IICA

FIRST REGIONAL WORKSHOP ON TROPICAL FRUIT CROPS

Roseau, Dominica, February 17-22, 1991

PASSION FRUIT

AVOCADO

CITRUS

MINISTRY OF AGRICULTURE
COMMONWEALTH OF DOMINICA

ADCU
OECS
AGRICULTURE DIVERSIFICATION
CO-ORDINATING UNIT

CARDI
CARIBBEAN AGRICULTURAL RESEARCH
AND DEVELOPMENT INSTITUTE

IICA OFFICE IN DOMINICA

"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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PASSION FRUIT, AVOCADO AND CITRUS

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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
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 Countries
FAO	Food and Agriculture Organization
HIAMP	High Impact Agriculture Marketing Project
IICA	Inter-American Institute for Cooperation on Agriculture
INRA	Institut National de la Recherche Agronomique-France
IRAT	Institut de Recherches Agronomiques Tropicales et des cultures vivrières
IRFA	Institut de Recherches sur les Fruits et Agrumes
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
SAPV	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

Fruit Crop Production and Marketing has been identified as one of the leading activities in the OECS Agricultural Diversification Programme. Particular attention is being paid to the minor exotics and the potential for penetration of the traditional export markets.

The OECS Agricultural Diversification Programme was developed through the joint efforts of the Caribbean Development Bank (CDB), the Caribbean Research and Development Institute (CARDI) and the Inter-American Institute for Co-operation on Agriculture (IICA). The Programme is being implemented through the Agricultural Diversification Co-ordinating Unit (ADCU) of the OECS whose offices are located in Dominica and St. Vincent and the Grenadines. This Unit, with the assistance of donors, supports projects in production, post-harvest handling, transportation and marketing.

Given this target activity in fruit crops, the ADCU in collaboration with CARDI and IICA has been actively pursuing field programmes in agronomic trials, demonstration plots and training in production and post-harvest handling of a selected fruit crop. Mango, avocado, passion-fruit, minor specialty fruits such as soursop and golden apple are being given special attention in its current work programme.

This opportunity for bringing those participants in one forum is an excellent opportunity to promote the joint activities considered essential in the development of the OECS Diversification Programme as a regional initiative. It is hoped that those who have participated in this exercise will be the standard bearers of this regional programme and will lead in the dissemination of the new information received to their colleagues in the field in a process of accelerating the production and marketing effort of fruit crops in the OECS.

The ADCU is particularly pleased to be associated with this demonstration of collaboration and coordination of regional institutions in the first of this series of training workshops in fruit crop being developed for our OECS technicians, producers and exporters in 1991.

Collin Bully
OECS/ADCU
Programme Coordinator

ACKNOWLEDGEMENT

We wish to acknowledge the interest and support received from many persons and institutions in organizing this Workshop.

Our special thanks to the Ministry of Agriculture of Dominica for hosting the workshop and to the OECS-Agricultural Diversification Coordinating Unit (ADCU), the Caribbean Research and Development Institute (CARDI) and the Inter-American Institute for Cooperation on Agriculture (IICA) for sponsoring this workshop.

Special gratitude to: the French Ministry of foreign Affairs (MAE), ADCU and IICA for financing participants and speakers as well as funding the publication of these proceedings and; the British Development Division (BDD) for financing some of the participants to the workshop.

We acknowledge the assistance of Mr. Peter Ramsammy in the technical editing of the documents and F.A.S.T.E.R. Publishing Service for the production of this publication.

Most of all we thank the participants for their active participation, without it we would not have achieved our goals and objectives.

Rafael Marte
Workshop Coordinator.

SECTION 1

COUNTRY PAPERS

ANTIGUA/BARBUDA

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I. Generalities

1.1 Projects

In Antigua/Barbuda there are four (4) major tree crop projects which are currently undertaken.

(i) *Greencastle Agriculture 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 investigations were also conducted. The objectives of the station have not varied significantly and Greencastle remains a centre where farmers, house-owners, etc. can obtain potted fruit plants, ornamentals, and vegetable seedlings.

The project is approximately 12.1 ha (30 acres) and consists of the following:

Mango orchard	3.2 ha	(8 acres)
Citrus orchard (bearing)	1.2 ha	(3 ")
Banana orchard	1.2 ha	(3 ")
Vegetable & food crop	4.0 ha	(10 ")
Young (citrus orchard)	2.4 ha	(6 ")

The technology in terms of tree crop propagation is obsolete but effective in terms of the project's initial objective and its socioeconomic spinoff or benefits in the community. Greencastle has the capacity to produce 1500 potted plants and 30,000 vegetable seedlings annually.

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

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

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) *Agricultural Extension Tree Crop Project* — The Agriculture Extension Division embarked on a Tree Crop Development Programme for the South-Western Agriculture districts. The programme began in 1978 and involves 21 farmers. Farmers are currently being taught techniques in bud-wood selection, grafting, pruning, 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.

(iv) *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 Agriculture districts. The project is not in the implementation phase; however, it will consist of the development of 121.4 ha (300 acres) of tree crop orchards. Farmers will be allocated 4.0 ha (10 acres) each with the primary objective to grow and develop fruit orchards specifically. 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 Agriculture 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 detail).

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 agriculture sectors, e.g. vegetable crops, that are more lucrative in short time span.

[1]Agricultural Research Officer.
[2]Agricultural Extension Officer.
[3]Station Manager, Christian Valley.

(iv) Seasonality of rainfall.
(v) Market uncertainity.

1.4 Cost of Production

Cost of production and return for citrus and avocado are shown in Appendices B, C, D, and E.

1.5 Seasonality of Production

The seasonal variations of the rainfall in Antigua/Barbuda has a marked effect on the bearing season for tree crop production. For example, the various cultivars of citrus and avocado normally begin to bear as shown in Tables 1 and 2, respectively.

Table 1
Seasonality of production for citrus in Antigua/Barbuda

Citrus	Cultivar	Season
Orange	Parson Brown	August–November
	Pineapple	August–November
	Washington Navel	November–January
	Valencia	December–March
Grapefruit	Marsh seedless (pink)	November–March
	Marsh seedless (white)	November–March

Table 2
Seasonality of production for avocado in Antigua/Barbuda

	Cultivar/type	Season
Avocado	Lula	November–January
	Pollock	August–December
	Simmonds	September–November
	Collinson	September–November
	"Bottle neck"	November–February
	"Bottle head"	November–February

1.6 Main Markets

The main markets for locally produced fruits are hotels, restaurants, and housewives (Vegetable Market, St John's). However, in spite of Antigua being a net importer of fruits and fruit-related products of some 55 t per annum, the marketing of its products can be difficult. There is serious ambiguity in the current import license systems which have led to frustration by local producers of fruit and vegetables. In addition, the demand for fruits is usually higher than the quantity supplied. This has been increased further because of the significant rise in demand by the tourism sector.

II. Pre-production

2.1 Cultivar Selection

2.1.1 Citrus (orange)

Cultivar	Bearing season
Parson Brown	Early
Pineapple	Early
Washington Navel	Mid-season
Valencia	Late

The selection of the citrus 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 just within and throughout the main tourist season (November–April). In addition, the fruit trade requires medium-to-small fruits. Cultivars selected and grown under Antiguan conditions can attain the necessary market size and fruit quality.

2.1.2 Avocado

Cultivar/type	Bearing season
Lula	Late
Pollock	Early
Collinson	Mid-season
"Bottle neck"	Late
"Bottle head"	Late
Simmonds	Mid-season

The importance of selecting and mixing avocado cultivars is as a result of the complex pollination characteristic as well as to produce an acceptable product for the tourism market and a cultivar that will produce under Antiguan conditions. As known, group A varieties (Lula, Collinson, and Simmonds) must be interplanted in close proximity of group B cultivars (Pollock, Fuerte, and Tonnage, etc.) for effective cross-pollination.

2.2 Propagation

2.2.1 Citrus (Orange)

Rootstocks used are Rough Lemon and Sour Orange and no problems are encountered with them. The inverted (T) is the main type of graft technique in use.

2.2.2 Avocado

Rootstock used is the local avocado type. Wedge graft is used predominantly.

2.3 Plant Demand and Supply

From 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.

III. Production Systems

3.1 Planting

The planting of tree crop orchards 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 with dimensions 46 cm × 46 cm × 46 cm (18 in. × 18 in. × 18 in.). Approximately 57–85 g (2–3 oz) of inorganic fertilizer (NPK) and pen manure are mixed thoroughly prior to planting.

3.2 Planting Distance

Planting distances within the orchards are as follows:

Orange	6 m × 6 m	(20 ft × 20 ft)
Grapefruit	8 m × 8 m	(25 ft × 25 ft)
Limes	6 m × 6 m	(20 ft × 20 ft)
Tangerine	5.5 m × 5.5 m	(18 ft × 18 ft)
Avocado	8 m × 8 m	(25 ft × 25 ft)

3.3 Crop Husbandry

3.3.1 Fertilization

For non-bearing trees the frequency of application of NPK is 3 times per year at a rate of 113–227 g (¼–½ 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 lbs) per tree or (5 lbs per application of NPK). Muriate of Potash and Potassium Nitrate are used for fruit development.

3.3.2 Crop Protection

The major problem within the citrus orchards is the sooty mold complex. Chemicals used are Malathion, copper fungicides (oil sprays), Perfekthion, etc. Sooty mold is usually a problem in the dry season.

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

3.3.3 Pruning

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, can 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

The yield per tree is as follows:

Limes	45–91 kg (100–200 lb.)/tree
Grapefruit	700 – 850 fruits/tree
Orange	n.a.

3.5 Factors Affecting Production

3.5.1 Site Selection

Presently the avocado trees at Christian Valley are experiencing a severe case of fruitlet dropping which can be as a result of the siting of the orchard within the lower watercourse of the stream.

3.5.2 Management

Management and upkeep of the orchard includes regular logging (charting) of the frequency of the spraying programme, handling of tools and equipment, and control labour.

3.5.3 Working Capital

Timely procurement of the working capital is necessary to carry out essential management practices, i.e. 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 Maturing Indices

At Christian Valley, problems are experienced in determining the correct stage to harvest avocado. The current technology is one of trial and error where fruits are collected and samples are taken. Then the time is calculated from fruit set to fruit development (maturity) as indices for harvesting.

V. Post-harvest Handling

5.1 Transportation from Field to Packhouse

Fruits are collected in field crates 30 cm × 46 cm × 91 cm (12 in. × 18 in. x 36 in.) with holes 1.5 cm (½ in.) in diameter, then transported by pick-up or tractor cart to field shed or office where they are sold.

VI. Marketing

6.1 Prices

Because of the demand for citrus and other tree crop products, they are not normally stored but are sold within 1–2 days. Prices are as follows:

Orange	EC $5.00/dozen
Grapefruit	EC $6.00/dozen
Lime	EC $2.50/lb. (0.5 kg)
Avocado	EC $2.00/lb. (0.5 kg)

6.2 Supply/Demand

Appendix F shows in detail the production at one of the tree crop projects: Christian Valley Plant Propagation Station.

Antigua/Barbuda is a net importer of most fruits and fruit-related products from Dominica, St. Lucia, and Miami (see Appendix G for details). In view of the proposed development of the tree crop industry in Antigua/Barbuda, it is envisaged that fruits will be sold locally within the fresh fruit trade as well as improving the prospects of developing cottage level processing industries. Some processing on an industrial scale may be possible once production can be justified.

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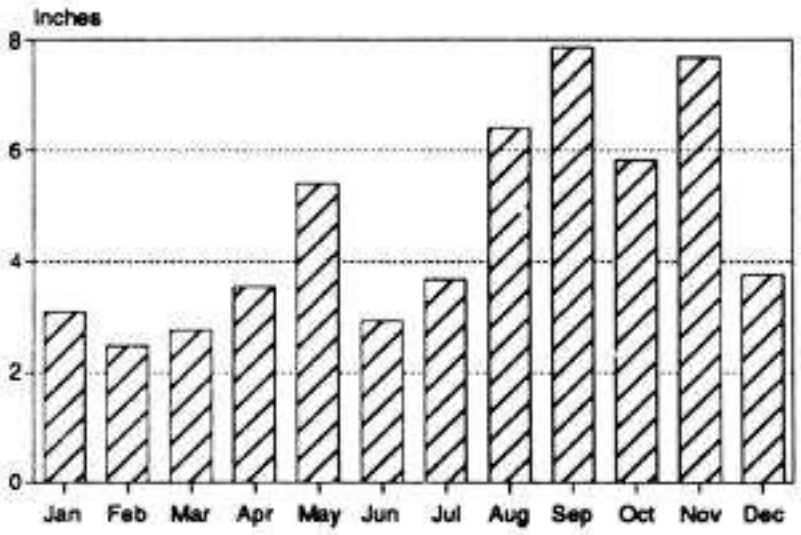
Appendix A

Monthly Rainfall
(Southern District, Antigua/Barbuda)
Average 1986–1990



Appendix B

Cost of Production and Returns (orange)
0.4 ha (1 acre)
Antigua/Barbuda

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Establishment cost	2254	82	—	—	—
Maintenance cost					
Labour	540	630	840	900	1080
Fertilizer	42	128	250	355	495
Chemicals	124	129	133	133	133
Transport (pick-up)	—	—	32	63	127
Maintenance cost	706	887	1255	1451	1835
Total variable cost	2960	969	1255	1451	1835
Revenue	—	—	792	1584	3168
Gross margin	–2960	–969	–463	133	1333

NOTE: Spacing: 6 m × 6 m (20 ft × 20 ft); Density: 110 trees/0.4 ha (1 acre).

Appendix C

Cost of Production and Returns (grapefruit)
0.4 ha (1 acre)
Antigua/Barbuda

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Establishment cost	1941	51.9	—	—	—
Maintenance cost					
Labour	540	630	660	900	1080
Fertilizer	28.40	59.9	116.9	171.2	228.2
Chemicals	124.60	128.9	133.2	133.2	133.2
Transport (pick-up)	—	—	—	134.4	336.0
Maintenance cost	693	818.8	910.1	1338.8	1777.4
Total variable cost	2634.0	870.7	910.1	1338.8	1777.4
Revenue	—	—	—	1209.6	3024.0
Gross margin	–2634	–870.7	–910.10	129.2	1246.6

NOTE: Spacing: 8 m × 8 m (25 ft × 25 ft); Density: 70 trees/0.4 ha (1 acre).

Appendix D

Cost of Production and Returns (lime)
0.4 ha (1 acre)
Antigua/Barbuda

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Establishment cost	2501	95	—	—	—
Maintenance cost					
Labour	601	720	1220	1720	2160
Fertilizer	18	89	220	316	316
Chemicals	124	129	133	133	133
Transport (pick-up)	—	—	176	352	528
Maintenance cost	743	938	1749	2521	3137
Total variable cost	3244	1033	1749	2521	3137
Revenue	—	—	2640	5280	7920
Gross margin	–3244	–1033	891	2759	4783

NOTE: Spacing: 6 m × 6 m (20 ft × 20 ft); Density: 110 trees/0.4 ha (1 acre).

Appendix E

Cost of Production and Returns (avocado)
0.4 ha (1 acre)
Antigua/Barbuda

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Establishment cost	1972	52	—	—	—
Maintenance cost					
Labour	540	630	660	840	900
Fertilizer	29	61	117	228	337
Chemicals	101	104	104	104	104
Transport (pick-up)	—	—	—	56	112
Maintenance cost	670	795	881	1228	1453
Total variable cost	2642	847	881	1228	1453
Revenue	—	—	—	1400	2800
Gross margin	–2642	–847	–881	172	1347

NOTE: Spacing: 6 m × 6 m (20 ft × 20 ft); Density: 70 trees/0.4 ha (1 acre).

Appendix F

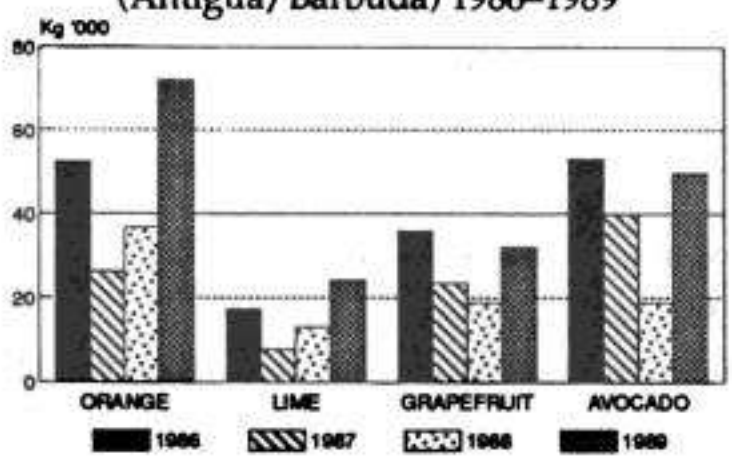
Tree Crop Production (kg) at
Christian Valley Propagation project

Crop	1986	1987	1988	1989
Orange	2863.00	7811.60	4551.00	2905
Grapefruit	2633.00	5085.00	2715.00	4458
Avocado	297	322	250	287
Limes	89	724	68	n.a.

SOURCE: Christian Valley Plant Propagation Project Files.

Appendix G

Importation of Citrus & Avocado
(Antigua/Barbuda) 1986–1989



BARBADOS

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Fruit crop development has made significant and organized progress within the last five (5) years. This development materialized with the establishment of the National Fruit Development Programme in 1986. This paper attempts to portray the problems encountered and the progress made with the emphasized crops—passion fruit, avocado, and citrus.

INTRODUCTION

Fruit crop production, although carried out for the most part at the subsistence level, has developed to the extent that some small commercial orchards can be recognized. The Fruit Development Programme with the Soil Conservation Unit (production centre for planting material) and Codrington Agricultural Station (Research) as its base has played a pivotal role in this development. Extension services provided by the Ministry, where farmers' needs and problems can be fully assessed and addressed, is a contributing factor to orchard development in Barbados. With the establishment of the Agro-processing Plant in Barbados, emphasis is now being placed on crops such as passion fruit, carambola, cherries, and guavas.

Limiting factors such as high cost of irrigation equipment, availability of subsidies, adequate local and external markets, praedial larceny, and a very worrying stray animal problem are some of the farmers' concerns that are hindering the process of the fruit orchard industry.

I. Generalities

A research passion fruit project, 0.4 ha (1 acre), is being established to observe trellising systems under our local environmental conditions. Trellising patterns will be 1-wire, 2-wire, and overhead arbor. Different spacings within these systems will also be looked at.

Germplasm banks of major cultivars of avocado and citrus are established at Codrington Agricultural Station. A research project in citrus is also being implemented. Its main objective is to seek an alternative rootstock in case of *tristeza* attack on the traditionally used rootstock (Seville Orange). The rootstocks that are being looked at are Rough Lemon, Citrus Volkameriana, Rangpur Lime, and Swingle Citrumelo. Scion material being used on these rootstocks are Ruby Red, Marsh, Thompson Pink, and Duncan.

Major environmental problems associated with fruit crop production are soil type (heavy clay soils which limit avocado production) and salt mist especially in the dry season. Most of the fruit crop farming in Barbados is still at a subsistence level with backyard farmers having about one or two trees. However, there are about 3.2 ha (8 acres) of avocado and 12.1 ha (30 acres) of citrus under commercial cultivation. There are no real figures on production costs and returns because most farmers do not have any properly kept records of their enterprise.

Seasonality for passion fruit and citrus are all-year whereas the season for avocado stretches from May to December. The main markets are on the local scene. There is a high demand for passion fruit and avocado but not for our locally produced citrus.

II. Pre-production

2.1 Cultivar Selection

Major cultivars being propagated are the following.

Avocado	Orange	Mandarin	Lime	Grapefruit/ shaddock
Semil 34	Valencia	Murcott	West Indian	Claybury
Booth 7, 8	Pineapple	Orlando	Seedless	Marsh
Lula	Parson Brown	Dancy	Tahiti	Thompson Pink
Pollock	Navel	Ponkan		Ruby Red
Waldin				Foster's Pink
Choquette				Duncan
Wilson				Triumph
Popenoe				Pomelo

2.2 Propagation

Propagation of the crops is done vegetatively. Seville Orange is the only rootstock being currently used for citrus propagation. There is no special emphasis on any particular type of rootstock for avocado production.

2.3 Plant Demand and Supply

There is usually a high demand for planting material, and the supply is adequate. The only distribution centre is located at the Soil Conservation Unit in the rural St. Andrew district. There is a need for other distribution centres to be located further inland so as to render easier access to planting materials.

III. Production Systems

3.1 Planting

Some farmers usually employ minimum cultivation where the area to be planted is cleared, the holes dug, and plants put in place. Most farmers, however, cultivate the entire land area, plant the fruit

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trees, and intercrop during the early stages of plant development.

3.2 Planting Distance

Planting distance ranges from 5 m × 5 m for limes; 6.5 m × 6.5 m to 8 m × 8 m for oranges and grapefruits, respectively, and 10 m × 10 m for avocados.

3.3 Crop Husbandry

3.3.1 Fertilization

Triple Superphosphate is applied to the holes at planting. Foliar feeds are applied during the first 3 weeks. Liberal doses of 24:0:18 are applied monthly throughout the life of the plant. Muriate of Potash is applied during the fruiting period.

3.3.2 Weed Control

Farmers who employ limited cultivation with their orchard systems usually encounter problems of competition and a proliferation of pests in the fields. More intensive farmers usually employ mechanical swipes for cutting the outfields while chemical weed control is adopted in the root zone area. Weeding usually damages surface roots.

3.3.3 Irrigation

Most of the commercial orchards in Barbados are under irrigation. Some of the farmers who still have rain-fed situations and have seen the benefits of irrigation have expressed interest in having their orchards irrigated albeit the constraints.

The main types of irrigation systems being utilized are drip, micro-jet, and mini-sprinkler systems. Only recently in Barbados, at a workshop on the "Management of Irrigation Systems," experts from Israel showed via lectures, video tapes, and slides, how to obtain maximum efficiency from these systems. Farmers, agronomists, and extensionists alike benefitted from this exercise.

3.3.4 Spray Programme

A four-month cycle of preventive application is usually followed by most farmers. This is supplemented by target spraying when the prevalence of increased pest concentrations is noted.

3.3.5 Pruning

Pruning is done basically for maintenance. Avocados seem to be predisposed to termite attack especially in their advanced years. Pruning helps in this case but is not always the solution. The Ministry of Agriculture, Food and Fisheries employs a technical team that provides pruning services to the farmers. The cost is then charged to the farmer.

3.3.6 Other Cultural Practices

There is usually major damage by birds to some citrus cultivars. "Netting" of the trees was used in the past but the high incidence of bird deaths as a result of entanglement rendered this system improper. No bagging is done but that will probably have to be looked at in the future. Wind breaks are an essential part of fruit crop production and more emphasis should be placed on using them.

There is no adequate data on production figures; this is due mainly to the high incidence of crop larceny. Happily, laws are presently being enacted to combat this problem.

IV. Harvesting

There are no major problems recognized in harvesting and this is mainly due to the small acreage of individual enterprises.

4.1 Methods

There is no mechanized harvesting of fruit crops in Barbados. All harvesting is done manually and somewhat primitively. In most cases, especially in avocados, someone climbs the tree, harvests the fruit, and throws it down for someone else to catch it. Rods with bags attached at the end are usually used to harvest citrus. The fruits are then placed in crates and transported from the field.

4.2 Maturing Indices

Scientific principles are not followed in recognizing the maturity of the fruit. Instead, firmness of fruit and colour changes are the main techniques used to ascertain maturity.

V. Post-harvest Handling

5.1 Transportation

Transportation from the fields is usually by vehicles. The fruits are usually placed in crates. Most orchards are easily accessible and due to the relatively flat nature of the land, transportation problems are minimal.

Because there are no specialized markets (locally or externally) for these crops, packhouse operations are at a minimum level.

VI. Marketing

The market system consists of hawkers, who buy produce on the farm and then peddle it on the street; wholesalers, who buy from farmers and sell in large quantities to hotels, restaurants, and supermarkets; institutions such as the School Meals Service and Hospitals; and the Barbados Marketing Corporation.

6.1 Supply/Demand

The demand for citrus is usually high but consumers seem to prefer fruits that are imported. The demand for passion fruit is high primarily because there is a locally produced passion fruit drink. Most of the pulp

that is used to produce this drink is at present being imported.

With the establishment of the Agro-processing Plant, there is now a wider market for these crops. The farmers have recognized this and there is a greater urgency to improve the quality and quantity of their products. The potential of these crops is great and the Ministry is responding well to this development.

VII. Conclusion

There are some problems that need to be addressed, including crop larceny, incentives, and advertising of our local products. However, the future holds good for the fruit crop industry, especially with more people becoming health conscious. With this emphasis, the farmers, the Ministry of Agriculture, and Barbados, in general, will be justly proud.

BRITISH VIRGIN ISLANDS

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INTRODUCTION

Agriculture has declined in the British Virgin Islands because of the terrain, the change in climate, and the increase in tourist attraction. Nevertheless there are presently 400 active farmers, 65% being part-time.

Up to September 1990, there were 300,000 tourists visiting the islands for the year. With the tourism industry expanding and the food import bill being so high (U.S. $10 million/annum), the need to sell more exotic fruits and vegetables of high quality and in large quantities over an extended period became apparent.

I. Generalities

1.1 Projects

The Department of Agriculture has embarked on several projects, some of them being:

1. To construct at least 20 mini-dams in various parts of the territory along with the necessary facilities such as watering troughs, an irrigation system, etc.
2. To construct feeder roads, in areas where farm lands are inaccessible.
3. To programme crop production to meet market demand and also to link producers to hotels, restaurants, and supermarkets.
4. To establish at least 40.5 ha of fruit orchard mainly in private land over an extended period.

The Government of the British Virgin Islands intends to spend funds totalling approximately U.S. $250,000 to assist with a Fruit Tree Orchard Project. Of this amount U.S. $55,000 has been approved. This project will be carried out over a period of five years commencing last year (1990). Over that period about 40.5 ha of fruit trees should be cultivated.

Unlike Dominica, the British Virgin Islands experiences a problem with water supply. This country depends heavily on public wells to water crops during the dry season. To alleviate this problem the Government has assisted the farmers by building mini-dams or providing water tanks whereby they can obtain water during the wet season for use over the dry season.

Farmers and homeowners of backyard orchards are provided assistance by the project in the form of labour and materials for fencing; irrigation equipment (hoses and water tanks); technical assistance; planting materials at a subsidized rate of $1.00 per plant; agricultural inputs — fertilizers, weedicides, insecticides, fungicides; and, in some cases, supervision at planting. Inputs are provided for establishment of the plant and up to the bearing stage of the crop.

There are some prerequisites for entering the project and these are as follows:

1. The location must be suitable for the crop to be planted.
2. The farmers must have the right to use the land.
3. Plantings must be in pure stands (one line of each cultivar) — intercropping or intergrazing is permitted.
4. An agreement must be signed by the applicant stating his responsibilities as well as the Department for the establishment and success of the Fruit Tree Project.

The area planted in 1990 was approximately 3 ha of the expected goal of 4 ha because of the lateness of the expected rainfall. The trees that are presently used in the project are citrus, avocados, mangoes, and dwarf coconuts.

Seventeen individuals participated in the project and these included both farmers and homeowners of backyard orchards. The maximum area was 0.2 ha while the minimum was as little as 0.03 ha.

In the future the Fruit Tree Project should be expanded to include more local fruit such as W.I. cherries, guavas, genip, soursop, sugar apple, passion fruit, etc. The project also hopes to make its own

selections of existing local cultivars that are more adapted to the environment; set up a museum plot of local plants; encourage farmers and other business enterprises such as hotels and restaurants to make local drinks, ice cream, etc. for sale to the tourists; educate the community regarding the need for diversification.

There are also some established fruit tree orchards and approximately 4 ha (10 acres) is under cultivation. The area is divided to accommodate several cultivars; however, no data has been recorded about the percentage of each cultivar and the production cost of the fruit trees on farmers' holdings or by backyard gardeners. Data relating to returns have been placed on the crop compensation file. Because of the above as well as the newness of the Fruit Tree Project, it is difficult to give information on production costs and returns, demand and supply, etc.

There is a problem with the propagation of fruit trees due the lack of a constant supply of good quality water in the nursery, a museum plot, and skilful workers in this area. Fruit trees therefore had to be purchased from Florida. The cultivars received for the Fruit Tree Project are as follows:

Mango cultivars

1. Keitt	4. Mitchell	7. Haden
2. Irwin	5. Glen	8. Edward
3. Tommy Atkins	6. Gold Nugget	

Of all the mangoes received, Keitt was 50%, Tommy Atkins 22%, and the other varieties 28%.

Avocado cultivars

1. Bernecker	2. Monroe

Citrus cultivars

1. Grapefruit	— Ruby Red
	— Marsh
2. Orange	— Valencia, Navel
3. Pomelo	
4. Tangelo	— (Grapefruit × Orange)
5. Tangerine	
6. Persian Lime	

Data on the importance and characteristics of these cultivars is somewhat limited.

1.2 Ecological Problems

1.2.1 Avocado

(i) *Drainage* — Avocado prefers a relatively dry climate with an annual rainfall of 12.70 cm. However, when there is a severe dry season, irrigation becomes necessary. Also, during the wet season the country experiences poor drainage with heavy soils so that proper drainage becomes necessary. This needs to be implemented since it is not a common cultural practice to make drains when planting avocado in the British Virgin Islands.

(ii) *Soils* — Although avocado grows on a wide range of soils, it does best on deep, well-drained fertilized soils of medium texture with a pH range of 5.5 to 6.5. In areas where avocado is established on heavy clay soils, drainage would become a necessity during the wet season.

(iii) *Irrigation* — Most farmers rely on the rainfall for the growth of their crops. The annual rainfall is about 12.70 cm and in some cases the dry season is very severe so that irrigation becomes necessary to continue the growth of the crop.

1.2.2 Citrus

(i) *Rainfall* — The country experiences two distinct seasons: a wet season and dry season. The dry season occurs from January to August with some rain in May and then the wet season begins from September until November–December.

During the dry season the crops are attacked by aphids and scales. If not controlled, leaves may be lost. Sooty mold is also a common disease during the dry season. This affects the appearance of the fruit thus reducing income to farmers.

(ii) *Wind* — Citrus needs to be cultivated in areas where the wind is not usually very high or in a place that has windbreaks. Most of the citrus grown is exposed to wind and sea blast and this causes top burn of the leaves, chlorosis, and eventually defoliation of the plants. Provision for windbreaks and selection of suitable sites should be made.

1.3 Area Planted

1.3.1 Avocado

There are approximately 10 ha of mixed avocado cultivars growing. These are located throughout the islands on farmers holdings, but some are also planted in backyard gardens. The existing cultivars are Lula, Pollock, Monroe, and Bernecker. The Fruit Tree Project hopes to expand to other cultivars such as Semil 31, Semil 34, and Gripina.

1.3.2 Citrus

The main citrus cultivars grown are the W.I. Lime, Sour Orange, Rough Lemon, Marsh grapefruit, and Valencia orange. The Fruit Tree Project is expected to cultivate other cultivars such as Pomelo, Tangerine, Ruby Red grapefruit, Tangelo, Persian Lime, Sweet Orange and Tahiti Lime.

1.3.3 Passion Fruit

The area planted is unknown because passion fruit is grown in backyard gardens. The plant is allowed to run freely up in trees. No pruning, fertilization, or spraying is done. The Yellow passion fruit is the cultivar that is commonly grown.

1.4 Seasonality

1.4.1 Avocado

Lula	September – January
Pollock	December – February

1.4.2 Citrus

Rough Lemon	January	– May
Sour Orange	January	– April
Tangerine	May	– September
W.I. Lime	January	– April
Marsh Grapefruit	May	– September
Valencia Orange	December	– March

II. Production Systems

2.1 Planting Methods and Planting Distances

Spacing for planting depends on the type of soil and the cultivar grown. The spacing for avocado varies from 6 to 9 m while the average used for citrus cultivars is 6 m × 7.6 m.

2.2 Crop Husbandry

Any available fertilizer with the ratio of 2:1:1 is used for both citrus and avocado. Approximately 500 g in split applications is recommended. Three applications are given beginning January, May, and October. Trees which existed before the Fruit Tree Project materialized have not been fertilized.

2.2.1 Weed Control

(i) *Manual* — Monthly manual cutlassing of drip circle area to keep weed free.

(ii) *Chemical* — Other areas of bed are sprayed with a weedicide (Gramoxone, Round-up) using a shield to avoid spray-drift unto young plants.

2.2.2 Pruning

Growth from the rootstock is removed. Dead and diseased branches are removed, and this is done at the owner's convenience.

2.2.3 Irrigation

Existing fruit trees before the start of the project were grown under rainfed conditions. Now the farmers and backyard gardeners who are involved in the Fruit Tree Project have been assisted with dams and irrigation hoses by the Government.

2.2.4 Supplying

Plants missing in the field are replanted.

2.2.5 Pest and Diseases Control

Bachac nest, fiddler beetle, and ants in the field are destroyed. A mixture of insecticide, fungicide, and foliar spray are sprayed monthly during the rainy season and bimonthly during the dry season.

III. Harvesting

No form of mechanization is used in harvesting the fruits. They are harvested manually. Because of the few existing fruit trees in the British Virgin Islands, fruits are not exported. They are used and sold locally. The main problem in harvesting of the fruits is bruising when they are being picked before they are stored.

The main techniques used to determine the maturity of the fruit are firmness of the fruit, colour changes, and sometimes fruit drop.

DOMINICA

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I. Generalities

1.1 Projects

The British Development Division in the Caribbean has approved funds totalling EC $1,710,000.00 to assist government with its Crop Diversification Programme. This programme is for a period of six years and proposes to establish 182 ha (450 acres) of fruits and spices on farmers' holdings around the island. The crops to be planted are Ruby Red grapefruit, passion fruit, tangerine, ortanique, soursop, nutmeg and cloves. The objective is to plant the crops over a two-year period. Special attention is being paid to zoning production to facilitate monitoring, management, and marketing.

The project assists farmers by making available technical advice, planting material, and agricultural inputs — fertilizer, weedicides, insecticides, and fungicides. Inputs are provided for establishment and four years of after-care. This applies to all crops in the programme except passion fruit for which assistance is provided in the establishment year only. Farmers will meet the labour requirements for the establishment and maintenance of all the crops in the programme.

There are, however, some prerequisites for project assistance:

- Farmers selected must be within the zone area for the particular crop
- The location must be suitable for the crop to be planted
- The farmers must have the right to use the land
- The plot size must be between 0.1 and 4 ha (0.25 and 10 acres)
- Planting must be in pure stands — intercropping permitted
- The applicant must agree in writing to follow the instructions of the Division of Agriculture, in relation to the operation of the scheme, and also to agree that all monies made available to him

must be on the condition that it is on a loan basis, but after, if all the operations recommended have been completed satisfactorily, the loan will be converted to a grant.

Provision has also been made for training opportunities for farmers and extension staff in the tree crop husbandry over the life of the project. The project has a component which includes establishing a series of observation plots around the island totalling 2 ha (5 acres). Tests will be carried out on various tree crops for which there is market interest but a lack of information on appropriate cultivars and growing conditions, e.g. lychee, carambola, mangosteen, durian, sapodilla, star apple, etc.

To date, this project is only 14.6 ha (36 acres) behind target with shortfalls in passion fruit, nutmeg, clove and soursop.

1.2 Ecological Problems

1.2.1 Avocado

(i) *Drainage* — Avocado does not like waterlogged conditions. In Dominica, specifically in the north and north-east areas which tend to have clayey (heavy) type soils, drainage should be a priority. Also, farmers do not tend to make drainage a common agronomic practice in the cultivation of avocado. This has led to the deterioration of quite a few avocado orchards in the north-east, particularly the Woodford Hill area. There is a need for farmers to implement drainage as a standard agronomic practice in avocado cultivation.

(ii) *Soils* — Avocado can be grown on a wide range of soils. However, with high rainfall regimes experienced in Dominica, soils with deep free draining profiles are recommended. Since most of the avocado orchards have been established in areas with heavy soils in Dominica, drainage is a must.

1.2.2 Citrus

(i) *High rainfall* — Most of the citrus orchards are located in high rainfall areas. In these areas and under such conditions fungal diseases such as citrus scab, melanose, and brown rot tend to proliferate; these fungal diseases generally affect fruit quality and this in turn brings reduced economic returns to farmers.

(ii) *Altitude* — Ruby Red grapefruit is the cultivar being developed by the Tree Crop Unit of the Division of Agriculture, for increased exports to the regional and extra-regional markets. Both markets require a grapefruit characterized by a "dark red colour."

In Dominica, it has been observed that high altitudes (244 m [800 ft] and above) seem to have a negative influence on dark red colouration of Ruby Red grapefruit and fruits tend to exhibit a pale pink colour instead of the dark red colour, which the market demands.

At the lower altitudes in places such as Hillsborough, Woodford Hill (close to the coast), and River Estate, Ruby Red grapefruit exhibits the desirable dark red colour.

It is recommended that for the cultivation of Ruby Red grapefruit, in order to meet the market criteria in terms of fruit colour, "Zoning" should be done.

1.2.3 Passion Fruit

(i) *High rainfall* — Areas with high rainfall are not ideally suitable for passion fruit cultivation. Pollination can be affected by heavy rain which causes bursting of pollen grains; this results in decreased pollination. High rainfall also reduces the activity of pollinators of passion fruit, specifically the carpenter bee (bumble bee). Also, from observations made in Dominica, in high rainfall areas, low pollination of carpenter bees tend to be the norm. Fungal diseases such as brown spot are more prevalent in passion fruit grown under high rainfall conditions.

(ii) *Wind* — The cultivation of passion fruit in windy areas is not recommended. From observations made in this country, trellises with vines tend to suffer heavy damage in locations which are windy and exposed.

(iii) *Topography* — The Fence-type trellis system is now recommended by the Division of Agriculture to farmers. Topography influences the type of system being used. For example, on slopes over 20°–30°, the Canopy-type system is the method of cultivation commonly practiced whereas on flat or gently sloping land the Fence or T-type trellis system is commonly used.

1.3 Area Planted

1.3.1 Avocado

There are approximately 168 ha (416 acres) of mixed avocado cultivars growing. During the last 10 years, 80.9 ha (200 acres) of the early and late varieties were planted. These are located throughout the island but with highest concentrations in the north-east, south, and south-western parts of the island. To combat the present foot rot problems, proper site selection is critical in any expansion programme. The introduction of resistant rootstocks is being considered.

1.3.2 Citrus

The main citrus cultivar grown is the Marsh Seedless grapefruit of which there are over 1214 ha (3000 acres). The expansion programme during the past years has mainly been with Ruby Red (182 ha [450 acres]). Oranges including the easy-peelers occupy 809 ha (2000 acres). These cultivations are scattered throughout the Central Belt of the island.

1.3.3 Passion Fruit

Over 121 ha (300 acres) of passion fruit have been planted during the last five years over the island. Greater concentrations are in the north-east and east

of the island. The establishment cost is $2,100.00 per acre (0.4 ha). The heavy investment on trellising and the durability of the poles limit the expansion of the industry.

1.4 Seasonality of Production

1.4.1 Avocado

The avocado season usually starts around June/July and runs through, tapering off in March. The Ministry has selected cultivars which fit into this bearing cycle. The main early cultivars propagated for distribution at the Government-owned propagation station are the Simmonds, Pollock, and Dominica Selected. This is followed by the mid-season to early-late with the Gripina 12 and Semil 31. Much emphasis is not placed on these cultivars as there is an abundance of fruit from the local cultivars at this time which satisfies the local and regional demand. The prices are also usually lowest at this time. Towards the end of the year, prices begin to rise and the early-late to late cultivars begin to appear, most popular being the Semil 34. High up on the demand list is the Lula, Collinson, and Gripina 5.

These cultivars listed above have all been selected to satisfy both the regional and extra-regional markets.

1.4.2 Citrus

The two cultivars of economic importance to Dominica are the Ruby Red and the Marsh Seedless grapefruits. Programmes of rehabilitation focus on the Marsh Seedless, whereas expansion programmes focus on the Ruby Red. Facilities are already in place for processing and packaging the crop.

Washington Navel, Valencia, and Ortanique are the most commonly grown oranges. They are all used in the fresh fruit trade in the local and regional market.

1.4.3 Passion Fruit

The Yellow passion fruit is the type commonly grown throughout the state. This type has been selected and geared towards the juicing trade which is the main market outlet. There is also a significant fresh fruit trade with the neighbouring islands which demands higher quality fruit and yields better prices.

II. Pre-production

2.1 Avocado

Avocados are propagated from seed collected from local seedling trees and further grafted onto the desired variety. The seeds are collected from fully mature seedling produced trees, hardy, and showing signs of a healthy and productive root system. Mature fruits are harvested and allowed to ripen, when the seeds are extracted and set into well prepared plastic bags. The most common medium used is one consisting of sand, soil, and pen manure. To avoid poor germination, the fruits selected for seed production must be fully mature and should not be allowed to fall to the ground. Wedge grafting is the most popular method of propagation and yields a high level of success. No soil treatment is presently undertaken.

The average yearly production of planting material is about 5000 plants. Most of these plants are distributed along the south, western, and north-eastern part of the island. Planting material is still heavily subsidized. The last costing revealed a production cost of $5.00 per plant as compared to a selling price of $1.00. Inferior quality bags present a major problem in plant distribution.

2.2 Citrus

Propagation is done by budding on Sour Orange which is the most popular rootstock. The citrus weevil and citrus scab present the greatest problem in the nursery. Citrus plants are propagated on open beds and are distributed as bare root plants. There has been discussion on the possibility of transferring to bags, but distribution under our condition presents a problem.

2.3 Passion Fruit

Propagation is done through unselected seeds and this probes a problem as the results are uncertain. There is need for seed selection for high quality, yield, and self compatibility adapted to different ecological conditions. The demand for planting materials varies annually and is usually connected to the existing programmes at the time. Due to the high trellising cost, over 95% of all plots established are under some assisted programme.

III. Production Systems

3.1 Avocado

3.1.1 Planting Methods and Planting Distances

The normal planting distance for avocado varies from 6 m to 12 m (20 to 40 ft) depending on the vigor of the cultivars and whether they are of upright or spreading growth.

On gently sloping lands, the Ministry of Agriculture recommends a spacing of 9 m × 9 m (30 ft × 30 ft). On hilly terrain, a spacing of 9 m × 7.6 m (30 ft × 25 ft) is recommended. Under the Ministry of Agriculture, Development and Expansion Programme pure stand avocado orchards are recommended. However, depending upon acreage of land farmers have, avocados are planted at a spacing of 10.7 m × 10.7 m (35 ft × 35 ft) for purpose of permanent intercropping.

3.1.2 Crop Husbandry

(i) *Fertilization* — A similar fertilizer regime used for citrus is applicable to avocado. That is 1- to 5-year-old trees each receive 0.5, 1.0, 1.4, 1.8 and 2.3 kg (1, 2, 3, 4, and 5 lb.) NPK (16:8:24), respectively, per annum. Mature and fully bearing trees receive 3.6 kg (8 lb.) NPK on a yearly basis. In the case of young trees (1–5 years) fertilizer is applied in three split

applications. Fully bearing trees receive fertilizer before flushing and flowering.

(ii) *Weed control* — Weed control methods include (*a*) manual cutlassing, (*b*) chemicals (Gramoxone, Round-up), and (*c*) mechanical (use of brush cutters).

(iii) *Irrigation* — Irrigation is nonexistent, avocado is grown under rainfed conditions.

(iv) *Spray programme* — A spray programme for avocado is nonexistent. There is need for such a programme since avocado rust mites seem to be an increasing problem in avocado cultivation here.

(v) *Pruning* — Pruning of avocado has been given little attention or priority. It is recommended that a pruning education drive should be implemented in the avocado expansion programme to sensitize farmers to benefits of this agronomic practice.

(vi) *Drainage* — Since avocado does not tolerate waterlogged conditions, on heavy soils commonly found in the north and north-east areas of Dominica, drainage is a must.

3.1.3 Yields

In Dominica, yields are variable depending on cultivar. On an average, mature and fully bearing trees may yield from 200 to 1000 fruits per annum.

3.2 Citrus

3.2.1 Planting Methods and Planting Distances

In Dominica, Government propagation stations provide farmers with bare root plants. It has been found that bare roots have some definite advantages:

(i) Easier to handle and transport
(ii) Facilitates farmers with holdings which are some distance away from access roads
(iii) Bare root transplants are cheaper than plastic bag transplants
(vi) Bare root transplants permit inspection for disease, nematodes, and physical damage

In spite of these advantages, bare root transplants require careful handling and should never be allowed to dry out as they are very susceptible to sun and wind injury. They must be planted immediately after digging and require larger planting holes.

The planting distance depends mainly on the nature and fertility of the soil and topography. In Dominica, spacing recommended by the Division of Agriculture is as follows:

(i) Grapefruit: 7.6 m × 7.6 m – 9 m × 9 m (25 ft × 25 ft – 30 ft × 30 ft)
(ii) Oranges and ortaniques: 6 m × 6 m – 7.6 m × 7.6 m (20 ft × 20 ft – 25 ft × 25 ft)
(iii) Limes and tangerine: 4.6 m – 6 m × 4.6 m – 6 m (15 – 20 ft × 15 – 20 ft)

Planting is usually done in square or triangular plots or on steep slopes, along the contour.

In Dominica, citrus can be found growing in pure stands or intercropped with bananas and root crops. Pure stand orchards usually consist of trees 6 years old and above. Since banana has become the priority and dominant crop to most farmers, citrus is usually intercropped with banana as a secondary crop.

3.2.2 Crop Husbandry

(i) *Fertilization* — Young citrus plants ranging from 1 to 5 years old are each generally given 0.5, 1.0, 1.4, 1.8, and 2.3 kg (1, 2, 3, 4 and 5 lb.) NPK (16:8:24) fertilizer, respectively, on a yearly basis. This is often applied as three split applications to individual trees.

Mature full bearing trees are usually given 3.6 kg (8 lb.) NPK (16:8:24) per annum and this is applied before flushing and flowering.

Citrus intercropped with bananas usually receive fertilizer applied to bananas.

(ii) *Weed Control* — Weed control methods include (*a*) manual (cutlassing) and (*b*) chemical (mainly Gramoxone). Weed control is done 2 or 3 times a year; where citrus is intercropped with bananas. When bananas are cleared of weeds, citrus is weeded at the same time.

(iii) *Irrigation* — Citrus is generally grown under rainfed conditions. Irrigation is not common.

(iv) *Spray programme* — The national citrus spraying programme conducted by the Tree Crop Unit of the Division of Agriculture involves spraying against (*a*) Rust and Broad mites (*b*) Melanose, and (*c*) Citrus scab.

Chemicals used include Benlate and Copper Oxychloride (fungicides) which is used to combat scab and melanose; and Ethion and Dicofol used against mites.

(v) *Pruning* — Pruning is an important agronomic practice which is useful in shaping citrus trees, allowing for free movement of air and penetration of sunlight. This tends to reduce humidity and hence the incidence of disease.

In Dominica, pruning of citrus has been given little attention or priority. Recognizing its importance and benefits, the Division of Agriculture in coordination with CARDI are presently engaged in an education drive to sensitize farmers to the usefulness of pruning in tree crop management.

(vi) *Liming* — This is highly desirable in spots, but not really practiced.

(vii) *Drainage* — The Ministry of Agriculture recommends proper soil drainage to assist with all the other practices to achieve high quality and production.

3.2.3 Yields

(i) Full bearing grapefruit trees can yield from 200 to 2000 fruits per tree per year.

(ii) Washington Navel orange and Ortanique can yield from 600 to 700 fruit per tree per year.
(iii) Valencia oranges and tangerines can yield up to 1000 fruits per tree.

3.3 Passion Fruit

3.3.1 Planting Methods and Planting Distances

Passion fruit is usually planted 3 m – 4.6 m (10 – 15 ft) apart and trained on the trellises of post and wire. Planting systems used in Dominica include: (*a*) Canopy-type system, (*b*) T-trellis system, and (*c*) Fence-type system.

The Fence-type system is generally recommended by the Ministry of Agriculture. Depending on topography or terrain, the system used may vary; in hilly areas, farmers tend to use the Canopy-type system whereas on gently sloping or flat terrain, the Fence or T-trellis is used.

3.3.2 Crop Husbandry

(i) *Training* — Two leaders are usually allowed to grow from each seedling and side shoots are removed until the vines reach the wires.

(ii) *Fertilization* — The compound fertilizer 16:8:24 is often used in fertilizing passion fruit. Two and sometimes three applications of fertilizer are applied before the first fruiting.

(iii) *Weed control* — Weed control methods used include: (*a*) manual (cutlassing) and (*b*) mechanical (use of brushcutters is increasing).

(iv) *Irrigation* — Passion fruit is grown under rainfed conditions; irrigation is nonexistent.

(v) *Spray programme* — No comprehensive spray programme has been developed for passion fruit cultivation.

(vi) *Pruning* — In passion fruit cultivation in Dominica, it is recommended for vines growing on trellises, that every alternate lateral should be pruned. However, because of the labour intensiveness of such an exercise, most passion fruit farmers who are banana producers do not have the time to maintain vines in a highly pruned condition. Generally, the farmers carry out basic pruning which involves removal of side shoots and dried vines.

(vii) *Rat control* — Rats cause great economic loss to farmers yearly. This is more prevalent in fields that are unpruned and those grown under the Canopy system. Baiting is a must.

3.3.3 Yields

Data collected from farmers indicate that average yield ranges from 4336 kg to 5443 kg (10,000 lb. to 12,000 lb.) of fruit per acre (0.4 ha).

IV. Cost of Production

Farmers grow crops to sell and make money. The profitability of a crop and the degree of security it provides the farmer in terms of regularity or stability of income are vital considerations in the choice of crops grown.

Tree crops often appear a riskier investment than short term crops. The longer the period from planting to first harvest, the greater the risk that the market situation on which the decision to plant was made may have changed.

A tree crop once established cannot be easily or cheaply replaced. Farmers therefore adopted a minimum maintenance strategy resulting in low costs but also lower yields. The major cost of production is therefore labour for harvesting and transport to market. The average cost of transport is 3.5 cents per pound (0.5 kg), or $115 for a pick-up or $315 for a 4-ton Bedford lorry.

4.1 Avocado

4.1.1 Cost of Establishment

The cost of establishing one acre (0.4 ha) is $2,100 over 5 years. At full production one should expect 150 to 250 fruits per tree. Cost of production is 11 cents per pound(0.5 kg). Price per pound is 50 cents. Margin is 39 cents per pound, income per acre (0.4 ha) is $4,100, and return per man day is $100. However, much avocado goes unpicked as quantities purchased by hucksters tend to be small.

4.2 Citrus

4.2.1 Cost of Establishment

The cost of establishment for grapefruit is $1,800 per acre (0.4 ha) over 4 years and for oranges $2,150.

4.2.2 Production

By year 7, grapefruit will produce 400 fruits per tree or 7 tons per acre (7 t/0.4 ha). Oranges will produce 300 fruits per tree or 5 tons per acre (5 t/0.4 ha).

Cost of production per pound (0.5 kg) for grapefruit is 8 cents per pound and for oranges 12 cents.

4.2.3 Sales and Returns

(i) *Grapefruit* — Grapefruit is sold into three different markets. These are:

The Huckster market where the price is 18 cents per pound yielding returns of EC $70 to EC $80 per man day.

The Citrus Growers Association where the price is 13 cents per pound yielding returns of $33 per day if 80% of fruit is accepted.

The DAI juicing where the price is EC 7.5 cents. Harvesting costs are greatly reduced, but fixed cost of heading and transport will determine profitability to the farmer. Farmers can make a profit of 3 to 5 cents per pound.

ii) *Oranges* — All oranges are sold on the Huckster market where price varies from 25 cents per fruit

to 45 cents or 50 – 90 cents per pound. At a price of 50 cents per pound a farmer makes 38 cents per pound — a return on labour of $315 per man day.

4.3 Passion Fruit

4.3.1 Cost of Establishment

The cost of establishment is about $4,000 to $5,000. The returns to Passion fruit are not fully calculated as yet. Average yields are below 10,000 pounds per acre (4.5 t/0.4 ha). Minimal pruning is done, reducing yields in later years and shortening the life of the vine.

An indicative profile is given below:

Year	Yield lb.	(t)	Value @ 50¢/lb	Cost/acre	Margin
1	2,500	(1)	$1,250	$5,000	3,750
2	10,000	(4.5)	$5,000	$1,200	3,800
3	10,000	(4.5)	$5,000	$1,200	3,800
4	10,000	(4.5)	$5,000	$1,200	3,800
5	10,000	(4.5)	$5,000	$1,200	3,800

It takes two years to break even.

V. Harvesting

5.1 Avocado

METHODS: By hand or picking pole (khali) usually involving climbing into tree.

TOOLS: Picking pole, field crate, or baskets.

MATURITY INDEXES: 'Normal" month of maturity for each variety reasonably well known. Other indicators used: skin shine, flesh colour, colour of seed coat, size of fruit, loose stones. CARDI is currently testing a technique for predicting avocado maturity using flowering date and fruit size.

MAIN PROBLEMS: Stalk removal is a common problem particularly with some varieties when picked by hand. Loose stones cause internal bruising. Germinated seeds occur in fruit while still on the tree. Reaching all fruit on the tree is difficult and costly in labour. Unevenness of fruit maturity particularly in some varieties. Difficult to determine maturity of individual tree/fruit — under and over mature fruit reaching the market. Variety identity not always known. Ministry of Agriculture, Dominica, have produced a photographic varietal identification booklet and key to varietal identification for the 13 main grafted pears grown in Dominica. Work has also been completed on the storage and ripening characteristics of the grafted pear varieties.

5.2 Passion Fruit

METHODS: Normally picked from the ground twice a week .

TOOLS: Bag, crate.

MATURITY INDEXES: Colour change from green to yellow.

MAIN PROBLEMS: Greasy spot, rat damage, rapid shrivelling after falling to the ground.

5.3 Citrus

METHODS: For fresh market, fruits are picked by hand; for processing, fruits are shaken from the tree.

TOOLS: Baskets, crates.

MATURITY INDEXES: Skin colour, taste, size, knowledge of orchard.

MAIN PROBLEMS: Small-sized fruit, particularly in grapefruit and orange. Late maturing fruit (to catch best markets) — grapefruit and lime. Fruit drop towards end of season prevents extension of market. Poor flesh colour of red grapefruit. CARDI is currently addressing some of these problems using improved production management practices.

VI. Post-harvest Handling

6.1 Avocado

Transportation from the field to the packhouse is usually by pick-up. The containers used are field crates. Bruising is a common problem.

Packhouse operations include:

- Receiving.
- Sorting: pears are not usually graded in any way.
- Washing: not usually carried out, sometimes wiped.
- Post harvest treatments: not usually carried out; 1 g/1 Benlate dip has been used to control stem end rot.
- Packing: single-layer carton, net wt. 4.5–7 kg (10-15 lb.), used for extra-regional export; multilayer box/jumble pack used for regional export.
- Storage: pears are normally packed immediately before shipment without a period of storage.

Rejection rate (1 = most common, 6 = least common) is as follows:

• bruising	1
• cuts	3
• spray damage	5
• smashing	6
• pests	2 (anthracnose, stem end rot, 'russetting")
• others	4 (internal blackening)

6.2 Passion Fruit

Transportation from the field to the packhouse is by pick-up. The containers used are crates and bags. Squashed fruit is the main problem.

Packhouse operations include:

- Receiving.
- Sorting: debris, leaves or rotten fruit removed before processing; firm and yellow fruit for fresh fruit export.

- Washing: not normally carried out for fresh fruit sale.
- Post harvest treatments: none.
- Packing: hucksters use bags (Antigua) or cartons.
- Storage: fruit may be stored for up to 4 days on the farm before transport to processor.

Rejection rate (1 = most common, 6 = least common) is as follows:

• bruising	6
• cuts	6
• spray damage	6
• smashing	2
• pests	1 (greasy spot/brown spot)
• others	6

6.3 Citrus

Transportation from the field to the packhouse is by pick-up. Containers used are crates or fruits placed directly on bed of vehicle.

Packhouse operations (CCGA) of grapefruit and oranges include:

- Receiving: initial sort and fungicide treatment given at CCGA before degreening with ethylene during early season.
- Sorting: approx. four separate sorting points on CCGA line prior to automatic size grader.
- Washing: using detergent and fungicide.
- Post harvest treatments: wax and fungicide applied.

N.B. None of the following operations are carried out by hucksters.

- Packing: fully telescopic citrus carton; cartons also used by most hucksters
- Storage: held in well ventilated room before shipping at 13°C.

Rejection rate (1 = most common, 6 = least common) is as follows:

• Bruising	2
• Cuts	6
• Spray damage	5
• Smashing	5
• Pests	2 (brown rot, green mold, rust mites, scab)
• Others	2 (picking blemish, contact blemish)

N.B. CARDI has carried out assessments on causes of rejection by the CCGA packhouse and a report can be found in the Post-harvest Group Report for June – December 1989.

VII. Shipping and Distribution

7.1 Avocado

REGULATIONS: Entry prohibited to Guadeloupe, Martinique, and the U.S.

COSTS: Sea/Air

N.B. The Post-harvest Group of Dominica has produced a booklet on handling of avocados for export entitled *Make More of Avocados*.

7.2 Passion Fruit

REGULATIONS: Export to Guadeloupe prohibited.

7.3 Citrus

REGULATIONS: Imports to U.S. prohibited.

VIII. Processing

8.1 Avocado

Avocados are not processed.

8.2 Citrus

Grapefruits and limes are processed into grapefruit concentrate, lime juice concentrate, and lime oil by Dominica Agro Industries (DAI).

During the 1990 grapefruit season, DAI processed 3939.3 tonnes of grapefruit, producing 49,000 gallons (196,000 L) of grapefruit concentrate. Grapefruit concentrate was sold in the U.S. in bulk -45 gallon drums.

The factory operates a completely mechanized system. However, the citrus plant has been experiencing problems of operating below capacity due to insufficient fruit reaching the factory, particularly from the north of the island. This is a result of the low price paid to the farmers. There are also problems related to frequent equipment breakdown as a result of aging machinery.

Oranges are not processed in Dominica.

8.3 Passion Fruit

Passion fruit is processed by two companies in Dominica, Corona Development Ltd and P.W. Bellot & Co. Ltd. Corona Development Ltd. extracts the pulp from fresh fruit while P.W. Bellot finishes and converts the pulp into passion fruit syrup and jelly, under the BELLO Brand. For the period January to December 1990, 150,612 kg (332,043 lb.) of passion fruit was processed by Corona, yielding 50,204 kg (110,681 lb.) of pulp.

Corona Development Ltd. has a plant capacity of 2,268 kg (5,000 lb.) passion fruit per hour; the plant is currently operating at 20% capacity. The plant uses equipment consisting of a rotary drum washer, a cutting unit with circular rotating knives, and a perforated conical basket extractor rotating at high speed to extract the passion fruit pulp. The pulp is packaged (in bulk) in plastic buckets.

The main problem affecting processing is the availability of passion fruit for processing. Corona Development Ltd. has been working closely with farmers to increase production with some success. HIAMP and the AIDB administer funding programmes for production of passion fruit while CARDI is conducting research in a production system for passion fruit.

IX. Main Markets, Demand and Supply

9.1 Avocado

The marketing period is divided between the early crop, main crop, and late crop. Prices are always higher for the early and late crops.

Principal markets are the region and the U.K. The regional markets have a marked preference for the large varieties. The varieties going to the U.K. are principally Lula and Semil 34. Lack of proper airline transportation has made it difficult to develop the market for other varieties. Islands in the region purchasing Dominica's avocados include Barbados, Antigua, Guadeloupe, U.S. Virgin Islands, British Virgin Islands, St. Maarten and St. Kitts. Higher prices are obtained in Antigua; however, much improvement is desired in the quality of fruit on that market. Prices are usually low during the main crop and this is due to the availability of local varieties during that time. Only in Guadeloupe is there a plant quarantine restriction on the import of avocados.

9.2 Citrus: Grapefruit, Orange, and Lime

The main regional market is Guadeloupe. Shipments of grapefruit to the U.K. between August and October has been decreasing every year. The islands north of Dominica are our major markets. Barbados to the south at one time was the major market, but supplies coming from St. Vincent and St. Lucia have outstripped Dominica's volume.

The availability period for oranges is relatively short (3 months) and there is need to extend this by increasing production of ortaniques which are a later variety.

The demand for imported grapefruits show an upward curve from March and this implies that the local supplies are exhausted. During this period, even St. Lucia which is a traditional exporter also imports supplies from Dominica.

9.3 Passion Fruit

The main market is the French island of Guadeloupe. Though somewhat barred by quarantine restriction, yet the fruit enters via Marie Galante. Dominica's main export port is Anse de Mai in the French state. Other supplies go to St. Maarten.

Demand has always been greater than supply and price offered to producers by fresh fruit traders has always been higher than that paid by the processor. During the year 1989, 7,257 kg (16,000 lb.) of fruit was exported.

GRENADA

CECIL WINSBORROW
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I. Generalities

1.1 Citrus

1.1.1 Projects

There are no fruit projects being implemented.

1.1.2 Ecological Problems

Rainfall is an ecological factor affecting production. Some species, e.g. mandarin, cannot be grown in the drier areas whereas such areas might only be suitable for lime production.

1.1.3 Area Planted

It is very difficult to determine the area planted because of the scattered nature of production. Although small areas of limes can be found, all the other citrus species tend to be interplanted between cocoa, bananas and nutmeg. Total production is probably about 508 t (500 tons) from about 60.7 ha – 80.9 ha (150-200 acres).

1.1.4 Production Costs and Returns

Establishment and maintenance cost over a 5-year period is around $7,000.00/acre (0.4 ha). Returns after 5 years for oranges is $4,000/acre (50 lb./tree × $0.50/lb × 109 trees/acre. Returns for grapefruit = $2,625.00 (70 trees × 150 lb. × $0.25) and for limes are about $2,895.00 (193 trees × 100 lb. × $0.15/lb) 1 lb. = 0.5 kg

1.1.5 Seasonility

Species	Season	Peak
Orange	Aug.–Mar.	Nov.–Dec.
Grapefruit	Nov.–Feb.	Dec.–Jan.
Lime	Sept.–Feb.	June–Oct.

1.1.6 Main Market, Demand and Supply

The main market is local and demand tends to be consistent. Gluts occur in grapefruit and lime during the peak periods and prices paid to the farmers can reach as low as $0.10 and $0.08/lb. (0.5 kg) respectively. In 1990 there was export of fresh fruit by MNIB and PFU. These were as follows:

Commodity	1989	1990
Orange	810	15,376
Lime	1,545	7,188
Grapefruit	0	18,375
	2,355	40,939

In the Trinidad trade, limes are probably the most important item and this is mostly so in the "off" season around January – April.

A wide range of citrus products are imported. In 1989 import of citrus products was valued at $1,091,051.00.

1.2 Passion Fruit

1.2.1 Projects

There are not projects being implemented in passion fruit in Grenada. A project profile "commercial production of passion fruit for fresh market Grenada and St. Vincent and the Grenadines" was developed by IICA to supply "Great American Farms" but the arrangement never got off the ground.

1.2.2 Ecological Problems

There are no major problems with the ecology. It is more difficult to set trellises on slopes and poor fruit set is a problem in some areas.

1.2.3 Area Planted

It is difficult to give the area planted since production is mostly on individual vines. Total size is approximately 1.2 ha (3 acres). Limiting factors to production are the cost of the trellising materials and the small size of the local market. Farmers are not fully aware of the potential of the crop.

1.2.4 Production Costs and Returns

Production cost is adopted from work done by CARDI. It is extrapolated from data collected from 72 vines at the field station on a per hectare basis.

Labour — 338 m/days @ $20.00/day = 6,760.00

Materials	
Wood	29,640.00
Wire	348.00
Fertilizer	113.00
Gramoxone	28.00
Total cost of materials	30,129.00
Total cost: material + labour	36,889.00

1.2.5 Seasonality

The main season is from May to July with smaller crops from October to December.

1.2.6 Main Market, Demand and Supply

The main market is local. Demand is not known. A market survey conducted by the Ministry was inconclusive; most of the outlets did not know how much they would need since they were not using the fruit.

1.3 Avocado

1.3.1 Projects

There are no fruit projects currently being implemented.

1.3.2 Ecological Problems

Two of the biggest problems are avocado die back and termites. Plants do not perform well towards the middle of the island or in exposed windy areas.

1.3.3 Area Planted

Avocado cultivation is scattered throughout Grenada. There are no large cultivations. Holdings vary from a few trees to 0.4 ha (1 acre). Total size is probably about 20.2 ha (50 acres). Limiting factors for production are pest and disease, and dependence on local types which causes gluts on the market giving the impression that the market is oversupplied. Total production is around 259 t (255 tons/year).

1.3.4 Production Costs and Returns

Establishment cost over a 5-year period is approximately $8,000.00 /acre (0.4 ha). Revenue after 5 years is approximately $4,800/acre if $0.30 is allowed per pound (0.5 kg) for a harvest of 16,000 lb (7 t).

1.3.5 Seasonality

The main season is from August to October. However, small harvests are made in June, July, and November.

II. Pre-production

2.1 Citrus

2.1.1 Cultivar Selection

Orange	Grapefruit	Lime
Washington Navel	Marsh seedless	West Indian
Valencia	Duncan	Tahiti
Parson Brown	Thompson pink	
Jaffa		
Pineapple		

Other minor types are Mandarin, Tangerine, Ortanique, Ugli fruit, King Orange, Rough Lemon.

2.1.2 Propagation

This is by inverted 'T' bud. Sour Orange is the primary rootstock although Rough Lemon and Rangpur lime are sometimes used. Sour Orange seeds are collected from October to December and sown either directly in bags or bins.

Seeds germinate in 10–12 days and reach budding size in 9 months. Plants are budded using scion material collected from mother stock at Mirabeau Propagation Station. Plants are distributed 7 to 8 months after budding. Approximately 3,000 plants, consisting of about 70% orange, 20% grapefruit and 10% others, are produced and distributed every year. Production is around 80%.

2.1.3 Plant Demand and Supply

Plant supply is not enough to meet the demand. Farmers are, however, repeating requests because of poor post-planting practices.

2.2 Passion Fruit

2.2.1 Cultivar Selection

The main cultivar is the yellow type *Passiflora edulis* f. *flavicarpa*. No cultivar selection has been done. CARDI Grenada is involved in analysing Hawaiian cultivars.

2.2.2 Propagation

Propagation is mostly by seed or cuttings. Seeds are pregerminated in bins and then potted out. Plants are ready for distribution in 10 weeks. Semi-hard

pieces of cuttings are used and rooting is done under the mist. Rootstocks are not used since grafting is not done.

2.2.3 Plant Demand and Supply

Plant demand is very small and propagation is done only on request since plants entwine if kept in the nursery.

2.3 Avocado

2.3.1 Cultivar Selection

Most of the production is based on local selections which are preferred for Trinidad trade. These tend to be mostly bottle-necked, thick, yellow-fleshed, and ripening red. Local selections which mature from August to October are Evans, Simpson, Griffith, Grand Bras, Cadrona, Miss Grenada, Need, Popo, and Anita.

Other varities with descriptions are the following:

Varierty	Season	Avg. Wt. (kg)	Type	Race
Pollock	July – Sept.	0.5 – 0.75	B	W.I.
Lula	Nov. – Dec.	0.25 – 0.4	A	G×W
Simmonds	May – Aug.	0.45 – 0.7	A	W.I.
Hall	Apr. – Sept.	0.55 – 0.85	B	G×W
Booth 7	July – Nov.	0.30 – 0.45	B	G×W
Choquette	Oct. – Feb.	0.6 – 0.9	A	G×W

Adapted from J.A. Samson, *"Tropical Fruits"* 2nd edition

Other varieties brought from Dominica in 1990 include Dominica selected; Semil 34, 43, 31; Gripina 5, 12; Everton 1, 2; and Collinson.

2.3.2 Propagation

Propagation is done using a wedge graft. Seeds are purchased from the general public at $0.10 each around August to October. About 20% do not germinate. Seeds are washed with chlorox, 56.7 g/4 L (2 oz/gal), after cutting and removal of skin. They are then dipped in Benlate solution and sown in a sterilized medium 3:2:1 of soil, manure, and sand.

After germination plants are wedge-grafted while the stalk and leaves are still pink. Grafts are then covered with diothene pots. Take is verified after about one month and distribution occurs in the following season. Production is around 80% except during periods of heavy rains.

2.3.3 Plant Demand and Supply

Plant demand is equal to supply. There is a need to increase plants of the later types, and to sensitize farmers to plant these types. In 1989, 1,216 plants were distributed, while in 1990, 2,000 plants were distributed.

III. Production Systems

3.1 Citrus

Most of the citrus is grown as described before. No special emphasis is placed on cultural practices. For the younger fields being established, plants are put at specific spacings with emphasis on weed control and fertilization. No special figures are available on yields per tree, estimates at year 5 have been given before.

The major factors affecting production are those of pest and diseases and non-pruning of rootstock. Sooty mold, scale, ant, mealy bug complex is found on almost every tree on the island. Many citrus plants also turn out to be rootstock growth because of lack of pruning.

3.2 Passion Fruit

Plants are usually spaced 3 m × 3 m (10 ft × 10 ft). Most of the passion fruit grown in Grenada are from vines allowed to climb live trees. Special attention is not given to spraying, fertilizing, or weed control. Fruits are collected once they fall to the ground. Attempts are being made to get farmers to use trellises and to adapt to production systems available in the region.

Extrapolated yield obtained by CARDI in the field station using 72 plants was 3,047 kg/ha or 39,611 fruits. ha^{-1} $year^{-1}$. Thirteen fruits weighed 1 kg (an average) there 40 fruits per vine per year and 988 plants/ha.

Crops are not grown in any organized fashion and as a result it is difficult to administer services.

3.3 Avocado

A spacing of 9 m × 9 m (30 ft × 30 ft) is recommended. Most of the avocados grown in Grenada are planted under shade between plots of cocoa, nutmeg, and bananas. Plants tend to grow long and thin, toppling sometimes when laden with fruits. No special emphasis is placed on fertilizing or other cultural practices. Plants tend to benefit from whatever practice is being carried out on the other crops.

Attempts are being made now to have trees planted in orchards without shade, and with proper drainage. It is recommended that three applications/year in the first 3 years using a mixture of sulphate of ammonia and some triple superphosphate be used as a fertilizer and later changed to a complete fertilizer.

On average the yield is about 136 kg (300 lb.)/tree.

IV. Harvesting

4.1 Citrus

Fruits are usually picked by hand with no special devices. Grapefruits and limes are usually harvested when skin colouration develops. Oranges are never allowed to mature fully or ripen on the tree because of problems with praedial larceny and local demand.

4.2 Passion Fruit

Passion fruits are collected once they fall to the ground.

4.3 Avocado

Harvesting is done by climbing or using a picking bag. For the Trinidad market fruits are picked by whatever means available.

V. Post-harvest Handling

5.1 Citrus

There is no special emphasis on post harvest care. Fruits are transported to the local market in black boxes, bags, or baskets and sold fresh. Except for maybe washing to remove sooty mold, no other treatment is done.

5.2 Avocado

For the U.K. market, fruits are transported to the packhouse in banana boxes. At the packhouse fruits are checked for bruises or disease spots, clipped of stem remains, and dipped in Benlate. There have been reports of a mixture of varieties in one box, premature ripening, stem end rot, and anthracnose. All shipments are done by air. For the Trinidad market no efforts has been made at grading, etc. Fruits are packed in wooden crates and transported by overnight schooner. Large amounts of premature ripening and spoilage occur.

VI. Marketing

6.1 Passion Fruit

Fruits are sold on the local market for $0.20 to $0.25 per fruit. Extrapolated gross revenue/ha = 39,611 × $0.25 = $9,902.75.

6.2 Avocado

The U.K. market showed an increase in 1990. Exports to the U.K. in 1989 were 13 t (28,388 lb.) and in 1990 were 31 t (68,096 lb.).

Actual figures are not available for the Trinidad Market. It is felt that exports to this market have decreased over the last couple of years. A conservative estimate is put around 101.6 t (100 tons).

Local consumption is put around 76 t (75 tons).

GUADELOUPE

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INTRODUCTION

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

Table 1 indicates that fruit growing other than banana represents only 10% of agricultural surface (580 ha).

Available areas in Guadeloupe are too limited to consider fruit export. Moreover, the local demand is by far not supplied. Though the situation is evolving, only a few farmers are very interested in fruit growing:

- Heavy investments as compared to long-term returns (three or five years between planting and cropping).
- High labour costs (more than 30 FF per hour).

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

Four 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 Passion Fruit

1.1.1 Fruit Project

A 40-ha subsidized project was initiated at the end of 1989. Unfortunately, only 1 ha has been planted to date. This situation can be explained by; the high investment for the purchase of vine supporting materials and plants (in spite of the subsidy) and perhaps by better understanding the possibility of the local market.

1.1.2 Planted Area and Value of the Production

Passion fruit planted is estimated to be about 14 ha, though the major part is non-commercial orchards. Estimated production is around 200 mt and production prices range from 5 to 6 FF/kg.

1.1.3 Production Costs and Returns

As indicated in Table 2, production costs per hectare range between 77,870 FF and 58,823 FF, and returns range between 81,000 FF and 90,000 FF.

Note the importance of investment in the first year for setting up of supporting structures and land preparation (83,193 FF). Vines are replaced after 3 years.

Table 1
Guadeloupe Soils Utilisation

Cultures	Areas ha	Areas %	Exploitation No	Exploitation %
Cereals	28	0	60	0
Industrial crops	16952	36	7837	47
Sugar Cane	16723	36	7591	46
Others	229	0	263	2
Vegetable crops	3815	8	6978	42
Tubers, roots bulbs	2127	5	5474	3
Fresh vegetables	1523	3	2550	13
Dried vegetables	162	0	530	3
Semi-permanent fruit crops	7715	16	3289	20
Banana	7328	16	2888	17
Pineapple	261	1	459	3
Others	26	0	49	0
Fallows	882	2	718	4
Permanent fruit crops	580	1	721	4
Grassed down surfaces	16233	35	9192	56
Planted grass lands	1080	2	560	3
Natural pasture lands	12502	27	7558	46
Productive heathland	2651	6	1743	11
Flower crops		0	113	1
Total crops	46740	100	16272	98

Table 2
Estimated Production Costs and Returns for Passion Fruit

Item	Year 1	2	3	4	5	6	7
Supporting structures	78643						
Material	72643						
Labour	6000						
Land preparation	4550						
Planting	18884						
Plants	12000						
Fertilizer	3284						
Labour	3600						
Fertilizer	3131	4468	4468	3131	4468	4468	3131
Material	2081	2968	2968	2081	2968	2968	2081
Labour	1050	1500	1500	1050	1500	1500	1050
Disease and pests control	3355	3355	3355	3355	3355	3355	3355
Material	1255	1255	1255	1255	1255	1255	1255
Labour	2100	2100	2100	2100	2100	2100	2100
Weeding	7800	7800	7800	7800	7800	7800	7800
Pruning	24000	18000	18000	24000	18000	18000	24000
Irrigation	1200	1200	1200	1200	1200	1200	1200
Harvesting	19500	24000	24000	19500	24000	24000	19000
Total Cost	161063	58823	58823	77870	58823	58823	77870
Production return (FF) (4,5 FF/kg)	81000	90000	90000	90000	90000	90000	90000

1.1.4 Seasonality

Flowering occurs throughout the year, but the two major production seasons identified on the leeward coast of Basse-Terre are May–June and October–November.

1.1.5 Main Markets, Demand and Supply

Passion fruit is commercialized as a fresh fruit and also for processing. At the present time, local processing outlets import more than 90% of their requirements by means of deep-frozen or concentrated deep-frozen pulp, which represents an equivalent of about 400 mt of fresh fruit. Besides increasing consumption connected with tourism development and some hope for exportation of processed products (fruit juices, jellies), it appears that there's a place for reasonable development of this product in Guadeloupe (about 600–700 mt).

1.2 Citrus

1.2.1 Fruit Project

Since hurricane "Hugo," several development projects have been prepared by local authorities but none have actually started. In the first stage, about a 100-ha plantation should be realized.

1.2.2 Planted Area and Value of the Production

Table 3 indicates an estimation of areas and production of citrus in Guadeloupe. These small areas are characterized by scattering. Most citrus exploitations have less than 1 ha and many of them are only dooryards. Production prices range from 5 FF to 8 FF/kt. Limiting factors for extension are the same as that for other perennial fruit cultures through investments and long delays before cropping.

1.2.3 Production Costs and Returns

Table 4 indicates a **theoretical** estimation. There is no knowledge of such production in Guadeloupe.

1.2.4 Seasonality

The major production seasons identified in Guadeloupe are the following:

Limes:	from June to November
Oranges:	from Nov-Dec to February
Mandarins:	from November to February
Grapefruits:	from September to February

Limes have an ever-bearing character. The same ever-bearing character has been observed with some orange varieties (especially Washington Navel) when grown at an altitude greater than 600 m.

1.2.5 Main Markets, Demand and Supply

As there are only a few areas planted, production is small and consumed locally. Importation is therefore needed to provide the demand.

Importations are essentially made from Dominica (Grapefruits), Cuba (Oranges), Florida (Grapefruits), Spain (Oranges, clementines).

Table 3
Citrus areas, production, and markets

	Area (ha)									
	Total		Bearing trees		Production (t)		Export (kg)		Import (t)	
	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988
Orange	54	62	48	56	602	616	101	113	1367	621
Mandarin	17	19	15	17	402	400	990	237	6	10
Grape-fruit	482	51	44	49	511	827	180	367	238	144
Lime	135	135	135	135	1669	2530	1205	—	15	92
Mexican Lime	8	8	8	8	106	106	—	—	—	—
Others	—	—	—	—	—	—	—	—	95	4
Total	262	275	250	265	3290	4479	2476	717	1721	871

Table 4
Estimated production costs and returns (FF) of an ha of citrus.

Item	Year 1	2	3	4	5	6	7
Land preparation	7700						
Planting	19835						
Plants	8000						
Fertilizer	5235						
Labour	6600						
Disease and pest control	1826	3252	5778	7884	8910	10715	12770
Material	1026	2052	3378	4684	5710	7970	7970
Labour	800	1200	2400	3200	3800	4800	4800
Weeding	7500	5500	6700	6700	6900	6900	6400
Pruning	—	600	1200	3000	3600	4500	4500
Irrigation	1500	1500	1500	1500	1500	1500	1500
Harvesting	—	—	1500	3900	12000	15000	18000
Total costs	38701	11517	17544	24189	34641	41026	45099
Production return (FF) (6 FF/KG)	—	—	12000	32000	96000	120000	144000

1.3 Avocado

The area planted with avocado trees is estimated at 26 ha for a production of 185 mt. This production is a dooryard one, so that very little information is available on it. IRFA has planned to realise local prospections to select local types combining fruit quality, diseases resistance (anthracnosis, *Cercospora* disease), and particularly staggering of production. It seems that few soils are available for avocado culture, particularly in relation to the gummosis problem (*Phytophthora cinnamomi*). New resistant rootstocks would be welcomed. Production costs and returns are estimated in Table 5, and production prices range from 6 to 10 FF/kg. The production season ranges

Table 5
Estimated production costs and return (FF) of 1 ha of avocado.

Item	Year 1	2	3	4	5	6	7
Land preparation	4550						
Planting	15205						
Plants	6000						
Fertilizer	4105						
Labour	5100						
Disease and pest control	958	1587	2673	3460	4246	4961	4961
Material	158	387	673	1060	1446	1761	1761
Labour	800	1200	2000	2400	2800	3200	3200
Weeding	7500	5500	6700	6700	6900	6900	6400
Pruning	—	1500	1500	2400	3000	3000	3000
Irrigation	—	200	200	200	200	200	200
Harvesting	—	—	1800	3600	5400	7200	9000
Total costs	28213	8787	12873	13360	19746	22261	20561
Production return (FF) (6 FF/KG)	—	—	12000	24000	36000	48000	60000

from early August to end of January. Consequently, the local market is only accessible, but local demand is by far not supplied. Some importations are made from Santo Domingo.

II. Pre-production

2.1 Passion Fruit

2.1.1 Cultivars

A mass selection programme of local types of *Passiflora edulis f. flavicarpa* was conducted in Martinique (IRFA). Plants selected for their agronomic qualities: yield capacity, juice production, and quality are propagated.

2.1.2 Propagation Methods and Technics

Passion fruit is propagated by cuttings — Semi-lignified tips are picked to make cuttings of 20–25 cm long with three internodes. Leaves are half-cut to reduce evapotranspiration. Cuttings are bevelled at the base. This bevel is powdered with rooting hormone (Rootone F). Then cuttings are set out in containers with moistened perlite, under mist of 1 mn every 12 hours.

Cuttings are regularly treated with fungicides. After about 3 weeks, cuttings have rooted and they are transplanted in a steam-sterilized substrate (⅓ bagasse compost, ⅔ sand.) Interval cutting-plantation is about 2½ months .

2.1.3 Plant Demand and Supply

There is no problem to supply the small demand for plants.

2.2 Citrus

2.2.1 Cultivars

The main citrus plant production is realized by IRFA (Neufchateau) that guarantees varietal identity and good sanitary conditions.

The installation of a new plot of trees reserved for bud-wood is outstanding. It will include more than 40 varieties free from viruses, viroids, and mycoplasmes (origin: IRFA Martinique).

2.2.2 Propagation, Rootstocks, and Related Problems

The main grafting method is T-budding (sometimes chip-budding). Rootstock choice is directed by pests and diseases (*Diaprepes abbreviata* and poropsis). *Citrus macrophylla* and Volkameriana are used for limes and grapefruits ("acid fruits") *Citrus aurantium* for oranges and mandarines.

These rootstocks are not resistant to *Tristeza* but neither the disease nor its main vector *Toxoptera citricidus* are present in Guadeloupe. Much is hoped for with rootstock trials planted by colleagues from IRFA Martinique.

2.2.3 Plant Demand and Supply

Main plant demand is from private individuals and not from farmers. About 9,000 citrus plants were produced and sold by the IRFA nursery in 1990. Actual demand could be about 10,000–12,000 plants/year.

III. Production Systems

3.1 Passion Fruit

3.1.1 Planting

(i) *Plant Spacing* — Recommended spacings are 2 to 2.5 m between rows and 5 m between plants in the rows (800 to 1,000 vines/ha). North/south or east/west orientation of rows could be looked into since areas that are sheltered from heavy winds may or may not be essential with regard to maximum exposure to sunlight.

A small mound 30 cm high is often made along the row before planting. This improves surface drainage.

(ii) *Supporting Structures* — Passion fruit is normally grown commercially on vertical trellises. It consists essentially of a series of posts 2-m high, set at 5-m intervals and supporting one wire strained to sustain the weight of the vines.

(iii) *Training* — The aim of training is to get the vines onto the wire as quickly as possible. Training is time-consuming and must be done weekly. After several weeks of growth, a vigorous leader is selected and trained to the top wire by tying or taping it. All other axillary shoots, flowers, and any fruit are removed. Once the leader reaches the wire, it is trained in the direction of the prevailing wind. So the main stem is trained along the wire and the canopy forms underneath.

3.1.2 Cultural Practices

(i) *Fertilization* — In full production, the amount of necessary nutrient is based on the following balance (gram per vines):

Nitrogen	400–500 g
Phosphorus	50 g
Potash	200–300 g

An example of inorganic fertilization recommended and based on urea and compound fertilizer (banana fertilizer 12:4:24:8) is shown in Table 6. Fertilizer is applied bimonthly.

(ii) *Weed Control* — When vines are young, it is recommended that paraquat be used, but when their base lignifies it is better to use systemic herbicides such as glyphosate.

(iii) *Irrigation* — The amount of water needed is about 30 to 40 mm per week. The best system seems to be micro-jet (one 360 jet or two 180 jets on each side of the vine).

(iv) *Pruning* — Passion fruit vines can be pruned to encourage new growth and reduce disease and pests infestation. However, because of labour costs, pruning might not be economically profitable. Therefore experimentation is necessary in Guadeloupean conditions.

Table 6
Citrus fertilization (grams of nutrients)

	Year						
	1	2	3	4	5	6	7 and+
N	100	200	300	400	600	800	1000
P_2O_5	25	50	75	100	150	200	250
K_2O	50	100	150	200	300	400	500
MgO	25	50	75	100	150	200	250

3.1.3 Yields

Yields vary largely with management ability of the grower. Disease control, fertilizing, and irrigation are the most important factors influencing yields. Owing to supporting structures and labour costs, yields would not be less than 20 mt/ha.

Experimentation managed in Martinique with a mass selection by IRFA Martinique (No. 1 and No. 4) yielded 30 t/ha, which would be satisfactory without effect of collar rot disease.

3.1.4 Factors Affecting Production and Fruit Quality

- Collar rot disease (*Phytophthora* and *Fusarium*) is the most important.
- Pollination: carpenter bee (*Xylocopa brasilanorum*)

is present in Guadeloupe. However, manual pollination could increase effectiveness.

Irrigation: good management is important for fruit size and fruit setting.

3.2 Citrus

3.2.1 Planting

Planting distances range from 6 × 5 m (mandarines) to 7 × 6 m (oranges and limes) to 8 × 7 m (grapefruits). The planting hole should range from 50 × 50 × 50 cm to 80 × 80 × 80 cm. When planting exceeds a certain number of trees, holes are often made by mechanical shovel.

3.2.2 Cultural Practices

(i) *Fertilization* — Fertilization per tree and per year is indicated in Table 7. Fertilizer is distributed into three applications per year.

(ii) *Weed Control* — Weeds between tree rows are removed by machine. Herbicide is used to control weeds around young trees, or in strips as trees become larger. Of the herbicides, Glyphosate is commonly used.

(iii) *Irrigation* — On the leeward coast of Basse-Terre and all Grande-Terre, irrigation is needed. Overhead or underhead sprinkler systems are commonly used because interplanted cultures are frequent (especially vegetable crops).

(iv) *Pruning* — Pruning is usually not done, except for removal of suckers, dead branches, and shoots or low branches.

3.2.3 Yields

Yields indicated in Table 8 represent an average for potential conditions for Guadeloupe.

Table 7
Citrus fertilization (grams of nutrients)

	Year						
	1	2	3	4	5	6	7 and+
N	100	200	300	400	600	800	1000
P_2O_5	25	50	75	100	150	200	250
K_2O	50	100	150	200	300	400	500
MgO	25	50	75	100	150	200	250

Table 8
Citrus yields

	Year						
	1	2	3	4	5	6	7 and+
Lime	—	0.5	1.5	5	10	15	25
Orange	—	—	1	3	6	9	12
Mandarin	—	—	1	3	6	10	15
Grapefruit	—	—	1.5	5	9	13	20

3.2.4 Factors Affecting Production and Fruit Quality

(i) *Pests and diseases* — The major pest is the weevil *Diaprepes abbreviata* (and *D. famelicus*). Other secondary pests are: scales on leaves and shoots (*Sclenospidus articulatus*); aphids on young leaves (*Aphis spiraecola*); mites on leaves and young fruits (*Polyphagotarsonemus latus*).

Major diseases are parasitic fungi (*Phytophthora parasitica* and *P. citrophthora*) and scaly bark virus (psorosis).

Other secondary diseases are:

- scab (*Sphaceloma fawcetti*) on fruits and young leaves (particularly on grapefruit trees and on sour oranges in nurseries);
- anthracnosis (*Colletotrichum gloeosporioides*): a problem particularly in nurseries on grapefruit trees;
- exocortis: on citrange rootstock and on certain non-regenerated limes;
- greasy spot (*Mycosphaerella horii*) and sooty mold (*Capnodium citri*) are minor diseases.

(ii) *Soils* — The choice of good soils (deep, relatively light, and well-drained) is of prime necessity, particularly with regard to sanitary aspects.

(iii) *Rootstocks* — From field experimentation more information must be provided for a good choice in accordance with diseases and pest problems while preserving quality and yield.

3.3 Avocado

Main part of avocado plant production (grafted plants) is made by the IRFA nursery at Neufchateau. Some private nurseries provide only a small part. People essentially want local types, and it seems that the local demand still remains unsatisfied.

IV. Harvesting

4.1 Citrus

Harvesting is done manually and with rudimentary fruit baskets. Pruning shears are often used to pick mandarins preserving a part of petiole and without tearing the fruit peel.

V. Processing

5.1 Citrus

This concerns essentially fruit juice production for small and medium-sized units. An estimation of production, importation, and consumption of fruit juice (all fruits) is as follows (1986):

Production

Local fruit	1,000,000 L
Fruit juices locally reconstituted	2,000,000 L

Importation	2,000,000 L
Consumption	5,000,000 L

A part of the citrus production is processed (real quantity is unknown) but volume of local production could be higher if, firstly, citrus growing was more important and, secondly, if practised prices were lower.

VI. Marketing

6.1 Citrus

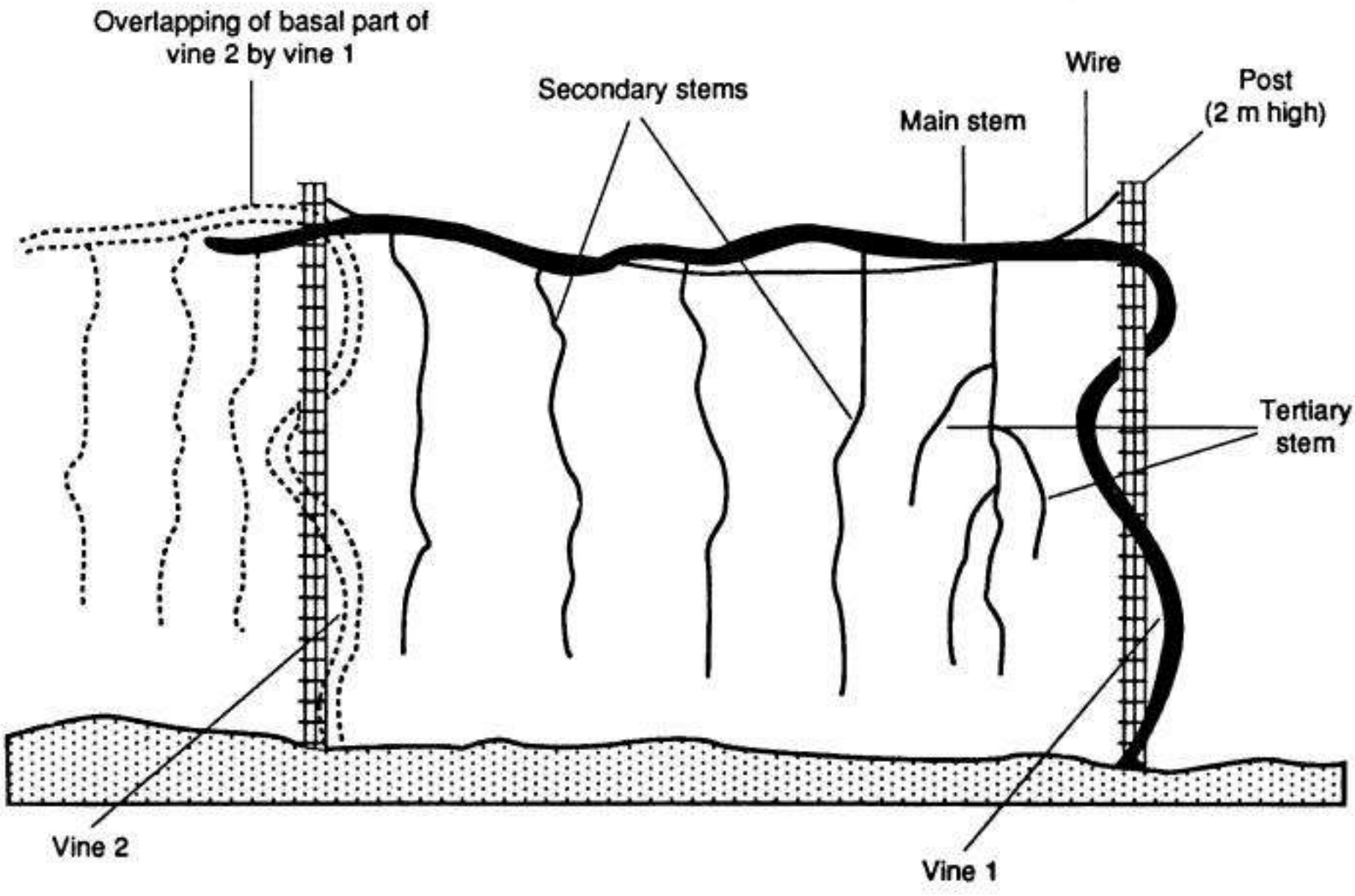
The citrus market is essentially a local market. Farmers sell their produce to retailers (to processing factories) who collect fruits. There are few middlemen. Some farmers also sell their produce directly to consumers to get better profits. The foreign market is insignificant.

VII. Conclusion

7.1 Avocado

Greater effort must be made to promote the development of this crop in Guadeloupe by:

- Research efforts:
  - control of gommosis (*Phytophthora*)
  - adapted techniques
  - staggering of production
- Extension efforts.



Trellising of Passion Fruit

GUYANA

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I. Generalities

The projects currently being undertaken with respect to the crop being considered can be grouped into two broad categories: (1) commercial holdings and (2) subsistence farmers. Farmers at the two levels are usually identified early in the year to form part of the Agricultural extension programme.

1.1 Passion Fruit

Passion fruit is a relatively new crop to Guyana with approximately 16 ha (40 acres) under commercial holdings and about 16 ha (40 acres) divided among subsistence farmers. This crop is grown on a wide variety of soils; however, during the dry periods, passion fruit planted on light soil (sandy soil) tend to undergo water stress and shed their leaves.

The major factor that limits expansion in passion fruit is one of an inadequate supply of young plants to farmers. Approximately 800 plants were sold to farmers in 1990 yet the demand was greater than the supply.

There seems to be no problem with production cost and returns. Farmers generally make huge profits. To produce 0.4 ha (1 acre) of passion fruit in 1990 cost a farmer about $3,000.00. The yield per acre ranged between 15,000 lb. and 22,000 lb. (6.8 t and 10 t/0.4 ha).Fruits are sold at an average of $20.00 per pound (0.5 kg).

This crop shows no rigid fruiting season. Some vines will bear throughout the year, with peak periods between January and March and August and October.

1.2 Citrus (Oranges, Tangerines, and Limes)

Citrus projects in Guyana suffer from generalized problems. These include poor drainage, inadequate extension service (lack of personnel and transportation), and pest and diseases (aphids, Acoushi ant, scale insects, and sooty mold). At the nursery level, citrus projects are usually affected by diseases such as scab and dieback.

Environmental problems with respect to citrus cultivation are few. Those experienced are infertile soils (sandy soils) and excess rainfall during the wet season.

Presently, citrus production ranges between 1214 and 1619 ha (3000 and 4000 acres). The limiting factors to expansion are on inadequate supply of young plants to farmers and the need for a better extension service.

Production cost for 0.4 ha (1 acre) of citrus over a five-year period is approximately $28,666.00. Yields range from 8,000 lb. to 10,000 lb. per acre (3.6 t to 4.5 t/0.4 ha). Fruits are sold at an average of about $15–$20 per pound (0.5 kg). Two crops are obtained per year during December–February and July–October.

Markets are primarily local. Consumers favour sweet, yellow, thin-skinned oranges, and have a preference for round limes. The export market has been affected by the incidence of fruit fly.

1.3 Avocado

This crop has not performed well on the coastlands of Guyana. It suffers from foot rot after attaining maturity and soon dies. It appears to do better on the lighter soils (sandy loam). Production has declined on the coastlands, whereas it is on the increase elsewhere.

The area planted is approximately 57 ha (140 acres). Production cost by the end of five years for 0.4 ha (1 acre) of avocado would be about $26,000. Yields have been good and range from 8,000 lb. to 12,000 lb. per acre (3.6 t to 5.4 t/0.4 ha). One major crop is obtained per year around June–August.

II. Pre-production

2.1 Passion Fruit

The yellow variety is *Passiflora edulis f. flavicarpa* mainly grown in Guyana primarily because it is better suited for cultivation in the lower and medium elevations (coastlands).

Plants are generally propagated by seeds. Seed selection is the problem in this regard because our nurseries are without parent stock (plants) and so we are dependent on farmers for seeds, which in many cases are of sub-standard quality.

2.2 Citrus

A wide range of orange cultivars are in Guyana. These include Valencia, Pineapple, Parson Brown, Washington Navel, and Hamlin. Valencia is mainly grown. The fruit is of medium size and has an excellent flavour. Seeds are very few.

Propagation is done by budding (T budding). The rootstocks used are Rough Lemon and Sour Orange. The amount produced in 1990 was 22,000. This represents about 25% of what was required by farmers.

2.3 Avocado

The varieties cultivated in Guyana are many with about 14 cultivars, seven of which can be regarded as local. Among these are Pollock, Lula, and St. Clair. In the country of Essequibo, there is a local variety which seems to be resistant to foot rot.

Avocados are propagated by grafting. Problems of dieback are sometimes encountered when grafting. The demand for the avocado plant is greater than the supply.

III. Production Systems

3.1 Passion Fruit

The recommended planting method is trellising. Only the farmers with commercial holdings are inclined to adopt this practice. At the subsistence level of farming, farmers generally plant near fences where it is observed that there is more negative growth than there is fruit set. Spacing is recommended at 3 m × 3 m (10 ft × 10 ft).

The problems associated with husbandry practices with respect to fertilization to both non-bearing and bearing plants is one of inconsistency—farmers are not prepared to fertilize their plants after the first year. Weeds do compete heavily with this crop for moisture. On sandy soils they succumb to moisture stress.

There are not many pests and diseases affecting this crop; however, incidence of stem borer and fungal diseases have been experienced. The fungus causes a blistering effect on the leaves. After the second year of growth the practice of pruning has to be intensified to keep the plants in good shape. For this reason, passion fruit perhaps needs to be considered as an annual crop.

3.2 Citrus

The planting distances used are oranges and tangerines 8 m × 8 m (25 ft × 25 ft); limes 5 m × 5 m (15 ft × 15 ft). Intercropping is normally practiced in newly established orchards. Like passion fruit, fertilization programmes are not consistent. Weed control is very costly. Farmers depend on rainfall for irrigation. Spray programmes are usually hindered as a result of an unavailability of chemicals. Farmers have to be constantly reminded to prune their plants.

3.3 Avocado

The husbandry practices given to this crop are very much similar to that of citrus. Spacing varies between 8 m × 8 m (25 ft × 25 ft) and 9 m × 9 m (30 ft × 30 ft). Young plants are often intercropped with legumes. Fertilization is generally practiced for the first two years or so. Pruning of the terminal bud to induce tree spread is not usually practiced.

IV. Harvesting

The method of harvesting is by handpicking and generally the same for the three crops. No special tools are used. Fruit colour is the index used to determine maturity in passion fruit and citrus whereas full firm fruits is the index used for avocados.

Harvesting problems are created by farmers who allow avocados to fall to the ground after maturing.

V. Post-harvest Handling

In relation to citrus and avocado, post-harvest losses result chiefly from bruises, cuts, and the smashing of fruits, because of bad handling on the part of farmers.

VI. Shipping and Distribution

None of the crops under consideration are being exported presently. Exportation of oranges to Barbados had to be stoppped because of a fruit fly problem.

VII. Processing

No processing of any of the crops is being done in Guyana. Consumption of the fresh fruit by consumers is the way the fruits are utilized. One farmer who is involved in the commercial planting of passion fruit is producing a very good fruit drink from the crop.

VIII. Marketing

All markets are local markets, and demand is usually greater than supply. Farmers sell their produce mainly to hucksters (middle men) at varying prices depending on the market situation. Citrus prices range between $15 and $20 per pound (0.5 kg) whereas avocado ranges between $20 and $40 per pound (0.5 kg). Farmers have no need to advertise because once the crops are available, these farmers will be approached by the middle men.

IX. Conclusion

Great emphasis is being placed on crop diversification in Guyana at this time. The potential, therefore, of these crops, is great. Also, because Guyana Marketing Corporation has been re-established to look into exportation, the future with respect to citrus, avocado and passion fruit production is a bright one.

MARTINIQUE

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INTRODUCTION

Since the 17th century, the economy of Martinique has been based on agriculture with the sugar industry. Actually, the banana industry is the major production on the island. The entire production is exported to Europe, mainly France, but also Italy and the Netherlands. The other crops are secondary in nature and in value.

I. Generalities

1.1 Projects

1.1.1 Avocado

After the disappearance of a great part of the banana field due to hurricane, the French Agricultural Direction planned to create diversification crops for an alternative to the banana monoculture in the 70s. Avocado was one of the selected crops. Two varieties were chosen: Lula and Tonnage. These varieties have a good productivity, more than 15 t by hectare, big fruit, over 400 g, and are well adapted to tropical conditions.

About 1000 ha of orchards were planted until 1981. Two problems had been met: one was agronomical and the other commercial.

— The agronomical problem is linked with a fungus: *Phytophthora cinnamomi* which is responsible for root rot and later, decline of the tree. An insufficient soil preparation and non-resistant rootstocks are the main cause of this problem
— The commercial problem is the result, in part, of the poor quality of the fruit brought to the market, in competition with fruits from Israel and the U.S.

The large size of the fruit is also a problem. In France, consumers are used to buying small sized Israeli avocados, of the variety Hass.

The lack of revenue for the avocado growers increased the agronomical problems by the decreasing care of the orchards. This situation ended last year with the disappearance of the last surviving orchard. Presently, in Martinique, avocado is not a true export crop.

1.1.2 Passion Fruit

Since 1977, a Passion Fruit Improvement Program was conducted in Martinique. Two goals were reached :

(i) Improvement of the production increased from 7 t/ha to an average of 35 t/ha for the best selection (1000 passion fruit tree by hectare)
(ii) Improvement of the longevity of passion fruit in two ways:

Selected wild passion fruits were introduced from the Amazonian forest for improving the resistance to the major disease in Martinique, a collar rot which includes *Fusarium*, *Phytia*, and other fungi. Rainfall and, poorly drained soils increase this disease. However, a quick decline occurs in 18 months after planting. The grafting technique has been improved for testing Amazonian wild varieties as rootstock, but, in 1988, a viral disease, the woodiness disease, was found in the selected mother block. The whole part of the parent plant was sent to the central laboratories, in Montpelier, south of France, for regeneration in-vitro. Presently we are waiting for re-introduction of our virus-free selection in Martinique where there is a demand from potential growers.

1.1.3 Tahiti Lime

Another crop chosen for a diversification plan is the Tahiti lime. These orchards appeared in the early 80s. Similar problems were found as in the avocado production. However, the agronomical problem is linked to a weewil, *Diaprepes abbreviatus*, which eats the roots during its larval stage, and eats the leaves in the adult part of its cycle. Commercial problems occur with the competition from Brazil, and the U.S. on the European market. In 1985, 550 ha were in production. Today, there are less than 100 ha able to produce export quality fruit.

In 1978, a germplasm of about 200 varieties of citrus and 30 kind of rootstocks was installed, in the Research Station. There is a lack of information in tropical areas on the behaviour of citrus. Therefore the main goal for this operation is the ability to send to the Caribbean, virus-free citrus trees of a well-known quality.

Quality means sugar content, acidity, seedless fruit, essential oils, but also productivity, yield, and longevity of the tree by well-adapted cultural practices. Excessive losses caused by viral diseases of citrus can be most effectively and economically controlled or avoided by an integrated protection programme including the use of clean certified stock, tolerant selection of scion-rootstock combinations; and appropriate quarantine, detection, and suppression measures.

II. Pre-production

2.1 Avocado (*Persea americana*)

Varieties:	Lula, Tonnage
Cultural needs:	Well drained, light soils
Propagation	
Rootstock:	Local varieties (non-selected)
Seedlings:	In peat moss disinfected. Transplanting in nursery in bags. Grafting

after 3 to 6 months with 5– to 7–cm long buds.

2.2 Passion Fruit (*Passiflora edulis* f. *flavicarpa*)

Varieties: Yellow passion fruit
Cultural needs: Well-drained, light soils, low rain
Propagation
- Rootstock: Local varieties (non-selected). Currently there is a research programme for improved rootstock.
- Seedlings: The use of seedlings is possible but not recommended. Grafting takes place when rootstock is about 0.5 cm in width.

2.3 Tahiti Lime (*Citrus latifolia*)

Varieties: SRA 58
Cultural needs: Well-drained, light soil, without too much wind
Propagation
- Rootstock: *Citrus macrophylla, Citrange Carrizo*
- Scions: Virus-free varieties from a certified nursery.

III. Production

3.1 Avocado

Planting distance: 8 × 10 m i.e. 150 trees/ha
Planting period: 11–13 months after seedling or 7–8 months after grafting
Fertilization before planting: 4 kg lime per tree
Life hopping for the orchard: 20 years
Crop husbandry
- Weed control: Mechanical with care of rooting zone for avoiding asphyxiation, pruning dead branches (limiting fungal diseases and height)
- Annual fertilization for mature tree: 5 kg of 12:12:24; 1 kg of Magnesium sulphate in 3 to 5 annual applications
- Chemical weed control: Paraquat 6L/Ha; Glyphosate 2L/Ha
- Yield: Tonnage 20 t/Ha; Lula 12 t/Ha

3.2 Passion Fruit

Planting distance: 2 × 1.8 m
Planting density: 1000 trees/ha
Planting period: When first trilobe leaves appear (60–80 cm high)
Fertilization before plantation: 1 kg phosphorus + 1 kg lime/tree
Life hopping for the orchard: 10 years
Crop husbandry: Shoot control manually every week (limiting height)
Monthly fertilization for mature tree: 100 g of 15:7:24; 50 g of urea
Chemical weed control: Paraquat 10L/ha; Glyphosate 5L/ha
Yield: 30–35 t/ha

3.3 Tahiti Lime

Planting distance: 7 × 8 m
Planting density: 192 trees/ha
Planting period: May–July
Fertilization before plantation: 3.5 t lime/ha in acid soils
Life hopping for the orchard: 10–15 years
Crop husbandry: Pruning for limiting height
Fertilization for mature tree: 5 kg of 20:4:10 + 8 Mg + 2 Ca every 3 months; 3 kg lime every year
Chemical weed control: Paraquat 6L/ha; Glyphosate 2L/ha
Yield: 15 t/ha (export quality); 40 t/ha (global production)

IV. Harvesting

4.1 Avocado

Harvesting period: July – September
Maturity period: September – December
Main fruit post harvest diseases
- *Diplodia natalensis*: Control with benomyl (400 g/ha) and copper (6 kg /ha)
- *Cercospora purpurea*: "
- Anthracnose: "

4.2 Passion Fruit

Harvesting period: 9 to 10 months after planting
Maturity period: Year-round
Main diseases
- Scales: Methidation (5L/ha)
- Caterpillar: Deltamethrine(3–5 cc / 10L)
- Fusarium: No control. Avoid water around the collar. Plants must be grafted high (more than 20 cm)
- Rats: Take off old fruit, use Coumatetralyl (50 g)

4.3 Tahiti Lime

Harvesting period: 3 years after planting
Maturity period: May–September (possibility of flower control)
Main diseases
- Scales: Methidation (2L1 /Ha)

Mites:	Sulphur (6 kg/ha in 1500 L)
Phytophtora:	Phosetyl-Al (35 g/10L)
Scab:	Copper (50 g/10L)
	Captafol (35 cc/10L)
Weewils:	No control. Need to use tolerant rootstocks as C. *macrophylla*.

V. Conclusion

Martinique welcomes any proposition pertaining to the possibility of initiating a cooperation on tropical fruit research regarding common problems, interests, and knowledge.

MONTSERRAT

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I. Generalities

1.1 Projects

Montserrat at present imports more than $500,000 worth of citrus and citrus-related products annually. Most of the fruit projects in the past have met with limited success. The boom days of the sixties have not been reproduced despite several attempts. Most of the large projects were in the area of mango establishment, and whereas over 8 ha (20 acres) of citrus have been planted in the last 10 years, there still remains a problem of supply. The local market has not yet been satisfied.

1.2 Limiting Factors

The problems associated with the availability and survival of citrus and avocado are the following.

(i) Land tenure system
(ii) Terms and conditions of projects (minimum land agreements)
(iii) Damage by loose livestock
(iv) Soil types on which crops are planted
(v) Long drought periods
(vi) High cost of labour and farm inputs

II. Pre-production

2.1 Cultivar Selection

Most of the cultivars were selected based on their adaptability of the region and on recommendations. They were drought-tolerant, disease-resistant, and highly productive. The Ministry of Agriculture is the main supplier of plants.

The citrus varieties include:

Orange	Grapefruit	Lime
Valencia	Marsh seedless	Persian
Washington Navel	Pink marsh	West Indian
Hamlin		Mexican
Ortanique		

The avocado varieties include Simmons, Pollock, and Lula

Passion fruit is non-descript.

2.2 Propagation

Propagation is done by grafting orange, grapefruit, or lime onto Rough Lemon or Sour Orange stock.

2.3 Plant Demand and Supply

Plant demands are often greater than supply, mainly because there is an increase in local landscaping and home garden activity. The hurricane "Hugo" also destroyed several trees which have not been replaced.

III. Production Systems

3.1 Planting

Most of the plantings are in small blocks, in individual mounds, with spacing from 3 to 7.6 m (10 to 25 ft). In some areas, closer spacings (less than 3 m) have resulted in shading and reduced productivity.

3.2 Crop Husbandry

3.2.1 Fertilization

Fertilization varies, depending on amount of money and local supply.

3.2.2 Weed Control

Weed control is not a major factor.

3.2.3 Irrigation

Irrigation is not yet fully accepted and is costly because of small orders.

3.2.4 Spray Programme

Spray programmes are not often followed. The application of insecticides and fungicides are minimal, resulting in fungal and pest damages to plants and fruits. The department is depended upon to provide leadership in this respect. However, farmers are reluctant to follow spray requirements.

3.2.5 Pruning

Pruning is a major problem. Farmers do not want to remove unnecessary branches or do not have the tools to do the job properly. They sacrifice production for aesthetics.

3.3 Yields

Yield per tree is low in some areas because of the

neglect of the trees or the poor siting of the same, lack of fertilization as a result of destruction of the flowers by strong winds on exposed slopes, and lack of moisture.

Avocado yields:	9–11 kg (20–25 lb.)/tree (max.) and 4.5–6.8 kg (10–15 lb.)/tree (normal)
Citrus yields:	75–100 fruits/tree (max.) 25–50 fruits/tree (normal).

IV. Harvesting

Harvesting is done manually, with the fruits picked and placed in boxes and bags. Stage of maturity is determined by the colour and fullness of fruit. The main problem is that fruit coloration is not always the best indicator and fruit may be harvested prematurely. Transportation is not a major difficulty but sometimes the containers (boxes and bags) are unsuitable and cause the fruits to be squeezed.

V. Post-harvest Handling

Because there are not too many large orchards existing, much emphasis has not been placed on post-harvest handling. Fruits, however, are often covered with sooty mold, canker sores, bruises from branches or fruit blotches (rings) from contact with other fruits. Washing of fruits for sale is not often done.

VI. Marketing

Regulations for the production and marketing of the crop are not strict because of the limited export activity. The cost of fruits are not set and will vary with seasons, depending on the quantity of imported fruit. Processing is minimal except for the production of lime concentrate (lime juice), which is done by one individual.

VII. Conclusion

Not much has been said of passion fruit because the fruit is only now being introduced at backyard level. Avocados have also been grown but on a limited scale. Montserrat continues to look at fruit crop production with the aim of becoming self-sufficient or as an alternative, limiting the imports of fruit tree products from within the CARICOM region.

NEVIS

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I. Generalities

1.1 Projects

On the island of Nevis there is one project involving the production of citrus and avocado being currently implemented. This project is the Cades Bay Tree Crop Project which was started in 1987. Of the fruit trees planted, 1 ha was citrus and 0.2 ha avocado. However, since the hurricane "Hugo" the area is mostly planted out in citrus. Along with this, there are small areas of varying sizes, with these fruit trees scattered throughout the island. Passion fruit is grown as a backyard crop.

1.2 Ecological Problems

The major ecological factors affecting these crops are the following.

(i) *Rainfall* — The rains are seasonal and the plants undergo stress during the dry season. Therefore, irrigation will have to be looked at as being necessary. The average rainfall is 10.16 cm – 15.24 cm per annum.

(ii) *Wind* — This is another factor which affects plants. It causes bending of the plants, damage to branches, and loss of young fruits and flowers.

1.3 Limiting Factors

Factors affecting production are an inadequate supply of planting material, the lack of a wide selection of scion material therefore preventing an extended fruiting season, inadequate management practices, and labour shortage.

1.4 Production Costs

Production cost is estimated at:

Establishment		
Land preparation	$1200	
Planting material	545	
Labour	300	
Total	$2045	per acre (0.4 ha)
Yearly maintenance	$2000	

1.5 Seasonality of Production

Avocado	August–November
Citrus	November–March

1.6 Main Markets

The major market is the local domestic market. A small proportion of the market is used for hotels and restaurants. However, small amounts of avocados are sold to neighbouring islands (U.S. Virgin Islands and

St. Maarten). There is often great demand for these fruits but supplies are limited due to seasonality.

II. Pre-production

2.1 Cultivar Selection

The cultivars grown are the following:

Orange	Grapefruit	Lime	Avocado
Valencia	Marsh (white)	Persian	Pollock
Washington Navel		West Indian	Lula

The objective of introducing different cultivars was in order to produce high quality fruit and also to extend harvesting period especially in the case of avocado where fruits are in high demand in the tourist season.

2.2 Propagation

Propagation of plants is mainly by budding and grafting of rootstock both in the nursery and also in the field. The major problem in propagation is the lack of a proper propagation unit which will help to increase the efficiency and production of good quality planting material.

Rootstocks used for Citrus are Sour Orange and Rough Lemon.

Local material is used for Avocado.

The major problem with avocado is fungal disease (*Phytophtora cinnamomi* and anthracnose) experienced in the nursery.

2.3 Plant Demand

There is always a great demand for fruit trees. To increase the efficiency and production of these plants, the Department of Agriculture is in the process of building a Propagation Unit.

III. Production Systems

3.1 Planting

Plants were established under normal practices by clearing land and lining and preparing holes along contour guidelines. Pen manure was incorporated in planting mix. Spacing used was 5.1 m × 5.1 m.

3.2 Crop Husbandry

3.2.1 Fertilizer application

Trees are not fertilized at regular intervals. However, when they are, NPK at a ratio of 15:15:15 is used.

3.2.2 Weed Control

Weed control is done mechanically with tractor and brush-cutter and manually by round-weeding.

3.2.3 Irrigation

Plants are rainfed.

3.2.4 Spray Programme

Spraying is not done on a regular basis, but whenever problems arise, plants are sprayed with insecticide, fungicide, and foliar fertilizers.

3.2.5 Pruning

Pruning is carried out fairly often to remove suckers and disease branches.

3.2.6 Mulching

Mulching of trees is carried out as a soil and water conservation measure.

3.3 Yields

Yields cannot be measured as most of these trees are not yet into production.

IV. Harvesting

Crops are harvested either manually by (*a*) hand picking or (*b*) using a stick with a hook.

The maturity indices used are fruit colour and by feeling the fruit.

The major problems with harvesting is the lack of harvesting skill in which case fruits are physically damaged. Another problem is the lack of proper packaging material.

V. Marketing

At present there is no exportation or processing of these fruits.

ST. KITTS

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Department of Agriculture, St Kitts

I. Generalities

1.1 Projects

The major fruit tree project currently being implemented on the island is approximately 6 km west of the capital, Basse-terre. This project is situated at an area called Wingfield Estate, hence the fruit tree project is called "Wingfield Tree Crop Project."

The project is managed by the St. Kitts Sugar Manufacturing Corporation (SSMC). The crops growing in that project are basically citrus, avocado, mango, banana, and plantain. A total of 12.8 ha is cultivated with the following crops (Table 1).

Table 1
Crops grown in the Wingfield Tree Crop Project

Crops	Hectares
Grapefruit	2.0
Orange	6.4
Tangerine	0.5
Pomelo	0.4
Avocado	2.0
Lime	1.5
Total	12.8

The project was initiated in 1976 though most of the initial planting was done in 1978. Trees of each crop are of varying age since the plants were established over several years. During 1986 some additional plants were transplanted to replace dead ones.

1.2 Ecological Problems

One of the major problems associated with the ecology under which these crops are growing is one of a "Wind Swept" problem and as a result fruits and flowers are lost.

The limiting factors for expansion in this project are too much rainfall and wind. The area also has a very high rainfall pattern and this affects the initiation and fruit setting. Alternative sites are under scrutiny for further expansion of the project.

1.3 Income Generated

Table 2 show the income generated for the 12.8-ha avocado and citrus plot over the last four years.

1.4 Revenue and Expenditure for 1990

The production cost for this project is very high. The main aim of the Government Corporation is to safeguard the jobs of its workers rather than to reduce expenses.

Tables 3 and 4 shows the revenue and expenses for the year ended 1990.

Table 2
Income generated for crops over a 4-year period

Crops	1987	1988	1989	1990	Total
Avocado	2,020.19	1,702.96	3,382.19	0.00	7,105.34
Grapefruit	8,033.75	3,565.05	2,691.25	2,891.00	17,181.05
Lemon	3,483.60	1,592.40	2,788.50	1,952.00	9,816.50
Lime	9,455.15	19,301.30	20,587.22	20,823.56	70,167.23
Orange	1,850.15	3,653.10	1,603.90	1,599.83	8,706.98
Pomelo	614.00	585.52	243.50	401.40	1,844.42
Tangerine	222.40	1,702.96	3,382.19	317.00	5,624.55
Total	25,679.24	32,103.29	34,678.75	27,984.79	120,446.07

Table 3
Total revenue received from the fruit crops for 1990

Crops	Revenue
Avocado	0.00
Grapefruit	2,891.00
Lemon	1,952.00
Lime	20,823.56
Orange	1,599.83
Pomelo	401.40
Tangerine	317.00
Total	27,984.79

Table 4
Total expenditure for the fruit crop activities for 1990

Activities	Value
Mechanical brush control	23,836.06
Planting	675.88
Chemical pest control	3,847.65
Pruning/sanitation	6,190.58
Reaping sales	9,053.72
Fertilizing	1,317.77
General & miscellaneous	8,089.59
Total	53,011.25

Therefore for 1990 the Corporation lost approximately $25,026.46 (53,011.25 - 27,984.79)

1.5 Seasonality of Production

The main season for citrus is basically the first 6 months of the year. Limes on the other hand fruit all year round. As regards avocado, there are two main seasons, the first being from August through October and the second from February through April.

The reason for establishing these two is to extend the bearing season over a longer period to cater for the tourist season.

1.6 Main Markets

The major markets for these commodities are the Central Marketing Corporation (CEMACO), hucksters who forms an integral part of the public market, hotels, and workers at CEMACO. The demand for limes is extremely high followed by grapefruits and oranges in that order.

Avocado also fetches a high price and has a great demand especially in the tourist season. However, because of the increase of praedial larceny in the area, little or no revenue is collected from that crop. In addition, for the 1990 season, due to the hurricane "Hugo," revenue for this crop was nil. Plants were badly battered by heavy prevailing winds up to about 209 km/h (130 mi./h).

II. Pre-production

2.1 Cultivar Selection

2.1.1 Citrus

The cultivars in citrus are as follows:

Lime	Lemon	Orange
West Indian	Rough seeded	Valencia
Persian		Navel
		Ortanique
		Pineapple
		Pomelo

2.1.2 Avocado

The varieties being propagated are Lula and Pollock. The importance of having various cultivars is mainly to extend the harvesting season over a longer period and to establish a host of scion material for propagation purposes, so as to introduce new varieties to farmers island wide.

2.2 Propagation

Propagation is done mainly by budding and grafting methods. There are no problems associated with rootstock establishment and preparation.

2.3 Plant Demand and Supply

There is a great demand for citrus. Most farmers prefer limes and oranges as opposed to grapefruit, tangerine, and pomelo. The Department of Agriculture is the main distributing unit. At the Department of Agriculture a target has been set for 5,000 plants to be established for distribution island wide which would satisfy the farming public in 1991–1992.

III. Production Systems

3.1 Planting

Method of planting has been established on a mound system at the Wingfield Tree Crop Project. As a result, over a period of years the soil around the high mounds disintegrated leaving roots exposed to sun, wind, and light which caused and is causing drying out of certain varieties of citrus.

3.2 Crop Husbandry

Tree crops are not fertilized at regular intervals. Weed control is accomplished by using a tractor with an attached brush-cutter. The spraying programme is untimely and as a consequence, sooty mold is prevalent among trees. The programme for pruning of trees is not adhered to and consequently trees die eventually as a result of progressive dieback of twigs. Fallen fruits are observed under trees resulting in poor sanitation and consequently trees die eventually as a result of progressive dieback of fungus.

3.3 Yields

Yields per tree cannot be measured successfully due to a high degree of praedial larceny in the area.

3.4 Factors Affecting Production and Fruit Quality

Factors affecting production and fruit quality in the field are as follows:

- Poor agronomic practices —weeding, spraying, pruning, field sanitation
- Severe wind gusts
- Praedial larceny
- Lack of trained personnel
- Too high a rainfall pattern
- High operation costs

IV. Harvesting

Crops are harvested either manually by (*a*) hand or (*b*) picking lever, i.e. stick with hook. Stage of maturity is determined by looking at fruit colour and feeling the fruit.

The main problems encountered in the harvesting of the crops are (*a*) insufficient labour/trained personnel and (*b*) lack of harvesting skills.

ST. LUCIA

COLIN PAUL[1]
Ministry of Agriculture, St. Lucia

I. Generalities

1.1 Fruit Projects

The fruit projects currently being implemented in St. Lucia fall under two broad categories viz. Non-Traditional Fruit and Exotic Crops Development Programme, which includes passion fruit, among others, and the Traditional Fruit Crop Development Programme which includes citrus and avocado. These are two programmes which form part of the Crop and Livestock Programme geared towards the diversification of the Agricultural Sector. The purpose of the Traditional Fruit Crop Programme is to supply both export and domestic markets with activities focussed on production enhancement and technological improvements. With respect to passion fruit, the purpose is for domestic markets with the main action centred around technological improvements. These are short-term goals and the expectation is that the focus will change as more information becomes available.

This is especially important for passion fruit as a pilot research project is currently being implemented by CARDI and it involves the testing of seven different lines (i.e. "yellow" and "pink" types for processing and as table fruit) in the major ecological zones. Farmers will receive 0.1 ha (¼ acre) of planting materials, trellis posts, wire imputs, including a technological package for production, while monitoring visits will be done by CARDI and as well as staff of the Ministry of Agriculture. The project is expected to cover 5 ha (12.5 acres) and is monitored by a management committee comprising members of the Ministry of Agriculture, CARDI, IICA, SLDB, Exporters Association, input suppliers and farmers' representative. To date, three plots have been fully established on farmers holdings.

The project was officially launched on September 19th, 1990 and training sessions have been held.

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. Supplementary water (irrigation) during the dry season and in dry areas are necessary for increased yields and improved quality. Wind problems are normally area specific and can pose problems for avocado and passion fruit. A more detailed technical zoning may reveal more opportunities. Hurricanes are always a serious threat.

[1]Agronomist.

1.3 Planted Area

Table 1
Area planted in acres (ha). Exports, recorded local purchases, and production estimates (tonnes).

Crop, Acres* (ha)	Av. exports	Av. recorded purchases	Total	Inflation factor	Est. prod.
Avocado 400 (162)	16.5	10.0	26.5	90	50.4
Orange 900 (364)	22.3	60.0	82.3	95	160.5
Grapefruit 200 (81)	38.5	39.9	77.9	95	151.9
Lime 200 (81)	0.5	17.8	18.3	90	34.8
Passion fruit —	—	0.5	0.5	75	0.9

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

1.4 Production Estimate and Value

Average exports were calculated as the mean of 1985–1989 data while the recorded purchases reflect the supermarket and hotel purchases. The inflation factor was taken from the Ministry of Agriculture Statistics Unit and used to estimate production. This gives an indication of the size of the local central market, which accounts for the largest single disposal avenue.

Table 2
Estimated production and value

Crops	Est. prod. (tonnes)	Av. price EC$/kg (1989)	Value EC$ ('000)
Avocado	50.4	1.50	75.6
Orange	160.5	1.50	250.8
Grapefruit	151.9	0.99	150.4
Lime	34.8	3.06	106.5
Passion fruit	0.9	3.50	3.2
Total	398.5		586.5

The estimated production was taken from Table 1, while the average price represents average local prices recorded in 1989. These have been used to estimate the value of the production, which totals EC $586.5 thousand for 398.5 tonnes of these crops.

1.4 Factors Limiting Production Expansion

(i) Low availability of suitable land. Competition with other crops and uses. This is so for all crops.
(ii) Lack of orchard stands. Avocado, citrus.
(iii) Lack of quantity of exportable cultivars. Avocado, citrus, passion fruit.
(iv) Low cultural/management practices. All crops.

(v) Low quality. All crops.
(vi) Low agro-processing. Avocado.
(vii) Pests and disease. All crops.

1.5 Production Costs and Returns

Table 3
Production costs and returns (EC$).

Plant Density	Avocado	Orange	Grape-fruit	Lime	Passion fruit
Trees/acre (0.4 ha)	58	70	60	155	400
Cost/ac^{-1}/yr^{-1}	1,172.00	946.35	1,080.85	1,169.05	3,300.00
Fertilizer 1.8 kg (4 lb.) NPK/tree	82.00	98.00	84.00	210.00	100.00
Herbicide	40.00	32.73	32.73	32.73	100.00
Pesticide	50.00	39.82	39.82	39.82	100.00
Labour	600.00	360.00	360.00	360.00	500.00
Transport	400.00	415.00	564.30	526.50	500.00
Poles & wire (Establishment 1st year only)	2000.00[d]				
Returns/ac^{-1}/yr^{-1}					
Farm gate price	0.50	0.20	0.25	0.25	1.00
Yield/tree	200[a]	220[b]	330[b]	130[b]	6000[c]
Rejects (%)	10	10	5	10	15
Income $EC	5,220	2,772	4,702.50	4,387.50	5,100
Net Return	4,048	1,825.65	3,621.65	3,218.45	1,800[d]

[a]No. of fruits.
[b]Pounds.
[c]Kilograms per acre.
[d]In the 2nd & 3rd years the cost of poles and wire is not incurred and so returns are increased by $2000, or an average of about $650.00 per year.

With the exception of passion fruit and avocado, these data have been extracted from the BDD Tree Crop Project findings.

Comparative advantages have been realised by farmers working in groups/cooperatives, where some items of costs are shared. Advantages are also obtained by group action because of coordination of efforts which also tend to reduce costs. These advantages occur all along the production to marketing chain.

1.6 Seasonality

	Availability period	Peak period
Avocado	May–Feb	Aug.–Oct.
Orange	Sept.–Apr.	Nov.–Feb.
Grapefruit	Aug.–July	Nov.–Apr.
Lime	June–May	July–Nov.
Passion fruit	May–Dec.	Nov.–Dec.

The seasonality has been extracted from monthly local purchases which reflect sales of the leading supermarkets and hotels as well as from exports. The yearly averages are presented.

Average yearly exports and local purchases (tonnes)

	Avocado	Orange		Grapefruit		Lime
	Export	Export	Local	Export	Local	Local
January	—	5.9	4.1	7.3	3.5	0.3
February	—	3.4	2.0	7.4	5.4	0.1
March	—	2.6	0.5	6.0	7.5	0.3
April	—	1.3	—	3.0	5.6	1.0
May	—	0.1	0.1	2.2	1.6	1.5
June	0.1	—	0.2	0.9	0.5	1.8
July	1.2	—	0.4	0.5	0.1	2.3
August	5.1	0.2	1.6	0.7	0.2	2.6
September	5.9	0.7	5.0	0.8	1.0	1.5
October	3.2	1.1	17.8	1.4	3.0	2.5
November	0.4	4.1	17.4	4.3	5.9	2.5
December	0.6	2.9	10.9	3.5	5.6	1.4
Total	0.6	2.9	10.9	3.5	5.6	1.4

Local purchases for avocado average about 10 t and for passion fruit it is about 0.5 mt using figures for 1988 and 1989. All the other averages are based on 1985–1989 information available from the Planning and Statistics Unit of the Ministry of Agriculture. The exports recorded for limes average at 0.5 mt. There has been no recorded exports of passion fruit.

1.7 Main Markets

Avocado: Local — Central markets, supermarkets, hotels, restaurants.
Export — U.K., St. Maarten, Antigua.

Orange: Local — Central markets, supermarkets, processors, restaurants, hotels.
Export — Barbados, Antigua, U.K., St. Maarten.

Grapefruit: Local — Central markets, hotels, supermarkets, processors, restaurants.
Export — Barbados, Antigua, U.K., St. Maarten.

Lime: Local — Central markets, supermarkets, hotels, restaurants, processors.

Passion Fruit: Local — Central markets, restaurants, processors, hotels.

For all the crops concerned the local central market is the most import outlet. Other local outlets including the leading supermarkets and hotels are also very important. The export market has potential and offers another important outlet for these crops.

II. Pre-production

2.1 Cultivars

2.1.1 Avocado

Many varieties are found in St. Lucia. They are mostly seedlings of West Indian origin. Selected types include Pollock, Simmonds, St. Croix, François, and Marcus. Marcus is late maturing while the others are early to mid-season. They tend to be medium to large fruit with smooth leathery skin and large loose seeds within the seed cavity. Fuerte and Lula have been introduced but Fuerte is not popular as it does not perform very well locally. The fruits tend to be small

and not very competitive on the local market. Avocados are grown in the lowland areas where annual rainfall is between 1500 and 2000 mm (60 and 80 in.) with a short dry period. Low moisture and good drainage is necessary to avoid root rot (*Phytophthora cinnamomi*) and eventual dieback. They are also susceptible to strong winds.

2.1.2 Citrus

(i) *Oranges* — The main varieties are Washington Navel and Valencia. Parson Brown and Pineapple are also grown. Washington Navel is early maturing, best suited to the coolness of higher elevations, and used as a table orange. Valencia is later, tolerates higher temperatures, and is used both for juicing and as a table fruit.

(ii) *Grapefruit* — The dominant variety is the Seedless Marsh White followed by Foster, Duncan, and Ruby Red. Both grapefruit and oranges are used for marmalade, jams, and other products in the local processing industry.

(iii) *Limes* — These are mostly of the West Indian type exhibiting wide variations in characteristics. Recently a seedless variety (Tahiti/Persian) was introduced. Limes are processed into juices, cordials, and other products.

2.2 Propagation, Rootstock, and Related Problems

The propagation of avocado is done by terminal wedge grafting on seedlings of any variety. Scions are obtained from the government stations while fruit and seeds from any source are used for rootstocks. There is a relatively low survival of grafted plants (60%), but they are usually available within 6–8 months after potting.

With respect to citrus, T-budding is the method used for propagation. Rootstocks are generally obtained from farmers and the only rootstock used is from sour oranges. This may be a source of spreading pathological problems as there is no virus indexing.

In general there is a lack of germplasm collections that are properly maintained. There are problems related to the state and condition of the physical structures as well as the need for soil sterilization and misting facilities.

2.3 Plant Demand and Supply

Table 4
Plant demand, supply, deficit, and distribution problems

Crops	Demand, av. sales/yr	Supply, av./yr
Avocado	2,000	3,000
Orange	4,000	5,000
Grapefruit	4,000	5,000
Lime	1,500	2,000

Problems in this area relate to distribution. Transportation, though available, is usually at a high cost. The mechanism of distribution also presents some problems resulting in plants being left back even to the point of overgrowing. Another problem relates to the expectation by farmers that plants be available on a year-round basis.

III. Production Systems

3.1 Planting

The production system is characterised by scattered plantings usually intercropped with bananas (i.e. for citrus and avocado) at very wide spacings and so acreage is usually expressed as acre equivalents. In the case of passion fruit, tripod trellises and fences are normally used.

3.2 Crop Husbandry

With respect to crop husbandry, 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 (i.e. when bananas are fertilized and sprayed, other crops in the system also benefit).

3.3 Yields

Yield per tree as extracted from the BDD Tree Crop Project Report is listed in Table 3. The yield per acre (0.4 ha) of passion fruit was obtained from the research project at the CARDI field station.

3.4 Factors Affecting Production

Factors affecting production and quality in the field include:

(i) Low quantity of improved varieties.
(ii) Low cultural practices.
(iii) Low 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

Avocado and citrus trees are commonly climbed, the fruits picked by hand and thrown to someone on the ground, or placed in a bag. V-poles with sacks attached (cali) are commonly used. A method unique to citrus is the shaking of trees and collection of fallen fruit. Limes are harvested by hand. The main problem in the catching of avocados is that they are subject to internal damage from loose seeds. Similarly, citrus that has been shaken to the ground can suffer bruising, splitting, and, or, internal damage. A general problem is related to collection of fruit from widely scattered plantings thus increasing the time and cost of handling and transportation.

4.2 Maturity indices

The most common index used is colour change. In

avocados, usually the skin gets dull, while in citrus the green colour gets lighter or yellowish. Size is also used 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. Avocados are usually packed in boxes or baskets. Citrus until recently was accepted in bags but this practice is on the way out as it is no longer accepted by exporters and supermarkets. Hoteliers are not particular and accept citrus even when they are transported loose in the carriage of vehicles. Improper packing in vehicles leads to shaking which results in bruising and internal damage.

The main reasons for rejection of fruit in the packhouse are bruising from underpacking and signs of squeezing and compaction from overpacking., Fruits showing noticeable signs of pest and disease damage are rejected in the field or at the farm gate.

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. For example, the current rates on BWIA are as follows:

Consignment Volume (kg)	Cost ($EC/kg)
1,000	2.12
2,000	1.92
4,000	1.66
6,000	1.50

British Airways is more expensive and recently, due to the Gulf War, cargo must be at the warehouse at least 48 hours before shipping.

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

VII. Processing

There is no processing of avocados. Citrus and passion fruit are processed locally by cottage-type processors into juices which are sold to hotels and restaurants. Citrus is also used to make jams and marmalades which are sold to hotels, supermarkets, and restaurants. The main problems relate to consistency of quality and packaging as well as the quality of labelling.

Data on volumes processed are not readily available, but processors claim that raw material costs tend to be high.

VIII. Marketing

As can be deduced from Table 1, the main market for avocado, citrus, and passion fruit is the local central market. Although exact quantification on volumes are difficult, any estimate will reveal the significance of this market. This is implied by the high correction factor used by the Statistics unit of the Ministry of Agriculture. The next important market for avocado is the export market while for citrus and passion fruit, the local formal markets (i.e. supermarkets, hotels, restaurants) are more important than the export market.

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ST. VINCENT AND THE GRENADINES

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I. Generalities

1.1 Projects

Currently, there is a passion fruit project geared towards satisfying the needs of the small farmers. It is financed by AVT-HIAMP and administered by the National Development Foundation (NDF). The objectives of this project is to establish 91 ha (226 acres) of passion fruit over a 4-year period. It will accommodate 201 small farmers with orchards of 0.2 to 0.8 ha (½ to 2 acres).

There are no projects for avocado or citrus. These crops are grown intercropped with bananas and plantains or grown as single trees in farmers' backyards or gardens. These trees tend to grow very tall because farmers cut off the lower branches to maximize land use. Also, regular application of fertilizer to bananas intercropped with avocado and citrus provokes much vegetative growth.

1.2 Area Planted

Passion Fruit: Presently 4.9 ha (12 acres) have been planted

Avocado: Presently 27.68 ha (68 acres) have been planted

Citrus: Presently 32.5 ha (81 acres) have been planted consisting of: Grapefruit 10 ha (25 acres), Lime 4 ha (10 acres), Orange 14 ha (35 acres), Others 4.5 ha (11 acres)

1.3 Limiting Factors

The limiting factors for the expansion of these crops are:

(i) Supply of hardwood posts for trellis system
(ii) Uncertainty of market
(iii) Limited land space

1.4 Production Costs and Returns

The production costs and returns are indicated in Tables 1–4.

1.5 Seasonality

Passion fruit: May to June with peaks in July, October, and December

Avocado: July to February with peaks in August to October

Grapefruit: August to March with peaks in November to February

Lime: December to October with peaks in June to August

Orange: June to February with peak sin November to December

Table 1
St. Vincent Passion Fruit Project 1-acre (0.4 ha) model.

Income statement					
	Years				
Item	1	2	3	4	5
Sales	4050	4050	4050	4050	4050
Operating costs					
Labour & materials	920	1040	920	1040	920
Transport of plants	100	100	0	100	0
Plants		370		370	
Trellis materials (replacement)		105	105	105	105
Fertilizer	150	250	250	250	250
Herbicides	160	120	120	120	120
Pesticides	50	100	100	100	100
Sacks	40	40	40	40	40
Sub-total	1,420	2,125	1,535	2,125	1,535
Replacement cost	433	433	433	433	433
Interest repayment	216	173	130	86	
Total	2,069	2,731	2,098	2,644	1,968
Profit/loss	1,981	1,319	1,952	1,406	2,082
Accum	1,981	3,300	5,252	6,658	8,740

Table 2
St Vincent Passion Fruit Production Project (Financing plan per farmer).

Labour		Cost/Farmer
Land clearing		300
Planting and lining		200
Construction of trellis		300
Weeding		240
Application of fertilizers		0
Maintenance of trellis		80
Application of herbicides and pesticides		120
Training and pruning		80
Harvesting		400
Sub-total		1720
Materials	**A.V.T.**	
Plants	370	
Fertiliser		150
Herbicides		160
Pesticides		50
Sacks		40
Pruning equipment		50
Knapsacks sprayer		300
Trellis materials	756	504
Staples	13	
Stakes		90
Achors		112
Wire (100 lb.)	340	
Sub-total	1629	1306
Rent		300
Transportation of plants	100	
Total costs	1729	3326

Table 3
Cost of production of 1 acre (0.4 kg) of avocado pears.

	Costs of 1 acre in $EC									
	Year									
	1	2	3	4	5	6	7	8	9	10
Conservation: ridging, draining etc.	150	—	—	—	—	—	—	—	—	—
Propagation	150	—	—	—	—	—	—	—	—	—
Clearing, lining, holding, planting	113	—	—	—	—	—	—	—	—	—
Fertilizer	8.6	17.3	34.5	51.8	51.8	51.8	51.8	51.8	51.8	51.8
Weedicide	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Refilling at 10%	—	15	—	—	—	—	—	—	—	
Harvesting	—	—	21	32	41	47	47	47	47	47
Marketing:										
Cost of bag	—	—	6	—	—	—	—	—	—	
Transport	—	—	98	152	197	240	240	240	240	240
Total costs	434	44.8	172	248.3	302.3	351.3	351.3	351.3	351.3	351.3
Yield/lb.	—	—	—	3,281	5,063	6,563	7,500	7,500	7,500	7,500

Table 4
Cost of production 1 acre (0.4 kg) of oranges

	Cost of 1 acre in $EC							
	Year							
	1	2	3	4	5	6	7	8
Conservation: ridging, draining etc.	200	—	—	—	—	—	—	—
Propagation	180	—	—	—	—	—	—	—
Clearing, lining, holding, planting	135	—	—	—	—	—	—	—
Fertilizer	45	45	82	120	120	120	120	120
Weedicide	—	20	—	—	—	—	—	—
Refilling at 10%	—	20	—	—	—	—	—	—
Harvesting	—	—	146	293	300	300	300	300
Marketing	—	—	675	1,350	1,350	1,350	1,350	1,350
Rent	75	75	75	75	75	75	75	75
Management income	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Tools depreciation	25	25	—	—	—	—	—	—
Total costs (EC$)	2,660	2,185	2,978	3,845	3,845	3,845	3,845	3,845
Yield of fruits (No.)	—	—	22,500	45,000	45,500	45,000	45,000	45,000
Cost per fruit	$0.17							

NOTE: Cost per fruit excluding rent and management income = $0.06.

1.6 Main Markets, Demands and Supply

Passion fruit: Local and regional market, with the demand greater than supply 3:1.

Avocado and citrus: Local and regional market, with the supply greater than demand in the peak season.

II. Pre-production

2.1 Cultivars, Importance, and Characteristics

Passion fruit: Large yellow, mainly used for concentrates and fresh fruit, it has a high fruit set and grows very vigorously. four to five fruits weigh 0.5 kg (1 lb).

Avocado: Most avocados are local "West Indian" "type, with selected cultivars such as "Lula", "Simmonds" and "Pollock".

Grapefruit: "Marsh seedless","Thompson pink," and "Duncan" are the most important cultivars.

Lime : "West Indian" lime is the most important.

Orange: "Valencia," "Parson Brown," "Pineapple," and "Washington Navel" are the most important cultivars.

2.2 Propagation, Rootstocks and Related Problems

Passion fruit: Propagation is by seed planted on beds then transplanted to potting bags when they have four to five leaves. When they are 254 mm (10 in.) to 0.3 m (1 ft) tall they are transplanted to the field.

Avocado: Propagation is by wedge grafting, there is no selected rootstock as there is a scarcity of rootstock material.

Citrus: Propagation is by T-budding, using Rough Lemon as rootstock. There is a poor nursery infrastructure.

2.3 Plant Demand and Supply

Passion fruit: Demand is tapered to meet supply. Three private farmers and the Ministry of Agriculture, Labour and Industry supply planting material.

Avocado and Citrus: To satisfy demand and regularize distribution, MAIL has established a system whereby farmers apply for seedlings in advance of the planting season.

III. Production

3.1 Planting

Passion fruit: The curtain-type trellis system is mainly used with a distance of 3 m (10 ft) between trellis and 3.7 m (12 ft) between plants.

Avocado: Mainly grown as single trees. Planting distance is 7.6 m × 7.6 m (25 ft × 25 ft).

Grapefruit: Mainly grown as single trees. Planting distance is 7.6 m × 7.6 m (25 ft × 25 ft).

Lime: Mainly grown as single trees. Planting distance is 4.5 m × 4.5 m (15 ft × 15 ft).

Orange: Mainly grown as single trees. Planting distance is 6 m x 6 m (20 ft x 20 ft).

3.2 Crop Husbandry

Passion fruit: Organic fertilizers are applied at planting, 6 weeks after chemical fertilizers are applied, mainly the banana fertilizer. There are four to five applications per year. Weeding is by hand, no irrigation. Dipel and Sticker is used to control the passion fruit worm. Pruning is done early.

Avocado and Citrus: Generally speaking management of these crops is very poor because there are very few pure stand orchards. There is no fertilization method nor irrigation. Some pruning is done and MAIL has a spraying programme for these crops.

3.3 Yields

Passion fruit: 5–4 kg (11 -12 lb)

Avocado and citrus: Not available.

3.4 Causes, Effects, and Control of Factors Affecting Production

Passion fruit: Lack of pruning causes more vegetative growth rather than fruit set. Also lack of pollinators and some pest damage. There is no major disease.

Avocado: Lack of proper management, tall trees, pests (scales, mites, and thrips), and disease (anthracnose, root rot) are the main factors affecting production and fruit quality.

Citrus: Lack of proper management, tall trees, pest (aphids, mites) and diseases (sooty mold, melanose) are the main factors affecting production and fruit quality.

IV. Harvesting

4.1 Methods

Passion fruit: Fruits are allowed to ripe and fall to the ground.

Avocado and Citrus: Climb/pick/throw method is mainly used.

4.2 Maturing Indices

Passion fruit: The falling of the fruit

Avocado and citrus: The farmers judgement.

4.3 Main Problems

Passion fruit: Rats eat fruit; weeds on the ground make gathering difficult, when fruit is left too long on the ground they rot.

Avocado and Citrus: Mechanical damage, uneven quality due to the lack of established maturity indexes.

V. Post-harvest Handling

5.1 Transportation from Field

Passion fruit: Fruits are placed in sacks then transported by head or vehicle.

Avocado: and Citrus: Fruits are placed in sacks then transported to Kingstown. The main problem is mechanical damage.

5.2 Packhouse operations

Passion fruit: Fruits are sorted, washed, and then stored at the packhouse.

Avocado and Citrus: Very little sorting, washing, and storage is done.

VI. Shipping and Distribution

A Phytosanitary Certificate has to be issued by the Plant Protection Unit in MAIL for all fruits exported.

VII. Processing

Passion fruit: The brand names are: Erica's Passion Fruit Juice and Rabacca Farms Passion Fruit Concentrate.

Avocado: No processing.

Citrus: Lime juice is made by the Richmos Academy.

VIII. Markets

Passion fruit: The market is mainly local via local processors. Fresh fruits are sold to hotels, restaurants and huskers. Local juice blenders can buy all the single strength juice. The price is $0.50 to $0.60 per pound (0.4 kg) for fruit and there is very little competition from imported syrup. Advertising is done only on labels and is not aggressive.

Avocado and Citrus: The market is local and regional, fruits are exported to mainly Barbados and Trinidad.

TRINIDAD AND TOBAGO

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INTRODUCTION

Trinidad and Tobago is the southernmost of the Caribbean Island chain. Tobago, the smaller of the twin-island state is located approximately 32 km east of Trinidad. Trinidad has a land area of approximately 4.828 km² and Tobago has approximately 380 km².

The average annual rainfall is about 2,250 mm in the major agricultural districts. Mean minimum and maximum temperatures are 22° C and 32° C respectively.

I. Generalities

1.1 Major Fruit Projects

1.1.1 Citrus

Of the three crops under discussion citrus enjoys the most activity. There are at least three important thrusts in citrus worthy of mention:

(i) *The Citrus Rehabilitation Programme* — This programme started in 1982 and completed the first phase of its work in 1987–1988. During this period it influenced the rehabilitation of approximately 2,000 ha of citrus.

The increase in production as seen from the number of crates delivered to the juicing plant Co-operative Citrus Growers Association (CCGA) is presented in Table 1.

[1]Plant Pathologist.

Table 1
The citrus crop (crates) received at CCGA juicing plant

Year	Grapefruit	Orange	Total
1981/1982	28,000	15,000	43,000
1982/83	50,000	15,000	65,000
1985/86	64,745	40,136	104,881
1986/87	44,541	43,414	87,955
1987/88	66,725	56,930	123,655
1988/89	48,005	58,145	106,150
1989/90	37,396	21,380	58,776

(ii) *Caroni (1975) Ltd. diversification into citrus* — Caroni (1975) Ltd started to diversify its operations away from sugar and went into citrus in 1985. It now has 1,673 ha of orange and 576 ha of grapefruit. The fruits from this programme are intended for processing.

(iii) *The Citrus Bud-wood Indexing Programme* — This programme was initiated in the mid 1980s. Caroni (1975) Ltd. orange and grapefruit plots are based on bud-wood coming out of this programme. At present, all orange and grapefruit plants produced by the Government propagation stations are based on bud-wood from this programme. The Citrus Research Unit at St. Augustine in Trinidad has been indexing for exocortis viroid and xyloporosis. Laboratory and greenhouse facilities for indexing for *Tristeza* and psorosis are being developed.

1.1.2 Avocado

There are no avocado projects of major significance except recent attempts to establish pure stands of the crop as mentioned earlier.

1.1.3 Passion Fruit

Passion fruit enjoys priority status in the eyes of the Government of Trinidad and Tobago's Ministry of Food Production. Being a relatively new crop it is receiving a great a deal of attention from the Ministry of Food Production Research Division. It has been pushed to the extent that in 1988 the Caribbean Industrial Research Institute (CARIRI), the Agricultural Development Bank, and the Ministry of Food Production sought to establish multi-fruit processing plants in various areas of Trinidad to fulfil the processing requirement of this crop. Their efforts have brought the crop into prominence. To date no multi-fruit processing plant as envisaged has yet been established. However, there are plants in Trinidad geared towards processing passion fruit (Table 2).

A fruit fly survey was initiated in May 1989 and is due for completion in March 1991. No new major fruit flies have been identified.

1.2 Area under Production

Of the three crops under discussion, passion fruit, avocado, and citrus, the latter is by far the most important economically occupying approximately 6,000 ha. The area under citrus is being expanded. Avocados are grown mainly as a backyard crop or as scattered seedling trees in large holdings among cocoa, coffee, and citrus. More recently, there are concerted efforts to establish pure stands in the Central Range of Trinidad. Passion fruit is a relatively new crop in Trinidad and Tobago. There are about 16 ha (40 acres) currently under production. Interest in passion fruit reached a peak in 1988–1990 but farmers are now disinterested in the crop due to the low price being offered by processors.

Table 2
Processors of passion fruit in Trinidad

Name of processor	Products	Remarks
Superior Foods	Juice box concentrate Passion fruit cordial	Exports to Canada & U.K.
	Pepper jelly Jams and jellies	Exports to Canada, U.K. & U.S.
Chase Foods	Sunpick passion fruit	Exports to U.S. & U.K.
Cannings Food Products	Cannings nutravera	
National Food Processors	Top-seed passion fruit cordial	Exports to Canada & U.K.
Hackshaw	Hackshaw's pancake	Exports to Barbados
	Hackshaw's passion fruit jams	Exports to Barbados
	Hackshaw's passion fruit juice	Exports to Barbados

1.3 Overseas Trade Statistics

Trade figures for the period 1988–1990 for the three crops are given in Tables 3–8. Imports and exports and the value are presented.

II. Pre-production

2.1 Major Cultivars

2.1.1 Citrus

The major citrus groups are the sweet orange, grapefruit, lime, and mandarin. Among the oranges the major early season varieties are "Parson Brown," "Hamlin," and "Washington Navel," maturing in January–February while the major late season variety in Trinidad is "Valencia" maturing in March–April. The "Valencia" is the most important orange variety in Trinidad.

The important grapefruit cultivar is "White Marsh" which matures in November–February. Small quantities of "Ruby," "Pink Marsh," and "Duncan" are also planted.

Table 3
Citrus imports for period 1985–1990

Year	Country	Imports(kg)	Value(TT$)
1985	Dominica	68,247	161,138.00
	St.Vincent	34,303	37,317.00
	Jamaica	15,513	33,469.00
		118,063	231,924.00
1986	Canada	490	540.00
	St Vincent	139,573	153,292.00
	Grenada	840	824.00
	Dominica	148,143	151,179.00
	U.S.	157	1,664.00
		289,203	307,499.00
1987	Grenada	10,418	11,464.00
	St Vincent	59,129	66,047.00
	U.S.	324	2,007.00
	Guyana	195	97.00
	Dominica	47,380	46,133.00
		117,446	125,748.00
1988	Grenada	39,372	43,371.00
	St. Vincent	121,133	132,766.00
		160,505	176,137.00
1989	Grenada	73,734	84,168.00
	U.S.	40	538.00
	St. Vincent	21,521	23,629.00
		95,295	108,335.00
1990	Grenada	17,705	19,473.00
	Rest of world	13,865	29,643.00
		331,570	49,116.00
	Total	812,082	998,759.00

NOTE: Data from Central Statistical Office, Trinidad and Tobago.

The predominant lime is "West Indian" which matures in June–October. Small quantities of "Tahiti" and "Rangpur" are also planted.

There are two major mandarin varieties, "Portugal" and "Dancy." "Portugal" matures in November–January while "Dancy" matures in January–February.

Table 4
Citrus exports for period 1985-1990

Year	Country	Exports (kg)	Value (TT$)
1985	United Kingdom	20	250.00
	Canada	125	145.00
	Barbados	30,445	21,992.00
	Stores	3,702	9,560.00
		34,292	31,947.00
1986	Canada	1,062	3,145.00
	Barbados	5,524	11,786.00
	Puerto Rico	10	100.00
	Cayman Islands	10	50.00
	U.S.	490	3,720.00
	Stores	3,315	8,685.00
		10,411	27,486.00
1987	Grenada	640	6,125.00
	Barbados	2,958	17,375.00
	Canada	2,844	6,625.00
	United Kingdom	727	5,040.00
	Netherlands	518	1,742.00
	West Germany	113	310.00
	U.S.	545	1,500.00
	Stores	1,617	4,085.00
		9,962	42,802.00
1988	Canada	2,736	4,614.00
	Grenada	3,301	5,045.00
	St.Vincent	495	186.00
	St.Lucia	32	100.00
	Antigua	14,292	24,760.00
	Barbados	1,000	1,000.00
	Netherlands	293	568.00
	United Kingdom	649	1,650.00
	U.S.	759	825.00
	Curacao	45	50.00
	Stores	3,452	8,390.00
		27,054	47,188.00
1989	United Kingdom	393	1,050.00
	Canada	3,186	4,371.00
	St. Vincent	450	200.00
	St.Lucia	245	498.00
	Antigua	18,102	45,025.00
	Barbados	225	675.00
	Japan	50	100.00
	Stores	4,949	64,490.00
		27,600	64,490.00
1990 Jan.–Oct.	Rest of World	36,255	63,192.00
	Stores	2,091	3,595.00
		38,346	66,787.00
	Total	147,665	280,700.00

NOTE: Data from Central Statistical Office, Trinidad and Tobago.

Table 5
Avocado imports for period 1985-1990

Year	Country	Imports (kg)	Value (TT$)
1985	Dominica	6,240	1,730.00
	Grenada	2,825	3,108.00
	St.Vincent	750,789	816,294.00
		759,854	821,132.00
1986	Dominica	2,947	3,632.00
	St.Vincent	939,025	1,073,308.00
		941,972	1,076,940.00
1987	Dominica	7,115	9,399.00
	Grenada	20,650	23,550.00
	St.Vincent	414,321	496,891.00
		442,086	529,840.00
1988	Grenada	100,231	120,218.00
	St.Vincent	737,976	909,347.00
		838,207	1,029,565.00
1989	Grenadines	91	100.00
	Grenada	81,099	91,368.00
	St.Vincent	280,701	336,653.00
		361,891	428,121.00
1990 Jan-Oct	Grenada	32,852	17,213.00
	St.Vincent	100,301	118,234.00
		133,153	135,447.00
	Total	3,477,162	4,021,085.00

NOTE: Data from Central Statistical Office, Trinidad and Tobago.

Table 6
Avocado exports for period 1985–1990

Year	Country	Exports (kg)	Value (TT$)
1985	United Kingdom	250	900.00
	Canada	16	100.00
	U.S.	20	200.00
	Venezuela	125	1,070.00
	Stores	70	460.00
		481	2,731.00
1986	United Kingdom	802	2,792.00
	Canada	4	32.00
	Venezuela	230	2,160.00
	Stores	20	120.00
		1,056	5,104.00
1987	United Kingdom	10	30.00
	Canada	342	1,085.00
	Grenada	15	117.00
	Stores	135	570.00
		502	1,802.00
1988	United Kingdom	1,314	4,297.00
	Canada	608	1,862.00
	St.Vincent	80	535.00
	Stores	160	880.00
		2,162	7,574.00
1989	United Kingdom	1,820	5,128.00
	Canada	1,440	2,973.00
	Antigua	1,120	6,295.00

Table 6 *(concluded)*
Avocado exports for period 1985–1990

Year	Country	Exports (kg)	Value (TT$)
1989	Barbados	454	1,000.00
(cont'd)	Netherlands	680	1,939.00
	U.S. Virgin Islands	10	20
	Stores	155	910.00
		5,679	18,265.00
1990	United Kingdom	2,980	8,970.00
Jun-Oct	Canada	4,547	5,157.00
	Rest of World	277	990.00
		7,804	15,117.00
	Total	17,684	50,592.00

NOTE: Data from Central Statistical Office, Trinidad and Tobago.

Table 7
Passion fruit imports for period 1985–1990

Year	Country	Import (kg)	Value(TT$)
1985	Grenada	1,200	1,320.00
1986	—	—	—
1987	St.Vincent	68	75.00
1988	—	—	—
1989	St.Vincent	455	597.00
1990			
Jan-Oct	—	—	—
	Total	1,723	1,992.00

NOTE: Data from Central Statistical Office, Trinidad and Tobago.

Table 8
Passion fruit export for period 1985–1990

Year	Country	Exports	Value (TT$)
1985	United Kingdom	2	5.00
	Canada	27	118.00
		29	123.00
1987	Canada	358	1,234.00
	Grenada	2,272	2,000.00
	Stores	10	65.00
		2,640	3,299.00
1988	Canada	19	8.00
	Antigua	48	50.00
	U.S.	30	120.00
	Netherlands	10	70.00
		107	248.00
1989	United Kingdom	292	580.00
	Canada	14	60.00
	Netherlands	470	924.00
		776	1,564.00
1990	United Kingdom	186	125.00
Jan-Oct	Canada	277	279.00
		463	404.00
	Total	4,015	5,638.00

NOTE: Data from Central Statistical Office, Trinidad and Tobago.

2.1.2 Avocado

The most important avocado cultivar is "Pollock", but smaller quantities of "Lula" and to a lesser extend "Blanch Fraser" and "Collinson" are also planted.

Pollock matures in May–August, Blanch Fraser matures in July–August while Collinson matures later in the year around October–November. Lula is the latest of all and matures in November–December but may be available as late as February.

Some local seedling types with excellent fruit quality and with the promise of extending the availability of avocados to year-round have been selected.

2.1.3 Passion Fruit

There are no named cultivars in the passion fruit industry in Trinidad and Tobago. However, the "yellow" type occupies a position of predominance over the "pink" type. Passion fruit is planted mainly for transformation into a processed product but some are juiced for immediate consumption at the local level.

The Research Division of the Ministry of Food Production has selected seven types for processing and three for the fresh fruit market.

2.2 Nursery Facilities

There are five major propagation stations, four in Trinidad and one in Tobago. These are government owned and operated and offer plants for sale at subsidized rates. These stations are La Pastora Propagation Station situated in Santa Cruz, St. Augustine Propagation Station situated in St. Augustine, La Reunion Propagation Station situated in Centeno, Marper Farm situated in Plum Mitan, and Louis Dor Propagation Station situated in Louis Dor, Tobago.

These propagation units have the physical capacity and human resource capability to meet the demands of the local fruit industry for avocado and citrus which require budded/grafted plants. Farmers normally produce their own passion fruit plants through seeds.

2.3 Rootstocks

2.3.1 Orange

Sour Orange is the major rootstock of Trinidad and Tobago's citrus. More than 95% of the industry is based on this rootstock. There is recent decision to broaden the rootstock base through the use of "Cleopatra" mandarin.

2.3.2 Avocado

The avocado plants in Trinidad and Tobago are not based on specific rootstocks. The usual practice is to use as rootstock whatever seed material is available and can be easily accessed.

2.3.3 Passion Fruit

Seedling plants are normally used to establish com-

mercial passion fruit plots. Cuttings and grafted plants are used by the Research Institutions to maintain specific types.

III. Production Practices

3.1 Cultural Practices

3.1.1 Citrus

Specific production practices are directed towards citrus. The magnitude of the effort and expenditure varies from farmer to farmer and ranges from almost nil to high levels of mechanization, maintenance of weed-free plots, and overuse (abuse) of pesticides.

The average farmer seeks to control weeds 2–3 times/year particularly at harvesting and fertilization, to fertilize 1–2 times/year, and to apply pesticides once per year. Farmers do not normally irrigate. Generally, production practices for citrus could be improved.

3.1.2 Avocado

Specific production/management practices are not directed towards avocado production because avocado occurs mainly as a backyard crop and as scattered trees. This crop does not enjoy fertilization application, nor the benefit of a pest and disease control programme.

At the backyard level, the plants generally benefit from the normal routine maintenance of lawns while at the plantation level they benefit from production efforts aimed at cocoa, coffee, and citrus among which they may be growing.

3.1.3 Passion Fruit

The production practices for passion fruit are essentially those outlined in IICA[1] and Rajkumar[2] passion fruit bulletins.

3.2 Yields

3.2.1 Citrus

Yields are variable but on average mature orange trees produce 1.5–2.0 field boxes per tree and grapefruit 2.5–3.0 field boxes per tree under Trinidad conditions.

3.2.2. Passion Fruit

Estimated yields for irrigated passion fruit are as follows:

First year	22,700 kg/ha
Second year	39,700 kg/ha
Third year	39,700 kg/ha
Fourth year	22,700 kg/ha
Fifth year	11,300 kg/ha

3.2.2 Avocado

Yield data for avocados are not available. However, individual five year old Pollock trees have produced 225 fruits and mature trees 650 fruits. Five-year-old Lula trees have been recorded to produce 530 fruits.

3.3 Constraints to Production

3.3.1 Citrus

The major constraint in citrus production revolves around inadequate management of the crop coupled with the presence of citrus viruses particularly a psorosis-like problem that is becoming increasingly prevalent.

Other constraints include unavailability of labour, cost of available labour, cost of agricultural inputs, relatively low price offered by the processing plant, and the inelastic demand for the fresh fruit on the local scene coupled with aesthetically unpleasant fruit unfit for export.

3.3.2 Avocado

There are two major constraints in avocado production. Firstly, there is *Phytophthora cinnamomi*—induced root rot dieback syndrome that affects the plant at almost any age. This disease syndrome seriously debilitates the plant and may very often lead to death. This is by far the more important of the two problems.

The second constraint is related to the general unthriftiness of the plant when established on rootstocks in a pure stand. The exact cause of the unthriftiness is not clearly understood but may be related to exposure to hash environmental conditions without shade.

3.3.3 Passion Fruit

The major constraint in passion fruit production is the low price ($0.66/kg) offered by the processors. Farmers demand at least $1.10/kg to become profitable producers.

Other factors that may become important in the future are pest and disease problems. Two distinctly separate stem-borer problems have been encountered. The causal insects have not been positively identified but have been tentatively identified as *Langsdorfia* sp. and *Azamora* sp. There is a barnacle-scale problem with the potential of becoming very serious. There are also at least two diseases, collar rot and Septoria-induced leaf and fruit spots.

IV. Processors

4.1 Citrus

There is one processor for orange and grapefruit—Co-operative Citrus Growers Association (CCGA) which produces single-strength canned juices. There is also one processor for lime —National Food Processors whose products are lime juice and lime cordial.

4.2 Avocado

There are no processors for avocado in Trinidad and Tobago.

4.3 Passion Fruit

Passion fruit processors and their products are presented in Table 2.

V. Conclusion

With the inclusion of Trinidad and Tobago into the Regional Fruit Programme in 1990, the development of the local fruit crop industry will facilitate easy exchange of information and fruit crop germplasm for mutual benefit within the region. Trinidad and Tobago is particularly interested in upgrading its capabilities for citrus virus indexing.

References

[1]Inter-American Institute for Co-operation in Agriculture 1987. Passion Fruit Production in Dominica. Extension Farmer Training Booklet No. 2.

[2] Rajkumar, D. 1987. Growing passion fruit in the West Indies. Regional Extension Communications Unit of the Caribbean Agricultural Extension Project/UWI/US Agency for International Development.

SECTION 2

TECHNICAL PAPERS

Nursery Management

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I. Introduction

Nurseries or propagation units are important components of most agricultural stations in the Caribbean region. Apart from a few private nurseries that are used for propagation of ornamentals and some fruit crops, most are owned and controlled by the public sector. Nurseries are often neglected and being subjected to low budgets limits their functioning and thereby their output, but nursery operations are critical to the future of any orchard.

There are two (2) fruit nurseries in Antigua and Barbuda, one (1) in Grenada, seven (7) in Dominica, three (3) in St. Lucia, seven (7) in St. Vincent & The Grenadines, two (2) in St. Kitts and Nevis, one (1) in Montserrat, one (1) in Barbados, four (4) in Trinidad, eleven (11) in Guyana, seven (7) in Suriname, one (1) in Guadeloupe, one (1) in Martinique, (1) in Haiti, and over forty (40) in the Dominican Republic. Surveys conducted by IICA in most of these countries indicate that **Nursery Management** is inefficient resulting in the poor quality plants produced by these nurseries.

Most training exercises including nursery management concentrate on plant propagation methods and tend to be weak in other important aspects of this subject, such as infrastructure and personnel management. Experience has shown that a nursery can have excellent propagators and yet be inefficient in its total output and in the quality of plants produced.

In recognition of the above-mentioned fact and in spite of the time constraint, we have tried in this workshop to present propagation methods and nursery management in two different sessions. It is not intended in such limited time to cover all the issues involved, but rather to increase awareness of the important issues to be considered.

II. Nursery Management: Areas To Consider

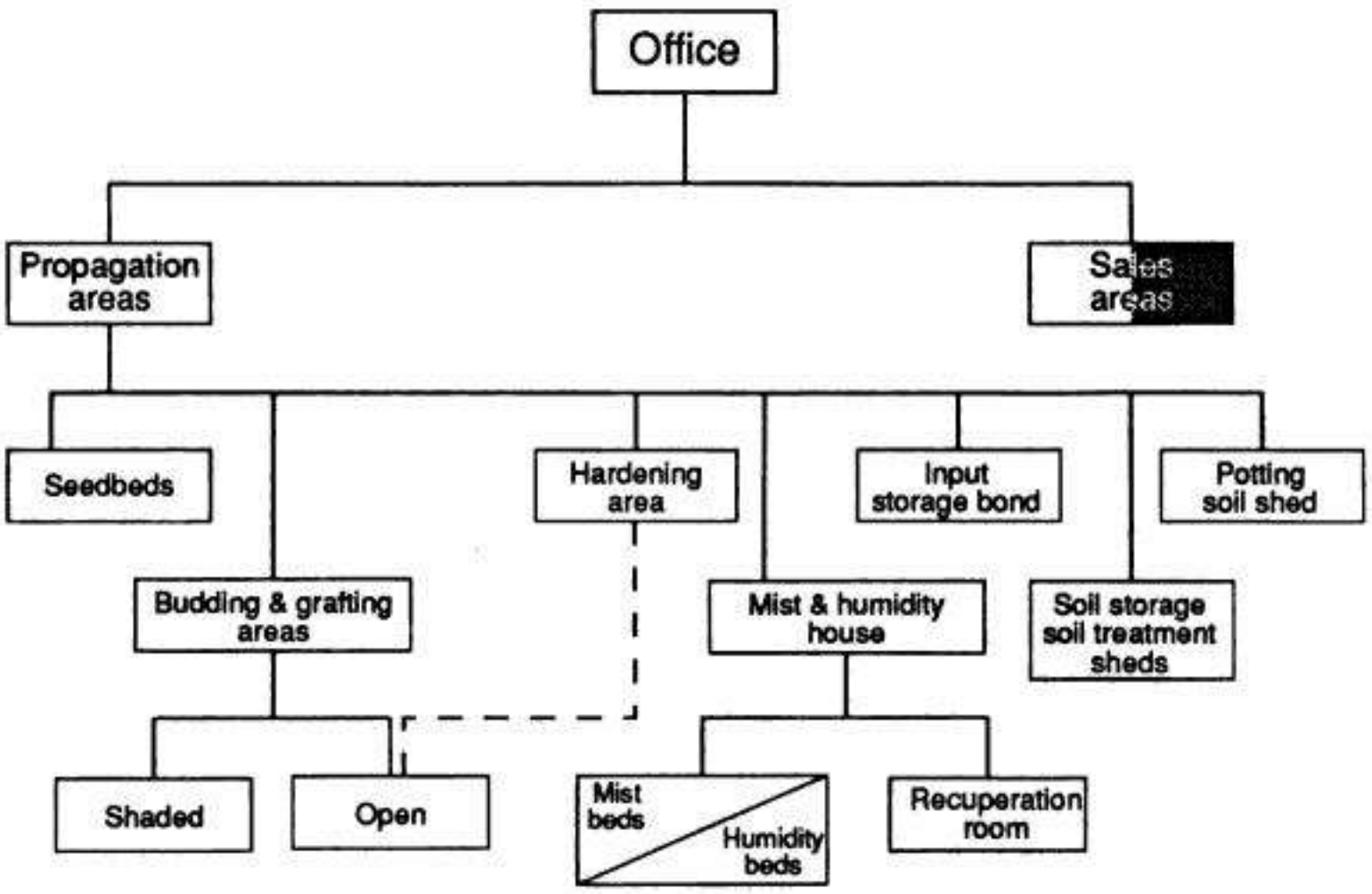
When discussing nursery management the three main components of a nursery that should be considered are:

(*a*) Infrastructure and equipment,
(*b*) Personnel, and
(*c*) Plants.

Although different in nature, these components should be managed together. The perfect orchestration in their management will provide the efficiency needed to produce enough plants of the desired quality. Nevertheless, for a better understanding of what they are and their individual role at the nursery, they are discussed separately.

2.1 Infrastructure and Equipment

Basic infrastructure is needed within a nursery to make it operational and efficient. An equipped nursery should have the following sub-components:



An example of a nursery layout is shown in Figure 1.

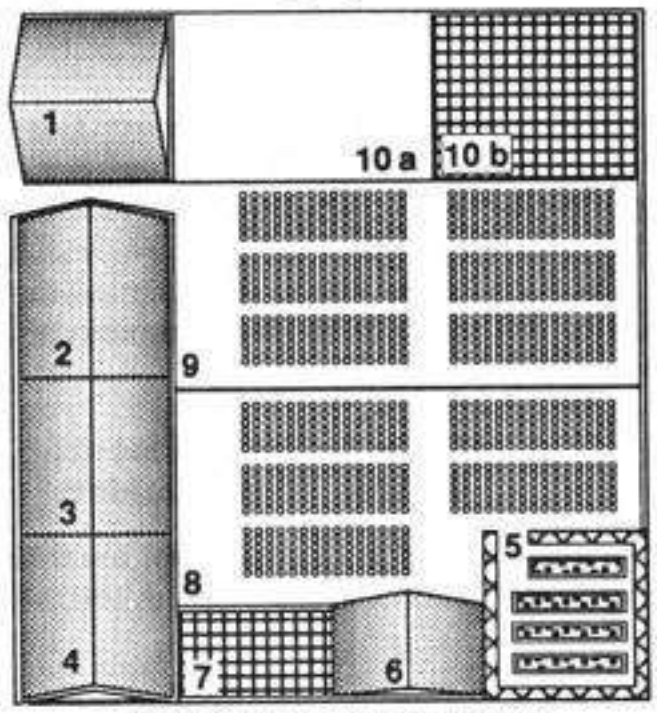


Fig. 1. Main Components of a Nursery:
Key

1. *Office*
2. *Soil Storage Shed*
3. *Soil Treatment Shed*
4. *Soil Potting Shed*
5. *Seedbeds*
6. *Misthouse*
7. *Recuperation Room*
8. *Budding Area*
9. *Growing Area*
10. *Sales Area*
    - *10a Open*
    - *10b Shaded (saran net)*

2.1.1 Office

The proper location for the office is important to nursery operations since the entrance of visitors or any other unauthorized persons to the propagation, potting or storage areas of the nursery should be prevented. This should be done not only to avoid the distraction of staff but more importantly to avoid contamination by diseases brought from farm to nursery or vice versa. Quite frequently, to save funds, the office is located in an area sharing space with the storage room or in the worst case, the same office is used as storage space. In both cases, this situation allows exposure of staff and visitors to harmful gases released by pesticides, fertilizers, and other chemicals. Whenever possible, the office should be at the entrance of the nursery and physically separated from the other areas.

2.1.2 Sales Area

Once the plant attains its established 'standard,' it is then passed to the '**sales area**.' This normally is an area of concrete floor near the office. The 'sales area' should be divided in two sections: one without and one with shade. Although visitors may be allowed to enter this area, they should be prevented from entering the other areas of the nursery. Both the office and the sales area should be located at the front of the nursery. Plants in this area should be properly identified in groups and with individual tags indicating the species, the cultivar, the date when they enter the sales area, and a code to track back the 'pedigree' of the plant if necessary. In all nurseries it is necessary to repot plants which have deteriorated containers . This contributes to the maintenance of a clean sales area, thus enhancing the whole operation and contributing to avoidance of any spread of diseases.

2.1.3 Propagation Areas

Each step in the propagation process may demand a different type of facility and environment. The most important propagation areas are discussed below.

2.1.3.1 *Seedbeds*

This area is basically composed of seed bins for sexually propagated plants. Seed bins vary in length and type of material used in their construction. Rectangular seed bins with sides made of concrete blocks are most common, although for temporary seed bins, banana stems or tree trunks may also be used. The propagator should know that the mixture of soil media to be used in the bins, as well as in the pots, depends on the species to be propagated. Basic materials used are soil, sand, and manure. Bagasse, filter press, coffee husk, compost, and other similar materials may also be used. More expensive materials such as peat moss, perlite, and vermiculite offer the advantage of being sterilized, thus reducing important problems such as weeds and pests. The proportion of these materials used in the mixture is mainly determined by the drainage required. A layer of gravel is normally placed at the bottom of the seedbed to improve drainage. The ideal seed bin has the facility to be covered during the early stages of propagation and can be uncovered during the hardening stage.

2.1.3.2 *Budding and Grafting Areas*

Areas for budding or grafting consist of a hard floor (concrete) with a section shaded by saran net or fiber glass sheets and another section exposed to open sunlight. Different species may require different environments for better results in budding and growth. The open sunlight section is also often used as the '**hardening area**' of the nursery.

2.1.3.3 *Hardening Area*

This area is a concrete section of the nursery where plants are allowed to adapt to full sunlight condition before they are released to farmers. In small-scale nurseries, this section is the same as the 'open-sunlight section' of the budding and grafting area.

2.1.3.4 *Mist and Humidity House*

Cuttings are normally rooted in mist and humidity beds. The first consists of beds, which ideally should be raised approximately 1 m from the floor, equipped with a 'mist irrigation system' and with 'bottom heat' equipment. A similar structure is used for 'humidity beds.' The basic difference is that in the mist beds application of water is minimal (8 – 15 sec), very frequent (every 3 – 10 min) but intermittent, while in

humidity beds, water is applied abundantly but only 2 to 4 times for the entire day. Moreover, humidity beds are covered with plastic to create an environment of high humidity surrounding the cuttings. In both cases, the house is covered by a material, e.g. fiber glass, which reduces the amount of light penetrating and prevents the impact of rainfall over the cuttings. The propagator should learn the particular requirement of each species and cultivar for rooting, to calibrate the watering and bottom heat equipment. Some species, such as soursop prefer the humidity bed to the mist bed in order to root well and rapidly. In other cases, e.g. breadfruit, a combination of both beds may be necessary at different stages (humidity bed to shoot and mist bed to root). In a well organized nursery, the mist and humidity bed house has an adjacent area known as the 'transplanting or recuperation room.' This area is used as an intermediate step to reduce the 'shock of transplanting.' This room or chamber consists of a concrete floor with saran netting at the top and sides and overhead mist. One of the most common mistakes at many nurseries is the use of mist and humidity beds as seedbins for the propagation of a wide variety of seeds. This practice is costly, since the high-cost materials used as media (peat moss, perlite, and vermiculite) in the beds deteriorate rapidly with the frequent addition of foreign material, e.g. organic matter, and subsequently become unsuitable for the rooting of cuttings.

2.1.3.5 *Input Storage Bond*

Chemicals should be stored away from areas where the nursery staff and visitors normally operate because the gases released by fertilizers, pesticides, and other chemicals are harmful. The storage room should be provided with air extractors to facilitate the work of the staff and they should use respirators anytime they are entering the storage room. Fertilizer should not be placed directly on the floor but on wooden pallets, and the staff should learn to handle all chemicals in storage. Any spillage should be promptly cleaned and damaged or broken containers should be replaced.

2.1.3.6 *Soil Storage and Soil Treatment Sheds*

The soil media used in beds and containers is frequently **stored**, then **treated**, and eventually **used**. Most nurseries lack appropriate structures for storage of soil, sand, and other plant-growing media. These materials are frequently dumped in areas close to the shed or placed where the containers are been filled. In places where rainfall is frequent, a covered shed with concrete floor for soil storage is essential. This ensures that the propagation process does not suffer interruptions after heavy rainfall. It is convenient to place the soil treatment equipment in the same shed as the potting area.

2.1.3.7 *Soil Potting Shed*

This area consists of a concrete floor inside a shed with open sides located next to the soil storage and soil treatment sheds. The shed should provide enough space to avoid a halt in the process of soil movement, potting, and pot removal. Quite often this area is also used as the 'transplanting area.' This use has the advantage that the operation is done more comfortably under shade which is convenient both to labor and to the plant.

2.2 Personnel

To increase efficiency in the operation of a nursery the staff must be specialized in different fields. A well organized nursery must have the following staff.

Administrator — He/she plays an important part in the nursery and is responsible for the entire operation including the staff. Depending on the size of the operation, he/she will have assistant(s), secretaries, and supervisors to help him/her to manage the nursery in different fields.

Foreman or supervisor — Each group of workers may have a foreman or supervisor. In small operations these persons are selected from among the group of their specialization but continue to perform their duties as ordinary members of their groups.

Budder and grafter — One of the most essential staff members of the operation. Budding/grafting requires expertise which is developed by practice and frequent training in new methods and techniques of propagation. This staff member also performs as a pruner especially for plants in the germplasm bank.

Spray man — He/she is responsible for the pest and disease control. He/she should know and practice proper calibration and handling of spray equipment, as well as safety rules for handling the chemicals.

Irrigation and fertilization man — Quite often these tasks are left to the general labour. Although some of them may occasionally do a good job, experience has shown that unless a careful person is selected to perform these tasks, damages are often incurred in the management of plants. Therefore, the recommendation is to select among the general labour one or two persons who are very careful and assign these responsibilities permanently to them.

General labour — These persons have the responsibility for cleaning and the general maintenance of the nursery. They may perform other duties such as moving plants, mixing, sterilizing and potting soils, sowing seeds, etc. They should receive frequent training not only in common but also specialized tasks, as they may be ideal candidates when new positions open.

Sales man — The size of the nursery may demand one or more full-time sales persons. However, in small operations, the foreman is responsible for all sales at the nursery.

2.3 Plants

When discussing the management of plants at the nursery two different areas should be considered:

plants in propagation, and plants at the germplasm bank from where the bud-wood is collected. In both cases it is critical that management learn the different needs at the level of species and cultivars. There are plants such as avocados, *Persea americana* which require shade throughout the period of propagation, from seed until the grafted tree is released to the farmer. Others, such as mango, *Mangifera indica*, only need shade at the early stages of development, before being grafted. The following are some examples of important crops and their demand for light during the propagation process.

Table 1
Demand for light by different fruit species during the propagation process.

Species	Prefer partial shade (saran)	Prefer open sunlight	Can do well in both
Citrus spp.	Early stage of seedbed		From seedlings to plants ready for release
Avocado	From seedbed to plant ready for release	Last 2 weeks at the nursery	
Mango	From seedbed to small seedlings	From established seedlings to plants ready for release	
Papaya	From seeds to small seedlings	From established seedlings to plant ready for release	
Passion fruit	From seeds to seedlings		From seedlings to plants ready for release
Breadfruit	From cuttings to established plants		From established cuttings to plants ready for release
Sapodilla	From seeds to plants ready for release	Last 2 weeks at the nursery	
Soursop	From seeds or cuttings to plants ready for release	Last 2 weeks at the nursery	

As with shade, the need for water during the propagation process is an important factor to consider. Some species, such as recently grafted avocados and mangoes, prefer frequent but small amounts of water directed to the container but not to the top of plants. Most seedlings can be irrigated over the top. Nevertheless, it is always recommended to use a deflector, e.g. a rose, to avoid the impact of water with pressure that may cause leaves and twigs to fall or may bend the trunk of the plant in the container.

The goal at any nursery should be to produce as many plants as possible, but of a desirable high quality. To reach this goal a criteria should be established to describe that 'desired quality.' These can be defined as 'standards' which may vary from one location to the other and with the respective species. When describing the 'standards' the following factors should be considered and included:

(*a*) Destination of the final plant (region and/or location where the trees are to be planted and their ecological characteristics).
(*b*) Species and cultivars to be propagated.
(*c*) Source of bud-wood.
(*d*) Species used as rootstock.
(*e*) Source of seeds for rootstock.
(*f*) Propagation method.
(*g*) Height of budding and/or grafting.
(*h*) Training system ('whip,' 'headed,' or 'free growth').
(*i*) Number and position of scaffold branches.
(*j*) Delivery criteria, e.g. general appearance, health, vigour, sizes, maturity, etc.

One of the most common problems related to (*j*) is the fact that many nurseries deliver trees with containers infested by weeds; this is often a vehicle for the spread of new problems from the nursery to the field.

Pruning and collection of bud-wood are operations that should be handled very carefully. The staff should be concerned about what instrument to use, type of wood to collect, where to cut, how to sterilize the tools and equipment, how to preserve the material, etc. Unfortunately there is not enough time and space to discuss all these issues in detail. However, because of its importance the sterilization or most accurately 'decontamination' process is discussed.

2.3.1 The Decontamination Process

Sometimes, it is difficult to determine if a plant is or is not free of a given pest. This is particularly true for plants affected by viruses. The simple use of a secateur or pruning shears that has not been decontaminated may cause contamination of the next trees and that of the bud-wood collected. Today, as a general practice, it is recommended that, whenever possible, secateurs, budding and grafting knives, or any similar tools used, be washed in a solution of sodium hypochlorite (5%) and rinsed in plenty water, *every time* the staff moves from one plant to the next. This precaution should be observed both at the nursery and at the germplasm bank.

III. Propagation Plan, Booking of Plants, and Record Keeping

Figure 2 provides a good example of the factors taken into consideration in the programming and budgeting process at a propagation unit.

The propagation plan for any nursery should define the target by species and cultivars to be propagated during the year. Ideally this plan should be elaborated by the fruit crop officer from information received about demand which should be provided by the extension service and the pre-booking of plants

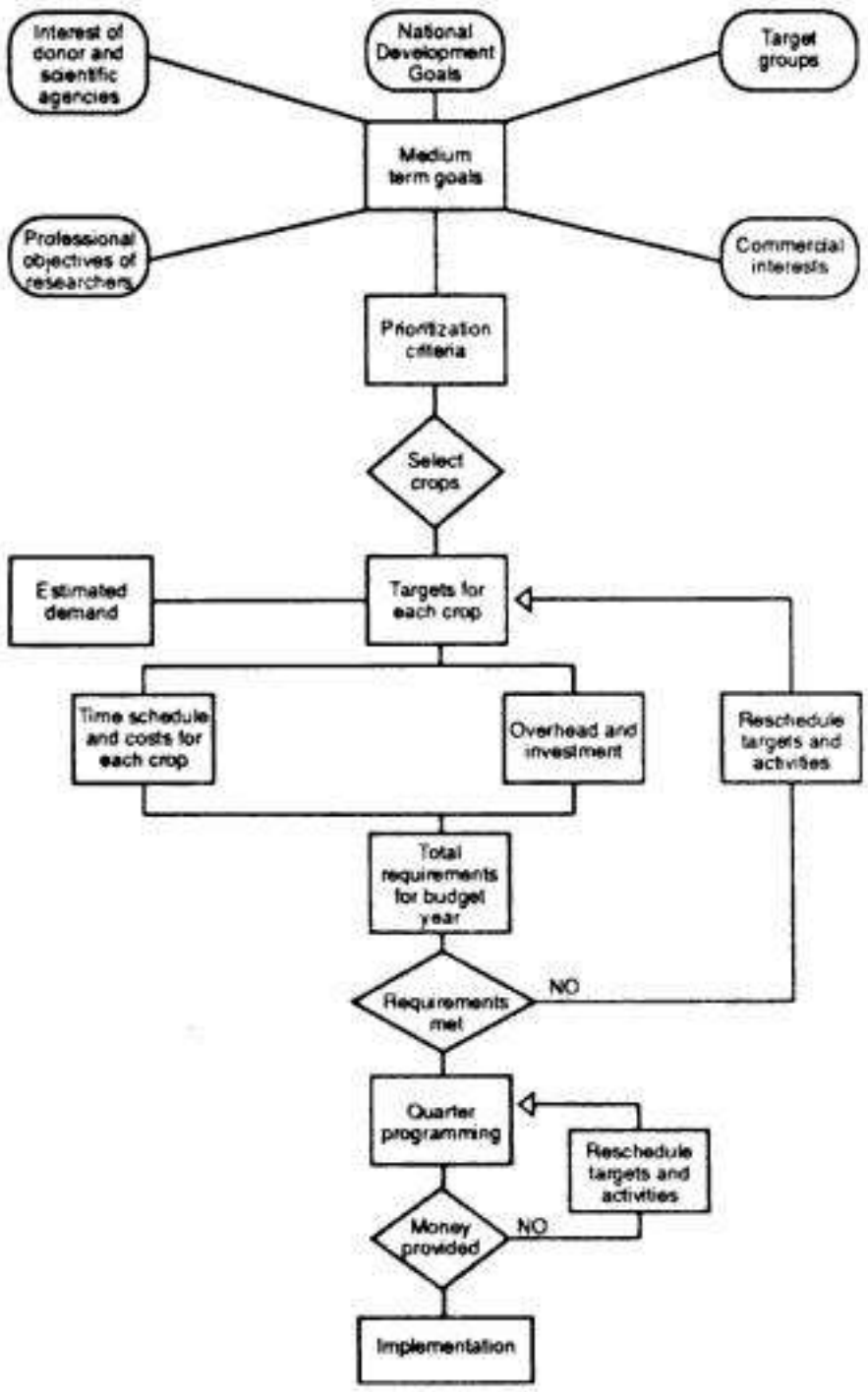


Fig. 2. Programming and Budgeting Process of the P.P.U.

by the farmers. Unfortunately, the experience has shown that this is not the case for most nurseries in the Caribbean. The main reason normally given is the slow feedback to the nursery from the extension service. Moreover, many nursery administrators complain that some extension agents book plants for farmers and never return to collect them.

Even if the propagation plan has to be done from experience, records from previous years are very important since they can indicate the trend of demand and avoid the normal oversupply in some species and the marked deficit in others. It is also important to note that a nursery should concentrate on the propagation of species suitable for planting in its area of influence. For example, it makes no sense to propagate mango in a high rainfall area.

A series of forms may be used to facilitate management and operation at the nursery.

Form 1 in the Appendix shows the type of information on targets included in a simple propagation plan.

Form 2 is used to calculate the inputs required by the crop, to reach the approved target.

The process of propagation can be compared to a ladder. You need to pass through several steps before reaching your target. For example, if you do not secure the fruit for the seeds, you cannot make ready the seedlings that later will be grafted and cared for until the final plant is ready to be released. **Form 3** is used to determine when each of these steps should be covered. An example is provided for citrus.

The nursery should be able to trace back the origin of each plant produced, in terms of the source of the bud-wood and seeds, chemicals applied, dates of sowing, transplanting, budding, or grafting, when plant was ready and when it was released. This information may be important to find out reasons for pest problems, bad quality, rootstock performance, etc. **Forms 4** and **5** are used with this intention.

The performance and effectiveness of budders and grafters is also important to monitor. This can be used to increase productivity and to pursue specialization in methods or species. With this intention, **Form 6** should be followed and completed. This form is also of great help to monitor the advances in the target proposed.

Monthly inventories should be conducted at the nursery to review the position in terms of the proposed target at the cultivar level. A good manager will use this inventory to modify his/her strategy when needed, and concentrate efforts in certain specific areas of deficiency. For example if the target for the different cultivars of mango was 2000 and only 500 plants have been propagated but the nursery still has 3000 rootstocks, the emphasis should be on grafting. But if the nursery only had 1000 rootstocks the emphasis should be to get seeds for the rest of the stock that is of course, without neglecting the grafting process. **Form 7** in the Appendix, is a simple example of the information collected in this type of inventory.

From time to time, growers visit the nursery and their presence should be used not only to book the plants they may want for future planting, but also to learn about his/her operation. **Form 8** describes the type of information that could be collected while the grower is comfortably seated at the nursery office. This information could later be used to update a 'farmer directory' for better technical assistance by the extension service.

APPENDIX

FORM 1

Propogation Plan
1991 Target for "Quality Fruit" Nursery

Species	Cultivars	Proposed	Approved
Citrus			
Sweet Oranges		40000	20000
	Valencia		17500
	Hamlin		500
	Parson Brown		500
	W. Navel		500
	Pineapple		500
	Others		500
Limes		16000	7000
	W.I. Limes		5000
	Tahiti (Bears)		2000
Grapefruits		3000	3000
	Marsh seedless		1500
	Duncan		300
	Thompson Pink		400
	Red Blush		400
	Ruby Red		400
Mandarins and Mandarin-like		6000	9900
	Satsuma		100
	Dancy		100
	Ortanique		100
	Murcott		100
	Orlando Tang		100
	Mineola Tang		100
	Ponkan		100
	Others		9200
		65000	39900

Inventory of Citrus by January 1991

Plants budded and/or released	9153
Rootstock on hand	
Rough lemon	6247
Sour orange	688
Total number of stocks required	65000
Seeds required	130000
Fruits required	
Rough lemon	15000
Sour orange	10000

Species	Cultivars	Proposed	Approved
Mangoes		8000	5000
	Julie		2300
	Buxton spice		2150
	Imperial		50
	Graham		50
	Ceylon		50
	Bombay		50
	Keitt		50
	Kent		50
	Tommy Atkins		50
	Carrie		50
	Sabiana		50
	Irwin		50
	Palmer		50

Inventory of mangoes by January 1991

Produced to date	67
Number of stocks on hand	
Number of stocks required	10000
Number of seeds required	15000
Number of fruits required	15000

Species	Cultivars	Proposed	Approved
Avocados		8000	8000
	Lula		2000
	Simmonds		1000
	Choquette		1000
	Booth 7		500
	Booth 8		500
	Ruhle		500
	Pollock		300
	Semil 34		300
	Gripina		200
	Monroe		200
	Popenoe		200
	Hall		300
	Dade		500
	Others		500

Inventory of avocados by January 1991

Plants produced	479
Stocks on hand	
Number of stocks required	10000
Number of seeds required	13000
Number of fruits required	13000

Species	Cultivars	Proposed	Approved
Less Traditional			
Carambola		650	550
	Arkin	250	200
	Golden Star	250	200
	B-10	150	150
Sapodilla		250	250
	Sugar Brown	150	150
	Early	100	100
Papaya		2500	2300
	Sunrise	900	900
	Kapoho	900	900
	Cartagena	700	500
Passion Fruit		1900	1900
	Dominica 1	800	800
	Guyana 10-11	700	700
	Trinidad Sweet	400	400
W. I. Cherries		1000	1000
	B-17	800	800
	Florida Sweet	200	200
Guava		1120	950
	Supreme	300	250
	Patillo	320	200
	Centeno	500	500
Soursop		400	400
	Buris	200	200
	DR-15	200	200
Breadfruit		300	200
Dunks		100	100
Bilimbi		100	100
Tamarind		100	100
Golden Apple		100	100
Ackees		100	100
Other Fruits		1000	500
Total		9620	8550

FORM 2
Fruit Crop Development Project
MAFCA - IICA
Nursery Planning

Crop _____

Number of Plants to be propagated
Method of Propagation _____
Number of Seeds Required _____
Number of Plastics Bags _____
Amount of Medium:
a) Soil _____
b) Baggase _____
c) Sand _____
d) Others _____

Fertilizer
1) Foliar: _____ Quantity _____
_____ " _____
_____ " _____
2) Granulated:
a) Compound _____ Quantity _____
b) Simple _____ " _____
c) Form _____ " _____

Pesticidies
1) Insecticides _____ Quantity _____
2) Fungicides _____ " _____
3) Miticides _____ " _____
4) Muluscicides _____ " _____

Growth Regulators
_____
_____
_____
_____

FORM 3
Fruit Crop Development Project
MAFCA- IICA
Nursery Operation Timetable

Crop Citrus

Activity	Month	J		F		M		A		M		J		J		A		S		O		N		D	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1. Collecting the fruit																									
2. Extraction of Seeds																									
3. Pretreatment of Seeds																									
4. Medium Preparation																									
5. Seedbed Preparation																									
6. Planting the Seeds																									
7. Transplanting to Plastic Bags																									
Getting the Bags																									
Preparing the Medium																									
Filling the Bags																									
Planting in the Bags																									
8. Budding/Grafting																									
9. Unwrapping																									
10. Forcing																									
11. Rebudding/Regrafting																									
12. Training the Plants																									
13. Plants Ready to leave																									

NEXT YEAR

FORM 4
Fruit Crop Demonstration Propagation Unit
MOA-IICA
Control of Seedbeds

Seedbed No. ..... Area ..... m²
Media ..... Sterilized with ..... Date .....
Fertilizer (s) added ..... Date ..... Rate .....
Species ..... Source of seed and Collection date .....
Extraction Date ..... Treatment ..... Date .....
Area Sown ..... No. of Lines .....
No. of Seed/Line .....
Date sown ..... Germination date: From ..... To .....
Second Fertilization Due ..... Done .....
Average no. of plants per line 2 months after planting .....
Dates of weeding .....
Transplanting Dates: Start ..... End .....
Number of Seedling Produced:
Total .....
Grade 1 .....
Grade 2 .....
Rejected .....

Problems Encountered:* .....
.....
.....
.....

Action Taken:* .....
.....
.....
.....

*Include Dates

FORM 5
Fruit Crop Demonstration Propagation Unit
MOA-IICA
Control of Seedlings Planted

Bin/Bed/Block No. ..... Area ..... m²
Media ..... Sterilized with ..... Date .....
Fertilizer (s) added ..... Date ..... Rate .....
Species ..... From Bin No. .....
Transplant Date ..... No. Transplanted .....
Second Fertilization: Due ..... Done .....
Third Fertilization: Due ..... Done .....
Date(s) of weeding: ....
Date(s) of Budding: No. Budded: Cultivar
....
....
....
Date(s) when ready for release: ....
Total number of plants for release: .....

Problems Encountered:* .....
.....
.....
.....

Action Taken:* .....
.....
.....
.....

*Include Dates

FORM 6
Fruit Crop Demonstration Propagation Unit
MOA-IICA
Daily Control of Plants Grafted or Budded

Grafter & Section No	Cultivar (s)	Source	Number of plants	Date			Number of plants that take
				Grafting	Unwrapping	Forcing	

FORM 7
Fruit Crop Demonstration Propagation Unit
MOA-IICA
Monthly inventory of fruit trees

Species	Cultivar	Number of Plants													
		(a) Recently budded or grafted		(b) Growing		(c) Ready to leave		(d) Leaving		(e) Dead		Total*		Target for the year	Dif.
		C	R	C	R	C	R	C	R	C	R	C	R		
Mangoes	Julie														
	Imperial														
	Ceylon														
	T. Atkins														
	Haden														
	Palmer														
	Irwin														
	Keitt														
Subtotal															
Rootstocks															
Avocado	Lula														
	Choquette														
	Booth 7														
	Semil 34														
	Catalina														
	Waldin														
Subtotal															
Rootstocks															
Sweet Oranges	Valencia														
	W. Navel														

* Include: a + b + c + d - e = Total number of plants leaving nursery to date

FORM 8
Fruit Crop Demonstration Propagation Unit
MOA-IICA
Distribution Control Form

1. **General Information**
   1.1 Name _____
   1.2 Address _____
   _____
   Phone No. _____
   1.3 Farm Location _____
   1.4 Total Area: _____ Area in Use: _____
   1.5 Farming Activities: _____

2. Plants Requested and Delivered

Species	Cultivar	No. Requested	No. Delivered

3. If you have fruit trees on your farm, please complete the following:

3.1 Type (Species or Cultivar)	Area/Quantity	Age (s)

3.2 Which are your main problems?
( ) Pest and Disease Management
( ) Poor Drainage
( ) Unavailability of Inputs
( ) Praedial Larceny
( ) Lack of Market
( ) Lack of Transportation Facilities
( ) Inadequate Technical Assitance
( ) Lack of Credit

3.3 Are you planning to extend your orchards? Yes ( ) No ( )
If Yes: When _____
Species _____
Area/No. of Trees _____

SIGNATURE OF PERSON COMPLETING FORM: _____
DATE: _____

N.B. Make any additional comments on back of form.

Propagation Techniques

GERARD BARBEAU
Fruit Crop Specialist, IICA, Trinidad and Tobago

In fruit production one of the most important aspects is the quality of the plants which will be used to initiate the orchard plot. Healthy and vigorous nursery plants will produce long-living, productive trees. On the contrary a plant which has been sick or poorly fed at its early stages of development will not produce a highly productive, long-living, and good quality fruit tree.

I. Sexual Multiplication and Vegetative Propagation

Fruit plants may be propagated in two ways:
— Directly from seeds (sexual reproduction).
— Vegetatively, i.e. by producing a new plant from a piece of plant (a sexual propagation).

Traditionally, fruit plants have been propagated by seeds, and presently, most of them are still being propagated this way. Although seed propagation is the easiest, generally it is not the best, because it scarcely allows for maintenance of the characters of the original plant. Offspring may be completely different from the mother plant as well as from each other in shape, growing habits, size, colour, and quality of fruits, etc. In addition, plants grown directly from seeds are slow to bear.

Whenever possible, vegetative propagation should be used because it allows for the multiplication of quick bearing plants in conformity with the original mother plant. In some cases a sexual multiplication may be the only way to assure the perenniality of

the species, especially when fruits are seedless or seeds are not viable (Washington Navel oranges, Tahiti limes, Breadfruit). Cuttings, layering, marcotting, shoots, slips, grafting, and budding are different methods of vegetative propagation commonly used. In this way each plant will be identical with the mother plant; that means it will have the same pattern of growth, the same shape of leaves and fruits, and the same period of flowering and harvesting, if placed under the same conditions. However, special care should be taken to ensure that the mother plants are healthy because many pests and diseases, especially viruses, may spread by means of vegetative propagation. Sometimes, plants grown from cuttings or air-layering nay result in a poor root system which will affect their behaviour in adverse conditions.

In both sexual multiplication and vegetative propagation special care is needed to produce large quantities of homogeneous, healthy, and high quality plants. Fruit plant propagation is performed in specialized places called nurseries.

II. Nurseries — Generalities

2.1 Location

A fruit nursery is a place where young fruit trees are grown and prepared for further transplantation in production plots.

Table 1
Preferred or recommended methods of vegetative propagation (Samson 1980)

	Popenoe (5) (1920)	Chandler (2) (1985)	Garner (3) (1976)
Avocado	*s*	*sb/sg*	—
Carambola*	*b*	*ag*	*sb/fb/vg/ag*
Cashew	*sb*	*b*	*m/ag/tg*
Durian	*sb*	—	*fb*
Guava	*sb*	*vg*	*fb/vg/ag/l/m/c*
Macadamia	—	*sg*[y]	—
Passion Fruit	*sb*	*b/g*	*ag/vg/sb*
Rumbutan	*ag*	—	*c/fb*
Sapodilla*	*c*	*c*	–
Soursop*	*m*	*m/b/ag*[y]	*fb/ag/m*
West Indian Cherry	*sb*	*g*	*ag/sb/fb/m*
	b	*b/g*	*c/sg/ag*
	—	*c*	*c/sg/m*

NOTE: — = no data; *b* = budding; *c* = cutting; *g* = grafting; *l* = layering; *m* = marcotting (air-layering); *ag* = approach grafting (inarching); *fb* = Forkert budding; *sb* = shield budding; *sg* = side frafting; *tg* = tip (or top) grafting; *vg* = veneer grafting; y = scion to be ringed two weeks before grafting.* = usually propogated from seed.

Table 2
Comparison of sexual and vegetative propagation

Sexual	Vegetative
Easy to perform	Requires some skill
Heterogeneity	Homogeneity
Late bearing	Early bearing
Good root system	Root system may be weak
Low risk of transmission of pests and disease	High risk of transmission of pests and diseases
Impossible for seedless varities	Difficult with some species

The main components of a fruit nursery are:
- the seedbeds for germination of the seeds
- beds for vegetative propagation
- the growing and budding (or grafting) area
- the sales area

Logistic support may be given through a soil preparation and potting area, and a storage room for the tools and the agrochemicals used in the nursery.

The location of a nursery must meet some basic requirements to get good results:
- Accessibility at all times.
- Protection against strong winds and hurricanes.
- Protection against domestic (pigs, hens and chickens) and wild animals (manicou, monkeys, and iguanas)
- Protection against leaf-cutting ants.
- Presence of water for complementary irrigation.
- Availability of good soil or compounds for preparing the soil mixture.
- Availability of seeds and vegetative materials in the surrounding area.

2.2 Soil Preparation

The main qualities for the soil used in a nursery are good water retention and good drainage of excess water. This can be achieved by mixing top soil with sand, sawdust, peat moss, crushed coconut shells, crushed bagasse, rice hulls, etc., in different proportions, depending on their availability and according to the texture of the original top soil and the desired final product.

It is recommended that the soil mixture be disinfected, at least in the first stage (seedbeds and beds for vegetative propagation), to avoid contamination of the seeds and cuttings by fungi and bacteria, to eliminate nematodes and other insects, and to kill the weeds.

For these small areas both sterilization by heat and steam, or liquid chemicals can be used. The sterilization by heat (100°C for 1½ h) requires expensive investment in machinery to produce hot air or steam, but the medium can be used immediately. If using steam or liquid chemicals like Formal, Methylbromide, and Metamsodium, etc., the investment is lower, but a waiting period of 5 to 20 days is necessary before sowing.

For the soil mixture in the growing area, after transplantation of the seedlings, disinfection, in the cheapest manner possible, may be carried out if some risks are likely.

For the huge volumes of soil mixture in the growing area, the use of granulated solid chemicals is easier and less expensive, and the waiting period is reduced to 4 to 5 days. Products like Aldicarbe (Temik) and Carbofuran (Furadan Curater) control insects and nematodes, while Metalaxyl (Ridomil) and Dazomet (Basamid) control many fungi.

In the specific case of citrus, Trifluralin (Treflan) incorporated in the soil has proved to be successful both with grasses and annual dicotyledons.

Dosage will depend on the formulation of the products. It is recommended that solid fertilizers be added to the soil before filling the polythene bags. Recommended dosage for 1 m^3 mixture would be about 2.3 kg (5 lb.) of a complete formula (15–15–15 or 12–15-10).

2.3 Early Care in the Nursery

After sowing, it is necessary to maintain enough humidity in the soil to guarantee good germination, but excess moisture may lead to development of diseases, so appropriate aeration is needed also.

If the soil has not been sterilized, weeds must be controlled as often as necessary because they compete with the young seedlings for water and nutrients.

Even with a sterilized soil, some pests and diseases may spread very quickly. Checking for sanitary aspects is a daily duty: pesticides must be applied as necessary.

When the seedlings reach a height of 5 to 15 cm, they can be transplanted in the growing area in polythene bags or directly in the ground. Special care must be taken not to damage the root system. For citrus and mango, polyembryonic seedlings have to be separated carefully and the weakest ones eliminated. If possible, it is best to transplant in the late afternoon, so the seedlings will have all the fresh hours during the night to adapt. Another precaution is cutting the leaves in half to reduce transpiration. Watering must follow transplantation immediately, even if the soil is moist.

2.4 The Growing Area

If polythene bags are used, the size depends on the final development of the plant and the duration of the growing period. For quick growing plants like papaya and passion fruit, bags 8 cm in diameter and 15 cm high are enough, but citrus, mangoes, and avocados will require bags of up to 25 cm in diameter and 40 cm high. Generally, young plants grow quicker in small containers than in large ones.

The advantage of polythene bags is to allow for the easy transportation and transplantation of the plants, with minimal stress.

III. Multiplication

3.1 Multiplication by Seeds

Actually, reproduction by seeds is used mainly for fruit grown in backyards. Most of these trees do not come from nurseries, but the seeds are collected by the inhabitants from attractive fruits bought at the market or given to them by their neighbours. West Indian limes, guavas, avocados, mangoes, sweet oranges, soursop, sapodillas, pomerac, etc. are to some extent still being propagated this way, although there is an increasing tendency to acquire nursery plants produced by vegetative propagation.

For some fruit trees, e.g. coconut, reproduction by seeds has so far been the only alternative. Some other species like cashew and chataigne are commonly multiplied by seeds because fairly good results are obtained, with respect to homogeneity of the offspring or the rapidity with which they bear.

In some citrus and mango varieties or cultivars, seeds contain several embryos: one of them has a sexual origin; the other ones develop from cells of the nucellar tissue and have a sexual origin. These are called nucellar embryos. The latter produce plants with the same characteristics as their mother plant; in fact it is a case of vegetative propagation. In citrus species, this peculiarity is used to rehabilitate old cultivars infested with viruses, because generally virus diseases are not transmitted by seeds, so it is possible to obtain new healthy plants genetically identical with the mother plant and to reconstitute the infested germplasm banks. Some secondary characteristics may differ slightly because they depend upon cytoplasmic heredity, for instance the importance of the spines.

In some ways, multiplication by seeds in many citrus varieties have preserved them from being infected by virus diseases, since these more often spread through vegetative propagation (use of infested bud-wood or contaminated grafted tools) or are related with the association of the rootstock and cultivar (tristeza).

Multiplication by seeds is widely used for the production of rootstocks. Seeds must be selected for their adaptation to the climatic and pedological conditions of the place where planting will occur. Local varieties of mangoes, avocados, and secondary fruits (sapodillas, soursop, pomerac) are suitable as rootstocks for cultivars of these species. For citrus, rootstocks must first be selected according to other factors like resistance or tolerance to pests, *Diaprepes*, and diseases (gummosis, virus, and virus-like diseases), and then climatic and soil adaptation must be taken into consideration. Seeds of these rootstocks are seldom available and have to be imported.

3.2 Seed Collection and Sowing

Seeds must be taken from well-matured, healthy fruits, collected from the trees. It is not recommended that seeds be taken from fruits that have fallen on the ground as fungal or bacterial infection may occur.

Seeds are hand-extracted, washed, disinfected, and allowed to dry in a shady, well-aerated place for no more than a couple of days, after which they have to be sown immediately or stored until sowing is possible.

Disinfection of the seeds is a good precaution against

fungal and bacterial diseases. Immersion in hot water at 52°C for 10 min generally is enough to prevent citrus seeds from *Phytophthora* sp. Avocado and mango seeds and seeds from other fruit species may be treated with an insecticide and fungicide mixture (against seed borers, fungi, and associated bacteria) by immersion for 10 to 15 min. Fungicides like carbamates (maneb, mancopper) or dicarboximids (captan, captafol) associated with contact insecticides of the organophosphorous group (malathion, parathion, pyrimiphos-methyl) give good results at the usual doses.

Since most tropical fruit seeds have a rather short shelf life at the ambient temperature, it is recommended that they be packed in polythene bags and stored in the vegetable compartment of the refridgerator where the temperature ranges from 8 to 12°C. Citrus, papaya, passion fruit, and avocado seeds can remain under these conditions for 1 to 3 months. Mango seeds are able to withstand the ambient temperature for several months.

Sowing in disinfected beds and then transplanting the seedlings into polythene bags is probably the most rational way to initiate a nursery. Seedbeds occupy a rather limited area, which can be easily disinfected and provided with temporary shade and irrigation. Meanwhile, there is time enough to fill the polythene bags with prepared soil and arrange them in rows in their final location. When seeds begin to germinate they are transplanted weekly into the bags, according to their stage of development. This system allows for homogeneous blocks of plants (same stage of development, no blanks) as well as polythene bags that are not exposed to too much sun.

3.2.1 Avocados

Avocado trees for seed production must be selected according to their adaptation to the local conditions, i.e. vigour, productivity, and lack of major pests and diseases. Seeds from cultivated varieties may be used.

After hand-extraction and washing, and before disinfection, a common practice consists of cutting the top of the seed to accelerate germination.

Avocado seeds are sown 5 cm apart in disinfected beds, leaving the cut top of the seeds uncovered. They germinate between 15 and 45 days after sowing, after which they can be transplanted into polythene bags. Some people prefer to sow the seeds directly in the bags.

3.2.2 Citrus

If there is no risk of 'tristeza' disease, sour orange can be used as a rootstock. Trees have to be selected according to their vigour, productivity, and reduced quantity of thorns. If tristeza is present, or specific requirements have to be met related to the soil or pests and diseases, than other rootstocks will be chosen, like *Poncirus* hybrids (Citranges), *C. volkameriana*, *C. macrophylla* or others (see list in the rootstock section).

Citrus seeds are sown in rows 10 cm apart with 2.5 cm between seeds, in disinfected beds. They are covered with 2 cm of soil. Germination occurs 2 to 3 weeks later; since polyembryony is quite frequent with citrus seeds, one to four or five seedlings will arise from each seed.

3.2.3 Mangoes

Mango trees for seed production are generally chosen from local varieties well adapted to the ambient conditions, such as 'rose mango' and 'long mango'. These varieties are also polyembryonic, so more than one plant can be obtained from each seed.

Mango seeds are sown 5 cm apart in disinfected beds and covered with 2 cm of soil.

Germination is slower than for avocado or citrus; it can take from 2 weeks to 3 months. Removing the shell is a way to speed it up, but the unshelled embryos have to be disinfected, since they are very sensitive to fungal and bacterial diseases.

3.2.4 Other Fruit Species

The general rule for collecting well-matured fruit directly from healthy trees is always valid. Hand-extraction, washing, and disinfection of the seeds are carried out in the same way as for citrus or avocados. In some cases selection of seeds by floating helps to eliminate infertile seeds (cashew).

Sowing first in beds, then transplanting in polythene bags, is always recommended. It is important to note that the seeds need to be covered with soil about twice their diameter.

Germination occurs very quickly for some species like papaya, carambola, passion fruit, or tamarind (1 to 2 weeks), while sapodilla and annonas may take up to 2 months.

For hard-shelled seeds like tamarind, *Annona* sp., sapodilla, and cashew, it is recommended that the seeds be immersed in water for 24 h before sowing. Germination is accelerated.

IV. Vegetative Propagation

Two systems can be distinguished: (1) parts of plants that make their own roots and (2) use of a rootstock.

4.1 Parts of Plants that Make Their own Roots

4.1.1 Cuttings

In propagation by cuttings, hard-wood or soft-wood cuttings may be used. Hardwood cuttings consist of fragments of ligneous defoliated stems, 20–30 cm long and 1–2 cm in diameter. Softwood cuttings come from herbaceous stems (from the previous growing period); they are about 10–15 cm long and some leaves or pieces of leaves are left at the upper end.

Cuttings are planted up to one-third of their length in a well-drained, disinfected soil. Artificial climatic conditions are needed, like high relative humidity

and slight shade. For softwood cuttings, the presence of a mist system or a polythene cover improves shelf life and subsequent rooting.

The natural ability of cuttings for rooting is directly related to their proximity to the ground on the mother plant. Cuttings taken from the base of a stem root more easily than those taken from the upper part. The closer the stems are from the ground, the better the results will be rooting. This can be explained by the fact that in perennial species juvenile characteristics are found near to the ground, while adult characteristics are located in the upper part of the trees.

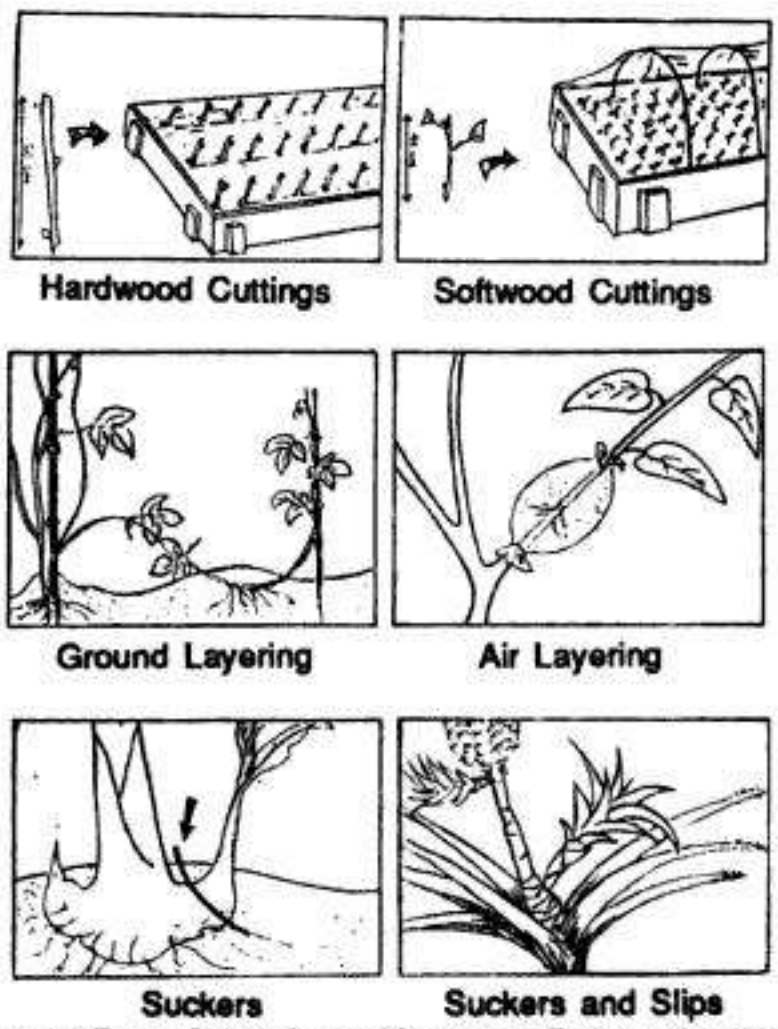
Juvenile characteristics mean that some cells of the tissue may differentiate to other organs related to propagation, like roots, while adults characters refer to the ability for flowering and bearing seeds (sexual maturity).

The application of growth hormones like IBA (indol butyric acid) or NAA (naphthalene acetic acid) at the base of the cuttings help to improve greatly the rooting percentage and the number of roots per cutting.

Propagation by cuttings is quite common with some fruit trees: West Indian cherries, pomegranates, fig, granadillas (barbadine), passion fruit (maracuja), and grapevines. For Jamaican plums large hardwood cuttings (2–3 m long, 3–5 cm thick) are usually used; they are planted directly in place at the end of the dry season.

Breadfruit is quite special; propagation is performed through root cuttings. Pieces of roots are dug out and planted in a moist mixture in propagation beds. Up-coming shoots are allowed to grow and then cut back and taken to rooting beds just like softwood cuttings. An improvement of this method has been developed in Trinidad; shoots from root cuttings are pruned to force the emission of secondary stems, and softwood cuttings are taken from these stems. New shoots will emerge and will be used a few months later. In this way the original root cutting is able to produce softwood cuttings over many years.

Very often young breadfruit plants can be found around old trees. They sprout out of superficial roots when these have been wounded. These plantlets can be taken out and grown in a nursery for some time before transplantation.



Source: Frutas Tropicales en Nicaragura, Barbeau G. 1990

Fig. 1. Vegetative propagation (Barbeau 1990).

4.1.2 Layering

In this type of vegetative propagation a piece of stem is forced to produce roots, directly on the mother plant. Two methods are used depending on the species:

Ground-layering — Long flexible stems are bent down to the ground and buried in 15- to 30- cm lengths. When rooting has taken place the stem is cut back, pruned, and transplanted. If it is too weak, it can be trained in a nursery before transplanting. Granadilla, passion fruit, and grapevine can be easily propagated this way. Sometimes it is a quick method to replace dead plants in a row; vines are conducted to the place of missing plants and buried there. New plants do not need to be dug out.

Sometimes it is possible to have stems developing roots at their base, by covering them with soil. It works mainly with fruit trees when trained as shrubs, like pomegranate and West Indian cherry, and with some fruits from temperate countries, like apple, when cultivated above 1200 m in a tropical climate. The stem of the shrubs are cut down to 20–30 cm above ground level, then covered with soil. New shoots emerging will develop a root system at their base. At the end of the growing season, they are separated from the mother plant and placed in nurseries or directly transplanted in the field. This is the main way used to produce large quantities of cheap rootstock for apple trees.

Air-layering (Marcotting) — This technique consists of producing a new plant from an aerial stem. A ring of bark is removed from the stem; this area is covered with a rooting medium (coconut coir dust, cocoa moss, peat moss, or moist soil) and wrapped in a polythene sheet for several months until roots can be seen through the polythene wrapping. Then the stem is severed from the mother plant below the rooting point and trained in the nursery before being transplanted. Many species can be propagated by air-layering: citrus, guava, cashew, and generally all the species which root easily by cuttings and ground-layering.

Layering techniques, especially air-layering, are time

consuming and do not allow for production of large quantities of plants except for some fruit trees from temperate areas. The result is therefore very expensive. For citrus, budded or grafted cultivars which are propagated this way lose the benefit of the presence of the rootstock. These reasons explain that layering remains a technique for amateurs.

4.1.3 Suckers and Slips

Suckers are plants which are born at the base or in proximity to the mother plant. Most of the time they are in relation with it through a rhizome system, and soon develop their own root system. They can be severed and transplanted in another place. Bananas and plantains are generally propagated this way.

Sometimes offshoots that appear at the base of trees originate from buds that had remained undifferentiated for several years. Palm trees, especially date palm and peach palm (pejibaye or peewah) are commonly multiplied in this way. The young shoots do not have roots at the beginning, so it is necessary to wait until they are big enough to be removed and transplanted. Even at this stage they may have no roots at all, but there is a sufficient amount of reserve in their trunk to allow for good rooting. Younger shoots can be properly grown using nursery equipment.

Pineapple plants have the capacity to produce slips and suckers very easily: they are young plants developing on the mother plant, without roots. Depending on their origin three categories can be distinguished:

— Ground suckers and suckers from the base of the plant.
— Slips, found on the stem just below the fruit.
— The crown that develops on the top of the fruit.

Sometimes slips can develop on the middle of the stem; they are called hapas.

After harvesting the fruits, suckers and slips are cut off and allowed to dry for several days to cicatrize the cut end. If planting material is very scarce, crowns may also be used. It is important to know that according to their origin they do not have the same potential. The suckers begin to bear earlier than the slips and the crowns. So do the big ones compared with the small ones. Suckers and slips must be classified by origin and by grade to have uniform plots.

Planting material does not need to go through nursery facilities; it can be planted directly into the field. Roots arise very quickly from the base.

4.1.4 Quick Multiplication

The natural aptitude to produce suckers and slips is an advantage if large quantities of planting material are needed and resources are limited.

For bananas and plantains the corm is the basic source of vegetative material. It may be divided into several pieces with one bud each. Each piece will develop a new plant.

For pineapple, after harvesting, the lower part of the main stem is cut into small disks, 2 to 3 cm thick. These are then divided into four to eight sections according to their diameter. Each section will give a new plant. Another method consists of cutting the stem longitudinally into two halves and planting these halves horizontally in a nursery bed. Young plants arising are taken off and transplanted to another bed or in polythene bags.

To perform the quick multiplication methods with success, disinfection of source material is necessary. Control of humidity and drainage are also very important.

After a six- to eight-month period, planting material can be taken to the field.

4.1.5 Tissue Culture

Modern plantations of pineapple and banana require huge quantities of healthy and homogeneous selected planting material. Through tissue culture this is now possible. In vitro plants are produced from apical meristems (the tiny extremity of growing buds). The rhythm of propagation is very rapid, much more than with the quick multiplication method, and there is no risk of propagation of pests and diseases.

Tissue culture techniques are also being developed for palm trees and mangosteen, which had a very low natural rate of multiplication.

4.1.6 Polyembryony

See section on Multiplication by Seeds.

4.2 A Rootstock is Used: Grafting and Budding

4.2.1 Definitions

Grafting is performed through the union of parts of different plants to form a new one. A piece of the cultivar which is to be propagated (scion) is cut from the mother plant and applied to a receptive plant (rootstock).

The scions may be a single bud or a short stem with three or four buds; techniques used to perform the union are called budding (a single bud) and grafting (a short stem with several buds).

The rootstock and the scion must belong to the same genus and very often to the same species, for instance:

— Sweet orange (species) cv. 'Valencia' budded on to sour orange (another species). Both of them belong to the same genus *'Citrus.'*
— Avocado cv. 'Pollock' grafted onto local avocado seedling (same species).
— Mango cv. 'Julie' grafted onto local mango seedling (same species).

Rootstocks must be selected according to their adaptation to local conditions of soil and climate. Resis-

tance or tolerance to pests and diseases must also be considered. Characteristics of the fruits are not important because the rootstock is not going to produce fruits.

Selection of the variety or cultivar to be grafted must comply with marketing requirements, so quality of the fruits, harvesting time, resistance to transportation, and regularity of bearing are among the characteristics to look for. External markets prefer:

- Medium-size, medium-fat level, small-seeded avocados cv.
- Medium-size, red-coloured, anthracnose-tolerant mangoes cv.
- Well-coloured, seedless tangerines and mandarins cv.
- Pink or red-fleshed, seedless grapefruits cv.

Table 3
Rootstocks for citrus cultivars*

I - Physiological aptitude transmitted to the scion

	Vigor	Productivity	Bearing Rapidity	Harvest Time	Fruit Quality
Citrange Carrizo	M	H	H	P	H
Citrange Troyer	M	H	H	P	H
Cleopatra Mandarin	M	M	M	M	M
C. macrophylla	H	H	M	M	L
C. volkameriana	H	H	M	M	L
Rangpur Lime	M	M	H	M	M
Rough Lemon	VH	VH	L	T	L
Sour Orange	M	M	M	M	M
Sweet Orange	H	M	M	M	M

Note: M (medium), H (high), L (low), T(late), P (precocious), VH (very high).

II — Sensitivity to pests and diseases

	Gumosis	*Tristeza*	*Diaprepes*	Exocortis
Citrange Carrizo	R	T		S
Citrange Troyer	R	T		S
Cleopatra Mandarin	R(or)S	T		T
C. macrophylla	R	S	T	T
C. volkameriana	R	T		T
Rangpur Lime	S	T		S
Rough Lemon	T(or)S	T		T
Sour Orange	R	VS	S	T
Sweet Orange	VS	T		T

NOTE: S (Suceptible), R (Resistant), T (Tolerant) VS (Very Suceptible).

III — Soil adaptation — Resistance to:

	Humidity	Drought	$CaCO_3$	Chloride
Citrange Carrizo	M	L-M	L-M	L
Citrange Troyer	M	L-M	L-M	L
Cleopatra Mandarin	L	M	M	H
C. macrophylla	M	?	M-H	H
C. volkameriana	M	H	?	M
Rangpur Lime	L	H	M-H	H
Rough Lemon	VL	M	M	L
Sour Orange	L	M	H	L
Sweet Orange	L	M	M	L

NOTE: L (low), M (medium), H (high), VL (very low).

* Adapted from Praloran J. C. "Les Agrumes" 1971

4.2.2 Advantages and disadvantages of grafting and budding techniques

4.2.2.1 *Advantages*

- The possibility to combine the best characteristics of two varieties or species in a single plant.
- Grafted trees come into bearing before non-grafted trees of the same species. Generally the first harvest is obtained 2 to 4 years after grafting, while the non-grafting trees may take 6 to 8 years before setting fruit.
- By grafting it is possible to propagate very quickly a tree that has fruits of outstanding quality; each single bud reproduces the original tree.
- Grafting allows for the production of some fruit crops in unfavourable conditions. Rootstocks can supply resistance to some kind of pests and diseases, and also adaptation to different classes of soil.
- With grafted trees it is possible to have homogeneous plots at a commercial level. All the trees have the same growth rhythm, the same flowering period, and fruits are homogeneous in characteristics and quality. All these make orchard management practices and marketing of the products easier.

4.2.2.2 *Disadvantages*

Propagation by grafting also presents some disadvantages.

- Skilled workers are needed, which increases the cost of labour.
- If the trees from which the scions are taken have some kind of disease, there is a risk of contaminating all grafted plants. Therefore care must be taken in selecting only healthy trees and to use disinfected tools.

4.2.3 Grafting Techniques

Generally grafting takes place when the trees are in a growing stage, therefore the bark splits easily from the wood and this is necessary for success of most grafting techniques. However, some of them can be done any time of the year (chip-budding).

The grafter requires some specific tools: a grafting knife, pruning shears and a hand saw.

Materials are very simple: polythene straps are used to bind the scion onto the rootstock. Sometimes a special wax is applied on large wounds of the trees to protect them from fungal infection.

4.2.4 Selection and Preparation of the Scions

Bud-wood must be taken from healthy adult trees, or mature twigs corresponding to the last or penultimate growing period.

Scions consist of short pieces of stems, 6 to 10 cm long, with or without an apical bud and at least two axillary buds. Sometimes a single axillary bud with a small piece of bark is used.

For mangoes and avocados, scions generally correspond to the terminal part of the stems; they have an apical bud which is about to develop. Avocado scions with spongy medulla are not recommended.

Scions for citrus must be taken from the medium part of the twigs where the stem has a round section. In less mature twigs, this section has angles, which make the budding operation more difficult.

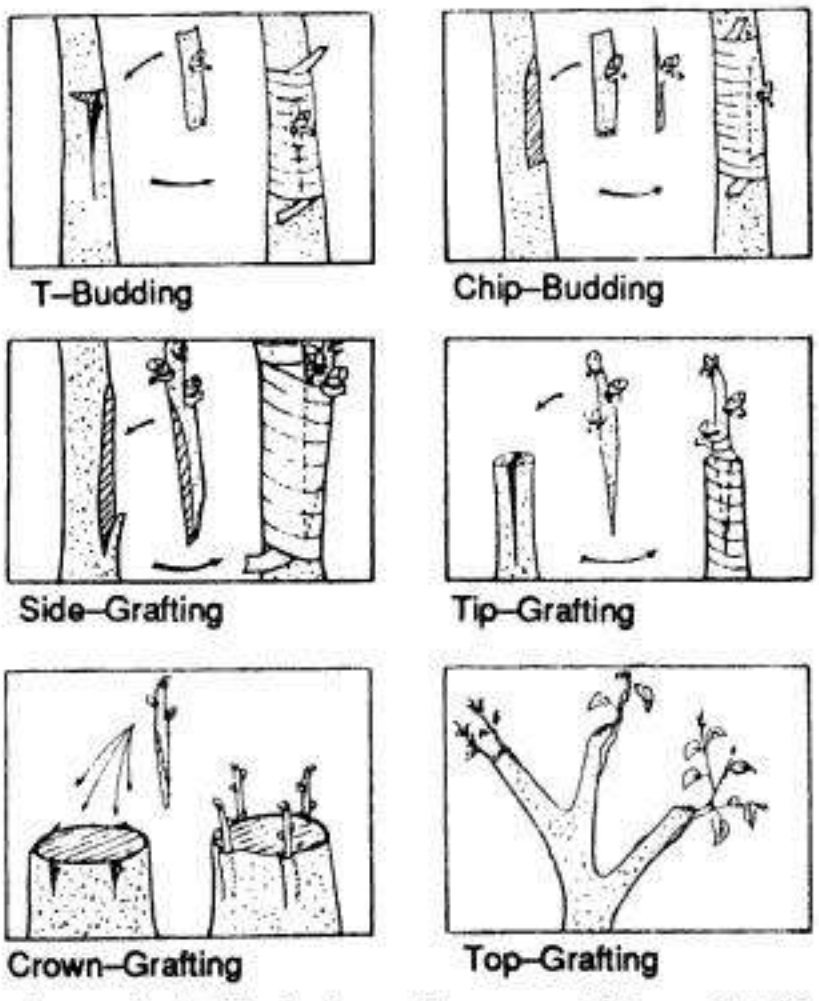
When preparing budwood, all leaves should be removed, leaving only a short piece of petiole, to reduce transpiration. If necessary, budwood may be preserved for a few days in a cool, humid atmosphere, for instance, wrapped in a polythene bag within a refridgerator or an icebox.

4.2.5 Grafting and Budding Methods

There are many methods for grafting and budding. The use of one of them depends on the species being worked with, the size of the tree to be grafted, the time of year and the ability of the grafter.

On young rootstocks, T-budding, chip-budding, side-grafting and tip-grafting are the most used techniques. On adult trees, crown and cleft graft types are well suited for cutback trunks, while top-working can be performed on the main branches. If young shoots are allowed to develop, they can be grafted with any of the methods used for young rootstocks.

The height of grafting is important to determine, since one of the functions of the rootstock is to protect the scions from possible contamination originating in the soil. A graft point too close to the ground may be infected at a young stage before cicatrization has taken place. The scion may also be infected later by fungi since spores can easily come in contact with it during cultural practices or heavy rains. Therefore a prudent height is recommended which is between 20 and 30 cm from the ground.



Source: Frutas Tropicales en Nicaragura, Barbeau G. 1990

Fig. 2. Budding and Grafting (Barbeau 1990).

The orientation of the graft is a factor worth considering; a side graft exposed to the south will receive a lot of heat during the day and much more so because it is covered by a plastic strap. Overheating through the plastic strap may be a serious cause of losses, so it would be better to graft on the northern side of the stocks.

Water supply is a decisive factor for successful grafting and budding. Regularity of supply should be guaranteed during the first 3 or 4 weeks when the scion–rootstock union is in process. If the plant suffers water stress just for a few hours, that may be enough to lose the graft.

4.2.5.1 *T-Budding*

With the budding knife a T-shaped incision is made on the rootstock at the proper height, generally where the stem has the diameter of a pencil. The sides of the bark along the cut are slightly opened to insert the bud.

A piece of bark with an axillary bud in its centre is taken from the budstick, in the form of a shield-shape bud, 2–3 cm long, and is slipped into the cut on the rootstock. The upper part of the bud should coincide with the horizontal bar of the T. Then the graft is wrapped with a strap of polythene, leaving the bud uncovered.

Another method consists in making an inverted T cut. This is particularly useful with some species which exude latex, so its drainage is improved.

T-budding is one of the most famous and easy-to-do grafting methods, mainly used for citrus and sometimes for avocados, mangoes, guavas and sapodillas. It is very economical since only one bud can reproduce the original tree.

4.2.5.2 *Chip-budding*

A lateral piece of bark, 3–5 cm long, slightly thicker at its base than at the top, is removed from the desired height. At the base an oblique cut is made to insert the bud.

An axillary bud is taken from a budstick, with a piece of bark thicker at the base than at the top. The width must be slightly less than the cut made on the rootstock. The base is oblique-cut to fit into the same incision made on the stock.

The graft is then wrapped with a plastic strap, covering the bud entirely. Two weeks later, the bud has to be uncovered but the graft should remain tied.

Chip-budding, although not so common as T-budding, is easy to perform, economical in use of bud-

wood, and has the advantage of being done even if the bark does not slip easily. The bud union is stronger than in the case of T-budding and the growth is quicker. It has been used for citrus and avocados.

A variation of this method called patch-budding has been used successfully on well-developed stocks of avocados, guavas and figs. It consists of removing a square patch of bark from the rootstock and replacing it with a similar patch of the scion, containing one bud. The whole graft has to be covered with a polythene strap. Two weeks later the strap can be removed and the stock partially cut down.

4.2.5.3 *Side-grafting*

The stock is prepared by removing a 3- to 4-cm-long vertical strip of bark on one side of the stem at the proper height. A second oblique-cut about 1 cm long is made at the base of the first one to form a lip which will receive the scion.

The scion consists of a terminal piece of twig, about 10 cm long, with a terminal bud and two or three lateral ones. The terminal bud must be ready to develop. A 3- to 4-m-long cut is made on one side of its base, while on the other side there will be a short cut, only 1 cm long.

The scion is applied onto the stock, so that the largest and smallest cuts coincide. The graft is wrapped with a polythene strap, leaving the extremity of the scion free. During heavy rain periods it is recommended that the top of the scion be covered with another piece of plastic to prevent water from entering the scion union.

The side graft method is popular for mangoes and avocados; it is used also for citrus, sapodillas, mamey sapote and mamey apple.

The only disadvantage is that great quantities of bud-wood are required since each graft needs one stick with three or more buds.

A variation is the veneer graft where the bud-wood is completely applied inside the corresponding wound made on the rootstock.

4.2.5.4 *Tip-grafting (apical grafting)*

Cleft-graft: the stock is cut back at the height where its diameter is about the size of the scion to be grafted. Then with the grafting knife a vertical cut 3–4 cm long is made in the middle of the stem.

The scion is prepared as for the side graft, the difference being that cuts on both sides are the same length, about 3–4 cm. It is slipped into the cut on the stock and secured with a polythene strip, allowing the top of the scion to remain free. In times of heavy rain or when sprinkler irrigation is used, a small white plastic bag should be placed on the top of the graft to prevent water from entering the graft union. This bag also prevents the scion from desiccation in hot dry weather.

This method gives good results with young avocado and mango stocks, 2 to 4 months old. Grafted plants must be protected from direct sunlight because the scion could dry out or be burnt through the plastic cover, since there are no leaves to protect it as in the other grafting methods.

Other apical grafts are sometimes used: the spliced graft and the whip and tongue graft.

4.2.6 Grafting Adult Trees

Cleft and crown grafts are used in the rehabilitation of adult trees that no longer satisfy the objectives of production, because this yield is insufficient, quality is poor, or variety is not adapted to the market demand.

Trees are cut back about 1 m above ground level. For the cleft graft the trunk is split vertically in its centre and the scions, prepared as for tip-grating on small stocks, are inserted at each extremity.

For the crown graft the bark is opened vertically, 3–4 cm in length at several places around the circumference, and slightly lifted. Scions are prepared as if for a side graft but only with a large oblique-cut. Then they are inserted in the vertical cuts around the stock.

Generally the scions do not need to be tied because the stock and the bark are strong enough to keep them in place. The section of the trunk and the base of the grafts have to be covered with a grafting paste to prevent them from desiccation and invasion by pathogenic organisms.

4.2.6.1 *Approach grafting*

This method is commonly used in South East Asia for rambutan and mangosteen. It consists of placing a potted rootstock close to an adult variety trained as dwarf as possible, in order to put in contact a small branch of the variety with the main stem of the rootstock. A strip of bark, 3 to 5 cm long, is removed on the facing sides of both twigs, then these are closely tied together with a polythene strap.

Approach grafting is not dependent on the season or age of the rootstock, but cost of labour is high and it is not a proper nursery technique since the future grafted plants have to be moved to where the variety is available. Quantities that can be made this way are also limited.

4.2.6.2 *Top-working*

Top-working is used when there is a need to change the cultivar in grafted adult trees or when it is necessary to graft adult trees that have never been grafted.

The main purpose is to try to adapt the cultivar to the market requirements, either for fresh market, for industry, or for export market.

Top-working can be performed in several ways depending on the rootstock and the ability of the grafters:

— Cutting back the trunk and using the cleft or crown grafts already described for adult trees. It does not present any problem for citrus, but mangoes and avocados could be easily infected with pathogenic organisms.
— Cutting back the trunk allowing young shoots to grow in order to graft them. Three or four shoots are selected according to their position on the trunk, the others are eliminated. This method is better for people that are not familiar with the cleft and crown grafts; they can use any of the techniques described for young rootstocks: T-budding, chip-budding, side-grafting, etc.
— Pruning the tree and grafting on the extremity of selected branches. Generally the side-grafting method is used. A lot of bud-wood is necessary and the operation is time-consuming since many branches have to be worked. This method is less stressful for the trees.

In all cases it is necessary to paint the trunk and the main branches with white lime to avoid sunburning.

Top-grafted trees are able to bear the following year and reach full production within 3 or 4 years.

4.2.7 General Care After Grafting

With T-budding, chip-budding and side-grafting, two weeks later it is possible to see if the graft is going to take. Then the upper part of the stock has to be half-broken to direct the sap flow towards the scion and force it to grow.

As soon as the scion begins to grow, the stock is cut about 5 cm above the graft point (approximately three weeks after grafting). The remaining short piece of stem will be used to tie the scion during the first weeks and to prevent it from being broken by the wind or by birds. For grafts on adult trees it is recommended that a small branch be tied to the trunk just to prevent the birds from resting on the young scions.

The polythene strap has to be removed three weeks after grafting in the case of citrus. For avocados and mangoes it is preferable to wait 6 to 8 weeks because it takes more time to get a solid graft union.

Suckers develop easily in recent grafted plants and it is necessary to eliminate them to avoid competition with the scion. Hand-removing at an early stage is preferable to pruning with shears or cutting with a knife, because of the risk of transmitting some diseases.

During the growing period and before the plants go to the sale area, they must be trained to form a trunk and the main branches. This can be achieved by stopping the growth of the terminal bud and pruning. Scaffold branches must be oriented in all directions and disposed at different levels on the trunk, making a 45 degree angle with it. The pieces of stem above the graft union has to be cut off before sale and disinfected with a fungicide paste. This will allow a good cicatrization at the graft point and will prevent suckers from overcoming the scion.

Just before sale, tender shoots may be cut back, so the plant will not wither during transportation.

Obviously, general care after grafting also includes watering, weeding, pest and disease control, as frequently as needed.

4.3 Multiplication Calendar

Plants ready for sale must have a minimum development, i.e. be strong enough to support stresses due to transportation and relocation. The following scheme is generally recommended:

Grafted plants	Age at planting time	Months after grafting
Avocados	10–12 mo.	4–6 mo.
Citrus	15–18 mo.	4–6 mo.
Mangoes	12–15 mo.	4–6 mo.
Sapodillas	12–15 mo.	6–8 mo.
Guavas	10–12 mo.	4–6 mo.
Carambolas	10–12 mo.	4–6 mo.

Non-grafted plants	From seeds	From vegetative propagation
Sapodilla	8–10 mo.	
Soursop	6–8 mo.	
W. Indian cherry		2–4 mo.
Breadfruit		4–6 mo.
Sugar apple	6–8 mo.	
Golden apple	6–8 mo.	
Guavas	6–8 mo.	4–6 mo.
Pomerac	4–6 mo.	3–4 mo.
Barbadine	2–3 mo.	2–3 mo.
Passion fruit	2–3 mo.	2–3 mo.
Pawpaw	2–3 mo.	
Cashew	2–3 mo.	
Tamarind	8–10 mo.	
Grapevine		3–5 mo.
Carambola	4–6 mo.	

One of the main problems faced by commercial nurseries is to meet demand, not only in quantity and quality but also in time. Very often the plant production schedule does not correspond with the time of the year when farmers need the plants, which coincides with the beginning of the rainy season. If the trees are not planted at the proper time (from June to August) they suffer and die. Production of plants out of season means losses not only for the farmers, but also for the nurseries which may face a very depressed sale during the planting period and after may be left with lots of overgrown trees.

It is important to adjust as close as possible to the natural rhythms: collecting the seeds at the right time during the available period and preparing the plants for sale during the first three months of the rainy season. The following calendar of multiplication gives an idea of what should be done.

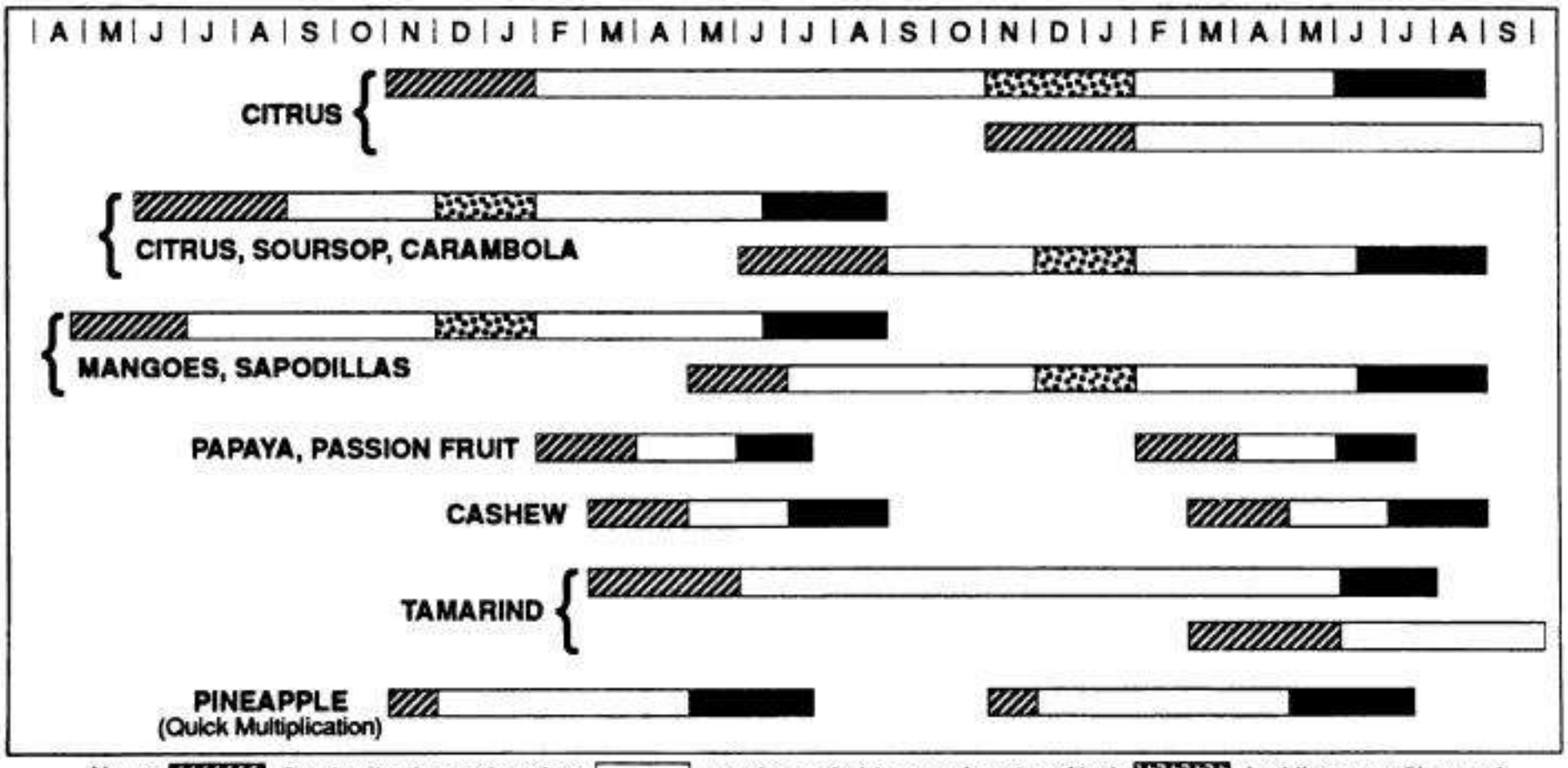


Fig. 3. Multiplication Calendar(Barbeau 1990).

Table 4
Propagation of tropical fruit trees

Family	Genus & Species	Common name	Propagation Methods: Seeds	Grafts	Slips & suckers	Layering	Cuttings	Quick Mult.	Tissue Culture
Anacardiaceae	*Anacardium occidentale*	Cashew	X	X		X			
	Mangifera indica	Mango	X	X					
	Spondias cytherea	Pommecythere	X				X		
	S. mombin	Hog plum	X				X		
	S. purpurea	Red mombin	X				X		
Annonaceae	*Annona diversifolia*	Ilama	X	X					
	A. glabra	Pond apple	X						
	A. montana	Mountain soursop	X						
	A. muricata	Soursop	X	X					
	A. purpurea	Cashima	X	X					
	A. reticulata	Custard apple	X	X					
	A. squamosa	Sugar apple	X	X			X		
	Rollinia deliciosa	Biriba	X						
Bromeliaceae	*Ananas comosus*	Pineapple			X			X	X
Caricaceae	*Carica papaya*	Papaya	X						
Chrysobalanaceae	*Chrysobalanus icaco*	Coco plum	X						
Euphorbiaceae	*Phyllantus acidus*	Groselle	X						
Flancourtiaceae	*Dovyalis hebecarpa*	Ceylon gooseberry	X	X			X		
	Flacourtia indica	Governor's plum							
Guttiferae	*Garcinia mangostana*	Mangosteen	X	X			X		X
	Mammea americana	Mamey apple	X	X					
Lauraceae	*Persea americana*	Avocado	X	X					
Lecythidaceae	*Lecythis zabucajo*	Paradise nut	X	X					
Leguminosae	*Inga edulis*	Pois doux	X						
	I. laurina	Sackysac	X						
	I. paterno	Pois doux	X						
	Tamarindus indica	Tamarind	X	X					

Table 4 (*concluded*)
Propagation of tropical fruit trees

Family	Genus & Species	Common name	Propagation Methods						
			Seeds	Grafts	Slips & suckers	Layering	Cuttings	Quick Mult.	Tissue Culture
Malpighiaceae	*Byrsonima crassifolia*	Savannah serrette	X						
	B. spicata	Serrette	X						
	Malpighia glabra	W. Indian cherry	X	X			X		
Moraceae	*Artocarpus altilis*	Breadfruit					X		
	A. heterophyllus	Jackfruit	X						
	A. altilis v. *seminifera*	Chataigne	X						
	Ficus carica	Fig		X		X	X		
Musaceae	*Musa* sp.	Bananas			X			X	X
		Plantains			X			X	
Myrtaceae	*Psidium friedristchalianum*	Costa Rican guava	X						
	P. guayava	Guava	X	X		X	X		
	Sygyzium malaccense	Pomerac	X	X			X		
Oxalidacae	*Averroha bilimbi*	Bilimbi	X	X		X			
	A. carambola	Carambola	X	X		X			
Palmaceae	*Acrocomia zapotecis*	Coyol	X						
	Bactris cuesa	Gree-gree	X						
	B. major	Roseau, Pic-moc	X						
	Cocos nucifera	Coconut	X						X
	Guilielma gasipaes	Peewah	X		X				
	Mammiliana caribbea	Cocorite	X						
	Mauritia flexuosa	Moriche	X						
Passifloraceae	*Passiflora edulis* v. *fl.*	Passion fruit	X	X		X	X		X
	P. laurifolia	Belle-apple	X						
	P. ligularis	Sweet granadilla	X	X		X	X		X
	P. quadrangularis	Barbadine	X			X	X		X
Polygonaceae	*Coccoloba uvifera*	Seaside grape	X				X		
Punicaceae	*Punica granatum*	Pomegranate	X	X			X		
Rhamnaceae	*Ziziphus mauritania*	Dunks	X						
Rubiaceae	*Genipa americana*	Juniper	X						
Rutaceae	*Citrus aurantifolia*	W.I. Lime	X	X					
	C. aurantium	Sour orange	X	X					
	C. deliciosa	Medit. mandarin		X					
	C. grandis	Pomelo		X					
	C. latifolia	'Tahiti' Lime		X		X			
	C. limetta	Sweet lime	X	X					
	C. limon	Lemon		X					
	C. macrophylla	Macrophylla	X						
	C. medica	Citron	X	X		X	X		
	C. nobilis	'King' mandarin		X					
	C. paradisi	Grapefruit	X	X		X			
	C. reticulata	Common mandarin	X	X		X			
	C. sinensis	Sweet orange	X	X		X			
	C. tangerina	Tangerine		X					
	C. volkameriana	Volkamer lemon	X				X		
	Fortunella Japonica	Kumquat marumi		X					
	F. margarita	Kumquat nagami		X					
	Poncirus trifoliata & hyb	Poncirus & cit.	X				X		
Sapindaceae	*Meliccoca bijuga*	Chenette/genip	X	X		X			
	Nephelium lappaceum	Rambutan	X	X		X			
	N. mutabile	Pulasan	X	X		X			
Sapotaceae	*Achras sapota*	Sapodilla	X	X		X			
	Calocarpum mammosum	Mamey sapote	X	X					
	Crysophyllum caimito	Kaimit	X	X					
	Lucuma nervosa	Egg-fruit	X						
	Manilkara bidentata	Balata	X						
	Pouteria multiflora	Penny piece	X						
Vitadaceae	*Vitis vinifera*	Grapevine		X		X	X		X
	V. caribaea	Wild grape	X			X	X		

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Glossary

VEGETATIVE PROPAGATION. The production of new plants other than from seed; offspring propagated vegetatively are usually exactly like their parent plants; progeny form a single individual, from the first and all subsequent generations of vegetative propagation, constitute a *clone*.

CUTTINGS. Pieces cut off a parent plant and treated so that they form new plants by regenerating the missing parts, i.e. new roots on leaf or stem cuttings and new shoots on root cuttings.

LAYERING. Shoots bent down and partly buried in the ground until they can be removed as new plants.

MARCOTTING (AIR-LAYERING). A shoot or branch is wounded and the wound surrounded with a pad of damp material kept moist until roots form; the rooted branch is then severed as a new plant.

BUDDING AND GRAFTING. Methods of joining a piece from another plant onto one that is already rooted so that they form a new (composite) plant; the lower part is the *rootstock* and the upper part the *scion*.

BUDWOOD. Shoots, with one or more buds, that are used to provide scions for budding or grafting.

BUDDINGS. Uniting a single scion bud onto a rootstock.

SHIELD BUDDINGS. Using a bud cut with a shield-shaped piece of bark.

T-BUDDINGS A T-shaped cut is made in the bark, either upright (T) or inverted (T), a shield bud is slipped underneath the bark, and the wound is then tied tightly to prevent it from drying out until it has healed (the bud has *taken*).

PATCH BUDDINGS. A patch of bark is taken, usually rectangular with the bud in the middle, and an exactly matching piece of bark is removed from the rootstock to accommodate the patch, which is then tightly tied in.

FORKERT AND MODIFIED FORKERT BUDDINGS. A strip of bark is peeled down, a shield bud inserted, and part of all of the strip folded back over the shield before tying.

CHIP-BUDDINGS. A chip of bark the shape of a finger nail is cut from the stock, with a nick at the base, and a matching shield bud is held in place by tying tightly.

GRAFTINGS. Uniting a piece of shoot, bearing one or more buds, with a rootstock.

TIP-GRAFTINGS. The ends of shoots or branches are cut off and grafts inserted at the cut ends.

VENEER GRAFTINGS. One of many ways of inserting grafts into the side of branches, which are usually cut back to the graft when it has united.

APPROACH GRAFTING (INARCHING). Two intact plants are united by cutting bark off the sides of a branch from each, then holding the wounded parts tightly together, usually wrapped to prevent drying out.

POLYEMBRYONY. Most seeds have only one embryo and produce a single seedling, but some plants (including citrus and mango) can produce several seedlings from one seed; one of these may be the result of sexual reproduction, and does not usually breed true, whereas the others (sometimes all) are of vegetative origin and grow into plants exactly like the tree that bore the fruit.

The Yellow Passion Fruit, *Passiflora edulis* f. *flavicarpa*,
Cultivars and flower biology

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I. The Passifloraceae Family

The passion fruit is a member of the Passifloraceae family which contains twelve (12) different genera and approximately five hundred (500) species. Most of these species are found growing in the warm tropical regions especially in South America. These species are characterized by their climbing habit, with tendrils, and their attractive flowers.

The flowers of the Passifloraceae are regular, axillary, usually hermaphrodite, with five sepals, five or no petals, usually five stamens, and one superior ovary. The fruit produced is a berry or capsule with seeds surrounded by a fleshy and juicy aril.

The *Passiflora* genus contains about 400 species but only a few have developed commercial interest for fresh consumption, industrialization, or ornamental purposes. Within this genus, the passion fruit is undoubtedly the species more commercially developed. This fruit species acquired its name from missionaries in South America with reference to a fancied representation in the flowers of the implements of the crucifixion (Purseglove 1968).

Only a few of the *Passiflora* spp. are well known in the Caribbean. Of these the most popular are the yellow passion fruit, *Passiflora edulis* f. *flavicarpa*, and the giant granadilla, *Passiflora quadrangularis*. Nevertheless, in some of the Caribbean countries the belle apple, *Passiflora laurifolia*, and the sweet granadilla, *Passiflora ligularis*, are also well known, but only the yellow passion fruit and the giant granadilla are grown commercially.

1.1 *Passiflora quadrangularis*

This species, a native from tropical South America, has been widely distributed throughout the tropics

where it adapted best to the hot, moist climate. Different from the passion fruit, it does not do well in high altitude preferring the low land of the tropics. The fruit is a fleshy oblong berry four to eight times larger than that of the passion fruit. Both the flesh and the pulp are edible. They are mainly used in sherbets (mixed with water or milk), ice cream, fruit salads, and jam. The immature green fruit may be boiled and consumed as a vegetable. The main root produces a fleshy tuber which is usually regarded as poisonous. However, reports from Jamaica indicate the tuber is used as a substitute for yam. Poor fruit set is often the main problem in commercial orchards and this is maybe due to the protandrous nature of the flowers. Hand pollination is recommended to increase the total production and the amount of pulp produced.

1.2 *Passiflora laurifolia*

This species, also known as sweet cup, waterlemon, and Jamaica honeysuckle can be found growing wild in the forest near rivers and gullies in most of Caribbean and South American countries. The fruit is ovoid-elliptic and quite similar to the yellow passion fruit, but the rind is softer and the juice is clear unlike the yellow or orange colour of the latter. The pulp which is succulent, acid, and aromatic is used like passion fruit. For its flavour and aromatic characteristics it is used in the preparation of drinks, cocktails, etc. This species is also used for its medicinal properties. The leaves are bitter and astringent and the roots are used as a human anti-helminthic. It grows better in the humid lowlands of the tropics.

1.3 *Passiflora ligularis*

Although more adapted to the mountainous regions of South and Central America and Mexico, the sweet granadilla can be grown at high elevation in some Caribbean countries. It produces vigorous growth and broad leaves quite different from the passion fruit. The fruit is similar to that of the passion fruit, oblong-elliptic, but the rind is very soft and brittle with white pulp. The juice produced is very aromatic and tasty. Preliminary observations have shown that this species has good tolerance to a combination of soil-borne problems in the tropics, e.g. *Fusarium*, heavy soil, nematodes, etc. For that reason it does have good potential as a rootstock for other *Passiflora* spp.

II. Forms and Varieties

Three main types of passion fruit are recognized: the purple passion fruit, *Passiflora edulis*, the yellow passion fruit, *Passiflora edulis* f. *flavicarpa* , and hybrids (purple × yellow and yellow × purple). There are marked differences between the two basic forms (purple and yellow). Table 1 shows the main differences between the purple and the yellow passion fruit. The hybrids have been naturally and artificially produced and often show a combination of the main characteristics of their parents.

Due to the greater tolerance of the yellow passion fruit to *Fusarium* and other soil-borne problems, it is often used as rootstock for the purple passion fruit.

Table 1
Main differences between the purple and the yellow passion fruit.

Factor	Purple	Yellow
Yield	Lower	Higher
Fruit colour	Purple	Yellow
Fruit size	Smaller	Larger
Fruit weight	Lighter (32-65 g)	Heavier (43-131 g)
Juice:		
By volume	Less	More
By weight	More	Less
Aroma	More	Less
Flavour	Higher	Lower
Sugar %	Higher	Lower
Ascorbic acid	Higher	Lower
Total acidity	Lower	Higher
Brix/acidity	Higher	Lower
Carotene	Lower	Higher
Vitamin A	Lower	Higher
pH	Lower (av. 2.8)	Higher (av. 4.2)
Seed colour	Deep black	Light black & gray
Opening of flowers	Morning. Before 12:00 noon	Afternoon. After 2:00 P.M.
Plant vigour	Significantly less	Significantly more
Total dry matter	Significantly less	Significantly more
Resistance to:		
Fusarium	Susceptible	Tolerant
Nematodes	More susceptible	More tolerant
Woodiness	Very susceptible	Less susceptible
Low Temp	More resistance	Less resistance
High Temp	Less adapted	More adapted
Economic life	Shorter	Longer

Source: Adapted from (Manica 1981; Medina et al.1980), etc.

Due to the self-incompatibility of passion fruit, for yellow forms propagation by seeds is preferred in most producing countries. This has been one of the main factors responsible for limited clonal selection. In fact, in contrast to any other commercially important fruit species of the same level, very few named cultivars exist within the yellow passion fruit. The tendency has been to name introduced material after the country of origin, e.g. Brazilian variety, Venezuelan variety, Dominica Variety, etc. However, the situation has been different for the purple passion fruit because most of the plants are vegetatively propagated (grafted over the yellow form). In Hawaii quite a few cultivars have been registered, e.g. Waimanolo (C-39, C-54, C-77, C-80), Sevcil, Kapoho, Yee, University Round, etc.

Hybrids between the purple and the yellow passion fruit have been artificially developed or naturally found in Australia and Hawaii. These hybrids normally were selected for the combination of disease resistance and high productivity of the yellow form with the higher juice quality of the purple. In fact, the passion fruit industry of Australia is almost en-

tirely based on these hybrids. Two of the most popular hybrids are 'Reedlands Triangular' and 'E-23'. In Hawaii, the 'Pratt hybrid,' B-74, M-21471A, are worthy of mention. In both of these countries, several natural hybrids have been also registered.

III. Pollination and Self-Incompatibility

Inadequate pollination has been documented worldwide as a major limiting factor to passion fruit production. Early studies about pollination (Akamine and Girolami 1959) have shown that cross pollination between flowers of different clones is necessary for good fruit set. This conclusion came after recognizing that most yellow passion fruit clones are self-incompatible. This condition is aggravated by the fact that in many cases planting with compatible clones results in poor fruit set due to one or more of the following factors:

- Lack or poor activity of pollinators
- Insufficient wetting of pollen
- Presence of a large percentage of upright-styled flowers
- Different flower production and/or opening time
- Bird and fly damage
- Others

Most authors seem to agree that self-incompatibility is more marked in the yellow than in the purple passion fruit. The majority of these authors also agree that the flower of the yellow form is self-sterile, the plant is self-incompatible, and a large percentage of them present a high degree of cross-incompatibility. These incompatibilities occur as a result of the inability of the pollen to fertilize the ovule.

Fruit size and the amount of seeds and juice depend on the efficiency of pollination. Theoretically, production can be doubled or tripled by hand-pollinating each flower in a plant. This is based on the fact that on the average, only a few of the flowers produced, set any fruit. In their early studies about passion fruit, Akamine and Girolami (1959), showed that the number of pollen grains deposited in the stigma influences fruit set percentage, fruit size, the number of seeds, and juice yield.

To understand the role and efficiency of different pollinators it is essential to look at some characteristics of the passion fruit flower. The flowers are axillary in young vines with only one flower per axil. Depending on the curvature of the stamens, three types of flowers are recognized: (*a*) Stamens totally curved (TC), (*b*) Stamens partially curved (PC), and (*c*) Stamens without curve (WC).

Different studies have shown that cross-pollination by insects is more effective on TC flowers and minimal on WC types.

The distance between the stigma and the nectaries (especially in WC flowers) is so large that many insects can make contact with the latter without touching the former. This is a basis of discussion among different authors about how effective the different pollinator insects can be. A distinction has been made between real 'pollinators' and 'visitors.' Although it is known that honey bees, wasps, flies, and other similar insects are effective pollinators of many fruit species, it seems their efficiency in passion fruit is quite limited, their size being the main handicap. Indeed wasps and flies have been classified as simple 'visitors' to the passion fruit flower and not as 'pollinators.' Undoubtedly, the most effective insect pollinator of passion fruit in the Caribbean is the 'Bumble Bee' or 'Carpenter Bee', *Xylocopa* spp. In other regions, other insects such as *Oxaea* spp., *Centris* spp., and *Aphis cerana* have been found to be also effective as pollinators of passion fruit flowers.

Due to the importance of *Xylocopa* spp. as pollinators of passion fruit, it is essential to create the local condition for attracting these insects to reproduce in the vicinity of the passion fruit orchard. Trunks with old rotten wood are attractive to *Xylocopa* for reproduction. This type of material should be brought into or near the plantation so as to avoid emigration during the reproductive period. Planting ornamentals with flowers and nectar that are attractive to these insects, e.g. hibiscus will help to keep them around year round at the orchard. It is important that the flowering period of the ornamental plant selected should be different from that of the passion fruit. Cassia, hibiscus, and other similar plants have been used with good results. It is very important also to develop and implement an Integrated Pest Management (IPM) System. Chemicals should never be applied during the flowering season. If the intensity of the attack of any pest demands treatment it should be done with safe products applied during the hours of the day when the activity of these insects is low. Bumble bees seem to be more active in the afternoon between 12:30 P.M. and 3:30 P.M.

The number of flowers produced and their opening time is influenced by the climatic conditions at the orchard. These conditions make flowering occur in cycles. Sudden changes in temperature may cause the vine to stop flowering and/or cause the flower to shed. On the other hand, humidity is essential for pollen germination. Different studies have shown that the length of day has a marked influence in growth and flowering. Long days (16 h or more) promote both growth and flowering. Natural days (12 h) retard growth but continue to promote flowering. In short days (less than 8 h) flowerings stop completely.

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Passion Fruit Production

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I. Establishment

1.1 Planting

Plants are normally placed about 15 cm deep. In sites of low fertility, some manure or a little fertilizer is mixed with the soil in the planting hole. Seedlings are best established when tendrils are first beginning to show.

1.2 Spacing

Normal spacing is 3 m × 3 m. Inter-row spacing can be decreased but beyond 2 m is acceptable resulting in increased yields. The closer spacings prevent the option of intercropping and may not be the most economic choice depending on the price of fruit.

1.3 Training

A piece of string or a stick is used for the vine to climb upon to reach the trellis wire. If string is used care must be taken to avoid girdling of the growing stem. Two or three leaders are encouraged to go upwards and on reaching the trellis wire these are looped around the wire to encourage growth in both directions along the row. Any shoots appearing alongside the leaders below the trellis wire are removed.

II. Trellis

2.1 Types

There are three basic types of trellises (Figs. 1–3):

(*a*) I or fence
(*b*) T or telephone
(*c*) Inverted U or shed

Additionally vines have been grown on wild or cultivated trees e.g. cocoa, glyricidia. Variations of the trellises are in terms of height, trellis material, number of strands of wire, and use of crosswires.

Research indicates that yield from the T-trellis approximately doubles that from the I-trellis. Producer claims for the shed type in similar, with the advantage of better weed control. Disadvantages include higher disease incidence and difficulty in trellis repair. Cross wires on the I-trellis also result in increased yield; however, movement within the orchard is greatly impeded. Along the row a single or double strand at the top of the post is all that is necessary.

Spacing of post may vary depending on the strength of the material e.g. metal posts can be spaced 10 m apart. If a severe pruning regime is to be employed annually, then wider spacing is possible even with wooden post. e.g. 5 m.

2.2 Construction

Treated hardwood posts of about 7 cm diameter and 2.5 m in length are planted 0.5 m deep and spaced as desired. At each end of a row (10–20 posts), a thicker post is used i.e. diameter 12 cm. Wire (12–16 gauge) is fixed on top of the posts or on T-pieces. These may be pulled taut and fixed in place or held loosely for tightening with some sort of turnbuckle arrangement. The wire is attached to a 'dead man' — a 1-m picket driven into the ground at an array away from the end post. Care must be taken not to leave a depression at the base of posts as this can collect water and accelerate rotting.

The following considerations are taken into account in determining trellis orientation:

(*a*) Row orientation across the slopes allows for better soil conservation.
(*b*) Row orientation in line with prevailing winds reduces stress on the trellis.
(*c*) East-west orientation of rows allows faster drying of alley ways. This is particularly important under heavy, wet soil conditions.

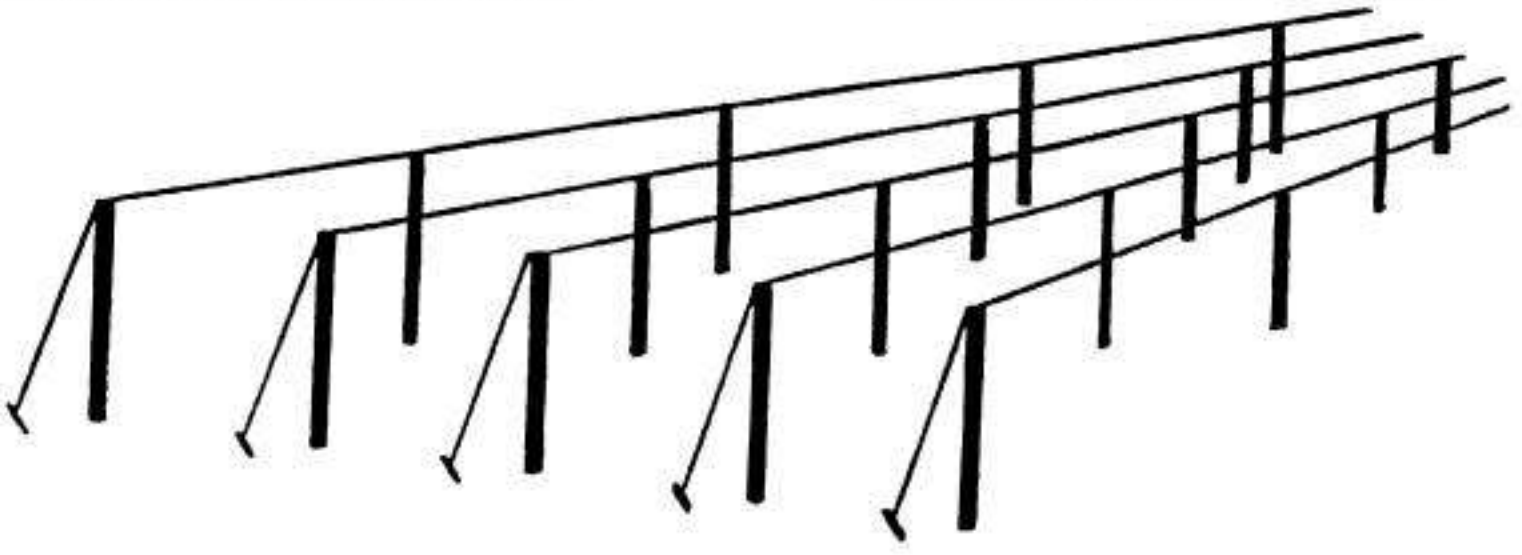

Fig. 1 **Vertical or 'I' Trellis**

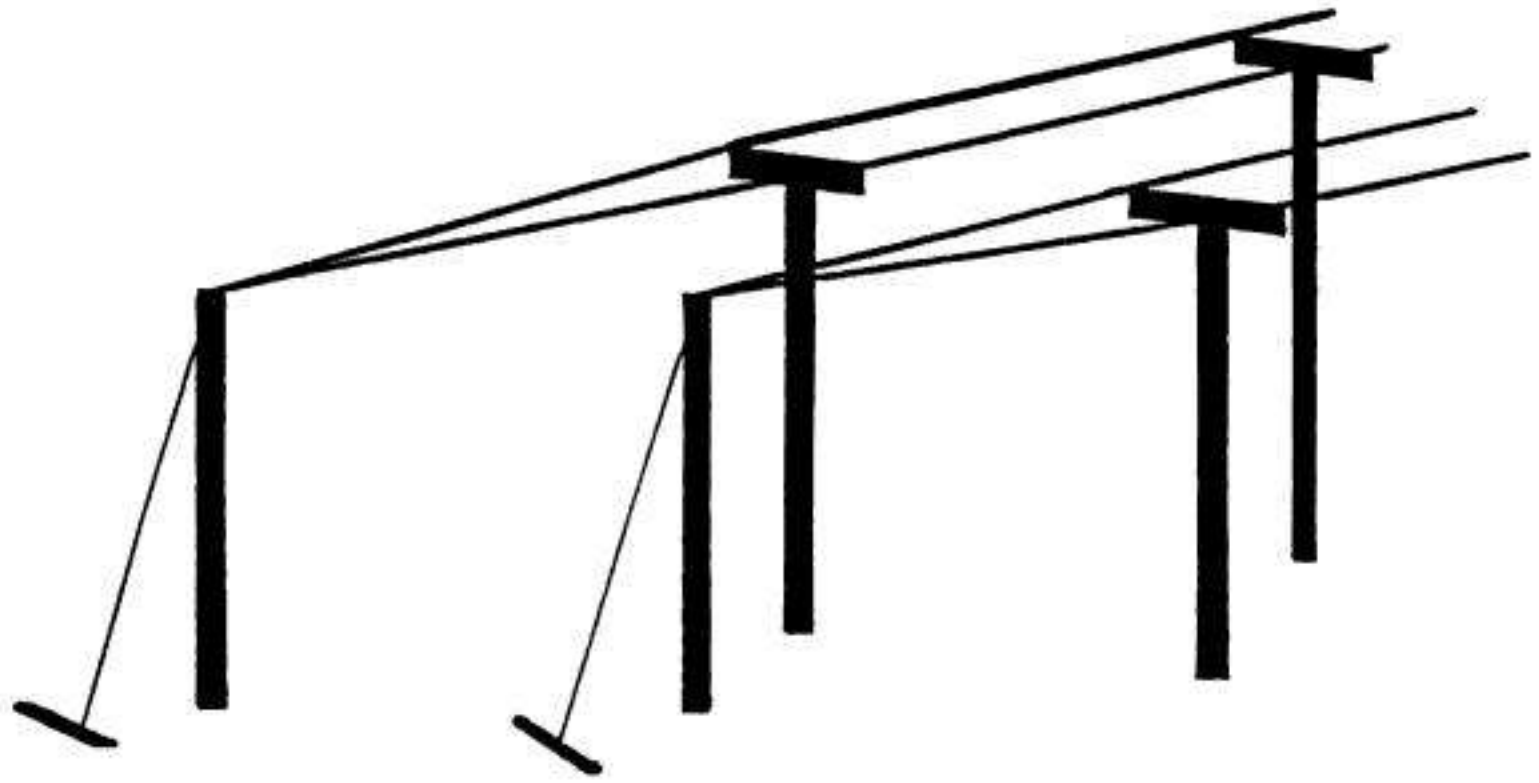

Fig. 2 Horizontal or "T" trellis

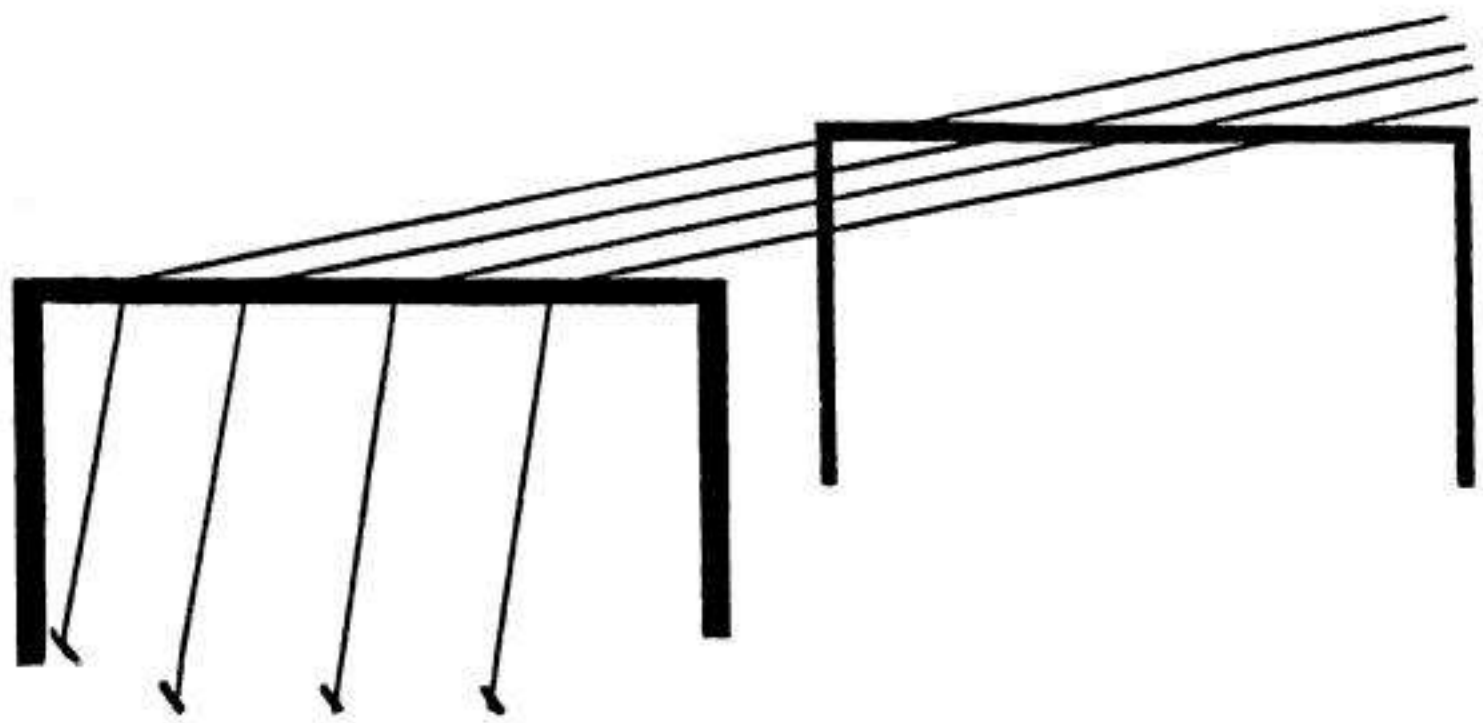

Fig. 3 Arbour or inverted "U" tellis

III. Pruning

The nature and extent of pruning practiced is usually predicated by the following objectives:

(*a*) Facilitating spraying for pest and disease control
(*b*) Reducing vine weight on the trellis
(*c*) Rejuvenation of vines
(*d*) Facilitating the harvesting exercises.

Minimum pruning has been recommended for yellow passion fruit. This is reasonable if vines are young and fruit are being grown for the processing market. In this case some degree of fruit blemish is tolerated in the interest of maintaining high yields. The minimum pruning technique usually refers to:

(*a*) Keeping vines off the ground by maintaining 'skirt' at 15–60 cm.
(*b*) Selective pruning , i.e. periodically removing unproductive branches.

Production for the fresh fruit market is best served by more severe pruning that results in heavier, blemish-free fruit. A technique currently being investigated is to prune the vines annually to the point where the leaders meet the trellis wire. Whereas minimum pruning occurs periodically throughout the year, severe pruning should occur after a peak fruiting period when vine mass has become problematic.

IV. Pollination

4.1 Natural Pollination

The yellow passion fruit is pollinated mainly by carpenter bees and honey bees but these are not always

abundant enough to cause a high promotion of flowers to set fruit. Fruit set from open pollination averages 15–22%. Rainfall within two hours of pollination reduces fruit set. During rainy or overcast conditions pollination efficiency is also lowered due to low activity of carpenter bees. These bees are also less likely to visit flowers on branches close to the ground.

4.2 Hand Pollination

This practice can increase yield greatly if done correctly and consistently since it results in 80–90% fruit set. Anthers are removed from flowers by use of forceps on the same day pollen is to be used. A small brush is used to apply pollen to the stigma of the flower. It is not necessary to apply pollen to all three lobes of the stigma. This exercise can be conducted from 1:00 P.M. to nightfall.

4.3 Recommendations

1. Place rotting wood, e.g. breadfruit, near to the passion fruit plot to provide nesting for carpenter bees.
2. Natural fruit set is lower on days that are overcast or have rainfall after 12:00 noon. It is therefore more necessary to hand-pollinate on those days.
3. Wait at least 2 h after rainfall to hand-pollinate (allow stigma to dry).

V. Irrigation

Yellow passion fruit seems tolerant to dry conditions but yield is low and vines appear stunted. Severe water stress reduces node elongation, node production, and flowering. Even mild moisture stress limits vegetative growth and potential yield in passion fruit. Irrigation should therefore keep the soil close to field capacity especially during flowering. If furrow irrigation is practiced furrows are placed in the middle of the inter-row space in mature orchards. If overhead irrigation is used application should be limited to morning or night periods. Irrigation needs for passion fruit have not been determined in the Caribbean. In Queensland, Australia, weekly applications of 25.4 mm (1 in) is recommended during the dry period.

VI. Yields

Yield vary from 5 to 6 t/ha and the factors discussed above, all function in determining final yield. In summary these are:

(i) *Pollination* — Pollinator population which varies in different places determines level of natural fruit set. If hand pollination is practiced then yields can theoretically be increased by 300%.

(ii) *Trellis* — The T-trellis has the potential of increase yield because it offers a greater surface for vine extension.

(iii) *Variety* — The purple passion fruit is a less vigorous and lower yielder than the yellow passion fruit. Selection work in Hawaii and Australia may account for varieties with high yielding potential in those countries. This work is just beginning in the English-speaking Caribbean.

(iv) *Plant density* — Research on yellow passion fruit indicates increase in yield (sometimes almost double) with increase in plant density.

(v) *Other* — (*a*) Age of vine for which yield is reported; (*b*) Dormancy — photoperiodism, temperature, moisture stress; and (*c*) Level of management.

Application of Fertilizers on Passion Fruit

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I. Research and Recommendations for Fertilizing in the Region

Very few countries in the Caribbean have conducted conclusive research work on fertilization of passion fruit. Undoubtedly, credit should be given to The University of the West Indies (Rajkumar) for pioneer work in Trinidad in the area of fertilization of the yellow passion fruit. Rajkumar's recommendations (1987) are given in Section IV (page 76).

Despite the interest in commercial production of passion fruit in the region the fertilization of passion fruit is a neglected area that needs attention. Most recommendations in this area are empirical and taken from imported literature. In a few cases, recommendations are based on soil analysis though still using parameters developed for other countries.

II. Passion Fruit Plant and the Uptake of Nutrients

2.1 The Root System

The total area covered and the depth of the root system of the passion fruit plant are important factors to consider when recommending fertilization and other cultural practices. In the absence of work conducted in this region, one can look at the work done in other regions. In South Africa, Kuhne (1965) found that 81.6% of all roots of a 2-year-old yellow passion fruit plant are concentrated in the area between 15 cm and 45 cm from the trunk. However, the fine roots are more uniformly distributed between 45 cm and 135 cm; 41.2% of the roots were found between 0 and 15 cm in depth. This confirms that passion fruit has a very shallow root system and suggests that

application of fertilizers in productive plants should cover a radius of at least 1 m from the trunk.

2.2 Removal of Nutrients

The amount of nutrients removed by 1-year-old passion fruit plants with a yield of 16.3 kg per plant and at a density of 1500 plants/ha is presented in Table 1.

Table 1
Total amount of nutrients removed by 1-year-old passion fruit plants (1500 plants/ha).

Nutrient		Unit	Yellow Passion Fruit: Whole plant + fruits	Yellow Passion Fruit: Fruit	Purple Passion Fruit: Whole plant + fruits	Purple Passion Fruit: Fruit
Macro	N	kg	205.5	44.5	194.1	58.9
	P	kg	17.4	6.9	18.9	6.7
	K	kg	184.2	73.8	110.7	49.8
	Ca	kg	151.6	6.7	173.8	7.8
	Mg	kg	14.4	4.0	16.9	4.2
	S	kg	25.0	4.0	25.6	5.1
Micro	B	g	295.8	37.8	252.3	47.4
	Cu	g	198.7	64.0	71.4	27.6
	Fe	g	779.4	88.0	732.1	93.9
	Mn	g	2810.2	180.2	1957.2	114.4
	Zn	g	316.9	108.1	248.5	103.5

Source: Haag et al. 1973

The data in Table 1 shows that of the macronutrients, only nitrogen, potassium, and calcium were removed in significant amounts. Taking into consideration that only the fruits go outside the grove the amount of potassium removed with the fruits (almost 50%) is the most significant. Although a significant amount of calcium is also removed, only a very small fraction is lost with the fruits. Phosphorus is used in small quantities but a significant percentage of this is on the fruit. Of the micronutrients, Mn and Fe are removed in large quantities but when looking at the percentage removed in the fruit, only a relatively small amount is lost.

The appropriate time for application of fertilizer is another critical area. According to Hagg et al. (1973), only small amounts of macronutrients are removed by the plant before it is 190 days old. From this period onwards there is a noticeable increase in the use of N, K, and Ca. For the rest of the elements the increase in absorption is only significant after 250 days. At this age, just before fruit set begins, the plant of the passion fruit shows the most significant increase in the use of N, K, and Ca.

III. Symptoms of Deficiencies and Nutrient Foliar Levels

Different studies have been conducted on the influence of macronutrient deficiencies on the development of the passion fruit plant. The plant also shows characteristic symptoms to deficiency of these elements. The following is a resume of these:

(*a*) *Deficiency of nitrogen* — Nitrogen is considered one of the essential elements for growth and productivity; therefore one of the first symptoms of nitrogen deficiency is a retarded growth. Other symptoms are as following:

- General chlorosis in all the leaves;
- Necrosis of the leaf apex;
- Leaves produced are of small size.

Upper leaves with nitrogen deficiency tend to concentrate phosphorus and magnesium. The level of potassium is lower than normal.

(*b*) *Deficiency of phosphorus* — Phosphorus deficiency tends to reduce foliar and root growth and deeply affects the production of fruits. Plants deficient in this element show the following symptoms:

- New leaves produced have narrow lobes and are smaller in size;
- Old leaves lack colour and appear as if burned by sunlight;
- Leaf margins fold inward;
- Petioles are smaller and with a purple colour;
- Fruits take a longer time to mature and acquire the typical yellow colouration.

(*c*) *Deficiency of potassium* — Potassium is essential to fruit development and quality. Deficiency symptoms in the plants include:

- Smaller new leaves;
- Yellowing of the leaves, starting from the midvein;
- Necrosis of old leaves;
- Weakened abscission points which cause a premature fall of flowers and fruits;
- Fruits with a thick hard rind and very little seed and pulp.

Plants with a deficiency of potassium tend to concentrate nitrogen in the upper leaves and phosphorus and magnesium in the lower leaves.

(*d*) *Deficiency of calcium* — Plants with calcium deficiency tend to have retarded growth. The characteristic symptoms are the following:

- Main vine is thinner than normal;
- Inter-veinal discolouration in new leaves;
- Narrow and small leaves;
- Necrosis on old leaves and defoliation;
- Fruit with thick rind.

Foliar analysis is a helpful method to determine the level of concentration of nutritional elements in the leaves and by interpretation, introduces changes in the recommended fertilization programme. However, the passion fruit is a plant of continuous, rapid, and exuberant growth that makes the selection of a standard leaf difficult for analysis. Nevertheless, to standardize the system it is recommended to chose leaves with a flower that is due to open next in its axil. Avilan (1974) worked out levels of normality and deficiency for macronutrients in the upper and lower leaves of passion fruit. These levels are presented in Table 2.

Table 2
Normal and deficient level of macronutrients in upper and lower leaves of passion fruit expressed as a percentage of the dry matter.

Element	Normal Leaves		Deficient Leaves	
	Upper %	Lower %	Upper %	Lower %
N	3.26	2.14	1.92	1.40
P	0.17	0.11	0.08	0.07
K	2.47	2.09	1.15	0.52
Ca	1.31	1.42	1.00	1.15
Mg	0.42	0.27	0.33	0.15

Source: Avilan (1974).

In similar work conducted earlier, Hagg et. al. (1973) presented tentative optimum foliar levels for plants before fruit set. These are presented in Tables 3 and 4.

Table 3
Optimum foliar level of macronutrients in passion fruit before fruit appearance.

Element	Yellow (%)	Purple (%)
N	3.63–4.62	3.58–4.56
P	0.21–0.30	0.21–0.26
K	2.36–3.24	1.64–3.08
Ca	1.74–2.77	1.88–2.07
Mg	0.21	0.21
S	0.44	0.44

Source: Hagg et.al. (1973)

Table 4
Optimum foliar level of micronutrient on passion fruit before flowering

Element	Yellow (p.p.m.) (%)	Purple (%)
B	39–47	38
Cu	5–16	8–9
Fe	116–233	188–230
Mn	433–604	449–522
Zn	26–49	31–42

Source: Hagg et. al. (1973)

IV. Fertilization Programmes

Each of the main producing countries have more than one recommended programme of fertilization, most of them are based on a fixed formula or amount of simple fertilizers. The most important are the following.

4.1 Hawaii

YOUNG PLANTS: Manure to the hole. N:P:K = 5:6:3 in two applications. First, at planting: 450 g/plant. Second, 4 months after 900 g/plant.

PRODUCTIVE PLANTS: 1.5 kg per plant per year of N:P:K = 10:5:20 in three or four applications.

4.2 Venezuela

YOUNG PLANTS: Nitrogen: 25 g/plant P_2O_5:25 g/plant K_2O:25 g/plant all in two applications. Fifty percent at planting and the remainder six weeks later.

PRODUCTIVE PLANTS: N:P:K = 90:90:90 g/plant. Two applications. Fifty per cent when a large number of fruit have been formed, and the remainder after harvest.

Haddad and Milan (1975) recommend N:P:K = 60:60:60 g/plant and 135:135:135 g/plant for young and productive plants, respectively. They recommend applying the fertilizer in an area of 20 to 45 cm around the trunk.

4.3 Brazil

YOUNG PLANTS: Carvalho (1965) recommends application before planting. Manure, 200 g ordinary superphosphate and 60–80 g muriate of potash. Then at 30, 60, and 90 days after planting, apply 50–80 g ammonium sulphate. Two months before flowering, apply 80–100 g ammonium sulphate, 200–250 g ordinary superphosphate and 100–150 g muriate of potash.

PRODUCTIVE PLANTS: Carvalho (1965) recommends three applications of N:P:K = 50:50:75 g/plant. (*a*) Beginning of rainy season; (*b*) middle of rainy season; (*c*) end of rainy season.

4.4 Colombia

YOUNG PLANTS: Rio-Castano and Salazar (1977) recommend N:P:K = 10:10:10 g/plant mixed with manure and top soil to be applied at planting time.

PRODUCTIVE PLANTS: Rio-Castano and Salazar (1977) recommend N:P:K = 20:20:20 g/plant after harvesting.

4.5 South Africa

YOUNG PLANTS: Kuhne (1965) recommends two weeks before planting, 9 kg manure and 450 g ordinary superphosphate per plant to be applied to the hole. Then for the first year: 50–100 g urea, 100–200 g ordinary superphosphate, and 100–200 g muriate of potash.

PRODUCTIVE PLANTS: Kuhne (1965) recommends in the second year: 100–200 g of urea, 200–400 g of ordinary superphosphate, and 100–200 g of muriate of potash. And in the third year: 200–300 g of urea, 200–400 g of ordinary superphosphate and 200–400 g of muriate of potash.

4.6 Trinidad

Rajkumar (1987) recommends 700 g/plant of N:P:K = 15:5:10 three times per year. First: soon after the rain begins (May), second: late August and third: late October. Method of application: broadcast around base 1 to 1.5 m away from trunk. Apply trace elements 10 g/L, 20:20:20 + trace in each crop protection spray.

4.7 Dominica

Since banana fertilizer (16:8:24) is the available formula, this is being recommended at 400 g/plant divided into two to three applications per year. A small amount of superphosphate is applied at planting.

Most authors recommend foliar application of trace elements during the normal crop protection sprays.

V. Main Conclusions

- There is an urgent need for research work in the area of fertilization of passion fruit in the Caribbean.
- Passion fruit has a very shallow root system.
- The main area to apply fertilizer is a radius of 1.35 m. Application should be 15 cm away from the trunk.
- Nitrogen, potassium, and calcium are the only macronutrients removed in significant amounts.
- About 50% of the potassium removed is lost with the fruits.
- Although only a small amount of phosphorus is removed, a significant percentage of this is lost with the fruit.
- Manganese and iron are two microelements removed in a very significant quantity. However, only a small amount is lost with the fruit.
- Only small amounts of macro- and micro-nutrients are used during the 190 days after planting. Use of N-K-Ca increases after 190 days but most significantly 250 days after planting.
- Symptoms of nutrient deficiencies can be used for corrective applications of fertilizers.
- Foliar analysis is helpful to determine the need of nutrients.
- The application of manure is recommended before planting.
- Most authors recommend dividing the fertilizer into three or four applications.
- Most authors recommend foliar application of micronutrients combined with the crop protection sprays.

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Citrus Production — Orange

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I. Orange Classification

Oranges are classified into three categories; sweet, *Citrus sinensis*, sour, *C. aurantium*, and hybrid, *C. sinensis* × *C reticulata*. Sweet oranges are navel, blood and non-pigmented or common like Valencia (late); Navel, Pineapple (mid-season); Parson Brown, and Hamlin (early). Sour oranges are acid, Cospo, and Seville sweet. While hybrids are Tangors, Ortanique and Temple.

1.1 Varieties

Valencia late or simply 'Valencia' is the most common commercial cultivar in the world. It is used both as a fresh or processing fruit and comes into maturity around March. A sugar:acid ratio of 9:1 is generally the accepted maturity index used for processing. This is achieved earlier than at full maturity. There are variants of Valencia that perform differently, e.g. degree of seedlessness, lateness, colour development. The Pineapple and Parson Brown are seedy types whereas Hamlin and Washington Navel are seedless.

Under conditions where budwood collection is not strictly monitored continious errors can be made. For example some other types are incorrectly referred to as Valencia, e.g. Homosassa, Lamb's Summer. There is a good opportunity for selecting local clones with superior characters of yield, colour, and internal quality.

II. Ecological Considerations

2.1 Temperature

The attractive orange colour characteristic of California oranges is due to cool high temperatures in addition to low soil temperatures. In the tropics good peel colour is achieved only at high elevation. The colour in blood oranges is due to development of anthocyanins under cool temperatures. In contrast, colouration in Ruby grapefruit is due to lycopene synthesis which is promoted by high temperatures.

High temperature is also responsible for the relatively shorter maturation time for oranges in the tropics as compared to subtropical production. The time difference is at least two months.

2.2 Rainfall

Where there are distinct wet and dry seasons, flowering is brought on by rains after a 6-week dry period. If there is a wet dry season, flowering tends to be scattered throughout the course of the season. Minimum annual rainfall required is 150 cm (60 in.).

2.3 Sunlight

Oranges require full sunshine for good production. For example trees that are intercropped with bananas into the third year of establishment tend to have long, thin, sparse branches with few fruits. Those trees in full sunlight tend to have a more compact canopy and are laden with fruit.

2.4 Wind

Wind stress results in stunted growth, dieback, and low yields. This is further compounded by attack of sucking insects. Areas exposed to constant heavy winds must be protected by a windbreak.

2.5 Soil

A deep loamy soil of pH 6–7 is best for production of oranges. However, oranges will grow under a range of soil conditions. The major soil problem in the region has been heavy, poorly drained soils. These have been managed by use of mounds or cambered beds.

III. Crop Husbandry

It is impossible to recommend a fertilizer programme suitable to all conditions. Variations are due not only to differences in soil fertility but also to irrigation, rootstocks and other factors. The best recommendation of course is based on leaf and soil analysis of the grove to be fertilized. Certain generalizations can be made, however, and these will be discussed.

Nitrogen (N) — Nitrogen is the major element affecting yield. If too much nitrogen is used, the fruit tends to be small and coarse, and also tends to retain the green colour. Deficiency is associated with a general yellowing of leaves and shorter leaf life span so that canopies look thin. More importantly, yield are low. Since nitrogen reserves are not built up in the soil then split applications are necessary.

Phosphorus (P) — Phosphorus accumulates in the soil and is not limiting in most groves. Notable exceptions are the red bauxite soil in Jamaica and the "Pine ridge" soils in the Stann Creek Valley in Belize. The average crop removes only about 20 kg/ha P_2O_5 so that phosphorus application can be omitted in some years.

Potash (K) — Potash is usually required in the same proportion as Nitrogen. Too much potash on acid soil results in large, coarse, acid fruit. Potash deficiency results in small-sized fruit. Light acid soils respond to potash better than heavy, calcareous soils in terms of fruit yield.

Magnesium (Mg) — Deficiency symptoms occur as a V-shape yellowing on mature leaves. This may be overcome by magnesium nitrate of sulphate sprays. ($MgSO_4 . H_2O$ at 1.5 kg/tree or 100 g/L low volume spray.)

Trace elements — Manganese, zinc, iron (Mn, Zn, Fe). Deficiency of these are common in citrus groves. In Jamaica boron and copper deficiency occur as well. These are all young leaf disorders. Correction is by foliar applications except for iron which requires soil applications in the form of "chelates". Organic manures are also useful supplements for providing trace elements.

Liming — Continued use of sulphate of ammonia on acid soils can result in a pH below 4. Liming is necessary to maintain soil pH and results in increased yields. Research indicates that movement of bases can be improved by area application following liming. Agricultural limestone ($CaC0_3$) is superior to hydrated limestone ($Ca(OH)_2$) as a liming material. The recommended rate for Trinidad is 2 t/ha per year.

Fertilizer rate — The Florida recommendation is for their infertile sandy soils which are too high for our conditions. The Weir recommendation is based on work done within the region and is more realistic for general application. Young tree fertilizer recommendations are usually for a 2:1:1 ratio for the first five years with applications three times per year on average. Thereafter the recommendation ratio is closer to 2:1:2 with applications twice per year. The first is in April/May and the second September/October.

3.1 Weed Control

Weed control is best done manually or mechanically as long as this is economically or logistically possible. If weedicides must be used, this method should be alternated with nonchemical methods and the types of chemicals used should also be alternated. Good control has been experienced with the following weedicides:

Weedicide	Rate	Comments
Round-up	50 ml/4.4.5 L	Avoid drift, use on actively growing weeds
Gramoxone	30 ml/4.5 L	For grasses mainly. Use half strength if used with Karmex
Karmex	450 g/30 L	Use when soil is moist
Dalapon	500 g/30 L	Avoid drift

Circle weeding of plants or strip weeding of row is sometimes the best approach when resources are limited.

3.2 Pruning

The types of pruning practiced are: rootstock pruning, maintenance pruning, and rehabilitation pruning.

Removal of rootstock shoots in the field is necessary as a monthly exercise in young trees. This problem may occur in older trees due to damage and exposure to light of the lower trunk.

Maintenance pruning involves removal of dead and diseased branches only. Where epiphytes have become strongly established it is sometimes simpler to remove that part of the branch or affected shoots.

Rehabilitative pruning may be done once yields begin to decline after about 25 years of production. It

may be done earlier especially after damage by bush fire or debilitation due to abandonment. The technique involves severe pruning which rejuvenates the tree. Old trees (40–50 years) or trees severely damaged by disease should be replaced rather than rehabilitated.

Citrus Production — Grapefruit and Lime

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I. Origin and History

The citrus species originated in Cochin China and adjacent sections of China. They were introduced and their growth has been attempted in almost every part of the world that offered any chance for their successful culture.

Citrus belongs to the family Rutaceae and are mainly trees or shrubs, rarely herbs, with aromatic, alternate or opposite, usually compound leaves dotted with translucent glands containing an essential oil.

1.1 Grapefruit

Grapefruit may have come into existence as a mutant or seedling in the West Indies. In Jamaica, as early as 1814, a citrus fruit was known by the name grapefruit. The name grapefruit was applied evidently because the fruit so frequently is borne in grape-like clusters of from 3 to 4 to 12 to 18.

There are some 18 to 20 varieties in existence of which the Duncan, Foster, Pernambuco, Marsh, Ruby, and Glen Red can be found in the Caribbean. The Marsh seedless is the best known and grown commercially.

1.2 Lime

Limes were introduced into the West Indies and other parts of the New World by the Spaniards. They have a very wide distribution in all parts of the tropics and are the most important acid fruit of these regions. Outside of the tropics and the warmer subtropical sections, they have never been successfully cultivated to any extent, for they are the tenderest of all citrus fruits. The tree does well on sandy soils or on marginal to poor soils. It can do well when poorly cultivated or cared for, or even when neglected.

The Mexican, also called West Indian lime, was initially propagated from seed which in most cases caused the tree to succumb to a root disease. Lime is used in the making of limeade and for seasoning food (fish). Citric acid, citrate of lime, concentrated lime juice, and lime oil are important products of lime. There are three principal varieties of lime: Bear seedless, Mexican, and Tahiti.

II. Locating the Grapefruit or Lime Orchard

The topic deals specifically with the grapefruit and the lime orchard but the selection criteria holds true for all citrus orchards.

When choosing a site for establishing the orchard, the prospective grower would be well advised to consider the following points. Facilities for transportation, the nature and direction of the prevailing winds, and exposure must be studied in relation to the prospective gains, the welfare of the trees, the quality of the fruit, and financial returns.

2.1 Drainage

Grapefruit and more so limes will not tolerate waterlogged soils, that is soils in which water stagnates and does not drain readily. During periods of heavy rainfall, surplus water must move away freely. If it does not air is excluded from the soil, respiration ceases, and the roots will either be damaged of killed. In low locations with heavy soils the two often go together. Natural drainage outlets are essential. These can be enlarged, deepened, and opened up if need be. In heavy soils and heavy rainfall areas, and on flat lands, it is recommended that plants be put on mounds.

2.2 Windbreaks

The foliage and mechanical damage to fruit caused by wind is a common occurrence in most Caribbean countries. In wind-swept conditions trees do not produce as they should and appear very unthrifty.

It is almost impossible to establish a grapefruit or lime orchard without establishing a proper windbreak. There are several hardy trees which may be used as windbreaks e.g. mango, Eugenia *malaccensis*, Galba, Mahogany, *Pinus caribbea*, sapucaia nut, are a few examples which the author has seen successfully being used.

2.3 Soil Type

Citrus trees possess a wide range of soil adaptibility but every kind of land cannot be used. Many soil types may be used by citrus if the right stock is chosen. Citrus trees (grapefruit and limes included) succeed best on well-drained soils of a rather open nature. The health and longevity of the trees and the flavour and quality of the fruit all are influenced by the character of the soil. It is essential to take several samples of the soil on which the orchard is to be established and have these analyses before hand. The analysis should include a mechanical analysis.

III. Preparation for Planting

If the piece of land chosen for the orchard is in forest or secondary forest the grower will have one of two choices: either partial or complete clearing. The latter is the preferred method.

Partial clearing can be made to work by clearing the rows in which the trees are to be planted and staking at the required distance. For grapefruit the recommended spacing is 7.6 m × 7.6 m (25 × 25 ft) to 9 m × 9 m (30 ft × 30 ft) and for limes 4.6 m × 4.6 m (15 ft × 15 ft) to 5.5 m × 5.5 m(18 ft × 18 ft). The spot in which the plant is to be established should be cleared of all roots. It has been found that these roots can harbour insects and/or root diseases.

It is much easier where clear felling is done as these areas can be mechanically or hand cleared and the felled trees placed in windows to decay or be burnt and the ash returned to the soil. In clearing standing timber, windbreaks can be allowed to remain. This windbreak (natural) can be felled after the establishment of the planted windbreak behind it and the planted windbreak has establish itself.

3.1 Orchard Plan

Several systems may be used in planting the orchard, e.g. square, triangular, contour, rectangular, etc. It is recommended that roadways be planned with allowance for the necessary drainage facilities. When the ground is laid off in preparation for planting, a stake is set where each tree is to be established. The trees should stand in straight rows. This not only looks rather better but it facilitates cultivation. A chain or measured string may be used in lining out the area.

IV. Planting the Grapefruit or Lime Orchard

The planting of the trees is the actual starting of the orchard, and any reasonable amount of time and care taken in the operation is time well spent. All details should be attended to well in advance and the person or persons doing the planting should receive advanced training. It is assumed that the right varieties have been selected, the trees were produced by a reliable nursery, the trees are disease-free, the stocks are of the right type with straight (not kinked) roots. In general, trees are received (nowadays) in bags. The following points must be borne in mind:

(1) It is advisable to prepare the planting holes or mounds well in advance and allow them to weather.

(2) If available, organic matter should be incorporated into the hole.

(3) When digging the hole, the top soil should be placed on one side and the sub-soil on the other.

(4) After the organic matter is added, the soil should be replaced in the same way as it was removed.

(5) When the plants have been received and at the start of the rainy season (if irrigation is unavailable), the procedure as in (3) should be repeated. Planting is best done in the late afternoon.

(6) The plant should be carefully removed from the bag to avoid damage to the root system.

(7) It is useful for a basal dressing high in phosphate and potash to be incorporated with trace elements where available and this covered with well-rotted organic matter.

(8) Place the plant at the same depth as it was in the bag in which it was received, in the centre of the prepared hole at the same time maintaining the straight line. The union of stock and scion should be on the windward side. The soil should be added in the same way it was removed compressing it firmly around the plant to avoid pockets into which water could lodge.

(9) After planting, the stake should be used at an angle on the leeward side to support the newly planted plant and to protect it from the wind.

(10) In wind-swept areas, three stakes may be placed around the plant, two on either side and one in front, and an old bag placed over this to protect the young tree from the wind.

When the earth is placed about the last tree and the steps followed as enumerated above, the orchard may be considered established. Most farmers consider their work complete and leave the young plant to fend for themselves. The next few months are crucial in the life of the newly established orchard. If irrigation is to be rainfed and rain does not fall in the days following planting, the young plants must be watered.

In unfenced areas plants should be checked frequently to assess if they are damaged by untethered animals. Also, in areas in which cutting insects are known to exist, if the young plants are being attacked the appropriate measures should be taken to avoid the damage.

4.1 Deshooting and Desuckering

In the first 2–3 years after planting the plants should be examined at one to two monthly intervals to deshoot and train the growing plant and to desucker or remove the growing rootstock. Farmers have been known to complain that they receive the wrong variety from the nursery, when in fact they allowed the rootstock to grow and establish itself and dominate the growth of the scion. It is useful in the first three to four years to remove all fruits to allow the energy to go into growth.

It is advisable to label the trees carefully and provide a simple map of the orchard on which the planting date has been recorded.

4.2 Care of the Young Orchard

Weed Control — Weed control in the young orchard or in the established orchard is by far the most time-consuming exercise for the Caribbean farmer, and the most expensive. Weeds may be controlled in

several ways, mechanically, by hand, or by the use of herbicides. The method of choice is left to the individual farmer. Weeds compete with the roots for water and nutrients in the soil and in addition harbour pests and disease.

V. Cultivating Young Groves

For four or five years after planting, grapefruit and lime trees occupy a relatively small portion of the total area on which they are planted. Their branches are not widely spread and their root systems do not take up the same amount of space in the soils as when they become established.

The author recommends the establishment of an inter-row cash crop, e.g. pineapple, papaya, plantain, and bananas which would help defray the cost of establishment but more importantly will ensure that the farmer visits the young orchard and observes the trees.

5.1 Fertilizers and Fertilizing

In a citrus tree — its roots, trunk, branches, leaves, flowers, and fruits — a number of chemical elements are found. These substances are needed for growth and reproduction and must be present in suitable amounts in the environment of the living tree. There is, however, no substitute for a fertile soil.

Research over the years have determined that some 15 chemical elements are required for normal growth of lime and grapefruit trees (citrus) as follows: carbon, hydrogen, oxygen which are supplied naturally; the major elements nitrogen, phosphate, potassium, calcium, magnesiumand the minor and trace elements manganese, iron, boron, molybdenum, sulphur, zinc and copper.

In the young orchard, a good rule of thumb would be to apply the fertilizer to the young trees in small amounts and often. On acid soils low in fertility, benefits from fertilizers can be supplemented by spraying matured foliage with a foliar spray of which several proprietary brands are in existence.

Once trees have come into production, it would be useful once the service is available to determine the type, amount, and timing of the fertilizer applications by taking soil and leaf samples, having these analysed, and be following the recommendations. The guidelines for this approach are well documented in Appendices I and II (*C.C. Weir*,. Citrus Fertilizing).

5.2 Pest and Disease Control

For control of the more injurious insects and related pests by direct means, resort may be made to baiting (in the case of *Atta* spp.), spraying, dusting, or fumigating.

The farmer is best advised to consult a specialist or the extension officer before embarking on a control or spray programme as:

(*a*) The right material must be used.
(*b*) Instructions must be followed for handling and use of chemicals.
(*c*) The timing must be at the right time and on time.
(*d*) They must be applied carefully and thoroughly.

Fungus diseases cannot be cured — they can only be controlled. It is better to prevent the disease if possible. It should be noted that when citrus insects are held in control by parasitic fungi there is a very minimal increase in their numbers when trees are sprayed with fungicides.

Spraying must be done thoroughly. Sprays should be applied only to dry trees and is therefore best started in mid-morning when the trees have dried out. The spray machine should be of the right type and properly maintained.

5.3 Citrus Diseases

Many citrus diseases are due to the attacks by fungi. These injure different parts of the tree, root, stems, branches, leaves, and fruits. Some of the disease include the following.

Foot rot — causal organism — *Phytophthora*. Treatment — use of resistant stock.
Scaly Bark — causal organism — either *Cladosporium citricolum* or virus (Xylosporosis).
Damping off — *Fusarium, Rhizoctonia, and Sclerotium*,
Wither tip — Anthracnose, bloom blight, leaf spot — causal organism — *Colletotrichum gloeosporioides*.
Citrus scab — causal organism — *Elsinoe fawcetti*.
Melanose —*Diaporthe citri*.
Areolate leaf spot — *Corticulum areolatum*.

5.4 Pruning Grapefruit and Lime Trees

Once grapefruit and lime trees have been established, no pruning (or little at planting time) is advocated. Pruning should be to remove dead or dry branches. It should be remembered that citrus bears principally on the young flush; by removing/pruning old branches, the potential sites for young flush, the yield potential is diminished.

5.5 Picking

The picking of citrus requires those who can be trusted to handle fruits carefully. Fruits must not be dropped, roughly handled, or bruised in any way. Slight bruises are not seen when they occur, but are there nevertheless and will show up later as soft rotten spots (blue or green molds). Too much stress cannot be placed on the proper care of picking and packing.

5.6 Weather Conditions

Temperature and moisture conditions both before and during harvesting have a definite bearing on the condition of the fruit. If wet weather has prevailed for some time, the fruit is likely to be more turgid, the rind more easily injured. Green and blue mold are much more active in damp humid conditions than

in dry weather. Greater care must be taken in handling the crop.

If trees and fruits are wet from rain or from early morning dew, picking should be delayed until they have dried off. Fruits should be picked in clear dry weather and, once harvested should not be left in the open sun. Harvested fruits should be placed in the shade until they are transported to the market. The principal sources of injury to fruits are caused by (1) finger nails of the pickers; (2) foreign matter e.g. gravel, twigs, in picking bags and boxes (thrash bags and boxes should be inspected and cleaned before being taken to the fields); (3) bruises caused by dropping or bad handling—bouncing against ladders, etc. (Where picking bags are used, the bags should be placed in the box and the fruits allowed to roll out gently; (4) receptacles used for collecting fruits—they should be free from splinters, nail points, etc. which may injure or puncture the rind; (5) fruit stems that are not carefully removed; and (6) cuts.

VI. Citrus In the Caribbean

In general, because of the small size and difficult terrain, citrus in the Caribbean should be produced for intra regional markets or for the local tourism trade. Where possible as in the case of grapefruit in Dominica, if a niche market could be exploited, this should be done. If a niche market is to be exploited, the fruit must meet all the criteria for the particular market, e.g. grade, maturity, freedom from blemishes, colouration, standards (total sugar: total acid). A dependable cheap transport system should be in place.

Appendix I

General citrus fertilizer programme for light acid and heavy acid soils[a]

Canopy diameter, m	N:P:K = 12:8:18 1st application about 6 wk before blossom[b]	20% N Fertilizer[c] 2nd Application about 4–5 mo. after blossom		Magnesium and trace elements	
		Light acid	Heavy acid	Light acid	Heavy acid
2	0.5 kg/tree	0.6 kg/tree	0.5 kg/tree	These should be applied when leaf analyses and/or deficiency symptoms indicate low values.	Normally no application required but can be added if leaf analyses and/or deficiency symptoms indicate low values.
3	0.9 "	0.9 "	0.6 "		
4	1.3 "	1.1 "	0.6 "		
5	1.8 "	1.3 "	0.9 "		
6	2.2 "	1.8 "	1.1 "		
7	2.7 "	1.8 "	1.3 "		
8	3.1 "	2.2 "	1.3 "		
>8	3.6 "	2.2 "	1.8 "		

Appendix II

General citrus fertilizer programme for neutral and alkaline soils[a]

Canopy diameter, m	1st Application of a 20% N fertilizer	2nd Application of a 20% N Fertilizer	Potash as Nitrate of Potash[d]	Phosphorous Magnesium and trace elements
2	0.9kg/tree	0.5 kg/tree		Normally no application of phosphorous is necessary but super phosphate should be needed. These must be supplied if leaf analyses or leaf deficiency symptoms suggest low values
3	1.1 "	0.6 "		
4	1.3 "	0.9 "	0.5 kg/tree	
5	1.8 "	0.9 "	0.9 "	
6	2.2 "	0.9 "	0.9 "	
7	2.2 "	1.3 "	1.3 "	
8	2.7 "	1.3 "	1.3 "	
>8	3.1 "	1.3 "	1.3 "	

[a] Adapted from Citrus Research Bulletin No. 8 by C. C. Weir

[b] A 12:8:18 fertilizer is used here but any other fertilizer with a similar ratio of NPK could be used.

[c] 20% N = calcium ammonia nitrate of sulphate of ammonia. 44% N = urea.

[d] Potash should be added once per year, preferable about 6 weeks before blossom.

NOTE: Conversion table: 1 kg = 2.2 lb; 1 m = 1.09 yd

Citrus Variety Improvement Programme in Martinique

R. COTTIN AND J. BOURDEAUT
IRFA/CIRAD, Martinique, French West Indies

Citrus was introduced in the Caribbean by Columbus during his second travel, November, 1493. Pomello was brought from the East Indies to Barbados a few decades before 1696. Grapefruit probably appeared after a mutation of the pummelo, in Barbados, around 1750. Therefore the cultivation of citrus in the Caribbean zone is already five centuries old. It developed mainly in Cuba, Jamaica, Trinidad, and Puerto Rico.

Only recently has a real effort been made in this to create a modern citrus industry in Martinique, a country 1000 km² with 340,000 inhabitants.

I. Sanitary conditions

The development of citrus production is linked to a favorable sanitary environment.

1.1 Surrounding Conditions

The satisfactory sanitary conditions in Martinique were very well pointed out by Pr. Salibe, Chairman of I.O.C.V. during his mission in August 1985. In fact, very few citrus-growing countries enjoyed such conditions with the absence of Tristeza (and its main vector *Toxoptera citricidus* Kirk. , mal secco, greening, citrus canker, or blight.

Furthermore, a very strict sanitary inspection is carried out at the customs by the SAPV (Service de la Protection des Végétaux).

1.2 Pests and diseases

Some minor pests and diseases are present on the island.

1.2.1 Mites

Broad mite, *Phyllocptruta latus*
Citrus rust mite, *P. oleivora*

1.2.2 Scale Insects

West Indies Red Scale, *Selenaspidus articulatus*
Citrus snow scale, *Unaspis citri*
Dictyospermum scale, *Chrysomphalus dictyospermi*
Purple scale, *Lepidosaphes beckii*
Glover scale, *L. gloverii*
Brown soft scale, *C. hesperidum*
Black scale, *Saissetia oleae*

1.2.3 Weevils

Sugar cane weevil, *Diaprepes abbreviatus, D. famelicus, D. marginatus*

1.2.4 Aphids

Spirea aphid, *Aphis spiraecola*
Black citrus aphid, *Toxoptera aurantii*

1.2.5 Fungi

Root rot, *Phythophthora* sp.
Greasy spot, *M. horii*
Scab, *S. fawcetti*
Anthracnose, *Gloeosporium limetticolum*

These pests and diseases are well known and their control have been studied in the past by IRFA/CIRAD. Therefore, a Citrus Variety Improvement Programme can be carried out in Martinique under satisfactory conditions.

II. Citrus Variety Improvement Programme in Martinique (CVIPM)

The creation of a regional bank of healthy citrus varieties to supply the Caribbean region is of great interest as (1) the development of citrus canker in Florida, Mexico and Brazil does not make it possible to transfer healthy citrus vegetal material from a contaminated area to a healthy one. (2) Tristeza has reached other countries such as Colombia and Venezuela during the last decades.

2.1 Localisation

The knowledge acquired by IRFA during 30 years of sanitary selection, bud source trees creation and nurseries is most helpful to realize this CVIPM. This programme is carried on at the IRFA research center in Fort-de-France. Actually, 193 virus free citrus varieties are available in a 5.5 ha mother block.

2.2 Origin of Mother Trees

All the mother citrus trees came from the Department of Virology of the Agronomical Research Centre of Corsica.
The Corsican Center guaranteed this material free from known transmissible diseases by:

- indexing
- shoot-tip-grafting and thermotherapy (for those contaminated by transmissible diseases)
- re-indexing
- pre-selection plots of pomological conformity

2.3 Indexing of Mother Trees

After planting in Martinique in July 1988, mother blocks were periodically controlled by two kinds of techniques:

- Horticultural techniques using indicator plants under indexation greenhouses for Psorosis, Exocortis, and Cachexia (Xyloporosis).
- Serological techniques using ELISA tests for Tristeza and Stubborn.

2.4 Horticultural Studies

The sanitary survey is only a part of a programme for the production of citrus material. Technical

practices and fruit quality under tropical conditions are the other parts.

2.4.1 Technical Practices

Trials on high density planting using dwarf rootstocks and proper soil preparation are two aspects studied for yield improvement.

2.4.2 Behaviour of Citrus Trees under Tropical Conditions

Phenology, pomology, flowering control are other studies for improving citrus fruit quality.

III. Future outlook

In the near future, IRFA will be able to supply Caribbean growers with 28 kinds of rootstock and 165 true-to-type transmissible disease-free and quality controlled citrus varieties. This will be of interest for countries of the area willing to create orchards within fruit production developing project. The varieties that are expected to be available are as follows:

Rootstock	28	accessions
Orange	33	"
Tangerine	61	"
Tangelo	11	"
Tangor	7	"
Grapefruit	16	"
Pomelo	4	"
Lemon	9	"
Lime	10	"
Miscellaneous	14	"

Cultivars and Races of Avocados and their Characteristics

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I. Introduction

The avocado belongs to the family Lauraceae, the genus *Persea*, and the species *americana*. Although several species are known within the genus *Persea*, only the species *americana* is commercially planted.

Among tropical fruit crops the origin of the avocado has for a long time been one of the most disputed. Different authors mention Central America as its origin whereas others affirm it originated in Mexico. The fact is that in both places, many wild species of the *Persea* genus can still be found.

This fruit is highly appreciated in the Caribbean region where it has been cultivated for a long time and eaten as a fresh fruit and as a salad component. Until recently, very little was done in this region in terms of industrializing the avocado fruit, with the exception of one or two industries which prepare a product known as 'Guacamole[1],' This happens, in spite of its well recognized characteristic as a rich source of fine oils which today are used in the cosmetic industry for the manufacture of a wide number of products ranging from facial creams to shampoos and rinses. Countries in other regions, such as Brazil and the U.S.A. (California) have developed technology to can avocado puree and whole avocado pieces.

The rapid increase in the demand for avocados in international markets was an incentive to most countries in the Caribbean to initiate the commercial exploitation of this fruit in organized commercial orchards. Despite this, for every plant in an organized orchard there are hundreds, perhaps thousands, of seedlings scattered in these countries.

[1]Guacamole is a popular Mexican food that combine avocado with sweet and hot pepper, onion, garlic, lime and other seasoning products.

Although it varies with the country, the average normal season for avocado in the Caribbean region is from July to September. Production from March to June is considered early and production from October to February is considered late.

Many selected cultivars have been introduced from around the world into this region, but only a few local selections have been made of the vast resources existing in the Caribbean. Most of these introductions have come from Florida, California, and Puerto Rico.

II. The Avocado Plant

2.1 The Tree

The size of the avocado tree is closely related to the variety, the method of propagation, and the ecological condition under which it is grown. Records indicate that a seedling can reach and exceed 25 m (82 ft) in height, and has a trunk diameter of up to 1.75 m (70 in.). The tree can survive and produce for 100 years or more. Nevertheless, on the average, the tree reaches 10 to 15 m (32 ft to 49 ft) in height, with a trunk diameter of 0.5 to 0.75 m (20 to 30 in.), and a commercial productive life of 40 to 50 years. As the tree ages the trunk becomes hollow losing up to 70% of its internal area.

Although the avocado is considered an 'evergreen' species, some cultivars lose their leaves as they bloom. However, even in those cultivars, new leaves appear immediately.

2.2 The Root System

The avocado root system is formed according to the foliar structure. In general, unless affected by exter-

nal agents, seedlings develop a tap root system while grafted trees and cuttings develop a lateral root system.

2.3 The Flower and its Biology

The avocado flower is complete and hermaphroditic. It is small, of a light to deep green-yellow colour. The calyx is composed of three sepals and the corolla, three petals. The flowers are born grouped in a panicle. Flower buds first appear terminally but the panicle and raceme soon become subterminal with the appearance of terminal vegetative growth. Only a small fraction of the huge number of flowers produced will set fruits. Chandler (1962) calculated that for every 5000 flowers only one fruit will probably reach maturity.

The avocado flower is dichogamous with two opening cycles. During the first opening the female organ (stigma) is mature and ready to receive the pollen but the stamens are not ready to shed them. In the second opening, the flower behaves as a male with the mature pollen coming from the stamen, but the stigma is already non-receptive. This barrier to self pollination is normally not restricted to the same flower but to the entire tree, or in most cases to all trees of the same cultivar. Fortunately, cultivars can be grouped according to the behaviour of their flowers, e.g. Group A and Group B.

Group A — Flowers of the plants within this group first open in the morning as female and close by midday. They open again in the afternoon of the following day, this time as male. The total cycle takes about 36 hours. Note that in the same day and same tree, many flowers will open in the morning as female and others will open (second time) in the afternoon as male.

Group B — Flowers of plants within this group first open in the afternoon as female and close in the night. The second opening is the next morning now as male. The total cycle for this group is 24 hours. Here again, the same day and for the same tree, many flowers will open (second opening) in the morning as male and many others open (first) in the afternoon as females.

Figure 1 provides an explanation on how the flowers within the two groups open depending on the time of the day. Here we can see then the advantages of intercropping with more than one cultivar of different flower groups to improve the percentage of pollination and therefore productivity. Many authors have shown that the climate has an important influence on the floral behaviour of the avocado plant. Bergh, in early studies, showed that the higher the temperature the earlier the flowering, but the shorter its duration. Nevertheless, it is widely accepted that, in terms of duration of the flowering period, the varietal influence is more marked than that of the temperature. In California, the low temperature tends to keep the flowers open for a longer period increasing the chances for tree self-pollination. In fact, large plantations of only one cultivar exist which produce well without the need of a second cultivar. However, even there, a significant increase in productivity is noticeable when an orchard with a different flower group cultivar is near to a solid planting with only one cultivar.

The intercropping of different group cultivars is an advantage and contributes to increase productivity. When selecting the cultivars for intercropping, one should be careful that not only they must be of different groups but as important, their flowering period must coincide. Undoubtedly, bees contribute to increased pollination.

	Morning	Afternoon	Total Cycle
Group A	♀	♂	36 h
Group B	♂	♀	24 h

Fig. 1. Behaviour of the Avocado Flower

2.4 The Fruit

The avocado fruit is classified as a berry, with only one seed. It varies in size from small to very large and weights from 30 g (1 oz.) to 2300 g (82 oz.) depending on the cultivar, the ecological conditions, and the husbandry practices applied. The fruit shape normally can be classified within four types: elongated, pear, round, and oblong (Fig. 2). Some irregular intermediate forms may also appear. There is a close relation between the shape of the fruit and that of the seed.

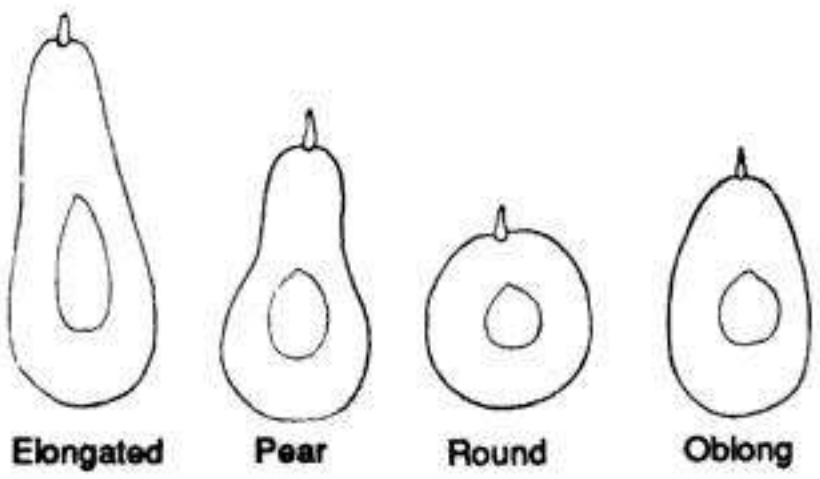

Fig. 2. Different shapes of the avocado fruit

The fruit is attached to the tree by a long peduncle which depending on the position of attachment, could be classified as symmetric or asymmetric (Fig 3). The exocarp or peel of the fruit also exhibits wide variation in terms of colour and texture, mostly related to the type of cultivar. External colour may vary from light green to purple. The fruit surface varies from completely smooth to rough. Some cultivars peel well,

Fig. 3. Symmetric and asymmetric attachments of the peduncle to the avocado fruit

that is the peel is flexible and do not break when detached from the mesocarp. In others, the peel texture is hard and breaks easily when an attempt is made to separate it from the mesocarp. The width of the mesocarp is also variable ranging from very thin (less than 1 cm) to very wide (more than 4 cm). One of the main differences between the avocado and other fruits is that it contains less sugar, more protein, and more oil than most fruit species.

On the average, sugar content varies from 1.5% to 3.5% for fully developed fruits, decreasing to 0.25% to 1.8% in ripe fruits. Normally the sugar content goes down as the oil goes up. The oil content is generally high, with some cultivars averaging 20% and more. Oil content is closely related to the avocado race; it is lower in the West Indian, intermediate in the Guatemalan, and higher in the Mexican race.

The seed is surrounded by two layers that contain variable amounts of inhibitors to germination. That is why it is always recommended that the seed be peeled before planting, to increase the percentage and speed up the process of germination. At maturity, the seed could be loose or tight in the seed cavity. In those cultivars where the seed is in the cavity, this characteristic is used to determine fruit maturity. Nevertheless it is an undesired characteristic since the fruit is easily damaged during transportation.

III. Races and Cultivars of Avocados

3.1 Horticultural Races of Avocado

Three avocado races are recognized: West Indian (also called Antillean), Guatemalan and Mexican. Some authors classify the Mexican race as a different species, *Persea drymifolia* while others have classify it as a subspecies *Persea americana* var. *drymifolia*. Nevertheless, most of the authors accept it as the third avocado race. All known avocado cultivars can be classified within one of these three races or as interracial hybrids. These hybrids have been naturally or artificially produced. In some of them, e.g. Sexton, all three races are present. The most marked difference between the three races is the colour and scent of the flush:

(*a*) Plants with flush of violet colour .....Guatemalan race
(*b*) Plants with flush of green colour
  b.1 Leaves with anise scent .....Mexican race
  b.2 Leaves without anise scent .....West Indian race

However, this key is only applicable to those cultivars which are not interracial hybrids, since in the latter a combination of characteristics is expected to occur.

Morin and Bakula (1967) summarized the main different characteristics reported for the three different races. These are presented in Table 1.

3.2 Main Commercial Avocado Cultivars in the Caribbean

Most of the avocados being commercially grown in the Caribbean belong to the West Indian race and/or are interracial hybrids between this and the other two races (Guatemalan and Mexican).

The fact that more than 90% of the total population of avocado plants being grown in the Caribbean are seedling trees is enough to explain the vast potential the region has in germplasm. Nevertheless, very few countries in the region have undertaken any serious selection programme and this potential continues to be eroded with time. Preference has been given to the importation of material mainly from Florida, California, and Puerto Rico.

In the characterization of cultivars the following factors are the most important:

The plant
  Race: West Indian, Guatemalan, Mexican, hybrid
  Type of growth: Upright, spreading, etc.
  Type of flower: A or B
  Flowering season: Months when it occurs
  Harvesting time: Early, normal, and late
  Yield: Low, medium, high

The fruit:
  Shape: Elongated, pear, round, and oblong
  Size: Small, medium, large
  Weight: grams
  Peel colour: Light and deep green, purple, black
  Peel texture: Flexible, brittle
  Peel surface: Smooth, rough
  Mesocarp colour: Light green, green-yellow, yellow
  Mesocarp width: Thin, medium, thick
  Flavour-texture: Dry, watery, oily
  Seed size: Small, medium, large
  Seedcavity: Small, medium, large
  Seed/cavity: Tight, loose
  Susceptibility to pests: Scab, mites, anthracnose, *Cercospora*.

Table 2 summarizes the most important cultivars being grown in the Caribbean and some of their most important characteristics.

Of the cultivars listed in Table 2, the following are the most recommended for the low to medium land of the Caribbean.

Semil 34 and 43: Both of these cultivars are of a high eating quality, high bearing, and with a low 'alter-

Table 1
Main difference among the three avocado races (Morin and Bakula 1967).

Character	Mexican	Guatemalan	West Indian
Origin	Highlands of Mexico and northern South America. (Over 2000 m)	Highlands of Guatemala (between 1000 and 2500 m)	Lowlands of Central and South America and the Caribbean (less than 1000 m)
Resistance to:			
Low temp.	More resistant plants die: 9°C below zero	Intermidate. Plants die 6°C below zero	Low. Plants die 4°C below zero
Salinity	Least resistant		More resistant
Anthracnose	Resistant	Resistant	Susceptible
Wilt	Least suspectible	More suspectible	
Leaves			
Flush	Pale green	Violet	Pale green
Size	Smaller	Intermediate	Larger
Scent	Anise	No anise scent	No anise scent
Flower	More pubescent	Less pubescent	Less pubescent
Fruit			
Size	Small	Large	Small to large
Pedicel	Cylindric and medium	Conic and of large volume	Like a nail and thin
Peel	Thin and smooth	Thicker, rough andbreak easily	Thin, flexible, and smooth
Lenticels	Isolated or in groups of three At surface level	Grouped and over surface level	Small groups especially towards the fruit apex. At surface level
Seed	Tightly held or loose in the cavity. Rough cotyledons	Tightly held. Smooth cotyledons	Generally loose. Rough cotyledons
Oil %	Higher	Intermediate	Lower
Time to maturity	6–8 mo.	10–14 mo.	6–9 mo.

nate bearing' performance. The production comes late in the avocado season and the fruits are of excellent quality, ship well, and resist refrigeration very well. The fruit is quite tolerant to scab and mites but relatively susceptible to anthracnose. Large fruit sizes may be a problem when not properly managed.

Lula: This cultivar is so prolific that sometimes it is necessary to remove some fruits after fruit set to avoid the production of large amounts of undersized fruits which do not meet export requirements. It has excellent eating quality and ship well, but it is very susceptible to mite attack. Production comes late in the season thus adding value to this cultivar.

Gripina 5: Very prolific cultivar with a low 'alternate bearing' performance. Excellent eating quality and ships very well. Resistant to refrigeration. Makes an excellent choice for intercropping with Semil 34.

Hall: Very prolific cultivar but could show a marked 'alternate bearing' if not managed properly. Excellent eating quality and ships very well. Relatively tolerant to mites and scab but susceptible to anthracnose.

Pollock: Although the fruit produced is sometimes larger than the export market preference, its excellent eating quality has gained it high popularity. Although not a heavy bearing cultivar, if well managed, it could bear a fair number of fruits. Relatively tolerant to mites and scab but susceptible to anthracnose.

Choquette, Taylor, Booth 7, and Booth 8: Although all of them produce fruits of excellent eating quality, because of their susceptibility to various problems, these are second choice cultivars for commercial production. Choquette produces fruits of excellent quality but it is extremely susceptible to scab. Taylor is more adapted to medium elevation and does not bear well in the lowlands. Booth 7 and Booth 8 are extremely susceptible to anthracnose.

Wilson Popenoe: is more a 'specialty' for backyard orchards. Its large fruit size as well as its shape make it attractive to home owners but production is too low for commercial planting.

There are several other cultivars being grown in the Caribbean including Simmonds (W.I.), Waldin (W.I.), Monroe (G. × W.I.), Utuado (G. × W.I.), Isabela (G. × W.I.), Linda (G), Queen (G), Naval (G), Fuerte (M), and Hass (G). Nevertheless, for various reasons they are not recommended for the Caribbean. **Simmonds** has a very marked alternate bearing; **Waldin** has a poor overall quality and is more used as rootstock; **Monroe** produces a fruit quite similar to **Choquette** but with a more marked alternate bearing; **Utuado** has a good eating quality but present some problems for shipping; **Isabela** lacks the export quality and it is marked in alternate bearing; **Linda** and **Queen** have not performed well in terms of production and have also a marked alternate bearing. **Naval, Fuerte,** and **Hass** are not adapted to the hot climate of the Caribbean. Relative good success has been reported at high elevations.

It is important to note that the seasonality factor is not only closely related to the cultivar being grown but also to the latitude and altitude where the

Table 2
Summary of the most important characteristics of commercial avocado cultivars being grown in the Caribbean

Cultivar	Race	Flower Type	Flowering Time	Fruit Size	Fruit Shape	Fruit Wt, (g)	Peel	Mesocarp Width	Seed/ Cavity	Tree	Harvest
Booth 7	G	B	Mar–Jul	S–M	Round	300–450	Thick, rough, deep green. brittle.	Medium	Tight	M–L spread.	Nov–Feb
Booth 8	G	B	Mar–Jul	S–M	Round, oblong, deep green, brittle	300–500	Thick, rough	Medium	Tight	M–L spread.	Nov–Feb
Lula	G × Me	A	Mar–Jun	S–M	Pear	450–700	Medium, rough, pale green. Flex-brit.	Thin to medium	Tight, some loose	L upright	Dec–Feb
Pollock	W.I.	B	Dec–Feb	L	Oblong with neck	600–1200	Thin, smooth, green. Flex.	Thick	Tight	S spread	Jun–Aug
Choquette	G × W.I.	A	Feb–Apr	L	Oblong	800–1200	Thick Smooth to rough, deep green. Flex-brit.	Thick	Tight	L spread	Nov–Jan
Hall	G × W.I.	B	Jan–Mar	L	Pear & oblong with neck	650–800	Medium, smooth, pale green. Flex.	Thick	Tight	L spread	Nov–Jan
Semil 34	G × W.I.	A	Feb–Apr	M	Pear	500–800	Medium, smooth, deep bright green. Flex.	Thick	Tight	L spread	Dec–Feb
Semil 43	G × W.I	B	Feb–Apr	M	Oblong	450–750	Medium. Smooth to rough, deep bright green. Flex-Brit.	Thick	Tight	L spread	Nov–Jan
Gripina 5	G × W.I.	B	Feb–Apr	S–M	Oblong with short neck	300–450	Medium, smooth, deep bright green. Flex-Brit.	Thick	Tight	L spread	Dec–Feb
Melendez 2	G × W.I.	B	Jan–Mar	M	Oblong. With neck	400–600	Medium, smooth, Green-yellow. Flex.	Thick	Tight	L spread	Nov–Jan
Taylor	G × W.I.	A	Feb–Apr	S–M	Pear	350–500	Medium, rough, deep green. Brittle	Thick	Tight	L upright	Jan–Mar
W. Popenoe	W.I.	A	Sep–Nov	L	Renif elongated	700–1000	Thin, smooth, pale green. Flex.	Medium to thick	Loose	S spread	Jun–Aug

Source: De la Rocha & Franciosi, Marte, Canizares, Pennock et al.
Note: G: Guatemalan Me: Mexican W.I.: West Indian S: Small M: Medium L: Large Flex:Flexible Brit.: Brittle

orchard is established. The Bioclimatic Law of 'Hoppkins' establishes that, the bearing season of a particular cultivar is delayed 15 days for every degree of latitude north and/or every 100 m of altitude.

Similarly, oil content varies markedly with the location. The cooler the place the higher the fruit oil content. In the lowlands of the Caribbean, oil content is very low as compared to Florida where it is medium, and California where it is very high.

Avocado Production

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I. Introduction

Avocado fruit is relatively new in the world-fruit trade. It is an important item in the diet of Central Americans but its consumption has spread to the United States, Europe, and Japan over the last 30 years.

The main producing countries in the northern hemisphere are the United States, California, Mexico, Israel, and Spain, where the season is from October to May. In the southern hemisphere, South Africa and Australia are the main producers and the season is from May to September.

The Avocado, *Persea americana* originated in Central America. It was introduced in Jamaica in 1650, and from there spread throughout the Caribbean region. These cultivars are presented in table 1.

Characteristics of the West Indian cultivars are low oil content, medium vigour, and sensitivity of trees and fruits to low temperature.

The varieties of economical importance are the interracial hybrids, e.g.:

Fuerte is a Mexican × Guatemalan hybrid.
Lula is a Guatemalan × West Indian hybrid.

Table 1
Avocado races and their characteristics

Race	Leaf Smell	Fruit Skin	Flower Set to Harvest	Oil Content
Mexican	Anise	Thin and smooth	6–8 mo.	30%
Guatemalan	None	Thick and brittle	9–12 mo.	8–15%
W. Indian	None	Smooth and leathery	6–8 mo.	3–10%

Most imported varieties grown in the Caribbean are hybrids introduced from Florida, e.g. Simmonds, Waldin, Tonnage, Booth 8, Booth 7, Hall, Monroe, Lula, and Choquette.

II. Different Aspects of Orchard Husbandry

2.1 Flowering and Pollination

The flowers of avocado are pollinated by insects, mainly bees. Receptivity of the stigma and the shedding of pollen are limited by the opening and closing of the flowers on either day 1 or 2. The different cultivars vary in the time of opening and closing of the flowers. Two patterns of flowering behaviour exist.

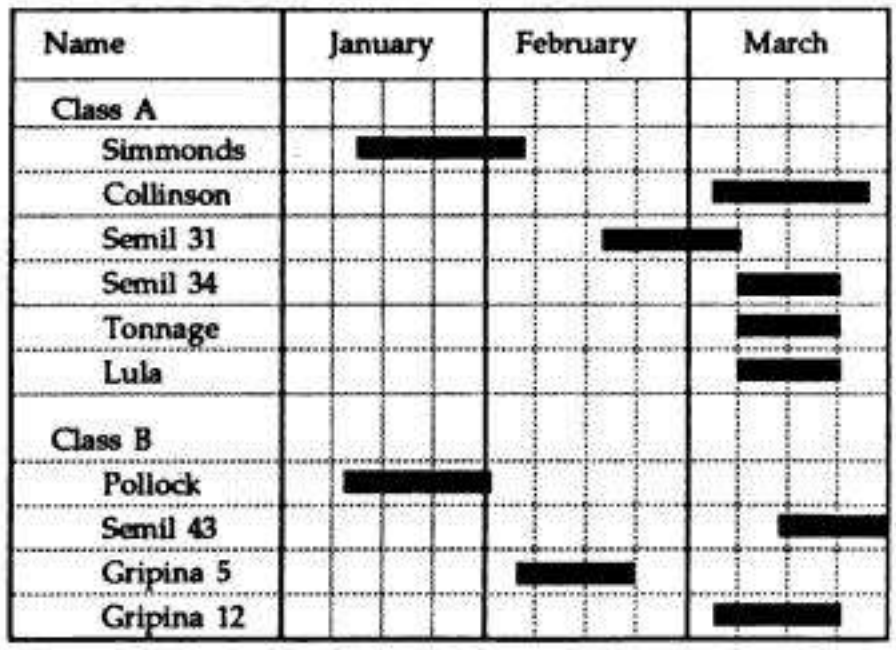
Class (A) opens in the morning of the first day this is when the stigma is receptive, and closes in the afternoon of the same day (female). It again opens in the afternoon of the second day (male) e.g. Lula.

Class (B) opens in the afternoon of the first day when the stigma is receptive and closes at night of the same day (female). The shedding of the pollen occurs the following morning (male) e.g. Pollock.

Most of the varieties exhibit marked periodicity in bright, warm weather and, therefore, it is recommended to inter-plant cultivars of both classes to ensure cross-pollination.

Table 2 shows the flowering time of cultivar classes and the possibility of using them in planning an orchard based on Dominica's Ministry of Agriculture guide to avocado identification.

Table 2
Flowering time of cultivars classes



When planning an orchard, the right cultivars for cross-pollination has to be chosen and it is also important to consider local experience.

There are big differences in the effectiveness of the cultivars and the pollinators in different countries, mainly due to climatic conditions and weather

patterns. For example, Lula (Class A) and Waldin in Florida cannot be pollinated by Booth 7, Booth 8, or Pollock (Class B), even though they flower together. While flowering class of the cultivars remains fixed and does not change it can still affect pollinating efficiency greatly.

When orchard establishment is contemplated, the harvest season may be controlled by selecting the right varieties. Booth 7 and Booth 8 varieties are susceptible to anthracnose and scab and therefore should not be planted in high humidity areas. But there is need for a museum plot and varietal selections.

2.2 Soil and Plant Requirements

Avocado can be grown on a wide range of soil types. The root system is shallow and most of it is found in the upper layers of the soil. The root system is extremely sensitive to poor drainage and it is recommended that planting be avoided in areas where there is a high water table. If there is any danger of water logging, trees should be planted on mounds. The branches are soft and brittle and susceptible to wind damage. Subsequently wind breaks should be provided, or the crop should be planted in sheltered areas.

When spacing the plants, the vigour and growth pattern i.e. the spreading or uprightness of the tree, should be considered when planting.

Pruning is necessary, especially in controlling upright grown cultivars. Usually, the central shoot is pruned to promote spreading. Pruning is also important in limiting the height of the trees to facilitate control of pests and diseases through spraying.

2.3 Major Diseases and Pests

The varieties of the vegetative rootstock that are resistant to the *Phytopthora cinnamomi* diseases are Duke, Martin Grande, Thomas, Toro Canyon, and Clonal rootstocks.

Cercospora spot which is caused by *Cercospora purpurea*, black spot (anthracnose), and *Colletotrichum aleosporides*, affects the leaves and fruits of the plant.

Other pests that affect avocado production are mealy bugs, mites, thrips, and scale insects.

2.4 Harvesting

Tables 3 and 4 records the harvest time of different cultivars of avocado in Dominica and the OECS.

Table 3
Harvest Time in Dominica

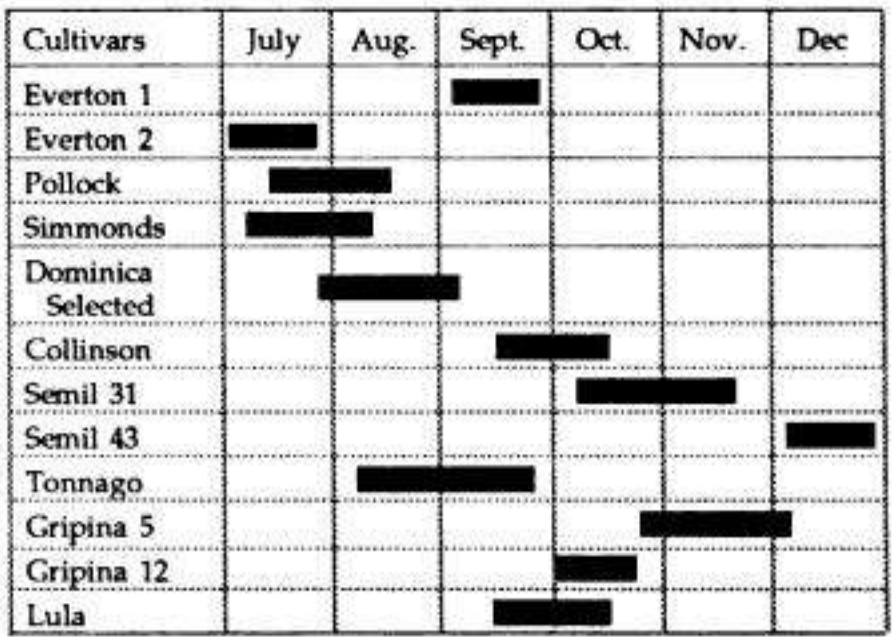


Table 4
Avocado Production in the OECS Countries

Country	Varities	Harvest period	Year	Acres	Av. Yield/Acre	Export Tonnes	Value of Export	Av. Price /Tonne EC
Dominica	Pollock, Lula, Dominica selected	July–March	1988	300	3	100	174,109	1741
			1989			71.16		
St. Lucia	Pollock, Lula, Francais, Marcus	Sept.–Nov.	1988	200	2.5	Ca. 9.3	17,368	1867.5
			1989		1.25	U.K. .60	630	1050
St. Vincent & the Grenadines	Lula, Simmond, Pollock	July–Nov.	1988	Total Production	203	447.5	510,228	1140
			1988	Total production	223	178.6	207,389	1161
Grenada	Lula, Pollock, Booth, Choquette	Aug.–Oct.	1988	50–115		TNT 350	392,000	1120
						U.K. 6.6	7,226	1095
			1989			U.K. 15		
			1990			U.K. 30		

Information is based on recently completed country profile done for the ADCU.

III. World Production and Exports

Production and exports for California, Spain, Israel, South Africa and Australia are listed below.

California:

Production area	75,200 acres
Production	147,300 t
Yield per acre	1,958 t
Price per tonne	US$1,411.00
Earnings	$207,900 (× 1000)
Main export market	Japan
Main Varieties	Hass, Fuerte, Bacon, Zutano

Spain: (89/90)

Production area	20,000 areas
Production	35,000 t

Expected production (1993)	70,000 t
Local consumption	10,000 t
Main export market	France, EEC
Main varieties	Hass, Fuerte, Zutano
Israel: (89/90)	
Production area	20–25,000
Exported production	45,000 t
Average price for F.O.B.	$1,335 US
Expected production (1991)	70,000 t
Local consumption	10,000 t
Main export market	France, EEC, United Kingdom
Main varieties	Hass, Fuerte, Reed, Nabal & Etinger
South Africa: (89/90)	
Exported Production	34,000
Main export market	E.E.C., U.K.
Main varieties	Hass, Fuerte, Pinkerton
Australia: (89/90)	
Production	22,000
Expected Production (1995)	55,000

Price forecast in the E.E.C. market is US$1,200.00

Pests of Fruit Tree Crops in the OECS Subregion and Strategies for their Control

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I. Introduction

The production of fruit crops for local consumption and for international trade is one of the main thrusts in an effort to diversify the agriculture of the OECS. Fruit tree crops present both major challenges as well as opportunities for integrated pest management (IPM).

Before reviewing the major pests of the crops being considered at this workshop, a few general points should be noted.

1. Generally for fruits and particularly for export-destined fruit, the tolerance for pest infestation is very low as in many cases external appearance is of critical importance for marketing, and even though absolute yield of eating quality may not be affected, blemishes can render fruits unmarketable.
2. Fruit tree crops are often established on the more hilly terrain and steeper slopes. In addition, cultural practices may be inadequate, producing very tall trees with dense canopies which provide hospitable conditions for pest species to thrive. Pest situations are usually very inefficient.
3. The perennial nature of fruit trees enables crop damage to accumulate from year to year, often causing severe debilitation of the plant.
4. Opportunities for biological control are greater in tree crops precisely because of their perennial nature; opportunities exist for dynamic equilibria to be established between the pests and their natural enemies.
5. Economic considerations usually dictate the adoption of technology. The implementation of pestmanagement practices by farmers can be discouraged by the relatively undeveloped marketing systems for fruits which exist in the region.

II. Passion Fruit Pests

Insect pests are not major constraints to passion fruit production. Nineteen species are listed as pests of the crop by Hill (1987). Of these, 15 species are African or Australasian. Four species are listed as major pests. FAO (1989) lists one insect pest of passion fruit in the Caribbean region, *Anisocelis foliacae* in Suriname.

In the OECS, the main pest of note is *Agraulis vanillae*, the vanilla butterfly. The adult butterfly is bright orange with silvery and black spots and frequents urban gardens. The larvae fed on the leaves and flowers of vanilla and passion fruits. Infestations are sporadic and are usually not serious on mature plants. However, young plants in propagation may be severely damaged.

If control with insecticides is required, the larvae are very susceptible to synthetic pyrethroids.

III. Avocado Pests

There are about 35 species recorded as pests of avocados in the Caribbean. Of these, 27 species are: 16 is for scale insects, 5 for white flies, 3 for mealybugs, and 3 for thrips (Pollard and Alleyne, 1985).

Scale insects and mealybugs although common are seldom of economic importance and are usually effectively regulated by natural enemies. Severe infestation results in defoliation and eventual death of branches. Infestation of fruit is of particular concern as the fruits are not scrubbed before being exported.

The important species of scales and mealybugs infesting avocado are *Saisettia hemispherica*, the hemispherical scale; *S. oleae*, the black shield scale, and *Lecanium corni* on the fruit.

White flies, particularly *Trialeurodes* spp., can be very destructive to young nursery plants.

The most important avocado pest in the Caribbean is the red banded thrip, *Selenothrips rubrocinctus*. The immature stages of this insect have a red band around the abdomen while the adults are fully black. Both stages occur together, usually on the underside of leaves especially adjacent to the main veins.

Damage to the leaves is due to the rasping of the cells and sucking of the sap. The leaf surfaces become bronzed and rusty and are dotted with numerous shiny black spots of excreta. In severe infestations, the leaves appear to be burnt and heavy defoliation can occur.

Fruits may be infested by thrips, often in a complex with various species of mites. The skin of infested fruit becomes severely bronzed and cracked.

Damage is of most concern in nurseries but serious localized infestations can develop in orchards, especially where trees are overgrown. In cases where these pests are of economic importance, effective control may be obtained with various systemic insecticides. The use of synthetic pyrethroid insecticides against them should be avoided.

IV. Citrus Pests

About 120 species have been reported as pests from countries in Latin America and the Caribbean (FAO 1989). Worldwide in the tropics about 40 species are recognised as major pests. The distribution of major pest species in the region is summarized opposite which is adapted from Pollard and Alleyne (1985).

Some of the major pests of citrus in the region are root weevils. Various species of these insects exist in most Caribbean islands.

Exophthalmus spp. and *Pachnaeus* are pests in Jamaica. *Diaprepes abbrevaiata* occurs in all the islands as does *D. famelicus* except in Jamaica.

The biology of all the species is essentially similar. Eggs are laid between two leaves, the edges of which are glued together by the female weevil. On hatching, the larvae fall to the ground and enter the soil where they feed on the roots of the plant. After pupation adults emerge from the soil, particularly during the main rainy seasons. Adults mate and oviposit in the foliage, feeding mainly on young flushes of leaves.

Leaf feeding by adults is only of minor economic importance. Plants are severely debilitated, however, by the decortification of the root system as a result of larval feeding. Severely afflicted plants exhibit chlorosis and other deficiency symptoms and often die. Of the various species, *D. famelicus* alone is primarily a pest of nursery plants, the others infesting plants of all ages.

These insects have long been recognised as major pests and various approaches have been taken towards their control. In the early decades of this century, picking of the adults from the foliage by hand, interplanting with the insecticidal plant *Tephrosia*, and planting on mounds were introduced as cultural practices to reduce infestation. Some of these measures are still being used in citriculture.

The use of insecticides against root weevils became the common practice since the 1950s with the application of dieldrin to control larvae in the soil. Recent concern over environmental contamination has led to the use of other soil insecticides but with limited success.

A number of soil-dwelling predators of the larvae are known, and egg parasites, particularly *Tetrastichus* spp., are important agents of biocontrol in all islands. Various species of entomopathogenic nematodes particularly *Neoaplectana carpocapsae* and *Heterorhabditis heliothidis* have been evaluated for control of root weevil larvae.

The indication are that these nematodes are potentially able to provide high levels of control. These evaluations are ongoing in Barbados, Dominica, Florida, Guadeloupe, Jamaica, and Puerto Rico.

Scale insects and mealybugs can also be serious pests of citrus. Usually, these insects are kept below economic threshold levels by the action of various natural enemies — predators, parasites, and pathogens. The major citrus scales and mealybugs in the region are the following:

Aonidiella aurantii — The California red scale. Small, circular, reddish-brown scales infesting trunk, branches, leaves, and fruit. Branch dieback can result from severe infestation.

Chrysomphalus aonidum — The Florida red scale (purple scale). Usually infests leaves along midrib and veins. Occasionally found on green shoots or twigs. Secretes toxic saliva which damages or kills plant tissue.

Coccus viridis — Green scale. Most often found along leaf veins and midribs. Major cause of sooty mold. Very common on citrus.

Icerya purchasi — Cottony cushion scale. First insect to be effectively controlled by the importation of an exotic natural enemy.

Lepidosaphes beckii — Mussel scale. Purplish, mussel-shaped scales infest leaves, skin, and fruit. Defoliation and dieback in heavy infestations.

Paralatoria ziziphi — Black scales. Infests twigs and leaves but most serious as a fruit contaminant; numerous small black scales adhere tightly to the fruit surface rendering them unmarketable as fresh fruit. This scale is of quarantine importance.

Saisettia spp. — Hemispherical scale and olive scale. Polyphagous scales. Large, roundish, conspicuous. Infests twigs, foliage and fruit. Rarely of economic importance.

Unaspis citri — Citrus snow scale. Large numbers

of powdery, white scale insects coat trunk and twigs of citrus. Particularly severe on lime.

Planococcus citri — Citrus mealybug. Although citrus is the main host in the region, this insect is of greater economic importance on other crops.

Aphids are also important pests of citrus. Although they rarely cause serious injury, they occur in very large numbers feeding on the underside of young flush leaves and on young shoots. This feeding produces a characteristic curling of the leaves which persists even after they have hardened. While various species of aphids infest citrus, the black citrus aphid, *Toxoptera aurantii*, is widely distributed throughout the region.

The related species *Toxoptera citricidus*, the vector of citrus Tristeza virus, is of quarantine importance. The citrus white fly, *Dialeurodes citri*, although commonly found in citrus nurseries and orchards rarely achieves economic importance. Similarly, the citrus blackfly *Aleurocanthus woglumi*, (in reality a whitefly — family: Aleyrodidae) once a major pest, is now effectively controlled by various species of introduced natural enemies. All the foregoing sucking insects (scales, mealybug, aphids, white fly) excrete honey dew which encourages the growth of sooty mold on the leaf surface. The sooty mold fungus is not pathogenic to the plant but the overgrowth on the leaves can significantly reduce photosynthesis.

Various species of mites infest citrus. The tea mite, *Polyphagotarsonemus latus*, is often a major pest of nursery plants. The citrus rust mite, *Phyllocoptruta oleivora*, may also feed on leaves and young shoots but the most important damage is to fruits which are reduced in size and develop a thickened, rust-coloured peel. Infested fruits are usually unmarketable.

Other notable citrus pests in the region include leaf-cutting ants, *Atta* spp., *Trachmyrmex* spp., and *Acromyrmex* spp., Pegone bee, *Trigona* spp., bagworm, *Oikeiticus abbottii*, fruit flies, *Anastrepha fraterculus*, 'Orange dog' caterpillars of citrus swallowtail butterflies, *Papilio* spp., citrus fruit-piercing moths, *Gonodonta* spp., the orange moth, *Gymnandrosoma* spp., and the stem-boring larvae of cossid moths, *Xyleutues* spp. The geographical distribution of these pests is restricted to one or two islands so they are generally not of regional significance. Localized outbreaks of some of them may occur but cultural practices are often enough to maintain them below economic levels. Hand-picking is effective against bagworm and orange dog; pruning and shade reduction against fruit-piercing moth. Treatment with insecticides is required for control of leaf-cutting ants.

Although insecticide application is often necessary to reduce damaging populations of citrus pests to below economic injury levels, natural enemies are of major importance in maintaining them at sub-economic levels over the long term. The cottony scale and the citrus blackfly are classic examples of effective pest control by natural enemies.

The larvae and adults of ladybird beetles are predators of aphids, mealybugs, and scale insects. These pests are also usually heavily parasitized by various species of parasitic wasps.

Emerging wasps leave clearly visible holes in the host cadavers — these characteristic exit holes can indicate the general extent of parasite activity. Entomopathogenic fungi can also be important mortality factors especially in humid conditions. Predatory mites help to keep the populations of some pest mite species below economically important levels. It is sometimes possible to control infestations by the supplemental release of these predators into the orchard.

In cases where pesticides need to be used, appropriate selection and timing of application are important considerations. Aphids, scales, and mealybugs are often effectively controlled by a mixture of malathion with white oils. Destruction of the nests of associated ants also tends to weaken the insect colonies.

Mite infestations can be controlled with acaricides, some of which have no deleterious effects on beneficial organisms.

Systemic insecticides are often used against sucking insects in citrus, but some of these pesticides may induce phytotoxic symptoms in certain citrus varieties. In general, the use of synthetic pyrethroid insecticides is best avoided in citrus.

Pest management in fruit tree crops must be integrated within the total crop management system. The selection of treatment options against pest infestations should be based as far as possible on an assessment of the prevailing biological and socioeconomic conditions rather than on uncritical prescriptions. The long-term stability provided by these crops affords clear opportunities for the successful application of IPM technologies.

Hill, D. S. (1987) Agricultural Insect Pests of the Tropics.
Pollard and Alleyne (1985); FAO (1989).

Diseases of Passion Fruit and their Control

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I. WILT

Fusaruim oxysporum f. sp. *passiflorae*

SYMPTOMS: Sudden and general wilt and collapse of vines within 24–48 hours after showing the relatively slight symptoms of slight paling of colour in the new leaf growth only. The wilt may be on one side of the plant before the entire plant is affected. Infected plants are consistently killed. Immature fruit may shrivel. Vascular discolouration, evident in roots and crowns, may extend several feet from the crown in lateral runners. Infected seedlings show vein clearing in the youngest leaves 7–9 days after inoculation. Leaf drop within 14 days of the diagnostic symptom of seedling infection. Wilted plants may occur at random in the field or be concentrated in localized areas.

CONTROL: Good cultural practices: healthy seedlings; proper land preparation ensuring good drainage; maintenance of soil fertility and adequate nutrients for the growing plants.

Use of resistant rootstocks, e.g. *Passiflora caerula* and *P. edulis* f. *flavicarpa*.

Limited and inconsistent control with use of fungicides.

II. Brown Spot

Alternaria passiflorae

SYMPTOMS: Leaf lesions are first small, dark-brown spots, which later enlarge, become rounded or angular, and develop light-brown centers. Severe infections may cause complete defoliation. Lesions, several inches long, and usually associated with leaf axils, form on the laterals which may be girdled and killed. Complete dieback of the plant can then result. Light brown, circular, sunken spots, sometimes with a dark green margin and up to 2 cm diameter develop on fruits. They become wrinkled and the fruit shrivels up in a firm rot.

CONTROL: Pruning to prevent pockets of dense foliage and to eliminate diseased foliage. Plantings should be wall-spaced, leaders trained systematically, and laterals pruned at least once a year.

Recommended fungicides include: copper, maneb, mancozeb, and zineb.

III. Phytophthora Blight

Phytophthora cinnamomi

SYMPTOMS: Blackening and death of young tip growth. Large water-soaked areas on leaves which become light brown in colour. Leaves fall readily. On fruits, large grey-green, water-soaked areas develop. Affected fruits fall readily and in wet weather may become covered with white fungal growth. The fungus, especially under wet, poorly drained conditions, can attack the roots causing root rot and dieback and declines of the vines.

CONTROL: Good cultural practices: proper land preparation, ensuring drainage particularly in cases of heavy or clay soils and high rainfall. Pruning to prevent dense foliage growth.

Soil fumigation using Dazomet or metham-sodium or applications of the fungicides metalaxyl or benomyl have been recommended.

IV. Septoria Spot

Septoria passiflorae

SYMPTOMS: Leaf lesions are initially light-green and indefinite, becoming light brown, circular, or irregular with minute black dots (fruiting bodies) scattered over their surfaces. Severe attacks may cause premature leaf fall. Infection of the calyx may spread to the stalk and cause blossom fall. Lesions occurring on young stems may girdle and cause death of young shoots. On fruits, spots at first green, becoming brown with minute black fruiting bodies and coalescing to cover large areas of the fruit.

CONTROL: Pruning and application of mancozeb.

Evolution of Collar Rot of Passion Fruit in two Locations of Guadeloupe: Identification of the Pathogens and Fungicide Testing

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Collar rot is the major disease of passion fruit, *Passiflora edulis f. flavicarpa* in Guadeloupe. This is actually a restricting factor of this crop, as 100% of the plants can be killed in less than one year. The symptoms observed are the following :

- An irregular and sunken rot appears at the base of the collar.
- This rot extends girdling the base of the plant, then, a wilt of entire vine occurs causing the death of the plant.
- The collar and roots are totally or partially rotted. Vascular rot is also evident within the basal wood.

In the present study, an attempt was made to precise the etiology of collar rot of passion fruit in Guadeloupe, and a first fungicide test was evaluated for the control of this disease.

I. Materials and Methods

1.1 Variety and Locations

The varieties used were rooted cuttings of two selections of *P. edulis f. flavicarpa* obtained in Martinique: RL1 and RL4. The test took place in two locations: Neufchâteau: altitude 250 m, annual rain of 3500 mm and Vieux-Habitants: altitude 60 m, annual rain of about 1000 mm. In these two locations, the soils are also very different.

II. Fungicides

As *Phytophthora nicotianae* cv. *parasitica* is known to be involved in collar rot in various countries (Australia, South Africa, Brazil), the fungicides evaluated were: (*a*) Phosethyl-Al alone: 3 g of a.i/plant, by spraying of the foliage and watering of the collar; (*b*) One application of Acylon superflo (25% metalaxyl + 50% folpel) was done at the plantation by watering the collar with 5 L of water + Acylon (2 g of metalaxyl). The following applications were with phosethyl-Al (see *a*); (*c*) Furalaxyl: 2.5 g of a.i./plant by watering the collar with 5 L. All treatments were monthly.

At Neufchâteau, RL1 was used in 13 plots of 12 to 15 plants. Each treatment was repeated twice with bordering control. At Vieux-Habitants, RL1 and RL4 were used in 20 plots of seven plants. Each treatment was repeated three times with bordering control.

III. Observations

The evolution of the disease and the mortality were rated every week.

IV. Isolation

Every week the dead plants (wilted) were collected and transported to the laboratory where isolations were made from the collar on various media: Agar, PDA, 3 P (PDA + Penicilline 50 ppm + Polymyxine 50 ppm + Pimaricin 50 ppm).

V. Results

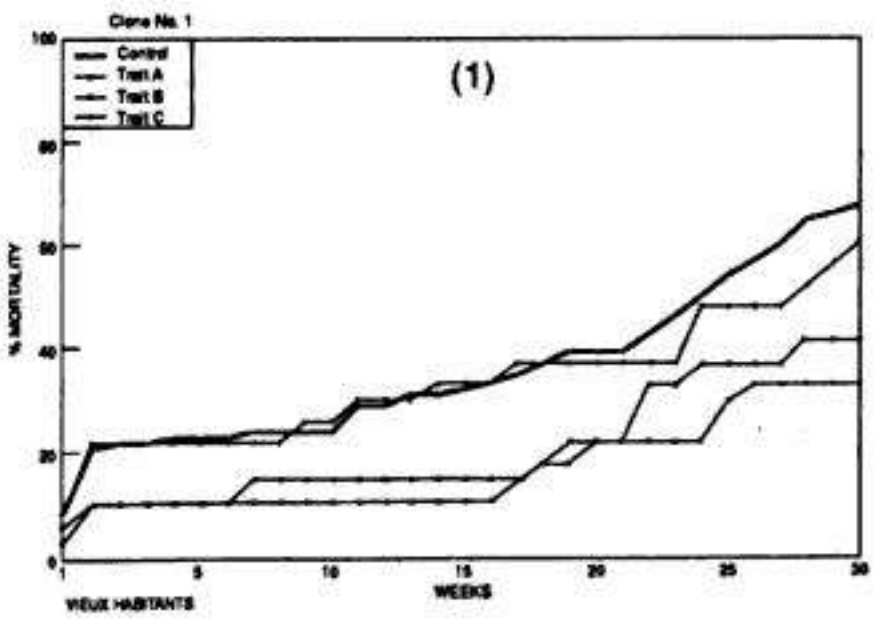
5.1 Efficacy of the Fungicides

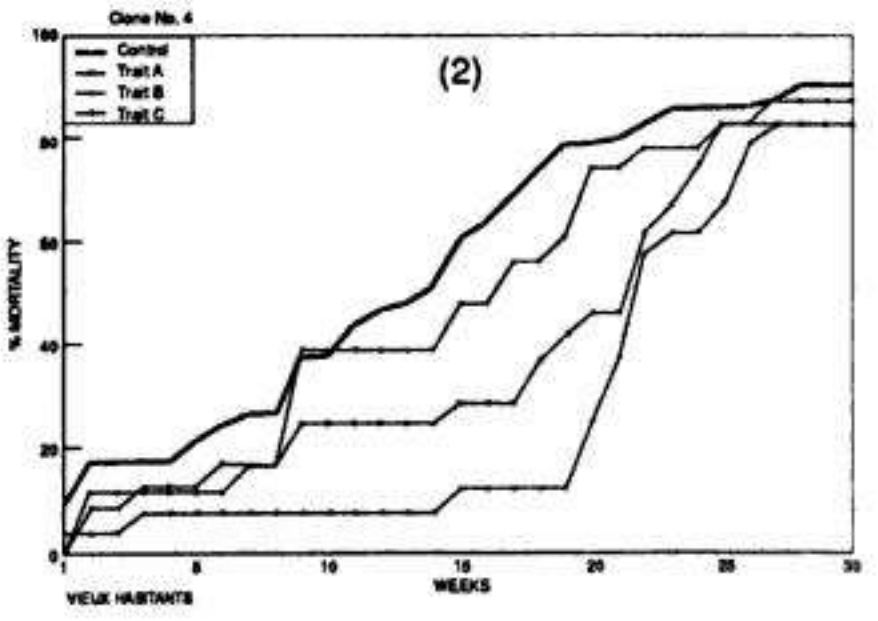
The observation of the figures indicates that none of the treatments enabled a good control of the disease. However, the treatments *a* and *b* (in which phosethyl - Al was used monthly) delayed the evolution of the mortality.

5.2 Isolation of Fungi

In the two locations, 61 to 67 of the mycoflora isolated was represented by *Fusarium* spp. (Table 1).

Evolution of Mortality on Passion Fruit (1–3)





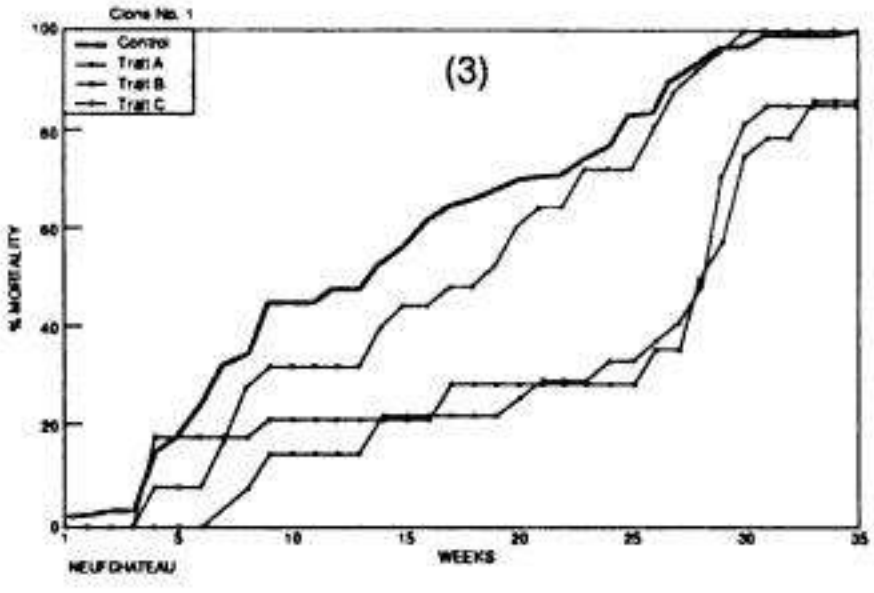


Table 1
Different fungi isolated from collar rot of passion fruit (%)

	Fusarium	*Colletotrichum*	*Pythiaceae*	None	Misc.
Vieux-Habitants	67	5	4	22	9
Neufchâteau	61	5	5	24	20

At least 50% of the *Fusarium* isolated was identified for species and the results indicate (Table 2) that *F. solani* is predominant (66–70%) on *F. oxysporum* (25–32). A small number of *F. roseum* was isolated.

Table 2
Proportion of the different species of *Fusarium* identified (%)

	F. oxysporum	*F. solani*	*F. roseum*
Vieux-Habitants	32	66	2
Neufchlateau	25	70	6

VI. Discussion

It is noteworthy that *Phytophthora* has never been isolated in any of about 300 samples treated at the laboratory. The high frequency of isolation of *Fusarium* species, and especially of *F. solani*, makes us suspect that *F. solani* might be the main pathogen involved in this disease. On the other hand, in the symptomalogy induced by infection with *F. oxysporum*, there is no collar rot involved.

Pathogenicity of *F. solani* has not been described on *Passiflora edulis* and remains to be cleared according to Koch's rules.

The light effect of Phosethyl-Al on the disease could be explained also by the absence of *Phytophthora* species. Nevertheless, it would be useful to go deeper into this study. In fact, the presence of a bordering control maintains a high inoculum in the field and masks the effect of the fungicide.

Diseases of Economic Importance in Citrus (grapefruit) and Avocado

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I. Introduction

Plant diseases do not occur. By mere definition plant disease is defined as harmful deviation from the normal functioning of physiological processes (BMS) as well as deviation from normal functioning of physiological processes, of sufficient duration to cause disturbance or cessation of vital activity (APS). A plant disease is a process, a resultant of a sequence of events. This definition is very applicable in the context of any discussion in plant diseases of orchard crops.

Several diseases found in orchards can be attributed to many a malaise in the nursery, some of which are technical and many others due to poor nursery management in planning, operations, etc. It is therefore necessary to stress the importance of a nursery or propagation unit to any orchard crop development. Proper planning and trained personnel are vital prerequisites of a successful tree crop programme.

There are several reports dated back in the early 1900s of several important diseases of citrus and avocado in the Caribbean caused by fungi, bacteria, viruses, nematodes, mycoplasmas, etc. There is evidence of diseases to have been responsible for the decline of orchard production in the Caribbean with Jamaica in the North and Guyana in the South.

Now, in the late 1900s, there seems to be resurgence of tree crop development and the recognition of the sector to become an important foreign exchange earner. This 'new' resurgence, it is hoped, would be pre-empted by proper linkages to processing. Socio-economic issues are implicitly interrelated and must be studied to ensure measurable successes at the turn of the 21st century.

This presentation deals mainly with principles of plant pathology including a few diseases of the two selected crops — citrus and avocado. It should be recognized that as the crops become *economic*, the diseases become *more economic*.

II. Diseases of Citrus

2.1 Citrus Scab, *Elsinoe fawcetti*

Citrus scab, *Elsinoe fawcetti*, is probably the singular most important disease of grapefruit in Dominica. Citrus scab is a common disease in the humid tropics. Fruit production as well as fruit quality are

affected. In severe attacks young immature fruits are so malformed that development ceases and the fruits drop. Heavy fruit drop is associated with high disease intensity. Air humidity and cool temperatures of 21°C – 23.5°C are more important factors than actual high rainfall, though the latter plays an important role in disease dissemination — disease spread. Rain splashing and wind are the essential means of disease spread.

In Dominica districts with high air humidity suffer varying losses of 50 — 66 per cent in fruit quality.

2.1.1 Symptoms

Scab is found on leaves, twigs as well as on fruit. The outstanding characteristics of the disease are the formation of irregularly raised lesions commonly referred to as warts or scabs. Scab appears on either surface of the leaf, the undersurface usually being more pronounced with scab symptoms. Lesions on young leaves are seen as pale orange spots. These become raised, appearing as lesions or warts. The tops of these wart-like growths become covered with corky tissue changing from pink to greyish, tan, dull-coloured and present an unsightly appearance. Distorted, wrinkled, or stunted leaves are also characteristic of warts on scabs.

On fruits the disease forms irregular scabby spots which are cream coloured to pale yellow orange, Young fruits when infected are misshapen with prominent wart-like projections. Lesions may coalesce to form scads of greater extent with irregular rough surfaces invaded by the fungal organism.

2.1.2 Disease Development

The scab fungus thrives in damp humid conditions as are often present in nurseries with fairly cool temperatures (approx. 21°C – 23°C). The fungus attacks young succulent flush tissues of leaves and twigs. Spread is mainly by splashing of water, and wind.

2.1.3 Control

1. Watering of young plants in the nursery should be regulated.
2. Humidity should be reduced in the nursery by proper spacing on the nursery floor.
3. A copper fungicide e.g. copper hydroxide 28 g/ 12 L water or copper oxychloride 28 g/9 L water should be used when spraying.
4. Diseased seedlings should be discarded when possible by burning in a rubbish heap.
5. A tolerant rootstock — rough lemon or any of the sweet orange stock, *C. sinensis* should be used.

2.2 Xyloporosis

Xyloporosis is sometimes referred to as cachexia and it is not clear weather they are not two different diseases of citrus (sweet orange, grapefruit, mandarin, sour orange, lemon, etc). Xyloporosis is probably present in all citrus-growing areas of the world, e.g. Argentina, Brazil, Israel, the Mediterranean, and the United States). The viral disease causes a slow decline eventually resulting in total replanting in less than 10 years. The virus seems to be able to have a wide host range and several scion/rootstock combinations — rough lemon and sour orange rootstocks are susceptible to xyloporosis.

2.2.1 Symptoms

Disease symptoms range from simple or milk wood-pitting to advanced bark-scaling, wood disorganization, and impregnation of affected tissues with gum. It is not easy to separate some of the effects of xyloporosis from symptoms of certain other viruses, e.g. gummy deposits and discolouration in the phloem; yellowing of leaves, dieback of twigs, unthrifty growth, and eventual death of trees.

Various stages of the diseases are recognized by peculiar symptoms — fruit stage of the disease is pitting of the outer face of the bark with corresponding pegs on the cambial surface. Later, pitting becomes more pronounced and the bark depressed in patches or bands. As the tree developes, there is often an uneven overgrowth at the union which gives a knee-like shape. Pits in wood are numerous at this stage and lie so near to each other that the wood seems to be perforated like a sieve.

2.2.2 Transmission and Spread of Disease

Spread seems to be certain through grafting and the use of virus-infected buds. There is convincing evidence that the large proportion of existing infected trees is due to grafting and budding using infected materials. There is no information about seed transmission. In general, very little is known of the disease transmission.

2.2.3 Control

1. Disease-free, certified buds should be used.
   - Indexing of trees using Orlando Tangelo as an indicator plant. Symptoms take between 10 and 12 mo. for expression. Similar symptoms as described would appear.
   - Gum formation in the phloem or on the cambial face of the bark, and pitting of wood, etc.
2. Diseased plants should be destroyed and burnt.

2.3 Sooty Mold, *Capnodium citri*

Sooty mold is found on the surface of leaves, stems, and fruits. The fungus is composed of a weft of black mycelial threads of several species of fungi. Sooty mold is common in citrus in the wet tropics. There is an association of sooty mold fungus, black scale insect, and aphids. The sooty mold fungus is saprophytic and does not attack the tissues of the trees but lives on the surface of the honeydew secreted by the insects.

2.3.1 Symptoms

Sooty mold, *Capnodium citri* appears as dense or sparsely black growth usually velvety membranous

film of coating on the leaves and fruits Under very dry conditions and with age the black superficial membrane may become detached and blown off in fragments by the wind or easily peeled in papery flakes. If the secretion of honeydew is abundant the entire surface of the leaves, fruit, and twigs may by covered with a dense continuous membrane resembling thin black tissue paper.

2.3.2 Disease Development

The black thin membrane constituting the sooty mold is really made up of a densely interwoven mat of branching hyphae. This superficial saprophytic fungus does not penetrate the plant tissues be it leaf or fruit, but lives entirely on honeydew secreted by insects, scales, and aphids. Though the sooty mold does not attack the tissue in any way, it interferes with photosynthesis and often indicates the presence of some harmful insect pest. The fungus is usually transmitted from affected to non-affected plants by the wind.

2.3.3 Control

Since sooty mold occurs in association with aphids and scales, prevention and treatment can be effected by elimination of these pests. Any systemic insecticide, e.g. Dimethoate at 25 g/9 L can be used for this purpose. Experience has shown that a copper fungicide (copper hydroxide) and dimethoate mixture at a rate of 25 g/9 L gives lasting control.

III. Diseases of Avocado

3.1 Phytophthora Root Rot, *Phytophthora cinnamomi*

Phytophthora root rot of avocado is one of the most serious diseases affecting avocado trees in many parts of the world (Australia, the Caribbean, Kenya, Israel, and the U.S.). The disease is caused by a fungus, *Phytophthora cinnamomi* commonly known as the cinnamon fungus.

3.1.1 Symptoms

Leaves of infected trees are smaller than normal, usually pale or yellow green instead of dark green, often wilted; they fall and give the tree a sparse appearance. Dieback of twigs, fruit drop, and defoliation are all above-ground symptoms.

In advanced stages of the disease, branches die back and the fruit is often small. Diseased trees will frequently set an abnormally heavy crop of fruit because the loss of many roots has a partial girdling effect.

Underground symptoms include diseased feeder roots which are black and brittle; as the feeder root system dies, its ability to take up water is reduced with the result that the tree wilts and eventually dies.

3.1.2 Disease Development

The avocado root rot fungus is known as water mold because it thrives in wet places. The fungal pathogen *P. cinnamomi* requires free water for the completion of its life cycle. The fungus can exist in soil for 6 years in the absence of a living host by forming resistant thick-walled spores. The infection begins with the zoospores (swimming spores) getting attached to feeder roots. Penetration takes place and infection results. The life cycle is completed with the production of sexual spores and a sexual spores both resistant forms under unsuitable environmental conditions.

Conditions of soil saturation due to poor drainage or heavy rainfall predisposes avocado roots to infection by the fungal pathogen, *P. cinnamomi* .

3.1.3 Control

1. Healthy planting stock should be used.
   - nurseries should be equipped with the necessary facilities of soil stem sterilizer, fumigation tanks, etc.
2. Efficient drainage and irrigation system is required. Drainage in the tropical Caribbean is more of a problem than irrigation. Avocado succumbs to water-logging soils which at the same time provides suitable conditions for *Phytophthora* infection.
3. Resistant root stocks, e.g. Duke 7 should be used.
4. Metalaxyl (Ridomil) at the rate of 0.15 g a.i./m^2 as soil drench, plus Phosetyl-Al (Aliette) injectable formulation at a recommended rate of 0.4 g a.i./m^2 should be used. The area given in square meters represents the canopy area of the tree. Drenching with Ridomil MZ was done by digging a trench around the tree below the periphery of the foliage canopy. This region was chosen because of the higher concentration of feeder roots.
5. Potassium phosphite (fos-ject 200) should be injected (method as above).
6. Alternative crops, e.g. citrus, should be grown.
7. There should be a replanting programme after removal and burning of infected trees.

3.2 Fruit Blemishes

Fungal Pathogens are *Botryodiplodia theobromae, Colletotrichum gloeosporioides,* and *Elsinoe persea.*

The avocado fruit can be severely affected by fruit blemishes due mainly to the three fungal pathogens mentioned above. The pathogens *Botryodiplodia theobromae* and *Colletotrichum gloeosporioides* alone and together can cause fruit blotches which may result in rots and render the fruit unmarketable.

Botryodiplodia usually occurs in the stem and results as a stem end rot as in the case of mango.

Grayish water-soaked spots are often seen in the centre of the blotch. As the fruit becomes mature the blotch becomes soft until the surface of the fruit sometimes breaks resulting in secondary infection. The whole fruit can then be reduced to a mushy mess.

Colletotrichum gloeosporioides, the anthracnose fungus, attacks several tropical fruits such as mango, papaya, and avocado.

This fungal pathogen infects immature avocado fruit in the orchard but remains quiescent until fruit ripens and the infection resumes developing lesions on the fruit. There seems to be no particular favour by *Colletotrichum* with respect to site infection on the fruit, unlike that of *B. theobromae* which shows a preference for infection to take place at the stem end (stylar end) of the fruit.

Small dark-brown sunken lesions develop as the fruit ripens and softens within 7–15 days after harvest. Some lesions may be located near the stem end (soft rot) and, together with *B. theobromae*, infections hasten fruit rot.

Colletotrichum infection is treated mainly as a post harvest problem which is directly related to proper conditions of transportation and storage. Post harvest dips under tropical conditions is only partially successful.

3.2.1 Control

Soft rot (stem end rot), *Botryodiplodia theobromae* and anthracnose, *Colletotrichum gloeosporioides* in fruit require primarily post harvest treatments including storage controls — temperature and humidity. Post harvest dips of several fungicides are being recommended (thiabenzaole, imazil, benomyl, etc.)

3.3 Avocado Scab, *Elsinoe persea*

Avocado scab, *Elsinoe persea* is a fungal disease which can severely reduce quality of avocado. Varietal differences in susceptibility/resistance can be seen in the Caribbean.

The familiar symptoms, if raised, are cream coloured to pale yellow-orange warts which can be found covering the fruit surface. However, no rot takes place as a result of "scab" infection.

3.3.1 Control

Avocado scab control, if at all feasible, has to be done in the field, pruning and aeration of trees would help.

Virus Diseases in the Citrus Industry

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I. Introduction

Virus and viral-like diseases have a major impact on citrus production worldwide and often become the dominant yield-limiting factor in grove management. The most obvious impact of these diseases is their lethal effect on specific hosts. Tristeza alone has destroyed approximately 50 million trees in the past 40 years. A less obvious but economically important effect is the variety of nonlethal response that reduces tree size, tree vigour, and fruit yield. In many cases, growers suffer significant losses from virus diseases without recognizing the nature of these diseases. Finally, citrus virus and viral-like diseases may restrict the grower's choice of rootstocks and scions which can be grown profitably in certain areas.

The purpose of this study is (1) to describe the symptoms of two major diseases of citrus: Exocortis, a viroid disease and Tristeza, a virus disease; (2) to discuss the diagnosis of these diseases in the field and in the laboratory, if possible; and (3) to review information on control measures for these kinds of diseases for citrus.

II. Tristeza Disease

2.1 Name and Synonyms of the Disease

Tristeza means "sadness" in Spanish and this name was widely used in the 1930s by the growers in Argentina to refer to a disease of trees grafted on sour orange. Other names of the disease were "quick decline" or "budunion decline." For historical reasons some authors use the name Tristeza only in connection with trees grafted on sour orange (Tristeza sensu stricto). Others use it in a broader sense and include under it Tristeza virus-induced "stem pitting of the grapefruit," "lime disease," etc.

2.2 History

The virus apparently originated in Asia and has been disseminated by the movement of infected plant materials and by aphid vectors.

Aphids were found in Brazil, in 1946, to be active vectors of this disease by Meneghini. Graft transmission was pointed out in California by Dr. Fawcett in the same year. The discovery of viral-like particles occurred only in 1964 by a Japanese research team.

2.3 Causal Agent

This is a graft- and aphid-transmitted virus. Viral particles are flexuous rods about 15 × 2000 nm. The particles contain a single-stranded RNA. The virus exists as a number of strains with distinct serotypes and different vigour. The virus is essentially phloem-limited, but it has been observed in the cortex of young shoots.

2.4 Distribution and Importance

Tristeza disease is present in most citrus-growing

areas of the world, except the major parts of the Mediterranean basin and isolated areas elsewhere. This disease killed approximately 25 million citrus trees in Brazil, Argentina, and Peru, about 3 million trees in California so far, and has caused extensive damage in Spain. Hundreds of thousands of sweet orange trees have been killed or rendered unproductive in Florida and seriously affected areas are enlarging; damage to grapefruit trees on sour orange has so far been slight.

2.5 Host Range

Two kinds of hosts of interest are: non-rutaceous hosts, e.g. *Passiflora gracillis* and rutaceous hosts — all species in the genus *Citrus* as well as some species in allied genera such as *Aeglopsis*, *Afraegle*, and *Pamburus* can be infected by the Tristeza virus.

The reaction of any species or variety of citrus to infection, however, depends on the nature of the infecting strain. Certain strong strains can produce symptoms on many different species and varieties whereas weak strains may be detectible on only one. The relationship is complex and is not yet fully understood. Trees on certain rootstocks, such as *Citrus macrophylla*, Eureka lemon, and Palestine sweet lime are similarly affected. Tristeza is, however, not only a rootstock problem and, as pointed out above, some varieties or species may show a decline as seedlings or as scions on a tolerant rootstock.

2.6 Susceptible Species, Varieties, or Combinations

In general, mandarins are especially tolerant to the Tristeza virus. Sweet orange, sour orange, rough lemon, and Rangpur lime are usually symptomless but may react to some severe isolates. Reactive hosts include limes, grapefruit, some pummelos, alemow, some sweet oranges, some citrus hybrids and some citrus relatives.

(A) Examples of species and varieties showing stem pitting whether used as seedlings, scions, or rootstocks are small acid lime, *Citrus hystrix*, Palestine sweet lime with the California Tristeza strain, grapefruit, sweet orange, and various citranges with the South African strain.

(B) Examples of species and varieties which decline when grafted on sour orange (Tristeza sensu stricto) include all species listed under (A) whether they show stem pitting or not.

2.7 Symptomless Species, Varieties and Combinations

2.7.1 Immune

Poncirus trifoliata is given as immune, but resistance depends probably on the Tristeza strain and *P. trifoliata* selection.

2.7.2 Tolerant

(*a*) *Seedlings of many citrus species and varieties* — Sour orange; sweet orange, but certain varieties show stem pitting under certain conditions (ex: Pera orange, a common sweet orange, in Brazil); mandarins, including 'Cleopatra'; tangerines; satsumas; tangelos; Rangpur lime (except with certain Tristeza strains); lemons; rough lemon, even though severe pitting was observed in Kenya.

(*b*) *Grafted trees* — Sweet orange (except Pera orange) or mandarin trees grafted on rootstocks such as rough lemon, Cleopatra mandarin, *Poncirus trifoliata*, Rangpur lime, Troyer citrange. More interesting, lemons can be grown on sour orange rootstocks. It really seems that tristeza is an association disease.

2.8 Symptomatology

Symptoms in the citrus host is highly variable and affected by the environment, host species, and the severity of the isolate.

2.8.1 General Aspect of Affected Trees

(*a*) Trees on sour orange roots may show slight to severe dieback and defoliation or may be slightly to severely stunted. In extreme cases complete collapse may occur. On affected trees fruit is often grouped in bunches.

At present, 90 per cent or more of the sweet orange trees on all rootstocks in Florida carry an identifiable isolate of Tristeza, but only a relatively small proportion of trees on sour orange show symptoms of Tristeza decline. Some trees on sour orange have been infected with the tristeza virus for more than 15 years without disease symptoms.

(*b*) Trees grafted on susceptible rootstock such as *Citrus macrophylla*, Mexican lime as well as seedling trees of susceptible species show stunting and decline, their leaves are small and yellowish.

2.8.2 Symptoms on Leaves

The virus induces typical and specific vein-clearing symptoms on acid limes. But, in Corsica, a strain of the Tristeza virus found on Kumquat does not induce symptoms on small acid limes.

2.8.3 Symptoms on Trunks, Limbs, and Shoots

In the early stages, starch reserves disappear below the bud union from wood and bark of sour orange. Later, longitudinal inverse stem pits may appear in the wood of the trunk, twigs, and roots of susceptible species of varieties such as acid limes. This inverse pinhole pitting also called honeycombing is a good indicator of the presence of the Tristeza disease.

In grapefruit, this stem pitting may eventually produce a pattern of longitudinal grooves on the trunk which is quite visible externally and which has been called grapefruit stem pitting. Overgrowth of the sour orange stock by the scion at the bud union is also a later characteristic. Trees in decline have extensive rotting of feeder and secondary roots.

2.9 Comparison with Other Diseases

No other known disease includes stem pitting and vein clearing on small acid limes. Both Tristeza and

Cachexia-xyloporosis induce stem pitting on Palestine sweet lime. Certain strains of Tristeza cause stem pitting on various orange varieties and/or grapefruit. Both Tristeza and Stubborn can induce inverse stem pitting on sour orange bark below the bud union.

2.10 Vector Transmission

Natural transmission is by aphids. In the southern hemisphere and in eastern Asia, *Toxoptera citricidus*, brown citrus aphid) is an efficient and common vector. *Aphis spiraecola, A. gossypii* and *A. citricola* are less efficient vectors.

2.11 Graft Transmission

Tristeza is often transmitted or propagated inadvertently by man in buds from symptomless trees of tolerant combinations.

2.12 Indexing

Two kinds of indexing methods are currently used for indexing the Tristeza virus:

2.12.1 The Use of Indicator Plants

Seedlings of West Indian limes are the best, quick indicators. They produce symptoms of vein clearing and stem pitting when inoculated with the Tristeza virus, but they do not distinguish between severe and mild isolates of the virus as far as other species are concerned. This method is slow, costly, and very dependent on the external environment.

2.12.2 The Use of Serological Techniques

The Tristeza virus may be detected most rapidly by DAS-ELISA, (Double Antibody Sandwich Enzyme Linked Immuno Sorbent Assay). The test is conducted in polystyrene microtiter plates. A homogenizer facilitates grinding large numbers of samples. The homogenizer is cleaned between samples by brief runs in two changes of water. Border wells occasionally may give a nonspecific reaction and are avoided for critical tests. Samples are positioned according to a planned data sheet.

Thorough rinsing between steps is essential. Plates are usually rinsed 13 times, and rinsed solution remains in wells several minutes between changes. A colour change in the substrate solution indicates the presence of enzyme conjugate bound to the well surface. Usually, the top two rows contain comparable dilution of healthy extract and the bottom rows contain buffer alone. Readings are made by colorimeter or directly by human eyes.

2.13 Control

Tristeza decline is best controlled by excluding viral-infected material from citrus-growing areas by quarantine measures or by eradication of any citrus trees which already carry the virus. Where such exclusion is not possible, control may be obtained by inarching seedlings of tolerant rootstocks into trunks of trees grafted on sour orange. The use of tolerant rootstocks requires that the scion be free of those viruses to which the new rootstocks are susceptible (exocortis in the case of *P. trifoliata* or Troyer citrange). Pre-immunization with mild strains is used in commercial orchards in Brazil, but this solution is only acceptable in the case of an already presence of a vigorous strain of Tristeza in the area. In other words it is not acceptable to introduce a strain, even a mild one, of Tristeza in a country free of this disease.

III. Shoot Tip Grafting (STG)

The most hopeful way to eliminate Tristeza is the use of shoot-tip grafting. This technique used in vitro to recover 'virus-free' citrus plants was first described by Murashige in 1972. It consists of grafting under aseptic conditions a small shoot tip excised from the infected plant onto a decapited rootstock seedling.

3.1 Preparation of the Rootstock

Young seedlings obtained by germination of seeds in vitro are used as rootstocks. Seeds are peeled by removing both seed coats, surface-sterilized, and rinsed. The germination medium is a plant cell culture salt solution solidified by agar. One seed is aseptically sown by tube and cultures are kept at constant temperature for two weeks in continuous darkness.

After this time seedlings are decapited leaving a 1- to 1.5-cm portion of the epycotil, the cotyledons and their axillary buds are removed, and the root is shortened. An inverted-T incision is made in the epicotyl under a dissecting microscope. At this point, the rootstock is ready for grafting.

3.2 Preparation of the Scion

Actively growing new shoots 5 cm long or shorter are stripped of large leaves and reduced to about 1 cm; then they are sterilized and rinsed. Some of the remaining small leaves are removed under aseptic conditions. The degree of grafting success increases progressively if larger shoot tips are used but the number of virus-free plants obtained decreases considerably.

3.3 Grafting and Care of Grafting plants

The shoot tip is the incision made on the rootstock. The grafted plants are cultured aseptically in liquid medium and kept at 27°C under a 16-h daily illumination. About 30 to 50% successful grafts are usually obtained following the described procedure.

The scions of successfully grafted plants should have, at least, two expanded leaves before transplanting to soil. This stage is usually reached two to six weeks after grafting. Plants are then transplanted to pots containing any soil mixture suitable for growing citrus, with polyethylene bags to reduce loss of moisture. After one week, bags are opened and after a second week, they are removed and the plants allowed to grow under standard greenhouse

conditions. With this method over 95% of the plants survive transplanting to soil.

3.4 Characteristics of the Obtained Plants

This technique has been effective in recovering citrus plants free of the pathogens of Tristeza, psorosis, concave gum, xyloporosis, stubborn, and exocortis. In addition to being virus-free, one of the most important characteristics of the plants obtained by shoot-tip grafting is that they do not revert to a juvenile state as do virus-free plants recovered through nucellar embryony. STG plants can be made available for budwood increase within one or two years from grafting. All the plants obtained by STG have morphological normal leaves identical with those of the parents, growth is normal, and the plants that have fruited produce normal fruits.

Considering the overall advantages of STG, this technique is recommended to be used in any citrus variety improvement programme with the objective of recovering 'virus free' plants for commercial propagation.

IV. Exocortis

4.1 Name and Synonyms of the Disease

The name of this disease comes from the Latin word *exo* which means outside and *corticis*, bark. Scaly butt is another name for this disease.

4.2 History

Exocortis was first described in 1948 by Fawcett and Klotz in California on *Poncirus trifoliata*.

4.3 Causal Agent

The exocortis pathogen has been identified as a free RNA chain without a protein coat. For this reason, it is not a real virus but a viroid. Several strains have been described, differentiated by the severity of symptoms in various hosts.

4.4 Distribution and Importance

This disease is present in all the citrus-growing areas. It is a destructive disease, particularly on susceptible rootstocks such as trifoliate orange, citrange, and mandarin lime. Trees on tolerant rootstocks are significantly retarded in growth. Average yields of severely affected trees on susceptible rootstocks may be reduced by as much as 40%.

4.5 Host Range

Genera of the families Rutaceae, Leguminoseae, Solanaceae, and Compositae are potential hosts for this viroid.

4.6 Susceptible Species, Varieties, or Combinations

Poncirus trifoliata, Etrog citron, sweet lime, lemons, rangpur lime, and citrange seem to be susceptible to stunting from the exocortis pathogen.

4.7 Symptomless Species, Varieties, or Combinations

4.7.1 Immune

Many herbaceous hosts are immune. No immune *Citrus* spp. are described.

4.7.2 Tolerant

Tolerant means symptomless carriers. While many *Citrus* spp. tolerate the exocortis pathogen in that they do not develop bark scaling, it is doubtful that any *Citrus* spp. can tolerate this pathogen to the point of not becoming stunted. Some common tolerant (non-scaling) plants are sweet orange, sour orange, rough lemon, grapefruit.

4.8 Symptomatology

4.8.1 General Aspect of Affected Trees

The effects are rarely lethal and the stunting effect is varying from severe to slight according to the strain of exocortis.

4.8.2 Symptoms on Leaves

The exocortis pathogen causes cracking of the underside of midribs, stem and leaf epinasty, yellow blotching of stems, and corky lesions of certain clones of Etrog citron and some lemon.

4.8.3 Symptoms on Trunks, Limbs, and Shoots

On trifoliate orange and some citranges, the exocortis pathogen causes vertical cracking and scaling of the bark, yellow blotching of twigs, and considerable stunting. On Cuban shaddock, some lemons and sweet limes, it causes cracking of the bark and stunting.

4.9 Comparison with Other Diseases

Scaling the bark of the lemon trunks due to shell bark disease may be confused with exocortis bark scaling. While the exocortis pathogen may be a factor in the development of shell bark of some lemon trees, many lemon trees do not respond to exocortis by scaling.

Psorosis scaly bark is similar in some aspects to exocortis but occurs on sweet orange. Exocortis does not cause bark scaling on sweet orange.

4.10 Transmission

The main vector for this disease is the human by his cultural practice, grafting techniques, and cutting tools.

4.11 Indexing

There is no serological method yet because of the lack of antiserum for this disease. Meanwhile, the use of indicator plants is well known.

4.11.1 Use of Etrog Citron

Two buds of the candidate tree are grafted into each of several seedlings of a suitable exocortis host, but are not permitted to develop into shoots. Bark patches

may be used. A bud from Etrog citron is then inserted in each seedling. The citron bud may be inserted on the same day as the candidate bud or up to 2 weeks after the candidate bud. Too early infection of a seedling may inhabit growth of the citron bud. Growth of the citron shoot is encouraged by cutting back or binding the seedlings. The citron scions should be grown as single shoots in a favourable environment in either the greenhouse or field, and pests must be rigorously controlled. Infected plants usually develop symptoms within 1 to 3 months and before the shoots are 0.6 m (2 ft) high. Taller symptomless citron shoots may be cut off about 15 cm above the bud union and a new citron shoot grown for about 3 months. High temperature (27–32°C) favours symptom expression.

The first and most characteristic symptoms of exocortis infection on citron shoots are epinasty of the leaves and cracking of the lower side of the blade twist to varying degrees from the normal plant. Other symptoms include dwarfing, small corky lesions, and vertical cracking of the stem.

4.12 Control

The use of exocortis-free propagative stock and sanitary budding is the only way to prevent spreading of exocortis. Nursery and field practice must be planned to prevent this disease by disinfection of tools between cuts into different plants by dipping into 10 to 15% solution of household bleach (5% of sodium hypochlorite in the concentrated bleach).

In recent years, some effort has been made to eliminate the exocortis pathogen from citrus by heat treatment. Results indicated that buds that survived these treatments still carried the pathogen. Recently, Roistacher, Navarro, and Murastige demonstrated that the exocortis pathogen could be eliminated from infection from clones by shoot-tip grafting.

V. Conclusion

The citrus industry is in evolution: diseases such as Tristeza and exocortis have made it necessary to abandon or restrict the use of some long-used rootstock varieties and to find others not subjected to these previously untried scion varieties of hybrid selections. With a change to new citrus types for both scion and rootstock use, new disease problems can be expected. Thus it is clearly evident that the research team will continue to play an important part in maintaining a successful and profitable citrus industry throughout the world.

Alphabetical list of rutaceous species and varieties: Their tolerance to citrus virus and virus-like diseases

Species, Varieties	Tolerant or resistant to
Aeglopsis chevalieri	Citrange stunt
Bergamot	Cristacortis
Calamondin	Stubborn
Chinotto	Impietratura
Citranges	
Carrizo	Cachexia-xyloporosis, concave gum, cristacortis, greening, multiple sprouting, Psorosis A, *Phytophthora*, Tristeza
Cunningham	Stubborn
Rusk	Cachexia-xyloporosis, concave gum, cristacortis, greening, multiple sprouting, Psorosis A, *Phytophthora*
Troyer	Cachexia-xyloporosis, concave gum, cristacortis, greening, multiple sprouting, Psorosis A, *Phytophthora*, Tristeza
Uvalve	
Citremons (1148–1449)	
Citrons	Cachexia-xyloporosis, concave gum, cristacortis, Impietratura, citron
(Etrog)	Cachexia-xyloporosis, concave gum, cristacortis, Impietratura, satsuma dwarf
Citrumelos	Cachexia-xyloporosis, multiple sprouting
Citrumelo 1452	
Citrumelo 4425	Tristeza
Citrus amblycarpa	Gummy bark
C. daidai	Psorosis leaf symptoms
C. excelsa	Citrange stunt, *Phytopthora*
C. hystrix	Cristacortis
C. junos	*Phytophthora*
C. macrophylla	
C. pectinifera	
C. volkameriana	Cristacortis
Clausena sp	Psorosis leaf symptoms
Clementine	Exocortis, rumple, Tristeza
Grapefruits	Cachexia-xyloporosis, exocortis, gummy bark, rumple
Harvey lemon	
Hassaku	Satsuma dwarf
Kumquats	Impietratura
Lemons	Cachexia-xyloporosis, citrange stunt, concave gum, cristacortis, exocortis, gummy bark, Psorosis A, tatter leaf, Tristeza
Limequats	
Mandarins	Exocortis, gummy bark, rumple, seeding yellows, Tristeza
Mandarin (Cleopatra)	
Mandarin limes	
Natsudaidai	
Poncirus trifoliata	Cachexia-xyloporosis, concave gum, cristacortis, greening, gummy bark, infectious variegation-crinkly leaf, leaf curl, multiple sprouting, Psorosis A, Tristeza yellow vein, *Phytophthora*
Poncirus x *Citrus*	
Pummelos	Cachexia-xyloporosis, exocortis, *Phytophthora*
Rangpur lime	Concave gum, gummy bark, gum pocket, leaf curl, Tristeza (A, B)
Rough lemon	Cachexia-xyloporosis, citrange stunt, concave gum, exocortis, Psorosis A, seeding yellows, tatter leaf, Tristeza
Satsuma	Tristeza
Severina buxifolia	Citrange stunt
Siamelos	*Phytophthora*
Sour orange	Cachexia-xyloporosis, concave gum, exocortis, gummy bark, Psorosis A, rumple, tatter leaf, Tristeza, *Phytophthora*
Sweet lime	Concave gum, Psorosis A
Sweet orange	Cachexia-xyloporosis, citrange stunt, exocortis, rumple, seeding yellows, tatter leaf, Tristeza
Sweet orange mediterranean, Pera	
Sweet orange on sour orange	
Tahiti lime	Cachexia-xyloporosis, concave gum, satsuma dwarf
Tangelo (Orlando)	Exocortis, gummy bark, satsuma dwarf, Tristeza
Tangors	Exocortis
West Indian lime	Cachexia-xyloporosis, citrange stunt, concave gum, cristacortis, exocortis, gummy bark

Alphabetical list of rutaceous species and varieties: Their susceptiblity to citrus virus and virus-like diseases

Species, Varieties	Susceptible to
Aeglopsis chevalieri	
Bergamot	Impietratura, multiple sprouting, *Phytophthora*
Calamondin	Stubborn
Chinotto	
Citranges	
Carrizo	Citrange stunt, exocortis, satsuma dwarf, stubborn
Cunningham	
Rusk	Citrange stunt, exocortis, Tristeza (B)
Troyer	Citrange stunt, exocortis, ringspot, satusma dwarf, Stubborn
Uvalve	Tristeza
Citremons (1148–1449)	Citrange stunt, ringspot
Citron	Greening, infectious variegation-crinkly leaf, leaf curl, Psorosis leaf symptoms, Tristeza
Citron (Etrog)	Exocortis, infectious variegation-crinkly leaf, Tristeza, yellow veins, *Phytophthora*
Citrumelos	Exocortis
Citrumelo 1452	Tristeza
Citrumelo 4425	
Citrus amblycarpa	
C. daidai	
C. excelsa	Ringspot, satsuma dwarf, tatter leaf, Tristeza
C. hystrix	Tristeza
C. junos	Satsuma dwarf, Tristeza
C. macrophylla	Cachexia- xyloporosis, Tristeza, *Phytophthora*
C. pectinifera	Cristacortis
C. volkameriana	Impietratura, woody gall
Clausena sp.	
Clementine	Cacheria-xyloporosis, concave gum, cristacortis, Impietratura, infectious variegation-crinkly leaf, satsuma dwarf, *Phytophthora*
Grapefruits	Concave gum, cristacortis, greening, Impietratura, infectious variegation-crinkly leaf, leprosis, multiple sprouting, Psorosis A, ringspot, satsuma dwarf, seedling yellows, stubborn, Tristeza (B), zonate chlorosis, *Phytophthora*
Harvey lemon	Exocortis
Hassaku	Tristeza (B)
Kumquats	Cacheda-xyloprosis, greening, multiple sprouting, stubborn, Tristeza (B), yellow vein, zonate chlorosis
Lemons	Greening, Impietratura, infectious variegation-crinkly leaf, leaf curl multiple sprouting, Psorosis leaves symptoms, ringspot, rumple, satstsuma dwarf, seedling yellows, stubborn, veination, yellow vein zonate chlorosis, *Phytophthora*
Limequats	Tristeza (B), yellow vein
Mandarins	Cachexia-xyloporosis, concave gum, cristacortis, greening, leaf curl, leprosis, Psorosis A, ringspot, satsuma dwarf, stubborn, veination, zonate chlorosis, *Phytophthora*
Mandarin (Cleopatra)	Infectious variegation-crinkly leaf
Mandarin limes	Exocortis, stubborn
Natsudaidia	Satsuma dwarf
Poncirus trifoliata	Exocortis, gum pocket, satsuma dwarf, zonate chlorosis
Poncirus x Citrus	Citrange stunt
Pummelos	Greening, infectous variegation-crinkly leaf, leaf curl, Psorosis leaf symptoms, seedling yellows, Trisetza(B)
Rangpur lime	Cacheria-xyloporosis, cristacortis excocortis, greening, ringspot, Tristeza (C), woody gall, *Phytophthora*
Rough Lemon	Cristacortis, greening, gummy bark, Impietratura, leprosis leaf symptoms, ringspot, satsuma dwarf, stubborn, veination woody gall, yellow vein, *Phytophthora*
Satsuma	Cacheria-xyloporosis, cristacortis, infectious variegation-crinkly leaf satsuma dwarf, stubborn, *Phytophthora*
Severia buxifolia	Fingspot
Siamelos	Concave gum, cristacortis
Sour orange	Cristacortis, impietraura, infections variegation-crinkly leaf, leprosis, multiple sprouting, Psorosis leaf symptoms, ringspot, satsuma dwarf, seedling yellows, stubborn, Veination
Sweet lime	Cacheria-xyloporosis, cristacortis excocortis, greening, infectious variegation-crinkly leaf, leaf curl, stubborn, Tristeza, *Phytophthora*
Sweet orange	Concave gum, cristacortis greening, gummy bark, Impietratura, infectious variegation-crinkly leaf, leaf curl, leprosis, multiple sprouting, Psorosis A, ringspots, satsuma dwarf, stubborn, veination, zonate chorosis, *Phytophthora*
Sweet orange mediterranean, Pera	Tristeza (B)
Sweet orange on sour orange	Tristeza
Tahiti lime	Exocortis, Tristeza (B), zonate chlorosis, *Phytophthora*
Tangelo (Orlando)	Cacheria-xyloporosis, concave gum, cristacortis greening, Impietratura, Psorosis A, satsuma dwarf, stubborn, Yellow vein
Tangors	Cristacortis, ringspot, Tristeza (B)
West Indian lime	Greening, infectious variegation-crinkly leaf, leaf curl, Psorosis leaves symptoms, ringspot, satsuma dwarf, seedling Yellows vein, stubborn, Tristeza, veination-woody gall, yellow vein, zonate chlorosis, *Phytophthora*

Post-harvest Handling Of Passion Fruit

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I. Introduction

Since most passion fruit is grown for processing into juice, post-harvest recommendations tend to be designed for the needs of the processor. Large-scale production and processing plants are well-established in Hawaii, Colombia, New Zealand, Brazil, Kenya, Zimbabwe, Thailand, and Indonesia. The market for fresh fruit in North America and Europe has remained small and is supplied by high-priced air-freighted fruit. It might be possible to bring down the market price and increase demand for fresh passion fruit if post-harvest systems suitable for sea-freighting could be developed.

II. Maturity Characteristics

Both yellow and purple passion fruit achieve optimum flavour if allowed to mature fully on the vine and fall naturally to the ground. Green ripe fruit, even if allowed to ripen off the vine before processing, can carry a woody off-flavour.

For the fresh market, purple passion fruit is generally

preferred for its sweetness and flavour. The fruit takes 85–125 days from flowering to full maturity and only during the last 10 days does the fruit change in colour from green to deep purple. For rapid marketing the fruit can be allowed to fall naturally. However, for export marketing it is harvested from the vine at 50–75% purple to increase the storage/shelf life and reduce the probability of post-harvest disease.

III. Harvesting Methods

Harvesting passion fruit can be an expensive operation since fallen fruit should not be allowed to stay in the fields for more than 2–3 days, particularly if conditions are wet. Pickers must therefore pass through the entire planting at least twice weekly during the harvest period. If the soil surface is clean and ridged beneath the trellis, fruit will tend to roll to the side and be most easily collected. Some pickers prefer to rake fruit into piles for subsequent lifting on shovels or forks, although this is not appropriate for fresh marketing.

For fresh marketing the best and fresher fallen fruits are often selected. However, for long-distance transportation fruit may be picked when 50–75% purple to maximize the storage/shelf life. Although this may result in a slightly reduced flavour, the risk of spoilage claims is much inferior for the exporter.

IV. Field Handling

Plastic crates cause less damage to fruit in the field than sacks and are normally used in large-scale operations. Where production is mechanized fruit may be transported in the field from picking bags or crates to large pallet bins carrying more than 100 kg of fruit. On a small-scale, where costs force growers to utilize sacks, the sacks should be kept clean and handled as carefully as possible. If fruit is not to be processed immediately it must be stored under well-ventilated conditions to avoid spoilage, preferably under refrigeration.

Fruit for the fresh export market must be collected in rigid crates and moved quickly to a cool packing area. Since water loss from the peel occurs rapidly, speed is essential to minimise shrivelling.

V. Packhouse

For most passion fruit production the packhouse is the processing plant. Fruit are received into a tank of water and then passed through a spray washer on a moving belt conveyor. The rotten and damaged fruit are then removed from a slow-moving conveyor before processing starts. Inspections are usually carried out for each delivery prior to dunking to ensure that excessively rotten and damaged batches do not enter the system. For export marketing, fresh fruit is wiped with a clean damp cloth and packed straight from the field in a cool building. Only the largest (at least 5 cm diameter) and blemish-free fruit can be packed. Best results are obtained if fruit is cooled to 6.5°C immediately after packing and held at this temperature until shipment.

VI. Packaging

For high-value fresh marketing in North America, Europe and Asia, passion fruit is packed in a single layer tray with a net weight of 2-4 kg. Since the fruit loses up to 25% of its weight through post-harvest water loss, resulting in characteristic peel shrivelling, payments must be linked to size and quality rather than weight shipped.

VII. Storage

Passion fruit is susceptible to chilling injury at temperatures below 6.5°C. Above this, spoilage due to microbial activity and senescence increases proportionately to temperature. At 6.5°C with good ventilation and 85-90% relative humidity passion fruit can be stored for up to 4 weeks. Weight loss will occur but will not affect subsequent juice quality. Since ripe passion fruit produces more ethylene than any other fruit on record, it should not be stored with ethylene-sensitive commodities.

VIII. Transportation

For processing, passion fruit is generally transported fresh by truck over the relatively short distance from field to factory. Long distance transportation for processing would not be cost-effective.

Exports of fresh fruit are currently made by air although potential should exist for sea freight from Caribbean Islands with reefer services to overseas markets, where the transit period does not exceed 12 days.

IX. Post-harvest Disease

The most serious fruit disease affecting passion fruit is 'brown spot' caused by the fungus Alternaria passiflorae. The number of fruit affected and the degree of browning and softening have an important influences on the quality of finished juice. Pulp from soft brown spots discolours and imparts an off-flavour to juice, and mould spores contaminate the product. Fresh fruit is affected by various surface moulds, especially where physical injury has occurred and when marketing temperatures are high. Post-harvest treatments are not effective in controlling these diseases which derive from field infections coupled with a post-harvest injury and stress. They are minimised by adopting hygienic production and post-harvest systems.

Post-harvest Handling of Citrus

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I. Introduction

Citrus is the most extensively grown and most valuable fruit crop on world markets and has a long history of international trade. Not surprising a lot of money has been invested in studying citrus production including post-harvest practices.

In many countries the handling of citrus has undergone substantial mechanization and requires a large capital investment, particularly in the automated packhouses.

Much of the information from the large producer countries is well documented and accessible and no attempt will be made to describe the range of harvesting, handling, and packhouse systems used around the world.

Post-harvest studies can include the following elements of the citrus handling system:

- Selection of cultivar
- Fruit maturity
- Harvesting operations
- Transport to packhouse
- Degreening
- Packhouse operations — washing, drying, sorting, fungicide applications, grading, waxing, boxing, machinery, etc.
- Fruit quality and presentation
- Grade standards
- Packaging and labelling
- Storage and shipping
- Post-harvest diseases and disorders
- Quarantine regulations
- Food regulations, pesticide residues — the consumer

II. Fruit Maturity

Citrus fruits are non-climacteric which means that they do not undergo any definitive ripening stage before they are ready to be consumed. Instead they gradually become edible and remain edible for much longer than the climacteric fruits such as avocado and mango.

As the citrus fruits mature they undergo physiological changes in juice volume (increases), and sugar (increases) and acid levels (decreases). These changes determine when harvesting can begin in order to get fruit of acceptable eating quality. These physiological factors are usually described by a maturity index which is the ratio of total soluble solids (mainly sugars) to titratable acid. The principle acid is, of course, citric acid. Measurement of total soluble sugars (usually called brix) and titratable acid is straightforward and does not require very expensive equipment. The brix:acid ratio is helpful in describing fruit to prospective buyers on international markets.

The level of brix:acid ratio will generally rise during the season as the fruit remains on the tree. There can be a small rise in brix:acid ratio after harvest.

Different markets, e.g. processing versus fresh markets, have different expectations of internal quality or maturity index. The maturity standards also vary from country to country. In the U.K. even each supermarket can have a slightly different standard for the same citrus cultivar.

An example of a maturity standard for White Marsh grapefruit from a U.K. supermarket is juice volume, 35% and brix:acid, 6:1. At this time of year in Dominica, brix:acid ratios commonly exceed 8:1. Maturity standards often also specify external appearance in terms of colour break.

To ensure orderly and profitable marketing, most countries have produced grade standards governing imported or exported citrus which include the maturity standards. The grade standards in many countries emphasize skin colour and freedom from blemishes thus discriminating against fruit grown in humid, tropical climates which inevitably have more blemishes and skin discoloration.

However, consumers the world over rely first on external appearance when buying their fruit. Taste alone will never be enough to persuade most consumers to by a scarred, green, or blemished fruit.

III. Fruit Handling

In any marketing system it is progressive decays rather than nonprogressive blemishes which cause major problems and loss in profits.

Extensive studies of experimental and commercial shipments in Florida have shown that almost without exception, decay of fruit occurring in transit and marketing is due to rough or careless handling at time of picking and packing.

Quality of picking and packing in Florida orange shipping exports (av. of 79 shipments)

	% decay			
	On arrival	1 wk later	2 wk later	3 wk later
Careful pick and pack	0.6	1.1	1.6	1.9
Commercial pick and pack	7.0	10.8	13.2	14.2

Comparison of commercial shipments from packhouses identified as doing careful or careless work.

	% decay			
	On arrival	1 wk later	2 wk later	3 wk later
5 careful packhouses	1.4	3.1	4.1	4.5
5 careless packhouses	17.6	27.9	34.0	37.1

In the very studies it was found that decay was less when the foreman did not pick and was thus free to supervise the pickers full time; decay was reduced by using smaller picking bags; decay was reduced when the foreman checked an occasional bag from each picker, fruit by fruit. (Ref. H. J. Ramsey. Proc. Fla. State Hort. Soc. 25:28–42, 1912.)

Recent studies in Dominica on huckster shipments bear out these findings. Most of the progressive decay found in a huckster shipment, of pink grapefruit to Guadeloupe was due to a oleocellosis and bruising with a total of 20–30% of fruit affected. Another shipment of oranges suffered from a high percentage of torn rind around the stem end thus allowing decay to develop. The torn rind would have been a result of poor picking techniques or very tender rind partly due to wet weather.

Oleocellosis (oil spotting) — The oil glands in the rind of citrus contain oils which are toxic to the surrounding cells. Rupture of these oil glands by injuries causes local browning of the skin and can allow entry of decay. The browning or necrosis becomes more severe with time and often does not become obvious in our ambient conditions until 48–72 h or more after the injury has occurred.

Limes, navel oranges, and any early season fruit are particularly susceptible to this injury but all citrus fruit can suffer from oleocellosis. It is particularly prevalent in Dominica when fruits are harvested during a wet period when the rind is very turgid especially in the early morning. The pressure of the pickers fingers may be enough to cause injury. The injury is also often caused by contact with the picking basket or the container used for transport. Fruit-to-fruit contact can cause this blemish if the fruits are gritty or sandy.

Fruit/container contact can be minimised by using larger container but if containers are being moved by hand a container with a weight of not more than 20 kg is recommended. During a wet spell it may pay to delay harvesting until later in the morning when fruit have lost a little of their internal moisture.

Despite the quality defects presents, the short period between harvest and sale of fruit, common in most huckster trade, means that the hucksters themselves do not experience a costly loss of fruit or loss of sales. However, the fruit will undoubtedly deteriorate quickly in the hands of the supermarket, retailer or end consumer. This makes the huckster trade increasingly vulnerable to competing suppliers, e.g. Cuba or even Florida or Israel, countries that provide a better quality product which will not deteriorate so quickly on the shelf or in the fruit bowl.

Mechanization of harvesting for fruit destined for processing is already a reality but there are many difficulties in finding mechanical systems that can handle fruit for the fresh market. Mechanical harvesting aids have been easier to develop. In our situations this could allow easier movement of fruit out of the field. Cableways have been used in the past to reduce harvesting labour costs. Well-managed and pruned trees also help to reduce harvesting costs as time spent climbing the tree is reduced.

IV. Degreening

Under subtropical or Mediterranean conditions citrus fruit will naturally turn from green to orange or yellow when they are stressed by low temperatures occurring at night. The fruit responds to the stress by the evolution of the growth regulator ethylene. This initiates the change in colour of the skin.

In many countries early season fruit are artificially degreened by the use of ethylene. Each country has developed slightly different techniques according to their own particular conditions. Batch and continuous degreening rooms are used. The CCGA packhouse in Dominica uses a continuous process. There are systems that are suited to small-scale operations, e.g. intermittent greening as used in Japan, plastic tents with trickle degreening as used in Australia.

Usually conditions for degreening need to be controlled fairly carefully. Temperature, humidity ethylene concentration and air circulation are important.

Ethylene at high temperatures can stimulate the development of some decay e.g. diploidia stem end rot. Fungicide dips or drenches are usually recommended before degreening. Any fungicide application should be applied as soon as possible after harvest.

Various sources of ethylene can be used e.g. pressured gas cylinder catalytic generator, acetylene in water. Equipment can be relatively simple.

Degreening works better in some conditions and on some fruit than others. Fruits that have already been waxed cannot be degreened.

V. Post-harvest Chemicals — Waxing

Why wax citrus? The most important reason is to reduce moisture loss. Citrus fruit is usually washed and rinsed to remove dirt or sooty molds. This disturbs the natural layer of wax resulting in increased moisture loss. Unwaxed citrus can lose moisture at the rate of 1% per day.

There are others reasons for waxing: (1) to improve appearance and marketability by the shine; (2) to provide a carrier for fungicides; (3) to provide a barrier to free gas exchange.

There are two main types of waxes: water based and organic solvent waxes. Within these two categories there are a lot of different formulations. Some formulations will perform better under a certain set of conditions than others.

Waxes are classed as food additives and legislation in many countries precludes the use of certain waxes

e.g. carnauba wax is not permitted in the U.K. This is an increasingly sensitive area as consumers become more concerned about food safety. Food safety regulations or consumer opinions is also affecting the use of some of the post-harvest fungicides used. Riphenyl-impregnated tissue fruit wrappers are not now commonly used in most European markets.

The performance of citrus wax is dependent on the method of application. The amount of wax applied and the uniformity of application are extremely inportant. There are several large consignments of fruit, e.g. seedless limes, that are perfectly acceptable in every other way rejected by customers because of ugly uneven wax application.

If wax applications being considered, then the type of equipment purchased should also be carefully considered. Expert assistance is advised.

Alternatives to citrus waxing have now been developed. Some of the fairly recently introduced sugar ester fruit coatings eg. Semperfresh, are said to be effective in improving citrus storage but these do not give the shiny appearance that guarantees customer appeal. Plastic shrink-wrapped citrus can now be found on the market particularly in the organic market sector. Both these techniques require some capital investment in equipment.

VI. Some points for further consideration

Would citrus grade standards be advantageous to the region?

In an area where agricultural labour is in short supply we should certainly be looking at reducing labour input e.g. by mechanical systems but also by making the labour we have more efficient of effective.

Improvements in man/woman management and supervision in the field and packhouse could help to reduce labour costs and improve fruit quality can we find ways of developing pools of skilled field workers?

Does washing and waxing fruit hold any advantage for our regional fruit sales? The cost of production would be increased but new markets may be secured.

Would we develop new or improved markets by introducing small-scale degreening facilities to the region?

VII. Conclusion

Regional as well as international markets are becoming increasingly sophisticated and competitive. The handling and packing systems we use for our citrus must respond to these changes.

Post-harvest Handling of Avocado

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I. Introduction

Avocado became increasingly popular on North American and European markets in the eighties. The U.S. is a major producer in California and Florida but imports from other countries are limited by quarantine restrictions. Although Mexico is the world's biggest producer (600,000 tonnes/year), quarantine restrictions prevent cross-border exports to the United States. Europe is a very minor producer but imports year-round from Israel, South Africa, Mexico, Florida, and various other countries. The market in Europe is widening to take different types and sizes of avocado, but quality requirements are high and can only be met if good post-harvest systems are established by potential suppliers.

II. Maturity Characteristics

Successful marketing of fresh avocado requires the selection of mature fruits at harvest. Even though immature fruit can soften after harvest, the time required for softening is much longer than mature fruit and the flavour and texture are inferior (grassy and bitter flavour as opposed to mellow and nutty, rubbery to soft texture as opposes to buttery). Avocados do not ripen normally on the tree.

Maturity determination is done by two distinct methods: oil content and fruit diameter/weight (in conjunction with earliest harvest date). The oil content method has been only successful for those cultivars that are naturally high in oil content and is generally not useful for avocados grown in the Caribbean Islands.

III. Harvesting Methods

Avocado fruit are harvested manually with the aid of ladders, picking bags, telescopic poles fitted with a cutting blade and catch bag, and hand clippers. The fruit is removed from the tree by either clipping or snapping the stem above the fruit. Clipping and leaving a short stem is preferred since this reduces the chance of bruising and puncturing adjacent fruit once they are placed in containers. About 6 mm of pedicel should be left attached to the fruit to inhibit the entry of pathogens.

The use of mechanical aids in harvesting and field transport is generally limited by the terrain. Orchards

on flat terrain can make use of a three-wheeled, self-propelled, hydraulically powered unit for positioning the work in areas of the tree not easily reached from the ground thus increasing the productivity of the worker and reducing damage to the fruit.

IV. Field Handling

The accumulation of harvested fruit in the field for transport to packhouse is generally done with the use of pallet bins or with small trailers. Fruits should be shaded following harvest to prevent an increase in internal heat. Precooling the fruit at the packhouse is recommended. Removal of excess heat before packaging will reduce the refrigeration required during shipment to maintain the fruit at recommended temperatures and provide a better control of the ripening process.

V. Packhouse

The modern packhouse, as used in major producing areas is completely automated except for the grading and packaging of fruit. The fruit is mechanically dumped from bulk containers onto conveyer belts. Leaves, twigs and other debris are removed with a series of soft roller brushes, sometimes with the addition of a water spray. The fruit is moved onto revolving rollers which continually turn the fruit for the purpose of grading. Skin defects caused by fungus and harvesting cuts and bruises are principal factors in grade reduction. Fruit sizing is done with either drop rollers or weight sizes, with each size range accumulated in separate bins.

VI. Packaging

Packaging is done by hand. Fruits are arranged in rows in either a single- or double-layer container. The container size is generally standardized for the industry and number of fruit per container will vary with the size of the fruit. Minimum net weights for the three containers used in Florida are 5.7 kg, 11.3 kg, and, depending on the cultivar, either 14.5 kg. The container must be well ventilated and durable to withstand stacking and damp conditions. Most of these containers are of fibreboard construction. The European market accepts only single-layer cartons packed to 4.5 kg net weight.

VII. Storage

Storage on tree — When fruit has reached maturity, it can be left hanging on the tree for several weeks; it will not ripen further. Although this provides useful flexibility for local marketing, it is not recommended for export fruit since the storage/shelf life of mature fruit is reduced when it is left on the tree.

Conventional refrigerated storage — The length of storage of avocados is primarily a function of cultivar, maturity, and temperature. The response of avocado fruit to low temperature storage for delaying ripening varies with each cultivar. Some can be stored for extended periods at 6°C whereas others (particularly West Indian) cannot be stored below 13°C without injury to the fruit. Chilling injury is characterized by greyish-brown discolouration of the vascular system, uneven ripening, and development of off-flavours. The recommended storage temperatures for cultivars of the West Indian race is 12.8°C (4°C for Guatemalan and 8°C for Mexican). The ripening time of the fruit stored for an extended period of time, two weeks or longer, is generally less than non-stored fruit.

Controlled atmosphere storage — By inhibiting the softening process with controlled atmospheric conditions, the fruit remains resistant to fungal invasion and development by *Colletotrichum gloeosporioides*. The pressure of low O_2 and high CO_2 (5–10%) tends to suppress the intensity of respiration. In addition, the high CO_2 reduces the effectiveness of ethylene in stimulating ripening. Studies in Florida have shown that the use of 2% O_2 and 10% CO_2 at 7.2°C doubled the normal storage life under refrigeration alone of Lula, Booth 8, and Fuerte avocados (maximum storage time was 6–8 weeks). Concentration of CO_2 must be kept below 15% to prevent unjury. With controlled atmosphere storage, lower temperatures can be used than with conventional refrigerated storage without causing chilling injury (the optimum temperature will vary with the cultivar).

Low pressure storage — This system operates by maintaining the commodity at a specific temperature in a sealed container at sub-atmospheric pressure. The system is essentially an aid to refrigeration and not its replacement. The unit is continually ventilated with moist air (80–100% relative humidity) with a vacuum pump. Several studies have shown a significant increase in storage life of avocados with low pressure storage.

Varietal differences — In a study performed in Dominica during 1985, fruits of eight varieties from Woodford Hill and one variety from Grand Bay were harvested at intervals after reaching maturity. Samples of 30 fruits of each variety were transported to Roseau where they were stored for 11 days at 8, 10, or 12°C before being ripened at 22°C. This period of storage is comparable with that occurring in refrigerated sea freight between Dominica and the U.K. When ripe, as assessed by softness, the fruits were cut and examined for chilling injury as indicated by grey discolouration of the mesocarp tissue. Of the 10 varieties examined after ripening at 22°C, three (Lula, Tonnage, Gripina 5) showed no signs of chilling injury under the condition of storage, regardless of harvest date, Semil 31 showed 90% chill-damaged fruits after 11 days of storage at 8°C. For Pollock, conditions of 8 or 10°C resulted in 100% chill damaged fruits. The remaining five varieties (Simmonds, Gripina 12, Collinson, Everton 2, Semil 34) showed increasing chilling susceptibility at 8°C, and 10°C, in the case of Simmonds, as harvest was delayed. No

variety was susceptible to chilling when stored at 12°C, irrespective of harvest date.

VIII. Transportation

Avocados are transported to export markets by sea and air, the choice depending primarily on costs and returns. Transit time is an important quality factor since wholesalers need at least 1 week, preferably 2 weeks, to market the fruit advantageously. The loading pattern of the shipping container should allow for adequate air movement between the stacked cartons. Shipment temperature will vary with cultivar (4.5–6.6°C for Mexican and certain Guatemalan types, 9–12.8°C for West Indian and certain Guatemalan cultivars).

IX. Post-harvest Diseases

The two most important post-harvest decays of avocados are black spot decay (anthracnose) and stem-end rot.

Black spot decay is caused by the fungus *C. gloeosporioides* while the fruit is still on the tree. The fungus is a weak parasite and is unable to penetrate healthy, uninjured fruit. If the fungus penetrates the fruit, it will cause greenish-black decay in the flesh during ripening, eventually spreading throughout the fruit. Control of the organism is dependent on the use of specific pesticides during fruit development. There are currently no fungicides available for the control of this disease once it has infected the fruit and developed the latent infection. Benomyl can help for fruit exported to Europe, but it is not permitted in the United States.

Stem-end rot can result in considerable fruit loss. Immature fruit are most susceptible to the disease. Control of the disease is best accomplished by harvesting mature, blemish-free fruit and shipping them under refrigeration.

X. Post-harvest Treatments on Avocados for Insect Control

Avocado is listed as one of the Mediterranean fruit fly host commodities. Only fumigation, cold treatments, and heat treatments have been accepted is disin-festation procedures by quarantine authorities in the United States. However, fumigants are difficult to use because of their extreme toxicity to humans, and cold treatments are of limited use for chilling-sensitive commodities like avocado. A study by the University of California which tested the effect of heat treatments (exposure to saturated water vapour at 43°C until the centre of the fruit reaches that temperature, then keeping the fruit at 43°C for at least 8 h) on avocados, concluded that the avocados exposed to such treatments did not soften or ripen normally, exhibited severe surface browning, weight loss, susceptibility to vibration injury, and loss of fresh avocado flavour.

The presence of fruit flies in most Caribbean Islands prevents the shipment of avocados to the continental United States without methyl bromide fumigation. However, in a recent study performed in Hawaii, treatment with methyl bromide at required dosages caused discolouration, pitting, and decreased shelf life in many varieties, resulting in unmarketable fruit.

A 1982 study conducted in Florida subjected 30 Florida-grown cultivars to two standard methyl bromide quarantine treatment schedules to evaluate phytoroxic effects. Of those tested, 21 cultivars (70%) successfully withstood methyl bromide at 32 g/m_3 for 25 h at 70°F (21°C) or above, followed by 7 days storage at 45°F (7.2°C). Fourteen cultivars (46.7%) were tolerant to methyl bromide at 32 g/m_3 for 4 h at 70°F (21°C) or above, followed by 3 days storage at 45°F (7.2°C) or 55°F (12.7°C). Ten cultivars (33.3%) tolerated either treatment, and 4 (13.3%) tolerated neither. Deleterious effects associated with the treatments varied with cultivar and included surface scald, lenticel spotting, anthracnose, stem-end rot, internal chilling injury, delayed or inhibited ripening, darkened vascular bundles, and tissue breakdown. Late-season cultivars were generally among the most tolerant to treatment. The treatment has not been adopted by any major exporting country.

XI. Ripening

Avocados are picked and shipped when they are mature but firm and thus require ripening before consumption. The temperature at which an avocado fruit is ripened has a pronounced effect on the rate of ripening and the quality of the ripened fruit in terms of flavour, texture, and appearance. One study of Florida cultivars found that the best temperature for ripening of these fruits are between 15 and 21°C. The average ripening time ranged between 2 and 6 days. Ripening of avocados at 30°C and above is unsatisfactory, as uneven softening, development of off flavours, discolouration of the skin, increased decay, and shrivelling of the fruit may occur. Initiation of uniform ripening with 500–1000 ppm ethylene gas in fruit ripening rooms has become common practice in importing countries.

Market Research and Analysis of Export Markets

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I. What Is Agricultural Marketing?

Agricultural Marketing is the movement of agricultural produce from the farm where it is produced to the consumer or manufacturer. There are several steps or activities involved between production and marketing. This includes physical handling and transport, initial processing and packing to simplify handling for protection of the product and reduction in wastage, grading and quality control to simplify sales transactions and meet different consumer requirements, and holding over time to match concentrated harvest season with the continuing demands of consumers. The farmer is interested in ensuring that the marketing system offers a convenient outlet for his produce and consumer and manufacturer is interested in being assured of a steady supply.

It must be noted that market does not start after harvest, but long before production begins at which time various markets are evaluated to determine when it is best to market the product. With reference to international marketing, the producer and marketing persons must acquire all the available information about the market to reduce the risk as much as possible related to:

(i) Producing an unwanted commodity
(ii) Trends in consumer demand, which can be reflected in levels of income and general economic activity
(iii) Transportation services
(iv) Marketing services
(v) Importers
(vi) Cultural considerations
(vii) Government policy to customs
(viii) Animal and plant quarantine requirements and all factors which can affect the marketing of the product.

It is therefore essential that persons wishing to be involved in export marketing think about it carefully and collect and analyze information for the development of the marketing plan.

Agricultural marketing also includes the marketing of production inputs to farmers such as fertilizers, pesticides and other agricultural chemicals, livestock feed, farm machinery, tools and equipment; and seeds and other planting material.

Finally, throughout the entire process of production to marketing, financing is essential, as easy access to credit is necessary if goods are to move freely and bargains be concluded without duress.

The exporters must have knowledge of the environment within which their products will be marketed and also the interactions between the overseas business community and its environment. This is termed the "market ecology" which is not simply the study of the cultural, political, economic, and social environment of one overseas country, but the analysis of what impact these parts of the environment have on business methods and export policy.

Market selection overseas demands some study of cultural as well as geographical distances, it is these distances which give rise to the term "communication risks" encountered by exporters. Distance and risk can be caused by differences in language, culture, political systems, and level of education. Some awareness of the cultural aspects of the market ecology is essential to the export marketing persons. Combined with socio-economic and political factors, the elements of market ecology are:

1. Political and demographic:
   - Power structure in the society
   - Density and distribution of population
   - Legal system
   - Government fiscal policy
   - Role of ethnic minorities
2. Socio-economic:
   - Levels of disposable and per capital incomes
   - Taxes
   - Centres of purchasing influence
   - The local chambers of commerce
   - Structure of social classes
   - Government fiscal policies
3. Cultural:
   - Educational levels
   - Levels of technical and managerial training
   - Status of women, the facility and status of ancestors
   - Religious belief and attitudes
   - Consumption system
   - Concepts of time and manners
4. Geographical/Environment:
   - Communication systems
   - Climate and topography
   - Proximity and sources of supply
   - Logistic systems

II. Export Market Action Plan

The following should be considered by any exporter when preparing an Export Market Action Plan.

(1) Identify key markets and then select target markets carefully before making financial and manpower commitments.

Usually key markets have large sales volumes, above average growth rates, and intensive consumption, but also usually more intensive competition, lower price levels, fewer opportunities for newcomers to enter and gain market share.

(2) One must be flexible enough to adapt produce and packaging to market requirements and to adapt prices to the current level, but only after a critical investigation of the necessity, the cost, and sales potential.

Very often exporters adapt their products only to find out that the modified product is too costly to produce, or cannot be produced with existing facilities.

(3) Exporters must recognize that markets are rarely alike and static and be prepared to use different strategies and plans.

(4) Copying what competitors are doing can be as successful as inventing a new way to market a product or inventing a new product/package.

(5) Limit your risks, especially in the early phases of an export programme by testing, by small-scale operations, and by trial agreements. Information is essential when making a business decision. The less information available when decisions are taken, the greater the risk of failure. Product test and market testing is important for exporters because it permits them to assess their product's market potential on a small scale before they make important financial commitments. It is best to make trial agreements with distributors, or agents, or large buyers.

(6) Make an estimate of the cost of becoming an exporter and the additional sales revenue and profit expected. It is essential to take into account the cost of additional staff, travel, research, investments in fixed and working capital, and communication cost.

(7) Exporters must constantly collect and use market information. Often, exporters make the mistake of collecting market information only once — when they prepare their initial marketing plan, they forget that markets are not static and unchangeable.

(8) Exporters should reduce "breakdown" risks, i.e., product quality control, production scheduling, order handling and shipping, collection and customer services.

(9) Select your associates carefully, i.e., distributors, importers, brokers. Listen to their versions and always discuss the situation at all times.

Maintaining contacts with agents and importers overseas requires prompt and continuous replies to queries as well as orders — a fax or telex query requires a fax or telex reply, an airmail query requires an airmail reply. All enquiries should be replied to on the day of receipt or at least on the following day. Staff at all levels in the company who have any "interface" or contact with overseas customers must by trained to react cautiously or accurately to enquiries.

The export business is always very complicated and should be considered in that manner. All aspects of product supply and quality is very essential for the long-term success of the business. Customer relationships are very important.

Markets in different countries are different. There are certain requirements, both in the market place and governmental policies, which must always be taken into account. The exporter must discuss his/her plans with certain government agencies, e.g. the ADCU who can advise them accordingly, because, in most cases, the market situation does not allow one to make too many mistakes.

Documentation is essential and there is no alternative. Exporters should allow a professional shipping agent to handle shipping operations; incomplete or inadequate customs documents can lead to delays at ports which can result in unsustainable losses and customer confidence. Agricultural products, because of its proneness to deterioration should be given special care and attention. Any delays in transit could be very disastrous.

III. The European Market for Exotic Products

During the last 20 years, the demand of the European market for exotics have expanded for the following reasons:

1. Consumers' interest in purchasing a broader range of fresh produce as well as obtaining fresh fruits and vegetables during the European winter (the off-season period).
2. There is a major emphasis on health foods. In the EEC, the import of avocados rose during the period 1982 and 1987 by 125% to 132,086 tonnes.

3.1 Avocado, *Persea americana* (Lauraceae)

Consumption of avocado is growing. France is the largest market, followed by the U.K. and Germany. European imports are higher in the October–April period than in the summer months. However, summer trade is also increasing steadily. The major suppliers are Israel, South Africa, Spain, and Martinique. Smaller suppliers are Kenya, Mexico, and the United States.

VARIETIES: Most popular — 'Hass,' 'Fuerte'
Less popular — 'Lula,' 'Pollock' (too large) but ethnic market prefers large varieties.

SIZE: 150–400 g with 270–330 g most popular. Although size requirements differ for different markets, accurate size grading is essential.

SHAPE: Pear shape, with no large, loose stones. Stalk must be less than 10 m and cut clean. Shape should be uniform.

COLOUR: Bright green, typified by 'Fuerte,' though 'Hass,' which turns a deep purple/black, is acceptable and is reported to have a longer shelf life than other varieties.

RIPENESS: Firm, slightly unique, no brushing or dis-

figurement. Long shelf life more important for wholesale market than for supermarket trade which sometimes ripens fruit centrally for consistency.

TASTE/TEXTURE: Smooth, creamy, no fibres, no bitterness.

PACKAGING: Fruit should be packed in a single-layer fibreboard box, of around 4 kg, net weight. Preferred number of fruits in a box are 12, 14, 16, 18, or 20 (depending on fruit size). Cartons should provide adequate ventilation. Dividers may be used to prevent rubbing during transportation and handling. The package should be attractively presented, clearly labelled with country of origin, and counted. Some fruit are also individually labelled.

All fruits from ACP countries receive preferential Tariff treatment (no duty) and must be accompanied by a completed EUR 1 form. Fruit should be clean and must be accompanied by the original phytosanitary certificate.

3.2 Passion Fruit, *Passiflora edulis* (Passifloraceae)

VARIETIES: Most popular — purple variety
Other acceptable — yellow variety

SIZE: 45–59 gs, 45–50 mm in diameter, uniform grading is important

SHAPE: Oval, sometimes round

COLOUR: Purple preferred, yellow acceptable

RIPENESS: Skin not too wrinkled or dimpled

TASTE/TEXTURE: Juicy

PACKAGING: Buyers are less restrictive in their requirements for passion fruit packaging. Kenyan exports were 2 kg net weight, single-layer trays with lids and internal dividers, about 40–48 fruits.

Some documentation is required for exporting to Europe or America.

3.2.1 Background

United States imports of fresh passion fruit are restricted from the Caribbean Basin because of fruit fly quarantine regulations. However, U.S. imports of fresh passion fruit decreased 32% between 1983 and 1987. This may be largely due to increased domestic production. Import levels of frozen passion fruit fluctuated widely suggesting that there may be market opportunities in the promotion of frozen passion fruit for processed uses.

DESCRIPTION: There are over 400 species of the edible fruit of the passion flower. Passion fruit is a small, egg-sized fruit with wrinkled skin. The flesh is yellow and jelly-like, and contains many small, black seeds. The pulp is fragrant and has a tart to sweet taste. The fruit is most wrinkled when ripe and is prone to drying.

SIZE: smaller, 7.6–12.7 cm (3–5 in.) in diameter; larger, 20.3–30.5 cm (8–12 in.).

ORGIN: Native to Brazil, the name resulted after early Spanish missionaries saw the passion flower and named it in honor of the passion of Christ. It is also called "granadilla," which means "little pomegranate," in Spanish.

COMMON NAME: Similar names, such as passion fruit, granadilla or grenadille, maracuya, and parcha may be used, though referring to different species. Names may be differentiated by the fruit's distinguishing colour, sweetness, and size. Some common types include:

1) *Passiflora edulis* Sims, purple passion fruit, purple granadilla;
2) *P. edulis* var. *flavicarpa*, yellow passion fruit, yellow granadilla, parchita amarilla, and sweet granadilla. Larger fruits tend to be spotted. These include:
3) *P. quadrangularis*, called giant granadilla, badea, barbadine; and
4) *P. mollissima* or banana, passion fruit.

VARIETIES: Native varieties — Fruits are distinguished by colour (yellow to purple; spots/no spots), size (small to large), and taste (sweet to tart to subacid). Best known are the purple and yellow smaller passion fruit. Some varieties — Golden, Hawaiian.

FORM OF EXPORT: Fresh/Frozen

STORAGE CAPACITY: 6–10 days at room temperature. Mold does not affect quality of ripe fruit, and can merely be wiped off.

PACKAGING/SHIPPING: Place fruit in cell-packed fibreboard or wood flat (count: 25–49), 10 lb (4.5 kg).

NUTRITIONAL QUALITIES: Source of Vitamins A, C, and B12, and, also, riboflavin and niacin; 376.8 J (90 cal) per 99-g (3.5 oz.) serving.

USES: Fruit flavouring for a variety of products, such as juice, nectar, puree, and ice-cream.

3.2.2 Market Supply

Total U.S. Imports: (metric tonnes)

	1983	1984	1985	1986	1987
Fresh	66	33	43	66	45
Frozen	50	105	50	134	28

CURRENT SUPPLIERS: APHIS fruit fly regulations restrict fresh passion fruit imports from the Caribbean Basin. Some exceptions admit exports to Guam and the Virgin Islands, though there were no reported exports to these areas in 1987. The major fresh supplier to the U.S. mainland has been New Zealand.

In 1987, CBI producers supplied 98% of frozen passion fruit imports to the U.S. Suppliers were the Dominican Republic (93%) and Costa Rica (3%). Suppliers which are not members of CBI, such as Colombia, Ecuador, and Indonesia, accounted for 4% of frozen quantities. Prior to 1987, however, CBI countries supplied roughly only 40% of all frozen quantities. Overall exports to the U.S. from CBI producers have been increasing since 1983. Other producers are the U.S., Kenya, Ivory Coast, South Africa, and South America.

STATUS FOR ENTRY: Not admissible from the Caribbean Basin in fresh supply since fruit is a fruit fly host.

U.S. PRODUCTION: Florida, California and Hawaii.

SEASONALITY: Available February–July (New Zealand), April–August (Florida), and November - January (California).

	J	F	M	A	M	J	J	A	S	O	N	D
U.S. Sources	X	X	X				X	X	X	X	X	X
U.S. Imports		X	X	X	X	X	X					

PRICE: Current wholesale prices for fresh passion fruit can range anywhere from $5.00 to $35.00 per flat (count: 24–42). Retail prices average at about $0.30 to $1.00 each. Prices tend to be higher during off-season and lower during peak season, varying according to each area of production. Price information is not available on frozen passion fruit.

3.2.3 Potential for Expanded Market

By virtue of its name alone, passion fruit has an enormous market potential. This is not limited to fruit in fresh supply. In fact, fresh passion fruit is very unattractive since it is prone to wrinkles and mold at the peak of ripeness. Also, the numerous, small seeds are bothersome to the consumer. In recent years, fresh passion fruit imports to the U.S. have decreased due to sufficient domestic supply and fruit fly restrictions. United States imports of frozen passion fruit were erratic but favourable for CBI suppliers as imports from the Caribbean Basin more than doubled since 1985.

U. S. DESTINATION MARKETS: California, Florida, Georgia, New York.

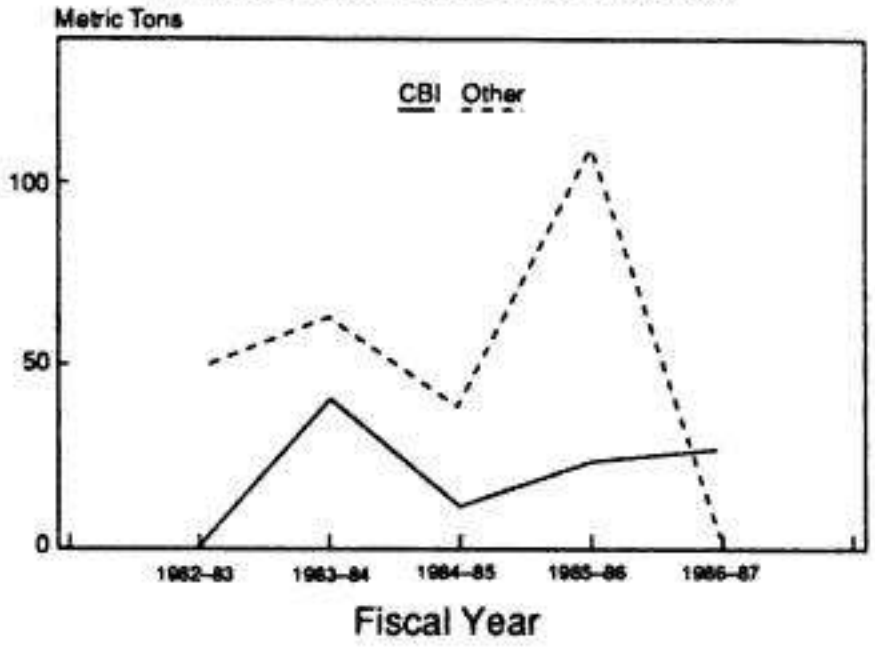
CROSS-OVER/MARKET POTENTIAL: Passion fruit has great appeal within international cuisine menus. Fresh consumption usually consists of scooping out pulp and eating chilled with lemon juice or cream. There are also several marketable processed uses for frozen passion fruit. One famous passion fruit dish is 'Australian Pavlova' which is a meringue case filled with pulp and topped with cream.

3.2.4 Exporters Note

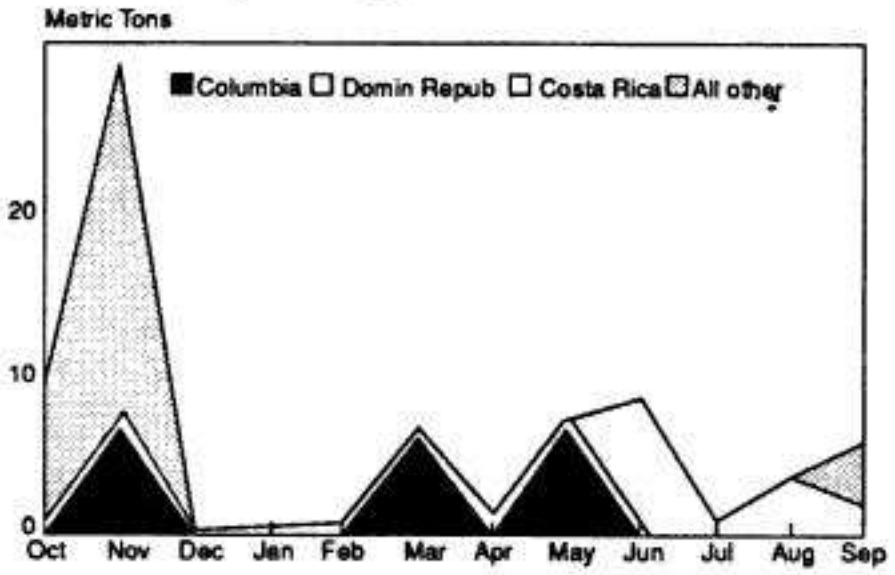
EXPORTING TO THE UNITED STATES — SOME IMPORTANT FACTS EXPORTERS IN THE OECS SHOULD NOTE: The importation of certain classes of merchandise may be prohibited or restricted to protect the economy and security of the U.S., to safeguard common health and well-being, and to preserve domestic plant and animal life. Some commodities are also subject to import quota or a restraint under bilateral trade agreements and arrangements.

Many of these prohibitions and restrictions on importation are subject, in addition to customs requirements, to the laws and regulations administered by other United States Government agencies with which customs co-operate in enforcement. These laws and regulations may, for example, prohibit entry; limit entry to certain ports, restrict routing, storage, or use; or require treatment, labelling, or processing as a condition of release. Customs clearance is given only if these various additional requirements are met. This applies to all types of importation, including those made by mail and those placed in foreign trade zones.

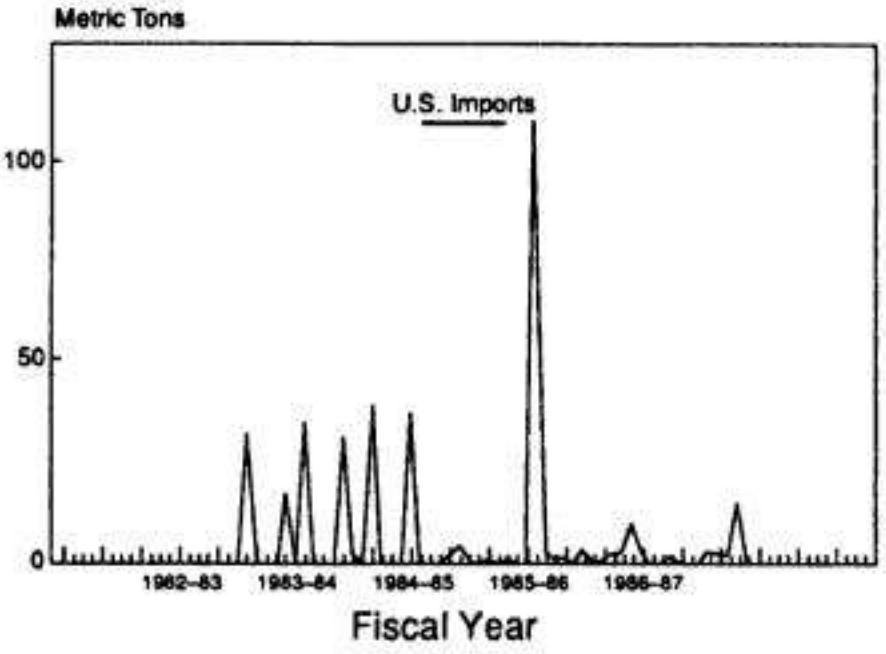
Frozen Passion fruit: Source of U.S. Imports
Annual Total, Fiscal Year 1983–87



Frozen Passion fruit: Source of U.S. Imports
Monthly Average, Fiscal Year 1983–87



Frozen Passion fruit: Total U.S. Imports
Monthly, Fiscal Year 1983–87



Exporters should make certain that the U.S. importer has provided proper information to (1) permit the submission of necessary information concerning packing, labelling, etc., and (2) that necessary arrangements have been made by the importer for entry under which the commodities are controlled.

Certain agricultural commodities (including fresh tomatoes, avocados, mangoes, limes, oranges, grapefruit, green peppers, Irish potatoes, cucumbers, egg plants, and dry onions must meet United States import requirements relating to grade size, quality and maturity. These commodities are inspected and an inspection certificate, must be issued by the Food Safety and import compliance. Inquiries on general requirements should be made to:

Agricultural Marketing Service, U.S. Department of Agriculture, Fruit and Vegetable Division, Room 2523, Washington, D.C. 20204. For information regarding requirements and restrictions imposed by the Animal and Plant Health Inspection Service (APHIS) of the U.S.D.A., under the Plant Quarantine Act:

U.S. Department of Agriculture, APHIS, Federal Building 838, Maryland 20782, U.S.A. Tel.: 301-346-8645.

The exporter must ensure that the importer has a permit for importation obtained from the above address.

EXPORTING TO EUROPE — SOME GUIDELINES TO EXPORTERS: Anyone wishing to export to Europe should be cognisant of some basic information and considerations:

Documentation — It is important that all shipments be accompanied by fully completed export and import documents. Produce from OECS countries are allowed entry into Europe duty-free because of their membership of the ACP group of countries. However, an EUR 1 form must accompany the produce sent from ACP countries.

Customs Entry — The importer is responsible for customs clearances and presentation of customs entry forms (C.88), however, exporters should ensure that all customs documents are completed by a qualified shipping agent. This will eliminate the risk of delays at the ports of entry in Europe.

Health and Hygiene Legislation — All fresh produce entering the EEC must be accompanied by the original phytosanitary certificate issued by the Ministry of Agriculture in the respective countries, from where produce is exported.

Supply Situation — The exporter must advise the importer of quantity and type of produce available and the seasonality, including peak periods of supply. Importers should advise on quality, size, shape, etc. The exporters must pack produce in approved packaging and ensure that this packaging is available when needed. Meanwhile, the exporter must inform the importer of the potential to improve or increase volume.

Transportation — This is very critical because fresh produce is very perishable, particularly from the Caribbean due to the high temperatures and humidity which provides the ideal climate for deterioration after harvest. The exporter must secure the best form of transportation (sea or air, depending on the commodity) before completing any business deal with an importer.

Exporter–Importer Relationship — As much as possible, the exporter–importer should try to build up a very trusting relationship, so that he/she is constantly in connection with the markets, weather conditions, consumer consumption trends, and all aspects of trade.

Exporting — Before going into the exports of fresh produce, all exporters should discuss this with their local Ministry of Agriculture or Trade Promotion Office for advice, or contact the following address:

The OECS Agricultural Diversification, Co-ordinating Unit, P.O. Box 371, Old Street, Roseau, Commonwealth of Dominica, Tel: 809-448-2240/6555, Fax: 809- 448-6755.

SECTION 3

CONCLUSION FROM WORKING GROUPS

Research Group Report

R. E. FLETCHER
Group Leader, CARDI, Dominica

I. Passion Fruit

1.1 Nursery Propagation

MAIN PROBLEMS:

Use of unselected seed as the main source of planting material in Dominica.

CAUSES:

No local research or technology transfer on vegetative propagation; no cultivar specificity expressed by processors.

ACTION NEEDED:

Introduction of techniques of vegetative propagation to main passion fruit nurseries; evaluating cost and effectiveness of techniques introduced; determine a phenological cycle for vegetative propagated material.

INSTITUTIONS CURRENTLY INVOLVED IN RELATED RESEARCH:

CARDI (St. Lucia) is involved in grafting using sweet granadilla as the rootstock: Propagation and evaluation of rooted cuttings is being done by CARDI (St. Lucia) and IRFA (Martinique). Work in Guadeloupe is focussed on grafting of selected passion fruit lines into wild *Passiflora* rootstock which are potentially resistant to collar rot. At the Ministry of Agriculture, Centeno, Trinidad, grafting is employed in the germ-plasm maintenance programme. Also production of true-to-type lines by in-breeding is being done at Centeno.

INSTITUTIONS WITH EXPERTISE IN THE REGION:

IICA, IRFA (Martinique), CARDI (St. Lucia), MoA (Trinidad).

POTENTIAL DONORS:

Financial—BDDC, USAID-HIAMP; Training: IICA, IRFA.

1.2 Cultivars

MAIN PROBLEMS:

Lack of information on sweet types for the fresh fruit market; no discrete cultivars.

ACTION NEEDED:

Regional cultivar evaluation programme with introductions from Brazil, Colombia, and Australia as well as evaluation of material already in country; evaluation of local self-compatibility germplasm.

INSTITUTIONS DOING RESEARCH:

IRFA, MoA (Trinidad), CARDI (St. Lucia), CARDI/IICA (Dominica).

INSTITUTIONS WITH EXPERTISE IN THE REGION:

IRFA, MoA (Trinidad), CARDI (St. Lucia), IICA.

POTENTIAL DONORS:

Financial—BDDC, USAID/HIAMP; Training—IICA, IRFA (Martinique), UWI (Trinidad).

1.3 Nutrition

MAIN PROBLEMS:

The status of fertilizer requirements and responses is varied and confused.

CAUSES:

Variable agro-ecological situations in which the crop is grown.

ACTION NEEDED:

Adaptive research to define appropriate fertilizer regimes in various agro-ecological zones; specific work on timing of fertilizer applications.

INSTITUTIONS DOING RESEARCH IN THE REGION:

Some work was done in Trinidad by Rajkumar in the early 80s. Work was also done in Venezuela and Brazil.

INSTITUTIONS WITH EXPERTISE IN THE REGION:

CARDI (St. Lucia/Dominica), MoA (Trinidad), IRFA (Martinique), UWI.

POTENTIAL DONORS:

BDDC, USAID/HIAMP, ADCU.

1.4 Pest and Disease Management

MAIN PROBLEMS:

Stem borer in Trinidad and Guyana; collar rot in Guadeloupe, Martinique; Foot rot (*Fusarium*) in Dominica; Septoria disease affecting fruits . Also greasy spot and *Alternaria*.

ACTION NEEDED:

Identification of causative organisms; development of control techniques; determining effect of diseases on juice volume and quality.

INSTITUTIONS WITH EXPERTISE IN THE REGION:

CARDI (Dominica), IICA, IRAT (Guadeloupe), MoA (Trinidad).

POTENTIAL DONORS:

BDDC, IICA (Training), ADCU; USAID/HIAMP.

1.5 Vine Management

MAIN PROBLEMS:

Uncontrolled growth vine resulting in excessive vegetative material and high humidity micro-environment which causes fruit blemishes; lower productive efficiency of vines; trellising materials not durable; reduced vine life.

ACTION NEEDED:

Updated recommendations on materials for trellis construction; further research into live posts (glyricidia) and economics related to trellising; a practical teck-pack for vine management that is cost effective.

INSTITUTIONS CURRENTLY WORKING:

CARDI (Dominica), IRAT (Martinique), INRA (Guadeloupe), MoA (Trinidad), CARDI (St. Lucia).

POTENTIAL DONORS:
BDDC, OECS/ADCU, USAID/HIAMP.

II. Avocado

2.1 Cultivars and Propagation

MAIN PROBLEMS:
Lack of germplasm banks for provision of quality material; lack of adequate information on rootstock characteristics and use of nondescript rootstock; need to improve nursery techniques and sanitation; inadequate information on cultivar compatibility in relation to the pollination factor.

ACTION NEEDED:
Certification of trees and groves for planting material generation and propagation; introduction of rootstock material with known stock/scion compatibility characteristics; review and update nursery techniques; inventory of cultivars in major producing countries.

INSTITUTIONS CURRENTLY INVOLVED IN RESEARCH:
IRAT (Martinique) is working on rootstock/scion compatibility and pollination compatibility.

INSTITUTIONS WITH EXPERTISE IN THE REGION:
MoA (Trinidad), IRAT (Martinique), INRA (Guadeloupe).

POTENTIAL DONORS:
BDDC, OECS/ADCU (Financial), IICA (Training).

2.2 Tree Management

MAIN PROBLEMS:
Lack of pruning and management of trees resulting in difficulties in pest and disease control programmes and harvesting.

ACTION NEEDED:
The basic technologies for tree management are available and need only to be transferred. CARDI/TROPRO is involved in technology transfer work in this area in Dominica; some research is required to determine optimal spacing and appropriate pruning practices; research is also required to determine the best mix of cultivars in orchards to ensure high levels of cross pollination and fruit set. Focus should be directed on early and late cultivars which have a distinct price advantage in the market place.

INSTITUTIONS CURRENTLY INVOLVED IN RESEARCH:
CARDI (Dominica) is working on maturity indices for selected cultivars; IRFA (Martinique).

POTENTIAL DONORS:
Financial—BDDC, ADCU, Training — University of Florida; IICA

2.3 Plant Protection

MAIN PROBLEMS:
Root rot caused by *Phytophthora cinnamonmi;* thrips and mites that cause fruit blemish.

ACTION NEEDED:
Country level surveys on the economic importance of root rot and insect pests (thrips and mites); technology transfer activities for root rot control; evaluation of ULV sprayers and other spraying techniques for control of insect pests; economic analysis (cost/benefit evaluation) for specific pest control techniques.

INSTITUTIONS CURRENTLY DOING RESEARCH:
CARDI (Jamaica)—currently working on spray technology appropriate for small-scale operations; CARDI (Dominica)—work on root rot (*Phytophthora*) control ongoing.

INSTITUTIONS WITH EXPERTISE IN THE REGION:
CARDI (Jamaica), CARDI (Dominica and St. Lucia).

2.4 Post-harvest

MAIN PROBLEMS:
Maturity determination of major cultivars, especially for the export market; harvesting techniques resulting in damaged fruit and post harvest problems; inadequate packaging for export; cold storage for shipping and artificial ripening.

INSTITUTIONS CURRENTLY INVOLVED IN RESEARCH:
MoA (Dominica) and CARDI on maturity indices; MoA (Dominica) and CARDI on packaging and shipping; MoA (Barbados) on maturity indexing by brix analysis.

INSTITUTIONS WITH EXPERTISE IN THE REGION:
University of Florida.

POTENTIAL DONORS:
Financial—BDDC, ADCU, Training—IICA, CARDI.

III. Citrus

3.1 Root Stocks and Cultivars

MAIN PROBLEMS:
Unsatisfactory performance of Ruby Red grapefruit in some agro-ecological situations in Dominica and need for deeper red fruits; the need for later and earlier maturing cultivars to extend the season of easy peelers in Trinidad and grapefruit in Dominica; rootstock/scion compatibility—inadequate information.

ACTION NEEDED:
Study of varietal characteristics in relation to stock/scion compatibility (Barbados/Dominica); introduction and adaptability of new more desirable cultivars - Star Ruby grapefruit, Tahiti lime, easy peelers (Trinidad); studies on root stock adaptability to various agro ecological situations (Marti-nique/Jamaica/Trinidad).

INSTITUTIONS CURRENTLY DOING RESEARCH:
IRFA/CIRAD (Martinique)—Rootstock scion germplasm collection and evaluation.

POTENTIAL DONORS:
Financial—BDDC, EDF; Training—IRFA (Martinique), CARDI, MoA (Trinidad), IICA.

3.2 Diseases

MAIN PROBLEMS:

Incidence of the virus complex in most producing countries; nematodes; scab on grapefruit in Dominica; epiphytes on citrus in Dominica.

ACTION NEEDED:

In country, programme of virus indexing and surveys to establish status of citrus viruses; validation of existing virus indexing systems; programme for establishment of virus-free nursery orchards; work should be initiated to determine the economic importance of nematodes.

INSTITUTIONS CURRENTLY DOING RESEARCH:

Bud-wood indexing—MoA (Trinidad), MoA (Barbados), IRFA (Martinique), INRA (Guadeloupe).

POTENTIAL DONORS:

Financial—BDDC; EDF; Training IRFA (Martinique), MoA (Trinidad), CAB/U.K.

3.3 Pests

MAIN PROBLEMS:

Fruit-piercing bee (Trinidad/Dominica); leaf-cutting ants and scab insects—Trinidad; Citrus weevil (*Diaprepes*)—Dominica, Martinique, Jamaica, St. Lucia.

ACTION NEEDED:

Continued research into management of the citrus weevil and possibly formation of a subregional working group; research into biological control of fruit-piercing bee; adaptive research and technology transfer for control of leaf-cutting ants and scab insects.

INSTITUTIONS CURRENTLY DOING RESEARCH:

IRFA (Martinique)—work on the use of pheromones and plant attractants for control of citrus weevil. Biological control using entomopathogenic nematodes at IRFA as well as CARDI (Dominica), MoA (Barbados), INRA (Guadeloupe) and MoA (Jamaica); work has been done in Trinidad on leaf cutting ants and other insects pests of citrus including scabs and aphids.

POTENTIAL DONORS:

BDDC, NRI/U.K.

3.4 Post Harvest

MAIN PROBLEMS:

Post harvest considerations are more important where fresh fruit trade is paramount as occurs in Dominica. The problems of scab, rust mites, and oil spotting on grapefruit result in blemishes which disqualify fruit from the very selective fresh market; juice quality is also an important post harvest consideration in processing and fruit can only be harvested when a certain level of brix:acid ratio is attained.

ACTION NEEDED:

Determination of the factors that contributes significantly to fruit blemishes; control measures for scab in grapefruit; devise systems of harvesting and handling that reduce the incidence of blemished fruit and consequently rejects at the pack house; agronomic techniques to improve volume and quality of juice to make processing more cost effective.

INSTITUTIONS CURRENTLY DOING RESEARCH:

CARDI (Dominica), controls measures for scab using an integrated pest management (fungicide and cultural practices) approach; harvesting and post harvest studies with grapefruit in an effort to reduce blemishes; Investigating factors responsible for poor colour and flavour of Ruby Red grapefruit.

POTENTIAL DONORS:

BDDC, NRI/U.K. A proposal for subregional networking in citrus research was raised at the workshop session and accepted in principle. This proposal is currently being formalized.

Production Group Report

RAFAEL MARTE
Group Leader, IICA, Barbados

I. Nursery Management

MAIN PROBLEM:

Farmers cannot get enough plants of the desired quality at the proper time.

CAUSES:

Untimely allocation and insufficient availability of resources and inputs; low level of skills of nursery management personnel; insufficient or poor nursery infrastructure; poor record keeping at the nursery; poor communication and information between farmers and nursery; and plants are subsidized regardless of destination, or use.

ACTION NEEDED:

Strengthening the capability of nursery officers in nursery management through more and better training; preparing detailed budget base on real needs and conditioning the total number of plants to the actual allocation of resources and infrastructure available; evaluating the available infrastructure in relation to the demand for plants taking into consideration the different requirements by species; limiting the plant subsidies to those farmers planting in suitable ecological conditions and for commercial purposes; organizing nursery

tours by farmers showing them what is available and the procedure to get it on time; and establishing and impose nursery standards.

INSTITUTIONS PRESENTLY WORKING IN THESE AREAS:

IICA—Conducted surveys and studies about the problem in most countries of the Caribbean region. This institution is presently organizing seminars on nursery management at the national level in most countries of this region. UNDP/FAO is providing direct technical assistance to St. Kitts/Nevis. The ARCD (World Bank) project involves funding nursery rehabilitation (infrastructure and equipment) in Grenada.

INSTITUTIONS WITH EXPERTISE IN THE REGION:

IICA and UNDP/FAO.

POTENTIAL DONORS:

CIDA, BDD, UNDP/FAO, IICA (for training only).

II. Propagation

MAIN PROBLEMS:

Low percentage of success in grafted and budded plants. (This problem is restricted to Nevis); very limited success in the propagation of plants requiring nontraditional propagation method e.g. marcottage, interstocks, cutting, tissue culture, etc.; high propagation and distribution of pests, diseases and weeds by the nursery.

CAUSES:

Low skill levels on traditional propagation methods (Nevis); insufficient training on nontradi-tional methods of propagation; poor sanitary conditions at the nursery. Personnel not trained in sanitation practices, e.g. tools, seeds, and soil sterilization; indexing programmes; past training had concentrated on generalities and has not been customized to the specific needs of each nursery in particular.

ACTION NEEDED:

Surveying the specific training needs at each nursery and organizing customized training accordingly, e.g. specific propagation methods, sanitation practices, indexing, management of virus-free material.

INSTITUTIONS WORKING IN THESE AREAS:

UNDP/FAO—St. Kitts & Nevis on propagation methods; IICA—Windward Islands, Antigua, Barbados, and Guyana in methods and practices of propagation. CARDI—Dominica in sanitation practices at the nursery. Ministry of Food Production and Marine Exploitation: (Trinidad)—indexing work on citrus viruses. IRFA (Martinique)—citrus indexing.

INSTITUTIONS WITH EXPERTISE IN THE REGION:

IICA, CARDI, UNDP/FAO on propagation methods and practices. IRFA (Martinique) for indexing. The University of Florida has in the past efficiently co-operated in this area.

POTENTIAL DONORS:

CTAP, BDD, FAO/UNDP, and IICA (for training only).

III. Germplasm

MAIN PROBLEMS:

Insufficient quantity of desirable types with market potential; lack of organization in the introduction and reintroduction of planting material which increases the risk of importing pests into the country.

CAUSES:

Poor maintenance of existing germplasm; poor availability of germplasm plots at propagation units, (the exception is Christian Valley in Antigua) lack of local selection and characterization programmes (exceptions: Dominica, Grenada and Antigua) local avocados selected but not characterized; lack of information on local, regional, and extra-regional sources of germplasm; lack of control in the importation of planting material. A protocol for the movement of germplasm within and from outside the region has been developed but not approved or institutionalized.

ACTION NEEDED:

More allocation or better distribution of the funds assigned to propagation units to maintain existing germplasm plots; reducing the cost of maintenance by evaluating the existing material and eliminating those that do not meet the quality demanded; completing study of all existing germplasm in the region and their present condition; initiating or re-enforcing programmes for local selection and characterization of germplasm; completing, approving and institutionalizing protocol for the movement of plants within and from outside the region; and restricting the importation of planting material to institutions capable of researching the potential sources and finding their limitations.

INSTITUTIONS PRESENTLY WORKING IN THESE AREAS:

IICA/FAO/CARDI—Developed protocol for movement of germplasm. IICA/CARDI/MoA Dominica—Selection and characterization of passion fruit clones. IICA-ADCU: Prepared project profile for regional germplasm bank.

INSTITUTIONS WITH EXPERTISE IN THE REGION:

Ministry of Agriculture with assistance from CARDI, IICA, FAO, UWI.

POTENTIAL DONORS:

CIDA, USAID, BDD, EEC.

IV. Establishment

MAIN PROBLEMS:

Low percentage of survival to total plants distributed; relative low number of commercial orchards established; development projects place too much emphasis on quantity (area planted) without due consideration to proper growing area.

CAUSES:
Poor follow-up at farm level of distributed plants; planting in unsuitable agro-ecological areas; present land tenure, e.g. tenants unwillingness to establish permanent crops. Lack of land title represents high risks for planting tree crops.

ACTION NEEDED:
Better assistance programme to growers. Require better training of extension service on planting and early care of young trees; improved technical criteria for crop production by lending institutions; zoning studies and implementation at country level; fact sheets for farmers on appropriate ecological areas for specific crops. Advantages and disadvantages to grow in different areas should be emphasized; Government subsidies and credit should be made available only to farmers planting in favourable areas.

INSTITUTIONS PRESENTLY WORKING IN THESE AREAS:
Although technical assistance in fruit crop production is currently provided to the different Ministries of Agriculture in the region by several institutions (CARDI, IICA, UNDP/FAO, etc.), the specific area of zoning is not being covered.

INSTITUTIONS WITH EXPERTISE:
Zoning—OAS with assistance from IICA, CARDI, UWI, and UNDP/FAO.

POTENTIAL DONORS:
OAS.

V. Cost of Production

MAIN PROBLEMS:
High cost of production for some specific crops, e.g. passion fruit, and long time needed for repayment of investments discourage many potential growers to plant in spite of existing markets.

CAUSES:
High cost inputs; short grace period on loans.

ACTION NEEDED:
Bulk purchasing of inputs, e.g. through farmer organizations; make credit available to growers with extended grace period where required; support farmers with information, training, and tax breaks.

IINSTITUTIONS WITH EXPERTISE IN THE REGION:
CDB, Barclay's Bank, others.

POTENTIAL DONORS:
CDB, CIDA, BDD, EEC.

VI. Husbandry

MAIN PROBLEMS:
Inadequate husbandry in general, resulting in low yields and poor quality.

CAUSES:
Lack of information on technology adapted to local conditions; widespread use of banana fertilizers; dependence on chemical company distributors as to what is available; poor training of trainers in specific cultural practices and early detection of pests.

ACTION NEEDED:
Better research programmes on husbandry practices and better dissemination of results; improvement of mechanism for distribution of information on husbandry practices; bulk importation of fertilizers and other chemicals by farmers' organization; more and better training of trainers in specific areas such as early detection of pests and diseases, pruning, etc.

INSTITUTIONS PRESENTLY WORKING IN THESE AREAS:
CARDI is currently expanding their research programme on these areas in the region; UWI has conducted research on some of these areas; IICA is active in the organization of seminars, publications, and field demonstrations to address these problems. These institutions are also very active in the area of farmer organization, pest and disease identification, and plant quarantine. UWI is currently organizing several courses through the CEPAT project to address some of these problems.

INSTITUTIONS WITH EXPERTISE IN THE REGION:
Research—CARDI, UWI, IRFA.

TRANSFER OF TECHNOLOGY:
IICA, CARDI, UWI, FAO/UNDP.

FARMERS' ORGANIZATION:
IICA.

POTENTIAL DONORS:
USAID, BDD, EEC.

VII. Harvesting

MAIN PROBLEMS:
High reject percentage as a result of poor harvesting practices and methods.

CAUSES:
Pickers poorly trained; poor practices and equipment; poor transfer of improved practices and equipment between countries; untimely harvesting edge satisfy pressure of demand.

ACTION NEEDED:
Training of pickers in harvesting practices, maturity indices, and proper use of equipment; transfer of experiences between country on practices and equipment; research new tools and equipment to facilitate harvesting.

INSTITUTIONS PRESENTLY WORKING IN THESE AREAS:
CATCO—training pickers.

INSTITUTIONS WITH EXPERTISE IN THE REGION:
CATCO, UWI, and CARIRI (tools and equipment).

POTENTIAL DONORS:
USAID, EEC, CIDA, BDD.

Marketing and Post-harvest Technology Group Report

ANDREW SATNEY
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I. Introduction

It is extremely important that the crop should be marketed before it is planted, and since these are tree crops, and there is a longer time lag between the initial planting of the crop to production. Producers and marketing agencies should be constantly aware of any changes taking place in the market place—such changes include consumer demand and trends in consumption as well as supply situations.

II. Citrus

With reference to citrus, Dominica has a particular problem in marketing its grapefruit crop. Dominica is the largest producer of grapefruit, and marketing of the crop both in the fresh and processed form needs to be improved. There is also the need for improvement in harvesting and post-harvest handling of the crop as well as fruit processing particularly in juice production for export to regional and extra-regional markets. Research is taking place in several local and regional institutions however, the results need to be co-ordinated. Training is required in post-harvest handling for farmers and extension officers.

2.1 Distribution/Transportation

The two areas of concern, are the cost and availability of transport. The collection and transportation of fruits are very costly because there are several growers who use their own vehicles to transport fruit to the local buying depot. It was suggested that local transportation should be established to lower cost.

The availability and cost of transportation to regional and extra-regional market countries seems to be a major impediment to marketing the crop.

2.2 Packaging and Presentation

The cost and supply of packaging material is inadequate to compete with what is used in other countries; this places local fruit in an uncompetitive situation. Therefore the need is to ensure that the right package is used.

2.3 Promotion

One area of concern is the lack of the expanded use of fresh fruit juice in the regional markets. This needs to be remedied. There is also need for improved linkages between tourism and agricultural sectors.

III. Passion Fruit

Production of this crop in the subregion is definitely below the required levels. In fact, Dominica has a processing plant which has been operating at 20% below capacity since its inception. Therefore the problem is the need to increase production while lowering production costs.

There are minor skin disease problems identified but these did not affect fruit quality because the juice is what is used. CARDI is required to continue its work on passion fruit production.

IV. Avocado

4.1 Production

There is the need to develop maturity indices for avocado so that fruits for the export market may be harvested at the right stage. Fruits need to be properly selected and graded. Training is required for farmers and exporters on grading and selection.

4.2 Transportation

Adequate transportation is unavailable and needs to be established. This problem is being evaluated by the ADCU in its transportation module under the TROPRO Project.

4.3 Packaging and Presentation

This crop faces the same problem as most others exported from the subregion. There is the need to improve on the package used to enhance the competitive value of the crop.

4.4 Promotion

It was decided that there was no need to promote the crop since there was no drastic problem in disposing of it.

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