	36.1	61,400	46,300	15,100	23.6	4.4	18.9
1984	40	2,590	46.3	80,500	67,000	13,500	13.1	3.1	11.4
1985	30	2,650	35.8	60,400	49,250	11,150	16.9	2.3	14.2
1986	31	2,355	35.2	61,000	50,100	10,900	21.7	2.3	18.2
1987	34	2,350	44.7	67,000	56,000	11,000	19.3	2.2	16.5
1988	35	2,300	n/a	69,000	57,000	12,000	21.0	3.2	17.9
1989	37	2,500	n/a	74,000	64,000	10,000	22.0	3.0	19.4
1990	34	2,400	n/a	68,500	58,000	10,500	25.0	2.9	21.6

Source: National Agricultural Statistical Service, USDA

1990 Wholesale Market Prices for Papayas - Los Angeles and New York — 1 Layer Cartons

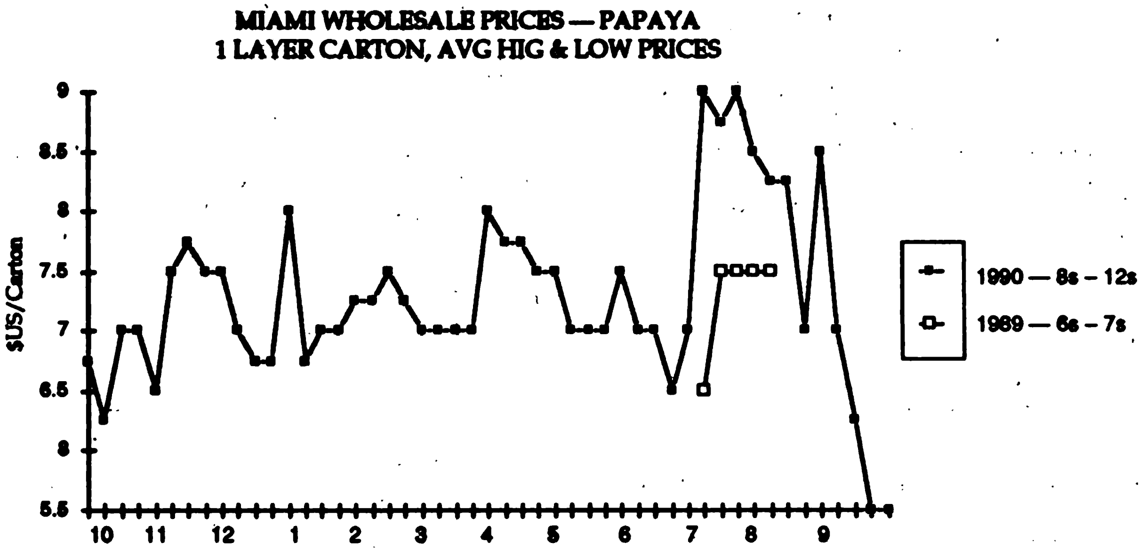
	New York Wholesale Market Prices -								L.A. Wholesale Prices	
Week	Hawaii 8s		Hawaii 9s		Hawaii 10s		Dominican Rep 5s-9s		Hawaii 8s-12s	
	Low	High	Low	High	Low	High	Low	High	Low	High
1/3	10.50	11.00	10.50	11.00					6.00	8.50
1/10	11.00	11.00	11.00	11.00					6.00	8.50
1/17	11.00	12.00	11.00	12.00					6.00	9.00
1/24	11.00	13.00	11.00	13.00			14.00	14.00	8.00	10.50
1/31	11.00	12.00	11.00	12.00			14.00	14.00	8.00	11.00
2/7	11.00	11.00	11.00	11.00			14.00	14.00	8.50	12.00
2/14	11.00	11.00	11.00	11.00			18.00	18.00	9.00	12.00
2/21	12.00	14.00	12.00	14.00			18.00	18.00	9.00	11.00
2/28	13.00	13.00	13.00	13.00			16.00	17.00	9.00	11.00
3/7	12.00	12.00	12.00	12.00			16.00	16.00	8.00	11.00
3/14	12.00	13.00	12.00	13.00					9.00	11.00
3/21	13.00	14.00	13.00	14.00			16.00	16.00	9.00	11.00
3/28	13.00	14.00	13.00	14.00			18.00	18.00	10.00	12.00
4/4			18.00	18.00	18.00	18.00	18.00	18.00	14.00	18.00
4/11			18.00	20.00	18.00	20.00	18.00	18.00	15.00	20.00
4/18			17.00	18.00	17.00	18.00			15.00	20.00
4/25			17.00	18.00	17.00	18.00			17.00	20.00
5/2			15.00	15.00	15.00	15.00			10.00	12.00
5/9	12.00	14.00	12.00	14.00	12.00	14.00			8.00	10.00
5/16	12.00	13.00	12.00	13.00	12.00	13.00			7.00	9.00
5/23	12.00	13.00	12.00	13.00	11.00	12.00	18.00	20.00	8.00	9.00
5/30	12.00	13.00	12.00	13.00	10.00	12.00	18.00	18.00	8.00	9.00
6/6	12.00	13.00	12.00	13.00	10.00	12.00			8.00	10.00
6/13	13.00	15.00	13.00	15.00					8.00	10.00
6/20	16.00	18.00	16.00	18.00					8.00	10.00
6/27	18.00	18.00	18.00	18.00			20.00	20.00	8.00	10.00
7/5	18.00	18.00	18.00	18.00			20.00	20.00	8.50	10.00
7/11	17.00	18.00	17.00	18.00			20.00	20.00	9.00	11.00
7/18	17.00	18.00	17.00	18.00	16.00	17.00			9.00	11.00
7/25	17.00	18.00	17.00	18.00					12.00	13.00
7/30	18.00	18.00	16.00	18.00	15.00	17.00			12.00	13.00
8/8	13.00	17.00	13.00	17.00	13.00	17.00			12.00	14.00
8/15	15.00	16.00	15.00	16.00	15.00	16.00			10.00	12.00
8/22	12.00	14.00	12.00	14.00	15.00	16.00			8.00	10.00
8/29	11.00	11.00	11.00	11.00			12.00	12.00	7.00	9.00
9/5	10.00	11.00	10.00	11.00					6.00	8.00
9/12	11.00	11.00	10.00	11.00	10.00	11.00			5.00	8.00
9/19	9.00	11.00	9.00	11.00					6.00	7.00
9/26	9.00	11.00	9.00	11.00					5.00	7.00
10/4	9.00	11.00	9.00	11.00					5.00	6.50
10/11	9.00	10.00	9.00	10.00					6.00	7.00
10/18	9.00	10.00	9.00	10.00	9.00	10.00			7.00	8.00
10/25	9.00	10.00	9.00	10.00	9.00	10.00			9.00	10.00
10/29			10.00	12.00	10.00	12.00			9.00	10.00
11/8			10.00	11.00	10.00	11.00			9.50	10.00
11/15			10.00	11.00	10.00	11.00			9.00	10.00
11/22			9.00	11.00	9.00	11.00	18.00	18.00	9.00	10.00
11/29			9.00	11.00	9.00	11.00			9.00	10.00
12/6			9.00	10.00	9.00	10.00	18.00	18.00	7.00	9.00
12/13			9.00	10.00	9.00	10.00	18.00	18.00	7.00	9.00
12/20			9.00	10.00	9.00	10.00			7.00	9.00
12/27			9.00	10.00	9.00	10.00			7.00	9.00

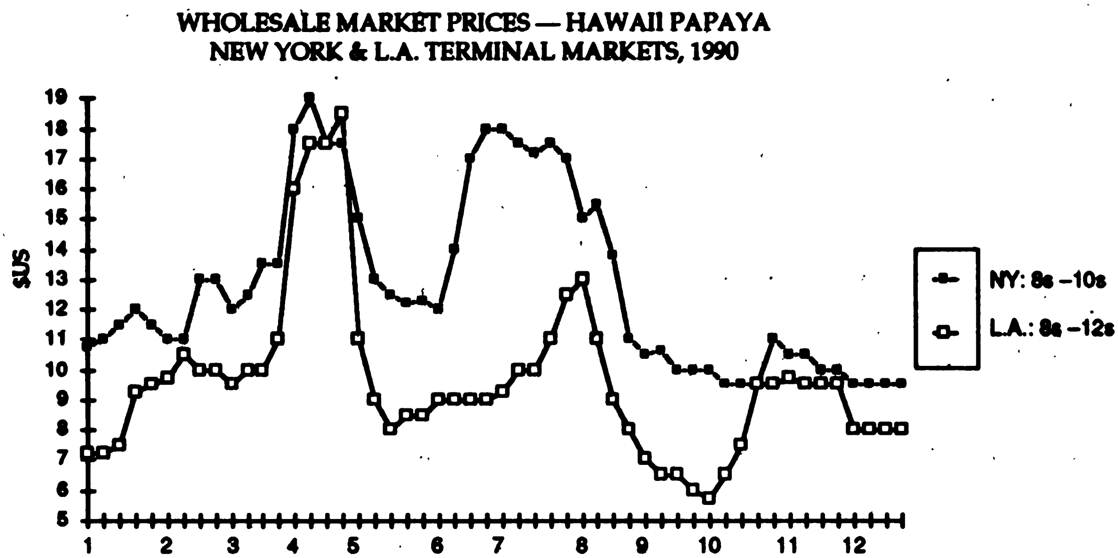
Source: USDA Market News Service (Miami, New York, Los Angeles)

10/89 -9/90 Season Wholesale Market Prices for Papayas - Miami — Import Sources: Jamaica, Dominican Republic, Bahamas, Belize

DATE	1 Layer Carton											
	6S		7S		8S		9S		10S		12S	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
10/4												
10/11												
10/18												
10/25							6	7.5	6	7.5	6	7.5
11/1							5	7.5	5	7.5	5	7.5
11/8							6	8	6	8	6	8
11/15							6	8	6	8	6	8
11/22							6	7	6	7	6	7
11/29							7	8	7	8	7	8
12/6							7	8.5	7	8.5	7	8.5
12/13							7	8	7	8	7	8
12/20							7	8	7	8	7	8
12/27							6	8	6	8	6	8
1/3							6	7.5	6	7.5	6	7.5
1/10							6	7.5	6	7.5	6	7.5
1/17							7	9	7	9	7	9
1/24							6	7.5	6	7.5	6	7.5
1/31								7		7		7
2/7								7		7		7
2/14							7	7.5	7	7.5	7	7.5
2/21							7	7.5	7	7.5	7	7.5
2/28							7	8	7	8	7	8
3/7							7	7.5	7	7.5	7	7.5
3/14								7		7		7
3/21								7		7		7
3/28								7		7		7
4/4						7		7		7		7
4/11						8		8		8		8
4/18					7.5	8	7.5	8	7.5	8	7.5	8
4/25					7.5	8	7.5	8	7.5	8	7.5	8
5/2					7	8	7	8	7	8	7	8
5/9					7	8	7	8	7	8	7	8
5/16						7		7		7		7
5/23						7		7		7		7
5/30						7		7		7		7
6/6					7	8	7	8	7	8	7	8
6/13							6	8	6	8	6	8
6/20							6	8	6	8	6	8
6/27							6	7	6	7	6	7
7/5					6	8	6	8	6	8	6	8
7/11	6	7	6	7		8		8		9		9
7/18		7	7	8	8	9	8	9	8.5	9	8.5	9
7/25	7	8	7	8		8	8	10		9		9
8/1	7	8	7	8	7	8	8	9	8	9	8	9
8/8	7	8	7	8	7	8	7.5	9	7.5	9	7.5	9
8/15							7.5	9	7.5	9	7.5	9
8/22							6	8	6	8	6	8
8/29							7	8	7	8	7	8
9/5								7		7		7
9/12							6	6.5	6	6.5	6	6.5
9/19							5	6	5	6	5	6
9/26							5	6	5	6	5	6

Source: USDA Market News Service - Miami





Papaya - European Market Survey

World production: World production of papaya stood at 3,900 million kg in 1989, up from 2,100 million kg in 1979 and from 3,800 million kg in 1988. Brazil accounted for 43% of world production in 1989. Other major producers (with corresponding production shares) included Mexico (17%), Indonesia (9%), India (9%), Zaire (5%), and China (3%). The Food and Agricultural Organization of the United Nations reports an additional 26 countries with production over 1 million kg.

EC production: Not available.

Imports - historical: The European Community (EC) imported over 7.2 million kg (ECU 12.0 million) of papaya in 1990, over 10 times the import level of 1980. In value terms, EC imports have increased over 1,300% over the period, reaching 12.0 million ECUs in 1990.

Germany imported 29% of all papaya entering the EC market in 1990. Other major importers, with percentages of total EC imports in parentheses, included: the UK (23%), the Netherlands (17%), France (11.7%), Italy (8%), Belgium/Luxembourg (6%), and Portugal (4%). All other EC countries imported under 100,000 kg in 1990.

German imports stood at 2.1 million kg in 1990, a 1,428% increase over 1980 figures. French imports in 1990 were 0.8 million kg (up 505% from 1980). Dutch imports surged upwards by 2,221% to just over 1.2 million kg, while UK imports increased a spectacular 1,641% to 1.7 million kg.

Market share: Brazil was the largest supplier to the EC market in 1990, with 3.4 million kg (47% of total EC imports). Other major suppliers to the EC included Costa Rica (1.4 million kg), the Netherlands (0.6 million kg), and Jamaica (0.4 million kg). These four suppliers accounted for nearly 80% of total EC papaya imports. Other suppliers with over a 1% market share included Belgium/Luxembourg (re-exports), France (re-exports), the Ivory Coast, Malaysia, Spain, and the United States.

German imports came primarily from Costa Rica in 1990, with a 38.2% market share, although Brazil and the Netherlands also supplied significant quantities to the German market (30.1 and 21.9% of the market, respectively). Together, they accounted for over 90% of German imports.

Brazil was by far the largest supplier to the French market with over 67 percent market share, followed by the Ivory Coast with a 20.8 percent share.

Dutch imports were sourced primarily from Brazil (56.8%) in 1990, with lesser quantities coming from Costa Rica (15.3%) and Malaysia (7.8%).

Brazil and Jamaica accounted for nearly 80% of UK imports in 1990, with 56.7 and 22.4% market shares, respectively. Lesser amounts arrived from Spain, France, and Barbados.

Intra-EC trade of papaya was 1.2 million kg in 1990 (or 17% of total EC papaya trade). It can be assumed that the majority of this trade was in re-exports and not in actual exports of local production. (However, EC trade statistics appear to indicate Spanish papaya exports of locally grown papaya at about 70,000 kg). The Netherlands, Belgium-Luxembourg, France, and Spain re-exported the largest amount of papaya to fellow EC member states — accounting for over 90% of total intra-EC trade. In the four top markets, Germany imported 25% of its papaya from EC countries, while the UK and the Netherlands imported 13 and 16%, respectively, of their papaya from other EC nations. French imports from other EC states were negligible.

Wholesale prices: New Covent Garden (UK) prices were analyzed to ascertain whether and when price fluctuations occur. New Covent Garden reported the 1990 weekly high and low prices for papaya imports from Brazil, Venezuela, Costa Rica, and South Africa. Prices ranged from a low of £1.50/kg to a high of £2.50/kg. The normal price ranged between £1.87/kg and £2.12/kg. Prices did not appear to fluctuate widely during the year or between different sources.

Using value and quantity import data supplied by the European Community, the Netherlands ranked the lowest of the top four EC markets in terms of value per kg (ECU1.40/kg). Germany had the highest import value (ECU1.84/kg), probably due to the significant percentage of papaya imports that were supplied by other EC member states. France had the second highest unit value at ECU1.72/kg, while the UK's unit value was ECU1.50/kg.

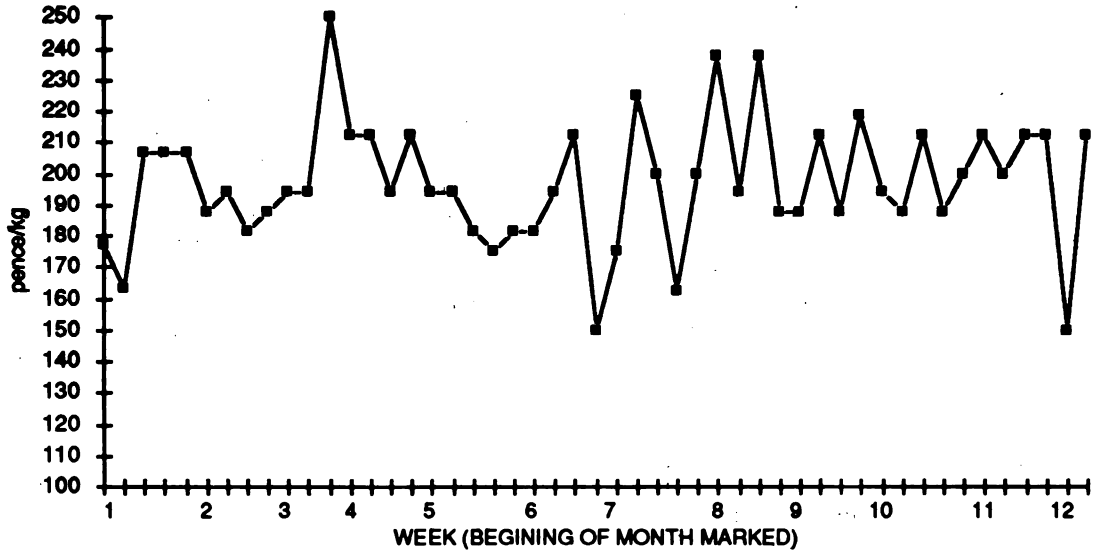
Market preference: Small (260 to 330 g) and medium (360 to 500 g) hermaphrodite fruit are preferred with 50–70% yellow coloration on arrival at the importer. Small female fruit are acceptable to some importers. Certain ethnic and catering markets may require larger fruit. Hermaphrodite fruit should be pear-shaped and female fruit uniformly round. There should be no shrivelling, discoloration or non-uniform ripening.

Papaya Wholesale Prices - New Covent Garden (U.K.) 1990 Pence/kg

	Week	Low	High	Source		Week	Low	High	Source
Jan	1	175	180	Brazil	Jul	26	1163	188	Bzl-Venez
	2	163	163	Brazil		27	225	225	Venez
	3	200	213	Brazil		28	200	200	S. Africa
	4	200	213	Brazil		29	150	175	Brazil
	5	200	213	Brazil		30	200	200	Brazil
Feb	6	175	200	Brazil	Aug	31	238	238	Brazil
	7	188	200	Bzl-Venez		32	188	200	Brazil
	8	163	200	Brazil		33	225	250	Brazil
	9	175	200	Brazil		34	175	200	C. Rica
Mar	10	188	200	Bzl-Venez	Sep	35	175	200	C.R.-Venez
	11	188	200	Venez		36	175	250	C. Rica
	12	250	250	Brazil		37	175	200	Venez
Apr	13	200	225	Bzl-Venez		38	213	225	S. Africa
	14	200	225	Brazil	Oct	39	188	200	Brazil
	15	175	213	Bzl-Venez		40	175	200	Brazil
	16	200	213	Brazil		41	200	225	S. Africa
May	17	188	200	Venez		42	175	200	Brazil
	18	188	200	Venez		43	200	200	C. Rica
	19	175	188	Bzl-Venez	Nov	44	200	225	Brazil
	20	175	175	Brazil		45	200	225	Brazil
	21	175	188	Bzl-Venez		46	200	225	Brazil
Jun	22	175	188	Venez		47	200	225	Brazil
	23	188	200	Venez	Dec	48	150	150	Brazil
	24	200	225	Venez		49	200	225	Brazil
	25	150	150	Brazil					

Source: New Covent Garden, U.K.

PAPAYA WHOLESALE PRICES — 1990 PENCE/KG
NEW COVENT GARDEN (U.K.) — AVG HI & LOW

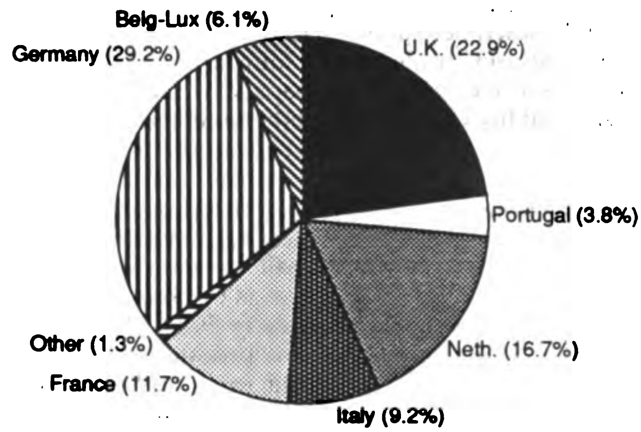


European Community Imports of Papayas (1980–1990), Value (1,000 ECUs) & Quantity (1,000kgs)

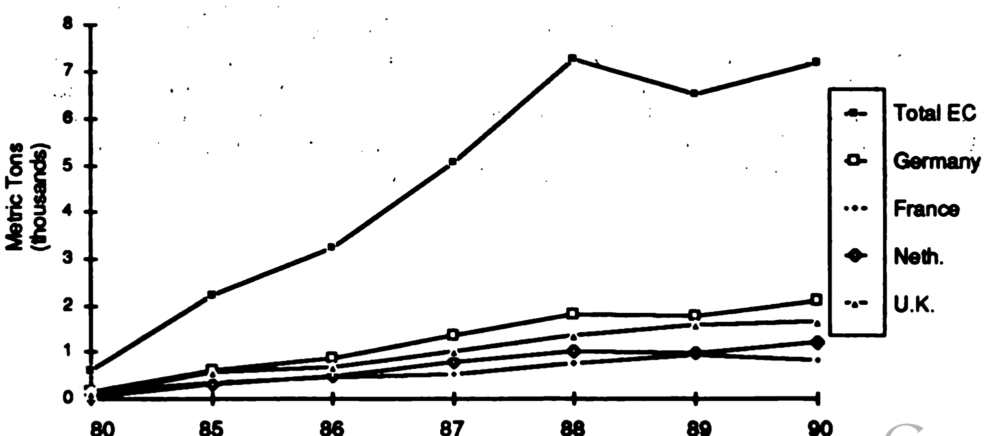
	1980	1985	1986	1987	1988	1989	1990
ECU (1000)							
Total EC	827	5360	6331	9142	10810	11800	11964
Germany	196	1582	1921	2721	3333	3532	3887
France	206	761	965	978	1416	1727	1444
Netherlands	80	624	792	1227	1437	1434	1691
U.K.	145	1246	1255	1698	2008	2659	2487
MTs							
Total EC	614	2205	3211	5074	7280	6514	7212
Germany	138	588	876	1362	1780	1752	2109
France	139	319	461	541	752	942	841
Netherlands	52	283	477	781	1020	974	1207
U.K.	95	565	681	1029	1363	1557	1654

Source: EC Commission

SHARE OF TOTAL EC IMPORTS OF PAPAYA
1990, KILOGRAMS



EC IMPORTS OF PAPAYA
1980 – 1990, 1000 MT



1990 EC Imports of Papayas, Top Ten Sources in 1,000 kgs, Total EC and Selected Markets

TOTAL EC			GERMANY			FRANCE			NETH.			U.K.		
Source	Imports	Share	Source	Imports	Share	Source	Imports	Share	Source	Imports	Share	Source	Imports	Share
Brazil	3403	47.2%	C. Rica	806	38.2%	Brazil	564	67.1%	Brazil	686	56.8%	Brazil	937	56.7%
C. Rica	1416	19.6%	Brazil	635	30.1%	Ivory C.	175	20.8%	C. Rica	185	15.3%	Jamaica	370	22.4%
Neth.	555	7.7%	Neth.	461	21.9%	U.S.A.	27	3.2%	Malaysia	95	7.9%	Spain	120	7.3%
Jamaica	386	5.4%	Thailand	58	2.8%	Belg-Lux	15	1.8%	Germany	74	6.1%	France	70	4.2%
Belg-Lux	272	3.8%	France	30	1.4%	Neth.	14	1.7%	Belg-Lux	57	4.7%	Barbados	45	2.7%
France	186	2.6%	Belg-Lux	26	1.2%	Thailand	9	1.1%	France	52	4.3%	U.S.A.	19	1.1%
Ivory C.	177	2.5%	Malaysia	23	1.1%	Togo	8	1.0%	Venez	17	1.4%	C. Rica	16	1.0%
Malaysia	146	2.0%	U.S.A.	22	1.0%	C. Rica	8	1.0%	U.S.A.	10	0.8%	Malaysia	14	0.8%
Spain	120	1.7%	Israel	12	0.6%	Venez	6	0.7%	Barbados	10	0.8%	Venez	10	0.6%
U.S.A.	104	1.4%	Jamaica	11	0.5%	Ecuador	3	0.4	S. Africa	5	0.4%	Neth.	9	0.5%
Other	447	6.2%	Other	25	1.2%	Other	12	1.4	Other	16	1.3%	Other	44	2.7%
Total	7212	100.0%	Total	2109	100.0%	Total	841	100.0%	Total	1207	100.0%	Total	1654	100.0%

Source: EC Commission

Pineapple - United States Market Survey

World production: World production stood at 9,800 million kg in 1989, up from 9,000 million kg in 1979, and slightly up from 1988 production levels. The top 10 producers (Thailand, the Philippines, Brazil, India, the US, China, Vietnam, Indonesia, Mexico, and South Africa) accounted for nearly 74% of total world production. Another eight countries produced over 100 million kg each in 1989. The FAO reports an additional 47 countries with production over 1 million kg.

United States production: United States production is primarily centered in Hawaii. Hawaii produced 521.5 million kg in 1990, down from 526.1 million kg in 1989. Hawaiian production has declined steadily since 1970, when it was 865.3 million kg. Hawaiian acreage in pineapple is nearly half of what it was in 1975, and Hawaiian production is centered on only 10 farms — as opposed to nearly 50 in 1970. Seventy-five percent of Hawaiian production is processed, while only 25% is sold fresh (although up from 4% in 1970). As total US production has declined, the amount made available to the fresh market has increased from 33 million kg in 1970 to over 131 million kg in 1990.

Imports - historical: The United States imported 112.6 million kg ($43.5 million customs value) of fresh, whole pineapples in 1990, up from 59.1 million kg in 1982 and from 96.5 million kg in 1989. US imports increased steadily since 1985. Assuming Hawaii produces 100% of US production (and it is not exported) and that all imports of fresh whole pineapples are not processed, imports supply roughly 46% of US consumption.

Market share: In 1990, Costa Rica accounted for 48.3% of US imports (54.3 million kg). Other major suppliers included the Dominican Republic (34.3% import share), Honduras (13.3%), and Mexico (3.4%). Mexican and Honduran import shares have dropped significantly since the early 1980s. Costa Rica and the Dominican Republic have been the main beneficiaries.

Monthly supply: United States imports were above 7 million kg in each month of 1990. Imports were over 10 million kg per month during the period April through July. Hawaiian production is generally highest from March through July — historically averaging approximately 10 million kg/month for fresh market consumption.

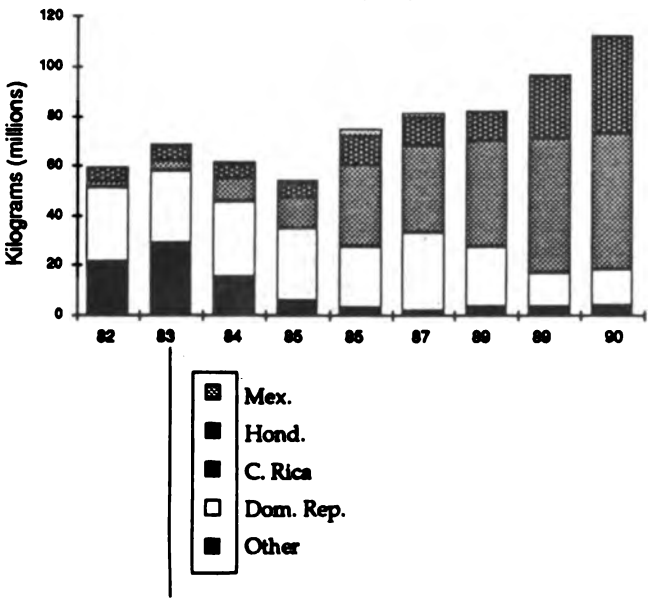
Wholesale prices: Weekly wholesale prices for pineapples, as reported by USDA's Market News Service departments in Miami, Los Angeles, and New York, were reviewed for calendar year 1990. In Miami, Hawaiian pineapple received a premium over pineapple from the Dominican Republic (generally $2–4 per carton more). Average prices for Hawaiian pineapple were slightly higher in Miami than in New York, although in both markets there was little price fluctuation (average prices of between $12 and $13 per carton in Miami, and $11 and $12 per carton in New York). Prices for Caribbean and Central American pineapple were slightly higher in New York than in Miami.

U.S. Imports of Pineapples — Fresh, 1982-1990, kilograms

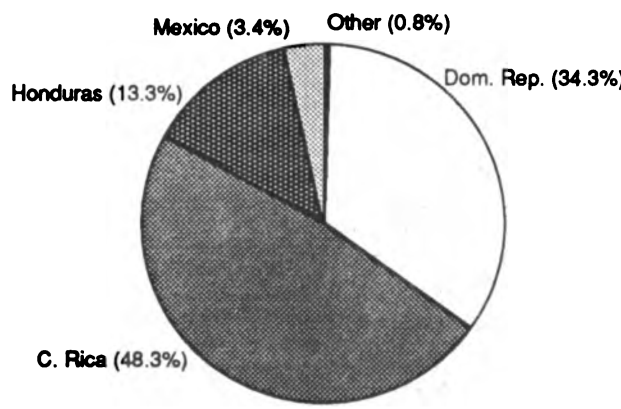
Country	82	83	84	85	86	87	88	89	90
Canada		55,314	14,933	5,530	14,165				
Mexico	21,276,700	28,785,188	15,046,617	5,520,601	3,014,525	1,936,119	3,161,310	3,183,064	3,859,229
Guatemala	319,207	194,904	146,917	539,190	1,519,760	425,189	49,849		
Belize									
El Salvador									
Honduras	29,900,812	29,062,757	30,352,900	29,074,952	24,323,549	31,050,553	24,423,044	13,639,717	14,936,527
Nicaragua									
Costa Rica	1,948,111	3,719,396	9,504,210	12,426,446	32,951,791	34,952,965	42,654,656	53,769,932	54,330,887
Panama			36,397	37,563	294,255	57,547			
Jamaica									
Cayman Islands									
Haiti	18,950								1,610
Dominican Rep	5,631,453	5,938,387	5,107,910	5,876,093		11,525,919	11,236,601	11,388,675	25,448,556
38,580,460									
Dominica				16,875					
Antigua									
French WI	7,006	15,111	1,141	3,546					
Colombia	9,875	70,838	178,610	215,199	185,643	81,662	7,853	344,921	527,167
Chile		490,211							
Ecuador		14,437		237,201	17,158	1,272,572	35,025		
Venezuela	21,674	31,208	48,979	10,413	21,128	3,889			4,588
Brazil		19,113	510,779						
France			14,290	17,236					
Denmark			14,789						
Italy			2,319						
U.K.						1,339			
Spain									140,477
Portugal		301		1,421	25,435		470		
Azorea	331								
Ivory Coast		3,466	23,696	18,570	673,140		14,903	23,031	
Senegal			7,669						
South Africa		5,641	11,751	7,190					
Japan			225						
Taiwan									7,330
Macao				1,816					
Thailand					26,856		74,051	73,940	147,329
Philippines								1,546	
Australia									273
Fr Polynesia								43,452	49,371
TOTAL	59,134,119	68,406,274	61,024,134	54,009,842	74,593,325	81,018,435	81,809,834	96,529,769	112,583,638

Source: U.S. Census Bureau

U.S. PINEAPPLE IMPORTS (1982–1990)
KILOGRAMS



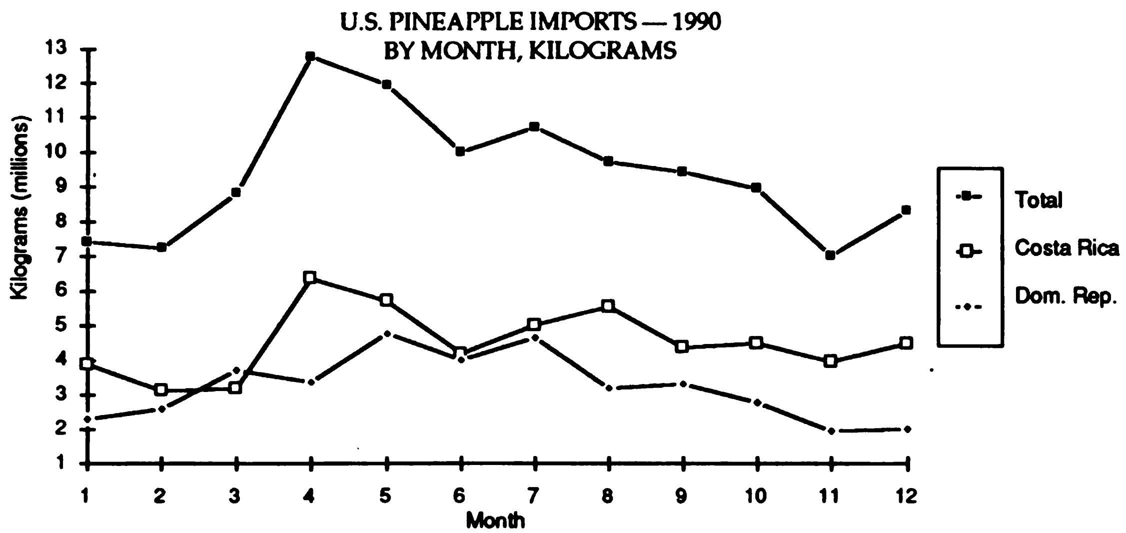
1990 U.S. IMPORT SHARE — PINEAPPLE
BASED ON WEIGHT



U.S. Imports of Pineapples — Fresh, 1990 by month, kilograms

Country	1	2	3	4	5	6	7	8	9	10	11	12	Total
Mexico	255,293	440,553	791,723	576,778	197,755	284,810	236,181	203,845	124,980	241,541	257,550	248,310	3,859,229
Honduras	948,993	1,063,235	1,065,950	2,411,605	1,146,835	1,477,472	775,213	761,149	1,445,030	1,386,451	833,187	1,621,407	14,936,527
Costa Rica	3,910,057	3,142,935	3,186,311	6,391,640	5,720,936	4,178,113	5,022,147	5,518,728	4,348,373	4,484,142	3,968,904	4,458,601	54,330,887
Dom Rep	2,321,744	2,564,763	3,722,850	3,346,963	4,787,350	4,007,868	4,635,012	3,193,670	3,322,654	2,760,602	1,919,481	1,997,503	38,580,460
Colombia	14,125	5,028	33,752	61,724	33,335	62,851	69,628	49,181	46,091	92,820	44,604	14,028	527,167
Venezuela			4,588										4,588
Spain									140,477				140,477
Thailand			11,400	12,000	91,050		3,500	7,530		16,092	5,757		147,329
Taiwan						7,330							7,330
Australia										273			273
Fr Polynesia	3,554	10,602	16,629	9,297	6,530	1,747		1,012					49,371
Total	7,453,766	7,227,116	8,833,203	12,810,007	11,983,791	10,020,191	10,741,681	9,735,115	9,427,605	8,981,831	7,029,483	8,339,849	112,583,638

Source: U.S. Census Bureau



Hawaiian Pineapple Statistics 1970-1990

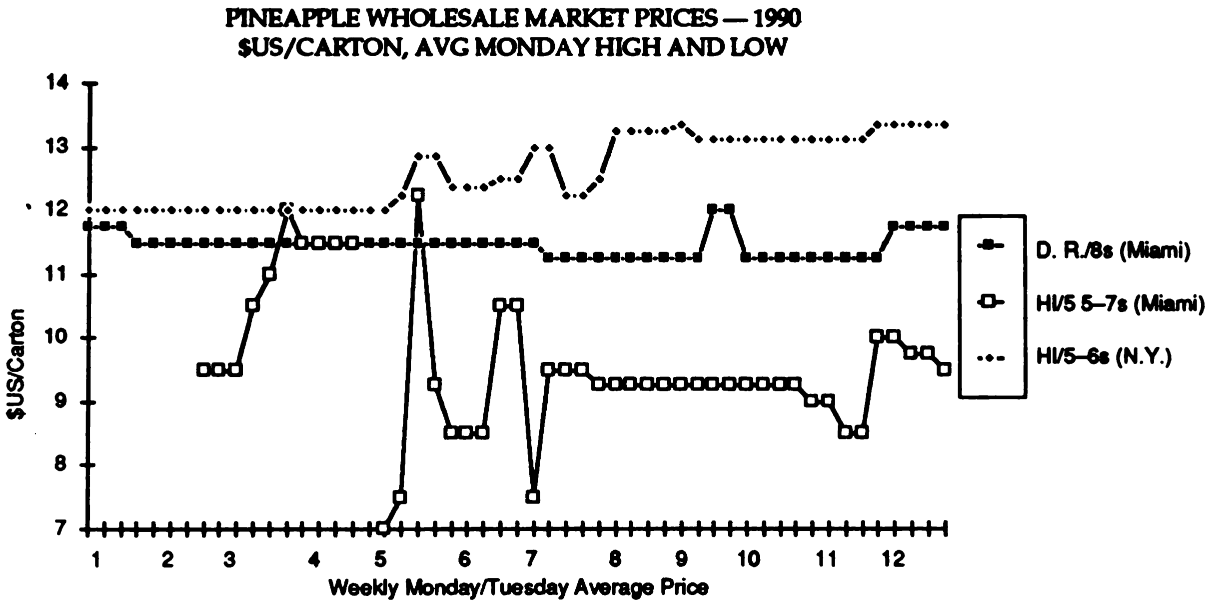
	Acreage	Farms	Disposition: Utilized Product	Disposition: Processed	Disposition: Fresh	Farm Price: Processed	Farm Price: Fresh	Value of Production Fresh
	1000 Ac	Number	1,000 ST			Dollars/Ton		$1,000
1970.	61.0	47	954	918	36	39	100	39,500
1971	61.0	36	942	911	31	40	120	40,300
1972	58.0	36	947	906	41	43	120	43,900
1973	57.5	33	810	748	62	43	120	39,600
1974	55.0	20	700	641	59	49	150	40,259
1975	50.0	20	720	657	63	48	160	41,616
1976	48.0	17	680	611	69	63	210	52,983
1977	45.0	17	690	607	83	67	260	62,249
1978	43.0	18	675	580	95	58	310	63,090
1979	44.0	18	681	587	94	67	320	69,409
1980	43.0	18	657	556	101	76	340	76,596
1981	41.0	18	636	519	117	85	390	89,745
1982	36.0	18	670	542	128	82	390	94,364
1983	35.0	18	722	602	120	88	395	100,376
1984	35.0	18	600	481	119	88	400	89,928
1985	34.5	18	565	441	124	90	410	90,530
1986	36.0	19	646	514	132	90	405	99,720
1987	36.1	12	692	558	134	91	362	99,286
1988	34.6	12	659	526	133	99	416	107,402
1989	32.7	10	580	435	145	90	408	98,310
1990	30.9	n/a	575	430	145	101	385	99,255

Source: National Agricultural Statistics Service, USDA

Pineapples: Wholesale Market Prices, 1990, Price per Carton (10s and 12s)

	Miami Terminal Market				New York Terminal Market						L.A. Terminal Market	
Week	Dominican Rep (8s)		Hawaii (5s-7s)		Hawaii (5s-6s)		Costa Rica (7s-8s)		Dominican Rep. (8s)		Hawaii (10s-12s)	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Jan 1			11.50	12.50	11.50	12.00					8.50	10.50
2			11.50	11.50	12.50	11.50	12.00	12.50	13.50	9.50	11.00	
3			11.50	12.50	11.50	12.00	14.00	14.00			12.50	14.00
4			11.50	12.50	11.00	12.00					13.50	14.00
5			11.50	12.50	11.00	12.00					14.00	14.50
Feb 6			11.50	12.50	11.00	12.00	15.00	15.00			14.00	16.00
7			11.50	12.50	11.00	12.00					15.00	16.00
8	9.00	10.00	11.50	12.50	11.00	12.00					13.00	15.00
9	9.00	10.00	11.50	12.50	11.00	12.00	15.00	16.00			10.00	14.50
Mar 10	9.00	10.00	11.50	12.50	11.00	12.00					9.00	13.50
11	9.00	12.00	11.50	12.50	11.00	12.00	13.00	15.00			9.50	13.00
12	10.00	12.00	11.50	12.50	11.00	12.00					10.00	13.50
13	12.00	12.00	11.50	12.50	11.00	12.00	12.00	13.00			9.00	13.00
14	11.00	12.00	11.50	12.50	11.00	12.00					11.50	12.50
Apr 15	11.00	12.00	11.50	12.50	11.00	12.00					13.00	14.00
16	11.00	12.00	11.50	12.0	11.00	12.00	11.00	12.00			12.50	14.00
17	11.00	12.00	11.50	12.50	11.00	12.00			6.00	11.00	11.00	12.00
18			11.50	12.50	11.00	12.00	10.00	14.00			9.00	11.50
May 19	6.00	8.00	11.50	12.50	11.00	12.00			8.00	9.00	9.50	10.50
20	7.00	8.00	12.00	12.50	11.00	12.00			8.00	8.00	12.00	12.50
21	11.50	13.00	12.50	13.25	11.00	12.00			12.00	12.00	12.00	12.00
22	8.50	10.00	12.50	13.25	11.00	12.00	14.00	15.00			10.00	15.00
23	8.50	8.50	11.75	13.00	11.00	12.00					14.00	15.00
Jun 24	8.50	8.50	11.75	13.00	11.00	12.00					14.00	15.50
25	8.50	8.50	11.75	13.00	11.00	12.00					13.00	15.00
26	10.00	11.00	12.50	12.50	11.00	12.00					13.50	15.00
27	10.00	11.00	12.50	12.50	11.00	12.00					13.00	15.00
Jul 28	7.50	7.50	12.50	13.50	11.00	12.00	13.00	14.00	9.00	10.00	12.00	15.50
29	9.50	9.50	12.50	13.50	11.00	11.50			7.00	8.00	13.00	15.00
30	9.50	9.50	12.00	12.50	11.00	11.50	10.00	12.00			13.00	15.00
31	9.50	9.50	12.00	12.50	11.00	11.50	8.00	8.00	8.00	8.00	13.00	15.00
32	9.00	9.50	12.00	13.00	11.00	11.50			10.00	10.00	14.00	15.00
Aug 33	9.00	9.50	13.00	13.50	11.00	11.50	9.00	10.00	8.00	9.00	13.00	14.00
34	9.00	9.50	13.00	13.50	11.00	11.50			9.00	10.00	12.00	14.00
35	9.00	9.50	13.00	13.50	11.00	11.50	11.00	11.00	9.00	10.00		
36	9.00	9.50	13.00	13.50	11.00	11.50					14.50	15.50
Sep 37	9.00	9.50	13.00	13.75	11.00	11.50					14.50	15.50
38	9.00	9.50	12.50	13.75	11.50	12.50					14.00	14.50
39	9.00	9.50	12.50	13.75	11.50	12.50	9.00	9.00	8.00	9.00	13.00	14.00
40	9.00	9.50	12.50	13.75	11.50	12.50	8.50	8.50	9.00	9.00	12.50	13.50
Oct 41	9.00	9.50	12.50	13.75	11.00	11.50					12.00	13.00
42	9.00	9.50	12.50	13.75	11.00	11.50			8.00	9.00	12.00	13.50
43	9.00	9.50	12.50	13.75	11.00	11.50			8.00	8.00	14.00	14.00
44	9.00	9.50	12.50	13.75	11.00	11.50					11.00	12.00
45	8.75	9.25	12.50	13.75	11.00	11.50	10.00	11.00			11.00	12.00
Nov 46	8.75	9.25	12.50	13.75	11.00	11.50			10.00	10.00	11.50	13.00
47	8.00	9.00	12.50	13.75	11.00	11.50	9.00	11.00	10.50	11.00	11.50	13.00
48	8.00	9.00	12.50	13.75	11.00	11.50						
49	9.50	10.50	12.50	14.25	11.00	11.50			11.00	11.00		
Dec 50	9.50	10.50	12.50	14.25	11.50	12.00						
51	9.50	10.00	12.50	14.25	11.50	12.00			11.00	11.00		
52	9.50	10.00	12.50	14.25	11.50	12.00	6.00	6.00				
53	9.00	10.00	12.50	14.50	11.50	12.00						

Source: USDA Market News Service Offices in Miami and New York



Pineapple - European Market Survey

World production: World production stood at 9,800 million kg in 1989, up from 9,000 million kg in 1979, and slightly up from 1988 production levels. The top 10 producers (Thailand, the Philippines, Brazil, India, the US, China, Vietnam, Indonesia, Mexico, and South Africa) accounted for nearly 74% of total world production. Another eight countries produced over 100 million kg each in 1989. The FAO reports an additional 47 countries with production over 1 million kg

EC production: FAO estimates that total European production is 1 million kg, all produced in Portugal. Production in the French overseas departments of Martinique and Guadeloupe is estimated at 21 million kg in 1989.

Imports - historical: The European Community (EC) imported over 271 million kg (ECU 174.3 million) of pineapple in 1990, nearly 180% over the import level of 1980. In value terms, EC imports have increased over 217% over the period.

France imported 29.6% of all pineapple entering the EC market in 1990. Other major importers, with percentages of total EC imports in parentheses, included: Belgium/Luxembourg (18.6%), Germany (15.0%), Italy (15.0%), the UK (7.7%), Spain (7.5%), and the Netherlands (5.1%).

German imports stood at 40.5 million kg in 1990, up from 12.6 million kg in 1980. French imports more than doubled over the period to 80.2 million kg.. Dutch and UK imports stood at 13.7 and 20.7 million kg respectively.

Market share: The Ivory Coast was the largest supplier to the EC market in 1990, with 141.1 million kg (52.1% of total EC imports). Other major non-EC suppliers to the EC included Costa Rica (29.3 million kg), Honduras (19.4 million kg), Ghana (6.1 million kg), and the Dominican Republic (3.8 million kg).

The Ivory Coast was the top source of imports for all four major markets studied, ranging from 22.6% of all German imports to 92.2% of all French imports. Other major German suppliers included Costa Rica and Honduras. The Netherlands and the UK also received significant quantities from Costa Rica, and Ghana supplied nearly 13% of the UK market.

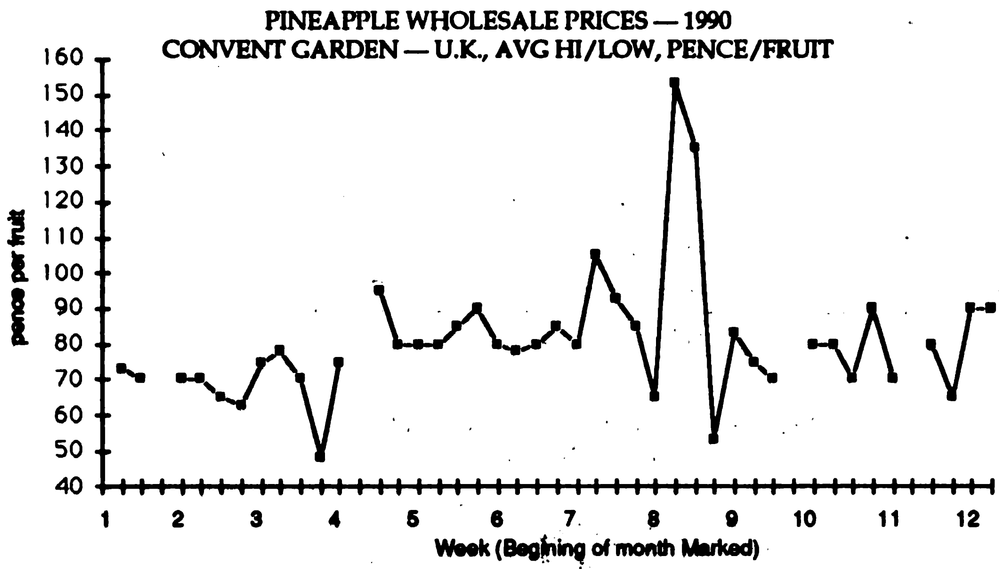
Intra-EC trade of pineapple was 64.2 million kg in 1990 (or 24% of total EC pineapple trade). All of this trade was in re-exports of pineapple imported from non-EC countries. Belgium and Luxembourg accounted for more than 50% of intra-EC trade, with both countries re-exporting over 70% of their imports in 1990. France, the Netherlands, and Germany accounted for most of the remainder of intra-EC trade in 1990.

Wholesale prices: New Covent Garden (UK) prices were analyzed to ascertain whether and when price fluctuations occur. New Covent Garden reported the 1990 weekly high and low prices for pineapple imports. Prices were given on a per fruit basis, making it virtually impossible to determine the per unit price received at the market. Prices fluctuated widely over the week and over the year. No discernable pattern was evident.

Using value and quantity import data supplied by the European Community, Germany and the Netherlands ranked the lowest of the top four EC markets in terms of value per kg (ECU0.48/kg and ECU0.50/kg, respectively). The UK had the highest import value (ECU0.80/kg), with France the next highest at ECU0.70/kg.

Pineapple Wholesale Prices - New Covent Garden (U.K.) - 1990, Pence per fruit

	WEEK	LOW	HIGH	AVG		WEEK	LOW	HIGH	AVG
JAN	1				JUL	25	70	100	80
	2	55	90	73		26	70	90	105
	3	60	80	70		27	80	130	93
	4					28	65	120	85
FEB	5	65	75	70	AUG	29	50	120	65
	6	60	80	70		30	50	80	153
	7	65	65	65		31	85	220	135
	8	55	70	63		32	90	180	53
MAR	9	65	85	75	SEP	33	50	55	83
	10	70	85	78		34	65	100	75
	11	70	70	70		35	60	90	70
	12	45	50	48		36	50	90	
APR	13	70	80	75	OCT	37			80
	14					38	60	100	80
	15	90	100	95		39	60	100	70
	16	70	90	80		40	60	80	90
MAY	17	70	90	80	NOV	41	90	90	70
	18	70	90			42	60	80	
	19			85		43			80
	20	80	120	90		44	60	100	65
JUN	21	90	90	80	DEC	45	50	80	90
	22	70	90	75		46	80	100	
	23	70	80	80		47			
	24	60	100	85		48			



European Community Imports of Pineapples (1980-1990) Value (1,000 ECUs) & Quantity (1,000 kg)

	1980	1985	1986	1987	1988	1989	1990
ECU (1000)							
Total Ec	54974	132500	131568	158009	160031	157343	174272
Germany	8012	19832	19840	21048	19482	17172	19562
France	19685	55844	45634	49610	51971	49673	56418
Netherlands	4513	10029	10480	9961	8123	7655	6857
UK	8742	15680	15090	15990	15264	15204	16614
MTs							
Total EC	97097	190541	201696	238936	249908	230766	270601
Germany	12589	34116	36341	38877	37946	34173	40529
France	39551	40969	67654	66304	76995	68978	80162
Netherlands	8077	17730	19337	18210	15373	14056	13684
UK	11906	18327	19150	21279	22347	20009	20749

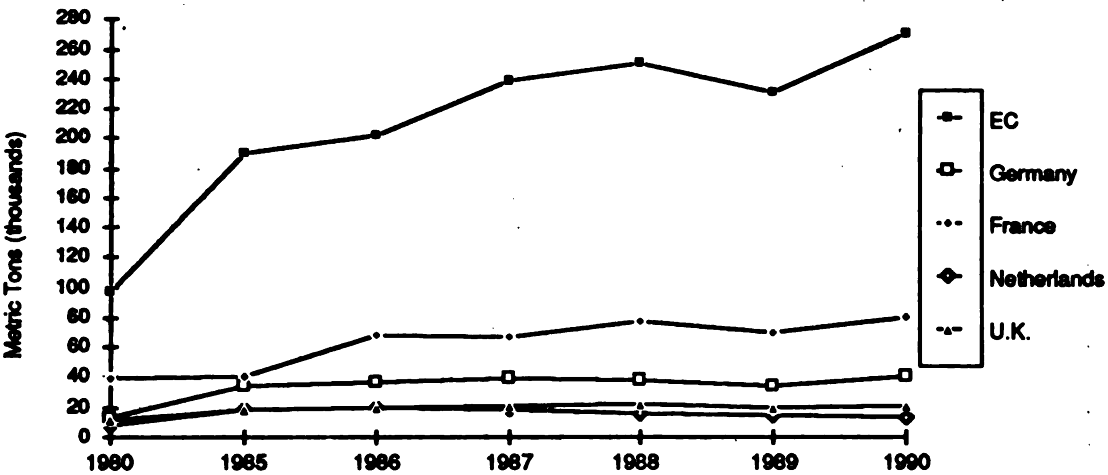
Source: EC Commission

1990 EC Imports of Pineapples, Top Ten Sources in 1,000 kgs, Total EC and Selected Markets

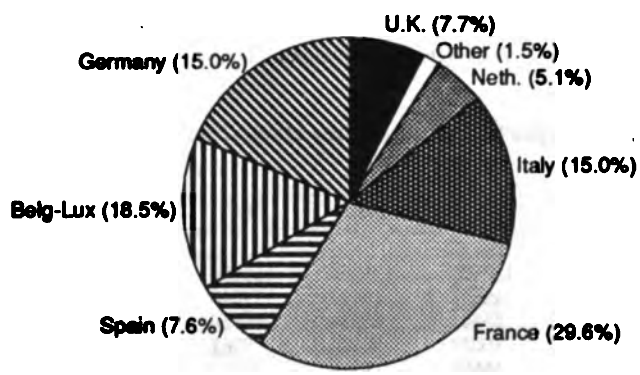
TOTAL EC			GERMANY			FRANCE			NETH.			U.K.		
Source	Imports	Share	Source	Imports	Share	Source	Imports	Share	Source	Imports	Share	Source	Imports	Share
Ivy Coast	141104	52.1%	Ivy Coast	9174	22.6%	Ivy Coast	73923	92.2%	Ivy Coast	5230	38.2%	Ivy Coast	7076	34.1%
Belg-Lux	35720	13.2%	C. Rica	8380	20.7%	Guinea	1502	1.9%	Belg-Lux	3580	26.2%	C. Rica	5530	26.7%
C. Rica	29349	10.8%	Belg-Lux	8058	19.9%	Ghana	1190	1.5%	C. Rica	2104	15.4%	Ghana	2646	12.8%
Honduras	19447	7.2%	Neth.	6848	16.9%	Belg-Lux	1017	1.3%	Dom Rep	1047	7.7%	France	1687	8.1%
France	16860	6.2%	Honduras	5009	12.4%	Fr.Guinea	798	1.0%	France	629	4.6%	Belg-Lux	1305	6.3%
Neth.	9265	3.4%	Dom Rep	1063	2.6%	C. Rica	192	0.2%	Germany	278	2.0%	Neth.	786	3.8%
Ghana	6060	2.2%	Ghana	796	2.0%	Neth.	176	0.2%	Thailand	144	1.1%	Germany	769	3.7%
Dom Rep	3781	1.4%	S.Africa	453	1.1%	Germany	123	0.2%	S.Africa	120	0.9%	Dom Rep	198	1.0%
Germany	2046	0.8%	France	450	1.1%	Dom Rep	74	0.1%	Ghana	75	0.5%	Thailand	190	0.9%
Guinea	1648	0.6%	Thailand	58	0.1%	S.Africa	36	0.0%	Honduras	26	0.2%	Honduras	14	0.1%
Other	5321	2.0%	Other	240	0.6%	Other	1131	1.4%	Other	451	3.3%	Other	548	2.6%
Total	270601	100.0%	Total	40529	100.0%	Total	80162	100.0%	Total	13684	100.0%	Total	20749	100.0%

Source: EC Commission

EC IMPORTS OF PINEAPPLES
1990, METRIC TONS



SHARE TOTAL EC IMPORTS OF PINEAPPLES
1990, BASED ON WEIGHT



Mango - United States Market Survey

World production: World production of mangoes stood at 15,100 million kg in 1989, up from 13,100 million kg in 1979 and up slightly from 1988. India accounted for 63% of world production in 1989. Other primary producers (with corresponding production shares) included Mexico (5%), Pakistan (5%), China (3%), Indonesia (3%), Brazil (3%), the Philippines (2%), and Haiti (2%). The Food and Agricultural Organization of the United Nations reports an additional 57 countries with production over 1 million kg.

United States production: United States production is primarily centered in Florida, where 1989 production was 10 million kg, up from 8.75 million kg in 1988, but considerably less than 1987 production of 13.75 million kg. The area under production has steadily increased from 720 ha in 1980 to 1,200 ha in 1989.

Imports - historical: United States imports of mangoes reached 59 million kg (US$58.2 million) in 1990, a 206% increase over 1981 levels, and up nearly 13% over 1989 imports. (Imports to the US must be certified as grown in medfly-free zones or treated according to USDA/APHIS regulations.)

Market share: In 1990, Mexico was the primary source of imported mangoes, with a 86.3% import share (50.9 million kg). Haiti was the second largest supplier to the US market with just over 7.8 million kg in 1990 (or 13.2% import share). All other suppliers had less than a 1% import share and included Brazil (168,000 kg), the Dominican Republic (40,000 kg), and Grenada (20,000 kg). Mexico and Haiti have dominated the market since at least 1983.

Monthly supply: Mango supply is very seasonal in nature. Peak months for imports are May through July, April, and August to a lesser extent. Although Haitian supply is much lower than Mexico's, Haiti is the only supplier to have shipped mangoes to the US for every month during the period January 1990 to March 1991. Haitian mangoes dominate the market in the off-season, especially from October to January. Brazil and Peru also ship in off-season months. Imports to the U.S. must be certified as grown in medfly-free zones or treated according to USDA/APHIS regulations.

The vast majority of US production enters the market from June through August.

Wholesale prices: Weekly wholesale prices for fresh mangoes, as reported by USDA's Market News Service offices in Miami and Los Angeles, were reviewed for calendar year 1990. Haitian mangoes fetched up to $20/carton (10-12s) during the off-season in Los Angeles. Haiti did not supply to this market when Mexican imports began in early March. Prices in Los Angeles for a carton (10-12s) of Mexican mangoes ranged from $4.00 to $14.00 in 1990, although the average price was in the range $5–8 per carton. Brazil made shipments of mangoes to Los Angeles in the last 2 weeks of 1990, with prices ranging from $13 to $22 per carton.

In Miami, where most Haitian mangoes enter the country, wholesale market prices for a carton (10-14s) ranged from $8–14 off-season, to $5–12 in-season. Floridian mangoes (Keitt, Kent, Tommy Atkins and Haden) were sold on the wholesale market from late May through early September, where they fetched a premium price of between $19 and $32 per carton (9-14s). The average price was in the $19–20 per carton range. Prices for Floridian mangoes were significantly greater in 1990 than in 1989, when prices ranged from $5 to $9 per cartoon.

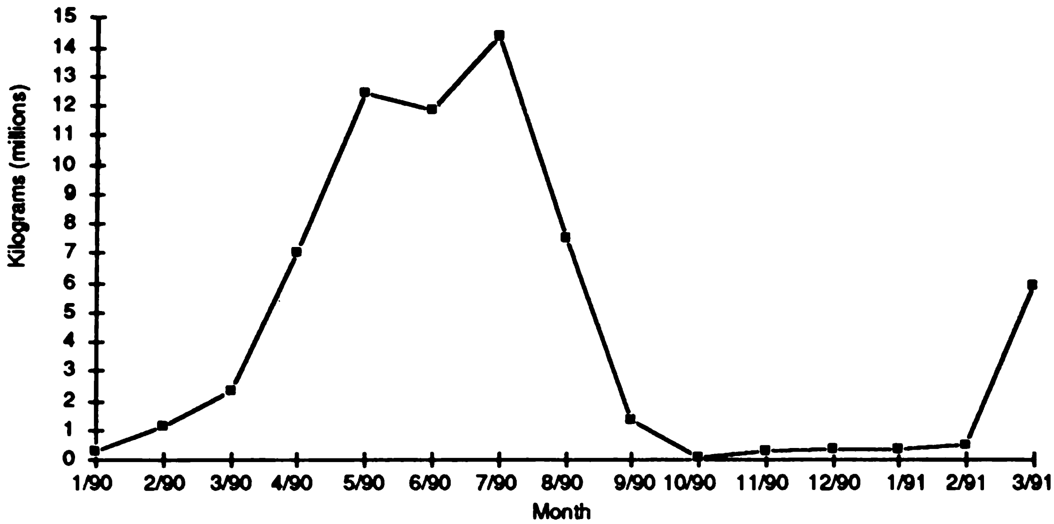
Market preference: Eastern Caribbean mango varieties which have a market in the US include Julie, Graham, Grenada and Peach. Julie Mangoes are targeted towards the ethnic market, while the other varieties are marketed to both the ethnic and non-ethnic consumers. Mango appearance should be clean, free from blemishes and other defects, uniform in size and ripeness, peel color of mainly red with yellow and green, and pulp color yellow-orange. Minimum size requirements for OECS export mangoes: Julie (250 g; 9 cm by 7.5 cm), Graham (350 g; 10 cm by 9 cm), Grenada (200 g; 8 cm by 7 cm), Peach (170 g; 7 cm by 6 cm).

U.S. Imports of Mangos, 1990 by month, kilograms

Country	1	2	3	4	5	6	7	8	9	10	11	12	Total
Mexico		624,305	1,287,557	5,262,170	10,492,034	10,934,810	13,533,174	7,439,601	1,333,506	15,120			50,922,277
Haiti	268,686	486,262	998,737	1,763,280	1,938,198	957,067	819,278	92,018	3,337	30,768	278,934	173,922	7,809,487
Dom Rep			5,870		4,610	8,970	9,280	3,500	7,967				40,197
Brazil												167,980	167,950
Thailand				1,814	800								2,614
Phil.								3,084	1,769				4,853
Taiwan								2,096					2,096
Malaysia							5,443						5,443
H. Kong											9,818		9,818
Colombia								809					809
Bahamas							6,490						6,490
Grenada							8,879	5,000	5,660				19,539
Malta				15,455									15,455
TOTAL	268,686	1,109,567	2,292,164	7,042,719	12,435,642	11,900,847	14,382,744	7,546,108	1,352,239	45,888	288,752	341,872	59,007,228

Source: U.S. Census Bureau

U.S. MANGO IMPORTS — 1/90 THROUGHT 3/91
KILOGRAMS

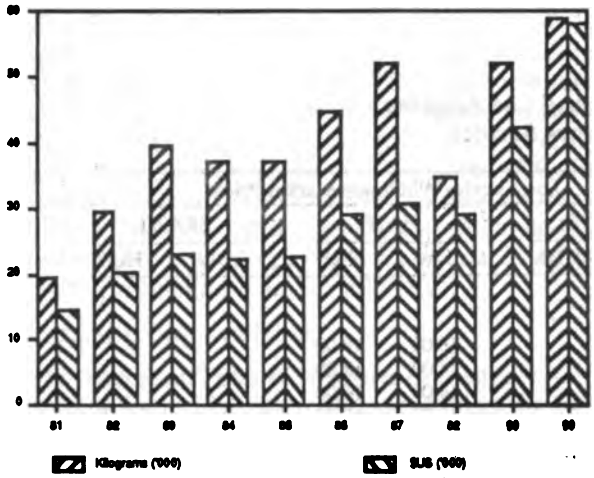


U.S. Mango Imports (1981-1990), in kilograms by country

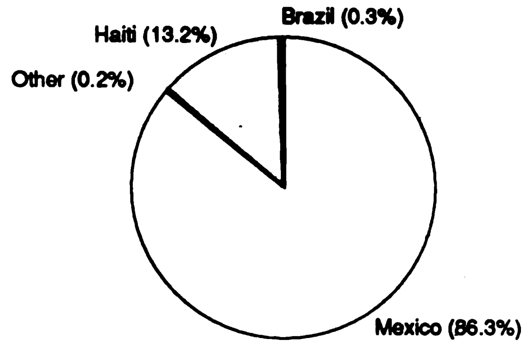
Country	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Mexico	14,846,701	24,426,796	32,431,722	28,637,162	28,538,412	36,761,066	42,703,130	27,225,420	43,922,533	50,922,277
Haiti	4,312,465	4,858,527	6,207,291	7,438,995	7,869,010	7,396,380	8,798,096	7,313,898	8,339,988	7,809,487
Dominican Rep	78,174	70,524	161,515	215,072		19,455	28,331	26,937		40,197
Chile	227									
Brazil	30,387	19,355	31,546	181,733	218,605	186,256	11,865			167,950
India	1,022	1,316	6,419	4,463	6,524	1,801	4,890	2,757	1,932	
Thailand	178	1,455	3,620	3,887	2,780	682	1,045	17,520	3,992	2,614
Philippines	1,291	23,227	31,702	1,529	227	8,880	1,084	30,686		4,853
Taiwan	625	1,430	2,429			4,299				2,096
Jamaica	965	35,894	12,352	6,591				46,273		
Costa Rica	5,680							3,904		
Malaysia		3,303								5,443
Hong Kong		245			450					9,818
Canada		12,209	27,145	24,058	15,505		14,036	33,591		
Montserrat		1,818								
Belize			664,972	440,141		242,914	252,806			
Honduras			10,909							
Colombia			3	175,292					1,300	809
Venezuela			90,156	2,545	6,000		164,185			
Indonesia			88							
Guatemala				5,272	261,253	107,096	6,545	9,797	3,137	
Peru				23,871			108,483			
Australia				220						
St. Lucia				1,236						
Trinidad				2,455						
Bahamas					7,159					6,690
France					16,048		10,200			
Dominica						18,441				
New Zealand						18,316				
Grenada								6,720		19,539
U.K.								824		
Malta										15,455
Total	19,277,715	29,456,099	39,681,869	37,164,522	36,941,973	44,765,586	52,104,697	34,718,327	52,272,882	59,007,228

Source: U.S. Census Bureau

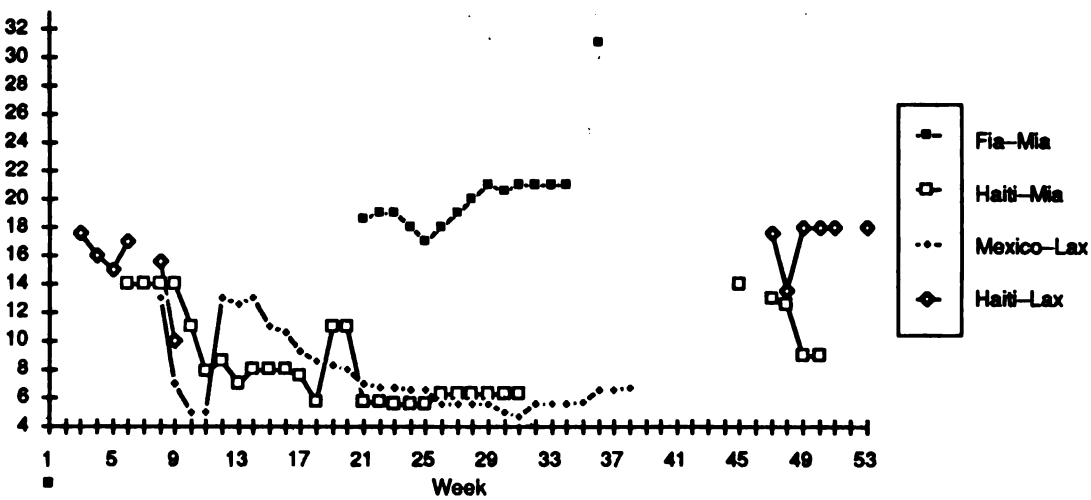
U.S. MANGO IMPORTS (1981 – 1990)



1990 U.S. IMPORT SHARE — MANGOES



MIA/LAX TERMINAL MARKET PRICES —1990
AVERAGE PRICE PER CARTON (9–14s)



1990 Terminal Market Prices for Mangoes - Miami and Los Angeles
US$ per Carton, 8s-14s — Source USDA Market News Service

	Miami Wholesale Market Prices				Los Angeles Wholesale Market Prices					
Source	FLORIDA(1)		HAITI(2)		MEXICO		HAITI		BRAZIL	
Date	Low	High	Low	High	Low	High	Low	High	Low	High
1/2										
1/8										
1/16							16.00	19.00		
1/22							14.00	18.00		
1/29							14.00	16.00		
2/5				14.00			16.00	18.00		
2/12				14.00						
2/20				14.00		13.00	14.00	17.00		
2/26				14.00	6.00	8.00	8.00	12.00		
3/5			10.00	12.00	4.00	6.00				
3/12			7.75	8.00	4.00	5.50				
3/19			7.00	8.00	12.00	14.00				
3/26				7.00	12.00	13.00				
4/2				8.00	12.00	14.00				
4/9				8.00	10.00	12.00				
4/16				8.00	10.00	11.00				
4/23			7.00	8.00	8.00	10.50				
4/30			5.50	6.00	7.50	9.50				
5/7			10.00	12.00	7.50	9.00				
5/12			10.00	12.00	7.00	9.00				
5/21	18.00	19.00	5.50	6.00	6.50	7.50				
5.29	18.00	20.00	5.50	6.00	6.00	7.50				
6/4	18.00	20.00	5.00	6.00	5.50	8.00				
6/11	16.00	20.00	5.00	6.00	5.50	7.50				
6/18	16.00	18.00	5.00	6.00	5.50	7.50				
6/25	16.00	20.00	6.00	6.50	5.00	6.00				
7/2	18.00	20.00	6.00	6.50	5.00	6.00				
7/9		20.00	6.00	6.50	5.00	6.00				
7/16	20.00	22.00	6.00	6.50	5.00	6.00				
7/23	20.00	21.00	6.00	6.50	4.00	6.00				
7/30	20.00	22.00	6.00	6.50	4.00	5.50				
8/6	20.00	22.00			5.00	6.00				
8/13	20.00	22.00			5.00	6.00				
8/20	20.00	22.00			5.00	6.00				
8/27					5.50	6.00				
9/4	30.00	32.00			6.00	7.00				
9/10					6.00	7.00				
9/17					6.50	7.00				
9/24										
10/1										
10/9										
10/15										
10/22										
10/29										
11/5				14.00						
11/13										
11/19			12.00	14.00			15.00	20.00		
11/26			12.00	13.00			13.00	14.00		
12/3			8.00	10.00				18.00		
12/10			8.00	10.00				18.00		
12/17								18.00		
12/24									20.00	22.00
12/31								18.00	13.00	18.00

Mango - European Market Survey

World production: World production of mangoes stood at 15,100 milliom kg in 1989, up from 13,100 million kg in 1979 and up slightly from 1988. India accounted for 63% of world production in 1989. Other primary producers (with corresponding production shares) included Mexico (5%), Pakistan (5%), China (3%), Indonesia (3%), Brazil (3%), the Philippines (2%), and Haiti (2%). The Food and Agricultural Organization of the United Nations reports an additional 57 countries with production over 1 million kg.

EC production: Not available.

Imports - historical: Total EC imports of mangoes were 38.5 million kg in 1990, more than four times the 1980 import level. In value terms, EC imports have increased nearly 371% over the period, reaching 58.0 million ECUs.

The United Kingdom imported 27% of all mangoes entering the EC market. Other major importers, and their respective percentages of total EC imports, include: the Netherlands (24%), France (21%), Germany (16%), and Belgium/Luxembourg (5%). All other EC countries imported under 1 million kg.

German imports stood at 6.4 million kg in 1990, a 557% increase over 1980 figures. French imports in 1990 were 8.3 million kg (up 262% from 1980). Dutch imports surged upwards by 462% to just over 9.3 million kg, while U.K. imports increased 217% to 10.4 million kg.

Market share: The United States was the largest supplier to the EC market in 1990, with 6.7 million kg. Other major suppliers to the EC included the Netherlands (4.7 million kg of re-exports), Brazil (4.3 million kg), Venezuela (2.9 million kg), and Mexico (2.2 million kg). These five suppliers accounted for over 54% of total EC mango imports. Other significant EC sources of mangoes (over 1 million kg) included South Africa, Pakistan, Peru, Mali, Israel, and Burkina Faso.

German imports came primarily from the Netherlands in 1990, with a 44.5% market share. Other significant suppliers included Costa Rica (with 11.3% of the German market), Brazil (7.8%), and the United States (5.4%).

Mexico was the primary source for French imports (13.1% 1990 import share). Other suppliers included Brazil (11.9%), Burkina Faso (11.0%), the Netherlands (10.1%), South Africa (9.6%), Mali (7.8%), and Cote d'Ivoire (7.7%).

Dutch imports were sourced primarily from the United States (39.1%) in 1990, with significant quantities from the Brazil (18.3%), Peru (7.3%), and Mexico (4.3%).

The top four UK sources of mangoes in 1990, which combined accounted for 60% of total imports, were the US (21.3%), Venezuela (17.7%), Pakistan (13.2%), and India (7.8%).

Intra-EC trade of mango was 6.9 million kg in 1990 (or 18% of total EC mango trade). Because the EC does not produce mangoes itself, the intra-regional trade can be assumed to be re-exports. The Dutch re-exported the largest amount of mangoes to fellow EC member states (over 50% of total Dutch imports). In the four top markets, Germany imported 51% of its mangoes from EC countries, while France and the Netherlands imported 12 and 11%, respectively, of their mangoes from other EC nations. The UK imported less than 5% of its mangoes from other EC nations.

Wholesale prices: 1990 UK prices at New Covent Garden ranged from £1.20/kg to £2.67/kg. Average prices were in the £1.30/kg to £1.50 range in-season (May through August). For the off-season (September through April) average prices generally ranged from £1.60/kg to £2.10/kg. Covent Garden reported on mangoes sourced from Brazil, Peru, Venezuela, the US, India, Mexico, Puerto Rico, Israel, and Kenya over the period.

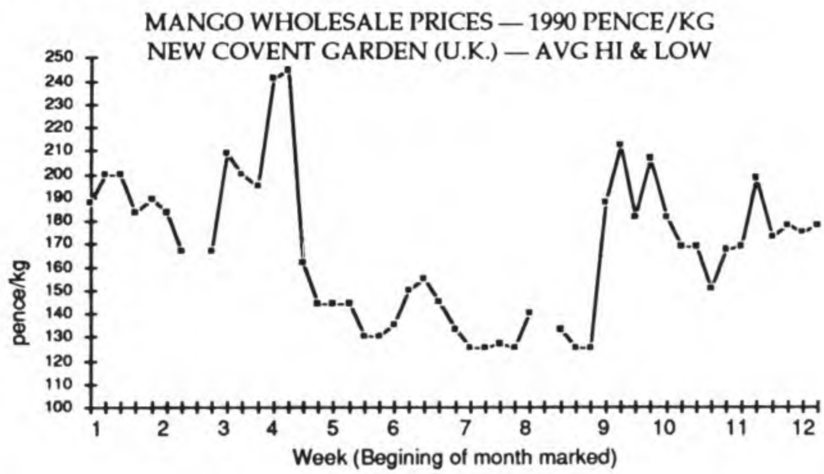
Using value and quantity import data supplied by the European Community, the Netherlands ranked the lowest of the top four EC markets in terms of value per kg (ECU1.38/kg). France has the highest import value (ECU1.63/kg), followed by Germany (ECU1.54/kg) and the UK (ECU1.46/kg).

Market preference: Eastern Caribbean mango varieties which have a market in the EC include Julie, Graham, Grenada and Peach. Julie Mangoes are targeted towards the ethnic market, while the other varieties are marketed to both the ethnic and non-ethnic consumers. Mango appearance should be clean, free from blemishes and other defects, uniform in size and ripeness, peel color of mainly red with yellow and green, and pulp color yellow-orange. Minimum size requirements for OECS export mangoes: Julie (250 g; 9 cm by 7.5 cm), Graham (350 g; 10 cm by 9 cm), Grenada (200 g; 8 cm by 7 cm), Peach (170 g; 7 cm by 6 cm).

Mango Wholesale Prices - New Covent Garden (U.K.) 1990 Pence/kg

	Week	Low	High	Source		Week	Low	High	Source
Jan	1	175	200	Bzl-Peru	Jul	26	120	130	Venez
	2	200	200	Peru		27	120	130	Venez
	3	200	200	Peru		28	120	133	India-Venez
	4	178	189	Peru		29	120	130	Mexico
	5	178	200	Peru		30	140	140	Mexico
Feb	6	178	189	Peru	Aug	31			
	7	133	200	Bzl-Peru		32	133	133	India
	8					33	120	130	Mexico
	9	156	178	Brazil		34	120	130	P. Rico
Mar	10	178	240	Bzl-Venez	Sep	35	175	200	Israel-PR
	11	200	200	Venez		36	200	225	Israel
	12	190	200	Venez		37	175	188	Israel
Apr	13	222	260	Bzl-Venez		38	200	213	Israel
	14	222	267	Brazil	Oct	39	175	188	Israel
	15	156	167	Brazil		40	163	175	Brazil
	16	133	156	Brazil		41	163	175	Israel
May	17	133	156	Peru		42	138	163	Israel
	18	144	144	Peru		43	150	175	Isr-Kenya
	19	120	140	Venez	Nov	44	163	175	Kenya
	20	130	130	Venez		45	175	222	Bzl-Kenya
	21	130	140	Venez		46	167	178	Bzl-Kenya
Jun	22	150	150	USA		47	167	189	Brazil
	23	150	160	USA	Dec	48	175	175	Kenya
	24	140	150	Venez		49	178	178	Brazil
	25	133	133	Brazil					

Source: New Covent Garden, U.K.



European Community Imports of mangoes (1980-1990), Value (1,000 ECUs) & Quantity (1,000 kgs)

	1980	1985	1986	1987	1988	1989	1990
ECU (1000)							
Total EC	12325	35978	40387	44868	52267	55689	58048
Germany	1404	4320	5819	7215	8388	8903	9787
France	2997	9575	10100	10442	12761	14150	13418
Nethlands	1835	5142	6875	7095	9501	10253	12908
U.K.	4992	13489	13799	14741	15370	15714	15203
MTs							
Total EC	8910	17160	24247	28011	31552	36766	38546
Germany	968	1745	3083	4227	4834	5507	6358
France	2281	5044	6171	6330	7171	8889	8252
Nethlands	1660	2544	4441	4954	6061	7466	9323
U.K.	3293	6463	8831	9622	10141	10929	10440

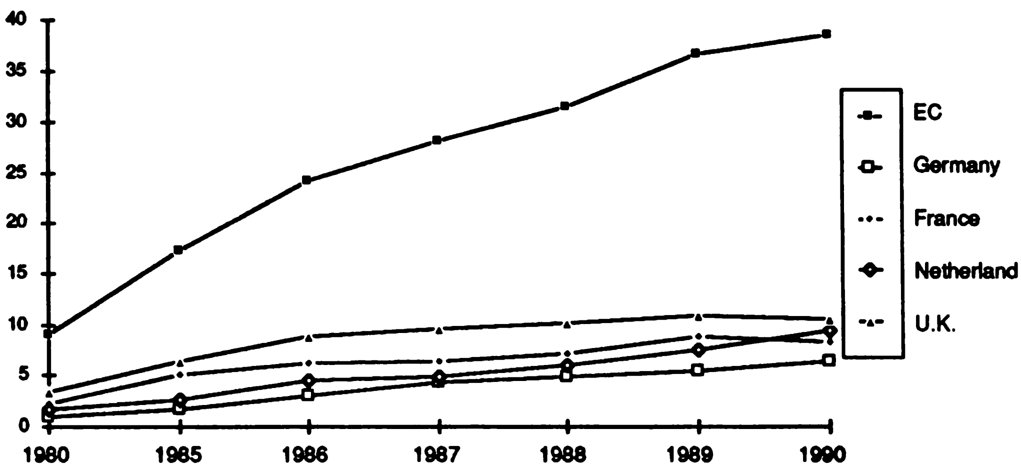
Source: EC Commission

1990 EC Imports of Mangoes, Top 15 Sources in 1,000 kgs, Total EC and Selected Markets

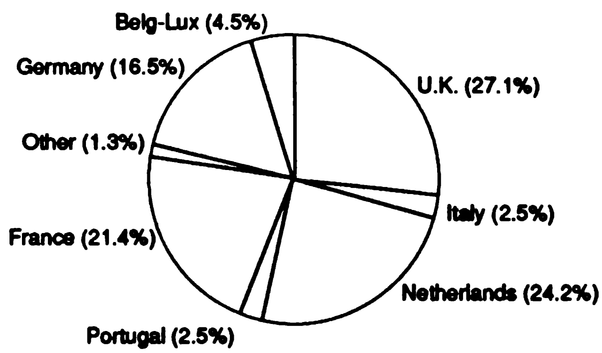
Total EC			Germany			France			Nethlands			U.K.		
Source	Imports	Share	Source	Imports	Share	Source	Imports	Share	Source	Imports	Share	Source	Imports	Share
U.S.A.	6745	17.5%	Neth.	2829	44.5%	Mexico	1081	13.1%	U.S.A.	3647	39.1%	U.S.A.	2219	21.3%
Neth.	4741	12.3%	C. Rica	716	11.3%	Brazil	978	11.9%	Brazil	1703	18.3%	Venez	1848	17.7%
Brazil	4346	11.3%	Brazil	499	7.8%	B. Faso	908	11.0%	Peru	683	7.3%	Pakistan	1377	13.2%
Venez	2943	7.6%	U.S.A.	346	5.4%	Neth.	834	10.1%	Mexico	402	4.3%	India	809	7.7%
Mexico	2207	5.7%	S. Africa	340	5.3%	S. Africa	793	9.6%	Belg/Lux	393	4.2%	Brazil	513	4.9%
S. Africa	1710	4.4%	Kenya	306	4.8%	Mali	644	7.8%	France	342	3.7%	Jamaica	458	4.4%
Pakistan	1513	3.9%	Belg/Lux	261	4.1%	Ivory C.	638	7.7%	Mali	335	3.6%	Mexico	433	4.1%
Peru	1496	3.9%	Israel	234	3.7%	Israel	553	6.7%	Venez	313	3.4%	Namibia	314	3.0%
Mali	1179	3.1%	Venez	139	2.2%	Peru	439	5.3%	Namibia	228	2.4%	Neth.	303	2.9%
Israel	1171	3.0%	Mexico	132	2.1%	U.S.A.	386	4.7%	S. Africa	227	2.4%	Kenya	302	2.9%
B. Faso	1014	2.6%	Ivory C.	132	2.1%	Guinea	147	1.8%	U.K.	161	1.7%	St. Lucia	299	2.9%
C. Rica	982	2.5%	France	125	2.0%	Belg/Lux	145	1.8%	Kenya	137	1.5%	Peru	279	2.7%
Belg/Lux	913	2.4%	Thailand	66	1.0%	Kenya	138	1.7%	Israel	75	0.8%	Gambia	248	2.4%
Kenya	904	2.3%	Colombia	54	0.8%	Venez	65	0.8%	C. Rica	68	0.7%	Mali	179	1.7%
Ivory C.	902	2.3%	Pakistan	47	0.7%	Indonesia	64	0.8%	B. Faso	67	0.7%	Grenada	141	1.4%
Other	5780	15.0%	Other	132	2.1%	Other	439	5.3%	Other	542	5.8%	Other	718	6.9%
Total	38546	100.0%	Total	6358	100.0%	Total	8252	100.0%	Total	9323	100.0%	Total	10440	100.0

Source: EC Commission

EC IMPORTS OF MANGOES
1990, 1000 MT



SHARE OF TOTAL EC IMPORTS OF MANGOES
1990 (BASED ON WEIGHT)



Reciprocal Horizontal Cooperation for Fruit Tree Crop Production/ Marketing Development in the Caribbean

ANTONIO M PINCHINAT
IICA, St Lucia

INTRODUCTION

The countries which form the Organization of Eastern Caribbean States (OECS) have jointly embarked on diversification of their agricultural sector. To underline their commitment they have set up an Agricultural Diversification Coordinating Unit (ADCU) under the institutional umbrella of the Economic Affairs Secretariat (EAS), within the purview of the OECS Central Secretariat General. The diversification drive is particularly focused now on joint marketing of non-traditional crop commodities. Basically the purpose is to lessen export dependency on traditional plantation crops such as banana, coconut, cocoa, nutmeg, in the Windward Islands, or sea island cotton and sugar cane, in the Leeward Islands. Other Caribbean countries have also embraced similar agricultural diversification policies.

Farmers are encouraged by Governments to venture into the production/marketing of hitherto subsistence crops which they have grown before or others which are new to their farming systems.

This undertaking, while exciting, poses new professional challenges for technologists (especially agronomists/researchers and extension officers) and breeds technical and managerial difficulties for farmers. For each new commerce-led crop commodity, a desired germplasm (species/cultivar) has to be grown, and market standards have to be maintained.

Professionals assigned to transferring technologies to farmers have to be informed about and trained in the handling of the new or newly commercialized crops. Valid production/marketing technologies have to be on hand for demonstration and transfer to the diversified farmers. Researchers have to borrow, adapt or generate relevant technologies to feed this process.

To be able to address those needs adequately the technology development and transfer system (TDTS) operating in each country must expand and strengthen its work agenda. Yet the required human, financial, physical, and informational resources for that purpose are minimal in small economy-scale countries as found in the Caribbean. Besides diversification of agriculture, other national issues also require the same or higher level of attention by governments. Competition therefore arises among the corresponding public sector institutions, pitching the Ministry of Agriculture for example against other ministries and state-funded structures.

This depicts the scenario that has been termed 'The small country dilemma', in setting agricultural research policy (Trigo 1988). International cooperation in agricultural research/development (R/D) has been proposed as a strategic approach to address the issue (Gamble and Trigo 1985). It has proved highly efficient and effective where applied to strengthen technology generation and transfer.

I. Networking

One form of international cooperation that has shown remarkable success among economically small countries is networking. It basically involves information-sharing and undertaking of joint activities in research/development (R/D).

Disciplinary research networks have been established through the International Agricultural Research Centers (IARCs) of the Consultative Group for International Agricultural Research (CGIAR), comparable commodity-focused R/D institutions such as the Asian Vegetable Research and Development Center (AVRDC), or Research/Training (R/T) institutions such as the Tropical Agriculture Research and Training Centre (CATIE) in Costa Rica. Usually they operate informally. The extent of country participation and decision-making is determined essentially by the involved professionals themselves. The Central American Cooperative Programme for the Improvement of Food Crops (PCCMCA) is a classic example of such networks.

Another model of networking entails more operational complexity, elaborate work programing and firm institutional commitments than the first. Typically the network in this class deals with disciplinary research, technology generation and communication as a set. It is based on a formal agreement among the cooperating parties, setting specified conditions and responsibilities of participation and funding. It operates through a program steering committee and is serviced by a secretariat managed by an external executing institution. International, regional or bilateral entities provide technical or financial support to network activities, stipulated in the cooperation agreement.

For over more than a decade to date, IICA has been serving as secretariat of several networks which fall into that second model. They have been established in Central (including Mexico and Dominican Republic), Andean, and South America (IICA 1991). Amongst the oldest, most successful and most firmly institutionalized the following stand out:

> The Cooperative Program for the Development of Agricultural Technology in the Southern Cone (PROCISUR), on forage, beef cattle, dairy cattle, wheat, corn, rice, soya bean, other oil seeds and weed management

- The Cooperative Agricultural Research Programme for the Andean Subregion (PROCIANDINO), on pulses, corn, potatoes, edible oil seeds, soil management and conservation, dual-purpose cattle, Andean Highland livestock and crops
- The Regional Cooperative Program for the Protection and Modernization of Coffee Cultivation in Mexico, Central America, Panama and the Dominican Republic (PROMECAFE), on coffee
- The Research Network on Animal Production Systems in Latin America (RISPAL), on livestock
- The Regional Network for Cocoa Technology Generation and Transfer (PROCACAO), on cacao

II. Current OECS R/D Networks for Agricultural Diversification

In the OECS there are two regional R/D networks, which represent an intermediate phase between the first group (informal, researcher-controlled) and the second (formal, institution-controlled). One is the OECS Regional Food Crops Development Projects Network (FCN), originally organized in 1989 in St. Lucia as the Yam Development Projects Network (YPN). The other is the OECS Regional Vegetable Development Projects Network (VPN) established in 1990, in Antigua.

Although they are distinct in thematic agenda, both aim at facilitating and supporting the technological modernization of agricultural diversification in the region. For that and other practical reasons, activities which are of common interest to the networks are combined. Such an arrangement includes the joint holding of general food and vegetable crop development review meetings periodically, e.g. every 3 years, and training.

2.1 Organization and Management

The two networks share a structural organization that requires the following four components.

2.1.1 Institutional Base

The base is formally provided by the Ministry of Agriculture (MoA), represented by the Network Coordinator. Currently for FCN it is ensured by the MoA in St. Lucia and for VPN, by the MoA in Grenada.

The Network Coordinator is chosen from among the participating MoA Project Leaders and authorization to discharge the duties of Coordinator is officially granted by the competent authority at the institutional base. This implies that each Project Leader is mandated by the corresponding MoA to commit institutional responsibility in the operations of the network.

2.1.2 Lead Technical Assistance Institution

The Lead Technical Institution guides and advises the technical programme of the network and co-opts additional technical support to network activities from other relevant and competent R/D and training institutions. FCN is technically led by the representative of the National Agronomic Research Institute-Antilles/Guyane (INRA-AG), in Guadeloupe and the VPN, by the representative of the Tropical Agronomic and Horticultural Research Institute (IRAT/CIRAD) in Martinique.

They are joined by specialists from the Caribbean Agricultural Research and Development Institute (CARDI), the University of the West Indies (UWI), the Technical Agricultural Mission of the Republic of China/Taiwan (ROC) and the French Agency for Cooperation (FAC). They also access the cooperation of other R/D institutions from within or outside the Caribbean.

2.1.3 Institutional Secretariat

This structure facilitates communication among participants (institutions/professionals) of the network and provides logistic and usual secretarial support to network activities. For both FCN and VPN, IICA temporarily serves as Institutional Secretariat (based at the IICA office in Grenada), through its Program on Technology Generation and Transfer.

2.1.4 Core Funding Institutions

Through the Secretariat and respective Lead Technical Institutions, funds are accessed from several sources to cover the costs of core network activities (Annex 1).

Both FCN and VPN receive their core budget from the represented MoAs. External financial support has been provided by ADCU, FAC, and IICA. Other institutions such as CARDI, UWI and ROC have also made financial contributions, mostly in kind.

2.2 Operation

A key distinctive feature of the networks is that they operate around specific crop/development projects, each under a specific Project Leader, assigned by the corresponding Ministry of Agriculture. This means that the MoAs may not be participating equally or all the time in all projects covered by the network. Furthermore, project mix in a network varies over time.

To strengthen operational management of intra-commodity network activities, a Commodity Team Leader is chosen from among the Project Leaders for a given commodity. For example in the FCN the MoA Project Leader from St Lucia covers yam and in the VPN, the MoA Project Leader from Antigua and Barbuda covers onion.

Similarly, a specific resource R/D institution assumes technical leadership for a particular crop commodity in each network.

2.3 Results

Proceedings of meetings, communications from Coordinators as well as Project Leaders and other documents available at the Secretariat attest to the satisfactory level of success achieved by this mode of networking in a very short time.

The most eloquent indicator of institutionalization of the networks has been the sustained and enthusiastic participation of Project Leaders and external cooperating entities in the implementation of current and planning of future activities of FCN and VPN. Continued internal and external financial support to both underscores this assessment.

III. The Case for Networking in Fruit Tree Crops R/D

Fruit tree crops, generally categorized as traditional, e.g. citrus, mango, avocado, non-traditional, e.g. passion fruit, papaya, golden apple, or exotic, e.g. carambola and the like, make up one of the groups of commodities which have received greatest attention and highest priorities in the diversification agenda of the MoAs in the OECS and other Caribbean countries. Their major attraction is their real or expected potential for export and small-scale agroindustry for local markets.

This has prompted a set of efforts concerted among relevant institutions in the region to materialize the potential, as follows:

- Several MoAs have reactivated and expanded their technology generation and transfer (TGT) programs on fruit tree crops.
- The ADCU has been assigned the responsibility for undertaking the Tropical Produce Support (TROPRO) Project, funded by the United States Agency for International Development (USAID).
- CARDI has assumed the administration of TROPRO and organized technical support to fruit tree crop R/D through its own professional staff and consultants.
- IICA in association with the Government of France cooperates with ADCU and CARDI in providing training and advisory assistance to MoA fruit tree crop programs and projects in the Caribbean. It also co-opts other agencies such as the Fruit Research Institute (IRFA) in Guadeloupe to access technologies developed outside but relevant to the region.

On the other hand, an International Citrus Network (IACNET) was launched in April 1991 in a meeting sponsored by FAO's Regional Office in Chile (FAO 1991). It comprises a Technical Subgroup to be coordinated by the United States of America and an Economic Subgroup to be coordinated by Brazil. The role of the Caribbean countries in IACNET is not specified. They could link with it though, as regional rather than individual partners, to achieve the most meaningful, strongest representation.

Considering the economies of scales that have been achieved through current R/D networking efforts to spur technological modernization of agricultural diversification in this region, the representatives of the MoAs in this workshop may wish to consider the convenience and timeliness of setting up a Fruit Crop Development Projects Network similar to the FCN or VPN. The new network would especially emphasize those fruit crops in which the region has an advantageous edge for production/marketing and greatest technological needs.

If requested, IICA would be willing to support such an endeavor through its Program on Technology Generation and Transfer, in cooperation with all other interested institutions as deemed relevant by the MoA Fruit Tree Crops Project Leaders in the participating Caribbean countries.

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ANNEX 1: OECS Commodity Development Projects Network Basic Work Programme

Main activities	Responsible party	Main activities	Responsible party
Technical Advisory Missions to the Countries	INRA-AG, IRAT/CIRAD, CARDI, IRFA	Diffusion of information (newsletter)	
Technical Meetings Project evaluation/planning General commodity development overview meeting	Network Coordinator	Technical assistance to formulation of network projects for external funding	
Secretarial Support Production/reproduction/ mailing of proceedings of meetings Acquisition/reproduction/distribution of technological information Intra-network communication support (newsletter, correspondence, fax/ telephone calls) Organization of meeting(s)	IICA	Distribution of Inputs for Regional Screening/Adaptation/Validation/ Demonstration of Technologies (Experimental Seeds, Chemicals, Small Tools, Software)	IRAT-AG, CIRAD, CARDI
		Training National Regional In-center/campus (Martinique, Guadeloupe, Trinidad)	 Local Project Leader Network Coordinator IRAT/CIRAD, CARDI, INRA-AG, UWI, IICA

SECTION 3

CONCLUSION FROM WORKING GROUPS

Papaya Group Report

Participating countries: Antigua, Grenada, St. Kitts/Nevis, Tortola, Barbados, Suriname, Dominica, French West Indies and Jamaica.

Institutions represented: IICA, CARDI, IRFA, MoAs, PCV, and farmers

Group leader: Rafael Marte

Group reporter: Joseph Kim

I. Country Status

Priority: Papaya is not a regional priority but it is a priority in Barbados, Jamaica, St. Kitts/Nevis, Tobago, Grenada, and the islands serviced by IRFA. In some other countries, some efforts are being given to promote papaya for the near future: Suriname, Antigua, and Trinidad & Tobago.

Regional Projects:

Jamaica:
- shipping by sea project
- utilization of papaya proposal
- collaboration with technical advisors from outside
- training implemented
- 600 ha development project

St. Kitts/Nevis:
- ROC, Deptartment. of Agriculture, and CARDI pilot project focusing on evaluation of current production and cultural practices.

Barbados:
- government funded Fruit Development Project includes papaya (mainly development with some research and evaluation); currently in transitional stage

Grenada:
- CARDI (fertilizer trial research), IICA (seed production), and MoA collaboration; an interdisciplinary approach
- CARDI, IICA, and MoA has done estimates on cost of production but more work is being done to achieve greater accuracy.
- CARDI *Erwinia* study in the pipeline

Antigua:
- CARDI, MoA, and IICA pilot project evaluation
- People's Republic of China project evaluation

Guadeloupe:
- *Erwinia* project (identifying tolerant strains)

Suriname:
- research on cultivation aspects on papaya on heavy clay soils of the young Coastal Plain with emphasis on agrohydrological aspects in relation to fertilizing and liming (MoA)
- Processing project ceased

Dominica:
- post-harvest project on pipeline

Projects outside the region:
- University of Florida (CBI) project on bunchy top, mainly with Puerto Rico but intend to expand to rest of the Caribbean.
- University of Provence, France: work on *Erwinia*
- University of London: work on somatic embryogenesis research

Studies carried out:
- Barbados, as well as Grenada, updating cost of production figures done in the 1980s.
- St. Kitts/Nevis did study on height, size, number of fruits and brix before the onset of *Erwinia*. Work being done now on cultural practices and data collection.
- Jamaica did cost of production (JAMPRO/MoA) and this is being updated periodically.
- Antigua has some rough cost of production figures.
- Grenada (CARDI) did assessment of production systems survey.
- Barbados did case study of production and will do survey on acreage planted. Michael Phillips (MoA) is doing a viral interaction study.

Country	Production area (ha) Current	Goal	Average yield (kg/ha)	Total production (kg)
Jamaica	200	600	62,000	12,400,000
Grenada	2.5	5	30,000	75,000
St. Kitts/Nevis	0.6			
Barbados	1.2		80,000	96,000
Suriname	4.5			
Antigua	2	4	30,000	60,000
Tobago	8			
Belize	60			
French Guyana				

Cultivars and main markets

Country	Cultivars	Markets
Jamaica	Sunrise, Kapoho, Local	US, UK
Grenada	Barbados Yellow, Barbados Pink	Local, UK, Holland
Barbados	Barbados Yellow, Barbados Pink	Local
St.Kitts/Nevis	Tainung No 2, Solomon, Sunrise	Local
Suriname	Victoria, Santo Puna (local processing)	Local
Antigua	Sunrise, Barbados Yellow Barbados Pink, Chinese	Local
Belize	Sunrise	Export
French Guyana		
Trinidad and Tobago	Known You, Tainung No1 Local	Local (processed & fresh)

II. Advantages

- shorter production cycle
- freight advantages (shorter distance and concessions)
- no Medfly except Suriname
- fruit fly-free status on Grenada, Antigua, Barbados, and Nevis
- preferential tariff

III. Main Constraints

Pre-production:

Propagation
- — lack of information and research concerning preservation of genetic strains over time
- — lack of resistant cultivars to *Erwinia*, bunchy top, DRS
- — lack of institutional structure
- — need of improvement program
  (a) tolerant lines
  (b) quality products
- — lack of training in non-traditional propagation techniques (tissue culture and anther culture at different stages)

Production:

Establishment
- — lack of information and training for farmers
- — inadequate research on plant density

Cultural practices
- — lack of farmer training
- — lack of research and information

Pests
- — mites (Barbados, Antigua, Suriname, Jamaica)
- — papaya fruit-fly (Trinidad & Tobago)
- — leaf hoppers
- — birds (due to lack of information, harvest is not timely)
- — monkeys (St. Kitts and Barbados)
- — predial larceny (all countries) due to lack of legislation and/or its enforcement; lack of consideration of socio-economic factors

Management
- — all countries recognize need for information and training
- — lack of realization that papaya is a high management crop

Cost
- — high cost of production
- — unavailability of appropriate technology/inputs
- — lack of comparative cost/benefit information

Harvesting:

Method — lack of information and training

Tools — lack of information disseminating medium

Indexing for maturity — lack of information and training

Labor cost/availability — lack of ergonomic study to increase efficiency

Post-harvest Handling:

Container — insufficient information and training

Transportation — lack of adequate farm roads in some countries

Pack-house operation — lack of personnel management; lack of design for small-scale operation; lack of information and research

Rejection — lack of information, equipment for small-scale operation and training

Equipment — lack of information

Shipping and Distribution:
- — high cost of shipping due to low volumes
- — lack of information and research

Processing:

Raw materials — limited supply; lack of research on new products

Marketing:

Demand — not able to meet quantity and quality demanded for fresh fruit
Channeling — lack of agents (such as CATCO), efficient marketing units
Competition
Supply — erratic supply
Price
Promotion — lack of promotion to sell what is produced

IV. Needs Assessment

Policy
- — Implementation and enforcement of legislation against predial larceny to increase awareness of the seriousness; socio-economic study of impact (being partially addressed in Grenada, Trinidad and Tobago, St. Kitts/Nevis,Barbados, and Jamaica)

  Responsible institutions: CARICOM MoAs, UWI could designate students to do theses on the problem as a framework for decision makers

  Specific task: Trinidad & Tobago delegates were recommended to contact the UWI

Training
- — Non-traditional propagation techniques (anther culture)

  Responsible institutions: IICA; IRFA

  Collaborating institution: CARDI

  Donor: IICA; IFC

  Status: available

  Weakness: MoAs need to specify candidates
- — Need for training in establishment

Responsible institutions: IICA; CARDI

Collaborating institutions: MoAs (Grenada, Antigua, Barbados, Jamaica, St. Kitts/Nevis) and ROC.

Donors: IICA; CARDI/AREP; ROC.

Status: available on request of users

Weakness: requests need to be made more specific by MoAs

Research and Development

— Development of improvement program for selections of high quality cultivars resistant to *Erwinia*, bunchy top, ring spot, and other diseases

Responsible institutions: IICA; INRA/IRFA; CARDI; MoA (Barbados); Galán (Spain); UK

Donors: EEC (STD-3); CIRAD

Specific task: group led by Dr. Marte will submit a proposal for STD-3

— Plant density research

Responsible institutions: CARDI; UWI

Collaborating institutions: IICA; MoAs

Donor: CARDI/AREP

Status: available partially

Weakness: need for future planning in order to be included in CARDI program

— Lack of availability of planting material

Responsible institutions: CARDI; some MoAs (Barbados)

Collaborating institution: IICA

Donors: USAID; CIDA

Specific task: group led by R. Andall (CARDI,Grenada) and comprising of L. Andrews (CARDI, St. Lucia), R. Marte (IICA, Trinidad and Tobago), S. Skeete (MoA, Barbados), C. Dick (Tobago House of Assembly, Division of Agriculture) will develop a proposal. Time frame will be by April 1992 for 2 days in Tobago.

— Research on cultural practices including control of *Erwinia* and use of fertilizer

Responsible institutions: CARDI; MoA (Grenada)

Collaborating institutions: IICA; IRFA

Status: on-going in Grenada and Jamaica

Weaknesses:
— does not cover all cultural practices
— need expansion to other countries

— Biological control for mites and general IPM

Responsible institution: UWI

Collaborating institutions: CME (Trinidad & Tobago); CARDI; University of Florida

Specific task: group led by Dr. G. Pollard (UWI) and comprising of L. Rhodes and J. Pena (University of Florida) was recommended to develop a proposal for biological control, IPM, mites, and other pests by April 1992

— Cost of production research

Responsible institution: CARDI (Grenada)

Collaborating institution: IICA (cost of production in other countries)

Specific task: R. Andall recommended to contact CARDI management to expand the cost of production study to other countries

— Tools

Responsible institution: CARIRI

— Methods

Responsible institutions: CATCO; CARDI/BDDC

Collaborating institutions: MoAs

Donor: BDBC

— Shipping and distribution

Responsible institutions: CATCO; CARICOM/ADCU

— Processing

Responsible institution: CARIRI

— Marketing

Responsible institutions: CATCO through CFC.

Pineapple Group Report

Group Leader: J. Ragoonath, Trinidad and Tobago

I. Country Status

Antigua

PRIORITIES:
Multiplication of planting material, training in management practices

PROJECTS:
Efforts concentrated on commercial production, rapid multiplication for planting material

PRODUCTION AREA:
40 ha

TOTAL PRODUCTION 1990:
680,00 kg

MAIN CULTIVARS:
Antigua Black; small amounts of Spanish (Red) variety

Barbados

PRIORITIES:
Identification of areas most suitable for pineapple production — soil characterization to increase acreage; training of farmers in management practices.

PROJECTS:
There is need for the above; no on going project

PRODUCTION AREA:
2.5 ha

TOTAL PRODUCTION 1990:
6,000 kg

MAIN CULTIVARS:
Antigua Black

British Virgin Islands

PRODUCTION AREA:
1.2 ha

Dominica

PRIORITIES:
Training in management of cultural practices; research into weed control

PRODUCTION AREA:
8 ha

MAIN CULTIVARS:
Antigua Black; Smooth Cayenne

Grenada

PRIORITIES:
Multiplication of planting material; training in management practices; organization of local marketing

PROJECTS:
No on going project

PRODUCTION AREA:
2 ha

TOTAL PRODUCTION:
13,600 kg

MAIN CULTIVARS:
Smooth Cayenne (Sugar Loaf); Local

Guadeloupe

PROJECTS:
No ongoing projects

PRODUCTION AREA:
200 ha

MAIN CULTIVARS:
Montserrat; Sugar Loaf; Smooth Cayenne

Guyana

PRIORITIES:
Better soil management; good farming system; training in post-harvest techniques

PROJECTS:
Supporting the development of tropical fruits for the Caribbean; FAO/Government of Guyana, improving the marketing system — intelligence and improving post-harvest techniques; tissue culture funded by UNDP.

PRODUCTION AREA:
520 ha

TOTAL PRODUCTION 1990:
9,700,000 kg

MAIN CULTIVARS:
Montserrat

Martinique

PRIORITIES:
Control of black rot disease; slip production; control of natural flowering; varying monoculture so as to avoid increase of pests and diseases; evaluation of fresh fruit; farming systems approach

PROJECTS:
Small farmer production system; varietal trial to screen symphylids attack

PRODUCTION AREA:
480 ha

TOTAL PRODUCTION 1990:
17,000,000 kg

MAIN CULTIVARS:
Smooth Cayenne

St. Kitts/Nevis

PRIORITIES:
Multiplication of planting material to increase acreage; varietal introduction and selection; training in management practices; research into weed control

PROJECTS:
Aid from CARDI — promotion of pineapple production on small farm trials; flower induction and management of the production system.

PRODUCTION AREA:
St. Kitts, 1 ha; Nevis, 0.6 ha

MAIN CULTIVARS:
Antigua Black; Local

St. Lucia

PRIORITIES:
Training of farmers; research into pests and diseases; organized marketing of produce

PROJECTS:
Flower induction experiment and fruit evaluation as per quality etc.

PRODUCTION AREA:
25–30 ha

TOTAL PRODUCTION 1990:
272,000 kg

MAIN CULTIVARS:
Smooth Cayenne; Local

St. Vincent and the Grenadines

PRIORITIES:
Propagation of planting material; research into weed control

PROJECTS:
No on going projects

PRODUCTION AREA:
2 ha

TOTAL PRODUCTION 1990:
45,000 kg

MAIN CULTIVARS:
Smooth Cayenne; Antigua Black; Montserrat; Local

Suriname

Traditional farming systems are in place.

Trinidad & Tobago

PRIORITIES:
Training; weed control; selection of varieties for fresh fruit and processed product; irrigation (Tobago)

Projects:

PRODUCTION AREA:
Trinidad, 40 ha; Tobago, 2 ha

TOTAL PRODUCTION 1990:
270,000 kg

MAIN CULTIVARS:
Trinidad — Deltada; Antigua Black; Smith Hybrid; Mundo Nuevo Red; Mundo Nuevo Green; Local.
Tobago — Antigua Black; Smith Hybrid; Mundo Nuevo Red

II. Priority

Pineapple is of major priority in; Antigua, Guyana, Trinidad and Tobago, Guadeloupe, Martinique and St. Lucia. Dominica, Barbados, British Virgin Islands, St. Kitts/Nevis, St. Vincent and the Grenadines, and Suriname have small amounts of planting material. Thus the major priority for the above countries was that of training and accessing information for the improvement of the techniques used for pineapple production. All countries were concerned about the availability of planting material, pests and diseases and the non-utilization by farmers of proper post-harvest techniques.

III. Projects

The following studies have been, or are being, done in the area:

- Cost of production just completed by OECS under TROPRO.
- FAO and Government of Guyana executed by New Guyana Marketing Corporation
- CARDI for St. Kitts/Nevis
- Marketing survey in Grenada done already
- CARDI in St Lucia monitoring fruit quality
- Cost of production to be done soon in Antigua

IV. Main Markets

For all the countries produce is sold on the local market as fresh fruit. Guyana exports to Trinidad and Barbados with small amounts to the UK, Canada and West Germany. Martinique exports to Guadeloupe and France. St. Lucia exports a small amount to the UK. The processed product is also marketed locally in Antigua, Martinique and Trinidad. Antigua exports jams to North America, while Martinique exports canned fruit and juices to France and West Germany. Trinidad exports jams, jellies, marmalades to CARICOM, UK, Canada, USA, Sweden, Aruba; juice to UK, Canada and CARICOM; and preserved candies to USA.

V. Main Constraints

PRE-PRODUCTION:
Too much farmer dependency on the governmental agencies

PRODUCTION:
During establishment of the pineapple crop need for timeliness; use of machinery.

MAJOR DISEASE:
Black rot

MAJOR PESTS:
Mealy bugs/ant relationship causing pineapple wilt; symphylids and gummosis associated with *Thecla* sp.

OTHERS:
Praedial larceny; damage by rodents and donkeys (Antigua)

MANAGEMENT:
Limited access to research information in the region — need for production package (slides, bulletins etc.) and monitoring to ensure that farmers carry out recommendations. Thus need to have a package approach and so develop a systems approach for the pineapple crop.

HARVESTING:
Management of time needs to be carefully looked

at. Suggestion of time and motion studies to be implemented so as to use effectively the labour on the farmers holding.

POLICY:

The level in the islands was variable. Where policy was not being addressed most of the specific tasks would be to:

- formulate marketing policy so as to encourage local regional production
- develop policy for the development of agro-industries
- develop land tenure policy
- encourage farmer investment, including provision of credit for orchard crop development
- implement policy for praedial larceny

POTENTIAL INSTITUTIONS:

CARICOM; OECS; CARDI; IICA

POTENTIAL DONORS:

EDF; IFAD

VI. Needs Assessment

POLICY

Where policy was being only practically addressed there is still need for policy so as to disallow the importation of pineapples and allow for more use of local markets.

RESPONSIBLE INSTITUTIONS:

Central governments and Ministries of Agriculture

COLLABORATORS:

CARICOM; OECS; CARDI; IICA

DONORS:

FAO; CIDA

STATUS:

There is still need for monitoring imports

WEAKNESS:

Still allows unfair competition

TRAINING

In all the islands it is thought that training has not been adequately addressed. The lack of training was found to be at all levels — farmers, researchers and technical staff.

There are three areas where there is need for training: (*a*) farmers and farmer organizations, (*b*) production techniques and (*c*) post-harvest handling.

POTENTIAL INSTITUTIONS:

IICA; CARDI; UWI

POTENTIAL DONORS:

INRA; IRFA; IRAT (in some countries, the French Government has been helping in providing funds and proper training facilities.)

SPECIFIC TASKS:

To increase planting material and/or to improve the technique of plant multiplication

RESEARCH

Research was partially addressed in some areas of pineapple production but not being addressed in other areas.

The following are being partially addressed:

- Propagation

  RESPONSIBLE INSTITUTIONS:

  French Agency for Cooperation (FAC); NARI in Guyana; MoAs

  COLLABORATORS:

  UWI; CARDI

  DONORS:

  EDF; BDDC

  STATUS:

  On-going

  WEAKNESSES:

  Limited production; inadequate work due to lack of funding/finance

- Cultivars

  RESPONSIBLE INSTITUTIONS:

  IRFA; INRA

  DONORS:

  French Government

  STATUS:

  On-going

  WEAKNESSES:

  Inadequate funding; lack of resource personnel

- Product utilization

  RESPONSIBLE INSTITUTIONS:

  CARDI; UWI; CARIRI

  DONORS:

  EDF

  STATUS:

  On-going

  WEAKNESSES:

  Inadequate funding; there is need for personnel awareness policy

- Post-harvest handling

  RESPONSIBLE INSTITUTIONS:

  MoAs in countries concerned

  COLLABORATORS:

  EDC; CARDI; CATCO; FAC; ADCU

  DONORS:

  USAID; EDF

  STATUS:

  On-going

  WEAKNESSES:

  — need for more investment
  — need for more facilities/equipment
  — need for more resource personnel
  — need for more video productions

The following areas are not being addressed at all:

- Farm systems approach, i.e. land utilization

  LEVEL:

  Farmer

  POTENTIAL INSTITUTIONS:

  INRA; CARDI; UWI; IRFA

  POTENTIAL DONORS:

  French Government; EEC; BDDC

SPECIFIC TASKS:
Formulation of tech-packs for small farming systems

— Post-harvest
LEVEL:
All levels — farmers; researchers; etc.
POTENTIAL INSTITUTIONS:
CARDI; UWI; CARIRI; IRFA
POTENTIAL DONORS:
French Government; BDDC; EDF
SPECIFIC TASKS:
Development of the protocol for handling fruits

Development

All islands suggested that some areas were partially addressed and some were not.

The following are being partially addressed:
— Small farm production project
RESPONSIBLE INSTITUTIONS:
MoAs
COLLABORATORS:
CARDI; UWI; IICA
STATUS:
On-going
WEAKNESSES:
— inadequate resources
— inadequate farmer awareness
— inactivity of farmer organizations

— Agro-industry project
RESPONSIBLE INSTITUTIONS:
MoAs
COLLABORATORS:
CARIRI; UWI
STATUS:
On-going
WEAKNESSES:
Inadequate financial and personnel resources

— Planting material production
RESPONSIBLE INSTITUTIONS:
MoAs
COLLABORATORS:
CARDI; IRFA; IICA; UNDP
STATUS:
On-going
WEAKNESSES:
Lack of training and facilities

The following is not being addressed:
— Networking
LEVEL:
All levels — farmers; researchers; etc.; regional and international
POTENTIAL INSTITUTIONS:
IICA; UWI; IRFA; CARDI
POTENTIAL DONORS:
French Government; UNDP; IADB
SPECIFIC TASKS:
Co-ordination of research in the Caribbean area; dissemination of pineapple information in the region; production of technical packages..

Mango Group Report

Participating countries: Barbados, Dominica, Grenada, St. Lucia, St. Vincent, Trinidad & Tobago

Institutions represented: IICA, CARDI, IRFA, MoAs, TROPRO, UWI

Coordinators: John Mc Intyre (MoA, Dominica); Cecil Winsborrow (MoA, Grenada)

I. Country Status

Priority:

Antigua	—	High
Dominica	—	High
Grenada	—	High
Guadeloupe	—	Medium
Martinique	—	Medium
St. Lucia	—	Low
St. Vincent	—	High
Trinidad & Tobago	—	Medium

Ongoing projects:

Antigua — Topworking Keitt, Julie (4 ha); orchard development (4 ha)

Dominica — Propagation; establishment of 120 ha; target areas are the dry zones in the north-west

Grenada — Propagation of 5,000 plants per year; pure stand establishment of Julie.

Guadeloupe — Expansion by 20 ha, by 1992; Julie, Florida types

St. Lucia — Topworking for Julie expansion (see Country Paper)

St. Vincent — Expanding production; target to establish 20,000-25,000 plants (200 ha).

Trinidad & Tobago — Processing, RPC/CARIRI; regional scope; cottage industry (see Fruit Crops Newsletter)

Studies:

Antigua	—	Cost of production studies
Dominica	—	Cost of production; fruit fly surveys

Grenada	—	Fruit fly
Guadeloupe	—	See Country Paper (cost of production)
St. Lucia	—	None (fruit fly)
St. Vincent	—	Fruit fly
Trinidad & Tobago	—	Fruit fly survey

Production areas:

Antigua	—	12 ha established
Dominica	—	320 ha
Grenada	—	200 ha (including seedlings)
Guadeloupe	—	100 ha
Martinique	—	>100 ha
St. Lucia	—	480 ha
St. Vincent	—	Not available. (12,000 trees)
Trinidad & Tobago	—	100 ha

Total production:
(total production figures are generally unavailable)

Antigua	—	12 t
St. Lucia	—	Not available (Export figures in Country Paper)
St. Vincent	—	Not available
Trinidad & Tobago	—	See Country Paper

Main Cultivars:

Antigua	—	Kidney; Julie
Dominica	—	Long; Julie
Grenada Ceylon	—	Julie; Long; Peach;
Guadeloupe	—	Julie (90%); Florida types
Martinique	—	Julie (90%); Florida types
St. Lucia	—	Long; Palvie; Graham<—>Julie
St. Vincent	—	Julie; Imperial; Horse; Long
Trinidad & Tobago	—	Julie; Starch

Main markets:

Antigua	—	Local
Dominica	—	Local; UK; Northern Caribbean
Grenada	—	UK; Holland; US
Guadeloupe	—	Local
Martinique	—	Local
St. Lucia	—	Local; UK (all varieties)
St. Vincent	—	Barbados (Imperial); Trinidad & Tobago, UK; Canada
* Trinidad & Tobago	—	Local; UK; Canada; Barbados

*Trinidad & Tobago exports processed mango products.

II. Main Constraints

Pre-production:

General lack of Training

Antigua	—	Disease, seed availability (mango seed weevil)
Dominica	—	No main constraints
Grenada	—	Management
Guadeloupe	—	Anthracnose; availability of scion material of improved varieties
St. Lucia	—	Seed availability (mango seed weevil); availability of scion material for improved varieties
St. Vincent	—	Nursery management
Trinidad & Tobago	—	No main constraints

Production:

— Lack of knowledge of all factors controlling yield.
— need for zoning and site selections throughout the OECS.

Antigua	—	Establishment; need farmers trained; cultural practices ; anthracnose; stray animals; aphids; praedial larceny
Grenada	—	Scattered production; anthracnose
Guadeloupe	—	Labor cost
Martinique	—	Anthracnose; erratic flowering
St. Lucia	—	After-planting management due mainly to interplanting bananas; anthracnose; mango seed weevil; Pest, (unidentified), possibly whitefly or scales
St. Vincent	—	Management; anthracnose;

fruit fly; mango seed weevil; mango gall midge

Trinidad & Tobago — Management; anthracnose; praedial larceny

Harvesting:

Antigua — Lack of training in harvesting methods

Grenada — Scattered production

Guadeloupe/ Martinique — Labor cost; training in tools and methods needed

St. Lucia — Labor cost high and availability inadequate

St. Vincent — Training in harvesting methods needed; cost of tools; training in maturity indices needed; labor cost

Dominica — Tree height

Trinidad & Tobago — Cost of tools; lack of training in all areas

Post-harvest:

— Training needed to change attitudes

Antigua — Lack of training in post-harvest methods; Lack of equipment (farmers)

Grenada — Lack of training

Guadeloupe/ Martinique — Lack of training

St. Lucia — Lack of training and information

St. Vincent — Lack of training

Trinidad & Tobago — Lack of training

Shipping and distribution

Antigua — Not available; no shipping

Grenada — Insufficient cargo space; transshipment in relation to fruit fly status; unsuitable cargo space for regional trade; high collection costs

Guadeloupe/ Martinique — Not available

St. Lucia — Insufficient cargo space

St. Vincent — Insufficient cargo space; transshipment in relation to fruitfly status; unsuitable cargo space for regional trade.

Trinidad & Tobago — Not available

Processing:

Antigua — Inadequate dissemination of processing information; full scale up of processing plants

Dominica — None

Grenada — None

Guadeloupe/ Martinique — High price of fruit

St. Lucia — None

St. Vincent — High price of fruit

Trinidad & Tobago — Unavailability of raw material; (see Newsletter)

Marketing:

Promotion - regional constraints

Antigua — Insufficient demand in peak periods; competition from imported fruits.

Guadeloupe/ Martinique — Inadequate promotion

St. Lucia — Low prices; informal marketing channels

St. Vincent — No constraints

Trinidad & Tobago — No constraints

Commercialization and business approach to marketing, particularly of Julie mangoes is a major constraint.

III. Needs Assessment

Policies

Zoning - Presently, mangoes are grown in unsuitable areas resulting in poor quality duc to anthracnose or improper choice of cultivar. Zoning practised by individual departments but not as policy. Need to develop zoning policy which will be expected by other institutions involved in assisting with mango production. Zoning was discussed more on an individual country basis.

Cultivars - Need for policy to place emphasis on Julie. Also, policy to screen other cultivars for existing markets. Increased emphasis on Julie because of availability of market, tolerance to anthracnose and better information base than other cultivars.

Mango network - Need for policy for formalizing a mango network regionally and to encourage formation of groups in the various islands for promotion of mango production and marketing. Only informal contacts presently exist.

Planting system - This was to be left up to the individual territory. Some islands would encourage pure stand plantings and others mixed cultivation.

Praedial larceny - This is to be addressed at the country level.

Joint marketing - Presently different islands compete for limited buyers; there is need for a policy on joint marketing. Although this is being addressed by ADCU, and governments have agreed in principle, there is no pressure on the various exporters to work together; policy should also include setting of regional standards and the policing of these standards.

Market development - Need for policy on development of markets for processing ; better working relationships between islands that have processing capability (Trinidad, Guadeloupe) and islands with supplies (St. Vincent, Dominica); or for extra-regional exports of young green mangoes.

Training:

— Need for training in nursery management and techniques especially in St. Lucia, St. Kitts, Nevis, Antigua and St. Vincent.

— Need for training in orchard/tree management including the various aspects of:
  - — orchard layout
  - — pruning
  - — weed control
  - — pest and disease control
  - — harvesting

Research:

Ongoing:
- — Anthracnose research in Dominica (CARDI; UWI)
- — Seed weevil, midge and fruit fly in Dominica (CARDI)
- — Post-harvest studies on Julie (CARDI, Dominica)
- — Evaluation of rootstock for coloration (MoA, Trinidad)
- — Flower induction for off-season crop production (MoA, Trinidad)

Need to research in:
- — Evaluation of yield potential of the different cultivars, especially Julie, and methods by which this can be increased.
- — Aspects of pest and disease control not presently being looked at.
- — Characterization of the various cultivars and to find if variability exists within the Julie cultivar.
- — Screening of varieties for late-bearing.

Development

— There is a need to give improved status and priority to mangoes. Best way to do this is to give farmers a guaranteed market with consistent prices.

— There is also a need to develop teams of individuals within the various Ministries of Agriculture, to work specifically with mangoes.

IV. Institutions/Agencies responsible for implementation

Policies

Zoning —Ideal conditions for mango growing to be given by CARDI and mapping of country by areas.

Cultivars —Screening of cultivars by CARDI and various MoAs.

Mango network — To be organized by IICA with assistance from ADCU and the French Agency for Cooperation.

Planting system policy — Emphasis on the different MoAs with assistance from ADCU (TROPRO)

Praedial larceny — To be addressed by the various MoAs.

Joint marketing policy — To be implemented by ADCU and the various MoAs and governments.

Training:

All the training needs are to be addressed by the various MoAs with assistance from CARDI, UWI, IICA, TROPRO, and IRFA/IRAT.

Research:

All research needs are to be addressed by CARDI with assistance from the UWI, IRFA and IRAT. Results of individual ministries (e.g. Trinidad) are to be circulated via the mango network.

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