IICA

PROCEEDINGS OF PAPAYA AND MANGO SEMINAR

Kingston, Jamaica

March 10-11, 1993

JAMAICA EXPORTERS ASSOCIATION

Jamaica Agricultural Development Foundation

IICA OFFICE IN JAMAICA

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 established 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 the 32 Member States, so as to better promote agricultural development and rural well-being.
With its broader and more flexible mandate and a new structure to facilitate direct participation by the Member States in activities of the Inter-American Board of Agriculture 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 1987-1993 Medium Term Plan, the policy document that sets IICA's priorities, stressed 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
- Marketing and Agroindustry
- Animal Health and Plant Protection

These fields of action reflect the needs and priorities established by the Member States and delimit the areas in which IICA concentrates its efforts and technical capacity. They are the focus of IICA's human and financial resource allocations and shape its relationship with other international organizations.

To further reach its objectives of encouraging, promoting and supporting the efforts of the Member States in the area of agricultural and rural development, the Institute renders technical services aimed at strengthening national institutions involved in this sector and serves as a multinational body for cooperation among member countries. IICA also provides direct advisory services and consultancies, implements projects, and acts as a forum and vehicle for the exchange of ideas, experiences and cooperation between the countries, organizations and other entitites active in the agricultural arena.
The contributions provided by the Member States and the ties IICA maintains with its twelve 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 Member States of IICA are: Antigua and Barbuda, Argentina, Barbados, Belize, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Dominica, the Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, the United States of America, Uruguay and Venezuela.

The Permanent Observer Countries of IICA are: Arab Republic of Egypt, Austria, Belgium, Federal Republic of Germany, Romania, Hungary, the Federation of Russia, France, Israel, Italy, Japan, Netherlands, Portugal, Republic of Korea and Spain.

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PRESENTATION

The Inter-American Institute for Cooperation on Agriculture (IICA) jointly with the Jamaica Exporters Association (JEA) and Jamaica Agricultural Development Foundation (JADF) presented a seminar on Papaya and Mango at the Jamaica Conference Centre in Kingston, Jamaica on March 10-11, 1993.

On the said seminar the main export markets, the current situation and the investment climate for Papaya and Mango in Jamaica were among the topics presented. Also their agro-ecological adaptability, varieties and lines, propogation and planting were topics which drew wide discussion among the different participants being producers, agriculturalists and researchers. Needless to mention that agricultural practices and other problems, thinning and removal of lateral shoots, fertilization, pests and pest management, disease and disease management as well as harvest and post harvest handling issues were presented.

The objectives of the seminar were three fold:

a) To focus attention on the current position and the export potential of these two crops;

b) To improve the variety and increase production of the crops and meet the standards demanded by the international markets;

c) To focus attention on the post harvest handling of the two crops presented - Papaya and Mango

The IICA Office in Jamaica is very pleased to publish the papers presented at this seminar and certainly we embrace the hope that the information in these papers will be useful and enhance and foster the production of Mango and Papaya in Jamaica.

Dr. Armando Reyes Pacheco
Representative

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THE MARKET FOR PAPAYA

By G. Barbeau
IICA Office
Trinidad and Tobago

1) Papaya world production.

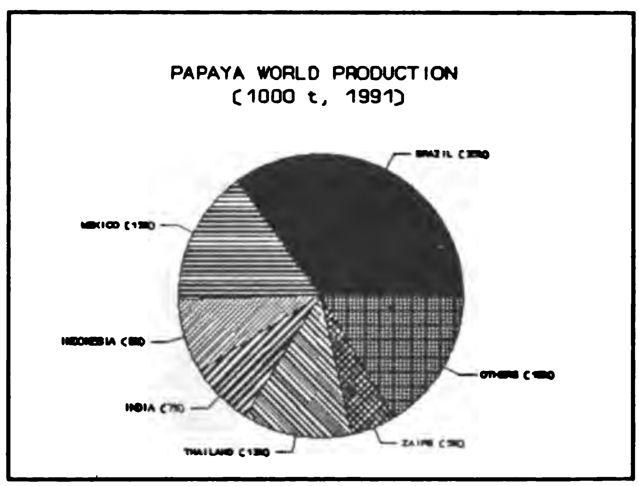
World production of pawpaw was estimated to be about 4.2 million tonnes in 1991 (FAO). Brazil accounts for 40% of the total, but a lot of African (Zaire), Asian (India, Indonesia, Thailand) and South American countries (Mexico, Costa Rica, Colombia) are also producing considerable amounts of papaya.

PAPAYA - WORLD PRODUCTION (1000 T)

COUNTRIES	1989	1990	1991
BRAZIL	1319	1350	1500
MEXICO	640	650	660
INDONESIA	323	354	360
INDIA	275	280	300
THAILAND	533	536	539
ZAIRE	205	205	208
OTHERS	703	702	698
TOTAL	3998	4077	4265

AMONG OTHERS:

MOZAMBIQUE	44	45	44
SOUTH AFRICA	26	30	30
COSTA RICA	9	9	10
CUBA	31	32	32
DOM REP	13	14	14
USA	34	31	25
COLOMBIA	80	80	80
ECUADOR	32	24	20
PARAGUAY	14	14	14
PERU	46	48	48
VENEZUELA	30	32	33
BANGLADESH	28	28	25
CHINA	76	80	82
MALAYSIA	27	28	30
PHILIPPINES	98	99	100
VIET-NAM	57	51	50



Source : FAO Production Yearbook
1991

2) Importers and exporters.

US Market.

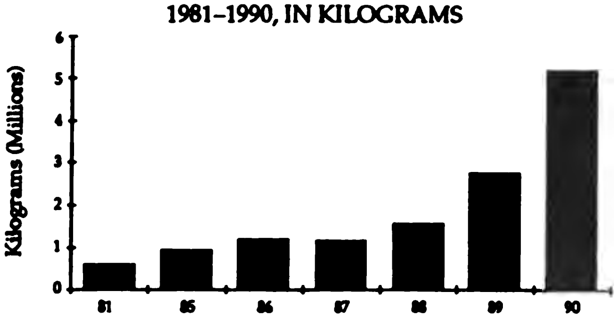
Production in the US is limited to Hawaii, with an average of 30-40,000 tonnes a year over the past 10 years, with a tendency to decrease (25,000 in 1991). Imports to the US have grown steadily to reach 5,200 tonnes in 1990, that means ten times the 1981 level. Mexico is the largest exporter to the US with about 3,000 tonnes. They are followed by the Bahamas, Belize, Thailand, the Dominican Republic and Jamaica.

U.S. Imports of Fresh Papayas, 1981-1990, kilograms

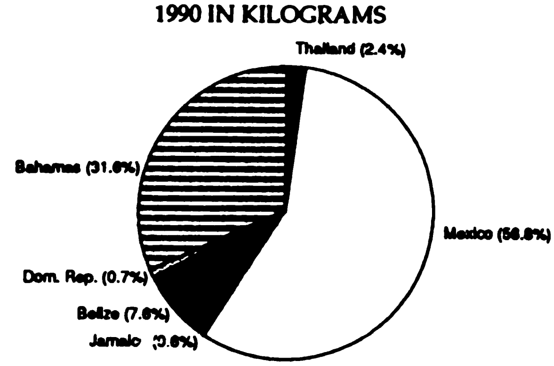
Country	81	85	86	87	88	89	90
Bahamas		700,009	362,022	91,349		264,914	1,646,910
Belgium	3,874	9,534		552		3,060	
Belize				149,910	20,431	82,331	395,873
Bermuda		23,835					
Brazil	99,655						
Chile					1,039		
China					336		
Colombia				14,660			
Costa Rica	2,275			16,734	47,352	2,970	
Dom Rep	15,508	38,438	4,358	61,572	38,262	205,159	37,354
El Salvador							
Guatemala		6,561	862				
Haiti					7,598	6,630	
Hong Kong		908					
Jamaica		21,944	16,605	145,333	312,251	40,835	43,378
Mexico		131,011	808,002	676,855	1,126,936	2,070,813	2,958,351
New Zealand				2,452			
Philippines	409						
Spain		7,627					
Taiwan							
Thailand						64,008	126,903
United Kingdom							
TOTAL	620,147	939,866	1,191,849	1,159,417	1,554,205	2,740,720	5,208,769

Source: U.S. Bureau of the Census

U.S IMPORTS OF FRESH PAPAYAS
1981–1990, IN KILOGRAMS

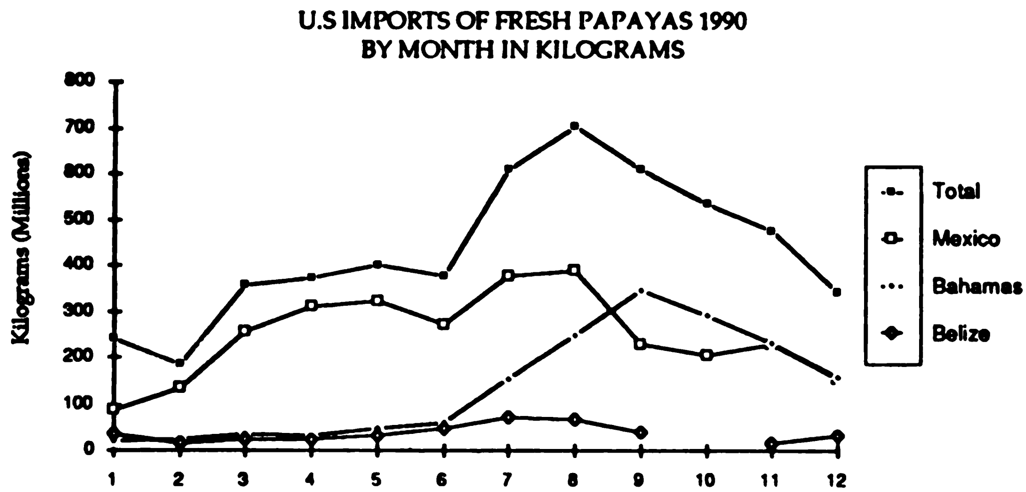


U.S IMPORTS SHARE OF FRESH PAPAYAS
1990 IN KILOGRAMS



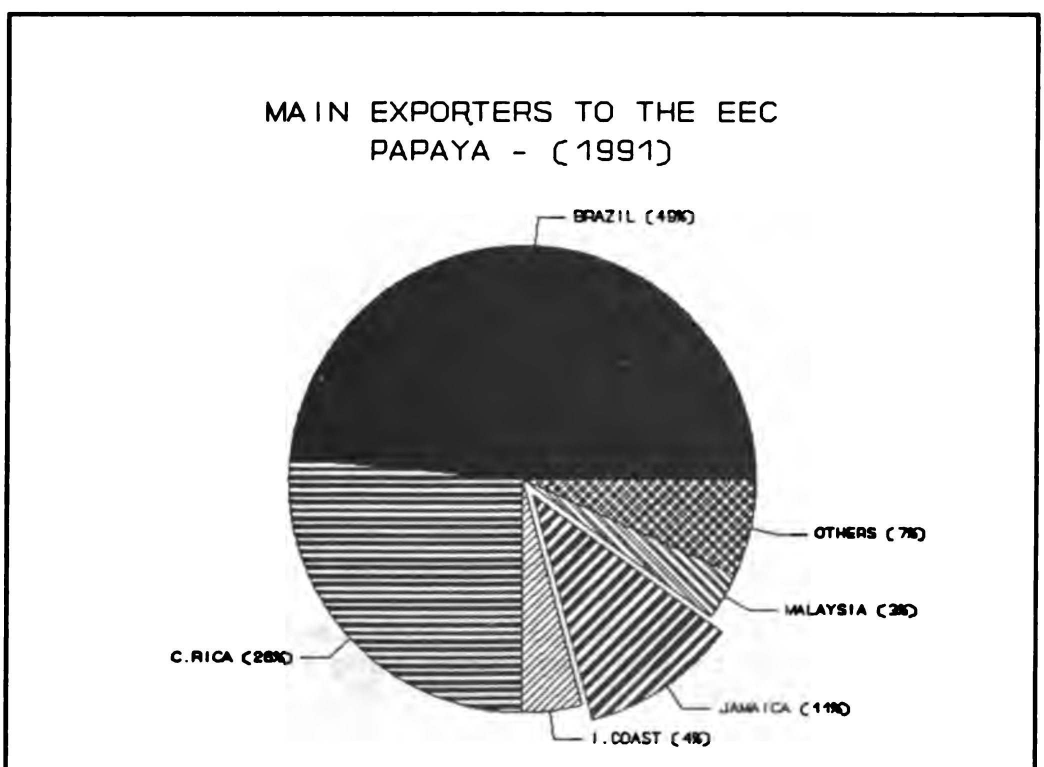
From Stephen New, TROPO-CATCO, in the Second Regional Workshop on Tropical Fruits, Antigua, December 1991

Seasonality

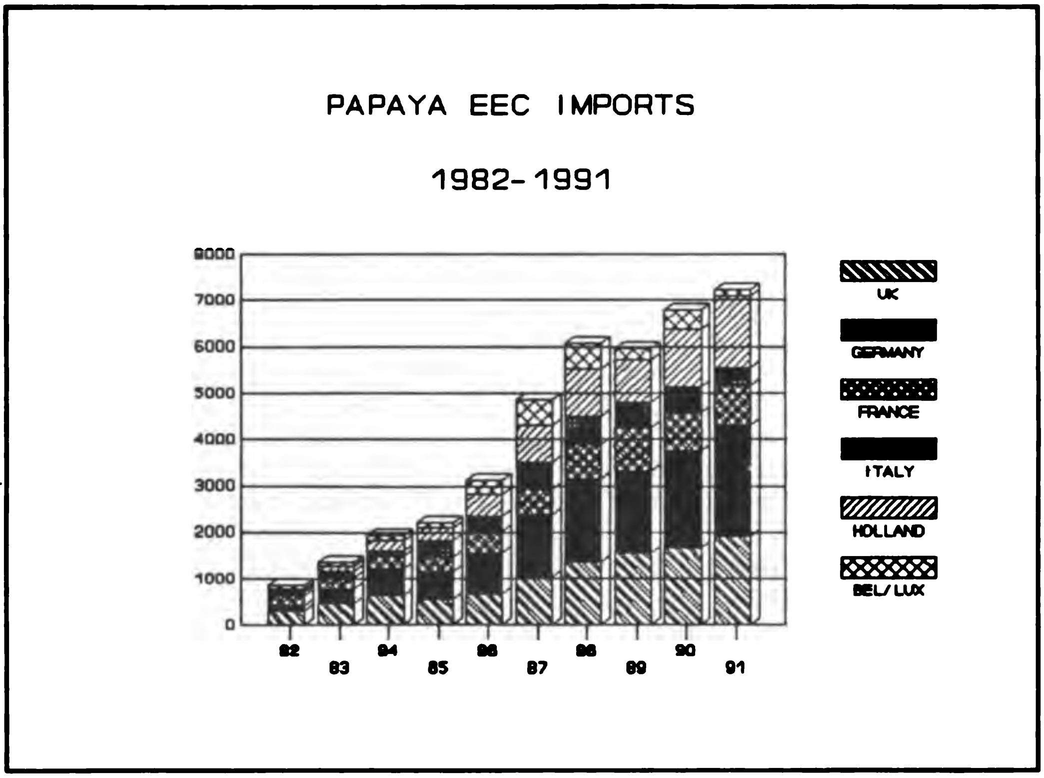


The EEC market.

Marketing of papaya has been expanding very quickly in Europe to reach 8,200 tonnes in 1991. Brazil is the main exporter with almost 40% of the total, but is beginning to lose part of the market because of the competition of new suppliers like Costa Rica (more than 20% of the market!). Brazil is present on the market all year, while other countries have a seasonal behaviour. In the Caribbean, exports from Jamaica are increasing very quickly (more than 700 tonnes in 1991) while those from Barbados have come to an end by 1990. Grenada began to export small quantities in 1989, as well as Antigua in 1991.



Main importers are Germany (27%), the UK (23%) and the Netherlands (22%) followed by France (12%). Consumers prefer small fruits, from 300 to 400 g which corresponds to the "Solo" group of cultivars or some Brazilian strains like "Amazon Red". Pink or orange flesh fruits are also preferred to the yellow ones. Fruits over 800 g are not imported. Some EEC countries intend to develop their own production (Spain and Italy), since import quality is a major problem.



The European Markets for pawpaw are in constant progress, but they experience irregular quality supply from some places. A main quality defect is lack or excess of maturity. Retailers want ripe pawpaws which can be conserved for a few days. Fruits more than 800 g are not imported in Europe. The most suitable fruits must weigh about 300 to 400 g and be sold at an affordable unitary price.

Numerous cultivars are available, but only a few are commercial in the EEC. Most important are:

SOLO: **Yellow-orange flesh, very sweet, flavoured, and juicy. Fruits weigh from 300 to 400g.**

WAIMANALO: **Firm flesh with excellent texture, sweet. Fruits are big, from 500g to 1kg, with a small cavity.**

AMAZON RED: **Red flesh, sweet and juicy. Weighs from 300 to 400g.**

EEC IMPORTS - PAPAYA (tonnes)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
U. K.	300	485	642	565	681	1029	1363	1556	1656	1908
WEST GERM	130	310	570	588	876	1362	1780	1752	2088	2413
HOLLAND	66	99	237	283	477	781	1020	909	0	1537
FRANCE	218	236	274	319	461	541	752	941	834	843
ITALY	64	138	111	355	334	589	602	568	0	391
PORTUGAL					6	76	106		0	304
BEL/LUX	81	81	101	97	309	562	564	247	0	130
SPAIN					1	70	1039	1147		50
DENMARK	3	8	12	13	54	52	45	49		13
IRELAND	1	1	4	4	11	11	8	3		2
GREECE			1	1	1	1				
TOTAL EEC	863	1358	1952	2205	3208	5074	7279	7174	7200	7591

EEC SOURCES OF SUPPLY

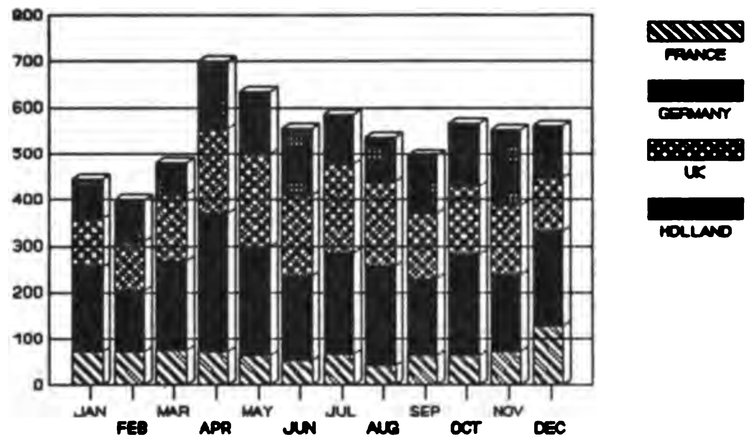
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
TOTAL EEC	863	1358	1952	2205	3208	5074	7279	7174	7500	8203
INTRA EEC	242	155	371	321	564	991	1284	1797	1524	1495
EXTRA EEC	621	1203	1581	1884	2644	4083	5994	5377	5976	6708
BRAZIL	621	1203	1480	1741	2059	2659	2094	3094	3403	3278
C. RICA					308	851	1051	1350	1416	1757
JAMAICA					15	87	55	71	386	729
IVORY COAST				100	208	247	259	234	177	289
MALAYSIA						5	10	143	146	215
THAILAND						26	71	95	68	87
U.S.A.					6	42	76	102	104	61
COLOMBIA						1	19	9	18	44
S. AFRICA						38	64	33	13	9
BAHAMAS			101		4		7			
ETHIOPIA				43	14		8			
MAURITIUS					30	14	5			
BURK.FASO					17	10	1			
OTHERS	162	46	193	175	114	103				

Source : COLEAPC

Seasonality.

SEASONALITY OF PAPAYA IMPORTS

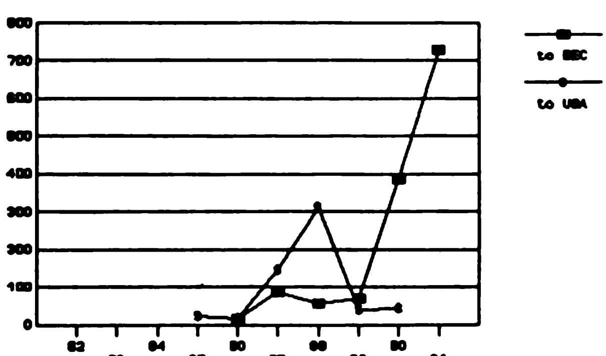
INTO THE EEC (1991)



Exports from Jamaica: After a period of export to the US peaking in 1988, Jamaica is now exporting most of its papaya to the EEC.

JAMAICA EXPORTS OF PAPAYA

to EEC AND US (Tonnes)



3) Standards

Standards for pawpaw do not exist so far, neither are there recommendations. In commercial practices, fruits for export must be healthy, clean, without latex, homogeneous in size and shape within the same box.

The reference of the pineapple classification by stage of maturity is used for the pawpaw but have not been generalized:

M1:	green to yellow
M2:	yellow on 1/3 of the fruit
M3:	yellow on 1/2 or more of the fruit

Pawpaws are highly perishable and their stage of maturity at harvest time is of much concern for export markets. If they are harvested immature, the skin wrinkles and the flesh lacks taste and fragrance. On the other hand, if they are picked ripe, it is difficult to preserve them.

Pawpaws must be packed in a single layer with protection at the base of the box. Divisions inside the box are not recommended. Fruits can be wrapped individually and reclined diagonally in the box. External sizes of the boxes are of Brazil type: 310 x 410 x 110 cm. Calibers express the number of fruits per box: 6-8-10-12-14-16. Weight can vary from 3 to 5 kg.

Pawpaws are sent mainly by air, but refrigerated sea transportation is being used by some countries. For storage for a short period of time, the recommended temperature is 15/16°C with 85 to 90% RH. For storage for a long period of time, opinions differ according to the specialists, but for a 2 to 3 week period of storage, good results are obtained with a 8.5°C temperature and 80 to 90% RH, for M^2 stage fruits. In all cases, temperatures below 7°C are responsible for an abnormal evolution of the fruit.

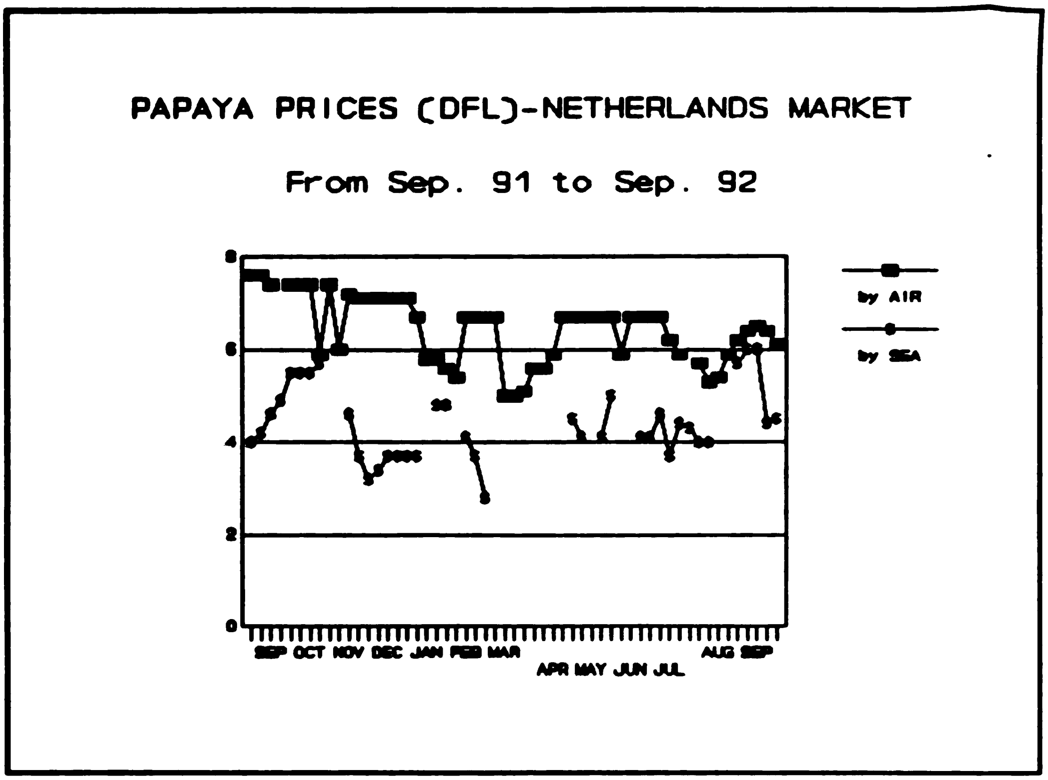
4) Prices

<u>US market</u>.

Prices are quite variable during the year and from one place to the other. Wholesales market prices in New York are higher and more regular than those in Miami or Los Angeles. (see table 1).

<u>EEC market</u>.

Prices vary from US $2.8 to 4.0/kg by air and from US $2.0 to 3.2/kg by sea. They are much more stable throughout the year than for mangoes. These prices are quoted at the importer to wholesaler stage (see table 2 for prices in the UK and Netherland markets).



Sources: COLEACP Bulletins
FAO Production and Trade Yearbooks
Second Regional Workshop on Tropical Fruits, Antigua, 1991

TABLE 1

1990 Wholesale Market Prices for Papayas - Los Angeles and New York — 1 Layer Cartons

Week	New York Wholesale Market Prices								L.A. Wholesale Prices	
	Hawaii 8s		Hawaii 9s		Hawaii 10s		Dominican Rep 5s-9s		Hawaii 8s-12s	
	Low	High	Low	High	Low	High	Low	High	Low	High
1/3	10.50	11.00	10.50	11.00					6.00	8.50
1/10	11.00	11.00	11.00	11.00					6.00	8.50
1/17	11.00	12.00	11.00	12.00					6.00	9.00
1/24	11.00	13.00	11.00	13.00			14.00	14.00	8.00	10.50
1/31	11.00	12.00	11.00	12.00			14.00	14.00	8.00	11.00
2/7	11.00	11.00	11.00	11.00			14.00	14.00	8.50	12.00
2/14	11.00	11.00	11.00	11.00			18.00	18.00	9.00	12.00
2/21	12.00	14.00	12.00	14.00			18.00	18.00	9.00	11.00
2/28	13.00	13.00	13.00	13.00			16.00	17.00	9.00	11.00
3/7	12.00	12.00	12.00	12.00			16.00	16.00	8.00	11.00
3/14	12.00	13.00	12.00	13.00					9.00	11.00
3/21	13.00	14.00	13.00	14.00			16.00	16.00	9.00	11.00
3/28	13.00	14.00	13.00	14.00			18.00	18.00	10.00	12.00
4/4			18.00	18.00	18.00	18.00	18.00	18.00	14.00	18.00
4/11			18.00	20.00	18.00	20.00	18.00	18.00	15.00	20.00
4/18			17.00	18.00	17.00	18.00			15.00	20.00
4/25			17.00	18.00	17.00	18.00			17.00	20.00
5/2			15.00	15.00	15.00	15.00			10.00	12.00
5/9	12.00	14.00	12.00	14.00	12.00	14.00			8.00	10.00
5/16	12.00	13.00	12.00	13.00	12.00	13.00			7.00	9.00
5/23	12.00	13.00	12.00	13.00	11.00	12.00	18.00	20.00	8.00	9.00
5/30	12.00	13.00	12.00	13.00	10.00	12.00	18.00	18.00	8.00	9.00
6/6	12.00	13.00	12.00	13.00	10.00	12.00			8.00	10.00
6/13	13.00	15.00	13.00	15.00					8.00	10.00
6/20	16.00	18.00	16.00	18.00					8.00	10.00
6/27	18.00	18.00	18.00	18.00			20.00	20.00	8.00	10.00
7/5	18.00	18.00	18.00	18.00			20.00	20.00	8.50	10.00
7/11	17.00	18.00	17.00	18.00			20.00	20.00	9.00	11.00
7/18	17.00	18.00	17.00	18.00	16.00	17.00			9.00	11.00
7/25	17.00	18.00	17.00	18.00					12.00	13.00
7/30	18.00	18.00	16.00	18.00	15.00	17.00			12.00	13.00
8/8	13.00	17.00	13.00	17.00	13.00	17.00			12.00	14.00
8/15	15.00	16.00	15.00	16.00	15.00	16.00			10.00	12.00
8/22	12.00	14.00	12.00	14.00	15.00	16.00			8.00	10.00
8/29	11.00	11.00	11.00	11.00			12.00	12.00	7.00	9.00
9/5	10.00	11.00	10.00	11.00					6.00	8.00
9/12	11.00	11.00	10.00	11.00	10.00	11.00			5.00	8.00
9/19	9.00	11.00	9.00	11.00					6.00	7.00
9/26	9.00	11.00	9.00	11.00					5.00	7.00
10/4	9.00	11.00	9.00	11.00					5.00	6.50
10/11	9.00	10.00	9.00	10.00					6.00	7.00
10/18	9.00	10.00	9.00	10.00	9.00	10.00			7.00	8.00
10/25	9.00	10.00	9.00	10.00	9.00	10.00			9.00	10.00
10/29			10.00	12.00	10.00	12.00			9.00	10.00
11/8			10.00	11.00	10.00	11.00			9.50	10.00
11/15			10.00	11.00	10.00	11.00			9.00	10.00
11/22			9.00	11.00	9.00	11.00	18.00	18.00	9.00	10.00
11/29			9.00	11.00	9.00	11.00			9.00	10.00
12/6			9.00	10.00	9.00	10.00	18.00	18.00	7.00	9.00
12/13			9.00	10.00	9.00	10.00	18.00	18.00	7.00	9.00
12/20			9.00	10.00	9.00	10.00			7.00	9.00
12/27			9.00	10.00	9.00	10.00			7.00	9.00

Source: USDA Market News Service (Miami, New York, Los Angeles)

Table 1 (con't 'd)

10/89 -9/90 Season Wholesale Market Prices for Papayas - Miami — Import Sources: Jamaica, Dominican Republic, Bahamas, Belize

DATE	1 Layer Carton											
	6S		7S		8S		9S		10S		12S	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
10/4												
10/11												
10/18												
10/25							6	7.5	6	7.5	6	7.5
11/1							5	7.5	5	7.5	5	7.5
11/8							6	8	6	8	6	8
11/15							6	8	6	8	6	8
11/22							6	7	6	7	6	7
11/29							7	8	7	8	7	8
12/6							7	8.5	7	8.5	7	8.5
12/13							7	8	7	8	7	8
12/20							7	8	7	8	7	8
12/27							6	8	6	8	6	8
1/3							6	7.5	6	7.5	6	7.5
1/10							6	7.5	6	7.5	6	7.5
1/17							7	9	7	9	7	9
1/24							6	7.5	6	7.5	6	7.5
1/31								7		7		7
2/7								7		7		7
2/14							7	7.5	7	7.5	7	7.5
2/21							7	7.5	7	7.5	7	7.5
2/28							7	8	7	8	7	8
3/7							7	7.5	7	7.5	7	7.5
3/14								7		7		7
3/21								7		7		7
3/28								7		7		7
4/4						7		7		7		7
4/11						8		8		8		8
4/18					7.5	8	7.5	8	7.5	8	7.5	8
4/25					7.5	8	7.5	8	7.5	8	7.5	8
5/2					7	8	7	8	7	8	7	8
5/9					7	8	7	8	7	8	7	8
5/16						7		7		7		7
5/23						7		7		7		7
5/30						7		7		7		7
6/6					7	8	7	8	7	8	7	8
6/13							6	8	6	8	6	8
6/20							6	8	6	8	6	8
6/27							6	7	6	7	6	7
7/5					6	8	6	8	6	8	6	8
7/11	6	7	6	7		8		8		9		9
7/18		7	7	8	8	9	8	9	8.5	9	8.5	9
7/25	7	8	7	8		8	8	10		9		9
8/1	7	8	7	8	7	8	8	9	8	9	8	9
8/8	7	8	7	8	7	8	7.5	9	7.5	9	7.5	9
8/15							7.5	9	7.5	9	7.5	9
8/22							6	8	6	8	6	8
8/29							7	8	7	8	7	8
9/5								7		7		7
9/12							6	6.5	6	6.5	6	6.5
9/19							5	6	5	6	5	6
9/26							5	6	5	6	5	6

Source: USDA Market News Service - Miami

destroyed. JAMPRO initiated a promotion program which h
extremely successful to date.

The crop is a viable economic activity and is presently more
than all fruit and orchard crops in Jamaica.

Table 1

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5	6	5	6	5	6

Market News Service - Miami

THE CURRENT STATUS OF PAPAYA PRODUCTION IN JAMAICA

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Prepared for and on behalf of Jamaica Exporters' Association for Seminar on Papaya & Mango. Jamaica Conference Centre, Kingston 1993 March 10-11.

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1. INTRODUCTION

Papaya is not new to Jamaica. The solo cultivars, however, are recent introductions. Commercial cultivation of papaya in Jamaica before 1983 had not exceeded five (5) acres of pure stand and was not on an organized basis. The varieties grown were restricted to the outlandish types which were used for processing and for the fresh fruit market. Very little or none at all was exported.

The parishes of St. Thomas and St. Catherine were the traditional papaya growing areas until recently. Since papaya cultivation became popular, the crop is grown all over the country with increasing acreages. Expanding from five (5) acres to over six hundred (600) acres in 1993. The crop suffered a setback in 1988 by Hurricane Gilbert when over two hundred and fifty (250) acres were destroyed. JAMPRO initiated a promotion program which has been extremely successful to date.

The crop is a viable economic activity and is presently more so than all fruit and orchard crops in Jamaica.

The crop is afflicted by several problems in production, and there are other logistical and organizational problems affecting the development of the industry.

2. PRODUCTION

The papaya crop is produced all over Jamaica under various conditions of climate, soil and agronomic practices. Prior to 1989 there were no organized production statistics available for the crop. Prior to 1989 there was no national coordination or encouragement for the production of papaya as a commercial crop. Between 1983 and 1989 investors produced an accumulative amount of five hundred and twenty (520) acres with the average orchard sizes of eighty-five (85) acres. In 1988 Hurricane Gilbert destroyed the acreage bringing it down to less than one hundred and fifty (150).

In 1989 JAMPRO began a program to promote the papaya as an economically viable crop. It was the intention to encourage investors to establish five hundred (500) acres of papaya on an annual basis to a maximum of fifteen hundred (1,500) acres in three years.

This acreage as envisaged by JAMPRO, was to produce a total of 66 million pounds (33,000 tons) with export volume amounting to 43 million pounds (19,500 tons), and 16.5 million pounds to the local fresh fruit market, and 6.5 million pounds for processing.

The ambitious program suffered a set back due to disease development and steep devaluation of the Jamaican dollar which elevated the cost of production, and axphixiating interest rates on agricultural financing.

The acreage in production fluctuates quite erratically due to a number of factors. Principal among them are:

a) Disease epidemic

b) Crop rotation procedures

c) Atrition.

2.1 Varieties

The varieties of papaya grown predominantly for commercial export are the solo types of which Sunrise solo is the most popular. Waimanalo and Kapohoo types of solo papaya were also grown, but their popularity is low due to a number of adverse horticultural characteristics under local conditions.

The large fruited varieties grown in Jamaica are mainly used for processing into mixed peels and chutneys for export and the local baking industry. These varieties are selections from the Homestead cultivars and the South American lines that are scattered throughout the island in backyard gardens and intercropping components by small mixed farms.

VARIETIES UNDER PRODUCTION

Varities	% of Area Under Production
Solo Sunrise	> 80.0
Solo Kapoho	< 00.5
Solo Waimanalo	< 00.1
Local types	< 08.0
Spanish lines	< 01.0
Homestead types	< 00.1

2.2 Acreage

The total production of papaya fruits comes from six hundred and sevent-six (676) acres of planting in various parts of Jamaica.

DISTRIBUTION OF ACREAGE OF SOLO PAPAYA - 1993

Parish	Acreage
Western Jamaica: Trelawny, St. James St. Elizabeth, Westmoreland	235
Eastern Jamaica: St. Thomas, Portland, Kingston	45
Northern Jamaica: St. Ann, St. Mary	200
Southern Jamaica: Clarendon, Manchester St. Catherine, St. Andrew	196
TOTAL	676

2.3 Potential Plantings

From the investment proposals viewed by the author, there will be well over four hundred and fifty (450) new acreage in the ground before year end, mostly concentrated in the east and southern parts of the island.

3. YIELD

The average yield from an acre of crop is twenty (20) tonnes over the economic life of 18 to 24 months. The crop commences harvest at 7 to 8 months after planting and continues to be productive for a continuous 11 to 12 months. During the 11 to 12 month continuous period of harvest, there is an average of nine hundred (900) pounds of fruit per acre per week. This yield fluctuates as a result of adverse environmental cues, biotic and abiotic diseases, insects and cultural and management prudence.

Yields vary between farms and their specific location. Some farms obtain yields above thirty-five (35) tons per acre, while others obtain as low as seven (7) tons.

In 1989, just prior to the commencement of JAMPRO's islandwide promotion programs, the average weekly production was at 80,000 pounds of which 60% was exported and the remaining 40% disposed of locally in various ways. In 1992 the average weekly production was 175,000 pounds of which 110,000 pounds (12,000 boxes) were exported and 65,000 pounds disposed of on the local market.

It is expected that during 1993, an estimated 13,000,000 pounds of fruits will be produced in the first 8 months and at the beginning of the last quarter, this may be increased to 15,000,000, if planned investments materialize and other factors are favorable.

4. LOCAL CONSUMPTION

The local demand for the solo papaya has been increasing exponentially since 1986. The amount of fruit that can be accommodated on the local market on a weekly basis, mainly through supermarkets, small marts and hotels since 1986 is shown below.

It must, however, be noted that since 1986, the amount of fruits available for the local market was determined by the export demand and fruit quality. Consequently, the volume fluctuates on a weekly basis. The volume of papaya taken off the local market has increased because there is a greater acceptance for the fruit by a wider cross section of the population. This increased acceptance does not run parallel with the demand because of the high retail price. Demand increases in the first and last quarter of the year due to heavy use of the fruit in the baking industry.

WEEKLY VOLUME AVAILABLE ON LOCAL MARKET

Year	Volume Sold Weekly	Retail Price $
1987	20,000	2.50
1988	26,000	2.50
1989	46,000	3.00
1990	50,000	4.00
1991	107,500	6.00
1992	83,000	7.50

5. TECHNOLOGY

Based upon the transfer of technology through the JAMPRO's program, the growers of commercial papaya employ appropriate technology whether semi high-tech or high-tech method of production. Without the employment of certain minimum technology the crop cannot be profitable.

Most growers employ the technology which includes the use of drip irrigation infrastructure, proper fertilization techniques directed by frequent laboratory test results, astute pest and disease management techniques based on target pest and consideration for the pesticide tolerance of the market place.

There are some growers who grow the crop under rainfed condition on slopes which cannot accommodate mechanical operation. These growers do as well as those with semi high-tech methods, in terms of fruit yield per acre, but the export yield is lower.

5.1 Technology Transfer

The Government Department of Agriculture is not involved in the transfer of technology. JAMPRO had employed the services of consultants from the private sector and from overseas for about one year, but this has been discontinued. The Jamaican Society of Agricultural Sciences (JSAS) also assisted by inviting international scientists to work in collaboration with local consultants in transferring technology.

To date, the industry has no organized and sustained program for technology transfer.

6. COST OF PRODUCTION

The cost of production of papaya vary according to the following parameters:

a) Location of the farm and relief.

b) Technology employed.

c) Farmstead inclusions.

d) Capital requirements.

The cost of production per acre in a high-tech farming system, when the investor will undertake all the farm development preliminaries is about J$90,000 per acre.

Those growers who do not initiate farm development preliminaries and have all the farmstead in place prior to establishment would be required to invest about $50,000 per acre.

(See Table overleaf [Page 10] for detail)

professional agriculturalists are available for training. Ther enough land area in Jamaica on which papaya can be grown to amount of three thousand (3,000) acres without any loss to the oth traditional export crops and vegetables.

7. SCOPE FOR PAPAYA IN THE AGRICULTURAL SECTOR

The scope for papaya being a dominant crop in the agricultural sector is extremely good, and it has the potential to be one of the front-line foreign exchange earners.

The papaya crop has generated interest among the entrepeneural class of farmers with large acreages of land, and who have or can acquire the technology for its production. The ecological factors that favor the maximum exploitation of the crops' propensities for profitable production exist all over Jamaica.

The soils are favorable, except in certain areas where poor drainage and adverse soil reaction exist. The papaya currently in production is on soils that represent the various types existing in Jamaica. The levels of success under each condition is varied and the management and husbandry practices employed in each case to realize success is different.

Water, being one of the key requirements for a good crop, exists in all major areas suitable for crop production in Jamaica.

The know-how and technology for successful papaya production exist in Jamaica, though not widespread among agriculturalists and farmers. The opportunities for training exist and sufficient professional agriculturalists are available for training. There is enough land area in Jamaica on which papaya can be grown to the amount of three thousand (3,000) acres without any loss to the other traditional export crops and vegetables.

The demand for the Solo Sunrize papaya on the North American and European markets is growing steadily, and without any promotions or marketing drive, over 65 tons are exported weekly. Each large grower has his own overseas market and there are numerous brokers and marketing companies that have shown interest in this Jamaican fruit. There are international fruit giants that have expressed interest in the Jamaican production, but the small acreage currently produced cannot excite their interest. All of the production is destined for the north eastern seaboard of North America and the United Kingdom.

The price paid for the fruit on the U.S. market in 1992 vary from a low of US$5.50 per box to a high of US$8.00 per box. This pricing structure gives a very encouraging gross return per acre of US$23,760 (J$527,472) or US$14,256 (J$316,483) in net export revenue.

The local fresh fruit market is presently demanding over seventy-five thousand (75,000) pounds per week in Kingston and the hotel trade. If the price of the fruit falls to a level of affordability by the lumpen, the demand may double that amount.

The processing of papaya into chutneys, puree, candied and nectars is another use to which the fruit can be put. The local confectionery and baking industries presently use papaya in their operations. Some of these by-products can be developed and marketed internationally.

In summary, the papaya has great potential for fresh fruit sale and tremendous agroindustrial potential.

8. AREAS OF CONSTRAINTS

The success of a papaya industry or a national papaya development and expansion program is inextricably bound to a number of auxillary services, operations and technological inputs. If one or more of these components are limiting, the program may be constrained with a resulting disappointing expectation.

These inputs and services are:

1. Comprehensive coordinated marketing plan.
2. Cargo space (air or sea).
3. Pre-export holding facilities and pre-cooling.
4. Planting materials.
5. Availability of credit.
6. Technology and personnel.
7. Infrastructure.

8.1 Cargo Space

This is one of the most important services that will determine the ultimate success of the industry. For the seven years that papaya is exported from Jamaica, there has been a major problem with cargo space.

There is no adequate cargo space available to export to Europe. Any one grower can and will occupy all the space available to London in any one day. Sea freight is available, but the pre-conditioning of the fruits prior to such voyage is not available.

8.2 Holding or Pre-Export Facilities

There is no adequate pre-export facility at either of the two airports and seaports. Growers who export large volumes of fruits do not have pre-conditioning facilities to meet the demand for standard, especially in the summer time.

8.3 Planting Material

Currently, seeds are obtained from two main sources:

a) Imported: mainly from Hawaii via Florida.

b) From a farmers plot: they a select a few trees and collect seeds from them.

The cost of seeds from Hawaii is very high and also the seeds are not necessarily adapted to the ecological and biological conditions of Jamaica. These considerations force potential investors to purchase from existing farmers. Some farmers purchase seeds from other growers or fruits, as a result of the paucity of knowledge of the farmers in the seed selection process, a high degree of variability occurs. The variability is already noticeable where, from tree to tree, there is a wide difference in tree uniformity, yield and fruit quality.

8.4 Technology

Because of the lack of experience for the commerical production and post harvest handling of these crops, Jamaica started out by introducing technology from Hawaii. Unfortunately, these imported technologies were implemented without being validated by scientists or growers. Consequently this situation brought about biological, nutritional and physical problems which neither the growers nor most technicians involved were ready to deal with.

There is no information bank in the Ministry of Agriculture. There is no instructional manual for papaya growing. There are no books on the problems associated with papaya production.

8.5 Infrastructure

Roads and irrigation facilities are important, and so too is export facilities for holding.

9. STRATEGIES EMPLOYED FOR THE DEVELOPMENT OF PAPAYA (CROP) INDUSTRY

The strategy employed by JAMPRO encompasses the sensitization of all support services and the cooperation of the growers with the coordination and promotional efforts.

9.1 Coordinating and Promotion

JAMPRO is promoting the growing of the crop throughout the country by sensitizing present growers and potential growers to the profitability of the crop and the soundness of the venture.

The promotional strategy employed by JAMPRO are:

a) Providing marketing informaion and market linkage.

b) Providing technical and financial data.

c) Encouraging financial institutions to provide credit support.

d) Coordinate the production of planting material needed crop expansion.

e) Arrange for technical assistance and technology transfer.

f) Trade information and market intelligence.

10. RECOMMENDATION

1. Transportation to the export market is problematic. To circumvent this limitation, there should be the use of sea freight. The shipping lines should be organized or sensitize to meet this challenge.

2. There is need for another pre-export facility in the west of Jamaica where more than 40% of the crop is grown.

3. There is need to upgrade and make more efficient the present pre-export facility at the Norman Manley Airport.

4. There is need for a pre-cooling facility with controlled environment gadgets for removing field heat (especially during the periods of high temperature) to delay ripening.

5. There is need for technical and logistic support for the production, post harvest and export activity of the papaya through the development of a sustainable system of technology adapted to the local conditions. To this end, the following should be done:
   a) There is need for higher quality seeds to be available to the farmers.

   b) There is the need for a cadre of agriculturalists and farmers to be trained on various aspects of the pre-production, production, harvesting, post harvest handling and shipment of papayas.

c) There is need for standardized quality control to ensure that product of certain minimum standard leaves Jamaica.

d) There should be the development of a technological package to be made available to all concerned.

e) All persons concerned with the papaya should be familiar with the major technological problems associated with the crop. This may be done through the production of pamphlets, fact sheets or bulletins.

6. A program for generating and transfer of technology should be invoked.

7. There should be the establishment of export quality standard.

Production of Papaya

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INTRODUCTION

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

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

I. Botany and General Aspects of the Papaya Plant

1.1 Taxonomy

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

— Carica
— Cylicomorpha
— Jacaratia
— Jarilla.

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

1.2 The Plant

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

1.3 The Flowers and Fruits

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

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

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

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

II. Varieties

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

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

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

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

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

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

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

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

Source: Marte (1986)

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

III. Propagation and Seed Production

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

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

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

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

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

3.1 Sexual Propagation

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

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

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

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

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

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

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

- Select the most outstanding bisexual plants in the grove showing desirable characteristics of yield, quality and tolerance to problems.
- Cover the flowers with small paper bags just before they open. Ensure the flowers are mature; this is easily recognized by a change in the color of petals from a pale to a deeper yellow color.
  In covering the flowers be sure that:
  - The bag is tied so no insects will penetrate
  - The tie will not strangle the peduncle causing the flower to abort.
  - The inside of the bag does not touch the flower.
  - The bag is secure enough not to wave with the wind
- Remove the bag 12 days after bagging the flower.
- Gently mark the fruit to ensure that this can be identified up to the date of harvesting. This can be done with permanent markers at the base of the fruit peduncle or by tying colored cotton strings on the peduncle.

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

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

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

The use of fresh seeds is always recommended. However, seed storage is usually required. When storing seeds it is important to ensure that they are properly dried and packed in plastic bags. The seeds can then be placed in the vegetable compartment of a refrigerator. A drop in the viability will be noticeable after 5–6 months but seeds under these conditions should last for 12 months, maintaining at least 80% germination.

IV. Ecological Factors

The papaya plant prefers fertile soils with good drainage, an abundant well distributed rainfall (800–2000 mm) and warm temperatures of 25–30°C. The plant does not tolerate strong winds, flooding or prolonged dry periods. However, the plant is adapted to a wide variety of soil types as long as they have good drainage and salt content levels are normal. Therefore, heavy clay soils and saline plots should be avoided. It does better on soils with a pH near neutrality (6.5).

At high elevations or cooler temperatures, plants are late in flowering, fruit maturity is slow and the fruits normally develop with a lower brix. High air humidity facilitates development of fungal diseases while very low air humidity usually means a need for more frequent irrigation. Plants subjected to waterlogging, shed their leaves, flowers and fruits and may die if the root system is badly affected. Under a prolonged dry spell leaves wither and flowers and fruits are shed. Fruit size and fruit quality are also affected by the amount of water available. A fruit growing under high soil moisture is larger and develops a watery pulp which is easily damaged during transportation. A plant growing under dry conditions bears fruits which are smaller and hard to eat.

V. Planting

5.1 Land Preparation

Land preparation depends on the type of soil, area to be planted, purpose of the orchard, and the equipment and labor available. For example, clearing can be done with machinery or by hand, the soil can be harrowed throughout or only partially. Sometimes only the spot where the plants are to be located is manually worked out with a hoe. Large contour terraces may be necessary or 'eye-brow' terraces individually constructed. In general, for flat land on a moderate acreage, the plot is cleared and harrowed once or twice. Depending on the drainage and the topography of the plot, the construction of a drainage system may be necessary. In some cases the soil may need to be chiselled and beds of various widths and heights constructed.

5.2 Layout

For good yield and high fruit quality it is important to orient the orchard to favor wind direction and maximize the use of sunlight, but it is also important to orient the orchard to prevent soil erosion. The selection of a suitable planting system depends on many factors including the variety to be grown, the topography of the plot, the scale of the operation and the machinery available for all operations within the future orchard.

As with other fruit plants, papaya can be planted under three basic systems: Square, rectangular and triangular. A combination of these systems is also possible, e.g. a double-row system. The square system is more common on small plots with limited mechanization of operations. The triangular system is used on soils with pronounced slopes. The rectangular system is the most common and mainly used where some mechanization is needed, e.g. for weed control. Recommended plant spacing varies from 1 to 3 m between plants within the rows and 2 to 5 m between rows. Plant density varies from 1000 to 3000 plants/ha. Some varieties support a higher plant density than others e.g. Barbados Yellow CP-5, Kapoho and Sunrise produce a lot of rejected undersized fruits when planted at more than 2000 plants/ha while Barbados Pink and the Tainung hybrids can support as much as 3000 plants/ha. The distance between rows may be increased to accommodate cultivation or harvesting equipment or simply for inter-cropping systems.

5.3 Establishment

Papaya is not the only plant to be established in a papaya orchard. Windbreaks, as well as inter-crops are frequently part of the orchard and need to be established as well.

5.3.1 The papaya plant

The size of the planting hole is directly related to the container in which the plants have been growing. In general, the hole should be twice the width, height and diameter of the container. It is always convenient to apply well decomposed manure mixed with top soil at the bottom of the hole. The container should be completely removed and plants with physical damage to the root system should be avoided. Three plants are normally planted in a triangle, each separated by at least 15 cm. The three plants are used to compensate for plant losses and will allow for selection of one hermaphroditic plant in most cases. When setting the plant in the hole, ensure that the level of the soil in the container is about the same level as the surface of the soil where it is planted. If necessary, a small basin is constructed around the plants to facilitate irrigation. Where irrigation is by furrow, small cambered beds are recommended and planting should be done in the middle between the top of the bed and the bottom of the furrow.

5.3.2 The windbreak

Papaya plants are very susceptible to strong winds therefore, protection should be provided whenever there is the hazard for wind damage to occur. Rows of sugar cane, banana, plantain and pigeon pea make excellent, temporary, live windbreaks for papaya. More permanent crops such as jamoon, cassuarina, etc. can also be used. In all cases live windbreaks should be established long before planting the papaya plants. Physical barriers can also be constructed with saran netting and polypropylene sacks.

5.3.3 The inter-crop

Inter-cropping with papaya is possible in two ways: (*a*) Using papaya as the main crop, and (*b*) using papaya as a temporary crop, e.g. within perennial plants such as citrus, mango etc. In the first case a quick-growing crop is selected. Peas, peppers and beans are among the most commonly used. Tubers and root crops such as yam, potato, sweet potato and cassava should be avoided since their cultivation and harvesting may damage the papaya root system. Species within the Cucurbitaceae family, e.g. cucumber, squash and other vine crops should also be avoided because their vines are difficult to keep away from the plant and normally will cause physical damage to the papaya fruits.

VI. Cultural Practices

6.1 Sexing

This term refers to the selection of hermaphroditic plants and the removal of male and female plants from the plot. However, the term has been extended to cover the removal of poor growing seedlings and plants affected by diseases prior to or at the time when the sex of the first flower can be identified. Thinning to only one plant per hole is done soon after hermaphroditic flowers can be identified. Since the female plants are more precocious than the bisexual, in most cases these are eliminated first facilitating the development of the other two plants. However, for small-scale operations, if only two plants remain per hole and the first flower to set is a female, this plant should not be removed until the other proves to be a bisexual plant.

Delays in sexing the plants may result in slender plants. In this case the first flowers are borne high on the stem losing productive space and time and making harvesting a more difficult operation.

6.2 Weed Control

No different from other crops, weeds on papaya fields must be controlled early in order to avoid competition and eliminate chances that these may become hosts for vectors and other insects. A rapid cleaning of the field will prevent the weeds having a chance to seed, making the future maintenance of the plot easier. It is advisable to clean the whole area of weeds except in cases of steep slopes where the weeds are maintained as a cover crop to reduce erosion and only mowed. Even in these cases it is advisable to maintain an area of about 1 m all around the trunk free of weeds. This area is usually referred to as the 'drip area'.

Most contact herbicides, e.g. paraquat, can be used on papaya fields as long as they do not touch the leaves or the stem while the latter is still green. The same applies for some systemic products such as Roundup. Grass killers such as Fusilade, Daconate, and Asulox are quite useful but some side-effects such as cracking of the stem were noticed in Barbados when using Daconate.

Pre-emergent herbicides are being used by several producing countries. Among these are Diuron, Dalapon and Goal. However, based on experiences in Barbados, the Dominican Republic, Antigua, Grenada and St. Vincent where application of Diuron and Dalapon caused flower abortion, fruit shedding and reduction of yield, the recommendation is that the product should be tried on a few plants before doing the application orchard-wide. Application of Diuron on heavy soils is not recommended.

Burning the stem with herbicide facilitates the entrance of *Phytophthora* and speeds up the decline of the plant even if this occurred in the early stages of development. This damage is commonly found when the herbicide is applied carelessly or without protecting the stem of the young plant.

It is difficult to prevent some drift of the herbicide during application and avoid touching the stem, even when a shield is used. This happens especially where winds are strong and frequent. The use of large buckets to cover individual plants in two or three rows at a time is a good practice to protect young plants. These buckets are systematically moved to other rows and weeds too near to the plant are manually removed. A similar practice is the one using a large plastic bag from the moment the papaya plant is transplanted. This bag is unfolded to cover the stem as the plant grows. The bag remains covering the stem at least for the critical period during which herbicide drift may affect the stem. The bag is supported by staples.

When the weeds are tall, the use of a 'chemi-hoe' is useful to prevent drift damage.

The papaya plant is very susceptible to 2, 4-D sprays used in plots nearby. Mature and young leaves normally curl and young leaves may be distorted, resembling leaves from plants affected by virus.

6.3 Fertilizer Application

This cultural practice if not the most critical, is undoubtedly one of the most important practices to obtain a good yield and high quality fruits. The papaya, unlike other fruit crops, is growing and bearing continuously. Therefore, to obtain good yields and to expand the tree life, water and nutrients must be continuously available.

Our region is characterized by a shortage of reliable laboratories where soil analysis and recommendations can be obtained to advise the grower of what and when to apply in a short but reasonable time. Due to this, empirical recommendations based on country experiences are useful.

A usual practice in most producing countries is to recommend a pre-planting application of $N:P_2O_5:K_2O$ at a ratio of 1:3:1, to the hole and the area immediately surrounding it.

In the particular case of papaya, phosphorus is particularly important for young plants, while potassium is needed after flowering. Nitrogen availability is critical at all stages from growth to flower and from fruit setting to fruit maturity.

Foliar analysis is useful in determining whether the contents of macro and micronutrients are adequate or deficient for a good yield and fruit quality. Studies conducted at the University of Hawaii showed optimal levels of nutrients in papaya leaves collected during the flowering period and related them to a very high production on soils with pH 5.9. These results are presented in Table 3.

Table 3: Percentage of macronutrients found in papaya leaves and petioles after flowering period related to a very high production in Hawaii.

	N (%)	P_2O_5 (%)	K_2O (%)
Leaves	1.15	0.185	2.78
Petioles	1.3	0.164	5.2

Cunha (1979) in Brazil determined the concentration of micronutrients and related them to the absorption by stems, leaves, flowers and fruits of 1650 plants/ha at different ages. The results are shown in Table 4.

In the same study Cunha (1979) also determined concentrations of macronutrients in dry matter and related those to the absorption by stems, leaves, flowers and fruits. These results are shown in Table 5.

Most producing countries have given general recommendations in terms of total or monthly applications for commercial production of papaya. Following are some of these recommendations with their respective reference.

HAWAII:
Ito et al.
225-450 g of 10-10-10 per tree per month.

University of Hawaii (1970)

At planting:	10-10-10; 62–144 g around the plant
From 3–5 month:	10-10-10; 80 kg/ha
After 5 months:	every month 10-10-10; 320 kg/ha
After harvesting:	every month 10-10-10; 454 g/plant

BRAZIL:
Anda (1971)
90 g N, 90 g P_2O_5 and 90 g K_2O per plant in three applications.

Pipaemg (1972).

Before planting:	20 l of pen manure, 60 g P_2O_5 and 30 g K_2O.
After planting:	Two applications of 20 g N, one application of 20 g N, 40 g P_2O_5, and 60 g K_2O.

ANGOLA:
Xabregas and Santos (1967)

Before planting:	10-10-10; 50 g/hole
3-4 months after:	10-10-10; 250 g/plant
Second year:	10-10-10; 500 g/plant when rains start and repeat at middle of rainy season.

INDIA:
Rao and Shanmugavell (1971)
50 g N, P and K every 2 months, until the seventh month.

SOUTH AFRICA:
Malan (1964)

At planting:	454 – 667 g/hole of superphosphate
Before harvesting:	56 g of a 20% nitrogen fertilizer; repeat every 6 weeks until plants are 1 year old.
After first harvest:	450 g superphosphate/ plant/ year during the Spring. NPK with ratio 2:1:2 or 2:1:3 for more potash deficient soils.

AUSTRALIA:
Cann (1966)
675 g/plant for the first year and 900-1350 g for older trees of NPK (8-12-6)

VENEZUELA:
Millan (1978)

	(g/plant)		
	N	P_2O_5	K_2O
Less than 6 months	10	10	15
6-12 months	40	40	60
More than a year	100*	100*	150*

*In two different applications.

BARBADOS:
Marte (1986)
12-12-17-2 at the following rates:

Planting:	110 g/plant
1-3 months:	110 g/plant/month
3-7 months:	335 g/plant/ month
after:	450 g/month

Complement with chelated micronutrient mixture (Mg, 2%; Mn, 3%; Fe, 1.5%; Zn, 0.5%; S, 4%) as follows:

4.5 l/ha at 2.5 months after planting
11.9 l/ha at 7 months after planting
11.9 l/ha at 11 months after planting
9.5 l/ha at 15 months after planting

Different studies on papaya have shown that applications of N, P and K can block or increase the absorption of other nutrients. For example application of N can induce a decrease in the concentration of K, P and Ca and/or increase the percentage of Mg, S, Mn, Zn and Cu. Applications of P can induce increases in the levels of Ca, S and Cu, while K can decrease the percentage of N, Ca and Mg. Studies conducted in Barbados by the author (Marte 1990, Unpub.) showed that deficiencies of Mn, Fe and Zn cause papaya plants to take up chlorine. This normally causes a severe chlorosis and decline of the plant which affects yield and may eventually kill it.

6.4 Irrigation

Unlike other crops, e.g. mango, papaya does not need a rest period in order to flower and set fruits. These are set on a continuous basis and therefore the papaya plant requires available water to grow and bear continuously. In general, the amount of water needed is influenced by the stage of development, spacing,

Table 4: Mean concentrations of micronutrients in dry matter and average absorption by the aerial parts of the papaya plant at different ages.

Micronutrient	Days from planting	Concentration (ppm) Stem	Leaves	Flowers & fruits	Absorption (g/ha) Stem	Leaves	Flowers & fruits	Total
	120	32.5	52.2		0.3	0.6		0.9
Boron	240	26.0	23.0		13.4	23.8	6.1	43.3
	360	23.5	38.0		39.1	42.8	19.6	101.5
	120	5.5	9.2			0.1		0.2
Copper	240	8.0	8.7	6.0	4.1	4.9	1.3	10.2
	360	9.0	7.0	6.7	15.8	8.0	6.0	29.7
	120	105.2	192.7		0.9	2.5		3.4
Iron	240	49.5	72.2	52.2	25.8	43.3	11.3	80.4
	360	85.0	123.2	62.7	147.8	136.7	53.6	338.1
	120	47.2	109.5		0.4	1.4		1.8
Manganese	240	49.5	77.2	66.7	25.8	43.3	14.2	83.3
	360	39.2	99.2	33.2	69.2	112.7	29.4	211.0
	120	0.05	0.215		0.0005	0.0025		0.0030
Molybdenum	240	0.03	0.095	0.165	0.0157	0.0538	0.0353	0.1048
	360	0.043	0.083	0.103	0.0718	0.0926	0.0899	0.2543
	120	24.25	19.5		0.21	0.25		0.46
Zinc	240	31.25	17.2	51.2	15.5	21.1	10.99	47.58
	360	32.50	19.7	26.0	56.2	27.8	22.3	106.4

Source: Cunha

Table 5: Mean concentrations of macronutrients in dry matter and average absorption by the aerial part of the papaya plant at different ages.

Micronutrient	Days from planting	Concentration (ppm) Stem	Leaves	Flowers & fruits	Absorption (g/ha) Stem	Leaves	Flowers & fruits	Total
	120	0.9	3.2		0.1	0.4		0.5
Nitrogen	240	1.2	3.6	2.0	6.1	20.0	4.44	30.8
	360	1.8	4.2	2.9	30.8	47.9	24.9	103.6
	120	0.2	0.3		0.0	0.0		0.1
Phosphorus	240	0.1	0.3	0.4	0.7	2.0	0.8	3.5
	360	0.2	0.3	0.3	3.4	3.4	2.9	9.7
	120	2.8	2.3		0.3	0.3		0.6
Potassium	240	2.1	2.6	2.8	10.8	14.8	6.1	31.7
	360	2.6	3.2	3.1	44.7	36.4	27.3	108.3
	120	0.9	1.4		0.1	0.2		0.3
Calcuim	240	0.9	1.2	1.1	4.6	7.0	2.4	13.9
	360	0.9	1.5	0.6	14.7	16.8	5.4	37.0
	120	0.4	0.5		0.0	0.1		0.1
Magnesium	240	0.4	0.4	0.4	2.1	2.3	0.9	5.3
	360	0.5	0.5	0.5	7.9	5.3	2.4	15.7
	120	0.3	0.5		0.0	0.0		0.1
Sulphur	240	0.3	0.3	0.4	1.7	1.9	0.9	4.6
	360	0.3	0.3	0.3	5.3	4.0	2.6	11.9

Source: Cunha (1979)

soil water retention capability, the topography, the temperature, the wind intensity, and cloudiness. General estimates suggest that papaya in its productive stage requires an average of 25 mm/week. Prolonged periods of drought affect yield and fruit quality. Leaves and flowers, as well as young fruits are shed under these conditions. Fruits developed under water stress are smaller and have a hard pulp which is difficult to eat. In general, young plants are more tolerant to dry spells than mature plants.

There are different systems in use today for irrigation of papaya. Each of them offers comparative advantages and disadvantages in terms of costs and effects; growers should analyze these before making an investment. Some of these are presented in Table 6.

Although at the initial stage one dripper per hole may be sufficient to supply the amount of water required, the number should be increased as the plant grows. Otherwise the papaya plants have a tendency to concentrate roots only on the side where the water is being applied, limiting its absorption area and its anchorage ability. This is one of the several advantages of microsprinklers over the drippers since there is a better distribution of water in the 'drip' area.

6.5 Removal of Lateral Branches

Some cultivars have a tendency to produce many axillary suckers. These should be removed early since they are borne at the same site where flowers and fruits are set, bruising the fruits in their early stage of development. Moreover, studies have shown that these shoots are preferred by mites where they hide from the effects of contact with miticide. A high concentration of N normally induces an increase in the production of these lateral branches.

6.6 Pesticide Spraying

The equipment used to spray chemicals in the grove depends largely on the scale of the operation, the topography of the terrain, the type of soil and the age of the plants. Large-scale planting requires large equipment such as power mist-blowers. In most cases however, knapsack sprayers are used for young plants. In cases where the soil is heavy it is important to avoid soil compaction. Therefore the use of heavy equipment such as ordinary tractors should be avoided. In those cases low pressure tyres and light vehicles, e.g. ATV, are useful.

Papaya plants are very susceptible to phyto-toxicity which can be easily induced by a high application pressure. Therefore calibration of the equipment prior to each application is important in order to avoid heavy stresses, fruit damages and burning of leaves.

In particular two products have been shown to be phytotoxic to papaya at any rate: Diazinon and Omite (also sold as Comite). However, phytotoxicity only occurs when a liquid formulation is used, not for the WP formulations.

Table 6: Advantages and disadvantages of different irrigation systems for papaya.

System	Main advantages	Main disadvantages
Furrow	Inexpensive initial investment	Waste of water. Not adapted to slopes. Facilitates soil erosion, leaching of nutrients and root diseases
Drip and micro sprinklers	Saves water Minimizes nutrient losses Facilitates fertilization by fertigation	High initial investments
Overhead	System can be used for other crops or plots	High initial investment. Impact of water may damage flowers and fruits

VII. Harvesting

The time from planting to fruit maturity varies mainly with the cultivar used and the temperature under which the papaya is planted. In tropical climates, fruits maturing during the summer take an average of 7 months from transplanting while fruits maturing during the winter usually take 8–9 months to mature. Those maturing during the autumn are intermediate (8 months). However, in sub-tropical climates, e.g. Hawaii, the plants take a longer period, usually 12-14 months, to mature the first fruit. Additionally, under tropical conditions harvesting is done three times a week while under sub-tropical conditions it is done once or twice per week.

Harvesting is done at the first change of color from green to yellow. This operation is first done manually or with the help of a knife. However as the tree continues to grow, additional help is required. When the fruit cannot be reached from the ground harvesting tools are useful. The use of a ladder (step or one flight) is common but cumbersome since the person harvesting has to move it for every individual plant being harvested. The Thailand harvester is an ideal tool but the harvest crew must be trained to hold not more than two fruits at the same time. The use of mechanical platforms although more expensive, is justified for large-scale orchards in flat or gently sloping terrain. There are many modifications, from pneumatic to interchangeable platforms.

In most cases the economical life of a papaya plant in the Caribbean is 18 months, after which it is preferable to replace it. This represents 9-11 months of harvesting. Yield is highly variable but a good production should average 90,000 kg/ha (80,000 lb/ac) of total fruits over the 18-month period.

VIII. Main Constraints to Production

Undoubtedly, the main constraints to the production of papaya in the Caribbean are those related to pests and diseases. Among these bunchy top, *Erwinia* and distortion ringspot virus head the list. Unfortunately, the only papaya improvement programme in the Caribbean, initiated in Barbados in 1983, is no longer active. An exception is the effort being made by INRA and IRFA in looking for tolerance or resistance to *Erwinia*. However, any serious attempt to develop the papaya industry in this region will have to address these and other problems as a package and not in piecemeal fashion. Following is a list of the most important needs.

8.1 A Papaya Improvement Programme

The most important role of this programme would be the development of new lines or improvement of the existing ones looking for:

— Tolerance or resistance to bunchy top, *Erwinia* and distortion ringspot. The final product should be a homozygous hermaphrodite variety.

- Elimination of the Carpellody condition.
- Reduction of the ovarian cavity.
- Elimination of 'crazy sex' (sterile hermaphrodites).
- Tolerance to drought.
- Tolerance to mites, thrips and other pests.
- Tolerance to waterlogging.
- High efficiency under low input management.

8.2 An IPM Programme Adapted to Local Condition

Such a programme would involve:

- Study of local natural enemies of main pests; if necessary introduction of others.
- Testing with less harmful chemical products.
- Determination of the level of pest population needed before recommending spraying.

8.3 An Applied Research Programme

The following should be addressed in this programme:

- Cultural practices, e.g. amount, kind and frequency of fertilizers, chemical weed control, etc.
- Spacing.
- Inter-cropping.
- Post-harvest, e.g. treatments, chemical residue studies, packaging, shipment by sea, etc.
- Cross-protection studies.

8.4. Promotion in the Market.

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MAIN LIMITING FACTORS TO THE COMMERCIAL PRODUCTION OF PAPAYAS IN THE CARIBBEAN

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Abstract:

Commercial production of papayas oriented to the export market has been attempted in almost all Caribbean and Central American Countries. However, few of these countries have been able to maintain a sustainable production and supply, despite the significant increase in the demand. With few exceptions, viruses eg. Distortion Ringspot and mycoplasma i.e. Bunchy Top has consistently been blamed as the only limiting problems. This paper discussed these and other problems which are often overlooked and are as important as the former. In fact, data from field studies conducted in the Caribbean showed that quite frequently DRV and Bunchy Top are triggered by mineral deficie[illegible] and are quite often second to these deficiencies and other fa[illegible]s.

Resumen:

La producción comercial de Papaya orientada al mercado de exportación ha sido intentada en casi todos los países del Caribe y Centro América. Sin embargo, pocos son los que han logrado mantener una producción y oferta sostenida a pesar de un aumento significativo en la demanda. Salvo algunas excepciones los virus ej. El virus del anillado y la distorsión (DRV) y el mycoplasma ej. Bunchy Top (BT), han sido señalados como los únicos factores limitantes. Este trabajo discute esos y otros problemas que frecuentemente son ignorados y son tan importante como el DRV y el BT. Datos provenientes de estudios de campo hechos en el Caribe muestran que frecuentemente el virus del anillado (DRV) y el Bunchy Top son incentivados por deficiencias minerales y usualmente son segundo a estas deficiencias u otros factores.

Introduction and Background:

The commercial cultivation of Papayas in the Caribbean Region is oriented mainly to supply local demand and as such quality control has been always second to quantity. Nevertheless, the oportunity to export to extra-regional markets and the successful attempts to compete with traditional suppliers, such as Brazil and Hawaii, have encourage several Caribbean countries to invest in the development of a sustainable production of papayas with export orientation. Among these countries Jamaica, Dominican Republic, Belize, Bahamas, Puerto Rico, Cuba, Barbados, Trinidad, Grenada, Antigua and Barbuda, St. Lucia, Guadeloupe, Martinique and St. Vincent & the Grenadines have done serious attempt to develop their papaya industry. The relative advantages over sub-tropical conditions eg. those under which Hawaii, Brazil and Florida grow papayas, have justified that despite frequent losses Caribbean countries continued attempting to develop the industry of papaya for the export market. Among these advantages are the shorter time required to flower, fruit set and harvest, the trade benefits which allow for duty free entrance of the products eg. Lome convention CBI, CARIBCAN; the competitive lower cost of transportation vis Brazil; the no need for hot water treatments vis Hawaii, etc. Despite these advantages, only Jamaica and the Dominican Republic have somewhat succeeded to maintain a constant presence in the extra-regional market for more than 3 years. Nevertheless, needless is to say that problems discussed in this study have significantly limited their expansion plan. As an example Jamaica has not been able to achieve a 5 year goal to develop 680 Ha of organized papaya orchards albeit having the market. In fact despite the efforts, rather to increase, the acreage under production in Jamaica continue going down.

Constantly "Bunchy Top", DRV and the papaya mosaic virus, and more recently the "Bacterial Decline" have been blamed as the main limiting problem to the development of a sustainable production in these countries. Although in general these diseases have been of a major importance their popularity has come to a point where in many cases they are secondary to other problems and still be blamed as "the cause" for the orchard decline.

Surveys and studies conducted in the Caribbean have shown a series of biotic and abiotic problems frequently affecting the plant performance and the fruit quality. Among the biotic, diseases of viral origin such as DRV and PMV; mycoplasmas eg. Bunchy Top; fungus eg. Anthracnose, and bacteria eg. Bacterial Decline, associated with mites, thrips, nematodes and other insects are responsible for low yield, poor fruit quality, plant decline and ultimate death of the plant. Among the abiotic are those associated with climate, soil and improper cultural practices. Although individually, biotic and abiotic problems has been recognized and reported extensively in Antigua (Marte 1988), Bahamas (Marte 1990), Barbados (Haque 1983, Marte 1984, 1986; Thomas 1984, Alleyne 1984), Grenada (Marte 1989), Guadeloupe and Martinique (Prior et al 1989), Trinidad (Persad 1989), Jamaica (Marte 1989, Thomas 1990) and Caribbean wide (Harvey et al. 1990, Marte 1992, Pollard 1992, MacDonald 1992) no one had study their interaction. Recent surveys have shown a close association between mineral nutrition and mycoplasmal, viral and bacterial diseases. Moreover, field observations (Marte 1992) have shown that indeed in many instances mineral deficiencies has been the main factor triggering the devastating effect of these diseases.

With the exception of Barbados, and to certain degree Grenada and the Dominican Republic, all other countries in the region have tried to implement a pure "market led" plan for the development of their papaya industry. That is why the use of cultivars within the "Solo" group eg. Sunrise, Waimanalo and Kapoho have always been recommended since these recommendations often came from the market side. However, these cultivars were developed in Hawaii and Brazil to respond to their specific problems and environmental conditions which are quite different to ours. These cultivars have proven to be of excellent quality and heavy bearer but very susceptible to most if not all problems (Marte 1986) being discussed in this paper.

II. MATERIAL AND METHODS:

Between 1985-1992 the author of this paper and some other associates travelled extensively to Antigua, Bahamas, Barbados, Dominica, Dominican Republic, Grenada, Jamaica, St. Lucia, St. Vincent, and Trinidad and visited most of the farms involved in commercial production of papayas. Diseases symptoms, insect damages and presences, and mineral imbalance were observed to occur quite frequently in association. This motivated the author and some other colleagues to start recording evidence of occurrences and collecting samples for laboratory analysis. The following are among the data collected: the cultivars being grown in each country, tree performance, presence of typical diseases symptoms, insects damages, mineral deficiency and level of damage. The contact with local scientistic, numerous photograph taken and the revision of local records were of invaluable help to the author. Table 1 summarize the most important findings with regard to this paper.

III. RESULTS AND DISCUSSIONS:

Table 1 shows the result from visits to more than 78 commercial papaya farms in 10 different countries over a period of 7 years. Although many other data were collected this table emphasize the fact mineral deficiencies and mineral imbalances have been a major factor involved in the devastating effect of diseases normally blamed as the sole causes of the problems. Furthermore, it shows that mineral deficiency either caused by the lack of, or the blockage caused by the imbalance of others was per se one the most frequent cause of the problem, where other factors eg. BT and DRV were being blamed. This of course is not to doubt on the importance of BT, DRV, PMV and BD as limiting factors to the commercial production of papayas in the Caribbean. But results from soil and leaves analysis showed that deficiencies of micronutrient such as Fe, Mn, B, and Mo were normally present where Bunchy top, DRV, PMV and Bacterial Decline were causing severe damages. Vice-versa, plants affected by these mineral deficiencies were eventually affected by one or more of these diseases. Although Mg and Nitrogen deficiencies were also found to be associated with these problems, the amount of K and P were normally found in excess as a result of traditional N-P-K fertilizer application. Probably the most important factor was the inter-relation of chlorine and micronutrient. It is known that under the presence of a good amount of chlorine, the papaya plants tend to absorb more Chlorine than needed. It is also known that for most soils, sulfates and nitrates are the logical substitute for chlorine. However, the author found a more direct correlation of chlorine with the micronutrient

Table 1. Summary of observations in 78 papaya farms in ten Caribbean Countries over the period 1985-1992.

Country	# farms visited	Varieties: Local market	Varieties: Export market	Most common problems found: BT	DRV	BD	BT DRV+MI BD	MI	CL
ANTIGUA	8	Local		Oc	N	Oc	VF:BT+MI	VF	BT
BAHAMAS	3	Sunrise Kapoho	Sunrise Kapoho	Oc	Oc	Ra	VF:BT+MI DRV+MI PMV+MI	VF	PMV DRV
BARBADOS	5	Bd Yel Bd Pnk	Bd Yel Bd Pnk	Oc	N	N	VF:BT+MI	VF	BT
DOMINICA	3	Local		Ra	N	Oc	VF:BD+MI	VF	BT
DOM. REP	15	Cartag Omblig Tainung	Sunrise Kapoho	F	Oc	Ra	VF:BT+MI DRV+MI BT+DRV+MI	VF	BT DRV
GRENADA	8	Bd Yel Bd Pnk	Bd Yel Bd Pnk	Oc	Ra	F	VF:BT+MI BD+MI	VF	BT BD
JAMAICA	16	Local	Sunrise Kapoho Wai'lo.	Oc	Oc	Ra	VF:BT+MI DRV+MI	VF	BT DRV
ST. LUCIA	7	Local	Bd Yel Bd Pnk	Oc	N	Oc	VF:BT+MI BD+MI	VF	BT BD
ST VINCENT	3	Tainung KnowYou Sunrise	Tainung KnowYou Sunrise	Oc	Ra	Oc	VF:BT+MI BD+MI	VF	BT
TRINIDAD	10	Tainung KnowYou	Tainung KnowYou	Oc	Ra	Oc	VF:BT+MI BD+MI	VF	BT BD

Legend:
Cl: Claim by local farmers and/or Technicians

BT: Bunchy Top
DRV: Distortion Ringspot Virus
PMV: Papaya Mosaic Virus
BD: Bacterial Decline
MI: Mineral Imbalance
.Deficiency
.Excesses

N: None
Ra: Rarely
Oc: Occasionally
F: Frequently
VF: Very frequent

deficiencies. In fact, whenever there was a deficiency of Fe, Mn, Bo or Mo there was a typical chlorosis and a high concentration of chlorine in the leaves' tissues. Apparently, under these deficiencies, the plant uses the chlorine as a substitute to the deficient micronutrient(s). Concentration of 1.5 % or less were found to be normal levels of chlorine in the leaves. Plants found to have between 1.5 and 2% Chlorine, although normally green, were typically characterized by frequent flower abortion, poor fruit setting and fruit drop. Symptoms of plants with >2-5 % of chlorine were very similar to those of papaya Mosaic Virus, Bunchy top, or DRV depending on the environment under which the plant was growing. All of these observations lead us to conclude that although BT, DRV, PMV, and BD are limiting factors to the commercial production of papayas in the Caribbean, mineral imbalances are factors contributing to facilitate their occurrence and undoubtedly triggering the expansion of their damages. Furthermore, the data shown help us to admit that in many instances these diseases are solely blamed as the major cause for the destruction of an orchard, when the imbalance of nutrient is the one allowing their occurrence and devastating effect in the first place.

Table 1 shows that Sunrise and Kapoho were and still are the most common cultivars being grown for the export markets. Despite the outstanding characteristics of these cultivars in term of quality and yield, the surveys conducted indicated a very high susceptibilities to BT, PMV,DRV and BD as well as mineral deficiency and other soil conditions. This fact makes us to question the future of these cultivars in the Caribbean as pure varieties. On the other hand Barbados was able to partially overcome the problem of Bunchy Top and succeeded to penetrate and establish a reputation in European markets with locally developed papaya lines; But the susceptibilities of these lines to mineral deficiencies and/or excesses drastically hampered the opportunity to remain in those markets.

In general the records collected during the visits showed that local lines or varieties were more tolerant than those introduced (selected) cultivars eg. Kapoho and Sunrise. This was especially true with regards to tolerance to the stresses caused by drought, excessive rainfall, waterlogging and poor soil fertility. This fact emphasize the need for local or regional breeding and selection programmes taking advantages of the genetic resources locally or regionally available. Unfortunately, the only programme with such orientation initiated in Barbados in 1983 was discontinued because of lack of support and resources albeit the successful release of lines with considerable tolerance to Bunchy Top.

IV. CONCLUSIONS

1. Despite the problems affecting the commercial production of papaya in the Caribbean, the region has a high potential to compete in advantageous position in the extra-regional markets.

2. Despite the high quality of Kapoho, Sunrise, Waimanalo and other solo cultivars, there is a need to initiate and support a regional selection and breeding programme to produce high quality and high yielding lines more adapted to the diseases, soil conditions and other stress present in our region.

3. Research on mineral nutrition must be emphasized. These should cover the inter-relationship with biotic and abiotic problems.

4. Farmers and technicians often confuse the symptoms of deficiencies with those of diseases and vice-versa. A more efficient methods of diagnosis for diseases, especially BT, DRV, and PMV is needed and local staff should be trained in those. A recent model Developed by INRA, IRFA, IICA and CARDI for the "Bacterial Decline of Papaya" is a good example of what is needed for diseases such as BT, DRV, and PMV.

5. Irrigation with water high in chlorine and fertilization with KCL should be avoided in soils deficient in micronutrient to avoid the accumulation of chlorine and the consequent damages to the plant.

NOTE: Paper presented by the Author at the XXVIII Annual Meeting of the Caribbean Food Crops Society (CFCS), Santo Domingo, August 9-15, 1992.

POST HARVEST HANDLING OF MANGO AND PAPAYA FOR EXPORT MARKETS

By

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Paper presented at IICA Workshop on Export Marketing of Mango and Papaya to Jamaican Exporters Association in Jamaica, 10-12 March, 1993.

Mango (*Mangifera indica* L.)

Introduction

Mango represents the world's second largest tropical fruit, and as such, are an important source of foreign exchange for many producing countries. Successful marketing of mango requires an understanding of the many factors that can affect the length of the post-harvest life and the quality of the fruit on its arrival at a market. It also requires an understanding of market quality requirements. Neglect of either can make the difference between profit and loss.

Varieties

The selection of a particular variety depend on the intended use of the fruit. The most popular varieties for the export market included Tommy Atkins, Haden, Keitt and Kent. Other acceptable varieties are Alphonso, Amelie, Graham, Irwin, Sensation and Zill. Varieties with good potential for the domestic market are Starch and Julie. The latter in recent times is showing increasing potential in European markets. Table 1 gives the main quality characteristics of some varieties.

Quality Requirements

Mango should be of similar varietal characteristics, clean, mature, free from damage, disease and insects. Fruits should weigh 225-400 grams, showing some visible colour (yellow or red depending on the variety). Fruits with red blush are very popular. Fruits should also be fully mature but firm, with no bruising or disfigurement.

Harvest maturity

Harvest maturity in most varieties can be judged by the position of the shoulders in relation to the position of the stem.. The following descriptions are appropriate for Julie and Graham mangoes and other varieties which show similar morphological characteristics.

(a) Fully mature: outgrown shoulders formation of a depression with ridges at the stem end, firm and green.

(b) Half-mature: shoulders in line with the stem with slightly ridged edges, firm and green.

(c) Immature: shoulders below the stem insertion with ridges absent, firm and.green.

Harvesting

Fruit can be picked entirely by hand, tipping the fruit to snap the stem, or by holding the fruit and cutting the stem, taking care not to bruise or puncture the fruit. Optimum harvesting involves using secateurs and cutting the stem 1-2 cm away from the fruit (this technique reduces latex exudation and staining and reduces the possibility of entrance of fungal organisms). Where harvesting by hand from the ground is not possible, harvesting implements should be used e.g. a picking pole equipped with a cutting blade and a small bag under the blade to catch the fruit. Also, climbers may use cotton bags which are filled and lowered to the ground.

Following harvest, latex should be allowed to drain away from the fruit. Harvested mangoes should not be left in direct sunlight, wind or rain, either in the field or during transport from the field to be packing-house facility.

On arrival in the packing area fruits should be sorted and graded as described in Table 2.

Post harvest treatments

Acceptable fruits should be placed in water containing 100 ppm sodium hypochlorite for washing to remove debris and latex stains. Mangoes collected from trees with Anthracnose requires a hot water dip treatment (55ºC for 5 minutes) containing 0.1% Benomyl (1 g/litre). After this treatment, the fruit should be allowed to cool and air dry in crates overnight. However, if time is short, the mangoes can be individually dried with a soft, absorbent cloth as they are packed.

Packaging

Carton size, design and method of packing depends on the market and the mango variety. Most large volume, extra-regional markets will require mangoes packed in a single layer with no fruit resting over another. Telescopic style cartons with separate base and lid are often preferred.

The number of mangoes per carton will vary with size of the mango but will typically be between 10-20. Regional markets tend to be more flexible in accepting a range of carton types and gross weights. The choice depends on a compromise between price of carton, effect of carton type on quality, carton availability and requirements of the market.

Whatever carton type is used, mangoes should be packed so that they are secure but not tight, with the stalk end upwards. Horizontal and vertical cardboard dividers can be used to add protection against movement in the carton. Shredded paper or tissue can also be used as padding.

The packaging used for mangoes should allow for adequate ventilation. The side walls should have air holes and any internal dividers should not restrict air passage through the carton.

Storage

As a general rule, only good quality mangoes that are clean, mature and free from disease and injury should be selected for storage. Diseased fruits may infect sound ones. Injured fruits are easily infected, as sites of injury serve as avenues for the entry of micro-organisms. Immature fruits do not have the potential for lasting long in storage and usually ripen with inferior quality. Unwashed, dirty fruits serve as sources of infection in storage.

There must be a minimum of delay between harvest and storage. Mangoes should be put into storage containers that are able to withstand stacking without becoming deformed and injuring fruits.

Ripe and unripe mangoes must never be put into the same storage room as ripe fruits give off ethylene which will hasten the ripening of adjacent unripe fruit. If commodities other than mangoes are to be put into the same storage room, one has to ensure that the particular commodity is compatible in storage with mangoes. For example citrus fruits, onions, give off a characteristic odour which would be absorbed by mangoes and adversely affect its eating quality. Such commodities therefore must not be stored with mangoes.

Sanitation in the storage room is extremely important. Storage containers and storage rooms must be cleaned between storage periods to prevent disease contamination from previous batches of fruit.

Mangoes have an inherently short shelf life of about seven days from the green mature to the ripe stage under ambient conditions. Refrigerated storage can be used to extend storage life. The best storage temperature for mangoes is 13°C (55°F) at which temperature the storage life ranges between 2-3 weeks. Storage below this temperature results in chilling injury of the fruit and increases susceptibility to anthracnose infection.

Pests

Two pests which are of concern are (a) the seed weevil (*Sternochetus mangiferae*). The adult insect lays an egg on the surface of the young mango fruit and it is covered by a brownish latex. The egg hatches and the grub bores through the flesh into the kernel where it feeds. The adult normally emerges only after the fruit has dropped and decayed or the flesh eaten. The weevil, therefore, does not affect eating quality. The importance of this pest is due to its effect on germination of the seed. (b) Fruit fly (*Anastrepha* spp.) lays eggs on mature fruit or younger damaged fruit whilst still on the tree. Their larvae, commonly identified as "worms" feed in the flesh making it unmarketable. As the season progresses the problem worsens due to build up of the fruit fly population. This increase can be controlled by growers keeping fields clear of discarded or dropped fruit. The decaying fruits are the source of hatching flies.

Diseases

Infection by micro-organisms is generally the most serious cause of post-harvest losses in mango. Disease incidence can be reduced by good orchard management, pre-harvest cultural practices, appropriate handling and post-harvest treatment procedures. Washing in static water tanks will increase disease incidence due to the increase in inoculum from infected fruit, therefore, water has to be changed frequently and contain sodium hypochlorite (100 ppm) and/or fungicide. Post-harvest applications of specific fungicides will assist in disease control.

Anthracnose (*Colletotrichum gloeosporioides*): infection occurs in the leaves, stem, young flowers and fruits. In the first three, infection results in depressed black circular or angular lesions; these enlarge and coalesce and affect large areas. Infections of the fruit are usually latent and manifest only as the fruit begin to ripen. Anthracnose is characterised in ripening fruit by small black circular lesions which gradually enlarge and coalesce as the fruit continues ripening.

Stem end rot (*Diplodia natalensis*) is particularly apparent during low temperature storage. Infection is characterised by light grey-brown areas in the stem region. Infection is believed to occur through the cut stem. Disease incidence can be reduced by leaving 1 cm of stem attached to the fruit.

Rhizopus rot (*Rhizopus oryzae*) develops rapidly at 25ºC and is characterised by skin splitting and development of coarse white mould with black spore heads. Infection takes place after harvest, usually through mechanical injury. The incidence can be minimised by careful handling, hygienic conditions and rapid cooling.

Physiological disorders

(a) Scarring

This occurs when the mango suffers physical injury during its development. Scarring reduces the eye-appeal of the fruit and therefore reduces selling price.

(b) Internal Breakdown:

The external appearance of the fruit is not affected by internal breakdown. However, when the fruit is cut open, there is a significant reduction in flesh firmness and a fermented odour may be detected. If the fruit has reached the half-ripe or fully ripe stage, one can clearly see a separation of the mesocarp from the seed.

TABLE 1

Grade Requirements of Mango

All grades shall meet the minimum requirements as well as the following additional requirements.

Grade 1	Grade 2	Grade 3
Individual Fruits		
1. Blemish shall not exceed more than 5% of the surface area	Same as grade 1	Blemish shall not exceed more than 10% of the surface area
Lot Tolerances		
1. Not more than 10% size difference	Not more than 20% size difference	Not more than 35% size difference
2. Up to 5% may fail to meet the specifications with not more than 2% of this due to damage and disease on receival by the buyer	Up to 10% may fail to meet the specifications with not more than 2% of this due to damage and disease on receival by the buyer	Up to 15% may fail to meet the specifications with not more than 2% of this due to damage and disease on receival by the buyer
Packaging		
New clean carton boxes fully protecting the fruits and holding not more than 20 lbs with each fruit separated by dividers	New clean carton boxes fully protecting the fruits and holding not more than 40 lbs	Clean boxes fully protecting the fruits and holding not more than 50 lbs

.0 Minimum Extra-regional Export Requirements

Grade two shall be the minimum grade exported to extra-regional markets.

TABLE 2 CHARACTERISTICS OF THE MAIN MANGO VARIETIES

Variety	Colour When Ripe	Average Weight (oz.)	Fibre Level	Turpentine Flavour	Sweetness	Proportion Of Production (a)
Babb	Yellow	3 1/2	High	No	Extremely sweet	2%
Bitter skin	Yellow	3 1/2	Moderate	Yes	Sweet acid	5%
Graham	Yellow	16	Low	No	Sweet	0.5%
Julie	Yellow/red blush	10	Low	No	Very sweet	30%
Lieka	Yellow/red blush	3 1/4	High	Slight	Very sweet	5%
Long	Yellow	7 1/2	Medium high	No	Sweet	50%
Rose	Pink	8	Low	Slight	Sweet	1%
Tommy Atkins	Yellow /red blush	19	Low	No	Medium sweet	0.05%

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

Papaya (Carica papaya L.)

Introduction

Papaya fruits are sensitive to quality outturns and high post-harvest losses, if harvesting, post-harvest treatments and handling techniques are inadequate or inappropriate. Papaya are climacteric fruits, and, for long-distance transport, must be harvested mature green. Care is necessary during harvesting, to minimize injury and to prevent latex (which oozes out of the cut stem-end) from disfiguring the fruit.

Harvest maturity

Papaya fruits should be harvested when the colour of the skin changes from dark green and when one yellow streak begins development from the base upwards. Fruits in this condition will continue to ripen normally after harvest. Those fruits harvested before this stage will fail to show complete ripening and those harvested after are more susceptible to damage and bruising during handling.

Harvesting

When papaya is hand-harvested the peduncle is snapped or cut from next to the tree, then immediately trimmed flush against the top of the fruit. A specialised implement for harvesting of fruit inaccessible by hand due to tree height, comprises a long pole, a small circular hoop at the top, a small mesh bag attached to the hoop and a horizontal blade above the hoop and the bag. The blade is positioned below the peduncle of the fruit and the pole moved upwards, the fruit is detached from the tree and then drops gently into the mesh bag below the hoop at the top of the pole.

After harvest, the fruits are placed in single layers into shallow, light coloured field crates, preferably containing a foam layer for cushioning. All stems should be trimmed after harvest to ensure that no stem to fruit rubbing occurs during transport to the packing facilities.

Post-harvest treatments

On arrival in the packing facility, fruit should be washed in water to remove latex and debris, then treated in a 0.1% Benomyl Solution (1 g/litre) for anthracnose control or with Thiabendazole (1.2 g/litre). Improved control is obtained by treating in a hot water dip containing the fungicide. The papaya are treated with hot water at 47°C for 20 minutes, followed by cooling. Care should be taken to avoid heat injury by either excessive exposure or too high temperatures. Heat-injured fruit fail to degreen and are often susceptible to blossom end rot caused by *Dothiorella* spp.

Storage and Ripening

Fruit harvested and placed to ripen at the yellow stripe stage will change to 60-70% yellow colouration within 6-7 days at 25-28°C. Fruit transferred to low temperature storage at 10-12°C, when harvested at the one-stripe stage, will store successfully for 14-21 days if post-harvest disease incidence can be controlled.

Storage of papaya below 10°C will result in chilling injury. The symptoms include surface pitting, discolouration of the peel and the flesh, incomplete ripening, poor flavour and increased susceptibility to disease incidence.

Fruits with 10-30% yellow colour can be successfully stored for up to 2-3 weeks at 12ºC, 85-90% r.h., provided they are treated against fungal infections. Fruits harvested and packed with 5-10% yellow colour should be kept immediately at 12ºC and shipped within 36 hours. Storage conditions during shipment should be 10-12ºC, 85-90% r.h. Under these conditions, the papaya will store successfully for 12-15 days and ripen subsequently when transferred to higher temperatures.

Post harvest diseases

Papaya is particularly susceptible to post-harvest losses arising from bruising and disease infection. Careful handling must be employed during harvesting, handling, storage, transportation and retail display.

Fruits with latex stains, bruises, scars, punctures due to poor handling will develop into dark soft regions leading eventually to secondary microbial infection during ripening.

(i) Anthracnose is an important disease in most papaya-growing countries. Symptoms appear only as the fruit ripens and may not be apparent at the time of harvest. Brown sunken spots develop on the fruit surface, enlarging into water-soaked lesions which may support colonies of salmon-pink spores, sometimes in concentric rings. The flesh beneath is at first soft, but rotting is limited in extent and the perimeter of the lesion becomes hard and black as the fruit resists further decay. Sometimes there are multiple small lesions of the "chocolate spot" type which only occasionally develop into typical anthracnose lesions. Orchard hygiene is important and fallen fruits and leaves should be collected and destroyed. The chief means of control is a carefully timed fungicide spray programme followed by a post-harvest hot water treatment or a fungicidal wax application.

(ii) Black rot is a firm dark rot which extends into the fruit from the stem-end. Alternately, small water-soaked spots may appear everywhere on the fruit, later becoming dark, sunken and irregular in shape. Severe rotting can occur in uninjured fruits during the rainy season but infection generally takes place via the cut stem at the time of harvest. In wet growing areas it is necessary to apply fungicide sprays in the orchard from the time fruit set. Post-harvest measures include a hot water bath or spray, which may be combined with a fungicide or irradiation treatment.

(iii) Phytophthora rot of papaya is a serious disease of papaya appearing as water-soaked spots on the fruit surface and covered afterwards with off-white mould supporting copious quantities of spores. Lesions may occur on any part of the fruit, including the stem end. If young fruits are infected they shrivel and fall to the ground, creating an abundant source of spores capable of initiating new infections in developing fruits. Recent infections may be undetectable at the time of harvest. Orchard fungicide sprays are essential to protect fruit in wet growing areas, and prompt hot water treatment is usually effective in preventing subsequent decay.

Stem end rots probably occur wherever papaya is grown. The skin around the stem-end becomes discoloured, and there may be development of moulds and spores or spore-bearing bodies. Lesions have a broad water-soaked margin and a rough black surface. The newly cut stem-end is usually exposed to contamination during and shortly after harvest and infection may occur before the wound has had time to heal. Spore production in the orchard can be reduced by fungicide sprays. With regard to harvesting techniques it has been noted that fruit is often prevented from rotting if part of the stem is left attached. Stem-end infections can be arrested by prompt immersion in a hot water bath, with careful control of time and temperature.

(v) Alternaria rot is not usually a problem if fruits can be marketed a few days after harvest. The symptoms are round to ellipsoidal black lesions on the skin of the fruit, followed by rotting of the underlying tissue. Where cool storage is used to prolong post harvest life, however, the fruits become increasingly susceptible to attack. Orchard fungicide sprays reduce the incidence of disease but cannot eliminate it.

(vi) Black rot of papaya does not cause decay, but market value is reduced by the blemish, the spots being up to 4 mm in diameter.

(vii) Greasy spot is mainly a leaf and stem disease but the fruit may also be attacked. The fungus is capable of direct infection of the intact skin, and produces circular to elliptical water soaked spots, especially around the stem-end. Under humid conditions dark spores are produced on the lesions.

THE INVESTMENT CLIMATE IN JAMAICA

by

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In the interest of time and in keeping with the theme of this seminar, my presentation will be confined to crop production - including investment potential and earnings from selected agricultural enterprises, as well as some of the problems and challenges facing agricultural investment.

Ladies and gentlemen; before I continue, I am sure you would agree with me that the high point of this presentation should be whether or not the current economic climate in Jamaica is conducive to agricultural investment.

I would like to go back to April 1992 when the interest rate on agricultural loans skyrocketed to 52% while the Jamaican dollar reached $26.23 to $1 US.

As a result, the cost of all agricultural inputs increased almost on a daily basis in keeping with the devaluation, as some suppliers then claimed. It was an open secret that some of these suppliers were marking-up their prices well above the rate of devaluation of the Jamaican dollar.

It was a very rough period for farmers as the interest rate on agricultural loans from the Agricultural Credit Bank (which provides the bulk of credit for the sector) was moving up in keeping with the weighted average TB yield at the ending of each quarter. This of course was based on the nation agreeing with the IDB/World Bank lending policies.

However, the following data on the Quarterly Agricultural Interest Rates and Foreign Exchange Rates for January 1991 to January 1993 give a graphical picture of where we are coming from and where we are today: at January 1991 interest rate was 35%; while the Exchange Rate was $8.16. January 1992 the interest rate was 39% (variable) and the Exchange rate was $22.63; and **in January, 1993 the interest rate was 29% (variable) and the Exchange rate $22.20.**

Since then the Jamaica dollar has been relatively stable; the inflation rate has been contained and the interest rate has also reduced significantly. Indications are that interest rates on agricultural loans are likely to be reduced further if we are able to manage the inflation rate.

Ladies and gentlemen, from these positive indicators we could conclude that the climate is right to invest in the agricultural sector. While the stock market is another area of investment - the market has its ups and downs; if I may say sometimes too many downs! - if the right agricultural enterprises are selected I'm confident, the returns will be more secured. In addition to those indicators, there has been an increasing demand for a number of agricultural produce - especially non-traditional export crops for which we are unable to meet market demands. These crops include mangoes; papaya, herbs, spices, and here we are talking about tarragon, basil, chives, thyme and mint among others.

On the other hand, let me hasten to say that in order for farmers to take full advantage of these opportunities, they must first learn how to effectively manage their operations.

I must emphasize this point, as frequently people are getting in the farming business without knowledge of which animal they should rear for milk - whether the pigs or the cattle.

This might seem a simple matter to you, but the reality is that at the end of the day your investment dollar will suffer from poor decisions.

If the project was not properly developed and implemented, (especially when there are numerous problems and constraints to take into account) it could also lead to heavy financial losses.

INVESTMENT OPPORTUNITIES

Nevertheless, based on studies carried out by the JADF, there are still several crops which could be produced and are being produced with reasonable returns on investment. Among those crops which I would like to refer to as the **Top Producers** are the popular ackee; papaya; mango; herbs and spices; coffee; non-traditional such as yellow yams; and vegetables - hot pepper (scotch bonnet) calaloo; yellow squash; and sweet potatoes.

Because of the uncertainty of the market and prices for citrus and banana on the export markets, I would place them in the **Marginal** category.

I would like to analyze the performance and the potential of some of our **Top Producers**.

I want to start with Ackee, not because it forms part of our national dish, but more so because the crop does not require much capital to establish and maintain. For example it is estimated to cost $11,164 to establish an acre of ackee with just over $5,000 as maintenance cost each year until year 4 when it starts to bear fruit. Gross revenues amount to over $22,802 per acre. In the 5th year gross revenue will more than triple to $80,173. At full bearing at age 7 total revenue per acre would be $114,345.

Another **Top Producer** is the papaya: the return on investment for this crop is over 30% in year 3 of operation. Over the past two years, farmers have been taking advantages of the growing market in the US.

According to the Foreign Agricultural Service of the USDA, imports of papaya over the first nine months of 1992 increased by 48% in volume and 60% in value over 1991. I must mention here that Jamaica has been receiving the highest price per ton compared to our competitors such as Costa Rica, Belize, etc.

Looking at **Mango** - it will cost approximately $15,639 to establish an acre of Mango - using the recommended varieties - Tommy Atkins, Julie and Keith. The yearly operating cost is some $7,000. Revenue should start coming in year three - at $8,000; by Year Four it should move up to $38,000. Revenue from the fruits should peak at Year Seven at $69,000. The internal rate of return on this investment should be as high as 30%.

Herbs & Spices - ginger, turmeric, non-traditional export crops including yams, hot peppers, callaloo, ornamentals have recorded increased earning in 1992 of US$17.8 million or 9.79% over the 1991 production.

In my opinion, the overall prospects for increased production, productivity and foreign exchange earnings is good.

However, we need to exploit the tremendous new marketing opportunities for products such as fresh and processed fruits and vegetables, herbs and spices, aquaculture products, ethnic food and exotic flowers.

There are also vast opportunities for the development of linkages and value-added products. Such as sauces and spices from peppers, purees from fruits, and continue to develop other products from coffee and cocoa.

I would like to comment again on the traditional export crops - sugar cane, banana, coffee and citrus. These crops over the years have been experiencing good returns and have contributed significantly to the country's foreign exchange earnings.

However, there are now concerns for citrus and banana export - as a result of declining prices for citrus and the unstable EC banana market. I am nevertheless optimistic that the market will bounce back.

In closing, I would like to suggest a few points that we will need to address to enhance the investment climate in the sector.

- Jamaica needs to produce much more in volume - on a consistent basis.

- The need to develop what I would call an integrated production scheme to maximize on the earnings from the various enterprises in agriculture.

- Farmers and exporters should seek more information on the international marketplace and devise strategies to deal with foreign competition. With the liberalized/free trade now taking over regional marketplaces we cannot ignore what's going on in other countries.

As Jamaica's only not-for-profit private sector venture capital institution the Jamaica Agricultural Development Foundation, will continue to promote and develop sustainable agriculture and agri-business projects.

We have the resources and are willing to help farmers, and investors who are interested in developing a sound agri-business enterprise. These services include: preshipment financing-loans to exporters and lease financing for agricultural vehicles and equipment and the Young Entrepreneur Programme - in which we get young people started in agriculture through loans or equity financing.

I trust my presentation has helped to throw more light on the sector, as well as interest from potential investors.

PRODUCTION OF MANGOS FOR THE EXPORT MARKET

By

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and

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INTRODUCTION

The mango originated in Tropical Asia, in the region from India to the Philippines. It is now cultivated universally (Fig. 1) in all hot tropical and subtropical areas of the world between the Latitudes 30° North and 30° South, except in the deserts where irrigation water is not available or it is too windy.

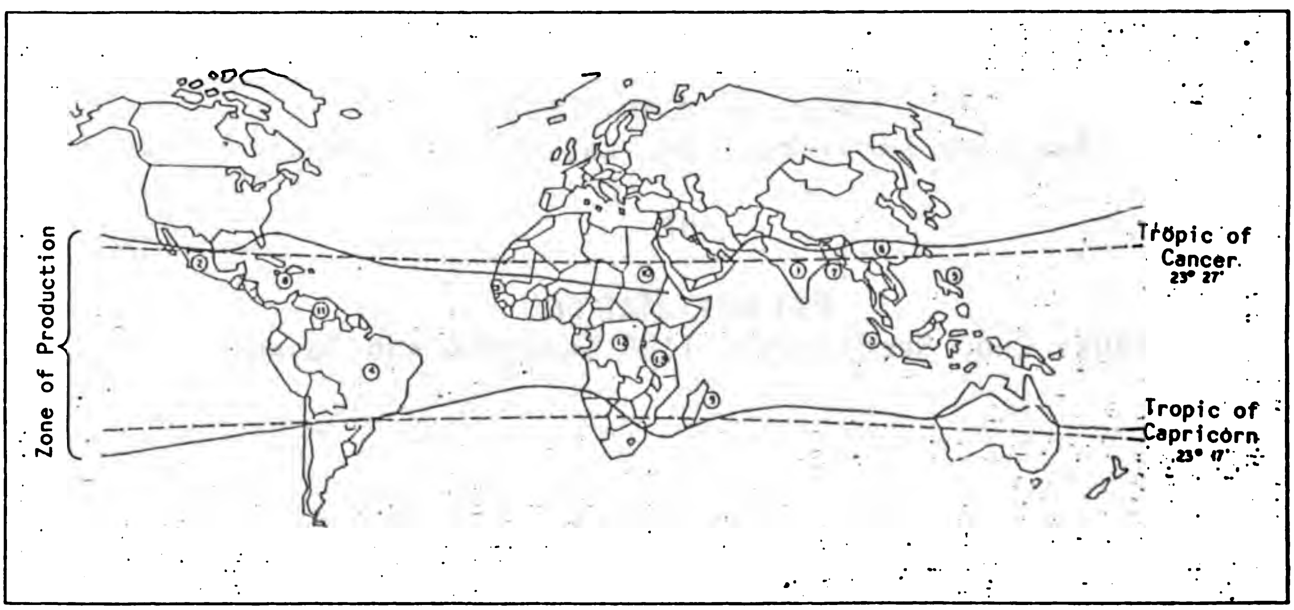


Fig. 1. Zone where the mango is commercially grown

The main mango producers are the following countries:

Africa: Ivory Coast, Kenya, Madagascar, Malawi, Mali, Mozambique, Sierra Leone, Sudan, Tanzania, Zaire.

Asia: Bangladesh, China, India, Indonesia, Kampuchea, Malaysia, Pakistan, Philippines, Sri Lanka.

Australia: Australia

North America: Mexico and U.S.A.

Central America: Belize, Costa Rica, Guatemala, Honduras, Panama

South America: Brazil, Colombia, Ecuador, Paraguay, Peru, Venezuela

The Middle East: Egypt, Israel

The Caribbean: Cuba, Dominican Republic, Haiti, Puerto Rico, Jamaica, St. Lucia, St. Vincent.

Many other countries produce mango fruit but in smaller quantities.

PART I. GENERALITIES, PROPAGATION AND NURSERY MANAGEMENT

1.1 Botanical aspects:

The mango *Mangifera indica* L., belongs to the plant family Anacardiaceae. Some 15 other species of Mangifera occur in Asia, but the mango is by far the most important of the group. Other related species in the same family are the cashew (*Anacardium occidentale*), the purple mombin (*Spondias purpurea*) and the golden apple (*Spondias cytherea*).

There are two main "races" or types of mango, the Indian and the Southeast Asian. The Indian race is best adapted to dry tropical and subtropical regions. It tends to have an ovoid fruit with a monoembryonic seed. The fruit is rather susceptible to diseases caused by fungi, such as anthracnose (*Colletotrichum sp*). The Southeast Asian race is better adapted to high rainfall areas in the tropics. It tends to have an elongate fruit with a polyembryonic seed. The fruit is less susceptible to fungal diseases than the Indian race.

Quite a few of the most important varieties now being cultivated throughout the world have their origin through selection and hybridization programs in Florida. However, important improvement programmes also exist in Israel, Brazil, South Africa and Australia. Their popularity and characteristics have influence the fact many horticulturists now consider the Floridian mangos as a group apart. Similarly, the great variability of the germplasm existing in the Caribbean and other Latin American countries, most of which remain non-selected, is being considered as another group presently referred to as "Turpentine mangos." This name is derived from the relative large amount of turpentine which flow from the absicion point at the base of the peduncle.

1.1.1 The tree

Mango trees are of medium to large size. Under favorable conditions in a tropical climate the height of seedling trees reaches 7 to 8 m in 12 to 15 years, and up to 30 m in 35 to 40 years.

Grafted trees often are somewhat smaller than seedlings. Cultivars vary a lot in tree size. They can go from as small as 3 m eg. Julie in certain areas to as high as 20 m eg. Kidney The form of the canopy may be upright, rounded, or low and spreading. A good nurseryman and/or growers usually prefer to train the tree to branch 30 to 50 cm above the soil surface and to develop 3 to 5 main branches.

The wood of the tree is fairly strong. Occasionally, branches are broken by wind or by a heavy load of fruit.

Vegetative growth occurs in several flushes during the year. New leaves are brownish to red in color and limp in texture, becoming stiff, thick, leathery and dark green after a few weeks. Leaf shape is elliptic-oblong to lanceolate, depending upon cultivar. A growth flush usually is preceded or accompanied by abscission of some of the older leaves. Sometimes all of the branches on the tree flush at once, but often new growth will occur on different branches at different times. The tree is evergreen, but some leaf drop occurs throughout the year. The leaves are retained on only the most recent 2 or 3 growth flushes, so the majority of leaves are on the outside of the tree canopy and the inside is relatively open.

1.1.2 The roots

The mango root system is extensive, but does not develop a large number of finely branched rootlets. Some roots penetrate deeply into the soil, but the majority of the root system develops in the upper 1 m of soil especially if the tree is grown on mounds or beds.

Although mangos, as many other perennial fruit trees, prefer loamy soils, the adaptability of the mango root system to different soils is very wide. The mango tree is capable of growing well in very shallow, rocky soils-less than l m in depth-provided they are well drained and otherwise suitable.

1.1.3 The flowers and the pollination

The flowers are produced in terminal panicles which have from a few hundred to more than a thousand flowers each. The flowers are either staminate or perfect (Fig 2), the perfect ones varying from 1% to more than 50%, depending upon cultivar and environmental conditions.

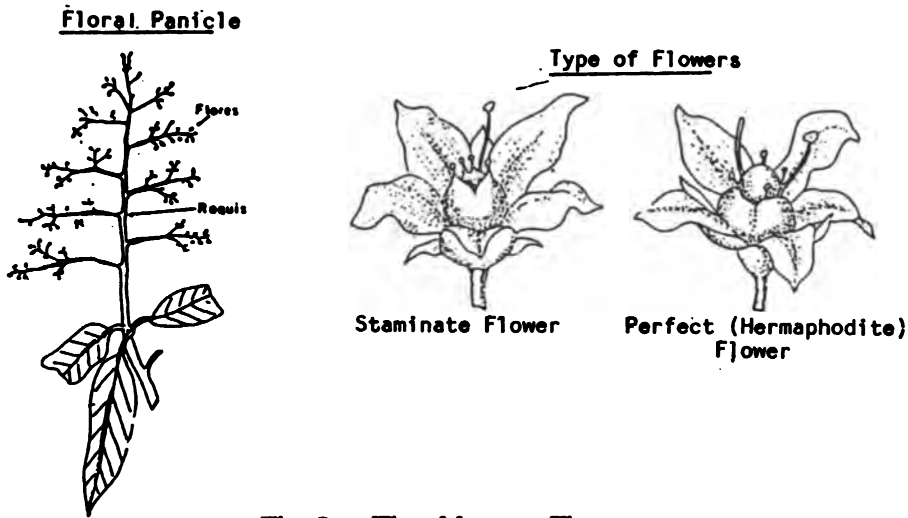


Fig 2. The Mango Flowers

The flowers are small (8-10 mm diameter), with 5 greenish, yellow or pink petals. The staminate flower has one functional stamen and one or more non-functional stamens. The perfect flower has a unicarpellate pistil which consists of a globular ovary and a unilateral style. Perfect flowers tend to be produced in largest numbers on the terminal portions of the panicle branches.

The time and sequence of flowering depend upon geographic location and climatic factors. In most subtropical regions north of the Equator the main flowering period is late December to March and the fruit matures from May to September. Often there is a smaller "late bloom" in late March to early May, the fruit maturing from August to October. Some cultivars may bloom as early as October or November in this region, with the fruit maturing in March to May. The seasons are reversed in regions to the south of the Equator. In places near the Equator there is a tendency for mango flowering to be less concentrated into specific seasons, and to occur sporadically several times a year. In all areas flowering is strongly affected by the occurrence of dry seasons or by times of relatively low temperature, so there is much variation in the dates of mango flowering from one place to another.

Mango flowers open from about 8 AM to noon. Pollen is shed by noon and remains viable for up to 48 hours. Although only one stamen per flower produces pollen, the large number of flowers on the tree assures an abundant supply of pollen. The stigmas are receptive around 18 hours before the flowers open and remain receptive up to 48 hours after flower opening. The mango flower is adapted to insect pollination. Only small numbers of honeybees visit flowers, so they are not important agents of pollination. The insects which visit the flowers in the greatest numbers include carrion flies, houseflies, wasps and thrips (Fig 3). The relative inefficiency of these insects as pollinators may account for low mango yields at times.

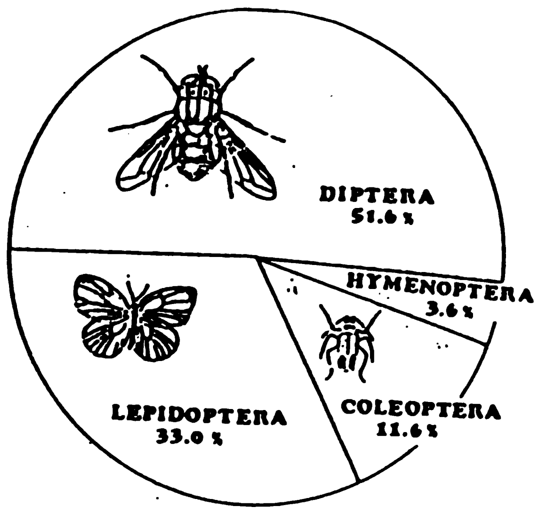


Fig 3. Insects and the pollination of mango flowers

Cultivars differ in self-compatibility and in cross-compatibility with other cultivars. There has not been sufficient research done to make recommendations as to which cultivars should be planted together for optimal pollination.

1.1.4 The fruit and the seed

Fruits are produced singly or in clusters. Since they are borne at the terminals of the branches, the fruits are concentrated in the outside of the canopy of the tree.

Botanically, the fruit is a drupe, consisting of an outer skin (exocarp), a fleshy edible portion (pulp or mesocarp), and a stone (endocarp) containing a single seed (Fig 4). Fibers from the stone extend into the pulp, the number varying from few to many and the texture from short and fine to long and coarse. Fruits of different cultivars are extremely variable in size, shape, color, flavor, fibrousness, resistance to disease, maturity period, and storage behavior. They vary from 5 to 25 cm in length and from 100 g or less to 2000 g or more in weight.

Two kinds of seed occur. Monoembryonic seeds contain one embryo which results from the sexual process of union of a sperm from the pollen of one tree with an egg cell in the ovary of a flower of the same tree or a different tree. Polyembryonic seeds contain 2 to 5 or more embryos, one of which (sometimes none) is produced sexually, the others being developed from the nucleus of the ovary by a process called apomixis (Fig 4). The apomytic embryos are genetically the same as the tree on which they are developed.

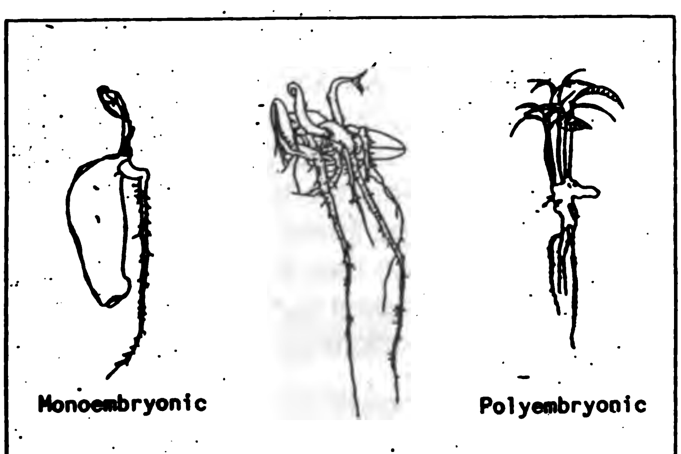


Fig 4. Monoembryonic and Polyembrionic seeds

Some cultivars develop at times a large numbers of seedless fruit (called "nubbins"). These develop to only about 20% to 30% of normal size and have a stone, but no seed. They are borne in clusters, even on cultivars which normally have only 1 or 2 fruit per panicle. Cultivars such as Haden, Lippens and Parvin are especially susceptible to this condition. In subtropical areas it has been considered that low temperatures at the time of flowering and fruit set cause the formation of seedless fruit, but the fact that it occurs also in tropical regions with uniform temperatures indicates that there must be other causes as well. Some cultivars, such as Edward and Earlygold, often produce fruit with aborted seeds, but the fruit develop to normal size.

There is always a large amount of post-pollination drop of very small fruit, as well as a gradual drop of immature fruit up to the time the fruit attains around 25% of full size. Diseases, especially anthracnose and powdery mildew, cause a lot of fruit drop if they are not controlled. Other possible causes of fruit drop are inadequate soil fertility and insufficient moisture in the soil. It is important to maintain good production practices in the orchard during the entire period of flowering and fruit development.

The mature mango fruit will begin to ripen on the tree. During this process the fruit becomes soft and changes color from green to various shades of yellow, red or purple; however, the fruit becomes physiologically mature on the tree 2 to 3 weeks before it ripens. At the "mature green" stage the fruit is still firm, but is capable of ripening normally after it is picked from the tree. Most fruit for long-distance shipping is harvested at the mature green stage.

1.2 Cultivars

Mango fruit range in shape from spherical to ovoid to elongate, with many variations in between. The surface of the fruit varies from smooth to undulating(smooth being preferable). Ripe mango fruit may be greenish yellow or yellow in color, or it may have a yellow background color with various shades of orange, red or purple which occur as a "blush" on a variable portion of the surface. The overall appearance of the fruit depends upon many factors. Color is important, but so also are such things as the lenticels (small dots on the surface which are white, yellow or brown in color) and blemished from disease or mechanical damage, usually brown or black in color. There is some tolerance for poor appearance of fruit sold in local markets, but fruit for international export must have excellent appearance.

Fruit weight of different cultivars varies from around 100 g to 2000 g or more, and fruit length from 5 to 25 cm. Buyers in large-scale commercial trade prefer fruit of 30 g to 600 g in weight (packing 8 to 16 fruit per 4.8 kg box or "flat"). Fruit varies a lot in skin thickness and resistance to damage. Fruit for long-distance shipping should have a skin that is relatively thick and resistant to damage.

The pulp of the mango fruit varies from light yellow to orange in color. Cultivars with dark orange pulp have the greatest content of vitamin A precursors. The texture of the pulp varies from soft and melting to firm and non-melting. Firmness depends to some extent upon the amount of fiber in the flesh. The best fruit for shipping has sufficient fine fiber in the flesh to make it firm, but not enough fiber to be objectionable to the consumer. Fiberless mango fruit is very difficult to keep in good condition during handling, storage and shipment.

The Indian race of mango is best adapted to conditions of relatively low rainfall. The flowers and fruit are susceptible to infection by fungal diseases like anthracnose. The Southeast Asian race developed in more rainy, humid climates and is generally less susceptible to fungal diseases. Cultivars developed in other parts of the world vary a lot in disease susceptibility. Growers should choose cultivars which are adapted to their specific environmental conditions.

In markets of North America and Europe, buyers prefer mango fruit with some red color over fruit which is entirely yellow. In North America buyers favor fruit with weight in the range of 400 to 600 g. In Europe the same sizes are sold, but smaller fruit-300 to 350 g-is also accepted. All buyers in international markets want fruit with good appearance and very little blemishing. Table 1 presents the most important tree and fruit characteristics of some cultivars presently being cultivated in the Caribbean, South, North and Central American Countries on a commercial scale.

The seed may be planted directly in containers, (such as plastic bags or pots), or in rows in nursery beds of disease-free materials like clean sand, sawdust, wood chips, peat moss, vermiculite or perlite. If soil is used, it should be sterilized and it must be light and well drained. Soil treatment may be done by the use of "steam" (preferred) or "chemical". After germination in seedbeds, the plants should be transplanted to containers when they reach a height of 8 to 10 cm. If seed is plentiful, nurserymen usually select just one plant from the polyembryonic seed and cut off the other shoots with a knife or pruning shears. If seed is scarce, nurserymen can separate the seedlings carefully and plant each of the healthy ones in a separate container.

1.3.2.2 Cleft grafting(wedge grafting):

Young, terminal scions of 6-10 cm diameter are used. The lower end of the scion is cut on 2 sides to form a wedge about 3-4 cm long. A young, tender rootstock plant 15-20 cm tall is cut off at a height of 6-8 cm above the soil level. The cut stump of the rootstock is split down the middle and the wedge of the scion is inserted into the cleft of

1.3 Propagation

1.3.1 Sexual propagation:

The easier way to grow a mango tree is to plant a seed: this is the most common way that trees are grown in many countries. Monoembryonic seed, having a sexual embryo, will not reproduce cultivars true-to-type, but will produce plants with highly variable characteristics. On the other hand, most of the embryos from polyembryonic seeds are genetically identical with the "mother" plant and produce plants which are uniform and true-to-type (Fig 4). Orchard trees of polyembryonic cultivars are grown from seed in many countries of the tropics.

There is an important disadvantage of growing trees from seed, however. Seedling trees must pass through a "juvenile" growth period before they begin to flower and produce fruit. Such trees require 6 to 10 years (or more) to bear their first significant crop, instead of the 4 to 5 years required for grafted trees. Seedling trees also are larger and less easy to manage than grafted trees. Therefore it is preferable to plant grafted trees for purposes of commercial fruit production.

Seed propagation is used universally for propagation of rootstock trees. Certain polyembryonic cultivars make the best rootstocks. They are known by various names, such as Turpentine (Florida), criollo (Latin America), hilacha (Colombia),

Seeds for rootstocks are taken from mature fruit. Some nurserymen prefer to use mature green fruit because they find it easier to remove the pulp and stone with a sharp knife. Others prefer to use soft, ripe fruit.

Many nurserymen prefer to remove the stone from the seed because they get a faster and more uniformed germination. The cleaned seed is allowed to dry overnight in the shade and then planted as quickly as possible since a mango seed will only remain viable for 3 or 4 days after removal from the fruit. The seed is planted on edge with the concave side down, because the embryo is on that side and the roots and stem will grow best if the seed is oriented that way. Planting the seed in other positions may induce the embryo and its root system to bend in an "S" shape causing the problem popularly known as "pot bound" trees. The seed should be covered to a depth of about 1 cm.

It is desirable to have uniformed rootstock plants in the nursery, so weak plants or exceptionally vigorous ones are eliminated. Germination of seed should occur in 2 to 4 weeks. The stocks are classified by size to facilitate that all plants in a block will be ready for grafting at almost the same time.

1.3.2 Asexual (vegetative) propagation:

The vegetative propagation of the mango can result in one-parted (where no rootstock is used) or two-parted trees (whe.:e a rootstock is used). Mango trees can be propagated best by making 2-parted trees. These consist of a scion and a rootstock joined together by a graft union. The scion forms the top of the tree and the rootstock forms the lower trunk and the root system. Vigorous, healthy seedlings with single straight stems and smooth green bark are best for rootstocks. The most efficient nursery practice calls for the use of rootstocks with a stem diameter of 6 to 8 mm, but some nurserymen use larger ones. Grafts should be made 10 to 15 cm above the soil level.

Scionwood is selected from actively growing leafy stems with smooth, green, non-corky bark. The buds should be well-formed and swelling. Dormant buds can be forced into active growth by removing the leaves from the stem 6 to 10 days before the scions are cut from the tree.

There are two main methods for making 2-parted trees; these are grafting and budding.

1.3.2.1 Veneer grafting:

This is a common and dependable method also known as "side" grafting. A terminal scion 6-10 cm long with several buds is used. A long, shallow "veneer" cut is made through the bark and slightly into the wood on one side of the scion. The length of the cut will usually be 3/4 the length of the scion or more. A shallow cut of similar length is made on the rootstock. The two cuts are joined so that the cambial tissues of the scion match those of the rootstock as well as possible. The scion is bound to the rootstock with plastic grafting tape. Small gaps are left at the sites of the buds so they may grow without interference. It is advisable to cover the full length of the scion with grafting tape to prevent it from drying out.

After the graft union is formed and there are new shoots on the scion, the top of the rootstock is cut off just above the graft union. Often it is desirable to put a stake in the soil of the container to support the tender young stem of the grafted tree.

1.3.2.2 Cleft grafting(wedge grafting):

Young, terminal scions of 6-10 cm diameter are used. The lower end of the scion is cut on 2 sides to form a wedge about 3-4 cm long. A young, tender rootstock plant 15-20 cm tall is cut off at a height of 6-8 cm above the soil level. The cut stump of the rootstock is split down the middle and the wedge of the scion is inserted into the cleft of the rootstock. Scion and rootstock are bound together with plastic tape. A small plastic bag is used to cover the unwrapped upper portion of the scion. The bag should be removed as soon as the buds sprout, usually within 10-15 days from the time of grafting.

1.3.2.3 Chip budding:

Scions should be taken from young branches with relatively long internodes. A thin section of bark 2-3 cm long, with a single bud in the center, is removed from the stem with a shallow cut extending slightly into the wood. A shallow cut of the same length is made on the stem of the rootstock, and the cambium tissues of scion and rootstock are matched as well as possible. The bud is bound to the rootstock with plastic tape. A small gap is left at the site of the bud so that it can grow without being impeded by the grafting tape.

1.3.2.4 Topworking:

Often growers wish to graft selected cultivars on seedling trees in the field, or convert grafted trees over to different cultivars. This can be done by cutting back the main limbs on the rootstock trees to stumps and making veneer grafts directly on the cut stumps. This is relatively easy to do on rootstock branches which are not larger than 5-6 cm in diameter. On larger branches, however, the bark is so thick that it is difficult to make veneer cuts. For that reason it is best to wait until new shoots grow out from the cut stumps, and then make veneer grafts on the shoots. Such grafts grow very rapidly and will bear fruit in 2-3 years.

One-parted plants:

These plants are made without the use of a rootstock. Several methods are used to induce the formation of roots on plant parts from the desired cultivar. They include marcottage (air layering), cuttings, and tissue culture. All have been demonstrated experimentally, in the nursery or the laboratory, but very rarely, they have been used to make plants for commercial orchards. At this time, grafting and budding are the main, maybe the only practical methods for vegetative propagation of mango nursery stock. However, the use of apomitical embryos could also be considered a one-parted plant with the disadvantage of taking a long time to come into bearing.

1.4 Care of young trees in the nursery:

Good sanitation is essential for a successful mango nursery. It is very important to have a clean, well-drained medium in the plant containers. Media can be made from various combinations of sand, sterilized soil, compost, sawdust, wood chips, vermiculite, peat moss, or perlite. Containers should be arranged in straight rows on a firm, level surface. Usually the containers are arranged in sections 2 to 4 rows wide, with the containers against one another for support, and with aisles between the sections wide enough for necessary operations to be done e.g. weeding, watering, fertilizing, & grafting.

1.4.1 Application of Fertilizer:

A granular balanced fertilizer should be applied in small amounts, to the soil in the containers, every 4 to 6 weeks. The objective is to keep the plants growing steadily so they will reach grafting size in as short a time as possible. A common practice in many successful nurseries in Latin America and the Caribbean has been to apply 60 g./plant of a complete formula e.g. 15-15-15 every 2 month, and in the month off apply 28 g. of Ammonium Sulphate. Monthly foliar application of a well balanced fertilizer significantly helps to make the waiting period for grafting the stock, as well as the time needed for transplanting, short.

1.4.2 Irrigation:

Water should be applied regularly as needed. The best method is to apply a sufficient amount of water to wet the soil to the bottom of the container and then wait until the surface layer starts to dry before applying water again, but without allowing the plant to show the symptoms of water stress. Obviously, the frequency of irrigation will depend upon rainfall, atmospheric humidity, wind conditions and the growth of the plants.

The best methods of irrigation in a mango nursery are overhead sprinklers or individual drip tubes because they provide uniformity and are easy to manage. Alternatives are the use of sprinkling cans or hoses with perforated nozzles. It is not recommended to place the plant containers in trenches and irrigate them by gravity (furrow) because there is too much likelihood of spread of disease.

1.4.3 Weed control:

Weeds should be removed from the containers by hand when they are small to prevent competition for water, nutrients and light. It is not advisable to use herbicides to control weeds in containers, because of the chance of damage to the mango plants. However, herbicides can be used in the aisle taking precaution to avoid drift. The use of shields and canvas/plastic skirts are very helpful to avoid the drift. In some countries, geese are used to prevent weeds to seeds in the nursery. Nevertheless, although in the long term this practice prevents the multiplication of annual weeds, the competition from perennial weed persist.

1.4.4 Disease control:

Anthracnose disease, mango scab, and powdery mildew are likely to infect tender young leaves of nursery plants at times. They can be prevented by regular application of fungicides before infection occurs. Usually monthly application will be sufficient, but in humid conditions it may be necessary to make applications as frequently as every 1 to 2 weeks. Maneb, Mancozeb, Benomil and cooper are the most common fungicides used in mango nurseries.

1.4.5 Pest control:

Scale insects frequently infest mango plants in the nursery. Occasionally, mites and aphids may appear in new growth of the young tree. Plants should be inspected frequently and sprayed with an effective insecticide if they are present. Malathion is perhaps the most popular insecticide/scalicide used in a mango nursery. Piretroids are also frequently used as insecticides/miticides.

1.5 Release of plants from the nursery

1.5.1 Timing:

With good care rootstock plants can be ready for grafting in 5 to 8 months after the seeds are planted. Trees 40-50 cm tall, can be ready for planting in the field 6 to 8 months after grafting. Some growers prefer to plant trees 90 to 100 cm tall or larger. It may take 12-16 months after grafting to produce trees of that size.

1.5.2 Recommended standards:

Trees ready for planting should have a well-developed trunk 1.5 to 2.5 cm in diameter. The trunk should branch 30-40 cm above the soil level and the tree should have 2 to 3 main branches. It may be necessary to cut back the stems of trees in the nursery to force branching at the desired height. Some growers prefer to plant single-stemmed trees and to train them in the field after the root system has become established.

The root systems of nursery trees should be developed well enough to hold the soil together when the plants are removed from their containers, but the roots should not be "pot-bound". The leaves should be large and dark green in color, without fungal diseases or pest infestations.

PART II. PLANTING AND POST-PLANTING CARE

2.1 Planning the orchard:

Many factors must be considered in the location and design of the orchard. The mango tree grows and produces fruit best at altitudes between sea level and 500 m elevation in the tropics, although a commercial crop can be produced at altitudes as high as 800 to 900 m above sea level if other conditions are favorable. Nevertheless, experience has shown that the higher the altitude, the more pathological problems are present and the less yield obtained. A hot climate, with 6 to 7 hours or more of sunlight daily is best for good fruit development. High winds will cause flower drop, fruit drop, or mechanical damage to fruit. Therefore, sheltered areas are preferred and the use of windbreaks may occasionally be needed.

Amount and distribution of rainfall are very important factors. The mango plant requires a rest period, normally supplied by a dry period, to flower and set fruit well. Areas with a dry season prior to flowering time and with an annual rainfall of 500 to 1000 mm are the best. Areas of lower rainfall are acceptable only if irrigation is available and it is not too hot and windy. In areas of annual rainfall higher than about 1000 mm, frequent fungicide applications for control of diseases will be necessary. If the rainfall exceeds 2000 mm, mango cultivation is not likely to be successful.

The mango tree can be grown in a remarkable variety of soil types. However, it grows best in sandy loam soils of medium fertility. Good drainage and aeration are essential, and heavy clay soils or soils with a hardpan should be avoided. A soil pH of 6 or 7 is best, but mangos are grown successfully in soils as low as pH 5 and as high as pH 8, if care is taken to prevent deficiencies of mineral nutrients. Deep soils generally give the best growth, but mango trees will grow well in areas of shallow rocky soils, provided there is enough soil to cover the roots adequately. Cultural practices in such soils can be difficult, however, so they are not recommended unless there is not another choice. Mango trees are easily injured by salinity in the soil or the irrigation water. Damage is likely if salinity exceeds 300 ppm chlorides, so saline conditions should be avoided especially because it is difficult to do anything to correct them once the orchard has been established.

Topography is an important factor also, affecting the planting pattern, soil erosion, and the ability to use machinery in the orchard. Often a grower does not have a choice in the location of the orchard, but must use the land which he/she has available. Nevertheless, sometimes it is possible to improve suboptimal conditions with the use of the available technology to produce crop profitably e.g. construction of individual "eyebrow" or continued terraces can help in the control of erosion and facilitate husbandry on hilly land.

Another important decision when planning the orchard is whether to grow the mango in pure stand--called monoculture--or interplanted with other crops on the same land--called multiple cropping. Monoculture is most commonly used in plantations on level land where a high degree of mechanization can be used. Production practices under monoculture are easier and more cost effective than under multiple cropping systems. Multiple cropping has the advantages of utilizing the available space in the plantation more completely and avoiding some of the buildup of pests and diseases which can often occur in monoculture.

2.2 Establishment

Clearing of the land may or may not be necessary before the orchard can be planted. Clearing can be done by hand or mechanically, the expense depending upon the topography and the type and density of existing vegetation and the area to clean. Cutlass, handsaw and powersaw are common tools used in clearing the land manually. In contrast, large bulldozers are used in mechanical clearing. The removal of debris is a cumbersome operation. Quite often the debris is piled up on the spot and then burnt to facilitate land cultivation.

After the land is cleared, cultivation of the soil is usually done by machine on flat or gently sloping terrain. A tractor and a disk plow or similar device are used. If the site has some drainage problems and the grower still insist on planting mangos, a sub-solator helps to improve the internal drainage of the soil. In hilly land, where mechanization is not feasible, planting sites about 1 m in diameter are prepared by digging and leveling the soil with a hoe or mattock. Then individual "eyebrow terraces" are formed where the planting hole is to be made. Alternatively, large terraces may be formed where the cost-benefits allows.

2.2.1 Layout:

Three main planting systems are recognized: square, rectangular, and triangular (Fig 5). The first two are used mostly on flat land. The triangular pattern is most common for planting on hillsides. Planting distance should be related to the management of the orchard and the cultivars to be used. Some cultivars have a "columnar" rather than a "spreading" growth thereby allowing them to be planted close together. Where mechanical equipment is to be used, the rows must be farther apart than where the operation is to be entirely manual.

In the past it was common to plant mango trees at spacings of 12 m or more. Although this spacing facilitate intercropping, it takes the trees a long time to grow together. Nowadays it is common to see mango orchards with tree spacings of 8 to 10 m. In those cases it usually is the intention of the growers to maintain the trees indefinitely at that spacing, reducing the size of the canopies occasionally by pruning to prevent crowding. This spacing also allow for intercropping in the early years (< 4 years) of the grove.

In very recent times another tendency has become evident. Many growers are planting trees very close together e.g. 2x4 and 3-6 m, with the intention of removing some of the trees as they become crowded. This planting system known as "High Density

Planting" brings high fruit yields early in the life of the orchard. Its success depends upon the willingness of the grower to remove trees when it is time to do so, a procedure that many people find difficult to do. High density plantings are most appropriate in places where land is scarce and expensive, and where production costs are high. The designs may be rectangular, with rows farther apart and trees close-spaced in the rows, or square with all of the trees spaced closely and no wide middles.

2.2.2 Planting:

As a general rule the planting hole should be twice the width and depth of the container in which the plant is grown. The tree should be removed from the container without disturbing the root system and planted so that the surface of the soil ball is slightly lower than the surface of the surrounding soil. In places where the topsoil is shallow, keep the topsoil separate from the subsoil. The soil from the planting hole should be replaced firmly around the soil ball of the tree, but not compacted so tightly that drainage and aeration are impeded. It is recommended to incorporate a small amount (100 g) of a complete mineral fertilizer and about 1 kg of well decomposed manure with the topsoil and to use this mixture to fill the space below and around the soil ball of the tree being transplanted.

Mango trees are usually planted in a square or rectangular pattern on land that is flat or gently sloping. These designs facilitate the use of mechanical equipment. The rows should be oriented so as to favor maximum exposure of the tree canopies to sunlight and the passage of winds through the orchard.

Much of the land in the Caribbean has slopes of 20% or more, so soil and water conservation are important issues to consider when planting any crop. Under these conditions mango trees should be established in triangular patterns, and on terraces if possible. The construction of large, continuous terraces is an expensive operation, but very effective in controlling erosion. Planting in individual "eyebrow" terraces which can accommodate one tree at a time is very useful in controlling erosion at a relatively low cost. Live plant barriers such as those made with Lemon grass and Vetiver grass provide extra protection to the soil from erosion .

2.3 Intercropping:

Agriculture in most of the Caribbean islands is characterized by multiple cropping systems. The combination of root crops, other food crops, and fruit trees is a normal pattern found throughout the region. The mango tree can be adapted to these conditions (including "agroforestry" systems), but the system can be managed most efficiently if the orchard is planned prior to the planting of the trees. Mango trees can be interplanted with banana, papaya, pineapple, annonas, citrus, tamarind, avocado, and other fruit trees. Interplanting of vegetables, grain crops and root crops is also feasible. With all of these crops, the most important consideration is to use plants for which the cultural operations are compatible with the main crop (mango). Unfortunately, in the Caribbean, the orchard is rarely planned prior to the establishment of any tree. Consequently, it is not unusual to find plots overcrowded, or scattered planted with open, misused spaces and/or with a wrong combination of species planted. Moreover, most farmers are opposed to thinning- out mature trees even in a situation where yield is too low due to high competition among the trees planted.

2.4 Windbreaks:

The wood of the mango tree is strong and not easily broken by exposure to winds. Windy conditions can make it difficult to establish young trees in the orchard, and they do a lot of damage to flowers, and especially to young fruit, causing fruit drop or scarring of the surface. Temporary windbreaks can be provided by pigeon peas, sugar cane, bananas, or plantains. Saran netting and polypropilene bags can be used to build individual windbreak barriers. Fruit trees such as mango seedlings or sapodilla, as well as Casuarinas or other forest trees can also be used as permanent windbreaks for mango orchards. Windbreaks have the disadvantage of competing with adjacent rows of fruit trees for light, nutrients and water. They also reduce the potential number of trees of the main crop, and add extra maintenance costs to the orchard. Therefore, in each particular case, growers should be sure that wind conditions are sufficiently injurious to economically justify the use of windbreaks.

2.4 Orchard management:

Care of the orchard is different for non-bearing trees than for bearing trees. Care includes application of fertilizer, irrigation, weed control, pruning, and pest and disease management.

2.4.1 Fertilization:

Although, most scientists agree that the mango can adapt to a wide diversity of soil and that it tolerates a very low fertility, the level of production is substantially increased on fertile soils.

Sixteen elements are considered essential for plant growth and development. These are Hydrogen (H), Oxygen (O), Carbon (C), Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulfur (S), Iron (Fe), Copper (Cu), Zinc (Zn) Manganese (Mn), Boron (B), Chloride (Cl), and Molybdenum (Mo). It is well known that naturally the plants obtain the first three elements (H,O, and C) from the Carbonic gas and from the water, while the rest are taken from the soil.

Several studies have shown that Nitrogen and Potassium are removed in larger quantities by a mango crop. These are followed by Calcium and Sulfur, then Magnesium and last Phosphorus.

The fertility of the soil must be considered in the development of the fertilizer program. A soil analysis is always helpful in determining the initial requirements of mango trees. Two types of fertilizer are recommended, organic (manure or compost) and inorganic (mineral). In the first few years a balanced formula high in nitrogen, phosphorus and potassium, e.g. 15-15-15, is usually required. Magnesium is frequently required as well, and can be applied in the mixed fertilizer or separately in the early ages. Frequent applications e.g. every 6-8 weeks, are made to the soil around young trees.

Although the amounts required will vary with local conditions, the program in most places is initiated with 100-200 g per tree per application, gradually increasing to 400g by the third year. The frequency of application is reduced to 3 or 4 times a year when the trees reach about 4 years of age. As with other tree crops, application of phosphorus is reduced or eliminated as the trees become older because this element accumulates in the soil and is available to the tree as the insoluble forms slowly break down in the microenvironment around the feeder roots.

In soils of pH 7 or below, the mango tree seldom has deficiencies of micronutrients. If the pH is higher, however, deficiencies of zinc, iron and manganese often appear. Iron deficiency normally is corrected by application of chelated products such as Sequestrene 138 and Sequestrene 330. Applications of 50-100 g are made by drenching into the soil. As an alternative, small amounts (10-15 g/tree) are applied through the drip or microsprinkler irrigation system every 2-4 weeks. Zinc and manganese are applied as inorganic compounds (sulfates) to the soil or as neutralized inorganic compounds sprayed on the leaves.

2.4.2 Weed control:

Weed control can be done manually, mechanically, chemically, or by a combination of these methods. Manual weeding is done with a hoe or a cutlass. Mechanical weeding is done with a mower or a drag, or by shallow cultivation with a rotovator or a disk plow. Normally, mechanical methods are used to control weeds in the space between the rows and, if the tree spacing is wide enough, between the trees in the row. Weeds near the tree trunk need to be controlled manually or chemically to prevent damage to the tree. Herbicides may be applied in a circle around the tree or in a continuous band in the row. These chemicals can be applied with a tractor-mounted boom sprayer, a knapsack sprayer or mist blower, or with a "chemi-hoe". The method used will depend upon the size of the orchard and the equipment available. The most commonly used herbicides are Paraquat, Glyphosate (Roundup), and Diuron. Other such as Simazine, Dalapon or selective grass killers such as Fusilade, Daconate and Asulox can also be used.

2.4.3 Pruning:

Mango trees grow fast and become very large in the tropics. Some growers prefer to control the size of the tree and the form of the canopy by selective pruning, begun early and continued throughout the life of the tree. The most commonly used method is periodic removal of the strongest shoots from the center of the tree canopy. This has the dual effect of controlling tree height and opening the canopy for more favorable penetration of light. In most countries, however, little selective pruning of mango is done.

Instead, pruning is limited to "topping" (non-selective reduction of tree height) and "hedging" (reduction of canopy width). If this is done frequently so that only small branches are cut back, it does not interfere significantly with subsequent flowering and fruit production. If large branches are cut back, they respond with strong vegetative growth and flowering usually does not occur in the following year or two.

Pruning may be done by machine, or by hand with saws (mechanics, neumatics or manuals) or pruning shears.

Researchers around the world are searching for dwarf cultivars of mango or for dwarfing rootstocks. One of the most popular cultivars in the English speaking Caribbean is the "Julie" which is considered a commercial dwarf-cultivar.

2.4.4 Flower Induction:

Researchers have discovered methods which can cause the induction of flowers on mango trees outside of the "normal" season of flowering. This discovery is important because it enables growers to force mango flowering under conditions where normal trees do not flower well, or to produce crops of fruit at times when the price is higher than during the normal season of production. In its simplest form the method consists of spraying the leaves of the trees with a solution of 40-240 g per liter of potassium nitrate (KNO_3) in water, causing flowers to form within a few weeks. Ammonium nitrate (NH_4NO_3) has been found to be effective also under certain conditions. Recently various commercial preparations have become available which contain other growth-regulating chemicals in addition to potassium nitrate e.g. Miracle Blum. Among other regulating chemicals, Paclobutrazol e.g. Cultar, and Uniconizol also have flower induction properties. The first one is widely used commercially in India and other mango producing countries. Uniconizol is still at the experimental phase and therefore not accepted for commercial used yet.

Chemical spraying to cause flower induction does not work under all conditions. Testing is in progress all over the tropics to find the best materials and the proper timing of applications. Until specific recommendations are available, growers will have to determine the best methods by experimentation in their own orchards with the different products available in the market.

2.4.5 Disease and pest management:

Mango growers should manage their orchards in such a way as to produce fruit acceptable for their intended market with as low a cost and as little use of chemical products as possible. Quality standards for fruit sold in international trade are much higher than for fruit sold in local markets. An integrated pest management (IPM) program should be used. Orchards should be established where environmental conditions are as favorable as possible. Cultivars resistant to diseases and pests should be planted if available. Biological control by natural predators and parasites should be encouraged. Growers should be aware of the economic benefits possible through the sale of "organic"

Erosomyia mangiferae	Gall midge	Inflorescences
Anastrepha spp.	Fruit fly	Fruit
Conodonta sp.	Fruit piercing moth	Fruit
Sternochaetus mangiferae	Seed weevil	Seeds

Source: Rhodes, L.F. 1992

Different Fruit flies species of the genera *Anastrepha i.e. obliqua, serpentina, ludens, striata, ocrecia and suspensa*, have been reported in the Caribbean causing extensive damage to the mango fruit. Other genera classified as quarantine pests such as Ceratitis and Dacus has not been reported for any of the islands but the latter is found attacking mainly carambola in Suriname.

fruit.

Although some diseases and pests can be controlled by biological methods, inevitably most growers will encounter problems which can best be solved by the use of pesticides. These materials should be used only according to officially recommended procedures, not only those of the country of production, but also those of the countries where the fruit is to be sold. Many "organic" products are now available in the market and growers should be encourage to use them to reduce the damage to natural enemies.

2.5 Yields:

where chelated products may have to be use regularly to avoid deficiencies wi elements.

The internal breakdown of mangos has being attributed to a problem of nutr balance where Calcium and Potassium play a major role. Some varieties such as Toi Atkins are more susceptible than others.

2.6.2 Pests:

Over sixty arthropod pests attack the mango but of these less than 15 are considered major pests. All parts of the mango plant can be attacked by pests causing in many cases a reduction on productivity or fruit quality. The mango pests can be classified according to the part of the plant that they affect. Table 2, list the main insects and mites pests which have been reported for mangos in the Caribbean.

Table 4. List of Insect and Mite Pests Recorded for Mangos in the Caribbean Region

List of insect and mite pests recorded on mango in the Caribbean

Scientific name	Common name	Plant part affected
Diaprepes spp.	Root weevil	Roots, leaves
Pachnaeus litus	Root weevil	Roots, leaves
Hypocryphalus mangiferae	Bark beetle	Twigs, stems
Apate monachus	Black stem borer	Twigs, stems
Xyleborus spp.	Ambrosia beetles	Wood, bark
Neotermes sp.	Termite	Stems, branches
Dialeurodes sp.	White fly	Leaves
Ceroplastes sp.	Soft scale	Leaves
Coccus acuminatum	Mango shield scale	Leaves
Coccus mangiferae	Mango scale	Leaves
Coccus viridis	Green scale	Leaves
Pulvinaria psidii	Green shield scale	Leaves
Aulacaspis rosae	Mango snow scale	Leaves
Insulapsis insularis	Snow scale	Leaves, fruit
Vinsonia stellifera	Star scale	Leaves
Ischnaspis longirostris	Black thread scale	Leaves, fruits,twigs,
Planococcus citri	Citrus mealybug	Leaves, fruit
Acromyrmex octospinosus	Leaf cutting ant	Leaves
Atta spp.	Leaf cutting ant	Leaves
Polyphagotarsonemus latus	Broad mite	Leaves,fruits
Selenothrips rubrocinctus	Red-banded thrips	Leaves
Macraspis tristis	June bug	Inflorescences

...cts as possible. Quality standards for fruit sold in international trade are much ...r than for fruit sold in local markets. An integrated pest management (IPM) program ...uld be used. Orchards should be established where environmental conditions are as ...avorable as possible. Cultivars resistant to diseases and pests should be planted if available. Biological control by natural predators and parasites should be encouraged. Growers should be aware of the economic benefits possible through the sale of "organic"

The presence of most *Anastrepha* larvae species in the fruit necessitates hot water treatment for compliance with strict quarantines against entry of infested fruit into countries like the Unites States and Japan.

The Mango seed weevil (*Stenochetus mangiferae*) is present in Barbados, St. Lucia, Dominica and the French islands (Guadeloupe and Martinique). Their larvae infest the seed of the fruit and there is no acceptable method of treatment which will enable the fruit to be shipped into countries which have a quarantine against this insect e.g. USA. Other pests of commercial importance include the rats and birds.

2.6.3 Environmental factors:

Several factors are important for good mango production and quality. The soil must be well drained. The trees must be grown in full sun; they will not produce well in the shade. There should be an abundance of sunshine most of the time. However, in some locations high light intensity usually combined with high temperature may cause sunburn to fruit overexposed. Although the tree can withstand drought conditions well, there must be a good supply of water during the first years after planting, to get the young trees established, and during the season of fruit set and fruit development. Excessive wind causes fruit drop and fruit scarring, so protection is advisable in windy locations.

2.6.4 Physical and chemical factors:

Physical damage to the fruit and the tree can be caused by careless use of machinery and improper handling of fruit. Growers should train their workers to use machinery carefully and to avoid handling injury to trees and fruit in the orchard. Careful use of pesticides is important also. Herbicide damage from improper application or spray drift is a common occurrence, if workers are not trained properly, or the application is done when wind intensity is high. Damage to the surface of the fruit can be done by pesticides if they are not applied according to recommendations. The external quality of the mango fruit may be damaged by the sap flowing either from the peduncle or peel of the same fruit or that of another fruit.

2.6.5 Nutritional factors:

On normal conditions the mango plant is not prone to have important nutritional problems, as long as a regular program of fertilizer application is maintained. Growers should understand that sustained high fruit production can be obtained only with a regular fertilizer application program. Nevertheless, special conditions applied to calcareous soils where chelated products may have to be use regularly to avoid deficiencies with minor elements.

The internal breakdown of mangos has being attributed to a problem of nutritional balance where Calcium and Potassium play a major role. Some varieties such as Tommy Atkins are more susceptible than others.

Part III HARVESTING AND POSTHARVEST HANDLING

3.1 Harvesting:

3.1.1 Methods and equipment:

Both the method of harvesting and the equipment used during the harvesting operation are important factors to consider to maintain high quality of the fruit picked. The basic objective is to remove the fruit from the plant in a rapid, yet economical, way and with the least possible damage that would contribute to its reject for the market. The mango fruit is picked from the tree by hand or with picking poles. If the trees are small they can be harvested by workers standing on the ground, but as the tree get larger, they must use ladders or mechanical devices such as hydraulic lifts. Workers must be trained to handle the fruit carefully to avoid cuts, bruises and abrasions to the skin. Fruit that is small, deformed, damaged or otherwise undesirable should be culled out during harvest and left on the ground in the orchard.

The picking pole consists of three parts: a) The pole which can be made of wood, aluminum or bamboo and normally is from 3 to 10 m long; b) The knife or blade, mounted on the end to cut the fruit stem, and c) a canvas or mesh bag to catch the detached fruit. Several manufactured models are available. The blade can be substituted by a wire bent in zig zag or U where the peduncle is broken by the action of pulling down the fruit (Fig. 6).

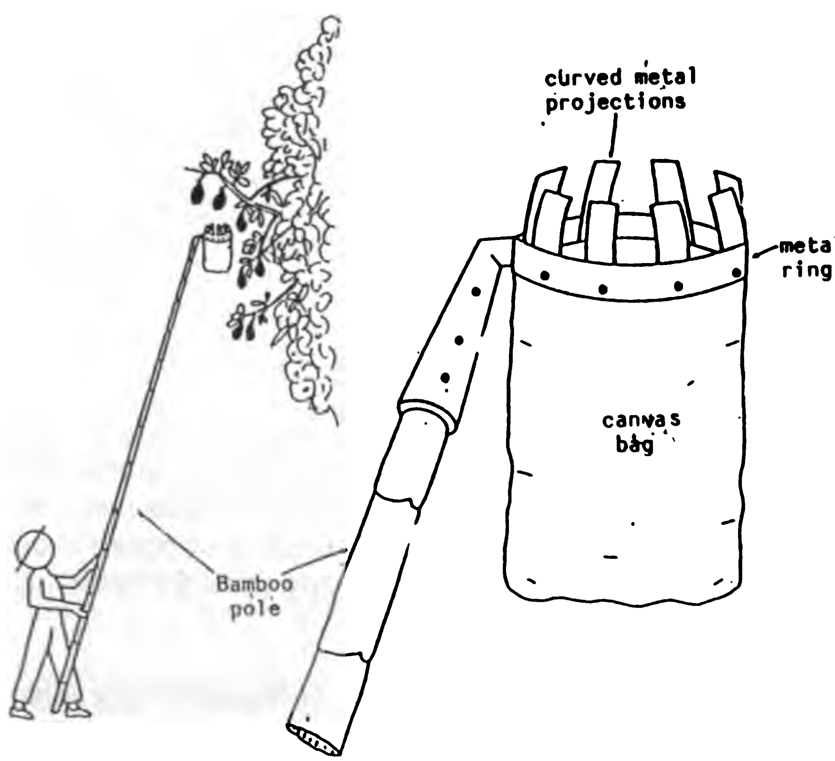


FIGURE 6. HARVESTING POLE

Mango trees usually grow too large to be harvested without the use of ladders or hydraulic lifts. Ladders can be used in any sort of terrain, but hydraulic lifts are practical only in relatively flat land.

The fruit is placed in containers of 10-12 kg capacity as it is picked from the tree. Plastic buckets are preferred over other containers in Florida because they cause less injury to the fruit. Other kinds of containers include metal buckets, wooden or plastic boxes, and cloth or plastic bags.

Various methods of handling are used. The small containers may be stacked directly on trucks or dumped into truck beds. A better method is to dump the fruit gently into wooden bins, which are sitting on the ground or on trucks. If the bins are large, a mechanical forklift is needed to lift them onto the truck from the ground. It is important to handle the fruit as carefully as possible when transferring it from one container to another.

3.1.2 Maturity indices:

If mango fruit is to be sold in local markets, it usually is picked from the tree after it has begun to change color on the tree from green to yellow or red. It is best to pick the fruit before it is soft, because soft fruit is easily damaged and has a short shelf life.

If the fruit is destined to be packed and shipped for long distances, it should be picked at the mature-green stage. At this stage the fruit is hard and green, but it is physiologically mature and is capable of ripening to good eating quality after it is picked from the tree.

Two main indices are used in Florida and elsewhere to determine when the fruit is physiologically mature. The best test is to cut away a section of the fruit with a sharp knife and to observe the color of the pulp. If the pulp is white, the fruit is immature and should not be harvested because it will not ripen normally. If the pulp has begun to turn yellow next to the seed, but still has a whitish color near the skin, the fruit is physiologically mature and will ripen after it is picked from the tree. This is the stage at which much fruit is picked for long-distance shipping because it will ripen to good quality, but has a long storage and shelf life.

The other test involves the shape of the fruit. Maximum mango fruit size is attained at the point of physiological maturity. At this stage the fruit is well filled out on the shoulders and on the "cheeks" or sides. The proper shape for each cultivar must be learned by experience. Usually these two tests are used together. A representative sample of fruit is cut to determine the color of the pulp. If the pulp has begun to turn yellow, than all of the fruit of the same shape and size can be picked with assurance that it is mature. Mature green fruit can be stored for 2 to 3 weeks and have a shelf life of 6 to 10 days after storage.

Moisture content of the mango fruit pulp has been used as a maturity index in some places, such as Australia. Starch content and specific gravity of the fruit have been investigated in Florida as indices of mango maturity, but proved to be unreliable.

CURRENT SITUATION OF MANGO IN JAMAICA INCLUDING INVESTMENT CLIMATE

by

DR. HERMAN HAMILTON

MARCH 11th 1993

I have been asked to deal with the current situation relating to mango in Jamaica. My approach is going to be to consider this within the context of what is currently happening in the world markets AND which have some relevance to a path we have already embarked on. This approach excludes a consideration of the dominant so called "common mango" or "hairy mango" which as of now has little place on world markets.

In the investment mode, the normal approach is to first consider your market and be quite clear on the product being offered to that market. With the focus on export, the product I am going to address is the Tommy Atkins variety of mango with a smaller interest in the Keitt Variety, and some interest in the Julie Variety- directed to an ethnic market.

We have in the past made some erroneous decisions as it relates to a mango industry for Jamaica by not recognizing the specific product we should be dealing with. You cannot examine international statistics relating to mangoes and use these to appraise our approach in embarking on Tommy Atkins production.

Now I would like to take a look at the varieties previously mentioned.

VARIETIES

The Tommy Atkins and Keitt varieties are of recent occurence. They were developed in Florida, and for the forseeable future will be the principal varieties for international commerce in so far as the fresh fruit market is concerned.

The characteristics which allows for their present pre-eminence comes out of the characteristic of a very extended shelf-life after harvest.

Let me deal firstly with the Tommy Atkins Variety.

SIZE : Average size is 500gm or 1Ib 2ozs.

COLOUR: Purplish to Deep Red.

A Thick Skin, facilitates the rigours of transport and packaging.

Harvested at Maturity, it will last for two weeks at ambient temperature, three weeks at controlled temperatures, and even greater than three weeks with a new type of fruit wax.

All these characteristics are very significant in the whole process of market access.

The Keitt Variety has similar extended shelf-life characteristics but lacks the colour of the Tommy Atkins Variety. It's decidedly larger size - average 1 Kilogram-is a fresh fruit market disadvantage which is partially compensated for by the fact that it is a late season variety following the Tommy Atkins by about four to six weeks and commanding a somewhat better price.

The Julie Variety is currently of interest to the ethnic markets abroad. It is smaller than the Tommy Atkins or Keitt, lacks the red colour of the Tommy Atkins and has a shorter but acceptable shelf-life i.e. 10-14 days.

The pattern of how we have been accessing World Markets recently is as follows:

MARKET UK (80%) - some transhipment occurs to other EEC Countries
Canada (8%)
Holland (8%)

The rest goes to Bermuda and the Cayman Islands principally. NONE goes ot the US Market which is the largest market. Hot water treatment of mangoes is required for us to access the US market. We presently lack the facilities required for ensuring the protocol demanded by the US. These facilities are likely to be in place within one to two years.

A potentially excellent market is the Bahamas. Some archaic legislation excludes entry of our mangoes to that country. I don't think a great deal of effort would be necessary to correct this, but the initiative by an organization such as the Jamaica Exporters Association could be more effective than that of any single individual.

POTENTIAL MARKETS:

Some potential markets not explored but realistically worthwhile looking into are Japan and the Arab Countries.

Shelf-life acceptability, we can definitely address BUT shipping and transit issues require some researching.

IN SUMMARY:

The international markets are there. Five years ago after completing a study, I projected that imports to Eurpoe would double in five (5) years. That has been exceeded and is likely to re-occur in the next five to six years. An expanding European Market is exemplified by shipments for the first time to be made this season to Germany, Switzerland and France. These countries have not been subject to the substantial devaluation that has taken place recently for the British Pound.

Now let us look at locations for production within the island.

LOCATIONS

(a) Currently there are 8 major producers of the Tommy Atkins, Keitt, and Julie mangoes. Orchard sizes vary from 80-450 acres.

(b) These orchards are spread out from St. James through St. Elizabeth, through Clarendon through St. Catherine over to St. Thomas and also in St. Mary. Until a couple of weeks ago, the current largest project being implemented was in Hanover with 300 acres i.e. 200 acres Tommy Atkins and 100 acres Julie. Recently , we have heard announced a joint venture for over 1000 acres by Jamaica Flour Mills and the Jamaica Producers Group. This is to be sited in St. Thomas.

(c) I don't wish to detract from the obvious advantage of locating where conditions are most ideal; but location is not so important as ultimate management. Our hairy root stock allows for establishment right across the island. A critical factor is rainfall - not so much in terms of quantity but more in relation to monthly distribution patterns. The ideal situation really is minimal rainfall with irrigation in place. Let us look at the current level of production in the island.

PRODUCTION

(a) Currently there are 1800-2000 acres of TA in Jamaica providing 600,000 cartons or 6 million pounds of exportable fruit.

Our export statistics show only 50% of this exported, so a considerable 50% balance reaches the local market or goes for processing. Since local fresh fruit market prices are not much different from export prices, this suggests an attractive situation. Incidentally, current production levels are higher than those for the US.

With most of our present orchards nowhere near "steady state" i.e. their full potential, we can anticipate production levels to increase by about 200% within the next four years. Such levels are probably still insignificant when you consider that single producers in Mexico have acreages similar to our total acreage. Our distinct advantage to be exploited I will deal with later.

In terms of production, let us look at some of the **PROBLEMS**.

(a) Anthracnose infestation both for pre-and post harvest.

(b) Fruit-fly attacks for which we have acceptable chemical control.

(c) Some incidencies of stem-end rot due to fungal infection.

Last July I attended the International Mango Symposium. This is held every four years and brings together producers form all parts of the world. In Miami we had over 500 participants from over 50 different countries.

I came away with the feeling we are blessed. In Australia, India, some Caribbean Countries they cannot get the Tommy Atkins variety to blossom normally.

(d) PRAEDIAL LARCENY - Not as troublesome as it is purported to be when you have large acreages. Local markets cannot readily absorb quantities of stolen mangoes as in the case of citrus for example.

ADVANTAGES TO BE EXPLOITED:

(a) In global terms, we have a precedence of producing the best Coffee, Pimento, Ginger, more recently Oranges- or certainly "concentrates". The markets have defined the product (mango) which they wish and we have the characteristics:

(a) Purplish Red Colour.

(b) A most recent study-not yet published finds UK end-users claiming to be able to differentiate in taste between the Mexican and Venezuelan product on the one hand and Jamaican on the other. They preferred the Jamaican. I don't know if there is a difference, but what is important is that if they know a difference- let's exploit it.

SOME NEEDS:

(1) There is no research being conducted by government institutions in relation to cultural practices or organomic concerns.

(2) Research in the Manipulation of Flowering is mandatory. Prices fetched on world markets can readily triple for the "out of season" product.

(3) Some concerted work in establishing valid protocols for anthracnose control pre-and post-harvest is urgently required.

(4) Continuing market studies in a dynamic market involving continuous new players must be addressed. What was valid in 1991 may not be so in 1993.

What of the current investment climate in Jamaica.

1. High interest rates- a disincentive not only for mangoes but all agricultural activity. The current "in xs of 30% interest rates would allow for a pay- back period on investment of about 10 years. This could dramatically and attractively be reduced by interplanting. An excellent choice of a crop for interplanting is papaya. It ensures a cash flow after 9 months and phases out as the bearing of mangoes phase in. Other crops for interplanting are possible determined largely by soil type and location.

2. A major concern for investors embarking on agricultural projects is the question of labour. My experience out of four major orchards that I am associated with suggests a permanent employee force of 1 to every 25 acres, which is low and attractive.

3. Because of seasonality, there are eight (8) weeks of intensive activities relating to harvesting and then a subsequent 44 weeks of relaxed orchard maintenance.

4. I have not dealt with the vast potential that exists for value-added products. Certainly they will assume greater importance as our levels of production for the fresh fruit market increases.

I am thinking of such products as purees, dried fruit, nectars, canned slices and more recently mango powders.

5. While I have to the largest extent dealt with the export market, there has been an expanding local market directed to the tourist trade for example. It is significant that non-exportable grade fruit commands a price not dissimilar from export prices.

6. Finally, a mango growers association now in its infancy is a very positive step in the right direction. Apart from the co-operative efforts to promote a JAMAICAN product in international markets, it will facilitate our access to technical assistance and funding from international agencies.

THE MANGO FRESH FRUIT MARKET

Prepared by G. Barbeau
IICA Office - Trinidad and Tobago

World production is estimated to be over 16 million tonnes (FAO, 1992). India is the first producer with more than 60% of the total (9,700,000 tonnes) and is followed by Mexico and Pakistan who together, are able to reach 10% of the world production. The fresh fruit market represents about 100,000 tonnes a year; Mexico dominates the exports with almost 50% of the total amount. On the side of processing, India is the main exporter of pulp and juices.

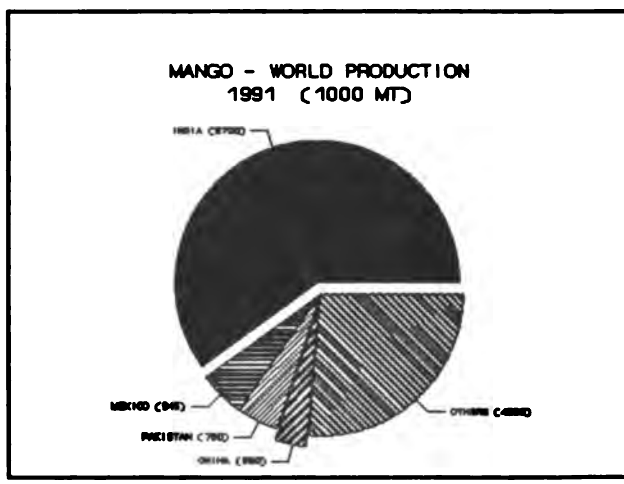
MANGO - WORLD PRODUCTION (1000 T)

COUNTRIES	89	90	91
INDIA	9500	9500	9700
MEXICO	826	800	845
PAKISTAN	765	761	780
CHINA	445	465	580
OTHERS	3325	4275	4222
TOTAL	14861	15801	16127

AMONG THEM :

THAILAND	569	614	614
VIET-NAM	NA	NA	507
INDONESIA	445	441	456
BRAZIL	400	415	395
PHILIPP.	370	375	346
HAITI	350	353	280
ZAIRE	208	208	210
MADAGAS.	195	196	205
DOM. REP	190	193	190
TANZANIA	185	186	187
BANGLAD.	159	175	160
EGYPT	129	144	140
VENEZUELA	127	127	130
SUDAN	125	100	130
PERU	59	60	62

SOURCE : FAO 1992



1) The exporters

Five countries have a significative presence on the fresh fruit market; these are by order of importance: Mexico, India, the Philippines, Pakistan, Thailand and Brazil.

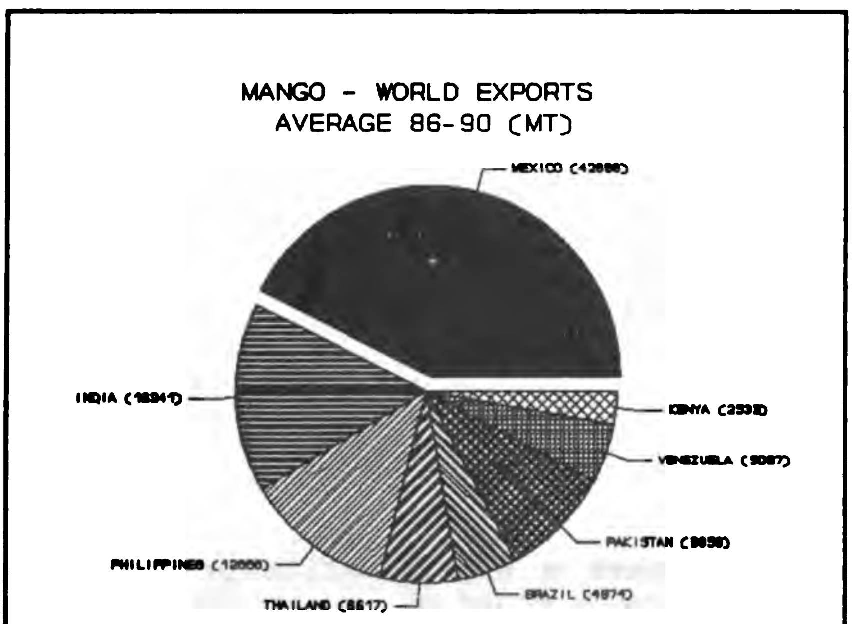
Mexico's exports are directed to the USA; they cover 86% of the US imports and supply the market from April to September with the same type of varieties as those grown in Florida: 'Haden', 'Tommy Atkins', 'Keitt' and 'Kent'. Small amounts go to the EEC and Canada.

India and Pakistan export their fruits to the Persian Gulf (Saudi Arabia, United Arab Emirates, Kuwait). Some attempts have been made towards the EEC but so far the cost of transportation has proved to be prohibitive. The most known varieties from India are: 'Alphonso' and 'Totapuri'. India also exports mango pulp (18,000 tonnes) and juice (8-12,000 tonnes). 90% of the pulp goes to Saudi Arabia.

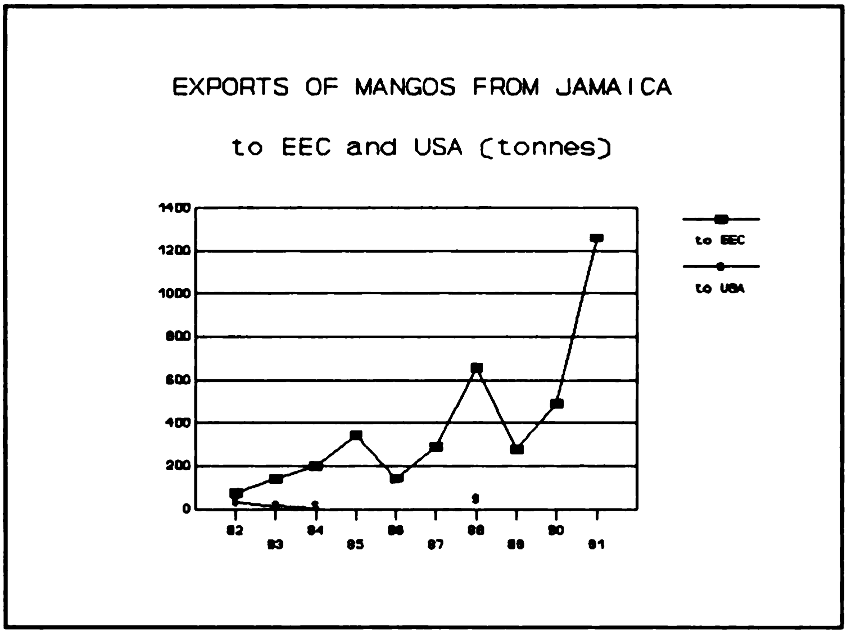
The Philippines and Thailand are targeting the Asian markets: Japan, Singapore, Hong Kong and Malaysia. A few hundred tonnes are exported to the EEC and Canada. Their varieties are generally long and green-yellow in colour.

Brazil has been developing its production very quickly. Since most of the varieties were of Asian origin, they are increasing the production of Floridian cultivars in order to satisfy the European and American consumers.

Many African, Latin American and Caribbean countries are also present on the market with volumes generally less than 1,000 tonnes a year. In the Caribbean some mango producing countries are able to find a market in the US (Haiti, Grenada) or Canada and the EEC. Grenada has been exporting about 1,500 to 2,000 T a year, Jamaica 1,200, St Lucia and Belize 400 to 500 and Dominica 100. Varieties include mainly 'Julie', 'Graham', 'Grenada' and 'Peach'. These varieties are targeted towards the ethnic markets.

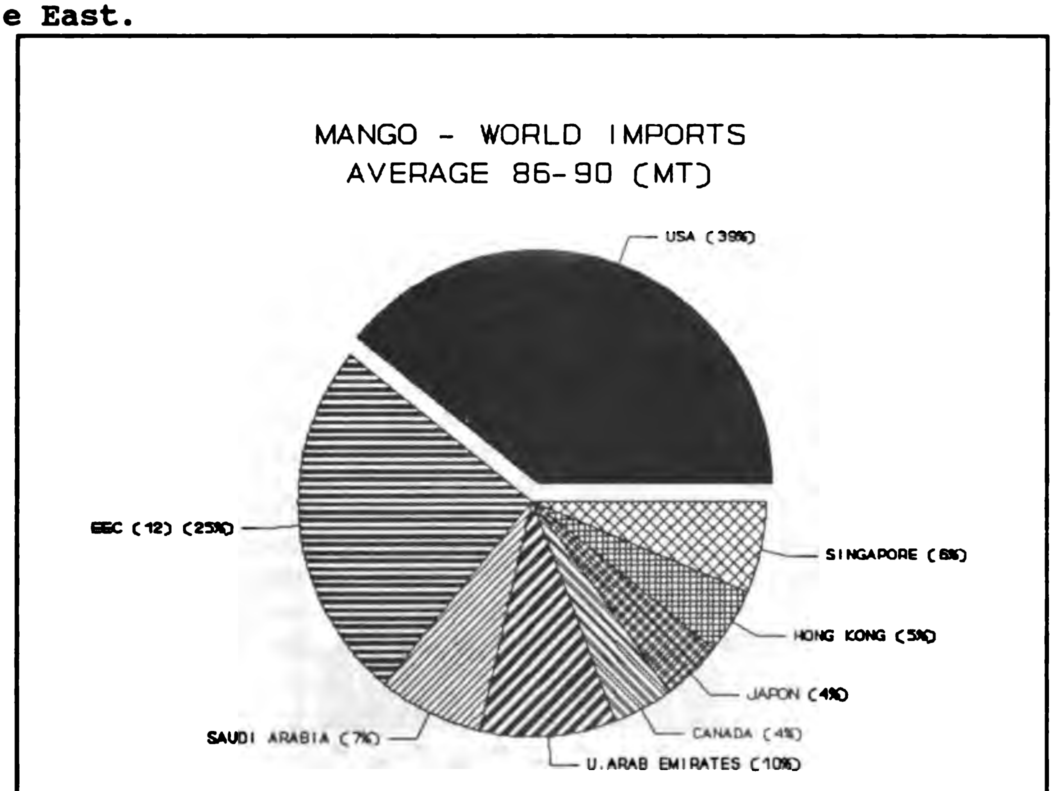


Jamaica seems to have directed most of its mango exports to the EEC.



2) The consumers.

Three markets import the bulk of mangoes: the USA, EEC and the Middle East.

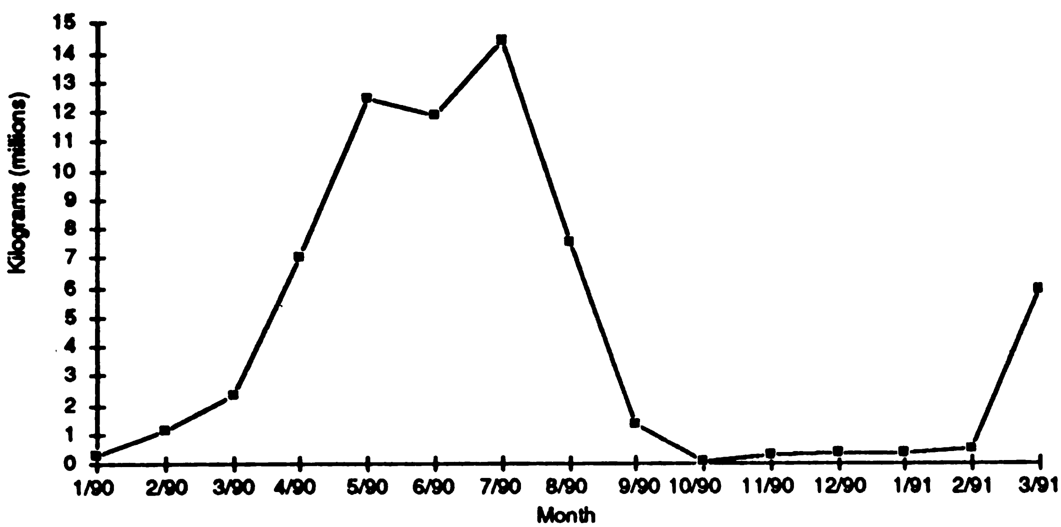


<u>a) USA</u> The USA is the largest importer of fresh mangoes with 90,000 tonnes in 1991 and 73,000 in 1992 up to September, of which 88% came from Mexico and 11% from Haiti. The annual Floridian production accounted for about 10,000 tonnes more until hurricane Andrew hit Florida in September 1992. Value of imports in 1991 was estimated at US $63 million, and was above US $67 million in September 1992. The US market had an increase of 50% in the last two years, which benefited only Mexico. However some problems related to phytosanitary regulations persist.

<u>Seasonality</u>

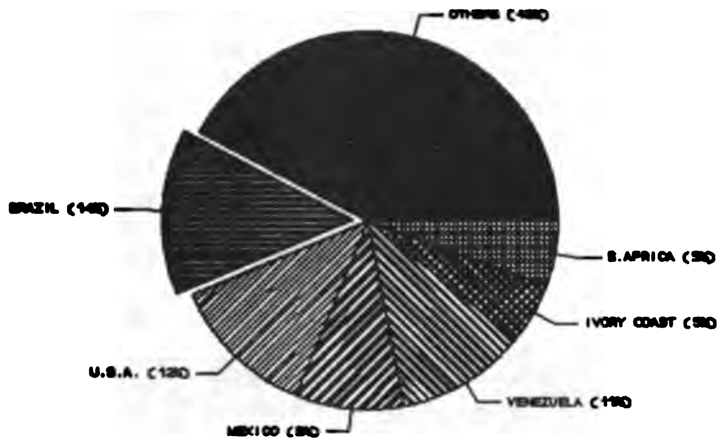
In the US the bulk of mangoes is imported from April to August. This may be because almost nothing is imported from the Southern Hemisphere.

U.S. MANGO IMPORTS — 1/90 THROUGHT 3/91
KILOGRAMS



<u>b) EEC</u> EEC imports of mangoes are increasing very quickly, from 2,000 tonnes in 1982 to more than 48,000 tonnes in 1991. A large number of countries are supplying the EEC. Ten years ago the African countries represented more than 30% of the volumes; they have now dropped to almost 20% because their green/yellow varieties are supplanted by more colourful ones ('Tommy Atkins', 'Haden') from Latin America which now has more than 50% of the market. Main suppliers are Brazil, USA, Mexico and Venezuela. African countries are present on the market from April to June in direct competition with Venezuela and Mexico (May is the month with more supply). Then comes the USA from July to September. October and November are months of less activity because of a lack of supply and also a poor demand. In December and January the market is dominated by Brazil and Peru. South Africa takes the advantage in February.

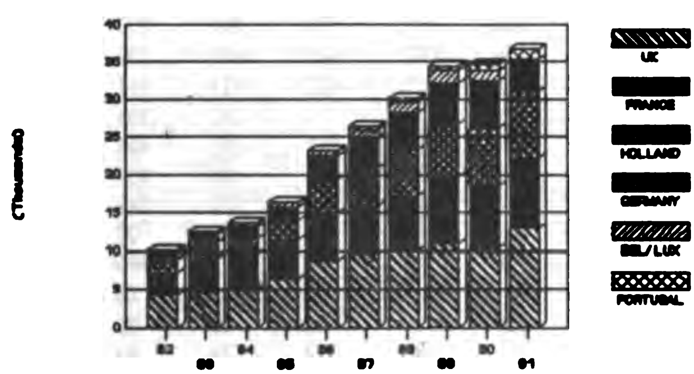
EEC IMPORTS - AVERAGE 86-90
Mangos (mt)



The UK maintains the leadership for imports of mangoes, with more than 30% of the total. It is followed by France, Holland and Germany. Customers prefer small-medium size fruits (250-350 g) with a nice yellow/red or red/purple color. Floridian varieties such as 'Tommy Atkins', 'Irwin', 'Sensation', 'Zill' and 'Haden' respond to these criteria. Other Floridian like 'Keitt' and 'Kent' are often considered too big for individual customers but have the favour of the restaurants. Some West Indian varieties like 'Julie' are also marketed in small quantities mainly in the UK.

EEC IMPORTS OF MANGOES

Extra EEC (1982-1991)



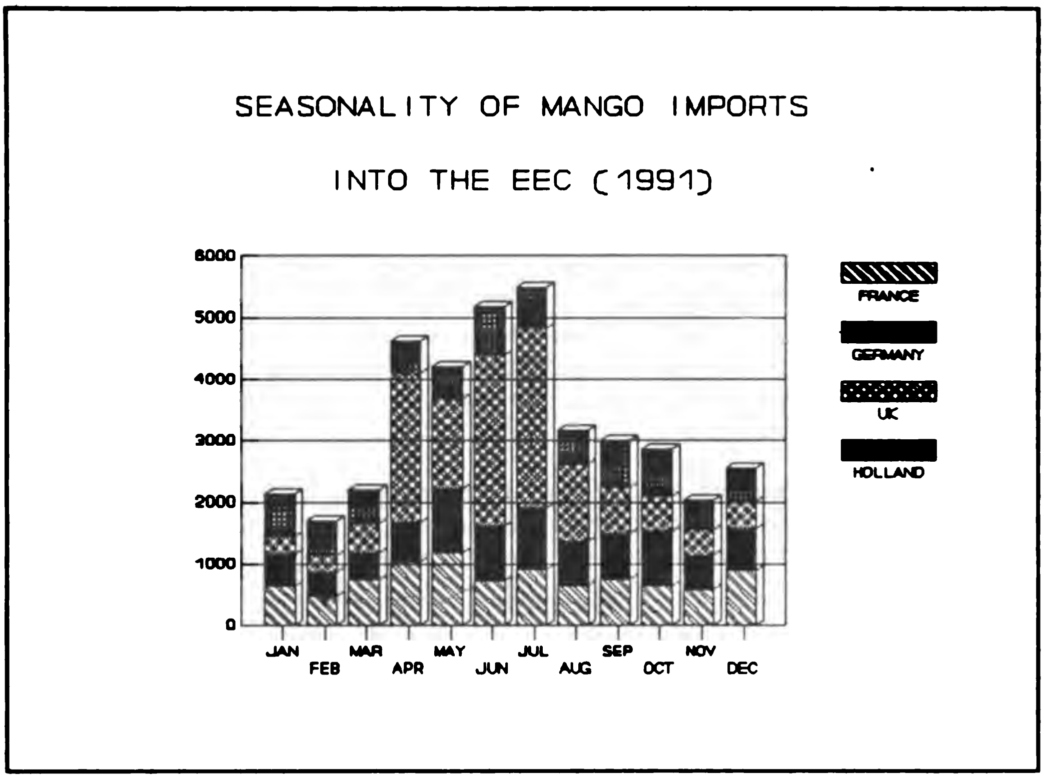
EEC IMPORTS - MANGOES (tonnes)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
U. K.	4292	4724	5178	6463	8831	9622	10141	10929	10440	13029
FRANCE	2985	4368	4514	5044	6171	6330	7171	8806	8222	9238
HOLLAND	1597	1960	2028	2544	4441	4954	6061	6999	7547	8901
WEST GERM	745	1135	1511	1745	3083	4227	4834	5507	6356	4261
BEL/LUX	498	382	458	529	656	833	1429	1666	1324	1697
PORTUGAL					69	527	568	578	839	1327
ITALY	158	233	304	553	598	1017	961	889	575	596
SPAIN					2	77	75	38	102	245
DENMARK	27	47	88	135	268	283	215	342	80	175
GREECE	10	6	6	43	23	31			31	28
IRELAND	111	40	150	104	105	110	42	24	7	1
TOTAL EEC	10419	12895	14267	17160	24247	28011	31497	35774	36552	39498

EEC SOURCES OF SUPPLY

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
TOTAL EEC	10419	12895	14267	17160	24247	28011	31497	35774	36552	48083
INTRA EEC	1208	1116	1169	1529	2571	3200	4202	3071	2993	8584
EXTRA EEC	9211	11779	13098	15631	21676	24811	27295	32703	33559	39498
U.S.A.	411	378	288	417	1179	3110	3315	4187	5183	5818
BRAZIL	586	937	1540	2310	2832	3412	3823	4566	5183	5735
VENEZUELA	436	227	640	1493	3022	3219	3182	2900	2994	3190
MEXICO	1213	1806	2446	1687	1983	2898	2581	3045	2359	2933
ISRAEL	394	366	216	826	728	916	431	1159	1059	2591
MALI	1417	1845	1711	1675	1910	765	1246	1453	1010	2144
S.AFRICA	194	841	545	555	700	1057	1256	2071	2320	2075
COSTA-RICA						228	484	910	1113	1914
PAKISTAN	574	755	644	803	1309	1371	1382	1190	1490	1828
PERU	592	357	882	808	1553	978	1761	1590	1687	1598
IVORY COAST		536	544	670	925	1586	1525	2131	980	1359
JAMAICA	77	139	199	340	139	289	659	278	490	1261
INDIA	470	542	533	647	763	807	933	1042	966	958
BURK.FASO	1167	982	1136	1333	1627	1015	732	847	1014	951
GUATEMALA		86	325	375	432	233	217	285	70	826
GAMBIA						216	103	169	249	467
ST LUCIA					250	277	400	261	300	452
KENYA	472	545	661	319	639	500	855	651	968	397
GUINEA	173	190	82	264	282	127	342	538	153	374
COLOMBIA							27	78	117	221
THAILAND	78	82	38	199	188	152	195	177	145	105
ZAMBIA						227	69	53	59	47
SENEGAL	237	174	120	77	60	68	26	42	24	34
GHANA				81	134	74	84	74	34	19
NIGERIA					138	137	78	36	9	12
OTHERS	720	991	548	741	840	3251				
NICARAGUA				11	43	122				

Seasonality



c) Persian Gulf

Saudi Arabia imports more than 12,000 tonnes a year, mainly from India, Pakistan and Sudan. The United Arab Emirates import about the same quantity; they are also customers of India and Pakistan. The mango market is mainly for immigrant workers in these countries.

d) Japan

Imports have been increasing quickly since 1983. They have now reached 6,000 tonnes a year; main suppliers are the Philippines (77%) and Mexico (21%).

3) Standards.

Standards for marketing of mangoes have been released by the UN/ECE Bureau of Standards (see annex 1); fruits are classified in two classes, I and II, and three sizes, A (200-350 g), B (351-550 g), C (551-800 g). Minimum weight must be no less than 200 g. Fruits are packed in a single layer in carton boxes 5 kg net weight. Common calibers are 10, 12, 14 and 16 which means the number of fruits per carton of 5 kg.

Minimum size requirements for mangoes from the Eastern Caribbean are: Julie (250 g; 9 cm by 7,5), Graham (350 g; 10 cm by 9 cm), Grenada (200 g; 8 cm by 7 cm), Peach (170 g; 7 cm by 6 cm). (Source : TROPO-CATCO, 1991)

4) Prices

USA Prices may vary greatly according to the season and the origin. Fruits from Mexico and Haiti can fetch from US $5/carton in the peak season (June-July) to US$ 14/carton around Christmas time (terminal market prices). Mangoes from Florida are available from the end of May until September, this means during the peak season; however prices for these fruits are much higher than for the imported ones. This is mainly due to factors such as freshness, quality and presentation. (see table 1: terminal market prices in Miami and Los Angeles).

In 1991, the average price for mangoes imported from Mexico was only US $0.71/kg (declared value at customs). It raised to US $0.91/kg in 1992 (from January to September). Better prices are expected in 1993.

EEC It is now possible to find mangoes on the European market almost all year, the higher prices correspond to the Christmas period when they can reach twice the prices of May. In 1992 mangoes transported by air fetched an average US $2.2-3.7/Kg (prices quoted at the importer to wholesaler stage). Fruits shipped by sea fetched between US $1.4 and 2.5/Kg. (See table 2: 1991/92 prices by air and sea for the UK and French markets)

Sources: COLEACP monthly bulletins.
CIRAD/IRFA (RA 91, Doc #4 /D. Loeillet: " Panorama du marché mondial de la mangue")
FAO production and trade yearbooks 1990, 1991
Horticultural Products Review, USA. Dec 1992.
Second regional workshop on tropical fruits, Antigua 1991

TABLE 1

1990 Terminal Market Prices for Mangoes - Miami and Los Angeles
US$ per Carton, 8s-14s — Source USDA Market News Service

	Miami Wholesale Market Prices				Los Angeles Wholesale Market Prices					
Source	FLORIDA(1)		HAITI(2)		MEXICO		HAITI		BRAZIL	
Date	Low	High	Low	High	Low	High	Low	High	Low	High
1/2										
1/8										
1/16							16.00	19.00		
1/22							14.00	18.00		
1/29							14.00	16.00		
2/5				14.00			16.00	18.00		
2/12				14.00						
2/20				14.00		13.00	14.00	17.00		
2/26				14.00	6.00	8.00	8.00	12.00		
3/5			10.00	12.00	4.00	6.00				
3/12			7.75	8.00	4.00	5.50				
3/19			7.00	8.00	12.00	14.00				
3/26				7.00	12.00	13.00				
4/2				8.00	12.00	14.00				
4/9				8.00	10.00	12.00				
4/16				8.00	10.00	11.00				
4/23			7.00	8.00	8.00	10.50				
4/30			5.50	6.00	7.50	9.50				
5/7			10.00	12.00	7.50	9.00				
5/12			10.00	12.00	7.00	9.00				
5/21	18.00	19.00	5.50	6.00	6.50	7.50				
5.29	18.00	20.00	5.50	6.00	6.00	7.50				
6/4	18.00	20.00	5.00	6.00	5.50	8.00				
6/11	16.00	20.00	5.00	6.00	5.50	7.50				
6/18	16.00	18.00	5.00	6.00	5.50	7.50				
6/25	16.00	20.00	6.00	6.50	5.00	6.00				
7/2	18.00	20.00	6.00	6.50	5.00	6.00				
7/9		20.00	6.00	6.50	5.00	6.00				
7/16	20.00	22.00	6.00	6.50	5.00	6.00				
7/23	20.00	21.00	6.00	6.50	4.00	6.00				
7/30	20.00	22.00	6.00	6.50	4.00	5.50				
8/6	20.00	22.00			5.00	6.00				
8/13	20.00	22.00			5.00	6.00				
8/20	20.00	22.00			5.00	6.00				
8/27					5.50	6.00				
9/4	30.00	32.00			6.00	7.00				
9/10					6.00	7.00				
9/17					6.50	7.00				
9/24										
10/1										
10/9										
10/15										
10/22										
10/29										
11/5				14.00						
11/13										
11/19			12.00	14.00			15.00	20.00		
11/26			12.00	13.00			13.00	14.00		
12/3			8.00	10.00				18.00		
12/10			8.00	10.00				18.00		
12/17								18.00		
12/24									20.00	22.00
12/31								18.00	13.00	18.00

- free of any foreign smell and/or taste.

Mangoes must be sufficiently developed and display satisfactory ripe

UN/ECE Standard FFV-45

concerning the marketing and commercial quality control of

MANGOES

moving in trade between and to European countries

I. DEFINITION OF PRODUCE

This standard applies to mangoes of varieties (cultivars) grown from Mangifera indica L. to be supplied fresh to the consumer, mangoes for industrial processing being excluded.

II. PROVISIONS CONCERNING QUALITY

The purpose of the standard is to define quality requirements for mangoes at the export control stage, after preparation and packaging.

A Minimum requirements

In all classes, subject to the special provisions of each class and the tolerances allowed, the mangoes must be:

- intact
- firm
- fresh in appearance
- sound; produce affected by rotting or deterioration such as to make it unfit for consumption is excluded
- clean, practically free from any visible foreign matter
- free from black necrotic stains or trails
- free from marked bruising
- practically free from pests
- practically free from damage caused by pests
- free from damage caused by low temperature
- free of abnormal external moisture
- free of any foreign smell and/or taste.

Mangoes must be sufficiently developed and display satisfactory ripeness.

The development and condition of mangoes must be such as to enable them:

- to ensure a continuation of the ripening process until they reach the appropriate degree of ripeness corresponding to the varietal characteristics;

- to withstand transport and handling, and;

- to arrive in satisfactory condition at the place of destination.

In relation to the evolution of maturing, the colour may vary according to variety.

B. <u>Classification</u>

Mangoes are classified in two classes defined below:

i) <u>Class I</u>

Mangoes in this class must be of good quality. They must be characteristic of the variety. However, the following slight defects may be allowed provided that these do not affect the general appearance of the produce, the quality, the keeping quality and presentation in the package:

- slight defects of shape;

- slight defects of the skin due to rubbing or sunburn, suberized stains due to resin exudation (elongated trails included) and healed bruises not exceeding 3, 4, 5 cm2 for size groups A, B, C respectively.

ii) <u>Class II</u>

This class includes mangoes which do not qualify for inclusion in the higher class but satisfy the minimum requirements specified above.

The following defects may be allowed provided that the mangoes retain their essential characteristics as regards the quality, the keeping quality and presentation:

- defects of shape;

- defects of skin due to rubbing or sunburn, suberized stains due to resin exudation (elongated trails included) and healed bruises not exceeding 5, 6, 7 cm^2 for size groups A,B, C respectively.

In both classes, scattered suberized rusty lenticels, as well as yellowing of green varieties due to exposure to direct sunlight, not exceeding 40 per cent of the surface and not showing any signs of necrosis are allowed.

III. PROVISIONS CONCERNING SIZING

Size is determined by the weight of the fruit.[1/] Mangoes are sized according to the following size groups:

Size group	Weight in grams
A	200 - 350
B	351 - 550
C	551 - 800

The maximum permissible difference between fruit in the same package belonging to one of the above mentioned size groups shall be 75, 100 and 125 g respectively.

The minimum weight of mangoes must not be less than 200g.

IV. PROVISIONS CONCERNING TOLERANCES

Tolerances in respect of quality and size shall be allowed in each package for produce not satisfying the requirements for the class indicated.

A. Quality tolerances:

i) Class I:

10 per cent by number or weight of mangoes not satisfying the requirements of the class but meeting those of Class II or, exceptionally, coming within the tolerances of that class.

ii) Class II:

10 per cent by number or weight of mangoes satisfying neither the requirements of the class nor the minimum requirements, with the exception of fruit affected by rotting, marked bruising or any other deterioration rendering it unfit for consumption.

B. Size tolerances:

For all classes: 10 per cent by number or weight of mangoes conforming to half of the permissible difference of the related size group above or below the range specified on the package with a minimum of 180 gr for those packed in the smallest size range and a maximum of 925 gr for those in the largest size range.

V. PROVISIONS CONCERNING PRESENTATION

A. Uniformity

The contents of each package must be uniform and contain only mangoes of the same origin, variety, quality and size.

The visible part of the contents of the package must be representative of the entire contents.

1/ Australia at present determines size of mangoes on the basis of diameter and has placed its reservation on this point ad referendum

B. Packaging

Mangoes must be packed in such a way as to protect the produce properly.

The materials used inside the package must be new, clean and of a quality such as to avoid causing any external or internal damage to the produce. The use of materials and particularly paper or stamps bearing trade specifications, is allowed provided that the printing or labelling has been done with non-toxic ink or glue.

Packaging must be free from all foreign matter.

VI. PROVISIONS CONCERNING MARKING

Each package[2/] must bear the following particulars, in letters grouped on the same side, legibly and indelibly marked, and visible from the outside.

A. Identification

Packer and/or dispatcher	Name and address or officially issued or accepted code mark[3/]

B. Nature of the produce

- "Mangoes", if the contents are not visible from the outside
- Name of variety

C. Origin of the produce

Country of origin and, optionally, district where grown or national, regional or local place name

D. Commercial specifications

- Class
- Size expressed as minimum and maximum weight
- Size code (optional)
- Number of fruit

E. Official control mark (optional)

2/ Package units of produce pre-packed for direct sale to the consumer shall not be subject to these marking provisions but shall conform to the national requirements. However, the markings referred to shall in any event be shown on the transport packaging containing such package units.

3/ The national legislation of a number of European countries requires the explicit declaration of the name and address.

PROPAGATION OF MANGOES

By G. Barbeau
Fruit Crops Specialist
IICA Office
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In fruit production one of the most important aspect 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- GENERALITIES

Mangoes are easily propagated by seeds which can germinate within 2-4 weeks depending on the conditions. This has been so for centuries until the beginning of the 20th century when grafting methods were introduced in some countries.

Within cultivated mangoes, two types are found. One is monoembryonic which means that the seed contains a single embryo and will give birth to a single plant. The other is polyembryonic; each seed contains several embryos (up to seven) and will produce several plants. In monoembryonic seeds, the embryo has a sexual origin while in polyembryonic seeds, one embryo has a sexual origin and the others develop asexually from nuclear cells (apomixis); they will produce plants identical to the mother plant: it is a case of vegetative propagation. Some secondary characteristics may differ slightly because they depend upon cytoplasmic heredity.

In many parts of the world, mangoes are still propagated by seeds. When polyembryonic seeds are used the cultivar or clone is maintained and it is possible to get a relative homogeneity. On the contrary, the use of monoembryonic seeds results in the creation of new cultivars. This explains why in countries where mangoes have been cultivated for a long time (Bangladesh, India, Pakistan) there is such a number of types.

The introduction of asexual propagation, mainly grafting and budding techniques, has contributed to the development of the international trade of this commodity since it was therefore possible to produce homogeneous commercial plots of a given outstanding cultivar.

II- PROPAGATION BY SEEDS

Unless used on purpose with polyembryonic cultivars, in commercial production the propagation of mangoes by seeds is mainly for obtaining rootstocks which will be grafted later on with the commercial cultivars.

Soil Preparation

The main qualities for 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, peatmoss, 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 of the nursery (seed beds) in order to avoid contamination of the seeds 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 one hour and a half) 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 FORMOL, 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 used in the growing area, after transplantation of the seedlings, disinfection may be carried out if some risks are likely, but in the cheapest manner possible.

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 DAZONET (Bazamid) control many fungi.

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 $1m^3$ soil mixture would be about 5 pounds of a complete formula (15-15-15 or 12-15-10).

1. Seed selection and sowing

Seeds must be selected for their adaptation to the climatic and pedological conditions of the place where planting will occur. Local polyembryonic varieties of mangoes such as 'rose', 'long', 'turpentine', 'mechudo' are generally suitable as rootstocks unless studies have demonstrated the contrary; in fact there are some cases where a given type of rootstock may induce the formation of a normal or inverse bottle-neck at the grafting point, thus indicating some kind of incompatibility with the grafted cultivar.

Seeds must De taken from mature or ripe, healthy fruits, collected from the trees. It is not recommended that seeds be taken from fruits that have fallen to 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. It can also eliminate seed borers when these pests are present (mango seed weevil - Stenochetus mangiferae). Mango seeds may be treated with an insecticide and fungicide mixture by immersion for 10 to 15 minutes. Fungicides like carbamates (maneb, mancopper) or dicarboximids (captan, captafol) associated with contact insecticides of the organo-phosphorous group (malathion, parathion, pyrimiphos-methyl) give good results at the usual doses.

The viability of the seeds is quite short: average of 5 days at the ambient temperature in tropical climates. One of the main reason is the high moisture content of the seeds which drops dramatically if they are left unprotected. Conservation at lower temperatures (10 degrees C) and high relative humidity allows for an extension of the shelf life up to 20 days (Parisot, 1988). Temperatures below 5°C are lethal to the seeds. Another promising technique consists of initiating the germination process and storing the germinating seeds at 15°C just after the emergence of the radicule (a few cms long). This way it is possible to keep the seeds up to three months (Parisot, 1988).

Seeds are sown 5 cm (2") apart in disinfected beds with the concave side down and covered with 2.5 cm (1") of top soil. Germination is slower than for avocados or citrus; it can take from 2 to 4 weeks. 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 infection.

Experiments have shown that the best conditions for germination of mango seeds are with temperatures between 30 and 35°C and a high relative humidity. However seeds can germinate from 20 to 45°C, but in extreme conditions the rate and speed of germination are lowered.

In polyembrionic varieties, the embryos in a single seed generally differ a lot one from the other; some are bigger and have two cotyledons, others are small with only one cotyledon. When germination takes place the bigger the embryos, the quicker their growth and the difference will amplify with time. Thus it is essential to make a selection according to the size in order to have homogeneous blocks of plants.

2. 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 ventilation is needed too.

Even with sterilized soil, some pests and diseases may spread very quickly. Main problems at that stage may come from leaf-cutting ants and anthracnose disease. Checking for sanitary aspects is a daily duty; preventive applications of copper-based fungicides every two weeks will prevent most of the problems. Leaf-cutting ants nests must be destroyed.

When the seedlings reach a height of 5 to 15 cm, they can be transplanted in the growing area in polythene bags or directly into the ground. Special care must be taken not to damage the root system. 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 eliminating half of each leaf, to reduce transpiration. Watering must follow transplantation immediately, even if the soil is moist.

Sowing in disinfected beds and then transplanting the seedlings into polythene bags is probably the most rational way to initiate a mango nursery. Seed beds 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 week after week into the bags, according to their stage of development. This system allows for homogenous blocks of plants (same stage of development, no blanks) and the polythene bags are not exposed to too much sun.

3. The Growing Area

If polythene bags are used, their size must be sufficient to hold the mango plants until they are transplanted into the field, that is at the age of 10-14 months. Bags of up to 25 cm in diameter and 40 cm high are required. Generally young plants grow quicker in small containers than in large ones, so it may be interesting to transplant at least once before grafting.

The advantage of polythene bags is to allow for the easy transportation and transplantation of the plants, with minimal stress. Mangoes are not easily transplanted bare-rooted; if not grown in plastic bags they must be dug out with a ball of soil. Planting the seedlings directly in the soil is an alternative when there is a scarcity of bags and the soil is clayish enough to form compact balls.

Bags are placed in double rows separated by paths which allow for easy access especially at the time of budding or grafting.

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 in sterilized soil weeds will appear sooner or later. Manual weeding is the only solution for weeds inside the bags or in the rows of trees. The paths in between the rows of bags or trees may be treated with herbicides, taking the usual precautions. Mulching with rice hulls or coffee husks in between the rows of bags helps to control the weeds and to keep moisture at the root level.

If fertilizers have been added to the soil before potting, there will only be need for application of nitrogen every month (a few grams/bag). If not, a complete formula (15-15-15) will be applied 2 weeks after transplantation (10 g/bag) and repeated two months later; nitrogen has to be provided as in the first case.

Obviously the water supply must be as regular as possible in order to get a rapid and homogeneous growth. Watering by hose may be a solution for small nurseries. In the case of large amounts of plants, sprinklers will be more accurate; however it is important to check carefully for the homogeneity of the water application, some parts of the beds receiving more water than others.

When plants get to a height of 40 to 50 cm they are ready for budding or grafting. That is when the diameter of the stem reaches from 0.6 to 1 cm at a distance of 15 to 20 cm from the ground.

III- ASEXUAL PROPAGATION

1. Budding and grafting

Budding and grafting are performed through the union of parts of different plants in order 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 scion may be a single bud or a short stem with 3 or 4 buds; techniques used to perform the union are called budding (a single bud) and grafting (a short stem with several buds) respectively.

Rootstocks must be selected according to their adaptation to local conditions of soil and climate. Resistance 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 (see seed selection).

Selection of the variety or cultivar to be grafted must comply with market requirements, so quality of the fruits, harvesting time, resistance to transportation and regularity of bearing are among the characteristics to look for.

a) Budding and 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 the 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 to large wounds of the trees to protect them from fungal infection.

b) Selection and preparation of the scions

Budwood must be taken from healthy adult trees, on 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, scions generally correspond to the terminal part of the stems; they have an apical bud which is about to develop. If the stem has already produced an inflorescence, there will be several buds at the end of it. If buds are dormant or inhibited, different techniques can be used to force them to develop (removing the leaves, girdling the stem, destroying the apical bud...).

When preparing budwood, all leaves should be removed, leaving only a short piece of petiole, in order 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 fridge or an ice-box.

c) 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 rootstock to be grafted, the time of year and the ability of the grafter.

On young rootstocks, T-budding, chip-budding, tip-grafting and side-grafting are the most used techniques. On adult trees top-working can be performed on the main branches.

The height of grafting is important to determine, since one of the rootstock functions is to protect the scion from possible contamination originating in the soil. A grafting-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 prudential height is recommended which is between 15 and 20 cm from the ground.

The orientation of the graft is a factor worth taking into consideration; 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 can be enough to lose the graft.

Side-grafting

The stock is prepared by removing a 3-4 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 in order to form a lip which will receive the scion.

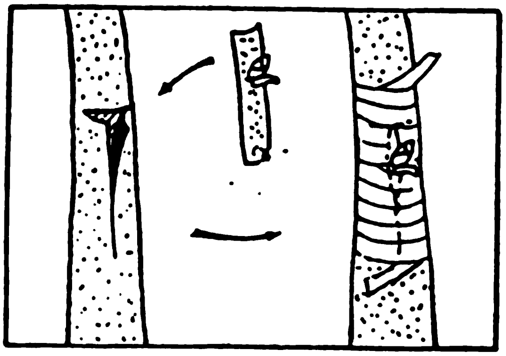
The scion consists of a terminal piece of twig, about 10 cm long, with a terminal bud and two or three lateral ones. The terminal bud must be ready to develop. A 3-4 cm long cut is made on one side of its base, while on the other side there will be a short cut, only 1 cm long.

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 or in dry conditions it is recommended that the top of the scion be covered with another piece of plastic in order to prevent water from entering the scion union.

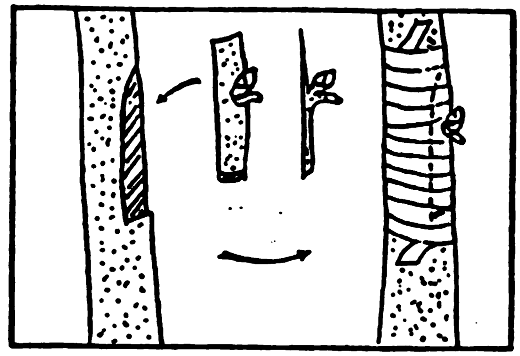
The side graft method is popular for mangoes. The only disadvantage is that great quantities of budwood are required since each graft needs one stick with 3 or more buds.

A variation is the veneer graft where the budwood is completely applied inside the corresponding wound made on the rootstock.

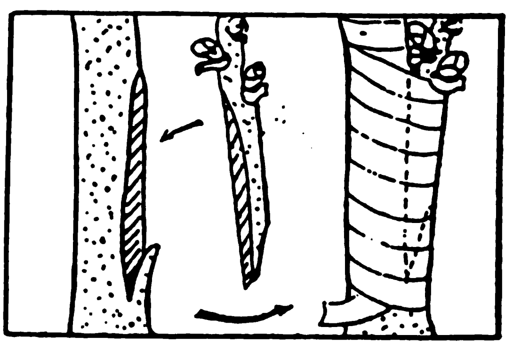
BUDDING AND GRAFTING



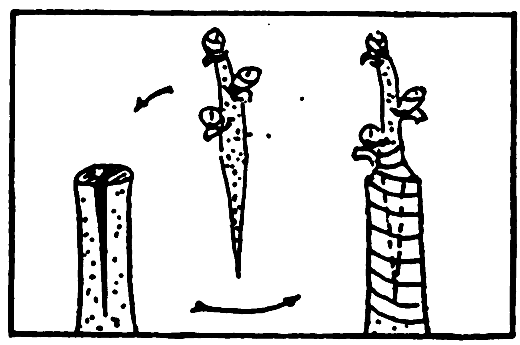
T-BUDDING



CHIP-BUDDING



SIDE-GRAFTING



TIP-GRAFTING

SOURCE: FRUTAS TROPICALES EN NICARAGUA, BARBEAU G. 1990

Tip-grafting (cleft or apical grafting)

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 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.

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 in order to insert the bud.

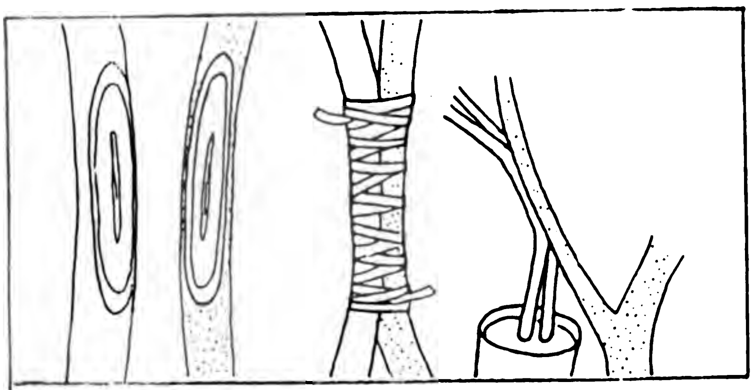
A piece of bark with an axillary bud in its centre is taken from the budstick, in the form of a shield-shaped bud, 2-3 cm long and is slipped into the cut on the rootstock. The upper part of the bud should coincide with the horizontal bar of the T. Then the graft is wrapped with a strap of polythene, leaving the bud uncovered.

T-budding is not widely used for mangoes. It is difficult to select lateral buds that are not dormant unless appropriate techniques are used (previous girdling of the stem, removing of the leaves or elimination of the terminal bud).

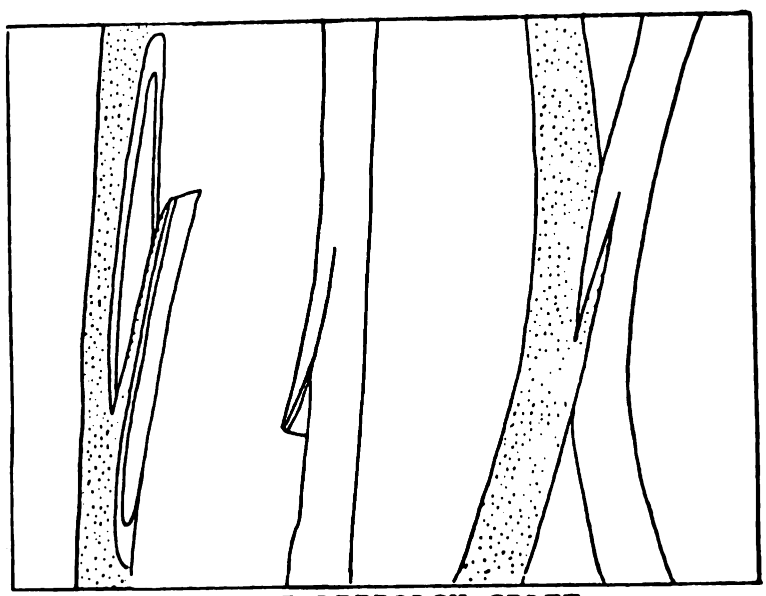
Chip-budding

A lateral piece of bark, 3-5 cm long, slightly thicker at its base than at the top, is removed from the stock at the desired height. At the base an oblique cut is made in order 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. Width must be slightly less



SPLICED APPROACH GRAFT



TONGUE APPROACH GRAFT

APPROACH GRAFT

SOURCE : "L'AVOCATIER, SA CULTURE, SES PRODUITS" by GAILLARD J.P. 1987 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 is easy to perform, economical in budwood, 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 is not very common for mangoes. The same remarks apply as for the T-budding.

Approach grafting

This method was commonly and is still used in India and South East Asia. 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 dependant 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.

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 in order to direct the sap flow towards the scion and force it to grow. At the same time the plastic cover must be removed from the growing buds.

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 mangoes it is preferable to wait 6 to 8 weeks before removing the polythene strap since it takes some 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 *departure of 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 piece 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.

2. Other vegetative propagation techniques

Cuttings

Propagation by cuttings has been tried in various countries to produce homogeneous rootstocks. Hard wood cuttings, 20-30 cm long and 1-2 cm in diameter, with 2 half leaves under mist, have given the best results. Rooting hormones such as IBA (indol butyric acid) or NAA (naphtalene acetic acid) must be applied at higher doses than for most other plants (5,000 to 10,000 ppm). The rooting percentage is improved if the stems where the cuttings are taken from have been circled a few months earlier.

When the roots are well developed the cuttings must be potted in bags under shade, in high, relatively humid conditions.

Air-layering (Marcotting)

This technique, quite old in South East Asia, consists of producing a new plant from an aerial stem. A ring of bark is removed from the stem and a rooting hormone is applied (NAA 2%); then this area is covered with a rooting medium (coconut core 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 (10 to 12 weeks). Then the stem is severed from the mother plant below the rooting point and trained in the nursery before being transplanted.

Air-layering is time consuming and do not allow for production of large quantities of plants, so the result is very expensive. These reasons explain why it remains a technique for amateurs.

Polyembryony

See chapter on multiplication by seeds.

IV- PROPAGATION CALENDAR

Plants ready for sale must have a minimum development, i.e be strong enough to support stress due to transportation and relocation. This is generally achieved at the age of 12-15 months, i.e. 4 to 6 months after budding or grafting.

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 will not have sufficient time to get established before the dry season and they will need extra irrigation or they suffer and die. Production of plants out of season means extra costs and losses, not only for the farmers, but also for the nurseries which may face very depressing sales after the planting period and 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.

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FLOWER INDUCTION ON MANGO TREES

J.P. LYANNAZ - CIRAD/IRFA (GUADELOUPE)

INTRODUCTION

In all the regions of the world where the growing of mango trees has been developed, according on one hand to climatology and on the other hand to grown varieties, some problems linked to flowering and consequently to production have been observed.

Erratic flowering

i.e - From January to May for the "Pico" and "Carabao" varieties in the Philippines.

- From November-December to March-April for some varieties from Florida in Guadeloupe.

Biennal bearing

Particulaly stressed among some Indian varieties ("Longra" and "Dashehari").

On the opposite, weak bearing periods lead to obvious restrictive conditions in the marketing of the production.

i.e - In the Colima Region of Mexico, 75 % of the production of the two most widely grown varieties "Haden" and "Manila", is concentrated from mid-May to mid-June only.

Up to now, the problems linked to the mango tree flowering have not yet found a scientific answer as regards to the chemical nature of the flowering stimulus in spite of numerous studies in many countries for the last decades.

Nevertheless, new methods have been tested which could bring satisfactory answers according to the field considered : climatology, varieties, producers level of technicity.

SMUDGING

In the Philippines this old and traditional technique was still used a few years ago for flowering induction, usually from October to December **when the trees have mature leaves** and when there are less chances of rain.

The common practice involves building smoky fires below the tree canopy and allowing the dense smoke to pass through the foliage. It is carried out first, by making a fire and putting on the top green grass, rice hulls, sawdust, leather trimmings, used tires and other combustible materials to produce a heavy smoke. It is done continuously for several days but it is stopped when no flower buds appear within 2 weeks. The process may be repeated 1-2 months later.

Thus, smudging is a laborious expensive and uncertain method of flower forcing. Even then, some mango growers still practice this old system because of their apprehensions about harmful effects of the chemicals used for forcing the trees to flower.

CHEMICAL INDUCTION

Different products have been tested lately with variable results according to varieties and regions of production.

Growth regulators - Growth retardants Ethephon - Nitrates.

Here below are the main results to consider for a better control of the flowering behaviour.

NITRATES

Two sorts of Nitrates can be used for the flowering induction on mango trees :

- Potassium Nitrate (13% N - 37% K)

- Ammonium Nitrate (16-17% - N Nitric)

Any of the Nitrate components can be used by spraying on the basis of 15 to 20 litres of solution per mature tree according to its size.

Preliminary and primordial conditions are required to obtain positive results : spraying must be applied on trees of **bearing age with fully mature dormant leaves and buds**. This is characterized by trees with **leaves that are brownigh to copper green and the buds are plumb but not yet growing**.

* KNO_3

Potassium Nitrate was first used in the early 70's in the Philippines whose output tripled between 1970 and 1975 owing to the wide extension of this technique. (Table 1)

- Rates

They can vary from 10 to 40 gr. per litre of water.

The doses usually applied are 10 g/l for the Philippines and extended to 40 g/l for the Colima Region of Mexico.

An experiment has been carried out on young "Haden" mango trees, aged 3, at the CIRAD/IRFA Research Station in Vieux-Habitants.

Boths quantities (10 g/l and 40 g/l) were compared and no significant difference was observed. (Table 2)

- Results

Generally when the treatment is positive, 10 to 15 days after spraying, a bud flushing on terminal shoots is obtained. A full flowering stage follows 30 to 35 days after spraying.

It is obvious that the flowering percentage is closely related to the percentage of **mature vegetative shoots**.

In the field of our experiment in Vieux-Habitants as previously noted, all terminal shoot buds were swelled and dormant and the spraying of 10 g as well as 40 g/l was 100% success flowering when pratically no flowering appeared on the control trees.

In the Colima Region of Mexico, when spraying is applied in the first half of November, a 20 to 30% rise of additional flowering panicles can be observed on "Haden" as well as "Manila" the highest percentage of panicles develops on vegetative shoots of **more than 6 months of age**.

While on "Manila", flowering of 3 to 4 months aged shoots can be frequently observed.

In Philippines, flushes produced from October to December can be sprayed to flower from February onwards of the following year. In some areas, flushes produced during the dry season are difficult to induce to flower before October. This may vary with location, cultivar and growing season. For example, April flushes of "Pahutan" trees in Laguna responded favorably with 100% success after having been sprayed with 1% KNO_3 in August, September, October. Carabao mango shoots of the same age, achieved 40% to 80% flowering when sprayed with 1% and 2% KNO_3 respectively in August. October spraying with 1-4% KNO_3 induced nearly 100% flowering.

*** NH_4NO_3**

After the success obtained with Potassium Nitrate, research was oriented toward substitutes and it was confirmed that Ammonium Nitrate was indeed responsible of flowering induction on mango trees.(NUÑEZ-ELISEA - 1986).

Therefore we have oriented our research on Ammonium Nitrate, cheaper and less rare.

- Rates and results

The most interesting and significant experiment was realised by NUÑEZ-ELISEA (1986-1987) at the Colima Station in Mexico.

Beginning of December 1985, the first test using 4 doses of NH_4NO_3 (5-10-20 and 40 g/l) showed that best results were obtained with **20 to 40 g/l doses**, equivalent to the KNO_3 treatment (40g/l). (Fig. 1)

A second test was applied to compare both treatments : NH_4NO_3 (20 and 40 g/l) and KNO_3 (40 g/l) from end of December 1986 to beginning of January 1987.

The previous results have been confirmed (Fig. 2) and conclusions are as follow :

NH_4NO_3 (20 and 40 g/l) and KNO_3 (40 g/l) are as effective to force flowering and harvest.

But the highest NH_4NO_3 dose has induced scorches of the foliage and defoliation.

With January sprayings, harvest time was 30 days earlier with regard to control.

NH_4NO_3 (20 and 40 g/l) and KNO_3 (40 g/l) have increased by 50% the fruit production.

*** OTHER PRODUCTS**

In some countries where military permission is required in acquiring and using KNO_3 or where its importation is prohibited many commercial flower inducers may be used : Agriblum - Rebloom - Mangovit - Mangotone - Miracle Blum - Flower Set.

Most of these products contain Potassium Nitrate and sometimes Ammonium Nitrate.

Mid-January 1991 an experiment was made at tne CIRAD/IRFA Station of Vieux-Habitants (Guadeloupe) with Miracle Blum (about 10% NH_4NO_3) and Flower Set (240 g KNO_3/l) on 10 year old "Eldon" mango trees, respectively with 15 cc/l and 15 g/l doses.

Figures 1,2 and 3 show the highly significant effect of both treatments with regard to control.

After the stage of natural flowering (T + 15 days) on control and treated trees, we observe a reflowering with a peak at T + 35 days on treated trees and on distinct superiority of the Miracle Blum powder.

* CONCLUSIONS

The way Nitrates act in the flowering induction process has not yet been identified and do not allow to generalize instructions for use.

Each country according to its climatology, varieties and growing techniques must experiment the treatments in order to insure the extension and development on a large scale.

PACLOBUTRAZOL (Cultar)

Cultar is a new growing regulator and is active on a great number of perennial cultures and at each stage of development of the tree.. It controls the growth and improves flowering and fructification.

This product seems to act systemically and reduces the giberellin production of the tree.

Large numbers of experiments have been carried out in different mango growing countries and results are as follow :

- Instructions for use

Experience has proved that the best application for mango trees is soil drench under the foliage with 10 to 40 g/l solution, according to the age and size of the tree.

In most cases there were no significant results with foliar sprayings.

Two important precautions are to be taken to improve the efficiency of the treatment :

- Cleaning of the soil under the foliage before treatment to avoid the loss of product.

- Necessary irrigation for satisfactory penetration of the solution (20 cm into the soil) when treatment is applied out of the rainy season.

- Doses :

4 to 5 g/tree is the optimal dose for an induced maximum yield. (Fig. 3, 4,5)

Higher doses can induce higher flowering without inducing higher fruit productions.

- Time applications :

Time applications depend on the desired period of production (Increase of the seasonal production, out-of-season production).

Compared to Nitrates, the constraints are different with CULTAR relating to the physiological stage of shoots.

In response to the treatment, time varies more or less according to the physiological stage :

i.e. : Cameroon - "Brooks" variety
End-April treatment induced flowering 11 weeks after.

Thailand - "Khiew Sawoay" variety
October treatment induced flowering 13 weeks after.

Ivory Coast - "Valencia" variety
November treatment induced flowering 6-8 weeks after.

For a better effectivness of Cultar, it is also recommanded to use 2 applications at 4 and 5 months intervals.

i.e. - In Ivory Coast with the Valencia variety (a relatively **alternating** variety) a first treatmeent in July 1988 (after picking time) was followed by a second treatment in November 1988 (about 7 weeks before first blossoming).

In this way, a saving of time from 10 to 15 days was obtained on the flowering of controls and production increased distinctly.

It was year "**OFF**"

The following year (year "ON") Cultar reduced the number of inflorescence all the while maintaining a superior quantity of fruits as regard to control.

For each year both doses were applied respectively at 2.5 g a.i./l for dose 1 and 5 g a.i./l for dose 2.

It has been observed that for the first year best results were obtained with dose 2 while dose 1 was best during the second year.(A Cultar accumulative effect ?)

The first results of Cultar repeated applications thus, seem to indicate that after 2 years of consecutive treatments on the same tree, a fall of the output can be observed.

- Growth reduction (Tables 3)

This effect is to be taken into consideration for easy picking and higher density orchards.

However the physiological alterations resulting from Cultar applications are not yet completely known to base a long terms programme on this technique.

- Conclusion

It is obvious that Cultar treatments can induce flowering and increase yields in mango. Response varied with cultivar in terms of length of time taken to achieve flowering, intensity and consistancy of flowering.(Table 4)

However, similar to Nitrates, the reproductivness of the tests will often rely on climatic factors which may vary year in and year out.

ETHEPHON

Though, it has been tested with different doses and several times, particularly in India, no exceptional results have been observed.

On one hand, a depressive effect on the plant has always been recorded.

On the other hand, this product acts by release of ethylene, a process often used to induce flowering on pineapples and maturation of some fruits (i.e. bananas). But recently, T.L. Davenport and R. Nuñez Elisea have discussed the reliability of ethylene on the flowering induction process on mango trees.

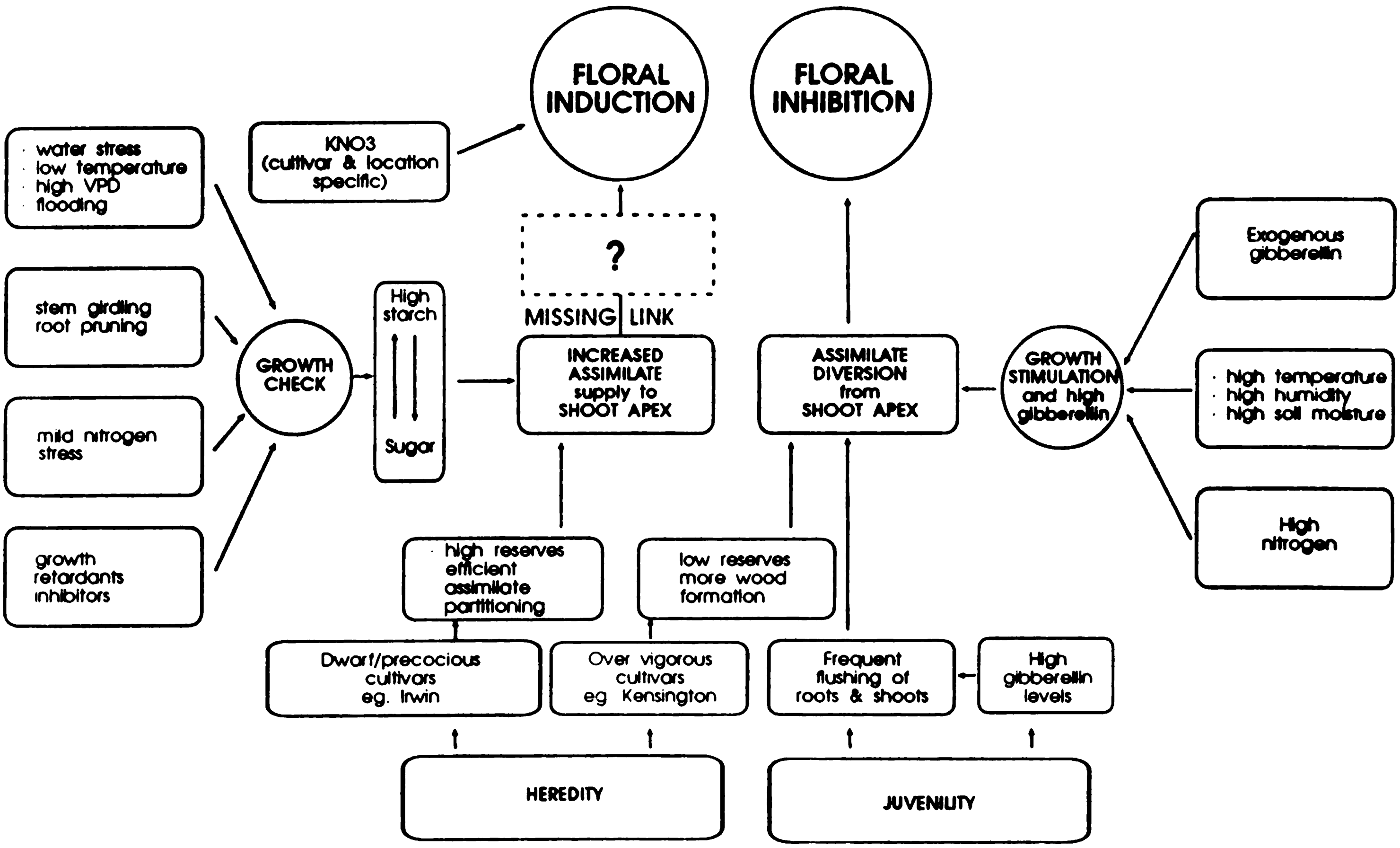
CONCLUSIONS

At this time, there are not yet universal "wonder-products" in the flowering induction treatment on mango trees.

Each country develops its own techniques which are characterized by climatic, varietal, technical and commercial constraints.

So, and we do insist on it, each country taking new initiatives in these technics will have to make sure of the technical consistency of the process prior to a wider extension towards producers.

Research and development's organisations must carry out the realisation of this preliminary work.



FLOWER INITIATION IN MANGO - A FUNCTION OF ASSIMILATE SUPPLY AND DIVERSION
(Adapted from Sachs and Hackett, 1969)

Table 1 : Increase in Production and Value of Philippine Mango Resulting from Adoption of Flower Induction Technology

Period / Year	Production (mt)		Value
	total	Per ha	(P million)
Before KNO3 (1970-72)	144.194	3.4	131.1
Early Adoption (1973-75	205.469	4.6	244.2
Wide Adoption (1976-78)	322.22	9.3	655

Table 2 : Effects of chemical on "Haden" cv. flowering

CIRAD/IRFA Guadeloupe 1991

	Number of inflorescence / Tree	Fruit number / Tree	Fruit weight /tree (Kg)	Weight / Fruit (Kg)
Control	1.76	0.94	0.37	0.39
KNO3 10g/l	59.25	25	7.16	0.29
KNO3 40g/l	32.75	14	4.30	0.31
Cultar	0	0	0	-
Flowerset	77	32	10.76	0.34

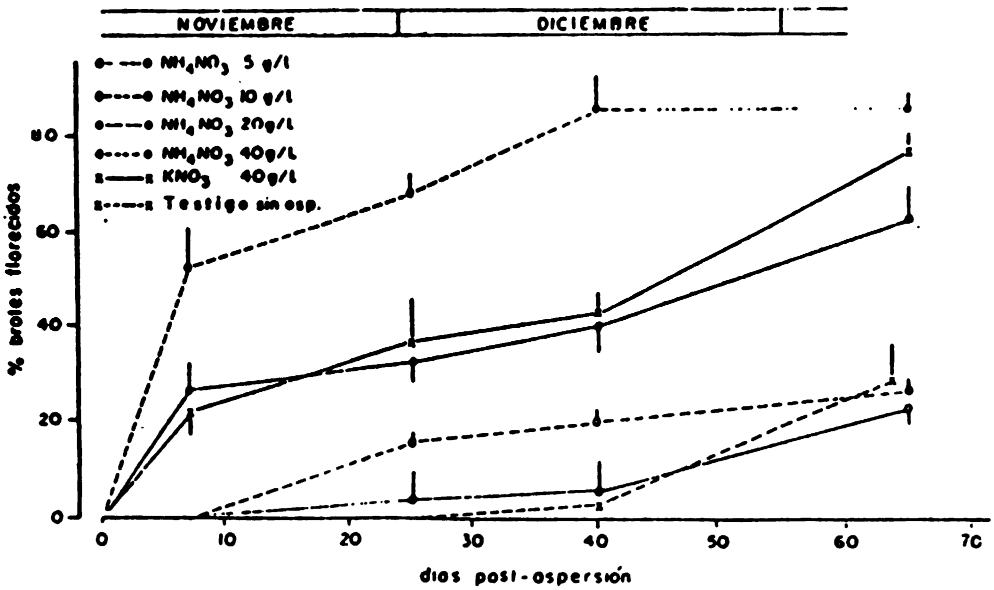


Figura 1. Efecto de aspersiones de NH_4NO_3 y KNO_3, en noviembre, sobre la intensidad de floración en mango 'Haden'.

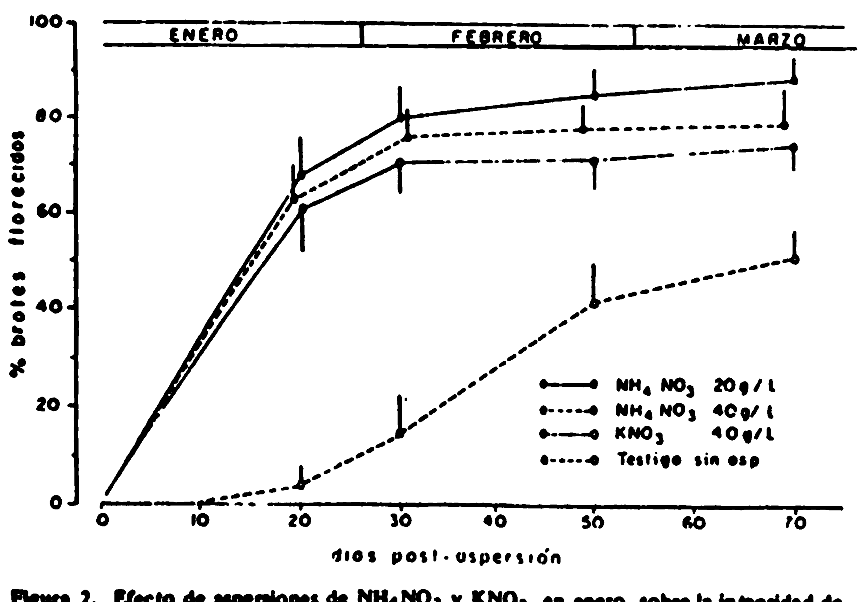


Figura 2. Efecto de aspersiones de NH_4NO_3 y KNO_3, en enero, sobre la intensidad de floración en mango 'Haden'.

Table 3 - Vegetative growth control by CULTAR soil application **Mean Shoot** Growth (cm) (IRA - Nyombe CAMEROON)

VARIETIES	CONTROL	TREATED
Kent	20.9	15.1
Irwin	21.4	7.2
Julie kasowa	23.4	10.5
Ruby	23.7	18.6
Lippens	23.7	19.7
Keitt	18.5	10.5
Am. Cameroon	26.8	29
Palmer	28.2	19.6
Valencia	20.8	10.4
Smith	22.2	16.7
Davis Haden	22.8	16.7
Brooks	21.8	15.5
Glazier	17	7.1
Early gold	23.2	17.3
Seed. Am. Cameroon	31.3	21.4
Hindi be sennara	30.6	33.9

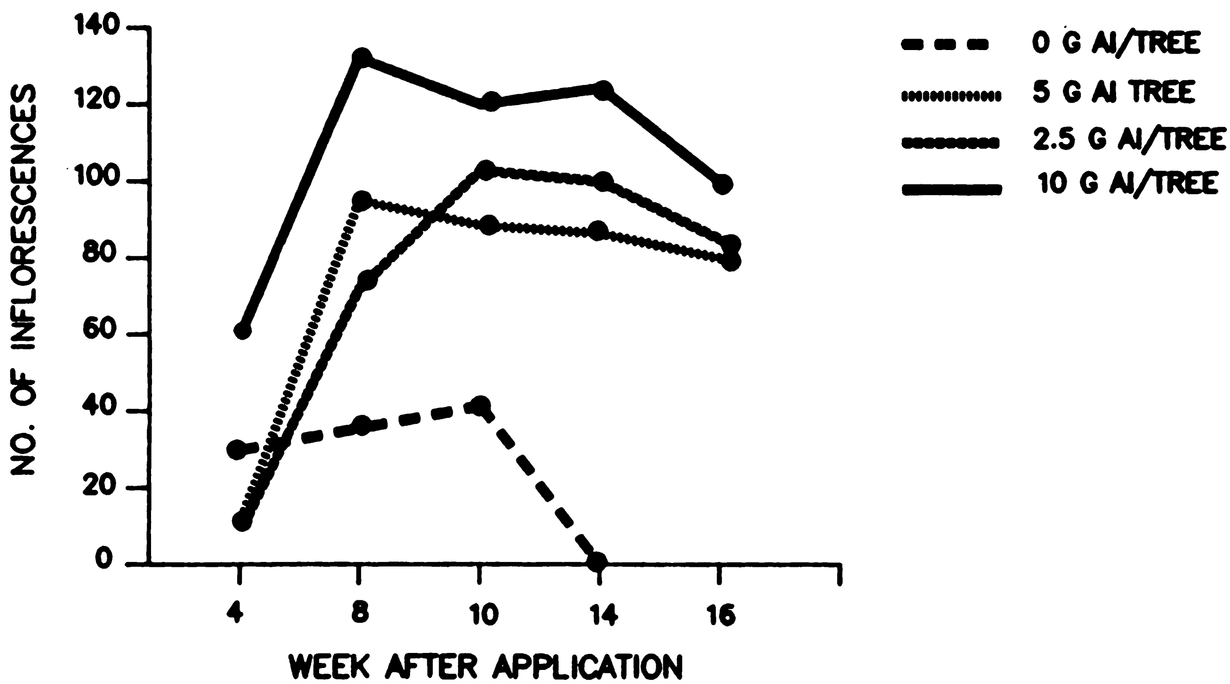
Table 4 Mango cultivar sensitivity to Cultar treatments

Highly sensitive Cultivars	
Nam Dok Mai (NDMT)	Thailand and Malaysia
Harumanis	Malaysia and Indonesia
MA 127	Malaysia
MA 165	Malaysia
PICO	Malaysia
Falun	Thailand
Indica	Taiwan
Sensitive Cultivars	
MA 124	Malaysia
MA 125	Malaysia
Golek	Malaysia
Avon	Malaysia
Nong Sang	Thailand
Chao Khun Tip	Thailand
Nangklangwan	Thailand
OK - Rong	Thailand
Irwin	Taiwan
Kensington Pride	Australia
Strawberry	Australia
Chaunsa	Pakistan
Baganapalli	India
Dashehari	India
Peddarasam	India
Alfonso	India
Moderately Sensitive Cultivar	
Kecw Seow Wai (KSW)	Thailand
RAD	Thailand
Carabao	Philippines

Fig. 3

EFFECT OF CULTAR* ON FLOWER INDUCTION ON 5 YR MANGO

(cv. Harumanis, Indonesia 1988)



* Soil treatment

Source: S. PURNOMO, IPB INDONESIA 1988

FLOWER INDUCING TEST ON MANGO TREE

AVERAGE NUMBER OF INFLORESCENCES PER TREE

(GUADELOUPE) CIRAD/IRFA

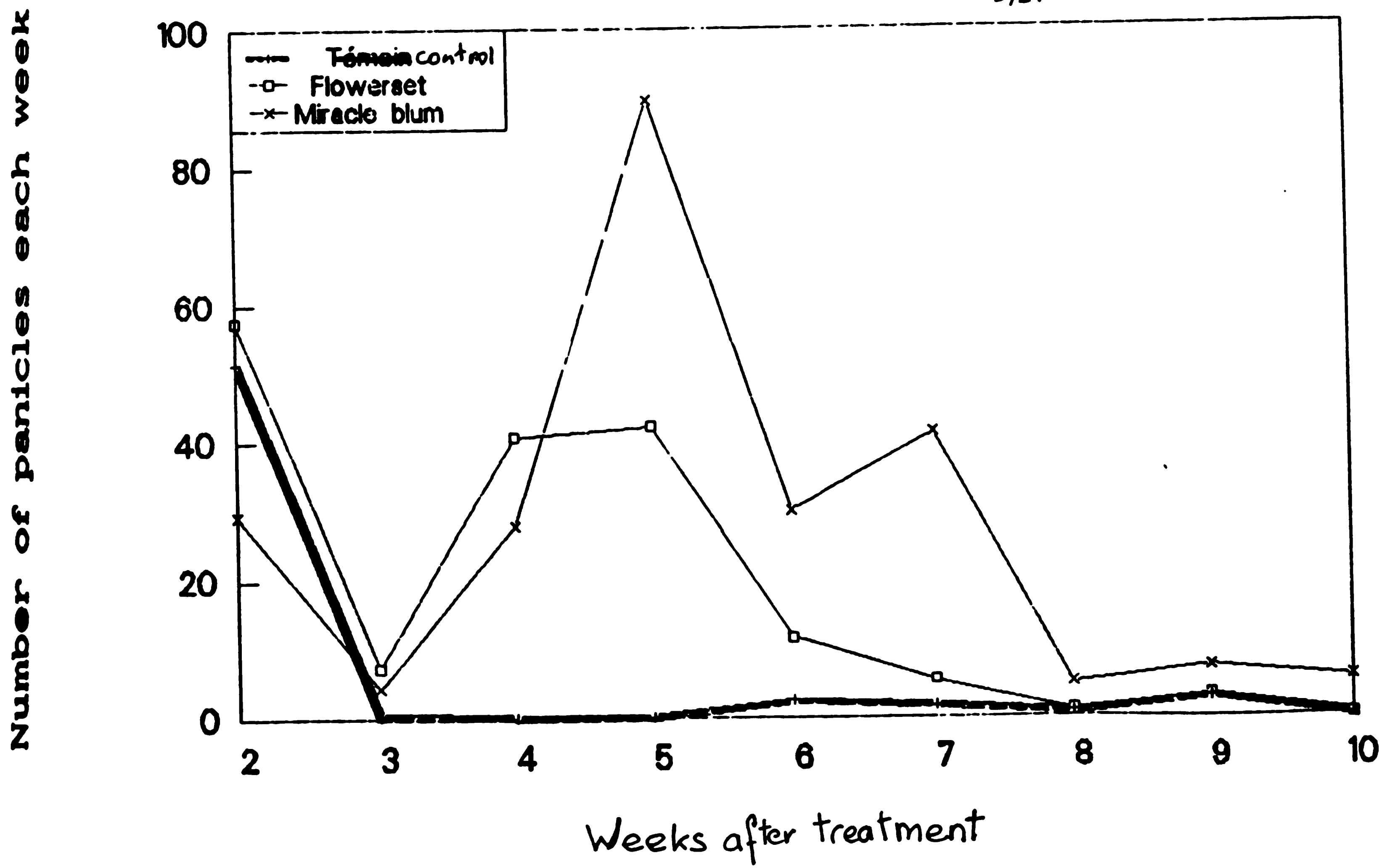


fig 2 FLOWER INDUCING TEST ON MANGO TREE

AVERAGE NUMBER OF FRUITS PER TREE

(GUADELOUPE)
CIRAD/IRFA

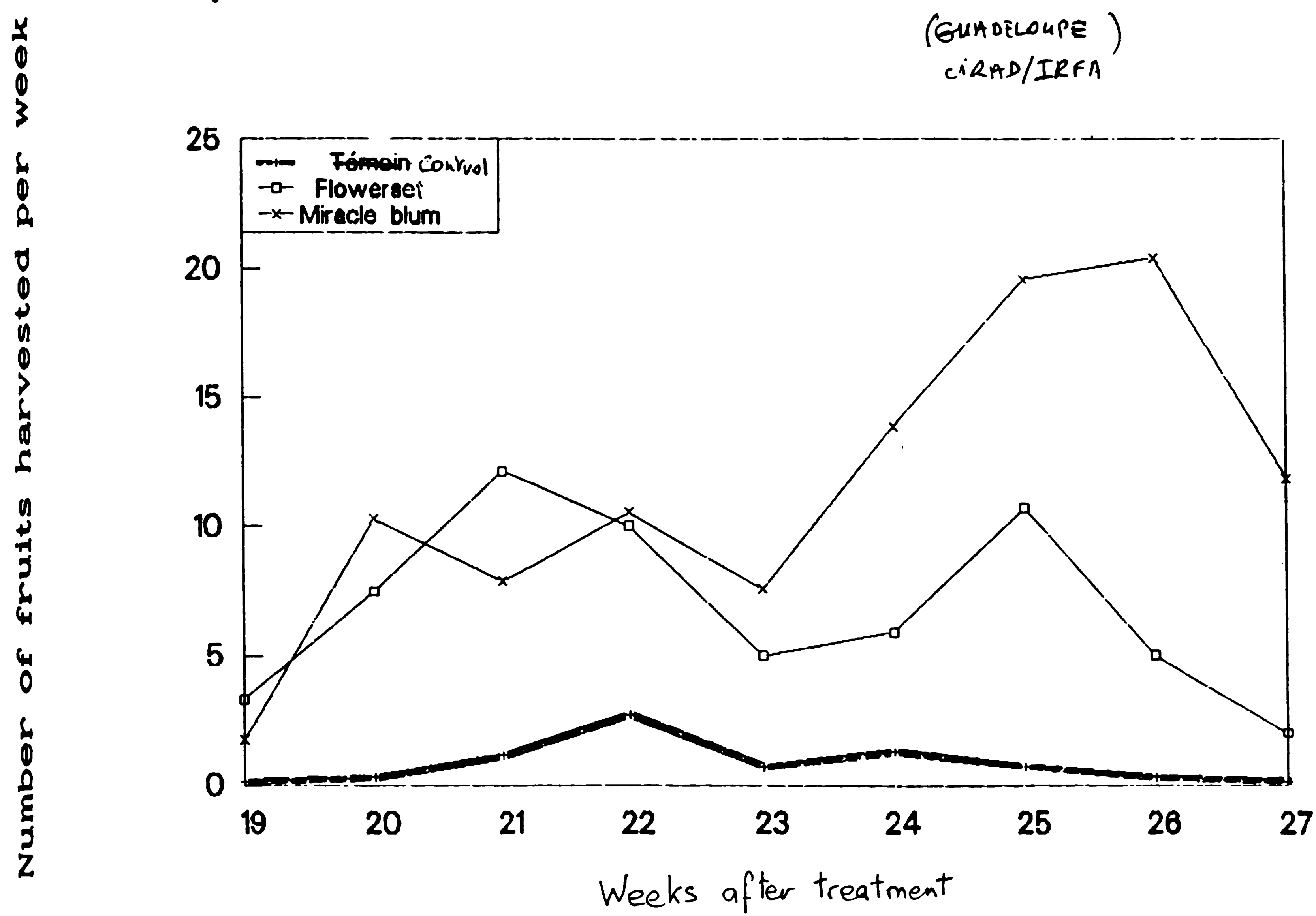


fig 3

FLOWER INDUCING TEST ON MANGO TREE

Weight of harvested fruits

(GUADELOUPE)
CIRAD/IRFA

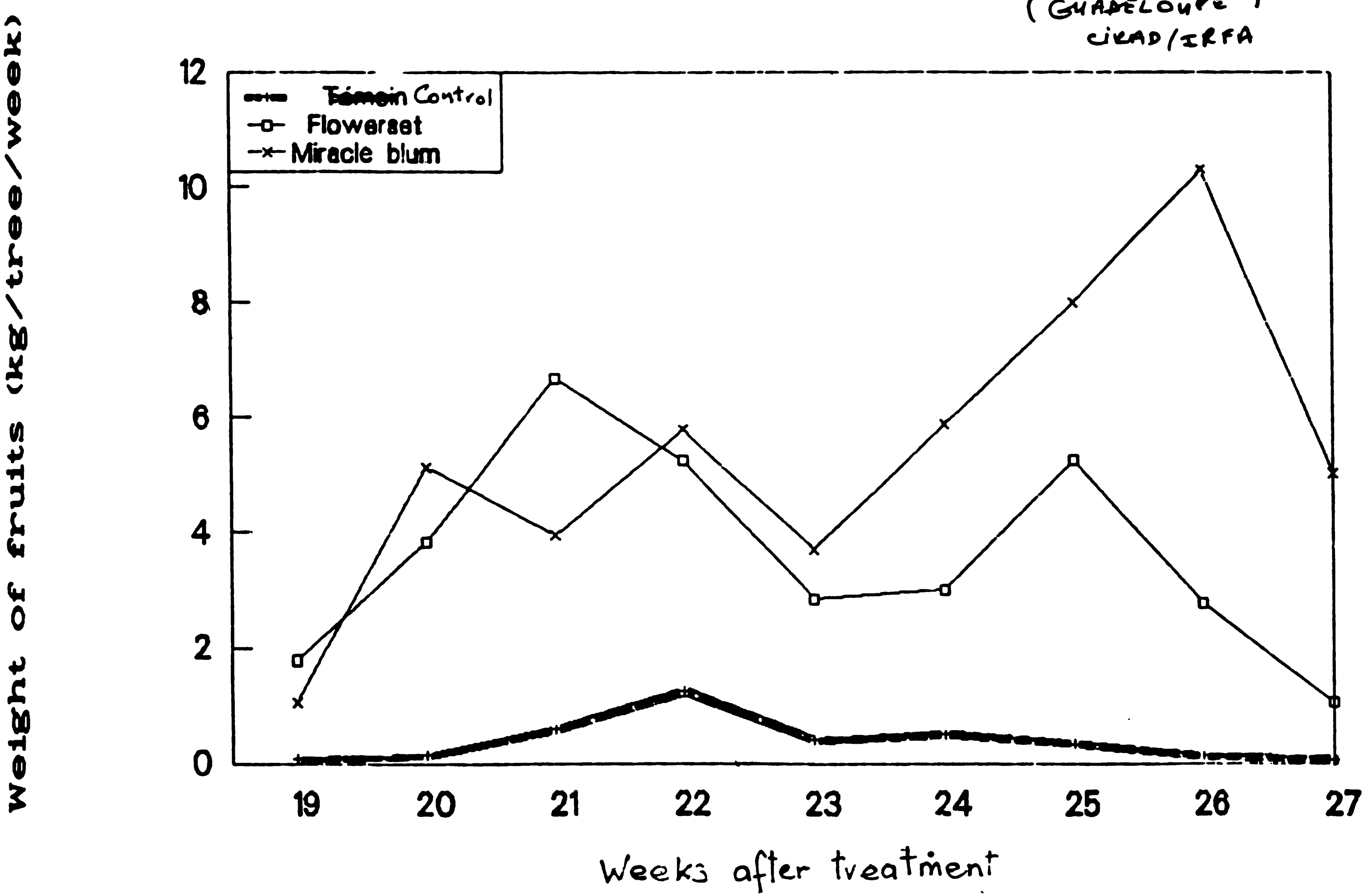


Fig. 4 EFFECTS OF CULTAR FOLIAR SPRAY & SOIL DRENCH TREATMENTS ON FLOWERING OF cv. NDMT, MALAYSIA 1986

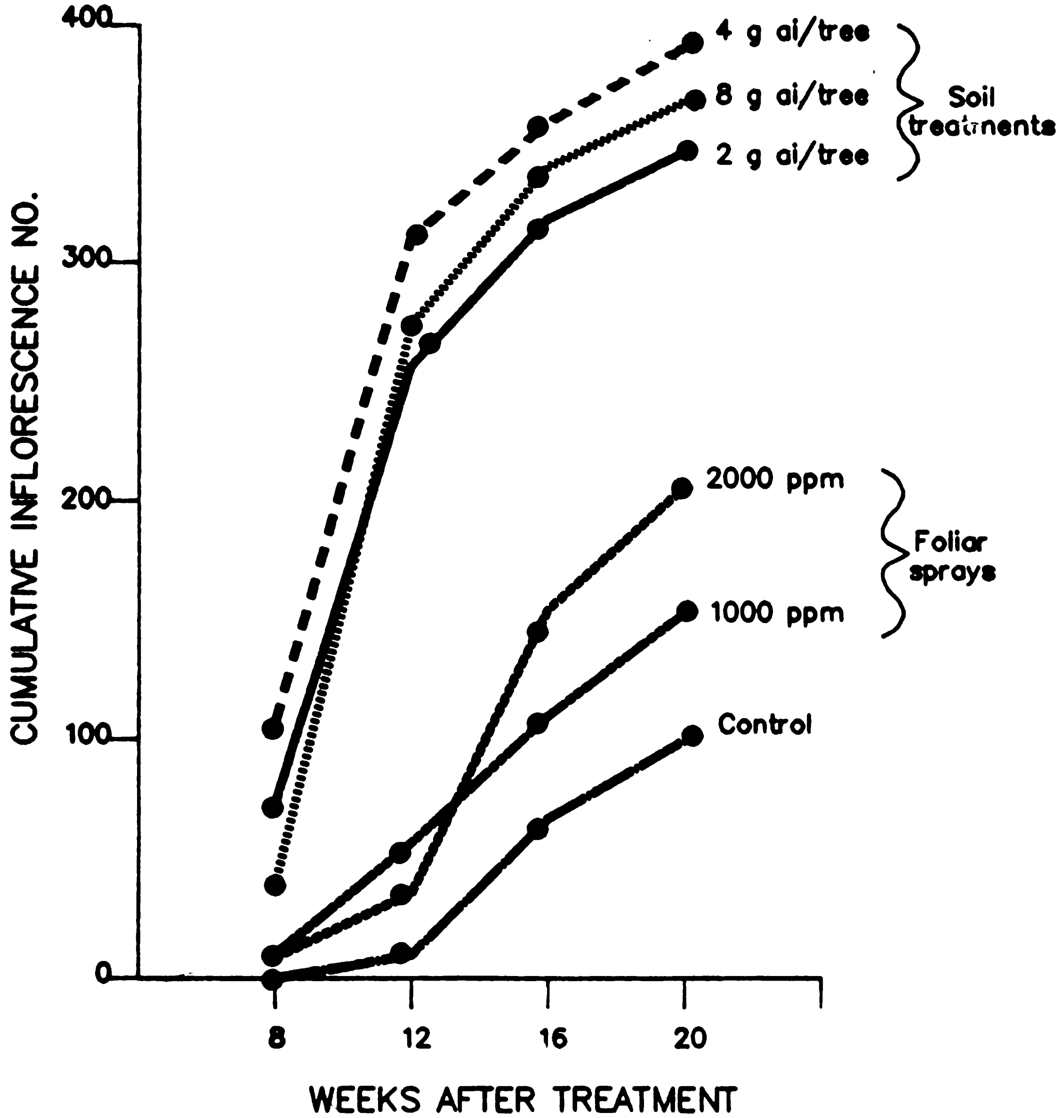
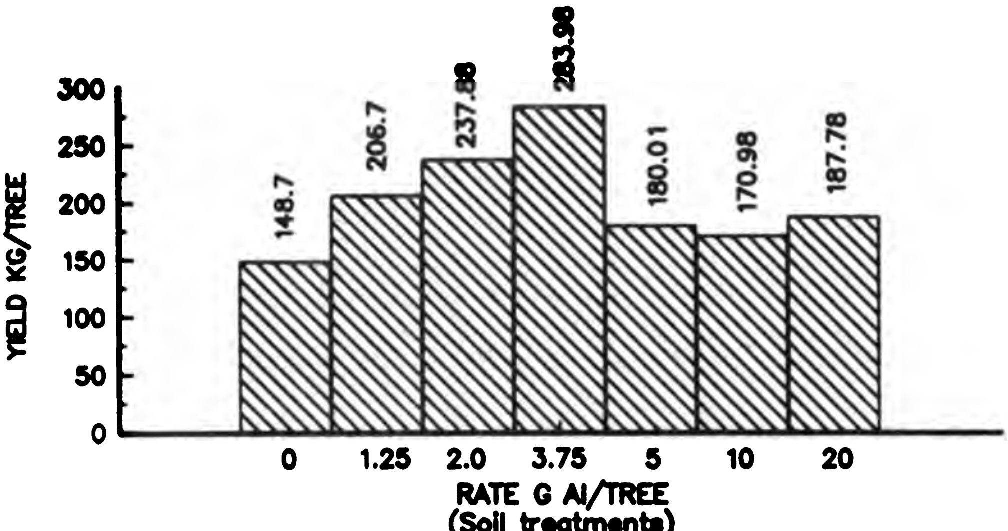


Fig. 5a EFFECTS OF CULTAR ON MANGO YIELD
cv. HARUMANIS, INDONESIA 1988



Source: S Purnomo, Indonesia 1988

Fig. 5b EFFECTS OF CULTAR ON YIELD OF MANGO
cv. KEOWSAWOEY (KSW), THAILAND 1986

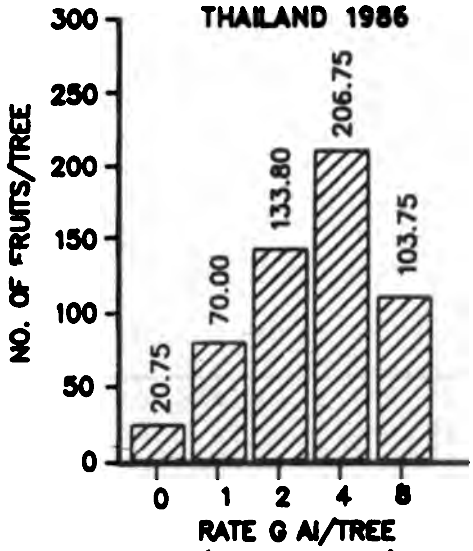
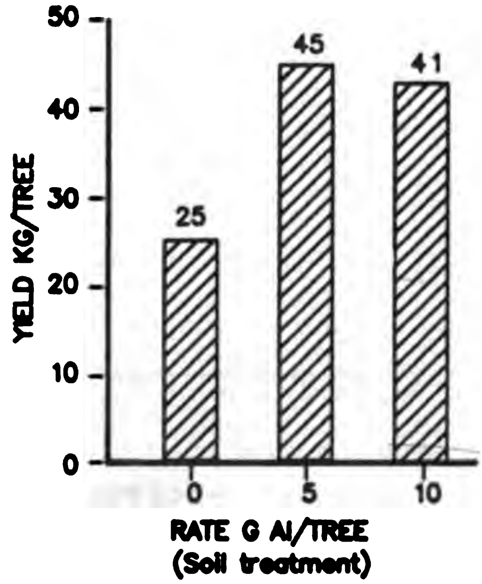


Fig. 5c EFFECTS OF CULTAR ON YIELD OF MANGO
cv. CHOUNSA, PAKISTAN 1988



INSECT AND MITE PESTS OF MANGO AND PAPAYA IN THE CARIBBEAN

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Presented
at
Workshop on ***Improving the Production-Marketing of Papaya and Mango for the Export Market,*** IICA/Jamaica Exporters' Association
10-12 March, 1993; Kingston, Jamaica, W.I.

INSECT AND MITE PESTS OF MANGO AND PAPAYA IN THE CARIBBEAN[1]

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INTRODUCTION

In many Caribbean countries, fruit production (exclusive of traditional export crops like citrus or banana, for example) is generally a backyard or small scale enterprise, except for small acreages of mango, papaya, avocado or pineapple in some islands (see IICA, 1992). Notwithstanding this, however, the significant intra-regional fruit trade suggests that hucksters do manage to collect and market sufficient fruit from such small holdings or backyard collections to earn significant income.

While any system of small-scale production is one in which pest populations will naturally tend to be kept at low levels, it is well documented (*e.g.* Pimentel, 1977) that any shift to larger monocultural systems will enhance the achievement of major pest status by an insect. Hence, it may be fairly safe to predict that any increase of fruit acreage in the region will result in increased pest status

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[1]Presented at Workshop on ***Improving the Production-Marketing of Papaya and Mango for the Export Market***, IICA/Jamaica Exporters Association; 10-12 March 1993, Jamaica, W.I.

both of existing pest species and perhaps even of previously non-pest species. To prevent or minimise this happening, adequate pest management programmes must be developed and implemented as important components of any scheme for increased fruit production.

This paper highlights and reviews major pests of mango and papaya in the Caribbean. Comprehensive reviews of these pests have recently been published (Pollard,1992; Rhodes, 1992).

MANGO

1.*Fruit Flies*

Of all major pests of mango reported for the Caribbean, tephritid fruit flies (Diptera: Tephritidae) should be considered to be potentially the most serious. Within the wider Caribbean there are 18 *Anastrepha* spp. reported so far, in addition to the papaya fruit fly, *Toxotrypana curvicauda* (Gerst) and the carambola fruit fly *Bactrocera* sp. While mango is listed as a major host of many of these (Table 1) the West Indian fruit fly, *A. obliqua* (Macq.), is the most important fruit fly species of mango in the Eastern Caribbean. Infestation levels may be as high as 100 percent in some instances with both the local and hybrid or grafted cultivars attacked.

All fruit fly species affect their host fruits in the same fashion. The female adult lays her eggs usually in mature ripening fruit except for the papaya fruit fly which may oviposit on young green fruit. These eggs hatch and the larvae tunnel through and feed on the flesh of the fruit which, as a result, loses its integrity, turning 'mushy' with eventual decay. The fruit then falls to the ground by which time the larvae are ready to pupate. They crawl out of the fruit and burrow a centimetre or so in the soil before pupating.

Pest Status and Economic Impact

Fruit flies are considered pests of major economic importance wherever they are found causing a direct loss through fruit infestation; the Caribbean is no exception. As far as mango is concerned the countries at risk include Guyana, Suriname, Trinidad and Tobago, St. Lucia, Guadeloupe, Martinique, Dominica, St. Kitts and Nevis, Jamaica and Belize. However, while Trinidad has the greatest number of fruit fly species in the region, mango is not a reported host in this country. Reasons for this are unknown. Within the Eastern Caribbean Antigua, St. Vincent, Grenada and Barbados are fruit fly free. Again there is no ready explanation for this given the fact that all these islands share relatively similar climatic conditions, have similar host plants and, as well, all participate in the intra-regional traffic in people and produce.

Apart from causing direct economic loss fruit flies are considered to be pests of major quarantine importance. The USA, one of the major target markets, will not accept any fruit unless completely free of fruit fly. Even within the Caribbean intra-regional trade in mango is dependent on the fruit fly status of the exporting country. There are no quarantine restrictions with regard to fruit flies with the European and Canadian markets (Prinsley, 1987).

Control

There are well established strategies for fruit fly control depending on the objectives which are being sought. Bateman (1972) discussed the concepts of control, suppression and eradication. Often **control** is feasible within a limited production area and serves only to control a particular pest population in that area, like an orchard. The use of bait sprays is frequently employed, for example, methyl-eugenol and malathion.

Suppression refers to the strategy of attempting to control an entire breeding population or a substantial part of that population in any season. The implication of this is that this must be a continual process every season as the pest reappears. Bait sprays or pheromone traps are usually employed, as well as applied biological control or the sterile insect technique.

Eradication aims to get rid of all flies within some given area on a permanent or semi-permanent basis. Such action is drastic and expensive and is only undertaken where there is every indication of success and where any re-infestations can be easily monitored and treated or even effectively prevented. Eradication, for example, may be attempted where there has been a recent introduction into an area, where this introduction is still relatively localised and where resources are in place to mount such a programme. This would involve a survey programme, bait spraying, sterile insect technique and perhaps a biological control strategy all combined in an integrated programme.

As far as the export market for mango is concerned post-harvest treatment for fruit flies is essential. This will be considered later.

2. *Mango Seed Weevil*

Pereviously associated with mango, its only known host, practically everywhere this crop is grown in the Old World, the mango seed weevil (MSW), *Sternochetus mangiferae* (F.) (Col: Curculionidae) has now been reported in the Caribbean - first in St. Lucia in 1984 and by 1986 for Guadeloupe, Martinique, Barbados, Dominica and French Guiana.

Pest Status and Economic Impact

MSW is generally regarded as an important economic pest of mango wherever grown. Eggs of MSW are laid on the skin of young fruit at the marble stage, or only on fruit 4 to 5 cm in length (Simpson, 1986); newly hatched larvae make their way directly to the seed where they now go through their entire development cycle. There has been, however, the odd report of larvae developing in the flesh of the fruit (Balock and Kozuma, 1964; Chandler, 1991). In the seed larvae feed on and eventually destroy the cotyledons, either totally or partially. Pupae and adults also live in the seed with the latter feeding as well. On emergence from the seed, adults are relatively inactive and conceal themselves on branches and trunks of host and other trees, in leaf litter and may even be found on fences or walls near to mango trees.

Usually there are no external signs of infestation particularly in early maturing varieties where adults leave the seed after the fruit has fallen and rotted . However, in late maturing varieties adult weevils emerge from the seed and exit the fruit after it has matured, resulting in both direct damage to the pulp and in secondary infestation by various pathogenic organisms.

MSW infestation levels may be quite high; 100 percent seed infestation in some areas in Hawaii, for example, (Balock and Kozuma, 1964) and estimates of damage between 46-93 percent for some parts of India (Shukla *et al.* 1985). Infestation data for another seed weevil, *S. gravis*, in India indicated that in one state with 9600 ha of mango under cultivation, no single tree was found free of infestation; 65-80 percent, and at times, 100 percent of fruit were found to be infested (Dey and Pande 1987). In fact, these authors considered *Sternochetus* spp. to be "... *the most serious post-blossom pest of mango*" in India. A recent survey for Barbados revealed infestation levels of fruit sampled from the tree as between 5 to 80 percent for Julie and Imperial varieties respectively; for fruit collected from the ground lowest infestation was 40 percent for Ceylon and as high as 93 percent for Graham (Chandler, 1991).

Because seeds are destroyed by MSW, losses do occur where these are required for propagation (Shukla *et al.*, 1985; Mann and Ambrose, 1990; Chandler, 1991). A mean loss of 30.9 percent (range 23.0 to 64.0 percent) was reported from three propagation stations of the Ministry of Agriculture of St. Lucia (Mann and Ambrose, 1990) while a 30 percent seed loss was reported for Barbados by Chandler (1991) who interestingly showed that seeds were still viable even with up to 66 percent damage but, on germination, such seedlings were significantly shorter than those from undamaged seeds of comparable age.

MSW infestation is also reported to cause premature fruit fall (Sundara Babu, 1969; Hill, 1975; Mann and Ambrose, 1990). The latter report from St. Lucia by Mann and Ambrose is the first for the Caribbean where they observed that on one farm Graham mangoes were dropping when mature but unripened and showed the following symptoms: "*(1) the skin at the tip of the fruit was yellow; (2) black specks in this area appeared to be insect damage and (3) underlying pulp was soft and darker orange/yellow than surrounding pulp*". The majority of such fruit were found to be infested with MSW late instar larvae.

Despite such losses as reported, other studies suggest that *S. mangiferae* should not be regarded as a pest of serious economic importance. Certainly Balock and Kozuma (1964) were of this view for Hawaii, despite high seed infestation levels and more recently Woodruff (1987) expressed the same opinion for some Caribbean islands.

What is certain, however, is that whether this pest is of direct economic importance or not in the field, it is always considered a pest of major quarantine importance (Balock and Kozuma, 1964; Shukla *et al*., 1984; Pollard, 1986; Dey and Pande, 1987), and in fact is now listed as a pest of quarantine importance for the Caribbean (FAO, 1989a; b). One implication of this is the impact on trade and the movement of fruit from infested countries.

St. Vincent and St. Lucia, for example, have been the major exporters of mango to Barbados. However, once St. Lucia had reported the presence of MSW in 1984, Barbados placed an immediate ban on the importation of mangoes from that country. According to Chandler (1991), for the period 1971-1984, St.Lucia exported 140,000 kg mangoes per annum to

Barbados compared with one shipment 1291 kg since the embargo in 1984. Entry of St. Lucian mangoes to the US market is also affected.

Control

Chemical Control

Because of the cryptic nature of the development of MSW, it is an extremely difficult pest to control. Various chemicals have been tested but reports generally indicate that chemical control is ineffective (Balock and Kozuma, 1964; Woodruff, 1987). However, Kok (1979) reported that spraying against adults which are found on tree trunks and stems could be effective. Shukla and Tandon (1985) also reported successful chemical control in India using foliar sprays, either alone or together with spot applications, applied during the oviposition period to target diapausing adults congregated on tree trunks. However, in terms of cost-effectiveness, these authors recommended the use of spot applications of 0.05 percent diazinon to tree trunks.

Cultural Control

Phytosanitary measures, *viz* the removal and destruction of fallen fruit and seeds from under trees, have been recommended for control of MSW (Kok, 1979; Dey and Pande, 1987). However such field sanitation has been shown to be ineffective in reducing the incidence of MSW (Hansen and Armstrong, 1990).

Biological Control

There have been no reports of biological control measures for MSW and despite an extensive study in India, no natural enemies were reported (Shukla and Tandon, 1985). However, one report of a new baculovirus pathogen affecting MSW suggests possibilities, perhaps, for microbial control (Shukla *et al.*, 1984) .

Quarantine Treatments

Since control of this pest is so difficult in the field, much effort has been put into quarantine measures. These are discussed later.

Status of MSW in the Caribbean

There is a strong feeling that MSW should not be considered an economic pest in the Caribbean particularly as early maturing varieties are most commonly grown. Since the fruit is utilised and the seed discarded before the pest has had the opportunity to leave the seed, no damage to the fruit and hence no economic loss occurs in such varieties. However, one recent assessment of the economic impact of MSW in Barbados estimated that this pest had cost BDS $104,123 since its introduction in 1986 (Chandler,1991). What was not costed was the potential loss due to plant quarantine restrictions on mango exports which would likely accrue as Barbados attempts to increase its production and export.

Despite this, however, there is the suggestion that the economic pest status of MSW and the restrictions on trade in mango currently existing in the region may need to be reassessed (Woodruff, 1987). In fact the quarantine pest significance of MSW itself may need reconsideration especially since the view has been expressed by Woodruff (*loc. cit.*) that it is likely that MSW would shortly be established throughout the Caribbean - an example, perhaps, of Kahn's "*inevitability-of-establishment hypothesis*" (Kahn, 1977). This view was based on the poor state of existing quarantine systems in the Caribbean coupled with the ease and frequency of inter-island travel and trade and only reinforced a similar viewpoint previously emphasized by Pollard (1986).

3. ***Thrips***

Three species of thrips (Thysanoptera: Thripidae) have been reported as adversely affecting mango and all are present in the Caribbean. However, only *Selenothrips rubrocinctus* (Giard.), the red banded or cocoa thrips, and *Heliothrips haemorrhoidalis* (Bouche) are found associated with the crop. The other species, *Thrips palmi* Karny, the palm thrips or oriental thrips, is one of the more recent introductions into the Caribbean where it has devastated various vegetable crops; so far it has not been reported on mango.

Selenothrips rubrocinctus

This is a very important pest species in the region where it attacks various tree crops (e.g. cocoa, cashew, avocado and mango) and may cause severe defoliation. In fact, in some countries, e.g. Grenada, this is one of the major pests of cocoa.

It has been reported that cocoa thrips attack is facilitated and intensified when the host plant is under stress. In the case of cocoa, the removal of shade trees and wind breaks sufficiently alters the micro-climate in fields to the advantage of the pest.

Wolfenbarger (1955) reported that *S. rubrocinctus* may be found *"...at all times on some mango trees"* in Florida though natural enemies and unfavourable conditions would usually keep population numbers at low levels. Both larvae and adults feed on the underside of leaves causing a bronzing and eventual leaf death.

Thrips palmi

This pest was first reported in 1985 from Martinique and Guadeloupe and has now spread to Antigua, Barbados, Dominican Republic, St. Kitts and Trinidad with unofficial reports for Dominica, St. Lucia and Suriname. In April 1991 introduction into mainland USA was reported for Florida. Since its introduction into the Caribbean this pest has caused severe losses in several solanaceous and curcubit crops but there have not yet been any reports of *T. palmi* affecting mango. In India, Verghese *et al.*, (1988) reported larvae and adults of *T.palmi* feeding on infloresences from the pre-bloom stage which caused retarded growth of the panicles; there was no quantification of loss. Given the severe losses in other host plants, should *T. palmi* have the same effect on mango, then this is certainly a major cause for concern.

Control

Control of thrips is difficult and has usually been dependent on the use of pesticides. The large size of mango trees can contribute to this difficulty. More importantly though is the fact that resistance can develop to the extent that pesticides become almost totally useless. This, for example, is the situation with *T. palmi*. Alternatives to pesticides therefore have to be found.

At present there are two projects underway at the Faculty of Agriculture in Trinidad investigating such alternative strategies for *T. palmi* control. These include the use of entomopathogenic fungi and predatory organisms. Preliminary data suggest that the fungi *Paecilomyces fumoso-roseus* and *Hirsutlla* spp.are good candidate agents for successful control.

4. Mango Midges

Mango midges belong to a group of insects referred to generally as gall midges (Diptera: Cecidomyidae). This group has not been well studied locally. This may be due to their unobtrusive nature. As Ananthakrishnan (1984) has described them, *"Gall midges are small, fragile insects, usually unnoticed except by the specialist* (but) *..the large number of species, the wide diversity of host plants they attack and their role in various ecosystems make them much more important than their appearance might suggest".*

Much of the current information on gall midges in the Caribbean is based on a series of papers published 50 years ago (Callan, 1940a; 1940b; 1941). Two midges attacking mango were listed as *Asynapta mangiferae* Felt, the mango shoot midge and *Erosomyia mangiferae* Felt, the mango midge. This account of these pests relies on the above reports. *Asynapta mangiferae* is the lesser important of these two midges and is considered a minor pest of mango. It was, at the time, only reported for Barbados by Callan. Larvae get below the bark of small shoots and cause death of the terminal parts of the shoot probably as a result of cambial feeding. According to Callan (1940a; 1941) *Erosomyia magniferae* is more widespread, being endemic to the Lesser Antilles with positive records for St. Vincent and St. Lucia and possibly Trinidad. Eggs are laid on young infloresences and young leaf buds. On hatching, larvae bore into the plant tissue causing small swellings or blister galls (Ananthakrishnan, 1984), as well as the exudation of latex (Rhodes,1992); the attacked flowers and leaves die. Callan (1941) also reported that secondary fungal infestation may occur at small decayed spots on the flower stalks. This has been confirmed by Rhodes (1992) who recently began detailed investigations on *E. mangiferae* in Dominica and have reported some preliminary results. According to Rhodes the pest status is somewhat unclear and the major cause of infloresence death may in fact be secondary infestation of fungi and bacteria through feeding wounds caused by the midge. This perhaps may be the reason in the past for confusing such damage with anthracnose infection (A. Whitwell, pers. comm.).

A similar gall producing species, *E. indica*, has been reported for India (Ananthakrishnan, 1984).

Control

Very little information on control was seen by this writer. Callan (1940a) reviewed control methods for gall midges in general and included preventative control (plant quarantine) and various cultural measures. However the latter were of more relevance to short term crops than mango, e.g. crop rotation, time of sowing to avoid the pest, post harvest field sanitation, destruction of volunteer plants and so on. Mention was also made of various natural enemies *viz.*

chalcid and proctotrupoid parasitoid wasps and the potential for applied biological control. More recently a fuller taxonomic study of chalcidoid wasps associated with mango gall midges has been reported (Boucek, 1986). However, Rhodes (1992) does not consider biocontrol to be a feasible option but, instead, more effective strategies such as the application of soil insecticides or tillage operations to control mature larvae or pupae in the soil and careful timing of selective insecticides (e.g. insect growth regulators) to infloresences to control larvae. In fact he was of the view that ".. *given dry environmental conditions and good cultural management mango gall midge may not be a serious pest*" (Rhodes, 1992).

5. *Scale Insects and Mealy Bugs*

Mango is host to a variety of scale insects, mealy bugs and white flies (Pollard and Alleyne, 1986; FAO, 1989b) with all parts of the plant subject to attack, the roots excepted. These pests are usually of minor importance but there may be instances of sporadic serious loss. Damage caused by these insects is typical of homopteran feeding. Yellowing occurs at feeding punctures and this may lead eventually to the entire leaf becoming dry and with consequent leaf shed. If fruits are attacked soft spots and consequent deterioration occur at the sites of attack. At times fruit development is impaired; they may fail to ripen and be prematurely shed

(Wyniger, 1962). There is also the growth of sooty mould fungus, particularly with heavy scale and mealy bug attack.

Pest status

Although the pest status of these insects is usually low some species may be of major importance at times; e.g. *Coccus viridis* in Cuba; the snow scale, *Insulaspis insularis* and the white fly, *Dialeurodes* sp. in Barbados (FAO, 1989b); *Aulacaspis tubercularis* Newst. in the Dominican Republic (Schmutterer, 1990).

Control

Usually, natural enemies are able to exert varying levels of regulatory control on scale insects and mealy bugs to the extent that these organisms may be effectively controlled as reported for Pakistan (CIBC-PARC, 1986). However, this same report indicates that indiscriminate pesticide use may result in these pests increasing in pest status.

6. Mites

There are few reports of mites attacking mangoes in the Caribbean. The avocado mite, *Oligonychus yothersi* (McGregor) and the broad mite, *Polyphagotarsonemus latus* (Banks) have been reported in Cuba and Barbados respectively (FAO, 1989b). Mites generally cause superficial damage resulting in malformed fruit.

PAPAYA

This is one of the crops recognised as having a great potential for commercial and export production in the region with a number of countries targeting increased production. Already Bahamas, Barbados, Cuba, Jamaica and Puerto Rico export extra-regionally but as one report suggests production is erratic and acreages too low to compete with major world producers like Hawaii and Brasil (Harvey *et al.*, 1990). In addition, there are many serious constraints to increased production of which pests and diseases represent just one of these.

1. *Leafhoppers*

This is one of the most, if not, the most important group of insects of papaya in the Caribbean. They cause the typical symptoms of homopteran feeding - yellowing and curling of leaves followed by eventual shed. In papaya, however, this damage is secondary to their role as vectors of Bunchy Top disease.

Two major leafhoppers affecting papaya are *Empoasca papayae* and *E. stevensii* (Haque and Parasram, 1973; FAO, 1989b). These are both vectors. In the absence of an effective pest/disease management programme, this disease is perhaps the single major constraint to commercial papaya production in the Caribbean. Resistant or at least tolerant cultivars, good conditions for plant growth and effective vector control are the elements of any effective pest management programme for Bunchy Top. This will be considered in greater detail in the next presentation by Rafael Marte.

2. *Scale Insects and Mealy Bugs*

Various scale insects and mealy bugs may be important pests of papaya. *Pseudaulacaspis pentagona* (Targ.), the white scale, (Homoptera: Diaspididae) has been reported as causing serious damage in Suriname (Van Dinther, 1960). Young trees, up to one-year old, are most severely attacked - leaf stalks, leaves and stems may become encrusted with the scale causing the stem to become thin and the bark shrivelled; plant death may occur.

Planococcus citri (Risso) (Homoptera: Pseudococcidae), the citrus mealy bug, is a more important pest of papaya in the Caribbean than of citrus. Heavy infestation may lead to leaf shedding particularly in young plants; buds may also wither.

3. *Papaya Fruit Fly*

Toxotrypana curvicauda Gerst. (Diptera: Tephritidae) is an important pest of papaya. It is of worldwide distribution. Though all reports generally indicate that papaya is the only host (e.g. Phillips, 1946) mango has also been reported as a host by some workers (Wolfenbarger, 1955; Schmutterer, 1990). The damage caused by this pest is similar to that of other fruit flies. However, apart from mature fruit the papaya fruit fly can oviposit in the seed cavity on young unripened fruit with early larvae feeding on the seeds and lining of the seed cavity and later larvae in the flesh. Premature ripening and early fruit drop result. Infestation of young fruit can be recognised by droplets of dried latex on the outer surface. This is caused when the adult makes an oviposition wound through which milky latex is expressed onto the fruit surface (Schmutterer, 1990).

4. *Mites and Thrips*

There are several reports of mites and thrips affecting papaya in the region. However, no comprehensive surveys seem to have been done to determine which species are of major pest status and their economic impact. Both thrips and mites can cause superficial damage to papaya fruits expressed as a silvering on the surface and which detracts from the appearance on ripening. Some of the more common mites, *Tetranychus* spp. (spider mites) cause yellowing of leaves.

Post-harvest treatments for mango and papaya

According to Couey (1989) heat treatments for the control of both fungal diseases and insect infestations of fruit have been used for many years but had become overshadowed by the success of chemical treatments. However, recent restrictions and even the banning of some of these chemicals have led to the revival of various heat treatments for post-harvest pest and disease control. For example, ethylene dibromide, one of the most widely used and effective post-harvest treatments for fruits and vegetables, has now been banned by the United States Department of Agriculture. One result, for example, was that Florida could no longer export mangoes to major markets both within and external to the United States (Japan, Hawaii, California, Arizona or Texas) since at the time there was no alternative quarantine treatment for Caribbean fruit fly, *Anastrepha suspensa* (Sharp *et al*, 1989).

In a recent review Couey (1989) has listed the several ways in which heat may be applied for pest control. These include the exposure of fruits and vegetables to:

- ***i. hot water***
- ***ii. water-saturated hot air (vapor heat)***
- ***iii. hot dry air***
- ***iv. infra red radiation; and***
- ***v. microwave radiation***

While all have been used experimentally, according to Couey only vapor heat and hot water have found pratical application, with the latter more widely used for post-harvest microbial disease control than for insect control. Notwithstanding this, there have been many instances of the use of hot water for the disinfestation of mango and papaya of tephritid fruit flies. Harvey *et al* (1990) describe a double dip hot water treatment for papaya consisting of 20 minutes at 46°C followed by 20 minutes at 42°C. Recently McIntyre and Malins (1992) reported that treatment of Julie mangoes for 25-35 minutes at 48°C-50°C would result in both fruit fly (*A. obliqua*) and anthracnose control. An earlier report by these same workers described a low-cost prototype hot water treatment facility in Dominica made from a 55 gal metal drum, a pump to keep hot water in circulation, a thermostat and dipper with electric hoist. This facility was able to accommodate 180 Julie mangoes (10 boxes of 45 kg each) per treatment (45 minutes at 46°C) and 71 boxes over an eight hour shift period (Malins and McIntyre,1991). What has not been explicitly stated in these various reports is whether these treatments , apparently all successful, do meet the required international level of quarantine security for fruit flies , *i.e.*, a probit 9 resulting in 99.9968 percent mortality at a 95 percent confidence level. What this really means in practice is that there must be no survivors from 100,000 treated individuals (Heather,1986). McIntyre and Malins (1992) did indicate that their treatment regime was to have been submitted to USDA for their likely approval. I do not know if this has been done.

There have also been various quarantine treatments recommended for MSW. However, because of the fragility of mature mango fruit many of the standard quarantine treatments, like hot or cold treatments and the use of ethylene dibromide or methyl bromide, while killing the pest can also cause injury to the fruit (Balock and Kozuma, 1964; Shukla and Tandon, 1985). In any event the use of EDB is now unacceptable. While reports suggest that gamma irradiation of marketable fruit is an effective treatment for MSW (Seo *et al.*, 1974; Kok, 1979; Heather,1986) this treatment would not be cost effective in the Caribbean. As a recent consultant's report has indicated, the lack of facilities in the region together with the relatively small quantities of fruit produced would make irradiation procedures prohibitive (Woodruff, 1987).

CONCLUSION

The above description highlights some of the more important insect and mite pests of mango and papaya in the Caribbean. These are summarised in Annex I. All these pests must be effectively controlled if the full potential of these crops is to be achieved but control is not always easy. Fruit fly control, for example, is an expensive on-going exercise which may require both pre- and post-harvest treatments. The latter is obligatory if one wishes to access the U.S.A. market. Many effective post-harvest treatments have not been adequately investigated in the Eastern Caribbean. Even those countries which are reportedly free of these pests - Grenada, Barbados, St. Vincent and Antigua - have had to undertake expensive and laborious surveys to prove that they are fruit fly free in order to gain access to US export markets. Such surveys have to be on-going.

Apart from the pests already existing in the Caribbean, this region is a target for potential pest introductions either *via* natural means or through deliberate, though inadvertent entry. Various factors put the region at risk - *(i)* the fact that the Caribbean is a major importer of agricultural products; *(ii)* the present agriculture diversification thrust which is partially dependent on the importation of germplasm; and *(iii)* the fact that the Caribbean is a major tourist destination.

Many pest introductions into the Caribbean have been reported over the past few years (Pollard, 1986). The most alarming and serious in the near past has been *Thrips palmi* but now the even more serious potential threat of Tristeza virus of citrus is very real. While national plant quarantine services have shown tremendous improvement over the past few years due to the efforts of various regional (*e.g.* IICA) and international (*e.g.* FAO/UN) organisations together with national efforts from local Ministries of Agriculture, there is still a greater need to make these services more functionally effective. The importance that must be attached to plant quarantine can be seen by only considering the serious losses that can result from new pest introductions. However, it appears at times that too little importance seems to be attached to intra-regional quarantine. One may recall an earlier suggestion for the free movement of agricultural produce within the region. Such a suggestion perhaps indicates ignorance of the distribution of some very important pests in the region. Those countries which are currently certified fruit-fly free, for example, would wish to maintain very strict quarantine measures to guard against introduction of these pests.

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Table 1: Distribution of Fruit Flies affecting mango (and other host plants) in the Caribbean.

Species	Common Nanes	Major Host Plants	Distribution in the Region
Anastrepha distincta	Pois-doux Fruit Fly	*Inga* spp.; mango	Guyana; Trinidad and Tobago
A. fraterculus	South American Fruit Fly	Sapodilla; grapefruit; orange; coffee; pommerac; mango; guava; hogplum	Guyana; Suriname; Trinidad and Tobago
A. ludens	Mexican Fruit Fly	Citrus; Mango	Belize
A. obliqua	West Indian Fruit Fly	Various plums *viz.* hogplum; mango; pommerac; guava; almond; grapefruit; sour orange; cashew	Throughout the Greater and Lesser* Antilles; Jamaica Trinidad and Tobago; Bahamas
A. serpentina	Sapodilla Fruit fly	Star apple; sapodilla; mango; sepote; orange	Dominica; Guyana; Suriname; Trinidad and Tobago
A. striata	Guava Fruit Fly	Guava; mango; various plums	Guyana; Suriname; Trinidad and Tobago
A. suspensa	Caribbean Fruit Fly	Almond; guava; pommerac; grapefruit; sweet orange; sour orange; hogplum; star apple; custard apple	Jamaica; Greater Antilles; Bahamas
Bactrocera sp.	Carambola Fruit Fly	Carambola; Curacao apple; guava; mango; W.I. cherry; suriname cherry; sapodilla; star apple; pommerac	Suriname; French Guiana
Toxotrypana curvicauda	Papaya Fruit Fly	Papaya	Trinidad and Tobago; Bahamas;

ANNEX I

Major Insect Pests of Mango and Papaya in the Caribbean with notes on their Distribution and Damage Symptoms

CROP	PEST	DISTRIBUTION	DAMAGE
MANGO	Fruitflies: *Anastrepha* spp. (Diptera: Tephritidae)	Wide distribution in the Caribbean region; Note: Antigua, Barbados, Grenada and St. Vincent are free of fruit flies.	Females lay eggs below skin of mature fruit; larvae tunnel and feed in flesh: Mature fruit with rotting spots; fruit falls.
	Thrips: Redbanded thrips or Cocoa thrips - *Selenothrips rubrocinctus* (Thysanoptera: Thripidae)	Barbados, Bahamas, Cayman Islands, Cuba, Dominica, Dominican Republic, Grenada, Jamaica, St. Lucia, Puerto Rico, Suriname, Trinidad and Tobago, St. Vincent and the Grenadines.	Adults and nymphs feed on under surface of young leaves particularly; leaves turn yellow or brown speckled with spots of excreta; leaf fall results.
	Oriental thrips: *Thrips palmi* (Thysanoptera: Thripidae)	Antigua, Barbados, Dominican Republic, Guadeloupe, Martinique, Puerto Rico, St. Kitts, Trinidad.	Not reported on mango in the Caribbean. In India: inflorescence infested, scab-like markings at feeding sites; retarded growth.
	Midges: Mango midge - *Erosomyia mangiferae* (Diptera: Cecidomyiidae)	St. Vincent, St. Lucia, Trinidad.	Young inflorescences and young leaf buds attacked to give rise to small blister galls; young flowers and leaves die as a result; secondary fungal infestation may result.
	Mango shoot midge- *Asynapta mangiferae*	Barbados	New shoots attacked by larvae who get below the bark with eventual death to terminal shoots due possibly to cambial feeding.
	Various scales and mealy (Homoptera)	Wide distribution in the Caribbean	Found on leaves and/or fruit may cause leaf fall; sooty mould infestations.

CROP	PEST	DISTRIBUTION	DAMAGE
MANGO	Snow scale: *Insulaspis insularis* (Homoptera: Diaspididae)	Barbados	Found on leaves and fruit; causes bronzing of fruit.
	Mango seed weevil *Sternochetus manififerae* (Coleoptera: Curculionidae)	Barbados, Dominica, French Guiana, Guadeloupe, St. Lucia, Martinique.	No external signs of damage in early maturing varieties but can cause postharvest damage to fruit of late maturing cultivars; infested fruit may show premature fall; extensive seed damage usually.

ANNEX I Continued

CROP	PEST	DIRTRIBUTION	DAMAGE
PAPAYA	White Scale: *Pseudaulacapis pentagona* (Homoptera: Diaspididae)	Antigua and Barbuda; Dominica; Suriname, Trinidad and Tobago	Attacks mainly young trees (1-year old); stems, leaf-stalks and fruits may be attacked. Plants develop small fruit; leaves turn yellow and wilt; stem may shrivel and split; death of plant follows.
	Citrus mealy bug - *Planococcus citri* (Homoptera: Diaspididae)	Widespread	Heavy infestation leads to leaf shredding; buds wither.
	Papaya fruitfly: *Toxotrypana curvicauda* (Diptera: Tephritidae)	Bahamas; Cuba; Haiti; Trinidad and Tobago	Females lay their eggs in the seed cavity of young fruit, feeding on seeds and then the pulp. fruit yellow prematurely and fall; mature fruit also attacked with larvae feeding and tunnelling in pulp.
	Leafhoppers of papaya: *Empoasca papayae* (Homoptera: Cicadellidae)	Antigua and Barbuda; Grenada; St. Christopher and Nevis; Montserrat; Trinidad and Tobago; St. Vincent and the Grenadines.	Vectors of Bunchy Top Disease
	E. stevensii	Trinidad and Tobago	

PROCESSING OF MANGOES, AVOCADOES AND OTHER MINOR FRUITS

by

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Fruits are important in our daily diet and the consumer trend today is towards fresh, natural, minimally processed yet convenient foods. The four main quality factors associated with fruits are colour, flavour, texture and nutritive value. Processing can alter the quality of fruits. The aim of food science/technology is to understand the chemistry underlying these quality attributes to be able to minimise deteriorative changes or enhance quality factors during processing.

Fruits are the mature ovaries of plants with their seeds. Fruits are nearly all acidic and are commonly referred to as "high acid" foods.

The composition of fruits depends on botanical variety, cultivation practices, weather, degree of maturity prior to harvest and the method of storage after harvesting. Generally they contain about: 85 percent water; structural carbohydrates namely protopectin, cellulose, hemicellulose and lignin; other carbohydrates in the form of starch or sugar or both; very little protein and fat; (except for avocadoes) and a wide range of vitamins (A and C) and minerals.

Fruits also contain aromatic or flavouring compounds: acids, tannins, sulphur compounds and many other unknown substances. Tannins give an astringent, sharp or bitter taste which diminishes on ripening. The full flavour of fruits develops on maturity and diminishes on storage.

COLOUR

The natural colour of fruits is associated with the pigments; chlorophylls (green), carotenoids (yellow and orange), anthocyanins (red, blue, purple) and anthoxanthins (creamy white, yellow). Anthocyanins and anthoxanthins are also referred to as flavonoids and include the tannins. Colour can be used as an indication of maturity in fruits. The yellows, red and blues increase with maturity while the green colour decreases.

Chlorophyll is highly unstable and rapidly changes to olive green or brown during ageing, processing or cooking. It is stable in alkaline solution but is readily converted to the brown pheophytin under acid conditions.

The carotenoids are fairly resistant to heat, changes in pH and do not leach out in water because they are fat soluble. They can be oxidized and this results in discolouration and loss of vitamin A activity on exposure to light and oxygen.

Anthocyanins are sensitive to pH and metal ions and are leached out in water during processing. An acid pH favours a bright red colour and metal ions cause red anthocyanins to become violet and blue.

Enzymes known as polyphenol oxidases, phenolases, tyrosinase cause enzymatic browning in foods. They catalyse the conversion of monophenols and diphenols to quinones which undergo a series of non–enzymatic reactions to produce brown, gray and black coloured pigments. During processing of fruits browning reactions are not desirable and several methods are employed to inactivate enzyme systems namely blanching, sulphiting, ascorbic acid treatment, or sugar syruping.

TEXTURE

The size and shape of the cells and the turgor (associated with the amount of water present and cellular components) determine the textural characteristics of fresh fruits The most important textural characteristics is firmness.

The parenchymatous cell comprises mainly of the cell wall and the cell vacuole. The cell vacuole contains most of the water and dissolved salts present in plant tissues. The cell wall encompasses the vacuole, provides rigidity and allows for salts and gases to diffuse in and out the cell. The cell wall comprises of layers, each of which is made up of different materials:

primary cell wall	–	cellulose, hemicellulose, lignin;
middle lamella	–	pectic substances (protopectin, pectinic acid and pectics acid).

Pectic substances are the glues to plant cells and their importance in the textural characteristics of fruits is widely accepted. During ripening, insoluble protopectin is hydrolysed to water soluble pectin, a substance which forms gels with sugar and acid. Pectin can be further hydrolysed by the enzyme pectin methyl esterase and this is associated with a loss in gel forming properties. In fruit processing, it is important to deactivate this enzyme by appropriate heat treatment.

Calcium and magnesium ions also play a role in the firmness of raw and processed fruits. Calcium forms calcium pectates which add rigidity to cell walls. In commercial processing of fruits, calcium salts are added to brines and syrups to improve the texture of the finished product.

FLAVOUR

The enzymes involved in the formation of off flavour compounds in fruits are peroxidases and lipoxygenases. These form highly reactive free radicals and hydroperoxides. Blanching is used to inactivate peroxidase activity in the production of shelf stable foods.

Over-processing destroys the natural flavour of fruits.

NUTRITIVE VALUE

The most important nutrients in fruits are Vitamins A and C, minerals and dietary fibre. Processing may have a destructive effect on nutritive value. Vitamin C is lost on heating and other water soluble nutrients can be leached out. Enrichment and fortification are used to improve nutritional quality of processed foods. Freezing results in maximum nutrient retention

OTHER FACTORS

RESPIRATION AND TRANSPIRATION

Fruits are living tissues and continue to live after harvesting. Respiration involves utilization of carbohydrate reserves (starch) and the production of carbon dioxide (CO_2), water (H_2O) and energy. Transpiration involves uptake and release of H_2O through stomata. These processes determine to a great extent the harvesting and processing of fruits.

Three generalizations can be made concerning compositional changes in fruits after harvesting. They are:

(1) In some fruits Starch is converted to sugars on ripening e.g. mango, pawpaw. Post harvest storage temperatures affect changes in starch and sugar content. Additionally if respiration is allowed to proceed carbohydrate stores are used up.

(2) Water–soluble pectin concentration increases and this contributes to the gradual softening of fruits during ripening and storage.

(3) Organic acids decrease during storage and ripening. This is linked to colour changes as pigments are pH sensitive and changes in the viscosity of pectin gels.

PRINCIPLES OF PROCESSING

The principles involved in fruit processing can be discussed under the headings – harvesting and postharvest practices. All processing technologies are aimed at stopping physiological and enzymatic activities.

HARVESTING

Fruits should be harvested at the correct stage of maturity and under ideal conditions preferably in the early morning or late evening when it is cool. Physical damage of produce should be avoided. Failure to follow these guidelines can result in poor quality product due to loss in sugars, increased microbial attack (due to build up of heat and moisture) and loss in water through transpiration.

Fruits should be processed immediately on arrival from the fields to minimize pile-ups and need for storage.

POSTHARVEST PRACTICES

Cooling

Fruits should be cooled to restrict deterioration without causing abnormal ripening. The method of choice depends on the commodity and anticipated storage life. Precooling methods involve:

(1) Use of cold air;
(2) Use of cold water;
(3) Evaporation;
(4) Direct contact with ice.

Washing/Cleaning

Fruits must be cleaned prior to processing to remove latex dust, dirt, insect hairs, fruss (larvae excretement) plant parts, filth, sprays and chemical residue. Wash waters containing sanitizers and other detergents can be used. Factors to consider in washing fruits include:

(1) Temperature of water; cold water is preferred;

(2) pH of H_2O;

(3) Mineral content of H_2O;

(4) Force with which water is applied.

Sorting/Grading

This is an important step to ensure only quality produce is used for the purpose for which it is assigned. Fruits that are rotten or infested e.g. anthracnose should be discarded.

Peeling/Cutting/Trimming

Several methods are used for removing skins. Manual methods are labour intensive but require minimal equipment and large amounts of water. Other methods involve use of lye (caustic soda) or boiling water or steam or flame. Fruits can be cut, trimmed, etc. mechanically or manually. This step increases the surface area exposed to enzyme and microbial attack. This step should be performed quickly and under ideal conditions.

PREVENTING ENZYMATIC BROWNING

Several methods are employed to minimize oxidation and thus browning. These include:

i) Blanching;

ii) Use of ascorbic acid or sulphur dioxide dips and sugar syrups.

Blanching

Blanching involves heating foods rapidly to a preset temperature, holding for a preset time and cooling rapidly to near ambient temperatures. Blanching time is influenced by:

i) The type of fruit;

ii) The size of the pieces of food;

iii) The blanching temperature and

iv) The method of heating.

Three methods of blanching include:

a) hot water blanching;

b) steam blanching and

c) microwave blanching.

A cooling treatment immediately follows the heat treatment to ensure minimum changes in texture and prevent further cooking.

The success of blanching can be determined by the inactivation of peroxidase and catalase which are the more heat resistant enzymes. A simple qualitative test which can be used involves adding one drop of 3% Hydrogen peroxide solution to the cut surface of the product. If bubbles are observed, catalase is present and if a pink to orange colour develops, peroxidase is present.

Blanching also:

i) reduces the number of contaminating microorganisms on the surface of foods;
ii) softens vegetable tissues to facilitate filling into containers;
iii) removes air from intercellular spaces which assists in the formation of vacuum in containers;
iv) fixes colour;

ASCORBIC ACID/OR SULPHUR DIOXIDE DIPS AND SUGAR SYRUPS

Ascorbic acid or Vitamin C minimizes fruit oxidation because of its anti-oxidant properties. It is added to fruits dissolved in a sugar syrup at levels ranging between 0.05–0.2%. Citric acid may also be used in conjunction with ascorbic acid to increase acidity.

Sulphur dioxide inhibits the activity of oxidizing enzymes and also has anti-oxidant properties. It also interferes with metal ions.

A 0.25% solution of sodium sulfite, sodium bisulphite or sodium or potassium metabisulphite can be used. Fruit or vegetable slices can be dipped for about one minute and removed so as not to absorb too much sulphur dioxide. This treatment can be used prior to freezing and drying of fruits.

Sugar syrups are used to inhibit browning as they coat the fruit and prevents contact with atmospheric oxygen. Additionally they minimize loss of volatile fruit flavours. Ascorbic acid and citric acid are normally added to sugar syrups or is used after an sulphur dioxide treatment.

In summary, fruit processing involves the use of high quality produce and it is important that the pre and post harvest processing steps identified above be adhered to. This would ensure minimal alteration to colour, flavour, texture and nutritive value.

PROCESSING MANGO

Mango can be processed into a variety of products namely:

1. **Puree:**
   Beverages, Juices, Nectars, Cordials
2. Canned Mango Slices
3. Dried Mango Slices
4. Candied Mango Products:
   Red Mango, Fruit Leathers, Cheese
6. Pickles Mango Products:
   Mango Anchar, Kuchela and Chutney
7. Jams

The general principles in processing fruits apply to mangoes but each category of product will be dealt with briefly.

MANGO PUREE

The unit processes involved in the production of mango puree include sorting, washing, peeling, blanching, slicing, dicing, acidification, pasteurization and packaging.

FRUIT SELECTION

Only fully ripe fruits which are free from rot should be used. The fleshy varieties; Julie, Graham, Calabash, Bombay etc. are preferred as they are less fibrous and the ratio of flesh to seed is high and peel is thin. A higher juice yield is therefore obtained.

WASHING

Wash fruits with a detergent and sanitizer providing 20 – 60 ppm active chlorine and rinse. Wipe dry if fruits are to be stored before processing.

PEELING

Peel manually. Fruits can be blanched before peeling. Steam blanching for 2 – 2 1/2 minutes makes peeling easier.

EXTRACTION & FINISHING

Pulp mangoes using a paddle or brush pulper. A paddle pulper with a 0.033 in screen removes fiber and small pieces of peel and finishes the pulp.

ACIDIFICATION

Acidify the puree to a pH of 3.5–4.0 using citric acid (0.3–0.5%w/v).

HEAT PROCESS/PASTEURIZATION

Heat the pulp to 85–90°C hold for three minutes, fill into sterilized buckets. Add .2% sodium metabisulphite or .1% potassium sorbate. Seal. Cool. Store at room temperature or freeze.

MANGO JUICE, NECTAR AND SQUASH CORDIAL

Standards of identity exist for production of juices, nectars and cordials. A mango nectar as described in the draft caribbean standards is the product made by adding potable water and nutritive sweeteners to the mango pulp and preserved by physical means. It must have the characteristic colour, aroma, flavour and consistency of mango nectar and the fruit content must not be less than 40% by weight. A juice is the pure, undiluted fruit extract.

A mango squash contains a high percentage of sugar (60 – 65%) and should contain at least 25% fruit pulp. A mango cordial is a sparkling clear beverage. The mango puree must be depectinized to obtain a crystal clear cordial. The enzyme normally used to achieve this is called pectinase or pectin esterase.

STEPS IN PRODUCING MANGO BEVERAGE

1. Prepare puree
2. Weigh all ingredients
3. Heat water to 70°C. Add sugar, stir to dissolve
4. Add puree and citric acid
5. Heat to 85 – 90°C. Hold for three minutes. Add preservative.
6. Fill hot into clean, sterilized bottle to 9/10 volume of bottle
7. Cap, seal tightly. Invert two minutes
8. Cool gradually. Label.

CANNED MANGO SLICES

The steps are as follows:

1. Fruit selection: Firm ripe fruits are recommended. A gravity floatation method has been tried in India. Fruits are placed in a 3% brine solution and those which sink are used for canning;
2. Peel;
3. Slice;
4. Fill into cans or jars;
5. Pour hot 35 – 40° Brix syrup containing 0.2 – 0.25% citric acid within 1/4" of the top of the can or jar. Cover lightly;
6. Exhaust to a center temperature of 85 – 90°C;
7. Heat process in an open kettle for 20 – 30 minutes at 100°C;
8. Cool in a water bath or air.

DRIED MANGO SLICES

The unit processes involved in the production of dried mango slices:

1. Fruit selection;
2. Washing;
4. Steeping in an acidified syrup for 18 – 24 hours the composition of which is:
   - 40°Brix Syrups
   - 0.3 – 0.5% Citric Acid
   - .03 – .05% Sodium Metabisulphite;
5. Draining;
6. Dry at 70°C for 3 hours;
7. Package;
8. Label;
9. Store.
2. Peel

CANDIED MANGO PRODUCTS

These products are based in the principle of osmotic dehydration. Sugar is used to draw the moisture out of the product thereby creating an unfavourable environment for microbial growth.

RED MANGO

The unit operations involved in this are

(i) Fruit selection – Wholesome, sound green mature slightly "turning" fruit are recommended. Long mango or mango vert is the most suitable.

(2) Wash

(3) Slice

(4) Brine (heavy or light salt) or blanch.

(5) Cook in acidified syrup of 30 – 50° Brix with 0.03% Red #40 and spices

(6) Drain. Store mangoes slices in clean, sterile buckets.

(7) Concentrate syrup to 60° Brix for storage, acidify with 0.3 –> 0.5% citric acid w/v. Add 0.1% w/v Potassium sorbates.

(8) Pour over mangoes. Seal buckets. Leave to infuse 1 – 32 weeks

(9) Drain

(10) Dry at 70°C for 3 hours

(11) Cool.

(12) Package in high density polyethylene bags. Allow to sweat for 24 hours

(13) Repackage

(14) Label

MANGO FRUIT LEATHER

The steps in production of this candy are outlined as follows:

(1) Select wholesome ripe fruit puree.

(2) Add sugar, citric acid and 0.2% sodium/potassium metabisulphite to the pulp, to achieve a total soluble solids of 25° Brix – 35° Brix.

(3) Heat to 75 – 85° C. Stir constantly to prevent burning/overheating.

(4) Pour on to greased trays to approximately 12mm thickness

(5) Dry at 70 –> 80°C for 2 1/2 –> 3 hours.

(6) Cut into squares

(7) Package and store in a cool dry place.

MANGO CHEESE

Mango cheese is prepared using mango pulp, pectin and sugar. The principle involves formation of a pectin gel which is dependent on the relationship between the sugar, acid and pectin present in the formulation CARIRI has found that a mixture of *Julie* and Graham pulp in a ratio of 3:1 is most suitable.

The steps involved in processing cheese are:

(1) Fruit selection

(2) Washing

(3) Pulping

(4) Mixing sugar and pectin to which is added in vert syrup and mango pulp.

(5) Boil at 105° C to achieve a 75° Brix

(6) Acidify

(7) Pour into lightly greased trays. Cover with a net

(8) Cool

(9) Cut

(10) Package in polyethylene or cellophane/polythene film.

(11) Seal

MANGO PICKLES

Mango pickles prepared locally are of three types; mango anchar, kuchela and chutney. The steps involved in the production of each product will be outlined.

(1) Fruit Selection. Mature green fruit are recommended for pickling. Varieties which can be used include Long/Vert, Rose, and other fibrous varieties

(2) Washing

(3) Cutting/slicing/shredding

(4) Blanching/or Brining: The mango slices can be dry salted or steeped in a brine solution. The salt concentration can vary from 5% which is increased daily until 15% is added or a saturated brine 20 - 25% salt can be used.

(5) Wash. The salted slices to remove excess salt.

CHUTNEY

In the production of chutneys a sugar syrup (80 - 85° Brix) is prepared in vinegar. The mangoes are cooked in the syrup to a pasty consistency, packed 85 - 90o C in warm sterile bottles at and sealed.

ANCHAR

This is an oil pickle. The oil is heated to 350_0 F and spices are blended in. The mangoes are added and the mixture cooked to 85 - 90° C. The product is filled hot (85° C), and a thin layer of hot oil is added and the bottles sealed.

KUCHELA

This is also an oil pickle. The oil is heated to 350° F and spices are blended in. The dried shredded mangoes are added to the hot oil, mixed well and filled into sterile jars. A layer of hot oil is poured over the product and the bottle sealed.

JAMS

The process flow for the production of Jam is given in Figure 1.

AVOCADOES

Not much work has been done on processing of local avocadoes.

MINOR FRUITS

All the above principles used in mango processing apply to minor fruits.

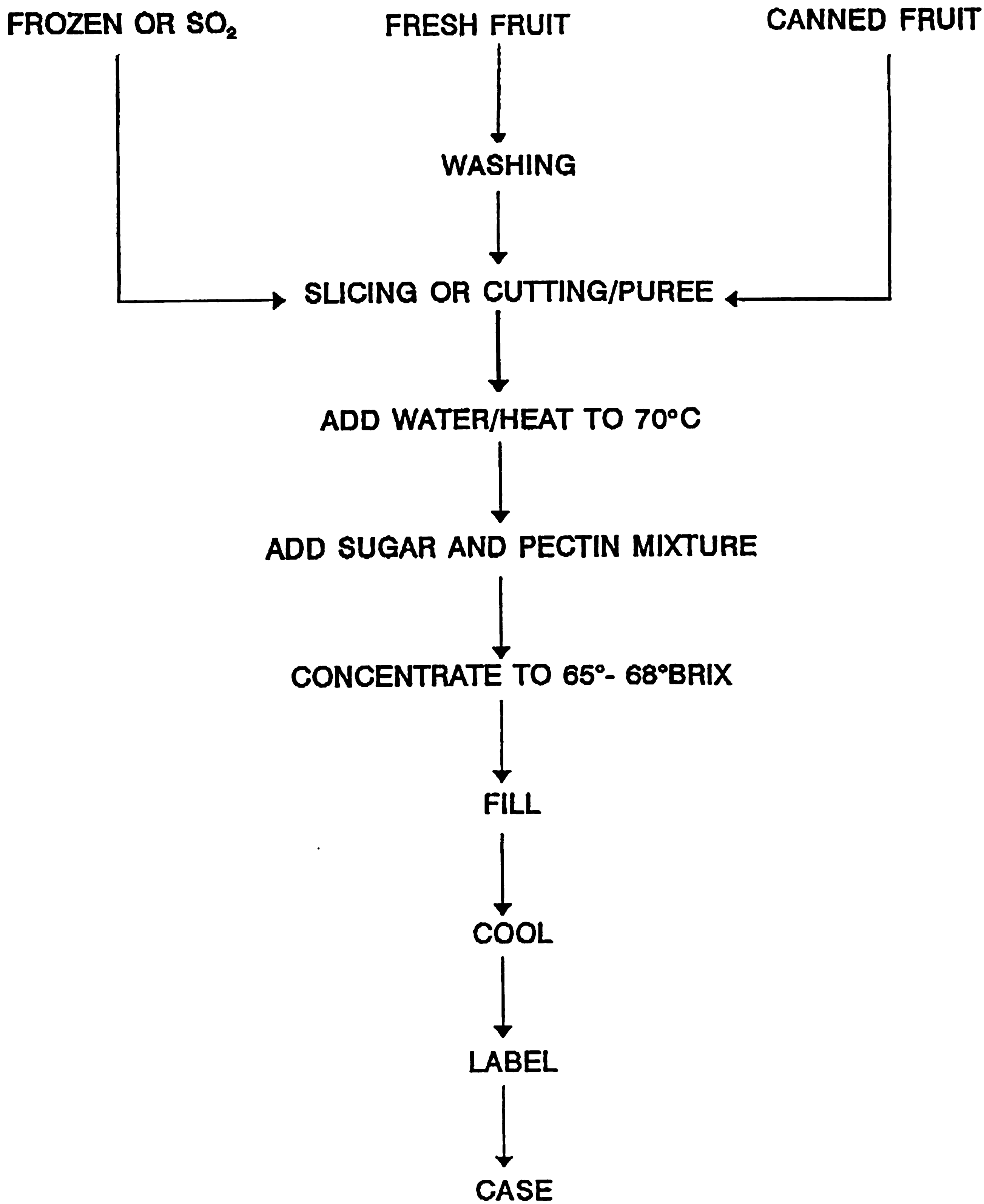

Figure 1 -Flow Sheet for making Jam/Jelly/Marmalade

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