Caribbean Pineapple Production and Post Harvest Manual

PROMOTING CARICOM/CARIFORUM FOOD SECURITY
(PROJECT GTFS/RLA/141/ITA)

(FAO Trust Fund for Food Security and Food Safety – Government of Italy Contribution)

Written by

Gregory Robin, Ronald Pilgrim, Sharon Jones and Dorian Etienne

Published by

Food and Agriculture Organization of the United Nations (FAO)
Caribbean Agricultural Research and Development Institute (CARDI)

2011
Acknowledgements

Consultant technical writers:
Gregory Robin CARDI, St Vincent; Technical Coordinator, OECS
Ronald Pilgrim CARDI, St Lucia
Sharon Jones CARDI, Dominica
Dorian Etienne CARDI, Dominica

Consultant technical reviewer:
Bruce Lauckner

Consultant graphic design and layout:
Cheringdell Depradine

This manual is a revision and reprint of the publication, entitled “A Guide for Sustainable Production of Export Grade Pineapple in Dominica”. Written by Gregory Robin, Ronald Pilgrim and Mervyn St Luce for the Nature Island Pineapple Producers Association, NIPPA of Dominica and published in 2008 by CARDI and NIPPA. The revision and reprint was supported by FAO and the Italian funded Promoting CARICOM/CARIFORUM Food Security Project (GTFS/RLA/141/ITA).

Disclaimer

“The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations, or of CARDI concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO, or CARDI in preference to others of a similar nature that are not mentioned. The views expressed herein are those of the authors and do not necessarily represent those of FAO, or CARDI”.

All rights reserved. FAO encourages reproduction and dissemination of material in this information product. Non-commercial uses will be authorized free of charge upon request. Reproduction for resale or other commercial purposes, including educational purposes, may incur fees. Applications for permission to reproduce or disseminate FAO copyright materials, and all other queries on rights and licences, should be addressed by email to copyright@fao.org or to the Chief, Publishing Policy and Support Branch, Office of Knowledge Exchange, Research and Extension, FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy.

© FAO and CARDI, 2011

CARDI PSC #: DO/002/11


Front Cover - Collage of two photographs

1. Pineapples offered for sale. Source - CARDI

2. Pineapples growing in field with black plastic mulch. Source - CARDI
**Table of Contents**

PREFACE 5

INTRODUCTION 7

PART 1 – GENERAL INFORMATION FOR MAKING APPROPRIATE MARKETING AND PRODUCTION DECISIONS 8

Marketing 9

Description of the plant and fruit 9

Commercial varieties 10

Highlights of CARDI’s research on varietal characteristics 14

Ecological adaptations, soil and climatic requirements and site selection 18

PART 2 – PRODUCTION: GROWING AND HARVESTING A HEALTHY PRODUCTIVE CROP OF PINEAPPLES 19

Features of a sustainable pineapple production system 20

Land preparation 22

Planting materials: types, selection and preparation for planting 24

Crop establishment 27

Fertiliser use and application 28

Weed control 29

Major pests and management options 32

Major diseases and management options 35

Artificial flower induction 37

Harvesting, in-field handling and transport 38
PART 3 – POST HARVEST

Post harvest handling

On – farm handling and transport

Final preparation of the fruit

Managing post harvest loss

PART 4 – PRODUCTIVITY

Yields

Price cost margins

FURTHER READING

APPENDIX 1: Cost of production (EC$) of 1 ha of pineapple in Dominica. Gross margin projections

APPENDIX 2: Conversion factors for metric and imperial units
This manual describes the best practices in all aspects of commercial pineapple production and post-harvest handling, utilising materials, technologies and support services that are generally available to the Caribbean farmer. The manual incorporates the principles of Good Agricultural Practices (GAP) for the production and delivery of pineapple to consumers as a safe, wholesome commodity.

This manual is a revision and reprint of the 2008 publication, “A Guide for Sustainable Production of Export Grade Pineapple in Dominica” written by Gregory Robin, Ronald Pilgrim and Mervyn St Luce for the Nature Island Pineapple Producers Association (NIPPA) of Dominica. The format and arrangement of this manual closely follows that of the original manuscript but the information has been revised to be applicable to the wider Caribbean. The content of this revision is divided into four main parts. Part 1 gives key information for choosing an appropriate marketing strategy based on the quality demands of the various marketing outlets, selecting the most suitable varieties to meet those demands and indicates the agronomic requirements of the crop so that an appropriate cropping system may be designed. Part 2 describes in detail the required crop management programmes to grow and harvest a productive crop of pineapples. Part 3 which deals with post harvest aspects explains the on-farm and off farm handling and post harvest practices that ensure that the pineapples reach the buyer in the best possible condition. Part 4 gives information on yields and productivity and includes an example of a price cost analysis for 1 ha of pineapple. Additionally, country specific information relevant to the production and post-harvest aspects of pineapples in Dominica is included in the sleeve of the manual.
INTRODUCTION

The commercial pineapple is the fleshy fruit produced by some varieties of the plant *Ananas comosus* (L.) Merr. which is a tropical member of the plant family, Bromeliaceae.

The first record of pineapples by Europeans was given by Columbus in a letter to a friend where he describes a fruit that he and his men tasted on the island of Guadeloupe in 1493 on his second voyage to the Americas, that was “in the shape of a pine cone, twice as big...is excellent and seems to be wholesome”. At the time of its ‘discovery’ by Columbus the pineapple was already a widely distributed domesticated plant throughout most of tropical South America and the West Indies as a result of being carried from its place of origin in southern Brazil by the region’s indigenous Guarani tribes on their subsequent migrations. However, following its introduction to Europe by Columbus and other early explorers, the cultivation of pineapples spread rapidly throughout the world to many tropical and subtropical regions, during the 16th and 17th centuries, due to the widespread appeal of the fruit and its associated symbolism of hospitality and wealth. Since the end of the 17th century and continuing today, the plant has been the subject of many research programmes to develop improved germplasm to address several production challenges and meet changing market demands.

Originally, pineapples were eaten only as a fresh fruit. With the development of the processing industry, the fruit is now prepared, canned and consumed in various forms such as pineapple chunks, slices, juices, syrups, jams, marmalade, crushed and dried pineapple. Pineapples are also used in cereals and as a snack food. Pineapple fruits are a good source of dietary fiber, vitamin A, vitamin B₁, vitamin B₆, copper and manganese. Wine can also be made from pineapples. Fresh pineapple and fresh pineapple juice contain a protein-digesting enzyme, bromelain, which can be used as a meat tenderiser. In the Philippines and Taiwan, the leaves of a particular cultivar are longer than normal and yield 2 - 3% of a strong white silky fibre, which is used for making a fine fabric called piña cloth.

Pineapples are an important non-traditional crop in the Caribbean where the increased commercialisation of local production is often featured in diversification programmes. In the Caribbean pineapples are widely grown in an extremely diverse range of production systems, from collection of wild types and small scale pure stand and integrated systems based on the local and highly adapted varieties to the intensive production systems utilising improved selections.
PART 1 – GENERAL INFORMATION FOR MAKING APPROPRIATE MARKETING AND PRODUCTION DECISIONS
**Marketing**

Trade in Caribbean grown pineapples is dominated by the Dominican Republic which exports the fresh fruit via air freight to the United States. In the English speaking Caribbean there is some inter regional trade (led by exports from Guyana mainly to Barbados) but this burgeoning sector was severely restricted in attempts to stop the spread of mealy bugs, gummosis and bacterial wilt. However, there is a thriving domestic market for locally grown pineapples in all the islands as the fruits are always in high demand, being a fresh fruit favourite with Caribbean consumers. Regionally, pineapple is also used in the production of processed products with products such as juices, blended juices, jams and jellies made for local trade and home use. Canned pineapple products are however, usually imported into the region.

**Marketing channels**

The common marketing channels for domestically grown pineapples are roadside stalls which may be permanent or seasonal, local markets, supermarkets and the hospitality industry (mainly hotels and guesthouses).

**Minimum quality standards for export**

To stimulate consumer appeal and to sustain marketability, the following standards have been adopted by the various marketing boards and producer organisations of the region as minimum quality criteria for pineapple:

- Mature, firm and well formed.
- Free of surface debris and stains.
- Have no wounds, scratches, punctures or bruises.
- Have no scars or residues from insecticides and other sprayed chemicals.
- Free of soft rots or surface moulds.
- Comply with individual market specifications with regard to size of the crown and ratio of crown to fruit length.

Another common requirement for the export of pineapples is grading according to weight. The average weight of fruit for export should be 1.4 - 2.3 kg. The export standards for grading according to weight are:

- Large is considered to be greater than 1.6 kg.
- Medium, 1.2 - 1.6 kg.
- Small, less than 1.2 kg.

**Description of the plant and fruit**

The pineapple plant is a herbaceous, short-lived perennial, monocot\(^1\), 0.8 - 1.5 m high, with a spread of 1 – 1.5 m. The plant forms a rosette\(^2\).

---

\(^1\) A monocot or more accurately a monocotyledon plant is a flowering plant in which the embryo has one cotyledon or food storage seed leaf. In monocots, the true leaves that later develop typically have parallel veins.

\(^2\) A rosette describes the form of a plant where the leaves emerge in a tight circle or spiral from a short stem, resembling the arrangement found in the petals of a rose.
of waxy leaves which are usually long and sword like generally bearing short sharp spines (or prickles) along the leaf margins and a needle shaped spine at the end. The leaves may be all green, or striped with red, yellow or ivory down the middle or near the margin.

The stem is short and thick, usually 20 – 25 cm long, with a diameter of 2 – 3.5 cm at the base, broadening to 5.5 – 6.5 cm near the apex with short internodes. The stems from plants grown from shoots and slips are curved at the base while those grown from crowns are straight. Vegetative branches, called suckers, may arise from the stem below the soil and are usually more slender with longer leaves than the shoots.

The plant has a shallow and limited root system. A seedling produces a primary root which soon disappears and is replaced by adventitious roots.

The flower, or more accurately the inflorescence\(^3\), which eventually forms the fruit, consists of 100 to 200 individual bluish flowers. Each flower sits in the axil of a bract\(^4\) and secretes nectar. In most cultivars, both pollen and ovules of each flower are functional but set no seed unless cross-pollinated. Fruits of compatible strains may contain up to 3000 very hard seeds. Usually, five to ten flowers open every day from the base up, over a period of 10 – 20 days. In the Caribbean and other parts of the New World the natural pollinators are hummingbirds.

The fruit is described as a syncarp or compound fruit formed by fusion of individual parthenocarpic\(^5\) fruitlets\(^6\) with the fleshy bracts of the central stalk of the inflorescence. The flesh of the fruit at maturity is both juicy and fleshy and, depending on the variety, nearly white to rich yellow in colour. During fruit development the peduncle or fruit stalk continues to grow through the fruit beyond where the flowers are attached (forming the core of the fruit) before emerging at the top as a tuft of small leaves, known as the crown.

**COMMERCIAL VARIETIES**

The varieties produced commercially in the region are generally original and improved selections of Smooth Cayenne, Red Spanish and Abacaxi types. Commonly seen are Smooth Cayenne which is widely grown in the region, the Montserrat which is the principal type produced in Guyana, two introductions from Taiwan bred specifically for the fresh fruit market, namely Tainung\(^7\) No. 4 (T#4) and Tainung No. 11 (T#11) and the varieties Red Spanish, Abacaxi, Sugar Loaf and Antigua.

---

\(^3\) An inflorescence describes a flowering structure that consists of multiple flowers. There are various kinds of inflorescences which are named according to the different shapes formed by the flowers.

\(^4\) A bract is a modified leaf usually forming a protective structure for a flower.

\(^5\) Parthenocarpic describes the ability of a plant to develop fruit without the ovules in the ovaries being fertilised.

\(^6\) A fruitlet represents one ovary in a compound fruit.

\(^7\) The names Taiwan No. 4 and Taiwan No. 11 may also be seen; ‘tainung’ translates to ‘taiwan variety’.
Black. Smooth Cayenne is an all purpose variety, that of all the aforementioned types, is most suitable for canning. T#4 and T#11 have excellent eating qualities and ship well and Red Spanish, Abacaxi, Sugar Loaf and Antigua Black are popular local adaptations suited for the fresh market trade. The grower should consider the site specific market preferences against the varietal characteristics of the germplasm when selecting the variety to produce. The varietal characteristics of the main varieties are outlined below:

**Smooth Cayenne**

The Smooth Cayenne (Plate 1) is suitable for fresh fruit and for canning having sufficient fibre for firm slices and cubes as well as excellent flavour. It was selected and cultivated by Indians in Venezuela long ago and introduced from Cayenne (French Guyana) in 1820. The margins of the leaves are free from spines (prickles) but there is a sharp spine (needle) at the leaf tip. The fruit has a cylindrical form with an average weight of 2 kg, shallow ‘eyes’ meaning that the ‘seeds’ are close to the rind, and an orange rind and juicy yellow flesh at full maturity. The flesh has a rich, mildly acid flavour. Smooth Cayenne is not the most suitable cultivar for export, because it has a relatively short shelf life and is susceptible to numerous pests and post-harvest diseases.

**Tainung No. 4**

The Tainung No. 4 pineapple (T#4) (Plate 2) is goblet in shape and has a small crown with spines. Average fruit weight is 1.1 – 1.6 kg. The flesh of the fruit is dense, with little fibre, very sweet (19.5° Brix) with a unique flavour but not juicy. The fruit is best harvested when turning to quarter ripe\(^8\) at which stage it transports well and has a shelf life of 2 – 3 weeks. The T#4 is hardy and seems more resistant to disease than the Smooth Cayenne. The plant is small, produces many suckers and side shoots and the leaves have spines.

**Tainung No. 11**

The Tainung No. 11 pineapple (T#11) is goblet in shape with a small crown and produces many suckers (Plate 3). The average fruit weight is 1.4 – 1.8 kg. The fruit is medium sweet (15.1° Brix) and juices well. The plant is medium sized with erect leaves that are spineless. Like the T#4, the TN#11 seems more resistant to disease than the Smooth Cayenne. The fruits have a long shelf life (of 2 - 3 weeks) when harvested at the quarter ripe stage.

**Red Spanish**

The Red Spanish (Plate 4) is extensively grown in the Caribbean and is used mainly in the fresh fruit trade. It can also be canned. The fruit is more or less round, orange-red externally with deep eyes, weight ranges are from 1.4 – 2.7 kg.

\(^8\) The quarter ripe stage is when 25% of the ‘eyes’ at the bottom of the fruit change from a green colour to a paler green colour.
The crown is 20 – 25 cm in length with long spiny curved leaves. The flesh is pale-yellow, fibrous, with a large core, aromatic and tasty. The fruit is hard when mature, breaks off easily and cleanly at the base during harvest and withstands handling and shipping well. The Red Spanish shows some resistance to pests and diseases, particularly mealy bug wilt. The variety is highly resistant to fruit rot, though susceptible to gummosis.

**Abacaxi**

The Abacaxi (Plate 5) cultivar is well known in Brazil, the Bahamas and Florida. The leaves are long, bluish-green with spiny margins. The plant produces numerous suckers which need thinning out. The fruit weighs on average 1.5 kg. The flesh has very small fibers, is pale yellow in colour, succulent and juicy, with a sweet flavor. The core is very narrow. It is too tender for commercial handling and it is not a good shipper unless harvested half ripe. It is resistant to heart and root rot.

**Sugar Loaf**

The Sugar Loaf (Plate 6) cultivar is closely related to Abacaxi. The leaves have serrated spiny margins and pull out easily from the plant and crowns. The fruit has an oblong shape, is dark green when mature but turns bright yellow with a strong aroma when fully ripe. The flesh is white to yellow, very sweet and juicy. The fruit averages about 2 kg in weight. This is a delicate variety, with a very short shelf-life; therefore it does not ship well.

**Antigua Black**

This variety is very popular in the Caribbean. It is hardy, and the fruits are suitable for canning. It is a spined variety. The Antigua Black pineapple (Plate 7) is conical in shape and major portion of the skin is a dark green colour when ripe. The flesh colour is golden yellow and it is juicy and sweet with a crisp texture and low acidity.
Plate 4: Red Spanish
(Source – http://botany.csdl.tamu.edu)

Plate 5: Abacaxi
(Source – http://robpacker.wordpress.com/2011/05/17/abacaxi-pineapple-pina/)

Plate 6: Sugar Loaf, mature green
(Source - http://www.amazon.com/Sugarloaf-Pineapple-Plant-Ananas-Indoors/dp/B000PC2092)

Plate 7: Antigua Black
Montserrat

This hardy variety has long stiff leaves with spines along the margins. The fruit is a conical in shape with flavourful, sweet, pale flesh and small pointed eyes. The average weight of the fruit is 1.5 – 3.0 kg. This is the principal variety grown in pure stand in Guyana.

Mausica and Tableland hybrids

These are cultivars from Trinidad where they are commercially grown, albeit in smaller quantities than Smooth Cayenne. As the two are very similar in plant structure, fruit shape and rind colour (with the Mausica being slightly larger and sweeter), a description of Mausica alone should suffice to gauge suitability for selection.

The Mausica pineapple is borne on a plant that is 87 – 90 cm in height with a relatively open rosette. The leaves are spineless for the most part except for a small group of spines near the tip. The fruit is conical in shape, weighs around 1.65 kg and is the rind is dark green before ripening to yellow. The internal flesh is whitish-yellow (yellow in Tableland hybrid), sweet 17.6° Brix), soft and juicy in texture with a core diameter of 1.4 cm.

Highlights of CARDI’s research on varietal characteristics

CARDI carried out research trials in Dominica in 2004 – 2007 aimed at identifying the effects of location, time of planting and cultivar on productivity (yield) and fruit quality (° Brix). This was to address the challenges faced by growers and producer organisations to produce a consistent supply of quality pineapples to service contractual marketing arrangements. Factorial experiments were conducted in three different locations (Grand Bay, Soufriere and Layou Park) where pineapples are predominantly grown, using four times of planting (August 2004, November 2004, February 2005, and May 2005) and three market tested cultivars (Smooth Cayenne, T#4 and T#11), to examine the effects of these factors on productivity and fruit quality, over a period of 3 years. The investigations focused on: 1) the impact of location on the yield of a cultivar 2) the impact of location and time of planting on the yield of a cultivar 3) the impact of location on days to maturity of a cultivar 4) the impact of location and time of planting on days to maturity of a cultivar 5) the impact of location on the sweetness of a cultivar. The data collected were: fruit weight, Brix, crown length and number of days to maturity.

Results showed that productivity and time to maturity of pineapple cultivars (Smooth Cayenne, T#4, T#11) grown in Dominica varies across agro-ecological zones. It was observed that the yields of Smooth Cayenne varied with location but this response was not observed in T#4 and T#11. Within each location, planting date had no effect on yield. Brix was shown to be a biochemical characteristic of the cultivar and was neither affected by location nor planting date. Additionally, across all locations, pineapples planted in the January/
February period took significantly less time to reach maturity than at the other planting dates; but within each location, planting date had no effect on the yield (see Tables 1 – 5). Table 6 displays a description of the climatic and agro-ecological parameters within the zones investigated.

The results indicate that critical productivity and quality indices of a cultivar can best be manipulated with the choice of location and time of planting. These findings are of great importance to commercial producers and exporters of pineapple, as it indicates the type of data that producers, extension and marketing agents must collect in order to make meaningful projections to support marketing and export arrangements. Additionally differences in fruit quality may also allow the commercial exploitation of differences in taste and other quality characteristics.
### Table 1: Effects of location and cultivar on fruit weight (kg)

<table>
<thead>
<tr>
<th>Location</th>
<th>Cultivar</th>
<th>T# 11</th>
<th>T# 4</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth Cayenne</td>
<td>1.9</td>
<td>1.3</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Layou Park</td>
<td>1.4</td>
<td>1.4</td>
<td>0.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Soufriere</td>
<td>1.9</td>
<td>1.1</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Overall</td>
<td>1.7</td>
<td>1.3</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

FPr: Overall location means ≤ 0.05, Overall cultivar means ≤ 0.001, Location*Cultivar means ≤ 0.01

### Table 2: Effects of location and time of planting on fruit weight (kg)

<table>
<thead>
<tr>
<th>Location</th>
<th>Planting Date</th>
<th>Aug 2004</th>
<th>Nov 2004</th>
<th>Feb 2005</th>
<th>May 2005</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Bay</td>
<td></td>
<td>1.3</td>
<td>1.5</td>
<td>1.5</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Layou Park</td>
<td></td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Soufriere</td>
<td></td>
<td>1.6</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td>1.4</td>
<td>1.3</td>
<td>1.3</td>
<td>1.4</td>
<td>1.4</td>
</tr>
</tbody>
</table>

FPr: Overall location means ≤ 0.05, Overall planting date means ≥ 0.05, Location*Cultivar means ≤ 0.05

### Table 3: Effects of location on cultivar on days to maturity

<table>
<thead>
<tr>
<th>Location</th>
<th>Cultivar</th>
<th>Smooth Cayenne</th>
<th>T# 11</th>
<th>T# 4</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Bay</td>
<td></td>
<td>394</td>
<td>413</td>
<td>374</td>
<td>394</td>
</tr>
<tr>
<td>Layou Park</td>
<td></td>
<td>471</td>
<td>459</td>
<td>414</td>
<td>448</td>
</tr>
<tr>
<td>Soufriere</td>
<td></td>
<td>411</td>
<td>407</td>
<td>385</td>
<td>401</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td>430</td>
<td>432</td>
<td>393</td>
<td></td>
</tr>
</tbody>
</table>

FPr: Overall location means ≤ 0.001, Overall cultivar means ≤ 0.001, Location*Cultivar means ≤ 0.001
Table 4: The effects of location and time of planting on days to maturity

<table>
<thead>
<tr>
<th>Location</th>
<th>Planting Date</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Bay</td>
<td>386</td>
<td>401</td>
<td>403</td>
<td>385</td>
<td>394</td>
<td></td>
</tr>
<tr>
<td>Layou Park</td>
<td>441</td>
<td>441</td>
<td>404</td>
<td>506</td>
<td>448</td>
<td></td>
</tr>
<tr>
<td>Soufriere</td>
<td>410</td>
<td>377</td>
<td>390</td>
<td>425</td>
<td>401</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>413</td>
<td>415</td>
<td>402</td>
<td>443</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FPr: Overall location means ≤ 0.001, Overall planting date means ≤ 0.001, Location*Planting date means ≤ 0.001

Table 5: The effect of location and cultivar on fruit Brix

<table>
<thead>
<tr>
<th>Location</th>
<th>Smooth Cayenne</th>
<th>T# 11</th>
<th>T# 4</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Bay</td>
<td>13.92</td>
<td>13.02</td>
<td>13.48</td>
<td>13.47</td>
</tr>
<tr>
<td>Layou Park</td>
<td>13.28</td>
<td>12.83</td>
<td>14.91</td>
<td>13.67</td>
</tr>
<tr>
<td>Soufriere</td>
<td>14.73</td>
<td>12.43</td>
<td>14.28</td>
<td>13.81</td>
</tr>
<tr>
<td>Overall</td>
<td>13.76</td>
<td>12.86</td>
<td>14.21</td>
<td></td>
</tr>
</tbody>
</table>

FPr: Overall location means ≥ 0.05, Overall cultivar means ≤ 0.01, Location*Cultivar means ≤ 0.05

Table 6: Climatic and agroecological parameters within the zones investigated

<table>
<thead>
<tr>
<th>Agro ecological characteristics</th>
<th>Location</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average annual rainfall</td>
<td>Soufriere</td>
<td>Grand Bay</td>
<td>Layou Park</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1250 mm</td>
<td>2400 mm</td>
<td>3700 mm</td>
<td></td>
</tr>
<tr>
<td>Rainfall pattern</td>
<td>Marked dry season – Jan. to May</td>
<td>Dry season – Jan. to May</td>
<td>Wet zone without a pronounced dry season</td>
<td></td>
</tr>
<tr>
<td>Moisture regimes</td>
<td>Ustic: Dry for more than 90 cumulative days in a year, but less than 100 – 120 mm in 90 consecutive days</td>
<td>Ustic: Dry for more than 90 cumulative days in a year, but less than 180 mm in 90 consecutive days</td>
<td>Udic: Dry for less than 90 cumulative days in the year</td>
<td></td>
</tr>
<tr>
<td>Moisture supplying capacity</td>
<td>Very low</td>
<td>Low to very low</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>25 °C</td>
<td>27 °C</td>
<td>15 – 22°C</td>
<td></td>
</tr>
<tr>
<td>Altitude</td>
<td>76 m</td>
<td>152 m</td>
<td>228 m</td>
<td></td>
</tr>
<tr>
<td>Natural vegetation</td>
<td>Dry scrub</td>
<td>Dry scrub</td>
<td>Tropical moist forest</td>
<td></td>
</tr>
<tr>
<td>Vegetation</td>
<td>Predominantly cultivated</td>
<td>Predominantly cultivated</td>
<td>Predominantly cultivated</td>
<td></td>
</tr>
<tr>
<td>Soil types</td>
<td>Smectoids, kandoids, latosolics and alluvium</td>
<td>Smectoids, kandoids, latosolics and young soils</td>
<td>Smectoids, latosolics, alophonic latosolics and young soils</td>
<td></td>
</tr>
<tr>
<td>Mean annual soil temperature</td>
<td>&gt; 25 °C</td>
<td>&gt;26 °C</td>
<td>15 – 22 °C</td>
<td></td>
</tr>
</tbody>
</table>
**ECOLOGICAL ADAPTATIONS, SOIL AND CLIMATIC REQUIREMENTS AND SITE SELECTION**

**Ecological adaptations**

The centre of origin of the pineapple is probably in the Parana-Paraguay river drainage area in south Brazil where wild related species occur. The pineapple is therefore a tropical or near tropical plant limited (except in protected locations and greenhouses) to low elevations between 30° N and 25° S. A temperature range of 18 – 32° C is most favourable, though the plant can tolerate cool nights for short periods. Altitude has an important effect on the flavour of the fruit and increased altitude increases fruit acidity. The species is drought tolerant and has several features of adaptation to water stress, including waxy leaves to reduce water loss and leaves positioned on the plant in a way that channels water towards water absorbing tissues at the centre of the whorl. Depending on the cultivar and atmospheric humidity, these drought tolerant features allow pineapples to be grown in areas receiving a yearly precipitation as low as 635 mm.

**Soil and climatic requirements**

The best soil for pineapple cultivation is a well-drained, sandy loam with high organic matter content. Soils should be friable to a depth of at least 60 cm and have a pH range of 4.5 - 6.5. Soils high in calcium and manganese tend to cause chlorosis in leaves. Pineapple cannot tolerate water-logging, therefore, where the subsoil is impervious, drainage must be improved.

Pineapples can be grown within a wide rainfall range i.e. from 635 – 2500 mm per year, but the optimum annual precipitation for commercial production is 1000 – 1500 mm.

**Site selection**

Apart from satisfying agronomic requirements for site selection, the land use history of the proposed site needs to be considered from a food safety standpoint. The risk of contamination of the pineapples and worker’s health from such hazards such as toxic chemicals, microbial pathogens, garbage, decomposing organic matter and human faeces should be minimal. It is recommended that before planting, a soil sample be taken and subjected to microbial analysis. Close attention should be paid to the risk of contamination of the pineapples by pathogenic organisms from the run-off from animal pens close to the cultivation site; it may be necessary to create physical barriers or deviate washings from the pens away from the plot. If the area is prone to heavy flooding it should also be avoided because this increases the incidence of root rots and may also pose a risk of contamination.
PART 2 – PRODUCTION: GROWING AND HARVESTING A HEALTHY PRODUCTIVE CROP OF PINEAPPLES
**Features of a Sustainable Pineapple Production System**

Sustainable pineapple production is based on the continuous supply of mature / ripe fruits for a prearranged export or domestic market. To achieve this, an effective and efficient farm management system must be implemented and maintained. The features of such a system include:

- **Staggered plantings for crop establishment** where plots are planted at different dates. This will ensure a continuous supply of fruits since there will be plots at different stages of maturity. The frequency of the stagger is also very important and is dependent on established acreages or potential acreages and the market demand. The aim is to achieve the required numbers of pineapple at each scheduled harvest to fulfil contractual obligations.

- **Crop established by uniform size and type** of planting material. Sizing and selection of uniform planting material by cultivar is also very important in ensuring that there is uniform flowering. Planting material of different cultivars should be kept separate at harvest, during propagation and at planting. Planting material of different cultivars, types and sizes should not be placed in the same row, plot or location because they do not have the same characteristics of growth and flowering. This increases the level of crop management required. Inconsistent fruit set, fruit size and fruit maturity is the result of the use of inconsistent size of planting material, as plants will not grow at the same rate i.e. weaker or smaller plants grow at a slower rate compared to bigger, stronger plants. This phenomenon makes forecasting difficult and in turn affects marketing arrangements.

- **Flower induction practices appropriate to the geographical location of the farm** so that uniform flowering and fruit maturity can be attained.

- **A comprehensive pest management programme** inclusive of cultural techniques.

- **The inputs used should satisfy the requirements of Good Agricultural Practices (GAP).** Producers should therefore ensure that the pesticides used are registered and recommended by the local Pesticide Board.

- **A high level of skill in crop management** and in identifying the different stages of fruiting and maturity.

- **Keeping comprehensive records on all aspects of farm management.** Various recording systems could be developed and maintained but should include a record of daily operations. Table 7 below gives examples of the types of records that should be kept to facilitate key management decisions.
Table 7: Examples of records that assist in farm management

<table>
<thead>
<tr>
<th>Management aspect</th>
<th>Examples of records required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning of the various field operations</td>
<td>Contractual arrangements with regard to times and required amounts of pineapples and cultivars preferred; crop management and performance records of the previous cropping cycle and previous performance of proposed cultivar; field history sheets.</td>
</tr>
<tr>
<td>Calculate cost of production</td>
<td>Type and cost of all production inputs; rates and application frequency of all production inputs (activity logs); operational expenses per cropping cycle; pro rated fixed asset costs per cropping cycle; harvest records; storage records; sales records.</td>
</tr>
<tr>
<td>Make accurate yield and harvest projections</td>
<td>Number of plants per field; cultivar used; type of planting material; date of planting; date of flower induction; weather data.</td>
</tr>
<tr>
<td>Ensure market and contractual arrangements are fulfilled</td>
<td>Contract documents; request for change orders; harvest records; storage records/inventory; sales records.</td>
</tr>
<tr>
<td>Ensure food safety for the consumer</td>
<td>Pesticide application log; soil and water tests.</td>
</tr>
<tr>
<td>Conduct worker safety and training exercises</td>
<td>Date and topic of training sessions; participant list/attendance sheet; date of hiring of employees; proposed job description of each worker; documented protocol of worker tasks; daily assignment sheet.</td>
</tr>
<tr>
<td>To know when to calibrate and carry out performance checks on equipment</td>
<td>Type and model of equipment; frequency of use; date of last equipment check.</td>
</tr>
<tr>
<td>To monitor pesticide use for residue analysis</td>
<td>Date, rate and number of applications of each pesticide; date and results of last pesticide analysis tests.</td>
</tr>
</tbody>
</table>


**Land Preparation**

Land preparation describes the methods utilised to prepare the soil to receive the plant and support crop growth and required crop care practices throughout the entire cropping cycle. Land preparation typically involves the removal of weeds and crop residues followed by varying forms of tillage which serve to aerate the top layers of the soil, incorporate and distribute pre plant fertilisers and or organic manures, disrupt weed and pest cycles and bring the soil structure into a good condition to support plant growth.

Land preparation can either be done manually or mechanically. Manual land preparation is required on slopes or small plots, where it is not cost effective to mechanise. Mechanical preparation is done on large, gently sloping, or flat areas. In manual land preparation, hand tools such as forks, cutlasses and rakes are used, whereas rotavators and other machinery are used in mechanical land preparation. Where possible, it is more cost effective to mechanise land preparation as this stage is very time consuming if done manually

- New lands must be cleared of all brush or weeds.
- When planting is to take place in a previously established location, any unusable plastic mulch, if present, should be removed and disposed of by taking to the solid waste land-fill or by placing in a covered hole on the farm.
- The previous crop is knocked down, chopped and forked into the topsoil as green manure.
- If the previous crop was pineapple (this is usually the follow on or ratoon crop), the plants can be removed and used for generating slips to be used as planting material, or can themselves be re-planted to establish a successive crop.
- Large clods of soil should be broken down into smaller pieces in order to obtain a fine tilth (uniform small sized aggregates of soil). Manually this is achieved using hand tools such as garden forks and hoes (Plate 8). A tractor drawn disc plough and harrow or hand plough may be used for mechanised land preparation (Plate 9). The area should be ploughed to a depth of 23 – 30 cm followed by a harrowing operation (Plate 10). Residual plant material (leaves and trash) can be incorporated into the soil as organic matter.
- The area should then be lined to mark out the planting beds and walk ways (Plate 11). The length of beds varies and is dependent on the farmer’s preference. The average width of the bed is usually 75 cm.
- The beds should be separated by drains which are usually 30 cm wide.
- Compost (decomposed manure and other vegetative/organic material) and or fertiliser may be worked into the bed during
**Plate 8:** Forking the land and simultaneously working vegetative material of the previous crop into the top soil

(Source - CARDI)

**Plate 9:** Ploughing land using a hand plough

(Source - CARDI)

**Plate 10:** Breaking clods of soil with a harrow attachment

(Source - CARDI)

**Plate 11:** Bed and walkway areas lined out; soil from walkway being used to cover compost on bed

(Source - CARDI)
land preparation, by spreading either over the area of the bed and covering with soil or working into the soil.

• Properly prepared fields should have beds and drains established along the contours of the land; this is especially important on slopping lands to reduce soil erosion. The beds should be well demarcated and labelled. The soil in the beds should be enriched with organic matter or pre-plant fertilisers and be worked into a fine tilth. The drains should remove water away from the root zone of the plants (Plate 12).

• In some instances farmers use **minimum till** methods and plant by only preparing the soil in the area where the plant will be placed. Minimum till is not recommended if soils are not free draining as water logging may become a problem, predisposing plants to soil borne diseases.

• Plastic mulch should be rolled over the beds and kept in place with stones, stumps of wood or coconut trunk. It can also be pinned with a forked stake or 20 cm piece of wire bent into a u-shaped staple. The mulch controls weed growth, protects the soil from the harmful effects of excessive rainfall i.e. reduces leaching of nutrients and erosion of the beds (Plate 13).

**Planting materials: types, selection and preparation for planting**

**Types of planting material**

Pineapples are propagated by vegetative material. These may be of several types which are classified by origin. The following types of propagating materials are commonly used to establish a crop of pineapples in the Caribbean:

• **Ratoon suckers** These arise from buds below ground level (Plate 14). These suckers are the most difficult to plant because of their large size. It takes an average of 15 – 18 months to harvest fruit from a ratoon sucker and their fruits tend to mature unevenly. Ratoon suckers, however give the highest yields.

• **Side shoots or suckers** These are leafy branches arising from buds in the leaf axils (Plate 15) and are therefore produced above the ground. Up to three side shoots may be produced on each plant but they are not produced in some varieties. They reach a length of 35 – 40 cm when mature, but are suitable for planting when 30 – 35 cm long. When left on the plant, side shoots produce a ratoon crop.

**Plate 12**: Well worked soil with beds and drains
(Source – CARDI)
• **Slips** These are borne on the peduncle just below or on the base of the fruit (Plate 16). The size and number (0 – 10) produced varies according to the health of the plant. The best slip material is from plants with no more than three slips. The average length of suckers from the Smooth Cayenne is 26 cm weighing 285 – 450 g, but those which weigh 350 – 450 g are the best for planting. Fruits from slips, take an average of 20 months from planting to harvest and they tend to ripen unevenly.

• **Crowns** They are located at the top of the fruits (Plate 16). Normally, only one crown is produced. At maturity, the crowns become dormant. Crowns tend to produce a more uniform crop. It takes an average of 22 – 24 months from planting to harvest. Crowns are not commonly used by farmers as planting material because the pineapples are sold with the crowns attached and commercial supplies are usually not available.
• **Plantlets generated from butts** Planting material may be obtained from the stem material of the harvested plant or ‘mother plant’ by promoting the formation of plantlets from vegetative buds within the leaf axils of the stem. This is done by placing the cleaned stem material called the butt or stump on a specially prepared raised propagating bed. The propagating bed should contain friable soil which has been cleared of weeds and other vegetation and worked into a fine tilth. Firstly, the leaves, roots and peduncle from the mother plant are removed to obtain the bare stem material (Plates 17 and 18). The butts are then placed horizontally on the surface of the propagating bed and covered with soil or preferably, river sand. After about 3 - 4 weeks, shoots emerge from vegetative buds within the butts and eventually develop into young plantlets which can be used as planting material as soon as they are 3 cm long (Plate 19).

• **Tissue culture (TC) plantlets** Tissue culture material can be used in commercial production. Before choosing to use TC plantlets for crop establishment, the producer should determine the cost effectiveness of using tissue culture material over the more commonly available planting material.

**Selection and preparation for planting**

Planting material must be selected from healthy, disease free plants. Any dried leaflets found at the base of the suckers or slips should be removed and the ends trimmed with a sharp knife.
Then the planting material should be submerged in a solution of an approved insecticide to control insect pest infestations. Suckers produced from the ground level should also be treated with an approved nematicide. The planting material can be stored by packing under shade in an upright position for about 7 days; contact with the soil should be avoided. Prior to planting, the suckers or slips should be graded according to size, type and cultivar (Plates 20 and 21).

### Crop establishment

For non-commercial, non-irrigated systems, establish plots preferably at the beginning of the rainy season. Commercial systems require year round planting. Where water is available and the farmer has suitable lands and resources, drip irrigation is recommended.

**Plate 19:** Plantlets generated from butt material on a propagating bed  
(Source – CARDI)

**Plate 20:** Graded/selected plant material by size, type and cultivar  
(Source – CARDI)

**Plate 21:** Graded/selected planting material ready for planting  
(Source – CARDI)

### Spacing

Plant density varies according to the variety grown, farmer preference, market requirement in terms of fruit size and weight, soil characteristics, particularly soil fertility and the level of crop husbandry to be implemented e.g. fertiliser and pesticide applications. Pineapples are normally planted in rows using a triangular formation, at a spacing of 45 – 60 cm between and within rows. The best arrangement for planting pineapple is double row planting.
which accommodates more plants while still permitting sufficient room to move between plants. Two rows are spaced 70 – 80 cm apart. The plants are planted in a triangular formation 45 – 60 cm within the rows. The distance between the double rows or every two rows should be 150 cm. This arrangement will give 28,000 – 45,000 plants/ha.

Another arrangement which is sometimes used in single row planting. The rows are spaced 150 cm apart and plants spaced 60 cm within the row. This only gives a population of 11,000 plants/ha.

Although close spacing gives the highest total crop yield per hectare, overcrowding has a negative effect, reducing fruit size and reducing the number of slips and suckers per plant. Smooth Cayenne which is spineless can be planted at a higher density.

**Planting**

The prepared planting material (suckers, slips or plantlets from butts) should be planted upright, set firmly into prepared soil at a depth of 9 – 10 cm. When planting, ensure that the whorl of the plant is above the soil level; if soil gets into the whorl of the plant and remains moist, rotting of the plant may occur.

**Fertiliser Use and Application**

Because of the varying soil types, both the quantity and nutrient composition of fertiliser used in pineapple production will be specific to the area in which it is to be used. It is therefore important that soil analysis and/or leaf analysis of the immediate previous crop be conducted before the new crop is established. These tests, carried out by special laboratories, are done to determine the soil nutrient status and what needs to be added to meet the crop requirements. Contact the local agricultural extension office to get information on available soil and leaf tissue testing facilities.

Pineapple generally requires mostly nitrogen and potassium for optimum growth and yield. Most times, all of the nutrients required are applied at land preparation. **At that time apply about 600 kg of nitrogen (N), 400 kg of potassium (K) and 150 kg of phosphorous (P) per hectare.**

Some farmers make a second application of about 20 g of a low nitrogen, high potassium fertiliser in the lower leaf axils, 1 month before flower induction.

**Application and handling of inorganic fertilisers**

The pineapple plant has a very restricted rooting system therefore granular fertiliser applied after crop establishment should be placed at the base of the plant or in the lower leaf axils where it can be efficiently absorbed. Excessive application of fertilisers is not only be wasteful and expensive, but can also lead to contamination of streams, rivers and wells through ground water or surface run-off. An increase in nitrates and phosphates in water sources above national limits can be a major concern as this affects aquatic life and
the quality of potable water. Inorganic fertilisers used in the production of pineapples should also be stored in a clean, dry and covered location. These storage conditions reduce possible contamination of waterways.

**Application and handling of organic fertilisers**

Pen manure may be used as a source of nutrients and soil enrichment for the pineapple crop but it should be properly composted before application to avoid the presence of microbial residues on the pineapples. When applying organic fertilisers the following guidelines apply:

- All animal manure must be properly composted prior to application; never use fresh or un-composted manure on the crop.
- Place composted manure or compost into the planting hole or incorporate in the planting bed before the mulch is applied.
- Organic fertilisers should not be applied when the crop is nearing maturity; the maximum time should elapse between the application of organic fertilisers and the harvesting of pineapples to minimise the risk of microbial residues.
- Measures should be taken to safeguard the health of workers handling pen manure. See Box 1.

**Weed control**

Weeds can become a major problem in pineapple fields (Plate 22). This is mainly due to pineapple plants being slow growing and not covering the ground quickly enough to suppress weeds. Weeds compete with the plants for nutrients, water and sunlight causing reductions in growth of the plant and poor yields; they also harbour pests that attack pineapples. Weeding is necessary particularly

---

**Box 1. Safe handling of manure and compost**

Animal manure and compost are potential sources of disease pathogens that affect humans and therefore precautionary measures need to be taken when handling pen manure. To safeguard the health of persons handling organic manures the following practices should be standard protocol for handling these materials

- Vaccination against tetanus (*Clostridium tetani*).
- Persons handling manure and compost should not have exposed wounds.
- Dust masks are to be worn to prevent inhalation of fine particles which is common when dry dusty manure or compost is being handled.
- Proper washing after handling raw manure and compost.
in the early stages of crop growth. It has been shown that where adequate weed control is maintained, average fruit weight is increased, when compared to where no weed control is practiced. Nut grass (*Cyperus* spp.) is one of the most difficult weeds to control. Weed control in commercial pineapple fields is best achieved using plastic sheeting as a mulch. Other options are mechanised brushcutting, herbicide spraying and manual weeding.

**Mulching for weed control**

Mulching with plastic sheeting (Plates 13, 23 and 24) is the recommended practice for weed control in commercial pineapple fields because in the long run it is more economical and convenient than manual or herbicide operations. However weeds will eventually become a problem in fields with plastic mulching if the mulch is not properly applied. For example if mulch does not cover drains and walkways (Plates 25 and 26) weeds can establish on the exposed soil and will require weed control operations which may be an unexpected cost. The main disadvantages of plastic mulch are the cost of the material, that it is difficult to collect and dispose of after use and that the material is not readily biodegradable. Green manure and other organic wastes may also be used as mulch. Mulch should be placed over established beds that are ready for planting.
Mechanical weed control

Brush cutters may be used to control weeds in the drains that are not covered in mulch and areas surrounding fields.

Manual weed control

Weeds can be controlled manually by cutlassing and hoeing but these activities expose the soil which may result in erosion during heavy rainfall (Plate 27). Manual weed control in pineapples is difficult (Plate 28) and expensive and requires protective clothing, gloves, eye protectors.

Plate 25: Un-mulched walkways and drains will soon be infested with weeds
(Source – CARDI)

Plate 26: Weeds are seen in the drain at right because it was not covered with plastic mulch
(Source – CARDI)

Plate 27: Clean weeded pineapple fields are prone to erosion
(Source – CARDI)

Plate 28: Farmer manually weeding a pineapple plot
(Source – CARDI)

Mechanical weed control

Brush cutters may be used to control weeds in the drains that are not covered in mulch and areas surrounding fields.
Chemical weed control

Herbicides are usually applied before and during land preparation to remove vegetation that has grown between cropping cycles. Where the area is known to have a problem with weeds, a pre-emergent herbicide can be applied, before the mulch is laid down, to hinder the germination of weed seeds. The pineapple plant is most vulnerable to herbicide damage when it is 3 - 5 months old as this is the most active period of growth. If chemical weed control cannot be avoided during this stage, great care must be taken during application.

- Use herbicides listed for use in pineapples and always follow label directions.
- To avoid phytotoxicity risks, the application of herbicides during the growing period should be restricted to the space between the rows.

Major pests and management options

In the Caribbean the major pests of pineapple are: the ant mealy bug complex, nematodes, caterpillars, rodents and birds.

The ant / mealy bug complex

Mealy bugs are soft bodied insects found on the roots, base of the leaves and around the bottom end of the fruit. They feed on plant sap by piercing plant tissues and sucking. The ant/mealy bug complex describes the situation where colonies of mealy bugs are tended by ants in exchange for plant sap (or honeydew).

The ants protect the mealy bugs by 1) making shelters from soil around them 2) attacking natural predators and 3) transporting the mealy bugs to new food sources. Mealy bugs are known vectors of several plant diseases including Wilt Disease of pineapple. Ants and mealy bugs pose a serious threat to pineapple production because the ants carry the mealy bugs from diseased plants (when these are no longer good sources of plant sap) onto healthy plants resulting in the spread of the disease throughout the field. Severe infestations can cause wilting of the leaves with the leaves eventually turning orange-brown and withering. Control becomes more difficult if there are weeds and other local plants acting as hosts for the mealy bug. Initial control should be directed against the ants to ensure success. When the ants are controlled, the soil shelters are no longer maintained and they collapse; pesticides can then be applied directly to the mealy bugs. Ants can be controlled either by drenching their nests with insecticides or by applying baits.

Ant control

- Apply a 0.2% Basudin spray as a drench to the ant nest. Mix 10 ml per 4.5 L of water. Soak nest thoroughly.
- Use Acoushi ant bait.

Mealy bug control

- Protect natural enemies. There are several natural enemies that feed on mealy bugs such as ladybird beetles and parasitic
wasps. These biological control agents are more effective however when the ants associated with mealy bug colonies are managed as the ants attack and kill these natural predators. The effects of pesticides on natural predators must be considered before the pesticide is used. Avoid widespread use of pesticides with long term residual effect.

• Remove infested material from field. Care should be taken to remove infested plant parts, crop residues, as well as other plants that harbour mealy bugs.

• Insecticide application is recommended throughout the plant growing cycle to keep the mealy bugs under control. Applications are particularly important during the early stages of plant growth and during the fruiting season. When spraying, ensure that the nozzle is directed towards the lower parts of the plant where the mealy bugs are found. Apply either of the following:
  
  o Basudin 60% EC. Apply 0.2% spray. Mix 10 ml per 4.5 L of water.
  
  o Malathion 50% EC. Apply 0.1% spray. Mix 5 ml in 4.5 L of water.

**Nematodes**

Pest nematodes are tiny slender unsegmented worms that infest plant roots, reducing root growth and causing root death thus reducing the plant’s ability to absorb water and nutrients. The result is a poorly developed root system causing stunting of plants. Leaves turn yellow and then red and are less erect than those of healthy plants. Tips are withered. Control of nematodes is achieved by the following practices:

• Pre-plant soil fumigation during land preparation using appropriate nematicides where nematode populations are high.

• Dipping the planting material in a solution of a nematicide or with a post-plant nematicide application; nematicides include Oxamyl e.g. Vydate L®, Fenamiphos e.g. Nemacur®. Liquid formulations such as Vydate L® can be used during the dry season.

• Crop rotation to reduce nematode inoculum in the soil as a preventative measure.

• Addition and incorporation of organic matter to enhance biological control by promoting the proliferation of nematode eating organisms. The addition of cassava residues and neem leaves or extracts appear to directly kill the soil dwelling stages of the pest.

**Butterfly larvae (caterpillars)**

Butterfly larvae can damage flowers and fruits. The adult butterflies lay eggs when the plants are at the flowering stage. To control, apply Sevin before flowering and continue at regular intervals.

**Rodents**

Rats can be very destructive pests in pineapple fields and also pose a serious hazard to pineapples in storage. Fatal diseases such as
Leptospirosis are spread by rats urinating and defecating on food consumed by humans. Rats damage pineapples in the field when they bite, urinate and or defecate on the crop making the fruits unmarketable. Even higher crop loss due to rodent damage may occur where pineapples are stored. Continuous surveillance is by far the most important and effective management technique because early observations of the presence of the first intruders coupled with timely interventions is cheaper than managing a widespread infestation, thus limiting the amount of crop loss.

Control of rodents in the field The rodent population in the field should be monitored for effective control. Field sanitation is very important as weeds and debris provide hiding places and nesting material. Control by using rodenticide baits such as Klerat. Baited traps may also be used.

Control of rodents in storage buildings The key for managing rats in storage buildings is maintaining an environment which discourages rodents from entering, establishing and reproducing. The building should be made rat-proof in order to discourage rodents from entering; ventilation openings should be covered securely with screens and cracks and holes should be quickly repaired and or sealed. All non-permitted points of entry should be sealed; some species are very good climbers (rain pipes or rough vertical surfaces are no hindrance) and therefore openings that are high or otherwise appear inaccessible should not be ignored. Doors should be kept closed when not in use and closed immediately after entry or exit. Garbage should be placed in bins with secured covers and removed or burned regularly. It is much easier to notice the presence of rodents if the storage area is clean and tidy. The storage area should therefore be swept regularly. Monitoring for rodent presence in storage areas should involve:

- Inspection of the storage area for possible points of entry or shelter and evidence of rodent presence. The presence of rodents is indicated through droppings, minor damage to bags, gnawed structures, burrows and holes in the floor and just outside the building.
- Setting of traps to establish the species that are present.

Selection of control methods The rodent management strategies selected need to address the likely sources of where the rodents are coming from and what is attracting them. Therefore the regimen of control practices need to consider the types of agricultural systems surrounding the pineapple fields or crop storage areas, the harvesting schedule and the distance between fields and villages. Extreme care should be taken when using rodenticides. See Box 2.

- Poison baits containing rodenticides should only be used if rats are present. In stores or buildings, it is suggested to use single-dose anticoagulant poisons, preferably as ready-made bait. Poisons should always be applied according to the manufacturers’
recommendations. Baits should be placed both inside and outside buildings. If domestic animals have access to the baited area, baited containers, with protected baiting points, should be used.

- Contact dust and tracking powders containing rodenticides can also be used. Rodents pick up these dust/powders on their fur and ingest them during grooming. This method is used against mice which are not easily attracted to bait stations. However, it should only be used where food cannot be contaminated by animals carrying the poison.

- Trapping may be used if operators do not want to, or cannot, use poisons because of possible contamination.

**Birds**

Birds eat and damage the ripening fruit. The use of scarecrows and intermittent noise simulations or the application of bird netting over the ripening fruits can minimise crop loss. Mature fruits may also be protected by covering with bags (Plates 29a and 29b).

**Box 2. Precautions when using rodenticides**

Farmers take note. Rodenticides are poisonous to most mammals (including domestic stock) and humans. Contact with rodenticides or contamination of produce with rodenticides must be avoided. Dead rats should be removed and kept away from other animals in order to avoid secondary poisoning.

**Plate 29a and 29b:** Fruit are sometimes covered with bags as a form of protection against birds

(Source – CARDI)

**Major Diseases and Management Options**

The major diseases of pineapples observed in the Caribbean are Wilt Disease, root rots, Phytophthora Heart Rot and Fruitlet Core Rot.

**Mealybug Wilt or Wilt Disease**

This disease is caused by a virus/toxin associated with the mealy bug. The most visible symptom is a bright bronze to red colouration of the leaves of the young plant or a pinkish and/or yellowish colouration of the older leaves. Wilting starts at the tip of the leaves. If the plants continue to grow, the leaves lose turgidity and curl outwards. Eventually, roots will stop growing and rot. As soon as symptoms
of damage begin to appear on infected plants, the mealy bugs move to neighbouring healthy plants. Fruits produced by these plants are usually small and/or distorted.

**Control of Mealybug wilt disease** The disease is prevented by controlling the mealy bug, using similar methods to those described on pages 32 – 33. Control should however begin with selection and treatment of healthy planting material. This is followed by the eradication of the ants associated with the mealy bug and the routine treatment of the plants to control the pest. All diseased plants which can act as a source of infection should be removed from the field and destroyed by burning.

**Root rots**

These fungal problems are caused by various *Phytophthora* and *Pythium* species. The symptoms of root rots are a reduction in plant growth with the development of reddish coloured leaves and the browning of the leaf margins. Affected plants eventually die.

**Control of root rots** The disease is managed by using disease-free planting material and avoiding long periods of excessive soil moisture.

**Phytophthora heart rot**

This disease is caused by the fungal pathogen, *Phytophthora nicotianae*. The symptoms are rotting at the base of the leaves in the centre of the leaf whorl (heart) of young non-flowering plants. In a more developed stage, young leaves can easily be pulled from the plant. The base of the leaves eventually rots and has a bad smell. The root system at this stage is dead and the plant can easily be pulled from the ground. The disease is common in poorly drained soils when pineapple slips and suckers are planted too deep and when soil comes in contact with the centre of the leaf whorl. Young plants are most susceptible to infection.

**Control of Phytophthora heart rot** An effective disease management programme for phytophthora heart rot requires the planting of resistant cultivars and an integration of cultural and chemical practices; cultural practices are important to the long term control of this disease. As the severity of the disease is related to the levels of pathogen in the soil, the aim is to reduce pathogen populations in the soil that initiate disease epidemic. Appropriate management options include:

- Planting on raised beds, mounds or ridges to reduce the period of wet soil conditions which limits the movement of the pathogen in the root zone.

- Preventing soil from getting into the whorl of the plant, especially in wet conditions; care should be exercised during planting and manual weeding.

- Crop rotation which removes the potential food sources for the pathogen. The strains of *P. nicotianae* are host specific therefore rotating out of pineapples for subsequent cropping cycles effectively starves the pathogens which reduces population levels in the soil. The duration of the rotation
should be at least 2 years but even longer rotations will not completely eliminate the pathogen because there may be limited colonisation of host weeds.

- Complete removal of harvested plants. The physical removal of the roots of harvested plants after the final harvest aids in lowering the population of the pathogen in the soil. This practice also aids in the management of pest nematodes, the activities of which cause root damage which increases the severity of root rot.

- Disease development is promoted by soil pH values greater than 6.2 and is suppressed by lower pH values. During land preparation, amendments should be added to the soil if necessary to bring the soil to a pH between 4.5 and 6.0.

- As a prophylactic measure, the planting material may be dipped or sprayed with a fungicide solution just before planting.

**Fruitlet core rot**

Fruitlet Core Rot is caused by a combination of *Penicillium* and *Fusarium* spp. Although the symptoms of this disease generally appear during storage, infection starts in the field. Mites are thought to be associated with this disease, through causing injury to the fruitlets; the soil borne pathogens then enter through the wounds to infect the fruit. The infected tissue of the fruit has a water-soaked appearance which eventually discourses becoming light to dark brown.

**Control of fruitlet core rot** The pesticide spraying programme should include a miticide in the rotation. Additionally, care should be taken during crop care activities to avoid soil coming into contact with maturing fruits e.g. workers should wash their hands before handling fruits in the field and before inspecting fruits in post harvest operations.

**Artificial flower induction**

Natural flowering in pineapples varies from year to year in a producing region. Research indicates that natural flowering is linked to the seasonal drop in temperatures which triggers flowering. Dependence on natural flowering can result in serious loss of revenue as seasonal climatic variations cause erratic flowering and varying maturity times. This increases crop management costs and affects the time and quantities of pineapples for sale.

Pineapples can be induced to flower and fruit by the use of certain synthetic compounds. The materials used for artificial flower induction all induce the generation of ethylene which acts as a hormone to trigger flowering in the pineapple plant if the plant is physiologically mature. Artificial flower induction can facilitate better scheduling of harvest because it promotes uniform flowering and maturity in the fruits and increases fruit size and quality. Producers use this practice to:

- Attain uniform maturity; in a mixed planting, ratoon plants and first crop plants can be brought into fruiting with the rest of the crop.
• Control the time of harvest; treatments can be timed to produce a harvest at a pre-determined date.

• Avoid overproduction in the peak periods.

• Maximise yields.

Plants are induced when they are on average 8 – 10 months old and at the 30-leaf stage or older. From induction to full maturity takes about 5 months. Hormone treatments for flower induction will only succeed when the nitrogen content of the plant is low. Additionally, an elevated rate of vegetative growth can inhibit or delay pineapple flowering, by reducing its sensitivity to the floral stimuli. Applications should take place during the cooler periods of the day e.g. early morning or late afternoon, with preference for the latter. The application is repeated 1 week later to ensure maximum inducement.

The main materials used to induce flowering are Naphthalene Acetic Acid (NAA), calcium carbide and Etherel.

• NAA is available in tablet form and treatment is achieved by placing ½ or 1 tablet into the centre of the whorl of each suitable plant.

• Calcium carbide is used by dissolving a 100 g piece in 5 L water (Plate 30) and, after effervescence has subsided, applying 50 cc to the centre of the whorl of the plant (Plate 31 and Plate 32). The solution should be used within 3 hours of mixing.

• Etherel is available in liquid form (Plate 33) and is used as a 0.1 - 0.2% spray solution which is applied to the centre of the whorl of the plant (Plates 34 and 35).

Effects of improper use of synthetic flower inducers

If the wrong rates of synthetic flower inducers are used the following problems may be experienced:

• Small fruits with large crowns.

• Elongation and bending of the peduncle.

• Reduction in the number of slips and suckers per plant.

• Damages and deformations to the fruits (very round or conical ones).

Harvesting

Planning the harvest operation is very important, as it prevents unnecessary mistakes and wastage, which could be costly. Before harvesting fruit, the pineapple field should be inspected to estimate the quantity of fruits to be harvested through an exercise in fruit maturity assessment.

The time for harvesting pineapple also depends on whether the fruits are for domestic or overseas market. Harvest only mature fruits tested for acceptable Brix levels and eating quality. Fully ripe fruits are suitable for local markets while unripe but mature fruits are more suitable for export.
Plate 30 - A 100g piece of calcium carbide is added to 5L of water
(Source – CARDI)

Plate 31 - The calcium carbide effervesces; solution should be used within 3 hours
(Source – CARDI)

Plate 32 - 50cc of the calcium carbide solution is then poured into the whorl of the plant
(Source – CARDI)

Plate 33 - Ethrel concentrate
(Source – CARDI)

Plate 34 - Ethrel concentrate
(Source – CARDI)

Plate 35 - Applying Ethrel concentrate into the whorl of the leaves
(Source – CARDI)
**Assessing maturity**

Pineapple is a non-climacteric fruit and so does not improve in eating quality after harvesting. For pineapples to attain maximum sugar content and best flavour, they must be allowed to ripen completely on the plant. If harvested too early, the fruit will be flavourless with poor aroma and have almost colourless flesh. The flesh will also be very acidic, and extremely susceptible to internal browning and chilling injury. Fruit harvested too late, is very sweet, with low acidity and with distinct yellow colour flesh. These fruits are very fragile and susceptible to fungal attack with the possibility of the onset of fermentation taking place. It takes an average of 18 - 24 months from planting to mature fruit.

It is difficult to determine the internal maturity of the fruit by the colour of the skin or any other external characteristics. The eyes mature progressively from bottom to top, with the lower part of the fruit being riper than the upper part. Fruit maturity is generally determined by the extent of fruit eye flatness and skin yellowing (Plates 36 and 37). The degree of skin yellowing observed at optimum ripeness, varies with season, rainfall, microclimate and field conditions. The market determines what stage of maturity the pineapples should be harvested.

Visually, fruit maturity can be determined using different methods, the two most common being colour stage and internal fruit appearance.

*Colour stage*. For Smooth Cayenne fruit maturity is evaluated on the extent of fruit eye flatness and skin yellowing. Colour stages (CS) are categorised as follows:

- **CS1**: all eyes green, no traces of yellow
- **CS2**: 5 to 20% of the eyes yellow
- **CS3**: 20 to 40% of the eyes yellow
- **CS4**: 40 to 80% of the eyes yellow

Plate 36 - Immature stage  
(Source – CARDI)

Plate 37 - Early mature stage  
(Source – CARDI)
CS5: 90% of the eyes yellow, 5 to 20% of the eyes reddish brown

CS6: 20 to 100% of the eyes reddish brown.

For the other pineapple varieties, colour stages (CS) are not as pronounced as in the Smooth Cayenne so one cannot assess the stages of maturity by this method. For the other varieties, a change of colour from dark green to light green of the entire fruit will only indicate that the fruit is at the CS1 stage of maturity.

Internal fruit appearance Observing the internal appearance of the flesh colour and translucency of the pineapple by slicing horizontally, at the point of the largest diameter the fruit, can also be an aid for assessing fruit maturity. When more than half of the area is translucent, the fruit is considered beyond optimum maturity (over mature).

Composition analyses standards for fruit maturity assessment Acceptable eating quality in pineapple is best assessed through composition analyses of sugar content and acidity of random samples of pineapples from the fields scheduled for harvesting. The level of sugar content as measured by the degree Brix also referred to as the Total Soluble Solids (TSS) of the fruit should be assessed in the field prior to harvesting using a portable Brix refractometer. The Brix should be measured on a random sample of fruits. The minimum average Brix required is 10% at the top and 12% at the bottom for the green mature pineapple. The acidity level is measured by titration in a laboratory and a maximum acidity of 1% is the standard for acceptable maturity; fruits with levels of acidity over 1% have not yet reached the acceptable maturity stage organoleptically for consumption.

Best practices in harvesting and in-field handling

In preparation for the harvest, farmers must ensure that:

- Workers are well equipped with protective gear particularly when picking fruits from spiny varieties (Plate 38).
- The proper harvesting tools are available (Plate 39).
- At least two persons are available to conduct the harvest so that the time to complete picking and in-field grading is shortened, thus reducing the length of time the harvested pineapples are in the field.
- There are adequate numbers of proper field crates for the estimated amounts to be harvested (Plate 40).
- All crates and harvesting tools are cleaned and sanitised before use

The correct picking techniques and in-field handling practices are outlined below:

- When transporting by sea, the fruits should be harvested on the day before the shipment is made.
- When exports are made by air, fruits can be harvested at a more advanced stage of maturity.
Fruits should be harvested in the early morning when temperatures are lower. High temperatures can reduce the shelf life of fruits. Harvest fruit with a sharp knife (Plate 41), leaving more than 2.5 cm of stalk attached to the fruit (Plate 42).

The stalk should not be completely removed from the base of the fruit (Plate 42). If this occurs, an avenue for the disease infection is created; this reduces the shelf-life of the fruit. This disease condition is more common in the Smooth Cayenne cultivar.

Plate 38 - Harvesters should be well equipped with protective gear
(Source – CARDI)

Plate 39 - Harvesting tools
(Source – CARDI)

Plate 40 - Ventilated field crates
(Source – CARDI)
Plate 41 - Harvest fruit with a sharp knife
(Source – CARDI)

Plate 42 - Leave at least 2.5 cm of stalk attached to the fruit
(Source – CARDI)

Plate 43 - Removing stalk completely from the base of the fruit must be avoided
(Source – CARDI)
PART 3 – POST HARVEST
**POST HARVEST HANDLING**

Post harvest handling is the manner in which fresh produce is treated during all operations between harvest and consumption. The customary sequential steps in a post - harvest handling system for pineapples are outlined in Figure 1.

**ON – FARM HANDLING AND TRANSPORT**

On farm handling describes any post harvest practices that are carried out on the farm in order to prepare the harvested produce for sale. These may include trimming, washing and cleaning, grading, storage and transport. The recommended on farm handling practices for pineapples are outlined below:

- Place fruit in field crates padded with foam to protect the fruits from bruising. Bruising or puncturing caused by poor handling, dropping or abrasion, will result in localised areas of softening and the development of secondary microbial infections. Polythene sacks or bags should not be used for packing and transporting fruit, as high levels of mechanical damage can occur.

- Store the harvested fruit in a cool place, that is, away from the direct sunlight. This reduces the fruit field heat (the ability of the fruit to respire). Harvested fruit should be packed either in the field or at a centralised packing facility. If the field contains mixed varieties, ensure that each variety is placed in a separate crate. Crates should be labeled.

- Preliminary grading should be conducted in the field, or farm pack house. Undersize, oversize, over ripe, under ripe, damaged, bruised, insect and fungal infested/damaged fruits should be rejected.

---

**Figure 1.** Flow diagram of a post-harvest handling system
**Transport by vehicle**

Transporting the pineapples by vehicle should be done in one designed to allow for proper air circulation and protection of the pineapples from direct sunlight. The transporting vehicle should be clean and the area receiving the fruits should be sanitised. Transport fruits in the cool of the day. If the farmer does not have enough cartons to carry the fruits, place the fruits at the back of the pick-up or van on a layer of foam. A layer of foam should be placed between each layer of fruit. Fruits should be covered and taken directly to the pack house to reduce the risk of potential contamination that may occur between field and pack house / storage facility. Farm workers and drivers should be careful while loading, unloading and transporting fruit and should avoid cross contamination from other produce, non-food items and unclean surfaces.

• The fruit stalk should be cut back to approximately 2.5 cm from the point of attachment to the base of the fruit.

• Remove all leaves at the base of the fruit and examine carefully for rots. Discard all fruits showing signs of rotting.

• Use a soft brush to remove insects (e.g. mealy bugs), dirt and other debris that may be present on the fruit surface. Areas around the bottom end (base) and top end of the fruit i.e. just below the whorl of the crown, should be given careful attention.

• The method of processing the crown is dependent on the buyers’ specifications i.e. the crown can be cut back completely, rosetted with a sharp knife or left normal (Plate 44).

**Final Preparation of the Fruit**

**Selecting, cleaning and trimming**

The following operations are required for the proper preparation of pineapples with regard to fruit selection, cleaning and trimming. These practices are mandatory when preparing pineapples for export.

- Damaged, deformed, over mature and over sized fruits should be rejected.

*Plate 44 - Methods of processing the pineapple crown*

(Source – CARDI)
Grading

Grading is an important post harvest practice when preparing pineapples for export markets. After the fruits have been inspected, cleaned and had their crowns processed, the fruits should be graded according to weight, size and stage of ripeness or colour. Most importers will stipulate the expected weight per box, or the size of the box will dictate the weight of fruit that the box can accommodate. Use a scale to obtain the weight range recommended by the importer. The net weight of packed fruits in the carton should be 14 – 15 kg. Fruits in individual cartons should be the same size resulting in a range of counts.

Accepted fruit sizes for different counts are as follows:

1) 6 count – over 1.6 kg
2) 12 count – 1.2 kg
3) 15 count – 1 kg
4) 20 count – 0.75 kg

Packing

The fruits should be packed in a telescopic two piece fibreboard carton. Cartons may or may not have internal dividers. Shredded paper should be placed at the bottom, around and at the top of the fruits to prevent rubbing, thus minimising abrasion and damage during transportation and handling. Cartons should be strengthened by taping the edges, thereby preventing fruits from accidentally dropping out of the box.

Fruits can also be packed upright, alternating the tops and bottoms (Plate 47). Shredded paper is used as padding between the fruits.

Plate 45 - Flat packing; positioning in box
(Source – CARDI)

Plate 46 - Flat packing; shredded paper added to minimise bruising
(Source – CARDI)

Plate 47 - Packing upright
(Source – CARDI)
Labeling for export

Pineapples packed for export must have the following information on each box (Plate 48):

- Name and address of the exporter.
- Weight of the box.
- The name and address of the importer.
- Box code.

Storage and transportation after packing

Packaged fruit should be stored in a cool dry place away from the elements. Facilities used for temporary storage of fruits should be:

- Designed for easy cleaning and sanitisation with sloping floors.
- Well protected to prevent entry of rats, birds and insects (have windows and doors screened).
- Kept free from residues and other waste materials that can introduce hazards into the facility.
- Managed with an established cleaning and sanitisation schedule.

Pre-export storage can be used and a suitable storage temperature should be 7.5 °C and 85 - 95% relative humidity. Mature green pineapples should be stored at a temperature of 8 – 10 °C and at a relative humidity of 85 - 90%. Under these conditions, pineapple should have a storage life of 2-3 weeks. Storage for extended periods below this temperature will result in chilling injury.

Guidelines for pack house selection

Wherever available, local producers should utilise the facilities and services of a certified pack house (Plate 49) to prepare pineapples for regional and extra regional markets. Guidelines for the selection of a suitable pack house are given in Box 3.

Plate 48 - All boxes should be carefully labeled
(Source – CARDI)

Plate 49 - A certified pack house
(Source – CARDI)
Box 3 Guideline requirements for certified pack houses

1. Must be clean.
2. Sound, weather-proof construction and adequately enclosed to prevent entry of animals.
3. Where possible, doors and windows should be screened to prevent entry of birds and insects.
4. Floors must have adequate drainage to allow easy cleaning and constructed to withstand normal “wear and tear”.
5. Layout should allow for a smooth flow of the fruits from the reception area through to the packaging and labeling areas. The raw product area should be clearly separated from that of the finished product.
6. The perimeter and surrounding areas must be kept tidy to prevent the build up of vermin and other contaminants.
7. Equipment should be sound and in a good state of repair. Routine inspection should take place to ensure equipment is clean and safe and a daily record of these inspections must be kept. All equipment should be cleaned at the end of fruit preparation and packing process.
8. Equipment used for weighing, sizing, temperature recording or any other measuring device, must be calibrated and checked routinely for accuracy.
9. Where water is used it must be adequate in supply. Only clean pipe borne water should be used in the final rinsing of produce before packaging.
10. Crop residues from handling and grading must be removed and disposed of regularly so as not to attract insects, birds and rodents.
11. All knives, probes, trimming tools, etc. must be of rust proof material. Stainless steel is recommended.
12. Non splintering material (durable plastic) should be used for work surfaces and containers.
13. Harvesting containers and packaging material should be stored in a dry, clean and designated area so as to prevent contamination by chemicals and pathogens.
14. Adequate ventilation is required to ensure proper air flow through the pack house.
15. Sufficient toilet and hand washing facilities should be readily accessible to workers. Hand washing stations should be clean and conveniently in or near the toilet. Soap should be provided.
16. A working area must be available for inspectors to inspect produce. A grading table as well as enough floor space to keep rejected fruit is also needed. Adequate lighting should be provided over this area.
17. Agricultural chemicals should be stored in designated areas separate from where produce, manure, mulch and packing materials are stored.
18. Waste water should be disposed of in a manner so as to prevent contamination of the production environment and also the water source used for agricultural and cleaning purposes.
19. Graded fruit must be stored within the appropriate temperature range.
20. A first aid kit must be readily available in the pack house.
The pack house shown in Plate 50 is used as a storage facility for fertilisers and chemicals. It is also unclean. The state of this pack house makes it unsuitable for processing fruits, as it does not meet the Hazard Analysis and Critical Control Point (HACCP) standard.

**MANAGING POST HARVEST LOSS**

Losses in pineapples during storage and air transport are minimal if careful handling is employed. During sea shipments, where storage is over a longer period, the fruits are more susceptible to post-harvest losses as a result of increased handling, temperature fluctuations and incidence of disease. Post-harvest damage to pineapples, often resulting in fruit rots and or blackening of the flesh, may be caused by any one or a combination of the following factors.

- Mechanical damage. Bruising or puncturing caused by poor handling and dropping of the fruit, will cause abrasions to develop in localised areas, this then becomes a source for secondary microbial infection.
- Low temperature storage. The sensitivity of pineapples to chilling injury is related to the level of ripeness of the fruit. Storage of green fruit at the level of CS1 (see page 40) should be at 8 -10 °C and 85 - 95% relative humidity. Storage for extended periods below 8 °C will result in chilling injury. Box 4 describes the conditions that promote chilling injury in pineapples.
- Pathological factors caused by disease organisms.

The following diseases may cause blackening of the pineapple flesh.

- The fungal disease **Black Spot or Brown Spot** caused by *Penicillium funiculosum* and *Fusarium moniliforme* results in browning and sinking of the eyes and browning of the internal fruitlets. The condition is not detected until the fruit is cut (Plate 51). The disease is caused by mite damage in the field, which allows entry of the fungi.
- **Black Rot** This is caused by *Ceratocystis paradoxa* causing a black watery rot of the flesh and a thin brittle skin. Infection occurs through the cut stem or through damaged areas (Plates 52 and 53).
- **Endogenous Brown Spot** (Plate 54) is a physiological disorder characterised by
Plate 51 - Symptoms of Black Spot
(Source – CARDI)

Plate 52 - Point of Black Rot infection
(Source – CARDI)

Points of infection

Plate 53 - Advanced Black Rot
(Source – CARDI)

Plate 54 - Endogenous Brown Spot (or Black Heart
(Source – CARDI)
watery spots, which eventually coalesce and turn brown. The incidence is found in certain varieties and production areas and is generally enhanced during long term storage particularly fruits at an early stage of maturity.

Management of post-harvest fruit rots

Recommendations to manage post-harvest fruit rots include:

- Rigid selection of fruit at both the field and pack-house level should be carried out to ensure that damaged fruit, which often escape the eye of inexperienced harvesters and packers, are not packed for export.

- Fruits harvested during the rains and then stored before packing, should be harvested at the green - mature stage (CS1): all eyes green, no traces of yellow. See page 40. Fruits should be allowed to air dry before packing. Under such conditions spoilage of fruit will be reduced.

- With regard to the blackening of fruit after removal from storage, ensure that fruits are stored at the correct storage temperature of 8 - 10 °C.

- Pre-harvest spraying should be carried out for control of mites if they are detected in the field.

- Fruit should be treated with fungicide (Dowicide A) if Ceratosystis is diagnosed as the causal agent for the fruit rot.

---

Box 4: Conditions that promote chilling injury in pineapples

Sensitivity to chilling injury is related to the level of ripeness of the fruit. Symptoms of chilling injury are incomplete colour development, wilting of the crown and darkening of the flesh and peel. If low temperature storage is used after packing the fruits, the temperatures will have to be maintained throughout the post-harvest and marketing chain so as to avoid condensation on the produce. Condensation may create the right conditions for fungal growth and diseases such as black rot.
YIELDS

Pineapple yields vary according to the location the crop is grown, variety, time of planting and crop management (the level of technology adopted). For plant populations of 29,640 –37,050 plants per hectare, yields of 44,460 –55,575 kg/ha can be obtained. For single row spacings of 11,000 plants per hectare yields of 16,500 kg/ha will be obtained.

PRICE COST MARGINS

The commercial profitability of the production of any output is largely determined by the price-cost margin. This is defined by the amount by which the price of a product exceeds its cost. For price-cost margin analysis it is very important to capture all costs of production. There are many variables affecting the cost of production of pineapple inclusive of variety, costs of inputs, water management, level of mechanisation, fertiliser programme, soil type, scale of production, location and micro-environment conditions. Overhead cost will also vary from farm to farm depending on the infrastructure systems in place. The price-cost margin generated by the production of 1 ha of pineapple produced in Dominica is given in Table 8. See Appendix 1 for a more detailed treatment of how this determination was generated.

Table 8: Pineapple gross margin summary

<table>
<thead>
<tr>
<th>Description</th>
<th>Value (EC$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total variable cost</td>
<td>30,706</td>
</tr>
<tr>
<td>Total marketable yield</td>
<td>25,000</td>
</tr>
<tr>
<td>Wholesale selling price</td>
<td>1.50</td>
</tr>
<tr>
<td>Total revenue</td>
<td>37,500</td>
</tr>
<tr>
<td>Gross margin per acre</td>
<td>6,794</td>
</tr>
<tr>
<td>Gross margin per kg</td>
<td>0.27</td>
</tr>
</tbody>
</table>
**FURTHER READING**


Integrated rodent management in post-harvest systems: management techniques http://www.fao.org/inpho_archive/content/documents/vlibrary/gtzhtml/x0280e/x0280e03.htm


Appendix 1: Cost of production (EC$) of 1 ha of pineapple in Dominica. Gross margin projections

<table>
<thead>
<tr>
<th>OPERATION</th>
<th>UNIT</th>
<th>FREQUENCY</th>
<th>QUANTITY</th>
<th>RATE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. VARIABLE COST</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. LAND PREPARATION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land clearing (casual)</td>
<td>Days</td>
<td>1</td>
<td>5</td>
<td>50</td>
<td>250</td>
</tr>
<tr>
<td>Herbicide (systemic)</td>
<td>Litres</td>
<td>1</td>
<td>8</td>
<td>25</td>
<td>200</td>
</tr>
<tr>
<td>Herbicide application casual</td>
<td>Days</td>
<td>1</td>
<td>2</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Ploughing (skilled)</td>
<td>Hours</td>
<td>1</td>
<td>3</td>
<td>80</td>
<td>240</td>
</tr>
<tr>
<td>Rotavating (skilled)</td>
<td>Hours</td>
<td>1</td>
<td>7</td>
<td>40</td>
<td>280</td>
</tr>
<tr>
<td>Banking (skilled)</td>
<td>Hours</td>
<td>1</td>
<td>4</td>
<td>40</td>
<td>160</td>
</tr>
<tr>
<td><strong>SUB-TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,230</td>
</tr>
<tr>
<td>2. WEED CONTROL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic mulch (400 m x 1.5 m)</td>
<td>Rolls</td>
<td>7</td>
<td>300</td>
<td></td>
<td>2,100</td>
</tr>
<tr>
<td>Applying mulch (casual)</td>
<td>Days</td>
<td>1</td>
<td>4</td>
<td>50</td>
<td>200</td>
</tr>
<tr>
<td>Stone collection (casual)</td>
<td>Days</td>
<td>1</td>
<td>2</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Hand weeding (casual)</td>
<td>Days</td>
<td>1</td>
<td>2</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td><strong>SUB-TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,500</td>
</tr>
<tr>
<td>3. PLANTING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planting material</td>
<td>Slips</td>
<td>12,500</td>
<td>1</td>
<td></td>
<td>12,500</td>
</tr>
<tr>
<td>Treatment (casual)</td>
<td>Days</td>
<td>2</td>
<td>50</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Labour (casual)</td>
<td>Days</td>
<td>5</td>
<td>50</td>
<td></td>
<td>250</td>
</tr>
<tr>
<td><strong>SUB-TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12,850</td>
</tr>
<tr>
<td>4. FERTILISERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPK</td>
<td>Bags</td>
<td>1</td>
<td>8</td>
<td>95</td>
<td>760</td>
</tr>
<tr>
<td>Urea</td>
<td>Bags</td>
<td>1</td>
<td>4</td>
<td>95</td>
<td>380</td>
</tr>
<tr>
<td>Labour (casual)</td>
<td>Days</td>
<td>2</td>
<td>4</td>
<td>50</td>
<td>200</td>
</tr>
<tr>
<td><strong>SUB-TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,340</td>
</tr>
<tr>
<td>5. PEST/DISEASE CONTROL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insecticide/nematicide (Vydate L)</td>
<td>Litre</td>
<td>1</td>
<td>0.5</td>
<td>140</td>
<td>70</td>
</tr>
<tr>
<td>Insecticide (Malathion)</td>
<td>Litre</td>
<td>1</td>
<td>1</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Labour (casual)</td>
<td>Days</td>
<td>2</td>
<td>2</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td><strong>SUB-TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>230</td>
</tr>
</tbody>
</table>

56
### Appendix 1 cont’d

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Quantity</th>
<th>Rate</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6. FLORAL INDUCTION</strong></td>
<td>Ethethon 2 Litre</td>
<td>1</td>
<td>190</td>
<td>190</td>
</tr>
<tr>
<td></td>
<td>Labour (skilled) Days</td>
<td>2</td>
<td>6</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>SUB-TOTAL</td>
<td></td>
<td></td>
<td>490</td>
</tr>
<tr>
<td><strong>7. HARVESTING</strong></td>
<td>Knives</td>
<td>4</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Labour (casual) Days</td>
<td>4</td>
<td>5</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>SUB-TOTAL</td>
<td></td>
<td></td>
<td>290</td>
</tr>
<tr>
<td><strong>8. GRADING</strong></td>
<td>Labour (skilled) Days</td>
<td>4</td>
<td>4</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>SUB-TOTAL</td>
<td></td>
<td></td>
<td>240</td>
</tr>
<tr>
<td><strong>9. CLEANING &amp; ROSETTING</strong></td>
<td>Cleaning brushes</td>
<td>2</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Knives</td>
<td>2</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Labour (skilled) Days</td>
<td>4</td>
<td>8</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>SUB-TOTAL</td>
<td></td>
<td></td>
<td>480</td>
</tr>
<tr>
<td><strong>10. PACKING</strong></td>
<td>Cartons Boxes</td>
<td>2,100</td>
<td>4</td>
<td>8,400</td>
</tr>
<tr>
<td></td>
<td>Shredded paper Bags</td>
<td>20</td>
<td>10</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Tape Rolls</td>
<td>10</td>
<td>30</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>Transportation Trips</td>
<td>4</td>
<td>4</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Labour (skilled) Days</td>
<td>8</td>
<td>60</td>
<td>480</td>
</tr>
<tr>
<td></td>
<td>SUB-TOTAL</td>
<td></td>
<td></td>
<td>10,180</td>
</tr>
<tr>
<td><strong>11. TRANSPORTATION</strong></td>
<td>Inputs to farm Hours</td>
<td>4</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Pineapples to port Hours</td>
<td>4</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Collection of slips Hours</td>
<td>2</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Labour (casual) Days</td>
<td>4</td>
<td>50</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>SUB-TOTAL</td>
<td></td>
<td></td>
<td>440</td>
</tr>
<tr>
<td><strong>12. ADMINISTRATION</strong></td>
<td>Labour</td>
<td>4</td>
<td>100</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>SUB-TOTAL</td>
<td></td>
<td></td>
<td>400</td>
</tr>
</tbody>
</table>
### Appendix 1 cont’d

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>13. TOTAL VARIABLE COST</strong></td>
<td></td>
<td></td>
<td>30,706</td>
</tr>
<tr>
<td><strong>14. GROSS REVENUE</strong></td>
<td>Kg</td>
<td>25,000</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>15. GROSS MARGIN</strong></td>
<td></td>
<td></td>
<td>6,794</td>
</tr>
</tbody>
</table>

Compiled by CARDI Dominica 2001; revised in 2006

Cultivar: Smooth Cayenne

Frequency: Number of times activity is carried out

Plant spacing: 30 cm x 60 cm

Average weight/fruit: 2 kg

Harvesting starts at 12 months after planting.
### Appendix 2: Conversion factors for metric and imperial units

<table>
<thead>
<tr>
<th>To convert metric unit into imperial unit multiply by:</th>
<th>Metric unit</th>
<th>Imperial unit</th>
<th>To convert imperial unit into metric unit multiply by:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.094</td>
<td>metre, m</td>
<td>yard, yd</td>
<td>0.914</td>
</tr>
<tr>
<td>3.281</td>
<td>metre, m</td>
<td>foot, ft</td>
<td>0.305</td>
</tr>
<tr>
<td>0.0328</td>
<td>centimetre, cm</td>
<td>foot, ft</td>
<td>30.480</td>
</tr>
<tr>
<td>0.394</td>
<td>centimetre, cm</td>
<td>inch, in</td>
<td>2.540</td>
</tr>
<tr>
<td>0.0394</td>
<td>millimetre, mm</td>
<td>inch, in</td>
<td>25.400</td>
</tr>
<tr>
<td><strong>Area</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.471</td>
<td>hectare, ha</td>
<td>acre</td>
<td>0.405</td>
</tr>
<tr>
<td>0.000247</td>
<td>square metre, m²</td>
<td>acre</td>
<td>0.00405</td>
</tr>
<tr>
<td>0.836</td>
<td>square metre, m²</td>
<td>square yard, yd²</td>
<td>1.196</td>
</tr>
<tr>
<td>10.764</td>
<td>square metre, m²</td>
<td>square foot, ft²</td>
<td>0.0929</td>
</tr>
<tr>
<td><strong>Volume</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.88</td>
<td>litre, L</td>
<td>imperial quart, qt</td>
<td>1.136</td>
</tr>
<tr>
<td>2.11</td>
<td>litre, L</td>
<td>US pint, pt</td>
<td>0.473</td>
</tr>
<tr>
<td>1.75</td>
<td>litre, L</td>
<td>imperial pint, pt</td>
<td>0.570</td>
</tr>
<tr>
<td>0.265</td>
<td>litre, L</td>
<td>US gallon, gal</td>
<td>3.785</td>
</tr>
<tr>
<td>0.220</td>
<td>litre, L</td>
<td>imperial gallon, gal</td>
<td>4.546</td>
</tr>
<tr>
<td>33.78</td>
<td>litre, L</td>
<td>US fluid ounce, fl oz</td>
<td>0.0296</td>
</tr>
<tr>
<td>0.0352</td>
<td>millilitre, mL</td>
<td>imperial fluid ounce, fl oz</td>
<td>28.4</td>
</tr>
<tr>
<td><strong>Mass</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.00220</td>
<td>gram, g</td>
<td>pound, lb</td>
<td>454</td>
</tr>
<tr>
<td>0.0352</td>
<td>gram, g</td>
<td>ounce, oz</td>
<td>28.4</td>
</tr>
<tr>
<td>2.205</td>
<td>kilogram, kg</td>
<td>pound, lb</td>
<td>0.454</td>
</tr>
<tr>
<td>0.0011</td>
<td>kilogram, kg</td>
<td>short ton (2000 lb), ton</td>
<td>907.</td>
</tr>
<tr>
<td>0.001</td>
<td>kilogram, kg</td>
<td>long ton (2240 lb), ton</td>
<td>1016</td>
</tr>
<tr>
<td>0.0197</td>
<td>kilogram, kg</td>
<td>hundredweight, cwt</td>
<td>50.8</td>
</tr>
<tr>
<td>1.102</td>
<td>tonne, t</td>
<td>short ( US) ton</td>
<td>0.907</td>
</tr>
<tr>
<td><strong>Yield and rate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.893</td>
<td>kilogram per hectare, kg/ha</td>
<td>pound per acre, lb/acre</td>
<td>1.121</td>
</tr>
<tr>
<td>0.446</td>
<td>tonne per hectare, t/ha</td>
<td>short ton per acre, ton/acre</td>
<td>2.240</td>
</tr>
<tr>
<td>0.398</td>
<td>tonne per hectare, t/ha</td>
<td>long per acre, ton/acre</td>
<td>2.516</td>
</tr>
<tr>
<td>0.107</td>
<td>litre per hectare, L/ha</td>
<td>US gallon per acre, gal/acre</td>
<td>9.350</td>
</tr>
<tr>
<td>0.089</td>
<td>litre per hectare, L/ha</td>
<td>imp. Gallon per acre, gal/acre</td>
<td>11.23</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/5 °C + 32</td>
<td>Celsius, °C</td>
<td>Fahrenheit, °F</td>
<td>5/9 ( °F – 32)</td>
</tr>
</tbody>
</table>