



Mauritius Research Council

Post-Harvest Quality of Banana

Final Report

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End Of Project Report

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EXECUTIVE SUMMARY

Banana, one of the most important fruits grown in Mauritius, is subject to heavy post-harvest losses as a result of poor handling, harvesting, ripening and storage practices.

The project reports on activities that were undertaken with the aiming of developing a package of appropriate practices to minimise post-harvest quality deterioration in banana. These focus on the determination of a harvest maturity index for commercially important banana cultivars, an optimum storage regime for extending shelf life of artificially ripened fruits and the identification of major post-harvest diseases and their control.

Trials related to the determination of a proper harvest maturity index showed that bunch harvest age and finger diameter are the best indices for judging time of harvest. However, variations of these indices were observed depending on varieties, growing sites and bearing season.

Fruits harvested at different harvest ages showed significant variations (9 - 25 days) in the potential green life and did not ripen uniformly at ambient conditions. On the other hand, under industrial ripening conditions or with Ethrel dip treatment, the fruits ripened uniformly and had a shelf life of 7 - 8 days.

Industrially ripened fruits had a shelf life of 13 days when stored at 18°C as compared 12 days when stored at ambient temperature and only 7 days when stored under warm conditions (temperature of 26 °C). Moreover, storage at 26°C was associated with inhibition of degreening of the peel and enhanced softening of the pulp, thereby resulting in poor quality fruits.

Market survey results revealed that the major post harvest diseases were the crown rot disease (*Fusarium* sp. and *Colletotrichum* sp.), anthracnose (*Colletotrichum* spp) and finger tip rot disease (*Colletotrichum* sp. and *Fusarium* sp.). Used as a dip immediately after harvest, Benomyl @ 250 ppm and thiabendazol @ 500 ppm were found to be effective in controlling the crown rot disease.

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1.0 INTRODUCTION

Banana is one of the major fruits produced all year round in Mauritius. It is very much appreciated for its taste and nutritive value. Its cultivation occupies some 500 hectares of land with an annual production of about 9,000 tonnes. All of the production is consumed locally, mainly as dessert banana. So far no loss assessment exercise has been carried out to quantify post-harvest losses in banana in Mauritius. It has however been observed that post-harvest losses in banana were quite high. In addition, the quality of banana fruits on the market is poor in terms of overall appearance (colour, size, firmness, severity of blemishes) and shelf life of the fruit. Thus marketing such fruits becomes difficult.

The major causes of post-harvest losses and poor fruit quality are namely:

- improper stage of fruits at harvest (too early or too late)
- mechanical damage to fruits as a result of poor harvesting and handling procedures
- physiological breakdown caused by poor ripening and storage conditions, particularly during summer
- pathological problems caused by latent fungal diseases developing during fruit ripening

In view of the increasing demand for high quality fruits, especially by hotels and supermarkets, it was felt imperative that research and development activities be undertaken to improve the post-harvest quality of banana and thus its marketability.

1.1 Aim of Project

This project aimed at developing a package of practices to minimize post-harvest quality deterioration of banana fruits through adoption of appropriate technology, with emphasis on the determination of optimum harvest maturity, post-harvest treatments to control diseases and the extension of shelf life after industrial ripening

1.2 Project Objectives

The specific objectives of the project were

- To determine the optimum harvest age of commercially important banana cultivars
- To assess the disease status on banana on the market and to evaluate the effects of potential fungicides in controlling the major post-harvest diseases
- To investigate the effects of different ripening regimes on the quality of fruits harvested at the same physiological age

- To investigate the effects of temperature during storage on the quality and shelf life of fruits after industrial ripening

2.0 PROJECT ACTIVITIES

The project activities comprised the following 4 experiments:

Experiment 1: Determination of the right maturity index for harvesting banana

Objective

To determine the optimum maturity stage for harvesting banana in order to obtain fruits of acceptable quality in terms of overall appearance (size, shape, colour), green life and good eating quality when ripe

Three trials were conducted and the details are given below:

Trial 1

Studies on variations in the maturity indices for

- banana variety Dwarf Cavendish harvested at different physiological ages from Medine during the summer and winter months and
- banana variety Williams of different physiological ages harvested from Britannia S. E. and Wooton Crop Research Station during the same period

- The objective of this trial was to determine the relationship between maturity stages (indices) and the physiological changes during fruit development.
- Physiological ages (time from flower emergence to harvest) at which banana bunches were harvested:

Period	Physiological ages
Summer:	12 to 16 weeks at weekly interval
Winter:	13 to 18 weeks at weekly interval

- Fruit bearing cycle:
 - Cultivar Dwarf Cavendish
 - Summer - October 1996 to February 1997
 - Winter - March 1997 to July 1997
 - Cultivar - Williams
 - Fruit bearing cycle : Winter months (March 98 to July/ August 98)

Methodology

1. Banana used for this experiment was produced according to standard commercial practices in a one year old banana plantation. At each site, the banana plantation was visited weekly and the date of emergence (shooting) of each bunch was recorded to calculate the physiological age of the bunch at harvest.
2. Preharvest bunch management practices such as bunch clearing (removal of any leaves that obstruct bunch development) and debudding (removal of male flower bud or “popotte”) were practised.
3. Five banana bunches at a given physiological age (between 12 to 18 weeks) were harvested at the same time and were dehandled in the field.
4. The following parameters were measured:
 - Physiological age of the bunch
 - Weight of the bunch
 - Number of fingers
 - Number of hands
 - Length of finger (external curvature) using banana finger gauge *
 - Diameter of finger using Vernier caliper *
 - Pulp : peel ratio **

Note :

* *readings were taken from the middle outermost finger of the second hand from the distal end of the bunch*

** *A sample of 10 individual fingers was taken randomly from each bunch at the time of harvest. The fruits were peeled with a sharp knife to separate the peel from the pulp and the pulp to peel ratio was calculated on a weight basis.*

Trial 2

Effect of harvest age of bunch on the green life and post harvest quality of fruits stored at ambient conditions

Trial Objective

To determine the optimum harvest age or caliper grade for harvesting banana (cultivar Dwarf Cavendish) in order to obtain fruits with a green life of 7 to 20 days for local market.

Methodology

Site of production: Medine S.E

Variety: Dwarf Cavendish

Period of bunch production – July to December 1997

Bananas were produced according to standard commercial practices at Medine Sugar Estate. The date of flower emergence (shooting) of each bunch was recorded to calculate the physiological age of the bunch at harvest. Five bunches of each of the 4 different harvest ages studied were harvested and the finger diameter (caliper grade) for each bunch was measured. Four hands (numbers 1, 3, 5 and 7 from the proximal end) were placed on trays in ambient storage to study the potential green life of the fruits in the Post-harvest laboratory at Wooton Experiment Station. Each treatment was replicated 3 times.

The fruit samples were daily scored for :

- peel colour (score 1 to 7 using banana ripening chart- Catalytic Generators, Inc.)*
- weight of fruit
- sign of ripening / softening
- splitting and
- post-harvest disease development

* Peel colour index

1 – Green

2 – Green with trace of yellow

3 – More green than yellow

4 – More yellow than green

5 – Yellow with green tips

6 – All yellow

7 – Yellow with brown flecks

The green life is calculated as the period (in days) between harvest and the start of ripening. The latter is recorded when coloration on any hand or finger in a sample is detected.

Trial 3

Effects of different ripening treatments on the ripening, post-harvest quality and shelf life of fruits harvested at different harvest ages

Trial Objective

To determine the optimum the harvest age for harvesting banana variety Williams

Methodology

Bananas of the variety Dwarf Cavendish were produced according to standard commercial practices at Medine Sugar Estate. The date of flower emergence (shooting) of each bunch was recorded, so as to calculate the physiological age of the bunch at harvest. Five of each of the 4 harvest ages (with

4 replicates) were harvested and dehanded. Clusters of 6 fruits from the 2nd and 3rd hands from the proximal end were selected from which samples of a total of 30 fruits were subject to different ripening regimes namely : (I) control (natural ripening at ambient conditions), (ii) industrial ripening conditions for 4 days and (iii) dipping in 1 % ethrel solution for 2 minutes prior to storage at ambient conditions.

The shelf life of the fruits was determined by daily assessment of the following parameters:

- Weight
- Colour of fruit peel
- Overall quality of the fruits

Experiment 2: Appraisal, identification and characterization of major post-harvest diseases and disorders in banana

Objective

To identify and characterise the major post-harvest diseases/disorders of banana in Mauritius.

Activities undertaken

A survey of the main markets was conducted at periods (June to October 1996 and April to August 1997) for visual identification of the major post-harvest diseases/disorders of banana and for collection of samples of fruits for the following assessments:

- Isolation and culture of fungal microorganisms from the diseased specimens.
- Identification of fungal pathogens involved.

Methodology

Eight markets situated in different localities were visited at monthly interval to detect major post-harvest diseases of banana fruits and to collect banana fruits for isolation of the micro-organisms from the infected parts. About 1 – 2% of fruits were bought from one or two sale points and transported in polyethylene bags to the Plant Pathology Laboratory for diagnosis.

The banana hands were kept in the laboratory for a few days under ambient temperature. Observations and isolations were made at regular intervals from the advancing margins of the diseases.

Diseased tissues were plated on standard potato dextrose agar medium and kept at room temperature for three to five days. Fungi growing on the plated medium were identified using a light microscope.

Experiment 3: Evaluation of fungicides for the control of economically important Post harvest diseases.

The survey on disease status of banana on the Mauritian market revealed that the crown rot is a major post-harvest problem. It develops rapidly during fruit ripening and very often results in the darkening and weakening of the pedicels, which then cause the individual fruit of the hand to separate easily from the crown. Consequently both the quality and marketability of the fruit is reduced. Devising of a simple and efficient means of controlling this disease was thus warranted.

Objective

Development of a practical method to control the major post-harvest diseases of banana

Methodology

The trials were laid out in randomized complete block design with four replicates. Each replicate consisted of one banana hand with 12 to 18 fruits. The treatments consisted of four fungicides at two concentration levels:

- thiabendazole (Mertect 20S TBZ) @ 500 and 1000ppm,
- benomyl (Benlate 250) @ 250 and 500 ppm,
- chlorothalonil (Bravo 500) @ 500 and 1000 ppm and
- prochloraz (Sportak 40) @ 500 and 1000 ppm).
- Water was used as a standard (control).

Bunches of banana var. Dwarf Cavendish of uniform maturity were harvested green and deheaded in the field as per established post-harvest systems. Thirty six unbruised and healthy hands were randomly selected and dipped for two minutes in 20 L of the respective fungicidal solutions incorporated with sticker Fidowett (@ 1ml/5L). The treated banana hands were then air dried and randomly placed in plastic crates prior to artificial ripening in temperature controlled room of a ripening unit for three and a half days. The fruits were then allowed to ripen at ambient temperature and assessment for crown infection on the crown area was carried out at three intervals (5, 7 and 9 days after harvest) till the fruits attained the optimal stage of ripeness. The ripening index used was based on an established banana ripening chart (catalytic generators inc., USA) with scale 1 to 7 (i.e 1= green to 7= yellow fruits flecked with brown spots).

Severity of infection was measured in terms of a Disease Index based on a slightly modified scale (0 to 5) developed by Frossard and Laville (1973);

where 0= Apparently healthy fruits

1= slight infection

2= 25 % of crown infected

3= 50 % of crown infected

4= 100 % of crown infected

5= Entire crown infected and infection progressing towards the pedicels (fingers)

Experiment 4: Evaluation of different storage temperature regimes (cold, ambient and warm) on the shelf life and post harvest quality of industrially ripened fruits harvested at the same maturity

Objective

To determine the best storage condition for the marketing of industrially ripened banana fruits for longer shelf-life and post-harvest quality.

Methodology

Banana bunches were harvested at full $\frac{3}{4}$ angularity (finger diameter 32 – 33 mm) and dehanded. Clusters of 6 fruits from the second and third hands were selected from which 5 clusters (total of 30 fruits), with replicates, were used per treatment. On the same day of harvest, the fruits were subjected to industrial banana ripening conditions at Soci  t   de la Reserve. The fruits were exposed to a source of ethylene under temperature controlled conditions (16 – 18  C) for 6 days for ripening. After the ripening treatment, the fruits were removed, scored for peel colour and then stored at cool (18  C), ambient(mean 22.5  C) or warm (26   C). The control consisted of storing the fruits immediately after harvest. The fruits were daily assessed for weight, peel colour, shelf life and for each treatment a representative fruit sample of 3 fruits was used for assessment of brix and pulp firmness at peel colour score 5.

3.0 RESULTS AND DISCUSSIONS

3.1 Determination of right maturity index (Experiment 1)

The parameters observed to derive the right maturity index are presented in Table 1. There was a positive correlation between mean fruit weight, mean finger length and finger diameter and harvest age of bunch (Table 3). Among the parameters observed, the physiological age of the bunch (i.e. age of bunch after emergence from the pseudostem) and the finger diameter (caliper grade) seem to be more appropriate for determining when banana should be harvested. They are reasonably precise, practical relatively easy and nondestructive methods of determining maturity stage of

banana. The fact that the finger diameter varies among hands in a bunch, it is usually measured on a pre-determined finger on each bunch.

Table 1: Parameters for maturity index determination in banana variety Dwarf Cavendish harvested at different harvest ages during the summer and winter

Bearing period	Harvest age (weeks)	No. of bunch	Fruit weight (g)		Finger length (cm)		Finger diameter (cm)		pulp/peel ratio	
			Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E
Summer	12	5	99.77	2.24	17.36	0.17	2.96	0.02	0.93	0.02
	13	5	106.64	5.56	17.20	0.51	2.98	0.13	1.04	0.05
	14	5	114.54	9.02	17.40	0.73	2.95	0.17	1.08	0.04
	15	5	108.22	3.78	17.40	0.18	2.99	0.07	1.08	0.06
	16	5	112.32	4.78	18.60	0.40	3.16	0.03	1.10	0.05
Winter	13	5	86.57	0.89	17.35	0.10	2.80	0.03	0.93	0.02
	14	5	88.19	1.63	17.50	0.50	2.86	0.06	0.95	0.02
	15	5	91.43	2.52	18.17	0.12	2.92	0.02	0.97	0.03
	16	5	93.60	2.69	19.25	0.25	3.14	0.07	1.01	0.01
	17	5	91.04	1.16	19.13	0.12	3.08	0.08	1.07	0.05
	18	5	106.92	1.65	19.60	0.10	3.13	0.08	1.21	0.01

It is taken as the thickness of the middle finger (at broadest end) of the outer whorl of the second hand from the proximal end of the bunch using a Vernier caliper. This measurement gives a good indication of the angularity of the fruit (degree of fillness) and for the variety. Dwarf Cavendish, results indicate that it is better to harvest the bunch when the finger diameter has attained a minimum of 31 mm to be able to get fruits of good overall appearance in terms of size, angularity (degree of fillness) and pulp: peel ratio (1:1 or above) and acceptable eating quality when ripe.

Although there is a general trend for mean fruit weight to increase with increase in harvest age of bunch, the high values of the standard indicate that it is not a reliable index. The variation in fruit weight can be explained by the fact that all the banana bunches do not have same number of fingers. Furthermore, it was observed that bunches harvested at same physiological age had mean fruit weight of lower values in winter cycle than in the summer cycle. This difference in growth rate may be attributed to variations in sum of mean daily temperatures obtained during the bunch growth cycle as reported by Ganry et al 1978.

The pulp to peel ratio also gives a very good indication of banana maturity. For the banana variety Dwarf Cavendish, it was observed that fruits from bunches with a mean pulp: peel ratio of 1: 1 or above showed an acceptable level of maturity for ripening. However, being a destructive method of

analysis, its use would therefore be of limited practical application to banana growers.

Table 2: Maturity indices of banana (cv Williams) at different harvest ages

Harvest age (weeks)	Mean finger weight (g)	Mean finger length (cm)	Mean finger diameter (cm)	Pulp/peel Ratio
12	110.41	19.50	3.07	0.97
13	116.83	19.59	3.11	0.99
14	123.79	19.75	3.23	1.15
15	124.31	20.17	3.25	1.24

Table 3: Correlation among the parameters for determining the maturity index that could be used for harvesting banana

Correlation	Harvest age	Mean fruit wt.	Mean finger length	Mean finger diameter	Pulp/peel ratio
Harvest age	1.0000				
Mean fruit wt	0.9559	1.0000			
Mean finger length	0.9441	0.8085	1.0000		
Mean finger diameter	0.9564	0.9639	0.8672	1.0000	
Pulp / peel ratio	0.9429	0.8758	0.9430	0.9636	1.0000

Table 4: Parameters for maturity index determination in banana variety Williams

Harvest age (weeks)	Mean fruit weight (g)	Mean finger length (cm)	Mean finger diameter (cm)	Pulp/peel Ratio
13	93.61	17.50	2.92	0.94
14	91.96	17.50	3.01	0.098
15	97.66	17.75	3.18	1.01
16	103.17	17.72	3.18	1.01
17	111.99	18.21	3.36	1.14
18	116.59	18.29	3.27	1.16
19	125.02	18.85	3.39	1.22

Observations made on variety Williams at Britannia E.S and Wooton Crop Research Station showed that the optimum harvest age of the same variety varies with the locality, climatic conditions and probably due to difference in management practices. At Britannia E.S, bunches harvested 14 weeks after flower emergence of optimum maturity while those at WES attained maturity after 16 weeks.

The high correlation coefficient (0.96) obtained between the mean finger diameter (caliper grade)

and the pulp: peel ratio indicates that finger diameter can be used as an easier, non-destructive index of harvest maturity. In order to get an acceptable minimum pulp : peel ratio of 1:1, it would be best to harvest the banana variety Williams when the finger diameter is in the range of 3.18 and 3.23 cm (see tables above). However, for practical reason, it would be advisable to recommend harvesting this variety when the finger diameter has reached at least 32 mm.

The present study was to determine an objective, simple and non-destructive maturity index that could be used as a commercial practice to harvest banana at the optimum stage of maturity. Among the other parameters such as mean finger weight, finger length and pulp : peel ratio, it is the monitoring of the finger diameter of a pre-determined finger on the banana bunch that provided a closer indication of optimum fruit maturity. Moreover it requires inexpensive equipment and can be readily performed by growers in the field. There is a special banana caliper available to growers to assess banana maturity in banana exporting countries. Consequently, introduction of this simple equipment among our banana growers can prove useful in view of improving the banana quality.

Previous research (Montoyo et al, 1984) has shown that it is impossible to set finger diameter or bunch age limit alone for universal application since the growth rate varied substantially according to fruit growing conditions. However, both bunch age and finger diameter should be used together as indices of harvest maturity.

Trial 2

Effect of harvest age of bunch on the green life and post harvest quality of fruits stored at ambient conditions

Results showed that the potential green life of individual bunches ranged between 6 and 46 days. Fruits from bunches of higher age have relatively short potential green life than bunches of lower age (Table 5).

Table 5: Potential green life of banana fruits harvested at different physiological ages

Harvest age (weeks)	Green life (days)		
	Mean	S.D.	
12	44.0	8.12	SD/ Mean 18%
14	28.6	4.32	15%
16	18.8	2.64	14%
18	8.8	1.92	22%

The variation in potential green life observed among bunches of different physiological ages may be attributable to the inclusion of older bunches which have a shorter green life in the experiment. Furthermore, it was observed that fruits from bunches harvested at higher age tend to ripen more uniformly as compared to fruits of lower bunch ages. It was also noted that when the fruits were stored beyond 2 weeks, there was a significant loss in weight (up to 19.2 %) and freshness.

Wherever natural off plant ripening practice is adopted, it is advisable to harvest the fruits when they have attained a maturity stage which would enable them ripen uniformly within 2 weeks, without suffering from appreciable weight loss. Banana bunches harvested too early take unduly long time to ripen naturally, the fruits have a stale appearance with desiccated and darkened skin, weakened, and withered pedicels and fungal rotting. On the other hand late harvesting may also result in greater losses due to premature ripening during storage and splitting during transport and handling.

Determining the optimum harvest age with an acceptable green life is particularly useful for commercial exploitation of banana production. The banana growers can harvest at the right stage and plan the ripening so as to supply the market with fruits of a predetermined stage of ripeness at required time.

Table 6: Peel colour score of untreated naturally ripened, ethrel ripened and industrially ripened banana var Dwarf Cavendish

		Mean peel colour score													
Days after treatment		0	1	2	3	4	5	6	7	8	10	12	16	20	24
Treatments	Harvest age (weeks)														
Ethrel dip tmt.	12	1	1	1	1.8	2.9	4.6	5.2	6.3	7					
	14	1	1	1	2.2	3.5	4.8	6.1	7						
	16	1	1	2.9	3.4	4.6	5.6	6.2	7						
	18	1	1	3.1	4.4	5.6	6.0	6.6	7						
Mean % wt. loss at c.s 7*									7.2						
Industrial ripening (4 days)	12	1			4.4	5	6	6	7						
	14	1				4.8	5	6	7						
	16	1				5	6	6.3	7						
	18	1				5	6	6.5	7						
Mean % wt. Loss at c.s 7								4.9							
Control (natural off-plant ripening)	12	1	1	1	1	1.6	1.9	2.8	3.4	3.9	4.6	5.2	5.6	6.3	6.5
	14	1	1	1.1	1.5	2.3	2.8	3.2	3.6	4.5	5.3	6.4	6.7	7	
	16	1	1.2	1.9	2.2	2.5	3.1	3.8	4.1	4.3	5.2	6.3	7		
	18	1	1	2.4	3.0	3.5	4.2	4.6	5.2	6.0	6.2	7			
Mean % wt. Loss at c.s 7											7.6			12.8	13.7

*c.s: Colour score

Trial 3

Effects of different ripening treatments on the ripening, post-harvest quality and shelf life of fruits harvested at different harvest ages

The time taken for fruits harvested at 4 harvest ages to reach end of shelf life (colour score 7) after being subjected to different ripening treatments is summarised in Table 6.

Whatever the harvest age, it was observed that compared to the control, fruits treated with Ethrel solution (dip in 1 % solution for 2 minutes) and ethylene under industrial conditions ripened significantly faster. However, significant variation in the ripening response was observed among the naturally ripened fruits harvested at different harvest ages. The more mature fruits reach the eating quality (colour score 5/ 6) more readily than the less mature ones. On the other hand, no significant variation in the ripening response was noted in industrial and Ethrel ripened fruits picked at varying physiological ages. This shows that bananas harvested at varying maturity stages can be brought to

ripen more or less uniformly when subjected to induced ripening whether with an ethylene releasing compound or ethylene gas itself.

Experiment 2: Appraisal, identification and characterization of major post-harvest diseases and disorders in banana

Table 7: Diseases and disorders recorded on ripening banana samples as well as the frequency of occurrence and the micro-organisms isolated

Disease / Disorders	Frequency (%) of occurrence	Micro-organisms isolated
Crown rot	86	<i>Fusarium sp.</i> , <i>Colletotrichum sp.</i> , <i>Cladosporium sp.</i> , <i>Verticillium sp.</i>
Peel injury , Bruising and Anthracnose	60	<i>Colletotrichum sp.</i> , <i>Fusarium sp.</i>
Anthracnose	9	<i>Colletotrichum sp.</i>
Anthracnose (latent)	8	<i>Colletotrichum sp.</i>
Finger tip rot	8	<i>Colletotrichum sp.</i> , <i>Fusarium sp.</i>
Ripe rot	5	<i>Fusarium sp.</i>
Uneven ripening*	3	

Results of the survey carried out over 8 different sampling periods with a total of 96 banana samples revealed that Crown rot was the major post-harvest disease on ripening banana fruits, followed by anthracnose and finger tip rot. Crown rot is primarily caused by *Fusarium sp.* in combination with *Colletotrichum sp.*, but in some rare cases *Verticillium sp* and *Cladosporium sp.*, were also isolated.

Table 8: Mean number of hands with crown rot index after treatment with fungicide

Days after harvest		5					7					9							
Crown rot index*		0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5
Fungicide	Conc. (ppm)																		
Thiabendazole	500	4.0						3.7	0.3					3.0	0.7	0.3			
Thiabendazole	1000	4.0						4.0						4.0					
Benomyl	250	4.0						3.7	0.3					3.0	0.7	0.3			
Benomyl	500	4.0						4.0						4.0					
Chlorothalonil	500	2.3	1.7						3.3	0.7					3.0	1.0			
Chlorothalonil	1000	3.7	0.3					3.3	0.7					0.7	3.0	0.3			
Prochloraz	500	2.7	1.3					2.7	1.3					2.7	1.3				
Prochloraz	1000	2.7	1.3					2.7	1.3					2.7	1.3				
Control (water)			1.3	1.3	1.3					0.3	2.7	1.0					0.7	2.3	1.0

* Disease index : 0 = Apparently healthy fruits

1 = slight infection

2 = 25 % of crown infected

3 = 50 % of crown infected

4 = 100 % of crown infected

5 = Entire crown infected and infection progressing towards pedicels (fingers)

Table 9: Severity of crown rot infection

Days after harvest		Mean Crown rot index		
		5	7	9
Fungicide	Conc. (ppm)			
Thiabendazole	500	0.0	0.1	0.3
	1000	0.0	0.0	0.0
Benomyl	250	0.0	0.1	0.3
	500	0.0	0.0	0.0
Chlorothalonil	500	0.4	1.2	1.3
	1000	0.1	0.2	0.9
Prochloraz	500	0.3	0.3	0.3
	1000	0.3	0.3	0.3
Control (water)		2.0	3.2	4.1

Results from Table 8 and 9 indicate that all four fungicides used controls crown rot development as compared to the untreated fruits. However, the effects of fungicides benomyl and thiabendazole were found to be superior as compared with chlorothalonil and prochloraz probably due to their persistence. Moreover there was considerable improvement in quality and shelf-life. Fruits treated with fungicide prochloraz developed an off-taste. No phytotoxicity was noted in all the treated fruits. Crown rot development was evident on the untreated hands after 5 days and the infection became severe 9 days after (Table 9).

The results also indicate that satisfactory control of the crown rot disease can be achieved with thiabendazole at 500 ppm and 1000 ppm and benomyl at 250 ppm and 1000 ppm. The values give a clear indication of the evolution of the Crown rot infection in the control and the prolonged effect of each fungicidal treatment with time. It must however be pointed out that Crown rot was always present in the control. Fungal growth in untreated bananas increased with time and a severe rotting of the crowns was observed when the fruits reached optimum stage of ripening (ripening index 5 to 6 after 9 days).

The fungicide treated hands on the other hand reduced the occurrence of crown rot disease. Chlorothalonil at 1000 ppm did provide absolute control of Crown rot (disease index 0) until day 7 only. In two trials (out of three), Prochloraz also provided absolute control of crown rot. Results of a tasting panel indicated that this fungicide led to an off-taste in the treated fruits. Benomyl and thiabendazole at both levels provided absolute control of crown rot disease until for 9 days.

Experiment 4: Effects of storage temperature regimes on shelf life of industrially ripened fruits

The temperature at which industrially ripened banana fruits are kept has definitely a significant effect on the subsequent shelf life of the fruits. Industrially ripened fruits stored at 18°C showed an extended shelf life as compared to those stored at ambient room temperature (mean storage temperature 22.5 °C). This extension of the longevity of the banana fruit represents an improvement in its marketability.

Table 10: Shelf life and mean colour score of industrially ripened fruits stored at different temperatures

Days		0	4	5	6	7	8	9	12	13	Mean % weight loss /fruit when fruit attain eating quality(c.s 6)
Ambient, industrial ripening	c.s	1.00	2.00	2.92	3.6	4.34	5.24	6.35	7.00		13.3
18°C, industrial ripening	c.s	1.00	2.00	2.4	3.0	4.0	5.0	6.0	6.57	7.00	7.8
26 °C, industrial ripening	c.s	1.00	2.00	2.42	3.42*	3.47**					9.1

c.s – mean colour score

Control – natural off plant ripening

Presence of Brown Flecks: * mild

** severe

However, under the simulated warm storage conditions (26 °C), the industrially ripened fruits failed to degreen uniformly, resulting in ‘green-ripe’ fruit with soften pulp.

After 2 days storage at 26°C, the fruits showed a mean peel colour score of 3.42 accompanied with the apparition of brown fleck, which is a sign of being over ripe. This is associated with fruits of very poor quality, very soft pulp with peel still partially green and the presence of brown flecks. These fruits are very difficult to market due to their short shelf life and poor appearance. Similarly, high temperatures prevailing in summer (> 24°C) usually result in similar problem.

Consequently, to avoid such problem particularly in the summer it is advisable to ripen banana under industrial temperature controlled conditions and to store ripened fruits in a cool ventilated place with temperature around 18 °C.

4.0 CONCLUSION

Banana harvest maturity index

The determination of the correct stage of maturity for harvesting banana bunch is important to obtain good quality fruits in terms of taste, flavour and overall appearance (fruit weight). The present study showed that physiological age (harvest age) and finger diameter (caliper grade) are reliable indices criteria for judging fruit maturity or time of harvest. Both maturity indices are however complementary and when used together gave better results. These indices can be readily adopted by growers to determine the correct maturity for harvest. However, a universal maturity index could not be devised as variations were observed among varieties, growing sites and season. Maturity index has to be worked out variety-wise for specific growing conditions.

Optimum harvest age

Harvest age was found to have a significant effect on the potential green life (time taken for commencement of ripening) of fruits. Trials have shown that banana variety Dwarf Cavendish harvested around 18 weeks from Medine has a relatively short green life of 1 to 14 days. They ripened uniformly without excessive dessication under ambient conditions. When harvested earlier (12 -14 weeks old), fruits in the hands failed to ripen uniformly.

Effect of different ripening treatment on the ripening of fruits of different harvest ages

Bananas of different harvest ages (varying maturity) were found to ripen successfully under industrial ripening conditions resulting in uniformly bright yellow coloured fruits with a general shelf life of 7 days. However, for fruits ripened by dipping in ethrel a slightly longer shelf life of 8 days was observed at ambient conditions for fruits from 12 weeks old bunches compared to fruits from 18 week old bunches which had a shelf life of 7 days. On the other hand, ripening of fruits of different harvest ages varied considerably in the time taken for the commencement of ripening (9 – 25 days). In addition, the fruits did not ripen uniformly and sometimes, it was observed that fruits of the lower harvest age failed to ripen properly, resulting in dessicated, dull “kaki” coloured fruits. Thus natural ripening is not suitable for ripening banana on commercial scale.

Major Post-harvest Diseases and control

Crown rot was the major post-harvest disease identified on ripening bananas on the Mauritian markets. It is primarily caused by *Fusarium* sp. in combination with *Colletotrichum* sp. Other post-harvest diseases identified were anthracnose and finger tip rot.

Result of trials undertaken to control crown rot disease development have shown that the quality and shelf life of banana fruits can be successfully improved through the use of fungicides like thiabendazole at 500 ppm or benomyl at 250 ppm used as post-harvest dip treatment immediately after harvest.

Shelf life of industrially ripened fruits stored at different temperatures

Industrially ripened fruits had the longest shelf life when stored at 18°C (13 days) as compared to ambient conditions (12 days) or simulated warm (26°C) market condition (6 days). Storage at warm condition (26°C) resulted in poor quality fruits. The fruits fail to degreen completely and the pulp softened rapidly resulting in fruits with brown flecks or spots on the skin at colour index 3.5 - 4 .

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RESEARCH AND DEVELOPMENT ACTIVITIES

1 Training of growers and extension officers on “Pre and Post Harvest Management Practices to improve quality of Banana”

The trainees were:

- 23 banana growers from the southern, eastern regions of the island as well as from the tea diversification areas, owning more than 1 ha of banana plantation
- 4 Senior Extension Officers
- 3 Extension Officers
- 1 Senior Extension Assistants and
- 3 Extension Assistants

Methodology

The one-day training session comprised a morning session devoted to talks, slides and 2 film show as well as discussion with growers and an afternoon session of a field demonstration on bunch management and harvesting techniques held at Medine Sugar Estates.

- The topics covered in the talk were as follows:

1. Bunch Protection Practices in the field

- Bunch clearing
- Deflowering
- Debudding
- Bunch cover
- Propping

2. Harvesting and Handling

- Harvesting grade
- Harvesting techniques (field dehanding)
- Post-harvest treatments (washing, delatexing and disease control)
- Packing
- Ripening procedures
- Storage

- The 2 films presented the practices adopted in commercial banana orchards in the Windward islands, namely:

-The treasure of the Windward islands

-Mechanical damage in banana handling : its consequences and how to avoid it (A Windband Production)

2 Demonstration

- The field demonstration session was conducted in the Banana orchard of Medine Sugar Estate and the practices demonstrated were:
- Field bunch protection practices
- Harvesting technique (care to be taken in this operation)
- Washing, delatexing and fungicide treatment
- Packing

3 Advisory leaflets

- Two information sheets specially prepared for this training were distributed to the trainees.

4 Follow up action:

Visit to large banana plantation and giving demonstration of bunch protection practices that can be adopted to improve fruit quality.

Giving advice to growers in setting up of temperature controlled room and ethylene source to be used.

5 Other Activities

Poster Presentation on “Control of Crown Rot Disease in Banana” by P. Peerthum at the 1998 Annual Meeting of Agricultural Scientist (August 1998)