MAURITIUS RESEARCH COUNCIL

INNOVATION FOR TECHNOLOGY

IMPROVING THE POST HARVEST OF FRESH RODRIGUAN LIMES

Final Report

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FINAL REPORT

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Summary

The objective of this project was to propose means of improving the post harvest quality of fresh Rodriguan lime in order to improve its marketability both for the domestic and export market. Through a Rapid Rural Appraisal undertaken in Rodrigues, pre harvest factors and post harvest practices limiting the post harvest quality of the Rodriguan lime were identified. Laboratory trials to improve shelf life of Rodriguan lime were carried out on (i) hot water and fungicidal treatments, (ii) harvest maturities and storage temperatures, (iii) respiration rate at different temperatures and (iv) effect of waxing and packaging. The findings of the RRA were used to propose training on orchard management while the outcomes of the laboratory trials contributed in the development of an adapted post harvest handling system for fresh Rodriguan lime. The quality of the fresh Rodriguan lime can be improved at (a) pre harvest level through better cultural practices (hole preparation, spacing, irrigation, fertilisation, pruning, control of pests and diseases), (b) harvest through selective picking of limes of diameter not less than 38 mm and (c) post harvest level through careful handling (to avoid bruises and contamination), sorting, grading and optimum treatment (with Candelilla wax at 10%), packaging (carton box lined with LDPE of 30 microns) ,transport (covered/refrigerated) and storage (13^0C).

INTRODUCTION

The Rodriguan lime, Limon Rodrigues, also known as the Mexican Lime (*Citrus aurantiifolia*, Swingle), is the most commonly grown fruit species in Rodrigues (Household Census, 2000). This is because it is the citrus species which is most tolerant to drought (Morton, 1987) and marginal growing conditions. An export market of fresh limes to Mauritius has developed over the past decades and amounted to 132 tonnes in 2005 (DOS, 2006). Moreover, processed limes into “piment limon” and “aigre-doux limon” have become popular and highly appreciated products from Rodrigues. These are indicators that opportunities exist for developing agribusinesses around fresh and processed Rodriguan limes.

Presently, the US, UK and Netherlands markets require mature green, size graded and waxed limes. The Rodriguan lime has characteristics which have export potential. It reaches maturity before turning yellow and the green rind makes the fruit competitive vis à vis other producing countries where the climate promotes rind yellowing at an early stage of maturity (P.Wahl, pers. comm., 2001). Furthermore, Rodriguan limes (Mexican limes), may fetch remunerative prices, 22 FRF/kg (Rs 88./kg) on the Rungis market, France. Therefore, Rodrigues could take advantage of this niche market.

However, the development of a sustainable industry around the Rodriguan lime is confronted with new challenges. Growers not only need to produce quality limes in terms of flavour and cosmetic appearance, they also need to prove that their produce is safe. Therefore, it is important to document the system of production of lime in Rodrigues in order to identify the constraints for producing quality limes and to formulate ways and means for improving post harvest quality.

PROJECT OBJECTIVES

Main objective

The main objective of this project was to look into pre harvest factors and post harvest practices which could improve the post harvest quality of fresh Rodriguan limes in view of increasing its marketability for the domestic as well as export market.

Sub-objectives

The sub-objectives of the project were to:

Objective 1

Identify the technical problems which are constraints to production of high quality limes.

Objective 2

Formulate solutions to resolve problems arising from (1) above.

Objective 3

Reduce post harvest decay of limes through hot water and fungicidal treatments.

Objective 4

Determine the storage life of the produce at different harvest maturities and temperatures.

Objective 5

Measure the respiration rate of the lime at different temperatures.

Objective 6

Extend the shelf life of the lime through packaging and waxing.

Objective 7

Develop a post harvest handling system for fresh Rodriguan limes

Objective 8

Train Rodriguan farmers on the production of quality limes.

1.0 PART I

1.1 Objective 1

To identify the technical problems which are constraints to production of high quality limes.

1.2 Researchable activities

1.2.1 Site visit to Rodrigues to conduct Rapid Rural Appraisal (RRA).

1.2.2 Validation of the findings of the RRA .

1.2.3 Assessment of the quality attributes of the Rodriguan lime.

1.3 Methodology

1.3.1 Activity 1 : Site visit to Rodrigues to conduct Rapid Rural Appraisal (RRA).

- A list of lime growers having more than 10 trees was obtained from the Agricultural Services, Rodrigues.
- From the list, stratified random sampling was conducted to choose 20 lime growers in different extension zones of Rodrigues. The table below shows the number of growers having more than 10 trees as per each region and the number of them surveyed.

Region	No. of growers having more than 10 trees	Number surveyed
La Ferme/ Maréchale	25	6
Citronelle	20	5
St. Gabriel	6	3
Trèfles	18	6

- A list of zones covered and growers interviewed is attached hereto (Appendix 1)
- An information record sheet (Appendix 2) was used to record the answers of our queries.
- The grower was prompted on an issue (e.g. pruning) and he was allowed to talk about his awareness and problems on the issue. His/her answers were then recorded. Very often, the investigators made direct observations to confirm their answers.
- The RRA in the fields was carried out on four consecutive days.
- The investigators also visited other stakeholders in the business of Rodriguan limes trade. The stakeholders included retailers, fruit collectors, exporters, handlers/porters, extension officers and distributors. The port area and the Port Mathurin open market were also visited to have an

overview of the practices conducted prior to the sales/export of fruits. All observations made were recorded.

- Air temperature at the port and the temperature inside the different types of packaging were noted using a temperature probe.

1.3.2 Activity 2. Validation of the findings of the RRA .

A Farmers' Participatory Workshop was conducted on the premises of the Agricultural Services, Rodrigues after the RRA.

- All the lime growers, retailers, fruit collectors, exporters, handlers/porters, extension officers and distributors were convened to the above-mentioned workshop in Citronelle, Rodrigues.
- Some 30 participants were present and they were asked to comment on the findings, which were presented to them by the investigators in the morning session. The findings were presented as per issue on the information record sheet (Appendix 2) and were confirmed by growers with few amendments
- In the afternoon session, the technical problems were categorised by the investigators and the participants prioritised them by the use of a scale 1 to 3 (1 for highest priority and 3 for lowest priority).
- During the same process, the participants proposed solutions, which were discussed before being accepted as future actions to resolve technical problems arising in the production of limes of good quality.

1.3.3 Activity 3. Assessment of the quality attributes of the Rodriguan lime.

- At the level of the retailers, fruit collectors, and exporters, samples of 100 fruits were taken randomly to record the following: fruit size, fruit weight, external appearance (presence of stalk, blemishes, disease symptom, firmness), °Brix, and % juice content, vitamin C content.

1.4 Results and Discussion

1.4.1 Findings of the RRA

1.4.1.1 Grower's Profile

The profile of the growers met is summarized in table 1

Table 1: Profile of lime growers

Identification		% of growers
Age Group	21-40	10
	41-55	65
	>55	25
Occupation	Full time grower	15
	Part time grower	85

The majority of the lime growers in Rodrigues were above 40 years old and were part time growers. For them, production from the lime trees was an additional source of income.

1.4.1.2 Profile of orchards

The profile of the lime plots is summarized in table 2.

Table 2: Profile of the lime plots visited

Orchard Characteristics		% of plantations
Production system	Full stand	65
	Mixed cropping	25
	Border tree	10
Size of plantation	< 20 trees	20
	20-50 trees	35
	51-100 trees	25
	>100 trees	20
Windbreak	absence	65
	presence	35

The RRA revealed that 65% of lime plantations were full stand, while 10% were planted along borders of vegetable fields and the rest interplanted with vegetables or other fruit trees. The majority of orchards (80%) consisted of more than 20 trees of which 27 % had established large orchards of 200 and 400 trees each.

Regarding protection against wind, only one orchard had “bread & cheese” (*Pithecellobium unguis*) planted as windbreak. In 65% of the orchards, there was complete absence of any windbreak while in the rest, the lime trees were either protected by a natural windbreak or were found in a protected valley.

1.4.1.3 Planting Method

1.4.1.3.1 *Hole size*

Out of the 20 growers, only 4 prepared holes of the recommended size of 0.6mx0.6mx0.6m for planting of seedling. The rest prepared holes whose depth was 30 cm or less, large enough to accommodate the seedling which was between 10 and 15 cm high at planting.

1.4.1.3.2 *Hole filling*

Most growers (60%) did not use any manure or fertilizer at planting. The others would use some manure (1/3 to 1/2 basket per hole) and fertilizers depending on availability of the latter.

1.4.1.3.3 *Planting density*

In 2 orchards, the lime trees were planted at regular spacing of 3m x3m. In the others, irregular spacing was used, varying between 1m and 5m. The spacing was often dependent on plot size. The smaller the plot size, the closer was the planting density.

1.4.1.4 Fertilisation

In 75% of the orchards, no fertilizer was applied during the whole productive life of the lime tree. In the other cases, fertilizer (13:13:20:2) was applied every 2 to 5 years, about 30 cm away from the trunk.

1.4.1.5 Irrigation

Water was scarcely available for irrigation. Most of the orchards were rainfed. No regular irrigation was practised except for 1 orchard where a drip irrigation system was functional. When agricultural water was available, lime trees would receive 2 to 5 watering cans of water per tree per week or fortnight. Newly planted seedlings were irrigated at the rate of 1 watering can for every 2 to 3 seedlings per week. In severe cases, the seedling was irrigated when it showed signs of wilting.

1.4.1.6 Pruning

In only 1 orchard, pruning was carried out regularly with appropriate tools (pruning saw and secateur). In all other orchards, no systematic pruning was carried out. Either, the grower did not have the know-how

or did not have appropriate tools. In 50% of the orchards, dead branches were removed haphazardly without the correct technique and tool. This resulted in damage to the trees and subsequent die-back.

1.4.1.7 Pests & Diseases

Table 3 shows the incidence of common pests and diseases in the orchards.

Table 3: Incidence of pests & diseases in lime orchards

Pests/Diseases	% of orchards infested
Mealy Bugs/Scale insects	40
Mites	20
Canker	40
Sooty Mould	40

Mealy bugs and scale insects accompanied by sooty mould were prevalent in 8 out of 20 orchards. The incidence was similar for canker where die back was observed in few severe cases. Mites were noted in 4 orchards where fruit quality was seriously impaired.

Growers were incapable of identifying pests and were unaware of control measures. In some cases, they waited for recommendations from extension officers for control measures or relied on the pest control programme of the Ministry of Agro Industry. Moreover, unavailability of a sprayer and appropriate pesticides were regular constraints.

1.4.1.8 Field Hygiene and Sanitation

In 60% of the orchards, manual weeding was carried out around the trees when required. In those orchards, a minimum floor management was carried out whereby fallen and rotten fruits were disposed of by burning or burying. In few cases, however, the rotten fruits were left in a corner of the orchard. Weed control and field hygiene were completely absent in the other orchards (40%).

1.4.1.9 Harvest, Postharvest handling and Marketing

In most orchards, limes were harvested on demand and not on maturity index. Green, turning yellow and yellow fruit were then harvested indiscriminately. The demand was high during departure of the ship to Mauritius. Then, fruit would be harvested 2 to 4 days before the date of shipment.

The time of harvest could be in the morning or afternoon and irrespective of the weather (e.g. rain). The method of harvest was through the use of a metal grip (crochet) tied to a pole for pulling down fruit

bearing branches. The fallen fruits were then picked from the ground and placed in raffia/gunny bags or buckets. The raffia or gunny bag would hold between 1000 and 1500 fruit depending on its size.

A minimal sorting was carried out in the field in few cases, to separate severely blemished and overripe fruits which were used/sold for processing.

Harvested limes were temporarily stored at the grower's house for eventual delivery to a collector or to the market. Depending on the request, a grading could be effected on the basis of colour (green, turning and yellow), size (small & large) and presence of blemishes. The sorting was carried out on the floor. In one case, the limes were spread on a blanket overnight before transferring to raffia bag.

The bags of lime were transported to Port Mathurin by bus, van or motorcycle. Up to 3 bags were allowed per bus at the cost of Rs 5.00 per bag. Many small growers often transported their fruits to Port Mathurin one to three days before date of shipment. These fruits were sold to buyers operating near the harbour. The latter purchased limes from different growers, packed them in raffia bags and stored them at ambient conditions prior to shipment. The bags of lime were kept directly on the floor of the stores which were not properly ventilated. In few cases, the exporter collecting fruits at growers' premises would carry out a quick visual assessment of the fruit quality to decide on the price. A bag sampled at random would be spread on the floor for this operation and then be repacked in the raffia/gunny bag . On the date of shipment, the limes packed in raffia bags, gunny bags, wooden boxes or nylon bags were brought to the port early in the morning (between 7.00 and 10.00 a.m.).There, they were placed on pallets, exposed to the sun until they were loaded (1.30 p.m.) in modified non-refrigerated containers (containers with two open slits of 1 foot width fitted with wire mesh netting to allow passive ventilation on the sides) and transported to Mauritius. The journey would last 24 hours.

At Port Mathurin, wholesalers would buy the fruit between 40 (peak production, May to September) and 75 cents (November to April) per unit. Occasionally, there would be a small demand from hotels with a remunerative price of Rs 1.00-Rs 1.50 per fruit.

1.4.1.10 Observations on temperature

The air temperature noted at the port was 31.3^{0}C

The temperatures inside the different packaging types taken in the shade and in the sun (at two different levels ,top & bottom) are listed in table 4.

Table 4: Temperatures inside the different packages of lime

Type of packaging	In shade	Exposed to sun
	Temperature (^{0}C)	

	On top	On top	At bottom
White raffia bag	28.2	31	26.4
Wooden boxes	25.7	26.7	25.7
Gunny bags	24.8	26.1	24.3
Nylon nets	25.2	29.8	25.2

The outside temperature at which limes were kept at the port was very high. Although the fruits were found in bags or boxes, the temperature to which they were exposed whether in the sun or the shade was deleterious for quality maintenance. At such a temperature, the rate of respiration is high and storage life is shortened (Wills et al, 1989).

1.4.2 Validation of the findings of the RRA

1.4.2.1.1 Constraints identified during RRA

The findings of the RRA were categorized under constraints associated with (i) preharvest factors (ii) harvest & postharvest factors and (iii) marketing. (Appendix 3)

1.4.2.2 Prioritisation of needs

The participants listed their needs for support as follows:

Priority order	Issue to be addressed
1	Training in order to improve lime quality
2	Variety improvement
3	Market study

1.4.2.3. Observations

- The need for training in orchard management, harvest and postharvest handling was unanimous among the participants.

- Growers perceived that the lime variety that they were growing had to be improved in order to increase its yield and quality.
- The price obtained by growers from the existing marketing channel was found to be unfair and this prompted them to request for a market study which could open new opportunities for them.
- Issues related to improvement of the handling chain through improved transport, storage and packaging were not listed as priorities. This could be attributed to a lack of know-how on postharvest technology and the perception that such improvement would entail additional costs with no financial benefit.

1.4.3 Quality attributes of the Rodriguan Lime

Visually, the limes could be sorted into 4 maturity groups. These were: small and green (M1), large and green (M2), turning or pale green (M3) and yellow (M4). The characteristics of the different maturity groups are shown in table 5.

Table 5: Characteristics of Rodriguan lime harvested at different maturities

Parameter	Maturity of lime			
	M1(small & green)	M2 (large & green)	M3 (turning)	M4 (yellow)
Unit fruit weight (g)	18.2	25.8	31.9	39.1
Unit fruit diameter (mm)	30.9	34.4	37.8	40.0
Weight of juice /fruit (g)	2.9	5.9	9.5	12.6
% juice content	15.7	21.2	29.7	32.7
^{0}Brix	8.0	7.7	8.0	8.5
% Titrable acidity (TA)	8.45	8.32	8.64	9.22
^{0}Brix:TA	0.95	0.93	0.93	0.92
Vitamin C content (ppm)	285	390	405	480

As the maturity of the limes increased, so did their weight, juice and vitamin C content. On the other hand, there was no significant difference among their total soluble solids (^{0}brix) and titrable acidity. For lime, the recommended maturity index in terms of juice content is 30% or higher (Arpaia & Kader, 2002).

With reference to the latter, only the yellow fruits were at optimum maturity followed closely by the fruits turning yellow. Fruits harvested at a diameter of 38 mm and above would have optimum maturity, based on % juice content. Fruit colour and diameter could therefore be used as non-destructive maturity indices. Lime being a non-climacteric fruit, it has to be harvested at optimum maturity (Wills et al, 1989).

The occurrence of defects on the limes sampled at the port was as follows:

Defect	% of limes
Blemish	14
Canker	12
Sooty mould	4
Flaccidity	0

The most common defect was the presence of blemishes on the fruits, followed by symptoms of canker. The blemishes which reduced the consumer appeal were attributed to mite attack and mechanical injury (abrasions & bruises) during handling. Control of mites in the orchard and improvement in postharvest handling practices would eliminate/reduce the blemishes. The sooty mould could be prevented by control of mealy bugs and scale insects in the field and eliminated on fruits by thorough washing. None of the fruit sampled showed lack of firmness, which was an indication of freshness of fruit.

1.5 Conclusion

- Orchard management in Rodrigues was suboptimal. Therefore, yield and quality of lime could be enhanced through better preharvest management.
- Rodriguan lime should be harvested when diameter is 38 mm and above for optimum physico-chemical characteristics.
- Rodriguan growers producing large fruits would benefit from selling on a weight basis.
- Postharvest handling of lime is not optimal for fruit quality.
- Training has to be provided to lime growers on orchard management and to players in the trade chain on postharvest practices.
- A market study has to be carried out to identify new remunerative markets for Rodriguan lime.
- The varietal stability of the Rodriguan lime has to be determined.

2.0 PART 2

2.1 Objective 2

To formulate solutions to resolve the technical problems which are constraints to production of high quality limes.

2.2 Methodology

For each of the constraints identified during the RRA and validation workshop, solutions adapted to the local conditions in Rodrigues were proposed. Moreover, existing protocols on postharvest treatment & packaging were tested (objectives 3, 6 and 7).

2.3 Solutions proposed to resolve the technical problems impairing production of high quality limes at orchard level

2.3.1 Training

Being given the age group of the growers who are predominantly above 40, demonstrations have to be organised in the fields on good orchard establishment and management. Orchards should be identified (preferably 1 in each extension zone) and demonstrations effected for groups of 10 to 15 growers at a time. Demonstrations should cover the following:

2.3.1.1 *Size of hole*

Although the seedling to be planted, has a small volume of roots, growers have to understand that the development of the root system will determine the development of the canopy. Therefore, if the hole in which the root is developing is restricted, poor root development will follow and canopy growth will not be vigorous. Since bearing area is directly correlated to size of canopy, the latter has to be promoted through optimum root development. Hence, the importance of a large hole although the seedling is small.

2.3.1.2 *Hole filling*

The difference between top soil and sub soil has to be demonstrated and the importance of filling the hole with a prepared mixture of top soil and manure highlighted. Moreover, the importance of placing a source of phosphorus at the bottom of the hole for early root development should be explained.

2.3.1.3 *Spacing*

Growers have a tendency to see short term when planting lime trees. They try to plant as close as possible in order to maximise land utilisation. This is a strategy which quickly leads to overcrowding, Mutual shading reduces flowering and fruiting and encourages incidence of pests and diseases through poor aeration. If left unchecked, shaded branches defoliate and die back. The optimum spacing is 7mx5m. The free space in the interrows during the early years of establishment can be planted with appropriate intercrops or cover crops (legumes). The intercrops can bring additional revenue while keeping off weeds. The cover crops prevent weed

growth and enrich the soil by fixing nitrogen and increasing soil organic matter when ploughed in.

2.3.1.4 *Windbreak*

In a country which is every year visited by cyclone/s, establishing windbreaks around the orchard is of utmost importance. Windbreaks reduce limb breakage, fruit drop and mite dispersal and also water evaporation from the orchard. Species which are planted as windbreak should be fast growing and hardy under adverse conditions. For Rodrigues, filao, acacia, “bread & cheese” and jackfruit are appropriate.

2.3.1.5 *Irrigation*

Being given the scarcity of water, the importance of manure or compost and mulching in soil water retention has to be demonstrated in-situ. Buried halved coconut husks around the planting hole help to capture rain and irrigation water underground. The importance of water during fruit enlargement cannot be overemphasized. Water stress during this critical stage will produce undersized fruits with poor juice content. Low cost systems of irrigation (e.g. Family Drip System) have to be demonstrated and promoted.

2.3.1.6 *Fertilisation*

Under Rodriguan conditions, the lime tree can flower and produce throughout the year. However, to sustain this production, the tree has to replenish its reserves through regular fertilisation. Application of nitrogen, phosphorus and potassium fertilisers has to be carried out at least 4 times per year in order to sustain a year round production of quality fruits. Absence of regular fertilisation, causes irregular bearing and die back of branches through depletion of food reserves after a heavy crop.

2.3.1.7 *Pruning*

First, the importance of pruning during the early years has to be demonstrated. This should consist of eliminating water shoots and thinning out dense interior shoots. Later, only dead branches and twigs should be eliminated. The technique of clean slant cuts using appropriate tools and use of wound dressing will increase lifetime of lime trees.

2.3.1.8 *Control of pests and diseases*

Growers have to be trained in recognising the symptoms of canker. Early detection followed by an application of a copper based fungicide will prevent spread of the disease and infection of fruits. Lime fruits with canker symptoms are unmarketable. The importance of burning diseased leaves and fruits has to be stressed.

Mealy bugs and scale insects will be dominant on stressed trees. Early control is important to prevent yellowing of leaves, defoliation and die-back. Sooty mould associated with the presence of mealy bugs and scale insects will disappear upon control of the latter.

In the case of mites, if no control is effected early enough, severe damage is caused to young fruits, rendering them unmarketable.

2.3.1.9 *Field Sanitation & Hygiene*

The importance of floor management in a lime orchard should be demonstrated. Weed control will eliminate competition for water and nutrients and will not harbour pests and diseases. Rotten fruits will not be hidden in tall weeds and can be eliminated by burying or burning.
Entering a healthy orchard after working in a diseased one should be avoided (especially in the case of canker). Similarly, pruning of healthy trees should be carried out before diseased trees to avoid transmission of pathogen. In any case, the blade of pruning tools should be disinfected with "Eau de Javel" when moving from one tree to another.

2.3.1.10 *Harvest*

The value of the Rodriguan lime resides in its colour and juice content. Therefore indiscriminate harvesting inevitably reduces the fruit quality. The characterisation of the fruits (objective 1, activity 3) showed that immature fruits had very low juice content. Fruits that will be marketed soon after harvest, e.g the local market, can be picked when yellow. For an export market, mature green limes should have a minimum of 38 mm diameter.

2.3.1.11 *Post harvest handling*

A postharvest handling system for fresh Rodriguan limes has been developed under objective 7.

2.3.2 Sensitisation on Good Agricultural Practices

If the Rodriguan lime is targeting niche markets in Europe, growers should be sensitised about Good Agricultural Practices (EurepGAP). GAP aim at meeting consumers' needs for products that are of high quality, that are safe to eat and that are produced in an environmentally and socially responsible way. The most important elements of GAP are:

- The Environment

Growers should minimise the use of chemicals in the control of pests, diseases and weeds in order not to harm the natural environment. Integrated Pest Management (IPM) is encouraged. If chemicals are used, it is important that:

- Only essential or "soft" chemicals be used
- Chemicals only be used on the fruit types for which they have been approved and registered
- They are used strictly in line with label instructions
- They are not used after their expiry date
- Usage of chemicals is carefully recorded in detail. Compliance with Maximum Residue Limits (MRLs) standards is strictly adhered to.
- All chemicals are safely stored and disposed of in accordance with national regulations

The application of fertilisers must also be based on fertility level of the soil (to avoid abuse of fertilisers) and application records detailed.

To prevent or reduce soil erosion, appropriate soil cultivation techniques have to be applied (especially when planting on slope).

In Rodrigues, usage of fertilisers and pesticides is still minimal in lime plantation. Therefore, IPM could be practised successfully and fertilisers used in a rational way. This would be feasible with the support of sound research and consistent monitoring.

- Irrigation

Only legally permissible and clean water sources may be used. Irrigation systems should ensure the most efficient usage of water possible. The water usage (date, time, consumption) must be recorded. With the scarcity of water in Rodrigues, such judicious use of water would be beneficial to the grower and the country.

- People (welfare of workers & consumers)

All people working in the lime orchard should receive adequate training on good hygiene practices. They should be well informed about the process to follow when reporting an injury, and records must be kept of the injuries and the remedial actions taken. They must be provided with appropriate protective clothing, especially those carrying out spraying. Since lime trees have thorns, protective armbands and clean gloves have to be used.
To protect the consumer, the ability to trace produce back to its origin is a must. Hence, the importance of a traceability system.

2.4 Conclusion

- Demonstrations on appropriate cultural practices (hole size, spacing, fertilisation, irrigation, pruning, control of pests and diseases, optimum harvest time), postharvest management have to be organised in all extension zones.
- Growers have to be sensitised on Good Agricultural Practices.

3.0 PART 3

3.1 Objective 3

To reduce postharvest decay of limes through hot water and fungicidal treatments.

3.2 Researchable activities

3.2.1 Effect of hot water treatment on shelf life of Rodriguan lime
3.2.2 Effect of fungicide treatment on shelf life of Rodriguan lime

3.3 Methodology

3.3.1 Activity 1. Effect of hot water treatment on storage life of Rodriguan lime

Randomly selected mature green fruits were dipped in hot water at 50^0C or 55^0C for 5 minutes and then stored at ambient room temperature or 13^0C. Fruits which did not receive any hot water treatment were used as control and stored at room temperature or 13^0C. Each treatment was replicated 4 times with a sample of 8 fruits in a completely randomised design. The fruit samples were packed in nylon mesh bags prior to storage. The fruits were examined at different intervals and the % weight loss and % of fruits with sign of disease development were recorded to determine % of unmarketable fruits.

3.3.2 Activity 2. Effect of fungicide treatment on storage life of Rodriguan lime

In a trial similar to activity 1, randomly selected mature green limes were treated with 2 different fungicides (Thiabendazole (TBZ), trade name Mertect 20 S) and Imazalil) each applied at two different concentrations (0.5mL/L and 1.0mL/L). For each of the treatment, the fungicide's emulsion was applied with a paint brush to the fruits' surface. The fruits were air dried prior to storage at ambient room temperature and 13^0C. Fruits which were not treated with any fungicide stored at room temperature and 13^0C were used as control. Each treatment consisted of 8 fruits and was replicated 4 times in a completely randomised design. Each replicate was packed in nylon mesh bags and stored at 13 ºC and ambient room conditions. At different storage intervals ,the fruits were assessed for % weight loss, fruit rind colour , % of fruits with sign of disease development, % of fruits with sign of wrinkling, and the overall marketability of the fruits.

3.4 Results and Discussion

3.4.1 Hot water treatment on lime

Result of trial showed that the fruits dipped in hot water at 55 ºC developed brown blemishes on the peel, symptoms of heat injury. Hot water dip of 50 ºC for 5 minutes reduced rot without impairing the fruit peel quality. However, as from 29 days at ambient and 31 days at 13 ºC, fruits dipped in hot water at 50 ºC also developed post harvest diseases, though significantly less than the non- treated fruits and those dipped at 55 ºC.

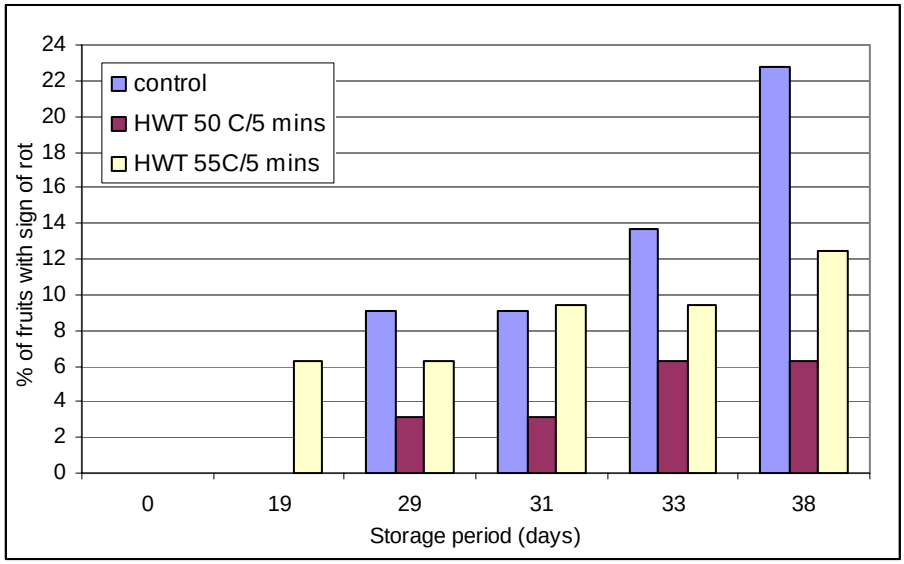

Figure 1 : % of fruits with sign of rot under storage at room temperature

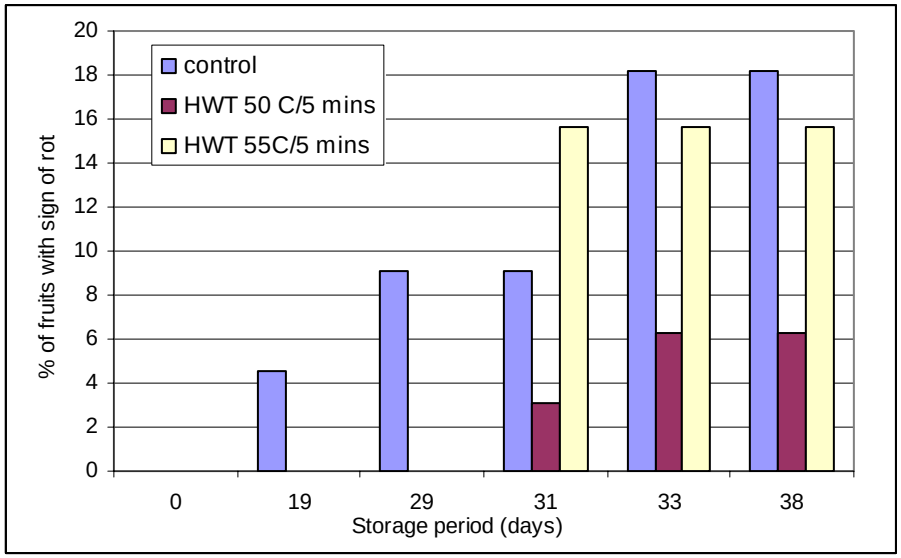

Figure 2 : % of fruits with sign of rot recorded under storage at 13 ºC

3.4.2 Fungicide treatment on lime

Under both ambient and cold storage conditions, Thiabendazole applied at the rate of 1.0 ml/L was found to give the best control against post harvest decay. After 1 month storage, only 4.5 % of the fruits were found to develop post harvest rot as compared to 22.7 % and 18.2 % in the control stored at ambient and 13 ºC respectively.

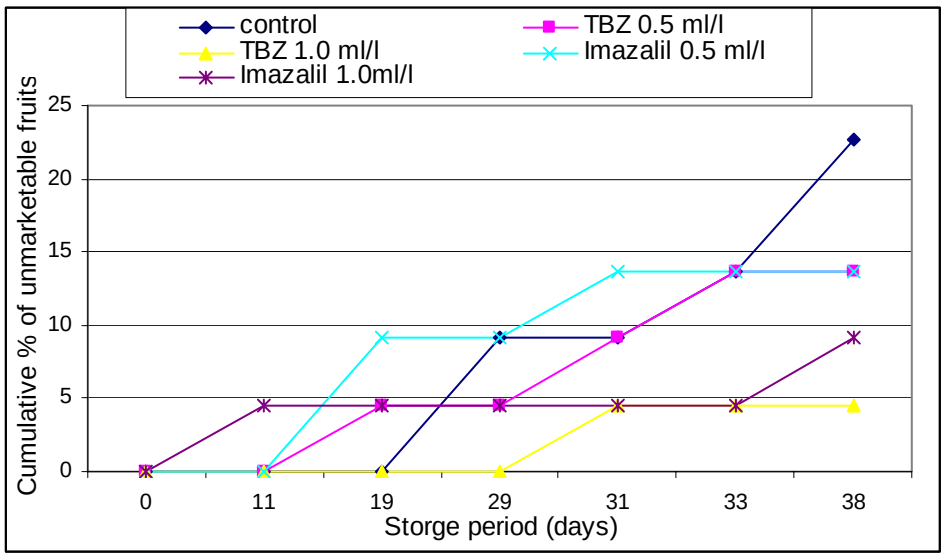

Figure 3: The cumulative % of unmarketable fruits recorded at different storage periods at ambient room temperature

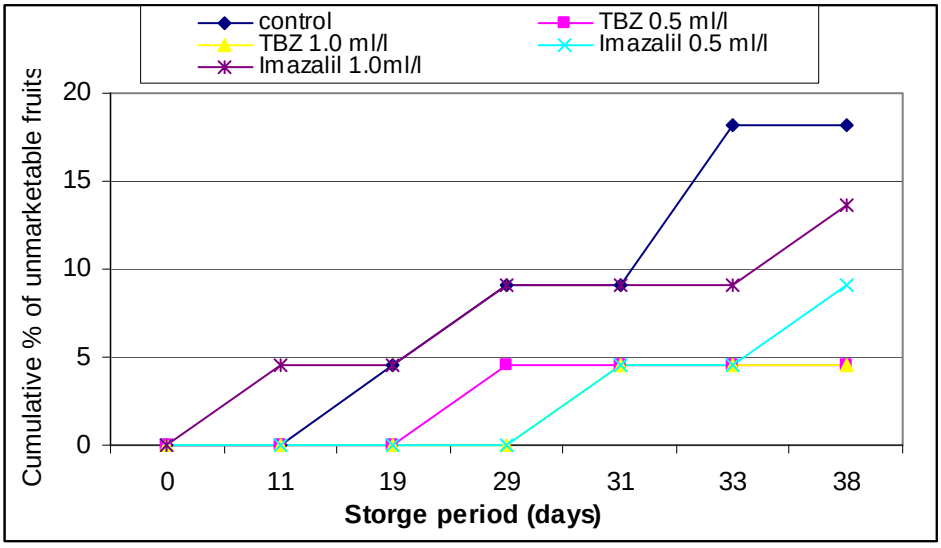

Figure 4 : The cumulative % of unmarketable fruits recorded at different storage periods at 13 ºC

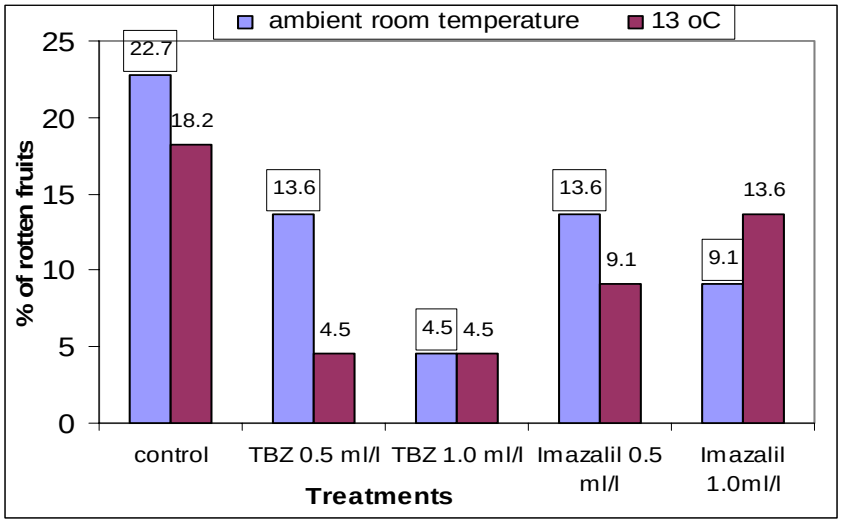

Figure 5: % of rotten fruits recorded for each treatment after 1 month storage under both storage conditions

3.5 Conclusion

- Limes dipped in hot water at 50^0C for 5 minutes, significantly reduced rot development compared to untreated limes.
- Thiabendazole applied at the rate of 1.0 ml/L significantly reduced rot development compared to untreated limes.
- Because of the risk of heat injury if technique of hot water treatment is not well mastered, treatment with Thiabendazole is favoured for reduction of rots in lime.

4.0 PART 4

4.1 Objective 4

To determine the storage life of the Rodriguan lime at different harvest maturities and temperatures.

4.2 Researchable activities

Determination of storage life of lime of 4 different maturities at ambient and 13^0C

4.3 Methodology

Freshly harvested limes were graded into 4 maturity stages: immature green (M1), mature green (M2), turning (M3) and yellow (M4), based on fruit size and peel colour. 12 fruits from each maturity were replicated 4 times, packed in nylon net and then stored at room temperature (25^0C) and at 13^0C (optimal cold storage temperature for lime).
The % weight loss, peel colour, and fruit firmness were assessed at 6, 10, 15, 20, 24, 28, 31 and 35 days after treatment, and the % marketable fruit determined.

4.4 Results and Discussion

Under ambient conditions, the immature fruits (M1) had lost above 15% moisture after 24 days, while the other maturities (M2, M3 & M4) were still firm (figure 6). At 13^0C, the immature and yellow limes had similar behaviour with a slightly shorter storage life than the two other maturities (figure 7).

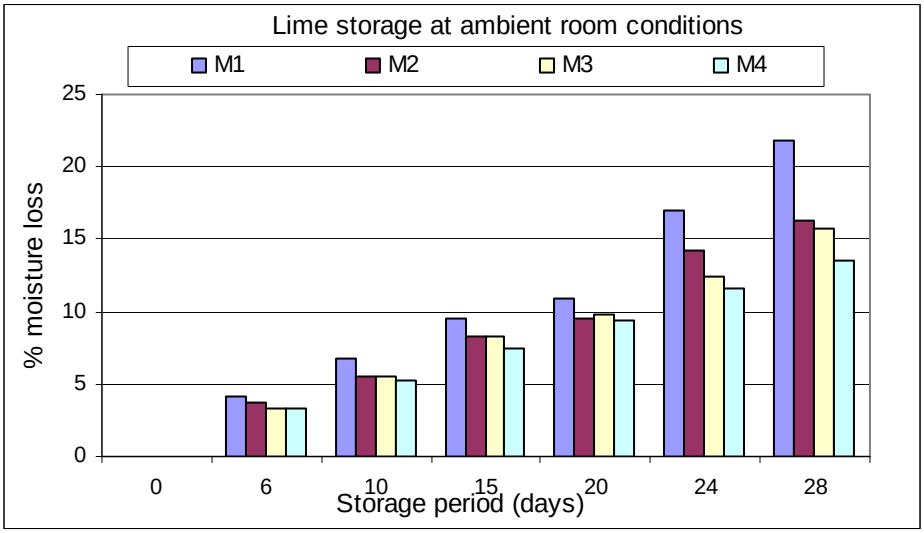

Figure 6: % moisture loss observed in fruits of different maturities under ambient room conditions

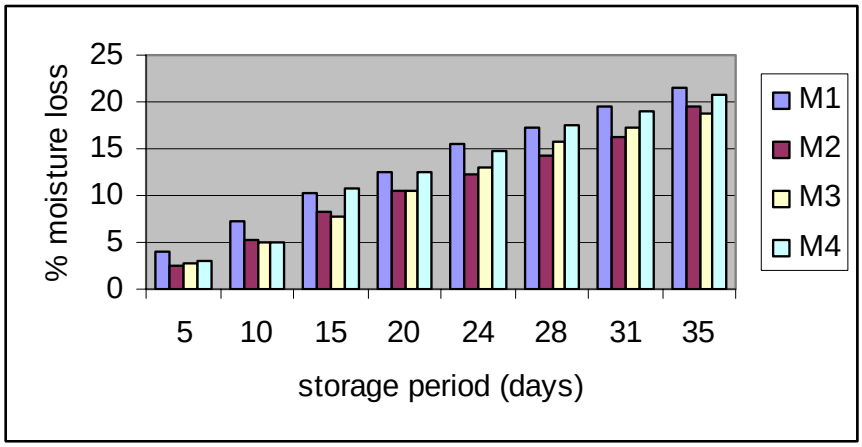

Figure 7: % moisture loss observed in fruits of different maturities at 13^0C

4.5 Conclusion

- Immature fruits lose moisture and become unmarketable as fresh lime at a faster rate than mature fruits.
- Mature limes remain fresh for a maximum of 24 days and 28 days at 25^0C and 13^0C respectively, when packed in nylon mesh bag.

5.0 PART 5

5.1 Objective 5

To measure the respiration rate of the lime at different temperatures.

5.2 Researchable activities

5.2.1 Determination of the respiration rate of limes of 3 different maturities at 2 different temperatures

5.2.2 Determination of the respiration rate of waxed and non-waxed green mature limes at 2 different temperatures

5.3 Methodology

5.3.1 Activity 1. Determination of the respiration rate of limes of 3 different maturities at 2 different temperatures

In view of the limited number of respiration jars available, the experiment excluded ripe fruits (Maturity 4) as a treatment. Thus, lime fruits of 3 different maturities (immature, green mature, and turning) were used for the determination of the respiration rate at 13ºC and 25ºC on 0, 1, 4, 5, 7, 8, 12, 13, 18, 21, 27, 34, and 36 days after harvest. The experiment was conducted using two replicate respiration jars and using lime fruits freshly harvested from a local grower's orchard.

The fruits were allowed to equilibrate with the temperature at which respiration rate will be determined for at least 2 hours before measuring the respiration rate. The jar was also equilibrated at the desired temperature. Then, 12 – 15 lime fruits of a specific maturity were placed in a respiration jar fitted with a gas sampling septum. The jar was closed and kept in a dark incubator set at 13°C or 25°C. Three gas samples of 5 ml were taken from the jar after 1.5 hrs and the samples were analyzed using the MAPTest 4500 Gas Analyzer. Oxygen concentration in % was recorded for the 3 samples and the mean was used to calculate the respiration rate of lime fruits in ml O_2 consumed per kg per hour. Once the reading of O_2 concentration taken, the jar was opened and the fruits were allowed to respire without any 'modified atmosphere' at the required temperature of storage (13°C or 25°C), awaiting the next determination of respiration rate.

5.3.2 Activity 2. Determination of the respiration rate of waxed and non-waxed green mature limes at 2 different temperatures

Green mature fruits were randomly split in two batches. One batch of fruits was waxed using Candellila wax at 10% and the other batch was not waxed. Waxed fruits were stored at 13ºC and 25ºC. Respiration rate of the fruits was determined on 0, 4, 5, 7, 8, 12, 13, 18, 21, 27, and 34 days after harvest.

The same procedure, as described in Activity 1, was used to measure respiration rate of the fruits.

5.4 Results and Discussion

Figure 1 shows that the respiration rate of the lime was higher at 25^{0}C than at 13^{0}C for the three maturities. At 25^{0}C, the immature fruits had higher respiration rate than the mature green and the turning fruits. At 13^{0}C there was no significant difference among the respiration rate of the three maturities.

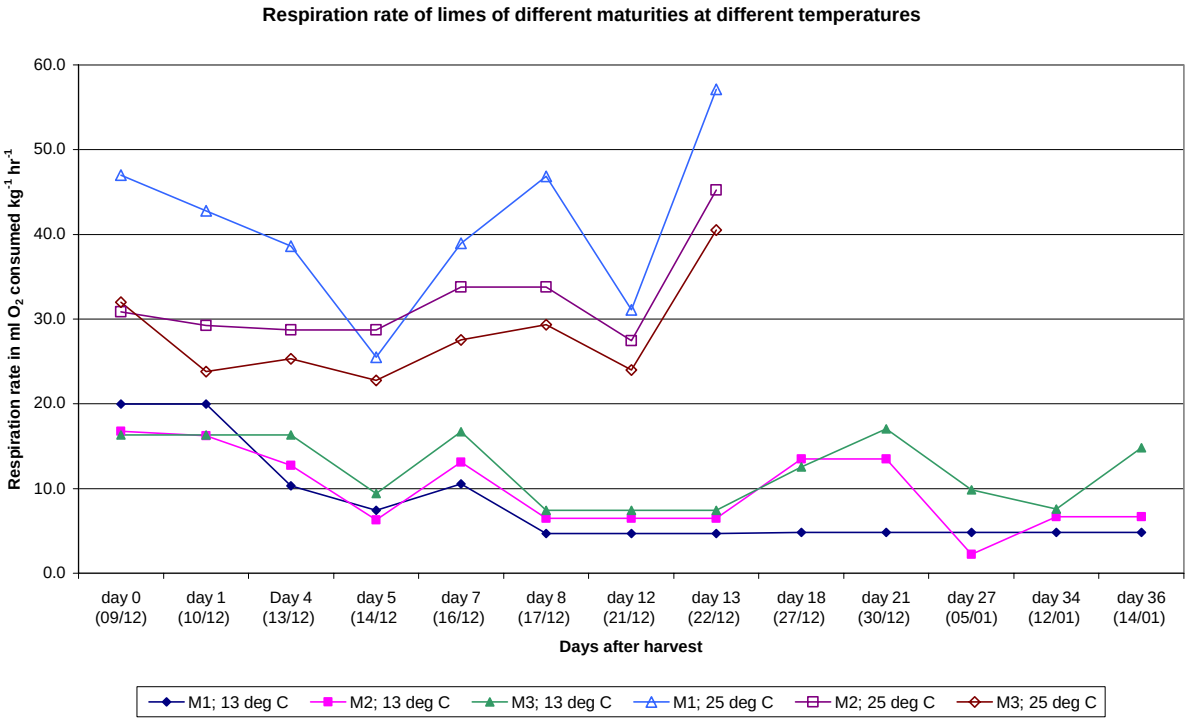

Figure 8: Respiration rate of limes of different maturities at different temperatures

The waxed limes had significantly lower respiration rate than the non-waxed limes at 25^{0}C (figure 2). Under non-refrigerated conditions, waxing of limes can significantly reduce respiration rate and hence extend shelf life.

At 13^{0}C, both waxed and non-waxed limes had similarly low respiration rate. In both trials, the lime showed low respiration rate. Therefore, the polymeric film to be used as packaging material can be of low permeability to gaseous exchange.

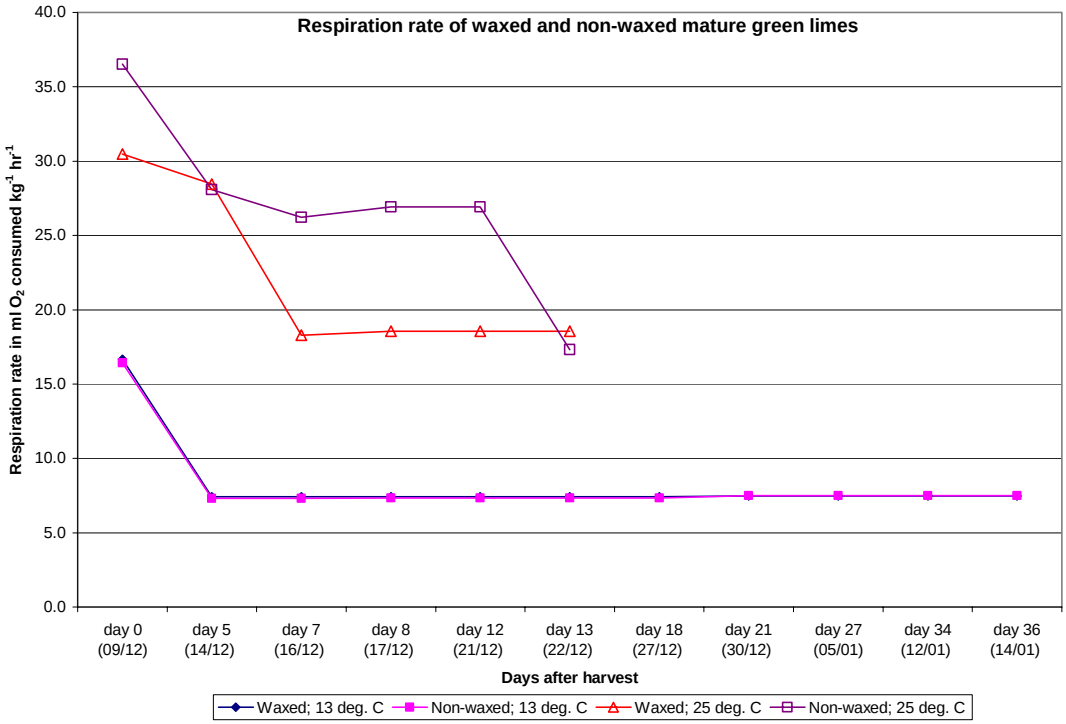

Figure 9: Respiration rate of waxed and non-waxed mature green limes

5.5 Conclusion

- Respiration rate of lime was significantly higher at 25^0C than at 13^0C.
- Waxing lime with Candelilla at 10%, significantly reduced the respiration rate at 25^0C.
- At 13^0C, waxed and non waxed limes respire at the same rate.

6.0 PART 6

6.1 Objective 6

To extend the shelf life of the lime through waxing. and packaging

6.2 Researchable activities

6.2.1 Waxing of limes to extend their shelf life

6.2.2 Packaging of limes to extend their shelf life

6.3 Methodology

6.3.1 Waxing of fruits to extend shelf life of limes

Randomly selected fruits of mature green stage were waxed and stored at ambient and 13^0 C. The treatments were as follows:

Wax	Concentration of wax emulsion used (%)		
Semperfresh , edible coating	1	2	4
Candelilla wax	5	10	20
Mixture of polyethylene and paraffin wax	5	10	20

Untreated limes were used as a control. The trial was set up using a simple factorial (3 x 3) with a completely randomised design. Each treatment was replicated 4 times with a sample of 12 fruits per replicate. The wax was diluted to the respective concentration and applied manually to the fruit sample with a paint brush. The fruits were air-dried and packed in nylon-mesh prior to storage at ambient room conditions and 13 ºC. At different time intervals, the fruits were assessed for moisture loss, % of wrinkled/flaccid fruits and % of fruits with sign of postharvest disease.

6.3.2 Activity 2 :Packaging of limes to extend their shelf life

Freshly harvested limes of maturity M3 were waxed with 10% Candelilla wax as in activity 1. The limes were then subjected to different packaging materials and storage temperatures.

Type of packaging: 3 levels (raffia bag -Rodriguan practice, perforated LDPE of 30 microns and non-perforated LDPE of 30 microns in carton boxes of size 22 cm x 16 cm x 10 cm.

Temperature: 2 levels (13°C and ambient)

Design: Simple factorial (3 × 2) with a completely randomised design

Number of treatments = 6

Replicates: 4 (25 limes representing one replicate)

The fruit samples were assessed for weight, peel colour, degree of wrinkling, fruit firmness, presence of sign of decay or mould growth and overall appearance 2,5,12,19,26,37,49,56,61,64,68 and 78 days after storage.

6.4 Results and Discussion

Effect of waxing on limes

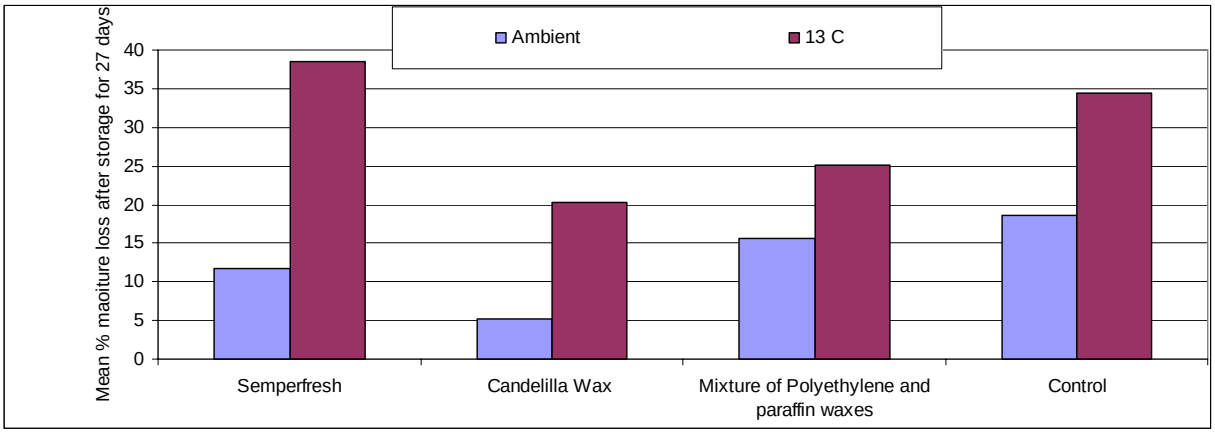

Figure 10: Behaviour of the different waxes under different temperatures after 27 days

After 27 days, moisture loss was significantly less at 13^0C than at 25^0C in the control and in the waxed limes (figure 10) .

Irrespective of the concentrations of the wax coatings used at 13^0C, it was observed that % moisture loss was the lowest in fruits brushed with candelilla wax, followed by semperfresh and the mixture of polyethylene and paraffin wax. Furthermore, the Candelilla Wax, improved the look of the fruit by producing a bright shine.

There was no significant difference in the performance of candelilla wax at 10% and 20%. Therefore, Candelilla wax at 10% can be recommended for improvement of storage life of Rodriguan lime.

Packaging of limes

Figure 12 illustrates the cumulative weight loss of fresh waxed limes under three different packaging materials and two different temperatures The raffia bag (Rodriguan practice) kept the limes marketable up to 64 days at 25^{0}C. At 13^{0}C, the limes remained marketable up to 78 days. The limes in non-perforated LDPE in carton box remained marketable up to 61 days at 25^{0}C and up to 78 days at 13^{0}C. The perforated LDPE lost much moisture at 25^{0}C providing a shelf life of less than 56 days to the limes. Under the conditions of the trial, waxed lime could be stored longer when it was packed in raffia bag or wrapped in LDPE inside a carton box and stored at 13^{0}C. However, the bag did not provide any protection against compression and bruises. For handling, it should be placed in crates. Moreover, the raffia bag did not improve the presentation of the produce. Being opaque, it did not allow the fruit to catch the eye of the customer.

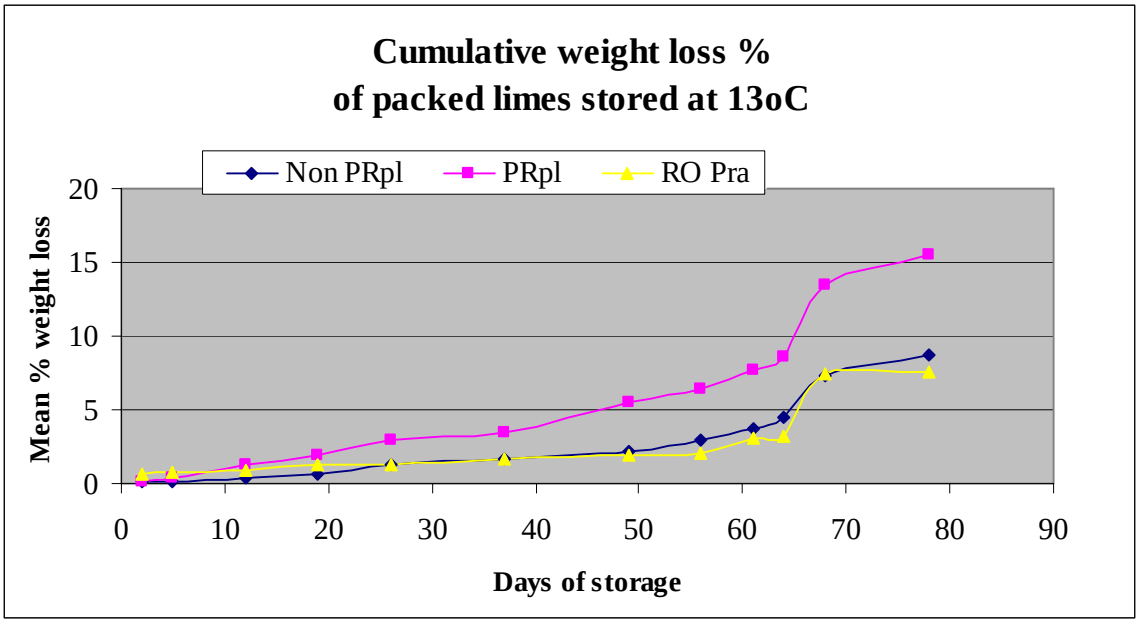

Figure 12: Cumulative weight loss of lime in different packagings at ambient and 13^{0}C.

6.5 Conclusion

- Candelilla wax at 10% applied to fresh lime reduced moisture loss four-fold compared to untreated lime.
- Marketable life of fresh lime extended to 11 weeks when it was waxed, packaged in unperforated LDPE bag of 30 microns and stored at 13^{0}C.

7.0 PART 7

7.1 Objective 7

To develop a postharvest handling system for fresh Rodriguan limes

7.2 Methodology

Findings from the activities developed to meet objectives 1to 6 were utilised to develop a post harvest handling system for fresh Rodriguan limes. The post harvest handling system describes how the produce needs to be handled since harvest. The salient features of the post harvest handling system of fresh lime would be: proper harvest/ maturity indices, Good Agricultural Practices pertaining to fruit harvest and field handling, market quality standards/ criteria, fruit grading and sorting, optimum storage conditions and possible marketing channels

7.3 Postharvest Handling System for fresh Rodriguan Limes

7.3.1 Harvest

Time of harvest. Throughout the year, day temperature is high in Rodrigues. Therefore, it is important that harvest is carried out very early in the morning or late in the afternoon to reduce field heat on the fruit. The higher the temperature of the fruit, the higher, the respiration rate and the faster it will deteriorate (loss of water and senescence).

Limes should not be picked when it is raining. They are then, more susceptible to bruises and rots.

Maturity index. In order to put quality limes on the market, the fruits have to be harvested when they have reached a minimum of 38 mm diameter and they are light green in colour. At that stage they would have reached the minimum juice content of 30%. Yellow fruits can be harvested for proximity markets. Their juice content is higher but international markets prefer green limes to yellow limes.

Method of harvest. Clippers with rounded tips should be used for harvesting of lime. To increase shelf life and to prevent entry of pathogens, limes should be harvested with stalk less than 2 mm long. Fruit should not be snapped away from peduncle. The absence of fruit stalk will leave way to entry of pathogens in the fruit. On the tree, the remaining receptacle retards new growth and encourages biennial bearing (P.Wahl, pers. comm., 2001). To harvest limes which are inaccessible, a lightweight ladder should be used. Branches should not be pulled down throwing fruits on the ground. As soon as harvested, limes are placed in the shade, in a clean, rigid ventilated container with smooth interior surfaces. The container should not be overfilled to avoid compression and impact bruising. Fruits which have fallen on the ground should not be mixed with sound fruits in the crate. They could be bruised and soiled. They should be placed in a separate container.

Fallen or unmarketable limes (split, diseased or bruised) should not be left on the ground. They should be collected and placed in a bag or container for burying or burning soon after.

7.3.2 Transport to packing house.

As soon as possible after harvest, the crates of limes should be transported to a clean and ventilated building. The transport used should be covered in order to protect the limes from sun and rain. In case tarpaulin is used, it should preferably be white and should be placed in such a way as to allow enough air flow to prevent heat build up. Transport carrying fresh fruits should not be parked for long hours in the sun to avoid overheating.

7.3.3 Sorting and grading.

In the packing house, the fruits are placed gently on a clean table for a preliminary selection. All overripe, bruised, blemished or undersized fruits which cannot be marketed fresh are separated and placed in a container. they can be sent for processing.

All sound limes are transferred into a container of clean water with javel (3ml/L of water). The limes are washed and placed over clean linen on a table for drying. After being air-dried, they are graded according to colour: yellow, turning and light green. The yellow limes are packed in (2 kg) carton boxes or crates lined with perforated LDPE bags prior to be sent to proximity markets (hotels, markets). The sorting/grading and packing area should be kept clean at all times and all diseased or damaged produce or any waste should be readily disposed.

7.3.4 Waxing.

The light green and turning limes are separately placed on a clean plastic sheet and treated with Candelilla wax (10%) using low cost waxing machine. The wax protects the fruit from losing moisture and from decaying. It also gives the fruit surface a light sheen which makes it look more attractive. The waxed limes are then allowed to dry before packaging.

7.3.5 Packaging

After waxing, the limes are wrapped into non-perforated LDPE of 30 microns, placed in ventilated attractive carton boxes of 2 kg and stored at 13^0C at a relative humidity of 90-95%, for marketing within 11 weeks. In

the absence of cold store facilities, the waxed limes are wrapped into perforated LDPE of 30 microns, placed in ventilated carton boxes and stored at 25^0C. The marketing should be carried out within 50 days.

7.3.6 Loading at the port

Packed limes should not be kept in the sun before ship loading. They should at all times be kept in the shade to avoid heat build up which rapidly deteriorates fruit quality.

8.0 Part 8

8.1 Objective 8

To train Rodriguan farmers on the production of quality limes.

8.2 Methodology

With the view to improve the post harvest quality of fresh Rodriguan limes, training of growers need to be conducted at two levels: at pre-harvest level to train the growers on Good Agricultural Practices (orchard management) pertaining to post harvest quality of lime fruits; and at post harvest level for the proper handling of fruits to preserve their inherent quality and to reduce any post harvest loss, including the loss of fruit quality. The post harvest handling system developed for lime fruits under objective 7 , will be very useful in training growers at post harvest level.

Training will be given on 2 key topics: orchard management and post harvest handling practices. The methodologies that will be used for training growers are on-farm demonstrations, short theory classes (in Creole/ French), video sessions and PowerPoint slide shows. Emphasis will be laid on illustrations during the training course.

8.0 Part 8

Conclusion

Part 1

- Orchard management in Rodrigues was suboptimal. Therefore, yield and quality of lime could be enhanced through better preharvest management.
- Rodriguan lime should be harvested when diameter is 38 mm and above for optimum physico-chemical characteristics.
- Rodriguan growers producing large fruits would benefit from selling on a weight basis.
- Postharvest handling of lime is not optimal for fruit quality.
- Training has to be provided to lime growers on orchard management and to players in the trade chain on postharvest practices.
- A market study has to be carried out to identify new remunerative markets for Rodriguan lime.
- The varietal stability of the Rodriguan lime has to be determined.

Part 2

- Demonstrations on appropriate cultural practices (hole size, spacing, fertilisation, irrigation, pruning, control of pests and diseases, optimum harvest time), postharvest management have to be organised in all extension zones.
- Growers have to be sensitised on Good Agricultural Practices.

Part 3

- Limes dipped in hot water at 50^0C for 5 minutes, significantly reduced rot development compared to untreated limes.
- Thiabendazole applied at the rate of 1.0 ml/L significantly reduced rot development compared to untreated limes.
- Because of the risk of heat injury if technique of hot water treatment is not well mastered, treatment with Thiabendazole is favoured for reduction of rots in lime.

Part 4

- Immature fruits lose moisture and become unmarketable as fresh lime at a faster rate than mature fruits.
- Mature limes remain fresh for a maximum of 24 days and 28 days at 25^0C and 13^0C respectively, when packed in nylon mesh bag.

Part 5

- Respiration rate of lime was significantly higher at 25^0C than at 13^0C.

- Waxing lime with Candelilla at 10%, significantly reduced the respiration rate at 25^0C.
- At 13^0C, waxed and non waxed limes respire at the same rate.

Part 6

- Candelilla wax at 10% applied to fresh lime reduced moisture loss four-fold compared to untreated lime.
- Marketable life of fresh lime extended to 11 weeks when it was waxed, packaged in unperforated LDPE bag of 30 microns and stored at 13^0C.

FURTHER WORK

- New avenues for the marketing of the Rodriguan lime has to be explored.
- The growers have to form a network in order to benefit from economies of scale. Otherwise, it will be difficult for a grower of 10 to 20 trees to envisage export. The grouping will enable the growers to apply for group certification. The assistance of APEXHOM (Association des Producteurs & Exportateurs des Produits Horticoles de Maurice) can be tapped for adherence of growers to agricultural codes of practice.
- Lime production in Rodrigues has up to now been a low input activity. Improving post harvest quality will imply additional inputs and expenses. The cost implications have to be worked out for the whole production and trade chain.
- Being given the specificity of Rodrigues, growers can consider applying for Fair Trade Label.
- Being given that a mild strain of *Tristeza* exists in the Rodriguan lime, a health assessment of existing trees has to be carried out on a regular basis to prevent decline of the species.
- A study has to be carried out on the genetic stability of the Rodriguan lime.

I certify that to best of my knowledge (1) the statements herein (excluding scientific hypotheses and scientific opinions are true and complete) (2) the text and graphics in this report as well as any accompanying publications or other documents, unless otherwise indicated are the original work of the signatories or individuals working under their supervision. I understand that wilfully making a false statement or concealing a material fact in this report or any other communication submitted to MRC is a criminal offence.

Principal Investigator Signature:	Date:

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The contribution of the following persons and institutions is gratefully acknowledged:

- Mr W. Tolbize, Mr J. Felicite, Mr Agathe and all staff who provided support for the project, from the Agricultural Services in Rodrigues
- Mrs M. Francois (ILO/STEP National Expert) of Leve Deboute, Rodrigues
- All the lime growers and other persons in the trade chain whom the project investigators met during the RRA and validation workshop in Rodrigues
- Mr & Mrs Seechurn, lime grower in Mauritius who provided freshly harvested fruit for lab trials
- Mrs N Ramma, Mrs S Munbodh, Ms D Moodelly, Ms N Nallee, Mrs T Jeewoo and all supporting staff from the Agricultural Research & Extension Unit
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APPENDIX 1

List of lime growers visited for Rapid Rural Appraisal

Date of field visit	Extension Zone	Name of grower	Address
20.05.02	St Gabriel	Pershyl Perrine	Mourouk
		George Agathe	Port Sud Est
		Apin Azor	Tamarin
21.05.02	La Ferme/Maréchal	Nicaise Speville	Rivière Coco
		Lorenzo Agathe	Mangues
		Antoine Ravina	Maréchal
		Marc Bégué	Maréchal
		Mason Leopold	B. Topaze
		Jean Marie Asong	La Ferme
22.05.02	Citronelle	Annick Adelaide	Mt Goyave
		Fabiola Perrine	Soupir
		Berthie Roussety	Grand Bay
		Patrice Bégué	Grand Bay
		Hilali Louis	Baie aux Huitres
23.05.02	Trèfles	Merlette Casimir	Gravier
		Marcel Larose	Pte Coton
		Boncoeur Lubin	Gravier
		Jean Marc Jolicoeur	Gravier
		George Simon Jolicoeur	Gravier
		Marcelin Perrine	Gravier

APPENDIX 2

Identification	Production System	Planting
Name: Address: Full time ……. Part time …….	Cropping system: A Full stand B Intercropping C Mixed cropping D Other Source of planting material: A Heritage B Barkly/imported C Ministry of Agriculture D Other Wind break? Yes …..... No ….... Type: Crop: Lime ….... Lemon ….... Orange ….... Mardarin ….... Other ….... Variety awareness/recognition Yes ...….. No ...….... If yes state varieties ……	Hole size …....ft x ……. ft x ..…..ft Fertilization before planting Yes ..…... No ..….. Manuring before planting Yes ……. No ……. Did you separate topsoil from subsoil? Yes …..... No ….... Did you cover graft union with soil (if using grafted pl.) Yes …..... No ….... Spacing of hole ……
Age group: <20 21 – 40 41 – 55 >55		
Site of plot:		
Plot area: ha:		
No. of trees: (i) bearing/productive (ii) juvenille		
Experience of grower:		

Propagation and RS	Fertilisation	Irrigation
Do you propagate your (i) variety Yes …… No …… (ii) rootstock Yes …… No ……	Do you use chemical fertilizers? Yes …… No …… If yes, when? Before planting …… After	Is your crop irrigated? Yes …… No …….. If yes, continue Availability of irrigation water Available ……. Not available ……

	planting……	
Variety propagation method: (i) Grafting (ii) Air layering (iii) Other	Before planting which fertilizer do you use?	Source of irrigation Water …… …….. ……..
RS propagation method: (i) Cutting (ii) Other	After planting which fertilizer do you use?	Are you happy with quality of irrigation water?
Are you aware of diff. RS varieties? Yes …… No ……	After planting at what frequency you apply fertilizer? A 1/yr B 3/yr C 2/yr D 4/yr	Do you know how much water to apply and at what frequency? If yes, please State …… …… ……
Source of planting material	Do you know (i) How much to apply? Yes No (ii) Where to apply fertilizer Yes No If yes, state the amount per tree	
Ease of availability		

<table>
<tr><th>Pruning</th><th colspan="5">Pest and disease</th><th>Field hygiene and sanitation</th></tr>
<tr><td>Do you prune your trees?
Yes
No

If yes, continue</td><td colspan="5">What are the major problems?</td><td>Do you carry out weeding regularly? Yes No

If yes, how regular?

A 1/year B 2/year
C 3/year D As need arises</td></tr>
<tr><td>Type of pruning:</td><td colspan="5">Can you differentiate between a pest attack and a disease outbreak? Y N</td><td>Type of weeding?

A Manual
B Mechanical
C Chemical
D Combination</td></tr>
<tr><td>Frequency of pruning:</td><td colspan="5">Do you use pesticide to control pest and diseases?

If yes, state pesticide used and problem corrected</td><td rowspan="7">When do you decide to weed?

Weed is

A <10 cm high
B 10-20 cm high
C >20 cm high</td></tr>
<tr><td rowspan="6">Timing of pruning:</td><td>Pesticide</td><td>Frequency</td><td>Time of application</td><td>Dosage</td><td>Problem carrected</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>For what reason do you prune your trees</td><td colspan="5"></td><td>Where do you weed?

A Throughout the field
B Around the trees only
C Circular bands around the trees</td></tr>
<tr><td>Equipment and tool used for pruning</td><td colspan="5"></td><td>Do you remove trees, branches/wigs affected by diseases from your field? Yes No
How do you dispose of it?
……..
……..</td></tr>
</table>

<table>
<tr><th>Harvest Methods</th><th colspan="3">Stage of harvest</th><th colspan="2">Time of harvest</th></tr>
<tr><td rowspan="3">A Picking
B Clipper/secateur
C Scisor
D Other</td><td colspan="3">Based on:</td><td colspan="2" rowspan="3">Morning before dew
Afternoon
Mid-day</td></tr>
<tr><td colspan="3">Colour (green pale green yellow)</td></tr>
<tr><td colspan="3">Size (mm)</td></tr>
<tr><td rowspan="3">A Use of ladder
B Pulling of branches
C Other</td><td colspan="3">Juice content</td><td colspan="2">Do you harvest just after rain? Yes
No</td></tr>
<tr><td colspan="3">Taste</td><td colspan="2"></td></tr>
<tr><td colspan="3">Market demand (details)</td><td colspan="2"></td></tr>
<tr><th>Handling</th><th colspan="3">Sorting</th><th colspan="2">Packaging in marketing chain</th></tr>
<tr><td rowspan="7">A Bare-handed
B Gloves</td><td></td><td>Please tick</td><td>Remarks</td><td></td><td>Capacity</td></tr>
<tr><td>Maturity</td><td></td><td></td><td rowspan="2">Sac gonie/raffia</td><td rowspan="2"></td></tr>
<tr><td>Colour</td><td></td><td></td></tr>
<tr><td>Diseased</td><td></td><td></td><td rowspan="2">Plastic bag</td><td rowspan="2"></td></tr>
<tr><td>Blemishes</td><td></td><td></td></tr>
<tr><td>Damage physical</td><td></td><td></td><td rowspan="2">Crates (plastic/wooden)</td><td rowspan="2"></td></tr>
<tr><td>Size</td><td></td><td></td></tr>
<tr><td>Personal hygiene (nails)</td><td colspan="3">Disposal of culls/rejects</td></tr>
<tr><td>Container used:

A Plastic crates Size: Depth:
B Panier Size: Depth:
C Sac Size: Depth:</td><td colspan="3" rowspan="4"></td><td colspan="2" rowspan="4"></td></tr>
<tr><td>Once harvested kept in:

(i) Shade
(ii) Sun</td></tr>
<tr><td>Lining of containers:</td></tr>
<tr><td>How long does it stays in container? …….. days</td></tr>
</table>

Transport	How it reaches the consumer	Selling		
(a) Transport Means of transport: A Van B 4x4 (single) Mixed transport of host-produce	A Direct selling in field Retail Wholesaler B Seller himself at market site C Processed form		% Market share	Price
		Retail in field		
		Wholesale		
		Processing		
		Retail at market site		
(b) Storage at: grower's premises Market site				

Appendix 3

Lime Production in Rodrigues - Constraints identified

Preharvest factors	Harvest & Postharvest factors	Marketing
1. Inappropriate hole preparation at planting. Hole size too small and inadequate preparation of mixture for hole filling 2. Irregular spacing and planting density too high causing mutual shading, sooty mould development and die back 3. Inexistence of windbreak 4. Absence / Insufficient manuring and fertilization to sustain production 5. Insufficient water supply, mostly rainfed 6. Lack of know-how on pruning & lack of appropriate tools 7. Lack of information on pest and diseases hence poor control 8. Poor field hygiene & sanitation	1. Harvest of immature & overripe fruit 2. Harvesting tool I not appropriate. It causes damage to branches and fruit falls to the ground. Fruit is damaged and soiled (unacceptable under GAP) 3. Harvest time is not restricted to the coolest part of the day (early morning and late afternoon) 4. Limes are prone to postharvest diseases when harvested during rain 5. Limes are not kept in shade soon after harvest 6. The bags used for holding limes cause fruit damage (bruises, heat build up) and reduce their shelf life 7. Insufficient sorting & grading of fruit for value addition 8. Limes harvested long before shipments and held in inappropriate packaging materials prior to shipment 9. Inappropriate inland transport system 10. Rough handling of bags of	1. There is no organized system for marketing of limes of small growers. They are at the mercy of intermediaries (poor negotiating power) 2. Insufficient market opportunities 3. Price too low 4. Lime sold on a unit basis, not adding value to large fruits.

	fruits during loading and unloading 11. Limes packed in bags are exposed to long hours in sun, awaiting shipment at Port Mathurin 12. No cooling facilities exist for storage of fruit