Julie Mango in the Eastern Caribbean
A comprehensive manual
JULIE MANGO
IN THE EASTERN CARIBBEAN

A comprehensive manual

Caribbean Agricultural Research and Development Institute (CARDI)
The Technical Centre for Agricultural and Rural Cooperation (CTA)

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All the photographs are placed in the centre of the manual, for economy in printing.
Acknowledgements

This Julie Mango Manual is the culmination of years of effort. It presents a set of technologies developed for production of the Julie mango in a number of member countries of the Organisation of Eastern Caribbean States (OECS).

We thank the authors of each of the chapters and particularly Mr Gregory Robin for his relentless efforts in coordinating the input of the authors across the region, the editors and the Information and Communication department at CARDI.

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Claudette de Freitas
Information Resources Manager
CARDI
Preface

Mango is a very important fruit in the Caribbean. During the season of mango fruit many people in the region consume a large number on a daily basis. The fruits contain extremely high amounts of vitamin A and are very rich in other important nutrients such as calcium, iron, thiamin and vitamin C. In common with many tropical fruits, mango’s nutrient composition indicates vast superiority to fruits such as apple, grape and pear which have to be imported into the Caribbean.

Caribbean people not only consume mangoes, but they are very knowledgeable about the various varieties. This knowledge extends to strong views about the rank preference of varieties. Although, to my knowledge, few formal scientific surveys have been done I suspect that most people would rank ‘Julie’ as the favourite variety.

This manual is a very comprehensive account of all aspects of producing and marketing Julie mango. The various chapters were written by CARDI scientists and their collaborators and were compiled by Gregory Robin of CARDI, Dominica. The writers are giving readers their knowledge gained from mango production and marketing in the OECS countries, but most of the information is readily transferrable to other Caribbean countries.

It is hoped that publication of this manual will stimulate increased production of Julie mango. This will not only improve the nutritional status of Caribbean people but also increase the trade in the commodity with a particular thrust towards extraregional markets.

Last but by no means least, there is potential for a viable processing industry utilising mango. The opportunities include cottage industries and large scale operations. The manual does not overlook these possibilities and the chapter on processing contains much of the information necessary for the entrepreneur who wants to know how to manufacture mango products.

F Bruce Lauckner
Manager, Research and Development (Ag)
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Introduction

The Exportable Fruit Crops Research and Development Windward Islands Project (EFCP) began in April 1989, initially for three years and was extended to August 1993. Subsequently a second phase ran until August 1996.

The overall objective was to develop regional technical capabilities which, through research, would lead to methods for increasing the potential of exportable fruit crops in the Windward Islands. The crops covered were avocado, coffee, grapefruit, mango, passion fruit, and sapodilla. Activities focused on improved agronomic practices, control of pests and diseases and reducing postharvest losses.

The specific objectives were:
- to develop appropriate methods for the control of pests and diseases.
- to develop economically sound cultural practices which would improve production of quality fruit.
- to introduce disease-free germplasm and evaluate varieties and cultivars for yield and marketability.
- to establish practices aimed at reducing postharvest losses in the field, in transport and by handlers/shippers.
- to publish recommendations arising from research and disseminate these to Ministries of Agriculture.
- to initiate training programmes for technical and professional workers, as part of an outreach programme.

The majority of the funding was provided by the UK Overseas Development Agency (ODA) through the Natural Resources Institute (NRI) and the British Development Division in the Caribbean (BDDC).

Strategically, project research activities were confined to Dominica to build on the research effort initiated by the Ministry of Agriculture Orchard Crop Management and Research programme which was financed by BDDC. Results were to be transferred to other Windward Islands.

Co-operative linkages were established between this project, the Agricultural Diversification Coordinating Unit (ADCU) of the Organisation of Eastern Caribbean States (OECS), the Inter-American Institute for Co-operation in Agriculture (IICA), The University of the West Indies (UWI) and other CARDI projects, to transfer relevant technical findings to the OECS through a series of regional workshops.

Training activities were also mounted in Dominica by the Ministry of Agriculture to train local farmers and extension officers. Specific institutional strengthening activities were effected with the UWI and the Natural Resources Institute (NRI) to upgrade the skills of CARDI’s staff.

The USAID-funded West Indies Produce Support Project (TROPRO) with Israeli technical assistance and with collaboration from the Dominica Ministry of Agriculture initially validated and then helped to extend the technologies emerging from the development project.
INTRODUCTION

The major constraints to production and marketing of mango were identified as fruit fly, anthracnose, gall midge, postharvest losses, irregular flowering and fruit set resulting in low productivity. Also, trees were often established in unfavourable agro-ecological zones, and orchards were poorly managed. Attention was focussed solely on Julie mango as this is the mango most commonly grown for export. The main results of the first phase are summarized in Annex 1.

During the second phase of the project, technologies emerging from Phase I - pruning, fertilizer use, fruit fly trapping, application of a rationalized spray programme to control anthracnose, and hot water treatment, were initially evaluated on three farms in Dominica. During the latter stages of the on-farm validations, the technological package was extended to 25 farms using the ‘Task Force’ approach. These farms also served as model farms, and formed the nucleus for the supply of high-quality export fruit.

In turn these activities contributed to the Joint Regional Marketing Programme, the objectives of which were to increase the profitability and foreign exchange earnings of fresh produce exports, working in conjunction with private sector exporters.

CARDI continues to monitor approximately 30 farms for fruit fly and anthracnose so that a management strategy can be planned, as well as to forecast crop production for the Dominica Export Import Agency (DEXIA).

This manual is a compilation of technologies from many parts of the world that have been successfully adapted and validated in the Eastern Caribbean. CARDI’s own research in the Windward Islands has contributed significantly to this information.

It is the most comprehensive source of information available to technicians and extensionists in the East Caribbean. It is hoped that the manual will act as an important resource for extension workers and students and assist the subregion’s farmers, exporters and processors to develop Julie mango to its full potential.

Project staff are listed in Annex 2.
The international mango market is in excess of one billion US dollars. Major producers are India, Pakistan, Mexico, Brazil and the United States (Florida). Mexico is the largest exporter of mangoes in the world. The US is the largest importer followed by the European Union and Canada. In Asia the largest importer is Hong Kong.

Mango is sometimes hailed as the most popular fruit in the world but until recently it was considered an exotic. There are more than 500 varieties but only about 10% are traded on the international market. In the major international markets of North America and Europe, competition is fierce because many producing countries have focused on the few most marketed/promoted varieties, categorised as 'Florida Varieties' i.e. Haden, Keitt, Kent, Tommy Atkins, Palmer, and Van Dyke.

All of the most important traded varieties have intense 'blush' characteristics, i.e. they appeal to the eyes of the customers. Meanwhile others with superior organoleptic qualities with little or no blush, such as Julie, are sidelined.

Julie mango has organoleptic qualities that set it apart from other mango varieties. These qualities are:

Taste: This can't be confused with that of any other mango. It is strong and exceedingly sweet. Anyone who eats a Julie mango will remember that flavour.

Aroma: When ripe, the mango advertises its presence and readiness for consumption. This smell is also a clear indication of its taste. This smell is so pungent that it dominates that of most other fruits when part of a fruit basket.

Size: The medium to small size of this mango makes it very appealing to consumers. A 4.5 kg (10 lb) carton contains between 14 to 20 mangoes. This size makes it convenient to serve a whole mango instead of slices.

Colour: When ripe, the colour of the skin is an array of red, rust, green, and yellow colours. This makes it attractive, although less eye-catching than the Florida types.

The low production of Julie, coupled with a short season in which fruits are available, enhances its 'exotic' marketing appeal. This makes the mango a prize fruit to many consumers. To ethnic West Indian populations in both Europe and North America there is ecstasy when Julie mango is available.

Julie mangoes in the Eastern Caribbean are best marketed as table mangoes between May and August. During this period production is at its peak, and quality is right. This is a relatively dry period of the year, and there is little or no anthracnose. In addition, the bright sunlight creates blush in well managed fields. This is also the beginning of the major fruit buying season in both major markets, i.e. late spring and early summer.

During the peak season mangoes are exported to United States from Grenada and St. Vincent and the Grenadines mainly by air, and to Europe from Dominica and St Lucia by sea. Some European importers, e.g. UK and France, also
import by air from countries with direct international air access.

The harvesting grades of mango for the fresh fruit market are dependent on the method of transportation used. Fully mature mangoes are harvested for air shipment or for sea journeys of less than four days. These are mainly exported to North America and Canada. Stage II mangoes are harvested for sea journeys longer than four days and are the grade which is mostly exported to Europe. (Figure 11.1)

Regional markets
The Caribbean market continues to be the major market for Julie mangoes. The two largest importers are Trinidad and Tobago and Barbados, followed by The Netherlands Antilles, the French Antilles, the British Virgin Islands and US Virgin Islands. However, the latter four countries with their large tourist markets purchase mainly Florida-type mangoes from Florida and Central America.

Nevertheless the market potential for Julie is good since the West Indian population in these islands enjoy Julie, and feel that it is the best mango.

These markets are small but relatively high priced. Mango market promotions are done by the leading suppliers from Miami, while very little is done for Julie and other West Indian varieties. Julie mangoes are sold mainly on their known organoleptic qualities rather than the ‘market push’ strategy employed by the suppliers of the Florida varieties.

International markets
US imports of mangoes doubled over the five year period 1990–1994. Nevertheless, consumption is considered very low when compared to other tropical fruits such as banana. However, US per capita consumption increased by approximately 10% per year during this period. Mangoes are mainly consumed in cities with high Latino, Asian, and West Indian populations. Demand is expected to continue to grow now that fruit is available year-round. Mexico is the largest exporter to this market supplying 88% of all US mango imports.

The Canadian market has grown by almost 75% over the past five years. Like the USA, Canada imports most of its mangoes from Mexico, 69% of total mango imports. The remainder come from the USA, Central and South America and the Philippines. Consumption patterns are similar to those of the US.

The European market continues to grow at approximately 10% per year. The leading importer of mangoes in Europe is the Netherlands which imports mangoes from a variety of sources and then ships them throughout Europe. The United Kingdom, Netherlands, and France are the three largest markets.

Table 1.1 Imports of table mangoes to major markets, 1994

<table>
<thead>
<tr>
<th>Country</th>
<th>Volume (tonnes)</th>
<th>Value (US$ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>123,100</td>
<td>107</td>
</tr>
<tr>
<td>Canada (C$)</td>
<td>16,400</td>
<td>19</td>
</tr>
<tr>
<td>Netherlands</td>
<td>15,500</td>
<td>18</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>11,200</td>
<td>12</td>
</tr>
<tr>
<td>France</td>
<td>10,300</td>
<td>14</td>
</tr>
<tr>
<td>Germany</td>
<td>10,050</td>
<td>10</td>
</tr>
</tbody>
</table>
The European market is supplied year-round from Brazil, Southern Africa, Cote d'Ivoire and the USA. Other suppliers are Mexico, Pakistan, Venezuela, and Israel.

Processed products
Tropical fruit juices are high-cost luxury items and their market prospects in Europe are somewhat limited, particularly during recession years. However, world trade in fruit juices has been increasing and is expected to continue to rise in the future. Separate breakdowns do not exist in trade statistics for tropical fruit juices, concentrates and pulp, other than pineapple. However, the principal three tropical fruit juices, concentrates and pulps (apart from pineapple) are banana, passion fruit, and mango. Together, these account for three-quarters of the trade in tropical fruit juices other than pineapple.

The principal outlets for tropical juices (other than pineapple) are the Netherlands (mainly for re-export), Germany, the United Kingdom, France, and Switzerland. Outside Europe, Saudi Arabia is probably the largest market. The United States is increasingly becoming a major purchaser, although quantities are still small.

Consumers' attitudes towards fruit juices have changed considerably over the last two decades. Traditionally regarded as a breakfast drink in many countries, these juices are now replacing beverages consumed during the rest of the day. One reason for this is the rise of health consciousness.

Orange juice is the preferred type of juice on most markets although some countries in Europe have traditionally consumed large quantities of apple juice. Other citrus juices and pineapple are common juices worldwide. In contrast, demand for tropical fruit flavours remains comparatively low on most markets, except in some Middle East countries. Tropical fruit beverages and dairy products containing tropical fruit are growing in popularity in many markets. (Tropical fruit beverages with a 100% juice content are rarely sold in the retail trade because of their high acidity, and/or viscosity and excessively strong taste.)

Importers in most of the major markets are interested almost solely in bulk-packed fruit juice raw material, in the form of single-strength juice, juice concentrate, or fruit pulp or puree. Demand is also growing for pieces and slices of some tropical fruits.

Fruit juice offered for sale to consumers must be 100% juice and should contain no additives. In recent years interest has increased in juices consisting of two or more fruits, for instance mango and banana; and orange, pineapple, passion fruit, and mango.

A fruit nectar usually contains juice and/or pulp, sugar and water. The minimum juice and pulp content usually varies between 25% and 50% in most nectars, depending on the fruit. The definitions of fruit juice drinks and fruit drinks are not generally precise but both have a much lower juice content than juices and nectars and may include various ingredients such as citric acid, essential oils, and preservatives.

The dairy industry uses imported fruit juice raw material to produce yoghurt, ice cream, desserts, and sauces, etc. It probably accounts for close to 30% of tropical pulp and juice imports. Yoghurt is the most important item in this context. Fruit yoghurts usually have a 10–20% fruit content. Ice cream is another important end-use for mango and other tropical fruit. The dairy industry uses increasing amounts of fruit pieces and slices - particularly of mango.
In addition to the beverage and dairy industries other food industries producing such items as jam, jelly, chutney, baby food, bakery products and confectionery, are estimated to purchase about 5% of tropical fruit juice raw materials imported. These industries also use large amounts of imported frozen and otherwise preserved fruit.

Demand for tropical fruit juice raw material is on the rise in most major markets, partly as a result of promotional activities undertaken by the beverage and food industries, and partly because more consumers travel to countries where they eat the fresh topical fruit. Full consumer acceptance of such juices may, however, take a considerable period of time. On balance, prospects for increased world trade in fruit juices are believed to be good, although any rapid development is unlikely for tropical fruit juices and pulp.

Tropical juices, concentrates and pulp are exported from several countries or areas in Latin America, Africa, and Asia. Mango (mainly pulp) is supplied primarily by Brazil, India, Mexico, the Philippines, Colombia, Venezuela, Thailand, Cote D'Ivoire, Haiti, Peru, Guatemala, Mali, and Taiwan. India is the main producer of processed mango products.
2 Quality and quality standards

The importance of quality
Trade in fresh mangoes is a truly global business. Multi-national companies compete vigorously with one another for consumers on the basis of quality, price, consistent availability, and presentation. Some of these 'improvements' may be real and others may be implied or perceived, as a result of the promotional efforts of the vendor.

In addition, the market for mango has also been affected in recent years by:
- downward pressure on product price
- restricted use of chemicals during production and after harvest (which has led to a decline in quality and consequently the price received by farmers)
- environmental impact of the production system and produce packaging (some importing countries may impose restrictions or require the use of more costly materials)
- concentration of the trade by large retailers performing direct procurement
- increased legislation relating to food safety.

The future for Eastern Caribbean mango growers
For growers in the Eastern Caribbean to continue to play a part in this highly structured worldwide business requires significant changes in the way the industry now operates. Producers and exporters need to become more competitive. The cost of mangoes delivered to the market is clearly a major component of that competitiveness but by no means the only one; product quality is the other major factor.

Success in selling any product or service depends upon satisfying customers. All world markets for fresh produce have become more sophisticated along the lines indicated above. Every year new sources of supply come on stream and add to the wide choice offered to customers. Customers make their choices based on the satisfaction level the product will provide. Customer satisfaction therefore, must be the first priority for any exporter of mangoes.

In summary, competition between mango suppliers in all markets is essentially won or lost on:
- product quality
- product availability
- product price
- the service that surrounds the product.

The customer wants quality, availability, price and service (QAPS) that matches his/her requirements. The customer not only demands QAPS but wants it consistently. A product which is variable from week to week, is difficult and expensive to work with, cannot be presold, makes the buyer’s business itself unreliable. Inconsistent products are bad for business.

Quality standards and quality assurance systems are the means of establishing optimum systems for the production and handling of mangoes for export markets, and so ensuring that quality mangoes reach the customer.
Quality standards

Standards describe the degree of quality of a given commodity that provide the basis for its usability and value. Standards provide a common basis for trade among farmers, exporters and importers; assist produce handlers in efficiently preparing produce for marketing; provide a basis for pricing and incentive payments; serve as a basis for price reporting; and help settle claims and disputes between sellers and buyers. As a result, standards are of benefit to all participants in the trade.

Statutory standards: Mandatory and voluntary standards have been introduced in many countries defining the quality of produce that can be traded within their boundaries.

US standards for fresh fruit and vegetables are voluntary except when they are required by state and local regulations, by industry marketing orders or for export. Currently no mandatory standards exist for mangoes imported into the USA.

The European Union (EU) has, and continues to, define standards for fresh produce which are mandatory in EU member countries for either produce of EU-origin or imported from outside. Standards are enforced by a horticultural inspectorate which performs assessments at packhouses, at ports of entry, and at markets. Failure to comply with these standards will result in either rejection, resorting and repacking at the exporter's cost or reclassification to a lower grade. The United Nations Economic Commission for Europe (UN/ECE) working party on standardization has published a standard for mango but this has not yet been converted into a common EU standard, which means that it is not legally binding. The UN/ECE standard is presented in Annex 3.

No statutory standards exist for fresh produce for trade within, and for export from, the OECS. However, draft OECS standards have been drawn up but have not yet been made mandatory. The draft mango standard is presented as Annex 4.

Industry standards: Many producer organizations, exporter associations, and import companies have developed their own commercial standards for fresh produce. For mango, it is these commercial standards that producers and exporters in the Eastern Caribbean have to satisfy to ensure market development. Quality control departments of all multiple retail stores use a detailed written specification particular to a given variety against which imports are checked. Entry into this market requires detailed study of these specifications and assessment of how best to achieve the buyers' needs. At present, Julie mango is not sold into these markets so a specific example is not available. Generally, the specification would refer to the following main quality features:

- general appearance should be clean, healthy, free from latex and abnormal surface moisture
- free from decay and spoilage
- free from pest contamination and/or damage
- free from soil
- free from spray deposits
- free from anthracnose
- free from cuts/mechanical damage (some tolerance may be allowed on bruising)
- free from off-flavours/taints
○ free from minor windscar/rub marks (some tolerance will be allowed)
○ fruit size and shape, characteristic of the variety
○ specific stone : flesh ratio
○ minimum sugar level at 10%
○ fully developed and capable of ripening to good eating quality
○ weight and counts ranges specified
○ precooling temperature
○ storage temperature
○ arrival temperature
○ type of packaging, specifying inner and outer design and net weight
○ labelling requirement.

CARDI has developed a general commercial specification for Julie mango, which can be used by farmers and exporters as a guide, and should be used by exporters to develop the common language required within the mango sector. (Table 2.1)

Standards are intended to protect all participants in the production and marketing chain.

Quality assurance systems
Once a quality specification is set–by whatever authority–producers and exporters must put in place measures to achieve it. This will involve technical innovations, management systems, information systems and records. The whole mechanism can be called a quality assurance (QA) system since it is primarily geared to ensure that product requirements are met consistently. The emphasis of QA systems today is “prevention is better than cure”. Designing production and handling systems to achieve a target specification is much more cost effective than trying to rectify problems when they arise. Quality assurance programmes are essential for the development of a competitive industry.

The essential components of a quality assurance system for mango include:
○ management commitment to quality
○ mango quality specification
○ production system designed to produce fruit to the desired specification
○ handling system designed to maintain fruit within the desired specification
○ critical determining points (high risk areas) in production and handling systems identified
○ production records
○ packhouse records
○ product inspection
○ control systems at all levels of the production and handling chain
○ farmer and packhouse worker training.

This manual provides information in support of some of these components but cannot attempt to describe the full detail of a QA system for Julie mango, nor is it practical since QA systems are always unique to a company.
<table>
<thead>
<tr>
<th><strong>Market</strong></th>
<th>extraregional</th>
<th><strong>Ripening</strong></th>
<th>Changing of peel colour from green to greenish/yellowish/orange, sometimes with a red blush. Fruit should be quarter-ripe (colour change should be 25%) for May to September shipments and half-ripe (colour change 50%) for shipments outside this period. These specifications are for the European market</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transport</strong></td>
<td>sea</td>
<td></td>
<td><strong>Pack</strong></td>
</tr>
<tr>
<td><strong>Cleanliness</strong></td>
<td>free of soil, sooty mould and insects minor latex contamination allowed</td>
<td></td>
<td>Class 1 &amp; 2, 5 kg (11 lb) net packed to specific counts</td>
</tr>
<tr>
<td><strong>Colour</strong></td>
<td>Class 1 strong red blush required Class 2 slight or no red blush acceptable</td>
<td></td>
<td>Size 14 = 14 count</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Size 16 = 16 count</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Size 18 = 18 count</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Size 20 = 20 count</td>
</tr>
<tr>
<td><strong>Condition</strong></td>
<td>to be cooled to shipping temperature within 24 hours of harvest</td>
<td></td>
<td><strong>Sizing</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>number of fruit/carton of fruit (g)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Size 14 320—360</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Size 16 280—320</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Size 18 240—280</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Size 20 200—240</td>
</tr>
<tr>
<td><strong>Appearance</strong></td>
<td>Class 1 free of blemish Class 2 minor blemish allowed Glossy, free of shrivelling</td>
<td></td>
<td><strong>Labelling</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>printed labels only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>on one short side: Julie Mango  Net weight  Count</td>
</tr>
<tr>
<td><strong>Grading</strong></td>
<td>difference in weight between smallest and largest not to exceed 15% as proportion of the largest</td>
<td></td>
<td>on one long side: Supplier name</td>
</tr>
<tr>
<td><strong>Maturity</strong></td>
<td>Fruits in the carton should be uniform in maturity. Only stage 1 &amp; stage 2 fruit are accepted. Stages are characterised by shoulders being level with the stem insert and yellowing of flesh colour extending to 50% from the seed</td>
<td></td>
<td><strong>Decay</strong></td>
</tr>
<tr>
<td><strong>Trim</strong></td>
<td>stem intact, cut smoothly to 6 mm (0.25 in) loss of stem will result in rejection</td>
<td></td>
<td>Class 1: no decay or fungal lesions on arrival in market</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Class 2: minor anthracnose lesions allowed</td>
</tr>
</tbody>
</table>
3 Varietal characteristics

Mango cultivars can be grouped into two categories – the 'Indian' and the 'Indo-Chinese'. The Indian types are mono-embryonic (producing one seedling per seed). Mono-embryonic cultivars normally produce highly coloured fruits and are usually very susceptible to anthracnose (a fungal disease). Examples of mono-embryonic fruit are Julie, Keitt, Kent, Palmer, Tommy Atkins, Hayden, and most of the Florida cultivars. They are well suited for commercial use.

Cultivars of the Indo-Chinese group are poly-embryonic (producing more than one seedling per seed). These cultivars normally produce fruits that lack attractive colouration and are relatively resistant to anthracnose disease. Most of the cultivars in this group are not commercially important, and are more suited for home use.

In many territories of the Caribbean, there are seedling mangoes which do not fit clearly into either of the above groupings, among these are Turpentine and Number Eleven.

Since the focus of this manual is on Julie, only its characteristics will be given. Information on other mangoes grown in the OECS is available in a Mango Monograph being prepared by Lennox Andrews, Caroni (1975) Ltd., Trinidad and Tobago.

Growth Pattern
Julie is the smallest of the commercial cultivars. Trees are semi-dwarf, with spreading branches. Branches are numerous, the lower ones spreading horizontally and the upper ones gradually ascending until they become nearly erect in the centre.

New shoots arise mostly as laterals from axillary buds around the stump of the bearing twigs of the previous year. Terminal growth is always in the form of an extension of shoots already produced.

Julie is commonly characterised by alternate or irregular bearing. Vegetative flushes are followed by flowering, and the extent and nature of flowering determines the extent and nature of flowering. Inflorescences are generally borne on shoots, and shoots which bear panicles of flowers do not produce vegetative growth until after harvest. However if fruit set fails or fruits fall early, lateral shoots may be produced early enough to initiate new flowering.

The tap root of the Julie elongates and continues until it reaches the water table, with only a few anchoring root branches developing at this time. After the elongation phase, surface roots begin to develop to form a dense network just below ground level.
3 VARIETAL CHARACTERISTICS

Season of maturity

<table>
<thead>
<tr>
<th>Country</th>
<th>Main season</th>
<th>Off-season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominica</td>
<td>May–Sep</td>
<td>Jan–Feb/Mar</td>
</tr>
<tr>
<td>Grenada</td>
<td>May–Aug</td>
<td>Mar–Apr</td>
</tr>
<tr>
<td>Montserrat</td>
<td>May–Aug</td>
<td>Nov–Jan</td>
</tr>
<tr>
<td>St Kitts</td>
<td>Jul–Sep</td>
<td>Jan–Mar</td>
</tr>
<tr>
<td>St Lucia</td>
<td>May–Oct</td>
<td>Mar–Apr</td>
</tr>
<tr>
<td>St Vincent</td>
<td>May–Oct</td>
<td></td>
</tr>
</tbody>
</table>

Fruit Characteristics

<table>
<thead>
<tr>
<th>Fruit shape</th>
<th>Oblong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance when ripe</td>
<td>Greenish/yellowish orange sometimes with red blush</td>
</tr>
<tr>
<td>Anthracnose susceptibility</td>
<td>Susceptible</td>
</tr>
<tr>
<td>Bruising</td>
<td>Quite easily</td>
</tr>
</tbody>
</table>

Eating Quality

Smooth, sweet, good flavour, strong aroma, soft flesh
Low fibre content
17–18% soluble solids

Suitability for processing

Canning                  | Poor            |
Juice pulp               | Good            |
Chutney                  | Poor            |

Yield Characteristics

The yield characteristics are based on well-managed trees between 8 to 10 years old, grown in areas with rainfall of 2,000–3,000 mm (80–120 in) per year (representative of the drier west coast areas of Dominica).

<table>
<thead>
<tr>
<th>Average fruit per tree</th>
<th>250–300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average fruit weight</td>
<td>200–350 g (7–12 oz)</td>
</tr>
<tr>
<td>Average seed weight</td>
<td>23–27 g (1 oz)</td>
</tr>
<tr>
<td>Ratio of flesh to seed</td>
<td>12:1</td>
</tr>
</tbody>
</table>

Regularity of bearing

Somewhat irregular

Phenology

<table>
<thead>
<tr>
<th>Main season</th>
<th>Off season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flushing</td>
<td>Dec–Jan</td>
</tr>
<tr>
<td>Flowering</td>
<td>Feb–Mar</td>
</tr>
<tr>
<td>Fruit set</td>
<td>Mar–Apr</td>
</tr>
<tr>
<td>Harvest period</td>
<td>Jun–Sept</td>
</tr>
<tr>
<td></td>
<td>Feb–Mar</td>
</tr>
</tbody>
</table>
### Table 3.1  Comparison of Julie and other mango cultivars in the Eastern Caribbean

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Country</th>
<th>Main season of maturity</th>
<th>Regularity of bearing</th>
<th>Average fruit weight (g)</th>
<th>Fruit shape</th>
<th>Anthracnose susceptibility</th>
<th>Quality and remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>St Vincent</td>
<td>May—Oct</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grenada</td>
<td>May—Aug</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dominica</td>
<td>May—Au/Se</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>St Kitts</td>
<td>Jul—Sep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Montserrat</td>
<td>May—Aug</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graham</td>
<td>St Lucia</td>
<td>May—Sep</td>
<td>Tendency to alternate bearing</td>
<td>400—500</td>
<td>round</td>
<td>susceptible</td>
<td>Smooth, good flavour with a slight taste of turpentine. Fibreless. Travels well. Green to yellowish in colour, developing a red sheen when exposed to the sun. Susceptible to fruit fly and weevil. Strong massive tree.</td>
</tr>
<tr>
<td></td>
<td>St Vincent</td>
<td>May—Aug</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grenada</td>
<td>Apr—Jul</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imperial</td>
<td>St Vincent</td>
<td>May—Aug</td>
<td></td>
<td>500—700</td>
<td>round</td>
<td>susceptible</td>
<td>Flavour is fair. Good colour develops when exposed to sunshine. Bruises easily. Large tree.</td>
</tr>
<tr>
<td>Mango</td>
<td>St Lucia</td>
<td>Apr—Oct</td>
<td>Alternate years</td>
<td>150—200</td>
<td>oblong</td>
<td>susceptible</td>
<td>Fibrous, poor quality. Large massive tree. Polyembryonic, commonly used for rootstock.</td>
</tr>
<tr>
<td>long</td>
<td>Dominica</td>
<td>Feb—Jul</td>
<td></td>
<td></td>
<td>cylindrical</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Montserrat</td>
<td>Jun—Sep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>St Kitts</td>
<td>May—Aug</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mango</td>
<td>Palai</td>
<td>May—Aug</td>
<td></td>
<td>200</td>
<td>round</td>
<td>highly</td>
<td>Fibrous, poor quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 3.2  Fruit characteristics of Julie and other mangoes in the wider Caribbean

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Av fruit wt (g)</th>
<th>Av seed wt (g)</th>
<th>Ratio flesh:seed</th>
<th>Soluble solids (%)</th>
<th>Fibre content</th>
<th>Colour when ripe</th>
<th>Suitability for Canning</th>
<th>Juice/pulp</th>
<th>Chutney</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphonso</td>
<td></td>
<td></td>
<td></td>
<td>low</td>
<td></td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Bombay</td>
<td></td>
<td></td>
<td></td>
<td>low/med</td>
<td></td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Buxton spice</td>
<td></td>
<td>med/high</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Calabash</td>
<td>236±9</td>
<td></td>
<td>18±0.5</td>
<td>low/med</td>
<td>green/yellow</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Ceylon</td>
<td></td>
<td></td>
<td></td>
<td>low/med</td>
<td></td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Doodooth</td>
<td>92±10</td>
<td>17±2</td>
<td>5.4:1</td>
<td>high</td>
<td>yellow+red blush</td>
<td></td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Graham</td>
<td>498±98</td>
<td>36±8</td>
<td>11.0:1</td>
<td>low</td>
<td>green/yellow</td>
<td>yellow+red blush</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Haden</td>
<td>486±27</td>
<td>44±6</td>
<td>11.0:1</td>
<td>low</td>
<td>yellow+red blush</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Julie</td>
<td>274±27</td>
<td>23±4</td>
<td>11.9:1</td>
<td>low</td>
<td>green/orange</td>
<td>yellow+red blush</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Kent</td>
<td></td>
<td></td>
<td></td>
<td>low</td>
<td></td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Long</td>
<td>209±28</td>
<td>40±4</td>
<td>5.2:1</td>
<td>high</td>
<td>green+yellow blush</td>
<td></td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Mayaro</td>
<td></td>
<td>med</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Rose</td>
<td>207±12</td>
<td></td>
<td>10.6±0.7</td>
<td>med/high</td>
<td>yellow/orange</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Sensation</td>
<td>266±24</td>
<td>31±5</td>
<td>8.6:1</td>
<td>low</td>
<td>yellow red blush</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Starch</td>
<td>130±23</td>
<td>37±2</td>
<td>3.5:1</td>
<td>low-high</td>
<td>yellow</td>
<td></td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Teen</td>
<td>114±13</td>
<td>23±2</td>
<td>5.0:1</td>
<td>med/high</td>
<td>pale green</td>
<td></td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Ten pound</td>
<td></td>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Tommy Atkins</td>
<td></td>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Zill</td>
<td>259±44</td>
<td>28±7</td>
<td>9.3:1</td>
<td>low</td>
<td>yellow/orange</td>
<td>yellow+red blush</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key:  Y = suitable; N = unsuitable
Propagation involves the grafting of Julie mango scions on to disease resistant rootstock (usually Long mango). This process involves a series of steps which are as follows:

**Rootstock selection**

There are many rootstock varieties in use around the world, some selected commercially or experimentally for different types of soil and climate. Rootstocks can either be monoembryonic or polyembryonic.

Mono-embryonic rootstocks are sometimes preferred because they grow faster, having more reserves at their disposal. These rootstocks are however much more heterogenous, therefore growers should use polyembryonic stock, which produce vigorous asexual seedlings.

Any variety which comes true from seed can be considered as being asexually produced and may be selected for use as a rootstock, if it is tolerant to soil borne diseases, is consistently a regular and heavy cropper, bears fruit with attractive skin colour and is very vigorous. The most common polyembryonic rootstocks used in the OECS and the wider Caribbean are the varieties Long and Rose.

**Preparation of rootstocks (seedlings)**

To produce rootstocks, collect seeds from the selected trees and allow to ripen. Remove seeds from ripe fruit, wash and air-dry the seeds for several hours. Place the seeds onto well-drained seed beds made of soil or preferably damp clean sawdust or in bins, for sprouting. (Alternatively, place the air-dried seed directly into the potting bag.)

When seedlings are at the 6 to 8 leaf stage, transplant the most vigorous seedlings into potting bags 20 cm wide by 30 cm high (8 x 12 in), containing a mixture of soil/sand/compost at a ratio of 2:1:1. The ratio varies depending on the clay and sand content of the soil. If the soil is clayey, add more sand until there is better tilth and drainage. If the soil is too sandy add more organic matter to improve the moisture retention and nutritive status of the mixture.

Place potting bags on a medium that is free draining in order to prevent waterlogging. During transplanting, clip the leaves in half to reduce transpiration. Place the seedlings under 55—60% shade netting, water daily if necessary and observe for pest and disease infestation. The seedlings remain under these conditions for about 3 to 4 months, to allow the stem to reach a diameter of about 6—8 mm (0.25—0.3 in). At this stage the seedlings are ready for grafting. Maintain the grafted plant in the same bag until planting out in the field.

**Scions**

Select scions from healthy growing plants, which have been in production for at least five years and demonstrated high productive traits. Take scion material from the penultimate flush (last season’s flush) of swelling terminal buds; trees should not be in the flowering stage.
Check rootstock diameters prior to cutting the scion material so as to select compatible (same size) material. After selection wrap the scion material in a moist cotton cloth or into some freshly cut clean grass so as to reduce transpiration (water loss).

Cut scion material in the early morning or late afternoon in order to minimize sap loss. Store material to be used the next day in the bottom compartment of the refrigerator.

**Grafting**

Begin grafting when the seedlings have attained stem thickness (diameter) of 6–8 mm (2.4–3.2 in), normally about 3–4 months after planting. This time will depend on the care and maintenance provided during the growth stage. Graft seedlings 12–15 cm (5–6 in) from the soil level, so as to reduce the incidence of soil borne diseases. The rootstock should be fully grown and free from anthracnose and mineral deficiencies.

A number of grafting techniques can be used, and the method selected will depend on the skill and preference of the operator, the size of the rootstock, and the age of the rootstock available. The two grafting techniques which are commonly practiced are terminal grafting (also known as crown or cleft grafting), and side or veneer grafting.

**Management of seedlings in the nursery**

Water seedlings daily, and apply foliar applications of fertilizer 2–3 weeks after bud-take to maintain sturdy plants. Keep the seedlings weed free at all times. Monitor plants regularly for signs of pest and disease, and spray with the appropriate fungicides, insecticides, and acaricides when necessary.

Unwrap the rootstock/scion union when the buds have caught and the new flushes have hardened. This takes approximately 3 weeks. Then fully harden the seedlings in direct sunlight for 2–3 weeks before distribution.

Seedlings should not spend more than about 6 months in the nursery. More time than this will lead to overgrown plants. The root system, with limited space to develop in the potting bag, will then become banded around in a ball, which in turn leads to poor tree establishment and nutrient uptake at transplanting.

**Transporting seedlings**

Transport seedlings in a flat bed truck, ensuring that they are properly supported to prevent toppling and also protected against wind generated by the movement of the vehicle. Seedlings not showing new growth, better tolerate the shock of transportation and transplanting.
5 Orchard establishment

Site Selection
Site selection is an important part of orchard development as it determines the method and cost of establishment, the method and cost of implementing management practices, the productivity of the orchard, the quality of the fruit, and the overall cost of production. In selecting a site, give priority to climatic factors more so than soil conditions.

The ideal site for Julie mango production should have the following characteristics:

Rainfall: Julie mango is best grown in areas with annual rainfall of 750–2,500 mm (30–100 in). However, rainfall distribution is more important than total precipitation. The most favourable distribution pattern for flowering and fruiting is one of marked wet and dry seasons. A dry season of 3–4 months averaging 50 mm (2 in) per month results in excellent flowering and fruit set. During the rest of the year an average of 150 mm (6 in) of rainfall per month is adequate.

At the lower end of the rainfall range (mostly in the Leewards) irrigation must be applied regularly to prevent water stress during early fruit development, when cell division is taking place, as well as to produce vegetative flushing after harvest. But changes in the rainfall distribution in recent years mean that high productivity cannot be achieved without irrigation, even in the Windwards.

Rainfall during flowering increases flower drop, prevents pollination by insects and promotes flower diseases such as anthracnose. High rainfall areas above 2,500 mm (100 in) should therefore be avoided. High rainfall can also promote vegetative growth at the expense of fruiting, causing yields to be low.

Humidity: Humidity between 70 to 80% is tolerable. High humidity (above 90%), mist and heavy dew increases anthracnose (fungal) attack and the need for regular spraying. When this occurs at flowering fruit set is reduced, which in turn affects overall yield. Julie mango should therefore be grown in drier, low rainfall areas (750–2,500 mm) which tend to have more suitable humidity levels.


Wind: Julie should be grown in sheltered areas in order to protect trees from heavy winds which cause flower and fruit drop and bruising of fruit. Do not plant orchards in areas where winds are strong and constant, as this impedes pollination and reduces fruit set. The constant rubbing of fruits on branches also causes fruit blemishes. Where this is likely to occur, wind breaks are required.

Since salt in the air damages young leaves and flowers, orchards should be established more than 1 mile from the coast.
**Soil types:** Julie mango thrives on a wide variety of soils, providing they are not too water logged, too alkaline or too rocky. Even shallow impervious soils produce healthy mango trees. However, Julie grows and produces best on deep, well drained, fertile soils. Soil structure and aeration are the most important factors to consider. A pH of 5.5–7.5 is preferred.

Soil should have a moderate water holding capacity. A ground water table at depths of 3–4 m (10–13 ft) is advantageous, as it allows the long tap root to access water in the dry season. On acid soils dolomitic lime should be applied to increase soil pH to a range of 5.5–7.5. Julie grown on very fertile soils in high rainfall areas may give rise to trees with heavy vegetative growth and poor yields. In highly alkaline soils deficiencies of iron and zinc appear.

**Altitude:** Julie mangoes are best grown at elevations from sea level to 150 m (500 ft) where rainfall, temperature, and humidity are more suitable for production. However, in the Windward Islands mangoes are often grown at altitudes of about 300 m (1,000 ft) thereby exposing the trees to high rainfall conditions.

**Slope:** In the Eastern Caribbean Julie mango is grown on a wide range of slopes. The steeper the land the more difficult it is to apply recommended crop management practices, e.g. spraying fungicides with a mist blower for control of anthracnose becomes more difficult and time consuming, sometimes even hazardous, in addition to which the effectiveness of the operation can also be reduced. All of the above can lead to lower yields, reduced labour productivity, and poor fruit quality.

Slopes of less than 5° are regarded as flat, 5–10° as gently sloping, 10–20° are moderately sloping, while 20–30° is steep.

**Land preparation**
The performance of an orchard begins at establishment, not when the trees begin to bear fruit. The type of land preparation will be dependent on the topography and the vegetation type. First, clear the area of all trees and brush. When clearing land, do not expose soil; as heavy rains will cause erosion. On flat land with heavy clay soils prone to water logging, ploughing should be practiced followed by the establishment of cambered beds for improved drainage. (Figure 5.1) The beds can be 6–8 m (20–26 ft) wide depending on the intended spacing of the trees.

If the land is sloping and cannot accommodate cambered beds and cannot be mechanized, build mounds (Figure 5.2). Establish beds and mounds at least one month before planting to allow the soil to settle. Restructure the mound if it loses its form. The longer that beds and mounds are prepared before planting, the longer they will maintain their form when exposed to the elements after planting; drainage and root aeration are also more efficient.

If the land is steep, cambered beds and mounds will not be practical. Plant directly into the slope, with the holes spaced more closely between the rows.

**Seedling characteristics**
Well-developed nursery-grown seedlings are essential for a successful orchard. A healthy Julie mango seedling has the following characteristics:

- Smooth and flush rootstock-scion union with no dry tissue
- Stems 10 mm (0.4 in) in circumference at 10 cm (4 in)
above the union
- Green foliage with a healthy appearance.
- Smooth bark (free of scars).
- Well developed root system with main root straight and unbanded (i.e. not curled upwards or banded around in a ball) at the base of the plant.
- Plant well established in bag (roots not emerging from the sides).
- Plant free from pests and diseases.
- Plant 1 m (3 ft) tall, with preferably 2 or 3 main branches.

The plant density selected normally depends on the following:
- Whether the farmer intends to do high density plantings, with the aim of thinning out at a later date, or plant at the normal density.
- Whether the farmer intends to intercrop the orchard.

- Agro-ecological factors - use closer spacings in dry conditions and in shallow soils. In fertile deep soils in higher rainfall areas use wider spacings as plants tend to develop more quickly.

Allow trees to reach a maximum manageable size of 5 m (16 ft) from ground level to the top of the canopy and a diameter of 5 m in order to obtain maximum yield. This will prevent unfavourable conditions such as overcrowding which creates an environment conducive to anthracnose, mechanical damage of fruit and reduced yield. Plant spacings should therefore be 8–12 m x 8–12 m (26–40 ft x 26–40 ft) on average for semi-dwarf varieties like Julie. The closer spacings are recommended for drier areas where trees tend to grow less vigorously.

These planting distances allow for an intercrop such as pineapple, which is low to the ground and does not compete
with the mango trees for light. This spacing prevents well managed orchards from overlapping before trees are 10–15 years old.

Since wide spacing results in low yields in the early stages of the crop, farmers may opt for high density plantings 4.5–5 m (15 ft) apart, and then remove alternate trees to prevent overcrowding (overlapping branches) as trees get older. The spaces thus created between the trees will also aid access and can be used for intercropping.

Planting patterns can be square, diamond, or rectangular. Square and rectangular patterns are best suited to flat land and diamond patterns to sloping land. On slopes or steep land, plant more closely to prevent erosion.

Planting holes should be a little bigger than the size of the potting bag and about 12 cm (5 in) deeper to accommodate fertilizer and pen manure placement at the bottom of the hole.

**Planting**
Incorporate in the hole about 91 (2 gal) of pen manure, and 0.5 kg (1 lb) of fertilizer, using a formulation based on soil requirements. If the pH is less than 5, also add 0.5 kg of lime. Cover these materials with about 5 cm (2 in) of soil before planting. The root system should be placed in the soil, no deeper than it was in the potting bag. Pack soil around the roots, wetting the soil as it is packed to avoid any air pockets. Cover the soil around the plant with a mulch of grass or other material to keep the soil surface moist and cool.

Plant at the beginning of the rainy season. Trees planted during this period have a longer time to become properly established, and stand a better chance of surviving the dry season.
6 Care of the young orchard

Like a baby, the better the care that young mango trees receive, the greater are their chances of a more productive future.

Pruning
Begin pruning when trees are about 60 cm (2 ft) so that the desirable tree height (dwarfing effect) and architecture (symmetrical dome with a sparse internal canopy) is obtained. Systematically thin out the central branches and top vigorously growing branches to facilitate a short and wide tree canopy with an open centre.

Promptly remove sprouts and suckers emerging below the main framework of branches. Remove dead wood resulting from insects, disease, or any other cause with sharp, clean pruning shears. Move dead wood well away from the young trees so as to avoid contamination and the development of pathogens on healthy tissue.

Remove all flowers and small fruit when the trees are less than 3 years old in order to encourage the growth of the tree. In year 3 reduce the number of fruits.

Young trees can be pruned throughout the year. However pruning is best done at the beginning of the rainy season, to allow for rapid stimulation of vegetative growth.

A young developing tree aged 1.5–2 yr should have the following dimensions:
- a trunk of no more than 60 cm (2 ft)
- 3–4 main branches no longer than 60 cm
- branches not growing from a similar junction.

Weed control
Keep the immediate vicinity of 1 m (3 ft) around the plant weed free. Use herbicides such as oxyfluorfen (Goal) at the rate of 160 g/L of water (1.5 lb/gal), paraquat (Gramoxone)

Figure 6.1 Desired shape of a young tree (2 years old)
at 2.5 L/ha (1.75 pints/ac) and glyphosate (Round-up) at the rate of 2 L/ha (1.7 pints/ac).

When Goal is applied, it is better to irrigate immediately afterwards, if it does not rain. This procedure increases the efficiency of the herbicide. Goal acts only on grasses, whereas Round-up acts on all weeds. All necessary precautions must be taken when applying herbicides.

The remainder of the orchard can be cut with a cutlass or a brush cutter, allowing the remainder of the orchard to have adequate ground cover thus reducing the risk of erosion.

Fertilizing
The total amount of fertilizer (NPK 16:8:24) applied in the first year should be approximately 0.7 kg (1.5 lb) per tree.

This quantity should be increased to 1 kg (2 lb) per tree per year as the tree gets bigger and requires more nutrients until full bearing begins (5 years). Preferably, applications should be split, i.e. Year 1, 60 g (2 oz) per tree per month; Years 2–5, 85 g (3 oz) per tree per month. Split applications reduce wastage caused by leaching and washing by heavy rains and allow for maximum use of the fertilizer by the plant.

These generalised recommendations are based on the nutrient requirements of mango, soil and leaf analyses of several farms, and the fertilizer which is generally available in the Eastern Caribbean.

Foliar sprays of NPK (23:7:23 or 20:20:20) in 1.5% solution plus 0.025% sticker (Agral), if applied monthly in addition to solid fertilizer, will result in a significant increase in the height and girth of the tree. (Agral enhances the spread and increases the rate of contact of the solution on the leaf.) The tree is drenched until dripping begins at the leaf edge.

Irrigation
Young trees require adequate amounts of water especially in dry areas. In areas where rainfall is below 2,500mm/yr (100 in) and irregularly distributed, proper tree establishment can take 3–4 years. During prolonged dry spells, loss of plants is common. Irrigation should therefore be an integral part of orchard establishment in drier locations. In areas where this is not possible use a mulch.

Two types of systems are recommended: drip and mini-sprinkler.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mini-sprinkler (litres (gal) /day/tree)</th>
<th>Drip (litres (gal) /day/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4–8 (1–2)</td>
<td>1–1.5 (0.25–0.5)</td>
</tr>
<tr>
<td>2</td>
<td>8–12 (2–3)</td>
<td>3–7 (0.8–1.8)</td>
</tr>
<tr>
<td>3</td>
<td>15–20 (4–5)</td>
<td>10–15 (2.5–4)</td>
</tr>
<tr>
<td>4</td>
<td>22–30 (6–8)</td>
<td>18–25 (4.5–6.5)</td>
</tr>
</tbody>
</table>

Notes to table
1. The figures are related to area with Pan Class A evaporation of 5–6 mm/day
2. Soil type – Medium texture, good percolation ability.
3. No rainfall is assumed, effective rainfall should be subtracted from irrigation water amount.
4. In heavy clay soil the smaller figure in the suggested range should be selected.
5. All figures should be used as a guideline only, local evaluations are necessary in order to make more precise recommendations.
Drip irrigation: The drippers are placed adjacent to the young plants. In the first year one dripper with flow rate of 2.3 or 3.8 L/hr (0.6 or 1 gal/hr) per tree is sufficient. After one year, a second dripper is added 1 m (3 ft) from the first one, and the other dripper line is shifted, so that tree location is in the middle of the two drippers. Another 1 to 2 drippers are added in years 3 to 4 along the dripper line 1 m (3 ft) apart from each other, on either side of the tree. (Figure 6.2)

Mini sprinklers: Since the root zone is small in the first year it is important to limit the water distribution to no more than 80 cm (30 in) diameter in the first year, in order to avoid water loss. Mini sprinklers with flow rates of 38 L/hr (10gal/hr) are sufficient for the first two years.

Figure 6.2 Configuration of drip irrigation

Frequency and quantity of water application
The question of when and how much water to apply to young mango trees, depends on the following factors: orchard canopy, soil type, climatic conditions, water salinity, and the type of irrigation system used.

It is not possible to provide firm recommendations regarding the frequency and quantity of water to be applied because of the numerous variables. However the following can be used as a guide: start from once a day and gradually reduce the frequency to once a week or more or as seems necessary. Water should be applied more, often when: (a) using drip irrigation (b) when soils are shallow or of a light sandy nature (c) when the orchard site is relative dry and/or windy, and (d) when the day length is longer.

Mulching
Where orchards are rainfed and water is not available for irrigation, mulching is a practical way to conserve moisture. Guinea grass is a suitable and readily available material used as a mulch in some Eastern Caribbean countries. It must be harvested before seeding occurs (to prevent the grass becoming established in the orchard), allowed to wilt and then placed about 7.5 cm (3 in) thick, in a 1 m (3 ft) radius around the plant.

Mulching not only conserves moisture, it prevents weed growth and adds organic matter to the soil, which in turn improves soil physical properties (bulk density, porosity and infiltration rate), stabilizes soil temperature, and promotes vigorous rooting on the soil surface under the mulch. It also prevents oxidation of fertilizers by the sun.
7 Care of the bearing orchard

Pruning
Pruning is a very important step in orchard management, as it helps the tree to maintain a good balance between growth and fruiting. If pruning is not carried out, humid conditions within the dense tree canopy are conducive to the development of fungal diseases, anthracnose in particular, as well as sooty mould. Also, management practices such as spraying for the control of fungal diseases become less efficient due to inadequate penetration of the sprays and coverage of the leaves.

Pruning increases sunlight penetration and free movement of air within the canopy which helps to improve fruit colour and reduce anthracnose levels respectively. It also helps to distribute nutrients among the bearing parts of the plant more effectively, ensuring that fruits are of an acceptable size and appearance for the overseas market. Furthermore it maintains tree height at a manageable level, thus making harvesting, disease and pest control, more efficient.

Prune after every main harvest, i.e. in the months of August and September each year. Severe pruning, also known as corrective, heavy or drastic pruning is used in orchards which have been unmanaged over prolonged periods. Corrective pruning involves removal of two to three large central branches, followed by the removal of a few branches all around the tree so as to thin out the canopy from the sides. This type of pruning is normally followed by the development of ‘water sprouts’ (young shoots which eventually grow up the centre and inner canopy of the tree). If left unpruned they turn into branches, creating a dense atmosphere in the inner canopy of the tree, preventing light penetration, air circulation and the penetration of pesticides.

Severe pruning will reduce yields at the following harvest and possibly at the subsequent harvest. Selective pruning is accomplished by thinning crowded foliage and lightening the centre of the tree. Tip pruning (‘tipping’), is a further form of pruning, although it is not a common practice in the Eastern Caribbean. It is used to control tree height and width and to stimulate flushing. It is accomplished by the removal of 20 cm (8 in) from the ends of the branches after harvesting has been completed. After 30-40 days new shoots, which will bear fruit the next season, should appear. Tip prune on alternate sides of the trees each season and particularly when branches from neighbouring trees are overlapping.

Routinely remove dead wood, weak branches, and low branches where fruit touch the ground.

Do not allow trees to overlap, as fruit which normally occur on the periphery of the canopy become prone to bruising and scarring, which in turn reduces quality. Thinning out of orchards is necessary when trees begin to overlap.

Systematically remove overlapping trees. Since several factors (loss of revenue, topography, plant density, and the
threat of erosion) will influence and be affected by thinning out, farmers are strongly recommended to consult with an extension officer. Conduct thinning over a number of bearing seasons in order to spread the initial negative effects on yield and income.

Pruning tips
- the pruner should have an image in his mind of the ideal form of the well-managed tree.
- it is better for two persons to prune a tree: one supervising from the ground level, where visibility with regards to branch selection is better, and the other doing the cutting.
- using a chain saw in the tree canopy requires special skill and is very dangerous, therefore such persons must be well trained.
- the pruner should take account of the growth patterns of individual trees while pruning
- when pruning a branch select, as the last bud on the branch, one that is already pointing in the direction you want the new twig to grow
- cut about 0.5 cm (0.25 in) above the remaining branch
- apply pruning seal, especially in high rainfall areas, to prevent the onset of fungal and other infections.

Equipment needed for pruning
- Chainsaw, medium size (1)
- Pruning saw: (2)
- Bow saw: (2)
- Secateur: (2)
- Step ladder: (2)
- Pruning seal

Smaller farmers, who cannot justify purchasing this equipment, should borrow or rent it in order to ensure that they have the correct equipment available for this important job.

Weed control
The immediately vicinity of the tree, i.e. under the canopy and the ‘drip circle’, should be weed free to allow for optimal fertilizer use. Goal and Round-up can be used to control weeds. Brush weeding or slashing with a cutlass is recommended for the remainder of the orchard in order to avoid erosion.

Fertilizing
Nitrogen and potassium have the greatest influence on tree growth and yield. Potassium improves fruit colour and flavour. If fertilizer is not applied, fruit become smaller, fruit quality and tree yields are also reduced. Nitrogen, Potassium, Magnesium and Zinc tend to be low on soils that are predominantly acid. Copper and zinc are needed in trace amounts and can be applied as foliar sprays.

Calcium Ammonium Nitrate is recommended at the rate of 4.5–7 kg/tree (10–15 lb) on the more acidic soils (as in north-east locations of Dominica). In some cases alternative applications of NPK (16.8.24) are recommended. However on acid soils, avoid heavy applications of NPK before fruit mature, as these tend to increase calcium deficiency. On selected, less-acid soils (as for example the West Coast of Dominica) NPK (16.8.24) plus 4 MgO is recommended.

Ideally, fertilizer recommendations should be based on soil and leaf analysis. In the Eastern Caribbean most Ministries of Agriculture can conduct analyses for the major elements - nitrogen, phosphorus, potassium, calcium, and
magnesium. But some micro-element analyses would have to be done in Barbados or Trinidad and Tobago.

Fertilizer application should be split, preferably on a weekly basis. If this is not possible because of time constraints, apply fertilizer bi-weekly or monthly. Split application of fertilizers prevents wastage through leaching, oxidation and/or washing. Apply fertilizer in the area of the canopy drip.

Half of the fertilizer application should take place in the period after the main pruning (September/October) up until one month before flowering. Apply the other half in the period after fruit set until two months before harvest.

The recommendations given above must be considered as a rough guide, and each grower on each farm must watch closely the results of fertilizer application on growth and fruiting. If growth and fruiting are satisfactory, then fertilizer treatments should be continued. If vegetative growth is excessive and cropping poor, then rates must be lowered or eliminated. If biennial cropping develops and persists, apply fertilizer in the on-year.

Fertigation
Soluble fertilizers can also be applied through the drip irrigation system described in the next section.

Irrigation
Most Julie mango orchards in the Eastern Caribbean are rainfed. In productive orchards, lack of water or even short periods of water stress may cause flower drop, poor fruit set or fruit drop. Dry periods after harvest has ended reduce the growth of new flushes which in turn reduces yields in the following year. Irrigation may be used as a means of breaking moisture stress and inducing flowering. It means that irrigation should be used where possible.

Selection of the irrigation system: In heavy and medium textured soils drip irrigation is preferred. Usually when tree rows are spaced 6 to 7.5 m (20 to 25 ft) apart, one drip line per row is enough. For light textured soils or soils with high infiltration rates such as sandy/gravel soils, mini-sprinklers are recommended. The objective is to wet at least 50% of the planted area.

In both systems, the irrigation rate should be increased in relation to the growth stage of the orchard. Orchards are considered mature when tree canopy covers 75% of the orchard area.

In order to make decisions on the irrigation intervals and the amount of irrigation water needed, essential meteorological and climatic data must be available. Such data is sometimes already available from local meteorological stations. Where data is not available, the water requirements of mango can be predicted by use of evaporation pans, and tensiometers.

The evaporation pan allows for calculation of the crop-coefficient, which is 0.4–0.5 for mango. The crop coefficient describes the relationship between the water requirements of the crop and the evaporation from a Class A pan. The amount of water to apply is calculated by multiplying the crop coefficient by the total evaporation during the irrigation cycle, less the amount of rainfall. Tensiometers measure the actual status of soil moisture in the root zone.

Irrigation frequency: Since mangoes are relatively tolerant to lack of water, it is possible to apply water on a weekly or 10
day interval and to adjust the amount of water to the accumulated evapotranspiration during the period from last irrigation cycle, minus any rainfall during this period. Generally, in light soil it is necessary to irrigate more frequently than in heavy soils due to the lower water holding capacity of light soils.

**Amount of water:**

a) **Class A Pan** – The amount of water can be calculated by multiplying the crop coefficient by the accumulated evaporation from the class A pan since the last irrigation cycle.

\[ Wr = EV \times C \]

Where:  
\( Wr \) = Irrigation water [mm]  
\( EV \) = Accumulated evaporation from pan [mm]  
\( C \) = Specific crop coefficient

b) **Tensiometers** – When the reading of the shallow tensiometer has reached a predetermined figure expressed in centibars, water should be applied. The amount of water should be calculated by using local experience.

The deepest tensiometer, is used to monitor access. When readings of the deepest tensiometer show increased water tension this mean that the roots are extracting water from this depth and the amount of water applied should be increased. If the opposite occurs, then the water is accumulating at this depth due to excess watering and the amount of irrigation water should be reduced.

**Irrigation Duration:** The duration of water application depends on the precipitation rate of the specific irrigation system and the amount of water required. It is possible to control the volume of the applied water by quantity or by time. It is more accurate to measure quantity rather than time. This can be done if the irrigation system is equipped with a volume valve.

**Flower induction**

Flower induction has recently been introduced as a means of enhancing off-season production, and obtaining higher prices on local and regional markets. Two chemicals are used to enhance flowering: Cultan (paclobutrazol), a growth retardant, and Potassium nitrate (KNO₃).

Cultan reduces shoot elongation and promotes flowering. It is applied as a soil drench. The rates are based on the age of the tree. Apply Cultan about 30 cm (1 ft) inside the canopy drip edge once every two years. More frequent application should be avoided in order to prevent a buildup in the soil which could cause stuntning of the tree, as the compound is not particularly soluble and has a long residual activity.

It should be applied during the fruit-bud stage or after the main harvest season, September/October. Flowering is induced 2–3 months after application and may increase as

**Table 7.1 Application rates for 'Cultan'**

<table>
<thead>
<tr>
<th>Tree size</th>
<th>Age</th>
<th>Application rate (ml/10 l [fl oz/gal])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>1–4</td>
<td>20–25 (0.25)</td>
</tr>
<tr>
<td>Medium</td>
<td>5–10</td>
<td>35–40 (0.4)</td>
</tr>
<tr>
<td>Large</td>
<td>&gt;10</td>
<td>50 (0.5)</td>
</tr>
</tbody>
</table>
much as six times the normal levels, leading to an increase in fruit production.

Potassium nitrate is applied by spraying onto the foliage of the tree with a mist blower at a rate of 4 or 6%. Apply until the canopy is completely wet and dripping at the leaf edges.

At flushing, use a rate of 4% and when there is no flushing, use a rate of 6%. Use a sticker, e.g., Bond.

Potassium nitrate induces a quicker flowering responses compared to Cultar, but flowering and fruit production are not significantly different.