HAP TECHNICAL STUDY

Postharvest Improvement Program for the Haitian Mango Industry (TS # 1)

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1. Executive Summary

Fresh mangoes are one of the primary agricultural exports from Haiti to the USA. Of mango that is accessible, only 30% of the crop production is of adequate quality for export; the remainder is rejected. This assignment was carried out to identify postharvest activities to reduce the rejection levels and increase the exportable volumes. A 20% increase in export volumes should result in an additional $2 million in revenue. This can be achieved by improving the field infrastructure and improving packhouse handling operations.

The current field handling processes are very basic, involve individual fruit handling at least 20 times and provide little or no protection to the fruit. The major recommendations made are to provide training in improved harvesting techniques including the use of plastic field crates from the harvest onwards, the development of collection centers with basic washing and grading infrastructure, and the use of field crates from the collection centers to the packhouses and improve selective packhouse operations. A $200,000 investment in harvesting and materials such as crates and collection centers will result in a return on investment with at least 10:1.

Other specific recommendations are made relating to harvesting tools, harvesting methods, handling systems and crate filling – simply changing the way the individual crates are filled could increase by 20% the volume of fruit treated per hot water treatment. Changing the fruit sizing system from a visual size basis to a weight basis will increase the number of exported cartons by 5 to 10% - with the same total amount of fruit - simply by ensuring more accurate net weights. The terms of reference have also been developed for the second phase of the program and recommendations given to begin parallel assistance in the processing of the fruit.

This report was prepared by Andy Medlicott, Postharvest Specialist and is based on a visit to Haiti from the 5th to 9th March 2001.

2. Background

Mangoes are an important and growing export product for Haitian hillside producers. However, current production and postharvest practices employed by producers significantly reduce potential income from mango sales. Haiti has one of the highest postharvest loss rates for mangoes in the world, reducing potential income to small farmers producing this crop. Although impossible to put an accurate figure on overall losses, they are substantial when one considers the transport chain from tree to shipping container with some estimates of rejection rates from 60-70 percent. Losses are caused by a variety of factors – many of which can be controlled with minimal investment and training.

Some losses are due to physical impact damage occurring when producers harvest the mangos in an immature state. Additional losses occur when producers or fourniseurs load fruit in woven straw baskets mounted on the backs of donkeys for transport down hillsides. The movement of the animals, coupled with the rough baskets used for mangoes, cause unacceptable damage to the skin of the fruit. Additional damage occurs when the fruit is exposed to sun and rain and also is transported over long distances over rough roads without the protection provided by transport bins. They usually end up on the bottom of pickup beds overlaid with other heavy cargo and people. Additional losses may occur as a result of the hot water treatment of immature fruit, which results in collapse of the pulp in the shoulder of the fruit and by jelly seed (soft nose), a disorder usually attributed to overly mature fruit.

3. Terms of Reference

The overall objective of the mango postharvest improvement program will be to reduce postharvest losses by HAP mango farmers by 25 percent during the first year of the program (measured both in-field and at the packhouse). This task order is divided into two phases:

- Phase I will design a program of proposed HAP training interventions and investments that will have immediate impact on HAP hillside farmer clients. A level-of-effort of ten days will be required from a senior postharvest physiologist with extensive experience with mangoes. Expected timing for completion of Phase I is February 2001.

- Phase II will implement the program, which will likely include investments in low-cost materials and equipment for farmer groups (e.g. harvesting implements, field crates, collection centers, etc.) and direct training to farmers and packhouse personnel in the latest postharvest techniques for mangoes. Phase II will likely involve two months of level-of-effort during the 2001 season (exact timing to be determined in Phase I) and will require the services of a senior postharvest specialist with extensive experience with mangoes.

The detailed terms of reference for Phase I (Design) are as follows:

- Visit up to three HAP client farmers groups and two mango exporters to assess postharvest practices and infrastructure;
- Make recommendations on improved postharvest practices during visits to farmers and packhouse staff during this assignment;
- Prepare a written and concise report that provides a brief background on current postharvest constraints (including estimated postharvest loss rates on-farm and at the packhouse to be used as a program baseline), detailed requirements on investments in equipment and materials required for HAP client groups (with recommendations on quantities required, sourcing, and percentage cost-sharing by HAP), proposed training programs (including sample training materials), and a detailed scope of work for Phase II of the program.

A detailed terms of reference for Phase II will be drawn up during Phase I.

This report summarizes the activities and recommendations carried out in Phase I of the program during a visit from the 5th to the 9th March 2001. The trip was coordinated by Fernando Correa with assistance from Junior Paul and Zach Lea.

4. Observations and Recommendations

Visits were made to exporter facilities in Port au Prince for observation of the facilities and discussions with 5 exporters. Visits were also made to three grower groups in Jacmel and Leogane. In addition to being fact-finding visits, several recommendations were provided to each of the exporters or grower groups (these are provided below). The following sections provide the rejection levels, observations and recommendations.

4.1. Estimation of Postharvest Rejection

Note: Haiti presently exports an estimated 45% of the total mango crop. The other 55% are not postharvest losses – the majority are postharvest rejections - fruit that are rejected at various stages of postharvest handling. This implies that they can be avoided. A small percentage of the fruit is actually lost. Most of the 55% is sold on the local market or for processing. The challenge is to reduce the number of fruit rejected to increase the percentage of exported fruit from the total available crop.

Based on figures provided by growers and exporters, the following estimates for rejection for export were developed for each handling stage:

Area	Rejected by	% Rejection	% for Export	Causes of Rejection
Tree	Grower	20%	80%	On-tree scarring & maturity
Field Collection Point	Grower / Buyer	15%	70%	Fresh mechanical damage & maturity
Packhouse Reception	Exporter	20%	55%	Fresh mechanical damage & maturity
Packed Fruit Prior to Shipment	Exporter	10%	45%	Fresh mechanical damage & over-ripe
		Total Crop Rejected	**55%**	

The 55% rejection is comparable with previous estimates by others in the sector. These are not necessarily postharvest losses as most of the fruit is not "lost", but simply downgraded in quality. With the exports valued at $8 million and coming from 45% of the total crop, a 20% increase in the exportable volume to 65% of the total crop, could increase the export value to almost $10 million. The challenge is to find simple workable solutions to reduce the rejection rates at each handling stage. The return of investment will then be high and readily accepted by all parties. As a reference, most organized mango production systems export 85% to 95% of the total crop.

4.2. Production Systems – Relating to Postharvest Activities

4.2.1. Observations

The mangoes are not grown under "standard" production practices for export fruit. There is no pruning, fertilization or disease control; trees are of varying ages and condition being dispersed over wide areas. Quality begins in the field – quality cannot be improved - only maintained. If the quality on the tree is poor, the final quality presented to the consumer will be poor. Estimates made during the visit indicated that up to 40% of the rejection will be caused by defects attributable to grower conditions such as fruit scarring from leaf and branch rub (Photos 1, 2 & 3), "rain" or water stains (Photo 4) and fruit to fruit stains (Photo 5). Anthracnose will also cause rejection later in the handling chain. These can be reduced by pruning of branches, stems, leaves and very young fruit.

Old panicles were noticed from the previous seasons harvest; these branches will not produce fruit (Photo 6). Over 25% of the terminal branches had old panicles. They should be removed after harvesting is completed to enable vegetable growth and subsequent flowering.


Photo 1. Rejected fruit at packhouse


Photo 2. Leaf rub causes blackening and scarring of the fruit skin.


Photo 3. Stems rub on the fruit surface that scar & blacken the skin.


Photo 4. High humidity will cause water stains with high levels of black specs in the lenticels on the skin.


Photo 5. Staining caused where two fruits rest against each other


Photo 6. Branches with last season's fruit panicle will not produce fruit.

4.2.2. Recommendations

Standard pruning practice recommendations will not be followed, nor will fertilization and disease control procedures. Farmers do not and probably will not invest in the trees. At the minimum, growers should be advised to lightly prune the trees after the current harvest, at least for those branches they can reach from the ground. This will also remove the old fruit panicles. Removal of the stems and some leaves during early fruit growth will prevent scarring – in fruits which can be reached from the ground. Efforts made in reducing in-field fruit scarring from the stem and fruit to fruit may result in a 10% reduction in rejections.

Yields could also be increased by fertilization. No-one fertilizes. Leaf and soil nutrient analysis will immediately provide recommendations for fertilizer requirements (both macro and micro nutrients). If fertilizers cannot be purchased, then natural or home produced fertilizers could be promoted. As the trees have never been fertilized it can almost be guaranteed that they will respond with increased production volumes.

Note: Maturity and ripeness are terms that are frequently confused. Harvest maturity relates to the physiological maturity at the moment of harvest. Immature mangos are those that will not ripen normally nor develop their full flavor characteristics after harvest. Fully mature mangos will ripen normally after harvest. Mature fruit are not ripe fruit nor vice versa.

4.3. Postharvest Handling Systems: In-Field

4.3.1. Observations - Harvesting

Harvesting is carried out with picking poles (Photo 7) either from the ground or climbing the tree and dropped to a catcher below (some trees are easily 12 m tall). Most of the damage occurring at this point is not seen until later during ripening. There are at least three areas where mechanical damage can occur:

- ☑ At harvest as the fruit falls into the bag of the picking pole (fruit to fruit). This is increased as more fruit are collected in the bag before emptying.
- ☑ As it is caught by hand by the catcher on the ground.
- ☑ More than likely, the catcher then drops the fruit onto the ground where the latex is supposed to drain. He will not be bending down to "place" every fruit stem down.

Photo 7. Harvesting using picking poles

There is limited control of latex flow that almost always results in staining of the fruit. Additional problems may occur when the fruit is placed on the bare soil as soil sticks to the latex, essentially creating a sandpaper effect which scratches the skin. Also, stem end rot caused by *Diplodia* can be picked up from the soil which will enter the broken stem.

Photo 8. Picking pole modifications are required, including adding a blade and shortening the bag.

4.3.2. Recommendations – Harvesting

There are several improvements that can be made at limited or no additional cost:

- ☑ Add a knife or cutting blade to the picking pole (at the "reduced neck" of the frame), so that the fruit are cut from the tree with the stem intact and are not "ripped" off the tree. (Photo 8) This will also reduce the effort required and will in most cases enable the fruit to be picked with the stem intact.
- ☑ The depth of the bag should be reduced to a maximum of 30 cm; this will reduce the distance the fruit has to fall after picking.
- ☑ With the shorter bag only 3 to 4 fruit should be picked before emptying.
- ☑ Dropping the fruit to a catcher is unavoidable given the height of the trees and the unlikely adoption of the technique of lowering the bags or poles to the ground. The catchers have to catch the fruit in a way to minimize the impact against the hands.
- ☑ If crates are available for transporting fruit from the field, one person should be located under the tree with the catchers to receive the fruit, break the stem and place (not drop) the fruit stem downwards on fresh banana leaves. As said before, the harvesters should not place the fruit on the bare ground. The stem should be removed by snapping and the fruit placed in a bucket of water with 0.01% chlorine for 2 to 3 minutes. If no chlorine is available, the water has to be changed regularly to avoid build-up of fungal spores. This will reduce latex staining, prevent the fruit from being dropped on the ground and prevent contamination with soil. If no water is available the fruit should be allowed to drain for at least five minutes on the banana leaves. The catchers should place the fruit into the field crates with the fruit upright and the stem end of the fruit pointing downwards (Photo 18).

- ☑ If crates are not available and transport from the field is done in sacks, the fruit should still be harvested with the stem intact. The stem should be removed by snapping and the fruit then placed in a bucket of water with 0.01% chlorine for 2 to 3 minutes. If no chlorine is available, the water has to be changed regularly to avoid build-up of fungal spores. This will reduce latex staining, prevent the fruit from being dropped on the ground and prevent contamination with soil. The fruit should then be dried or allowed to dry before placing in sacks. If no water is available the fruit should be placed stem end downward on green banana leaves and allowed to drain for at least five minutes before placing in sacks.

These changes should reduce the rejection rate by 3 to 5%.

4.3.3. Observations - Transport to Collection Centers

At present, the fruit are collected and placed in sacks, then loaded on donkeys for transport to collection centers. This will cause a variety of problems from latex staining to major mechanical damage in the form of bruising and scarring. The actual rejection levels from fresh mechanical damage from this area is not known but could easily account for 10% of the 20 to 25% rejections which occur at the collection centers.

4.3.4. Recommendations - Transport to Collection Centers

There is no easy cheap solution to this problem. The mangos have to be transported in plastic field crates – the same as in almost all fresh produce handling systems. Field crates will reduce the mechanical damage to at least 5%. Solutions have to be found for carrying field crates on donkeys. Frames can be built to fit the specific crates used, made from 1" angles or wood. These would carry 5 crates with 13 to 14 kg or their equivalent, totaling 60 to 70 kgs. Recommendations for field crates are provided in Section 4.3.8.

4.3.4. Observations – Collection Centers

Photo 9. Collection centers lack ventilation and are not conducive for ease of handling.

Several collection centers were visited although they did not contain fruit. They were characterized by the lack of infrastructure and less than appropriate conditions for handling and storage (Photo 9). The fruit at this stage is probably handed 4 or 5 times and it is placed in piles on the floor, sorted by the buyer into another pile, maybe moved again to another pile inside a room for holding and then loaded into crates or loose onto pick-up trucks. The multiple handling of individual fruit guarantees mechanical damage of all forms, which will be noted at the packhouse reception or when the fruit commence ripening. In addition to damaging the fruit, this method is highly inefficient both in terms of the time required and in the grading process. The "stores" or holding areas observed were small and enclosed with little or no ventilation. Fruit stacked in piles on dirt floors under these conditions for any length of time will result in rapid quality loss, and poor shipping and shelf-lives.

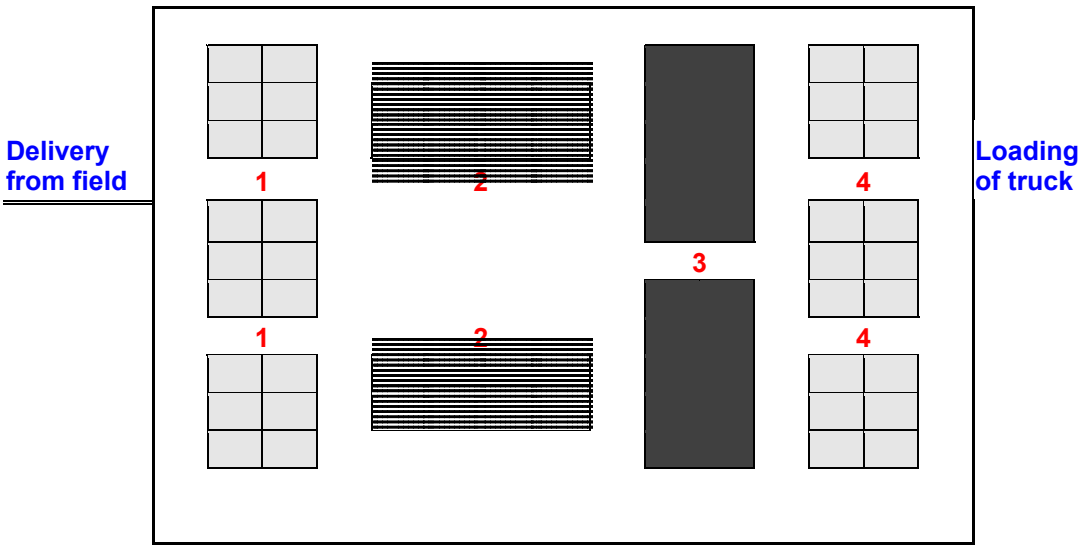
4.3.5. Recommendations – Collection Centers

There are several improvements that need to be implemented to reduce the handling (and mechanical damage), improve efficiencies and provide more suitable conditions for temporary storage. The collection centers need to be "centers" in the true sense of the word - not just a center by location. As such, they should have basic facilities including a roof, a cleanable floor (preferably concrete), water, a wash tank (preferably fiberglass) and sloped grading tables (wooden). These should be able to be built for below $2,000. Fruit entering the facility enters in

plastic crates and after washing and grading, is placed straight back in the crates for holding prior to loading on the truck for transport to the packing plant. The 4 or 5 times individual fruit handling is reduced to 2. The process becomes more efficient and more accurate. Temporary holding could be carried out in the crates under the same structure where there is ventilation and overall lower temperatures. Improvements made in this area could reduce the subsequent rejection levels by 5 to 10%.

Collection center size would depend on the expected fruit volumes, but given the basic nature of the facility, they can easily be expanded by adding more roof, additional wash tanks and grading tables. A basic schematic design is given in Figure 1. A 3.5 m x 5.0 m structure with two wash tanks and two grading tables would have the capacity to wash and select 400 to 500 Kgs and hour. If volume requirements are lower, only one tank and one table would be required. The key points are that the fruit on arrival is transferred in field crates, emptied into a water tank, washed and placed on a sponge lined grading table, and the acceptable fruit place straight back into the plastic crates for holding prior to transport. The cost benefits of this operation should easily be justifiable in terms of the reduced fruit damage and subsequent rejection, plus the improvements in efficiency, productivity and accuracy. After the mango season, the center could also be used for other fruits, or for other activities if the tables and tanks are moved.

Figure 1. Schematic Layout for Mango Collection Center



1 = Delivery area for "dirty" fruit from field; held in field crates

2 = Raised fiberglass wash tanks (W 1m x L 2m x H 0.5m)

3 = Sloped wooden grading tables covered with sponge and plastic.

4 = Holding/loading area for clean fruit; held in field crates.

Suggested size for and equipment for 400 to 500 Kgs fruit per hour: W 3.5 m x L 5 m

4.3.6. Observations – Field to Packhouse Transport

Transport systems observed ranged from loose fruit on a pick up truck to a container truck with fruit in bins and crates. People, spare tires and other items were normally seen on top of the mangoes (Photo 10). From the point of loading the fruit to off-loading at the packhouse reception maybe each individual fruit was handled up to four times. While some roads did appear good, there were also many roads in somewhat poor condition that would definitely contribute to mechanical damage. -

Photo 10. Mango transport in pick-up trucks complete with benches.

4.3.7. Recommendations – Field to Packhouse Transport

In reality, there is little point in trying to improve on the existing loose fruit loading systems, nor in trying to get pick-up trucks to stop putting people and articles on top of the fruit. The same recommendation to use plastic crates for field transport and collection centers applies here. The minimum amount of damage and maximum efficiency will be obtained by directly loading the crates onto the trucks. This would probably eliminate the use of pick-up trucks unless they use an outside frame. In order to help with quality maintenance, the fruit in the trucks should not be totally enclosed, but simply covered to protect from the sun and rain, with some ventilation possible. It may be possible to reduce the damage occurring in this area by 25%.

4.3.8. Recommendations – Field Crates

Crates have to be purchased. Without crates very little reduction in rejection will be seen. The type and size of the crate should be decided in consultation with the exporters and based on costs, number and logistics as well as the effects on the fruit during handling. While there are some cost benefits for the smaller “milk” crates there are some limitations in terms of mechanical damage from the large ventilation on the sides and base (Photos 11, 12 and 13). Technically the 13 kg capacity crate is the most suitable. While the milk type crate is not considered the best for handling purposes because of the mechanical damage, it does appear to offer benefits in terms of the weight when full and is relatively inexpensive.

Standard plastic field crates weigh between 13 and 18 kg when full, while the milk crate probably weighs less than 10 kg when full; this makes it easy for handling for both sexes. Cost benefits are also found: less than $3 for the milk crate compared to $6 to $9 for the standard field crates – less investment cost and lower unit replacement costs if lost or broken. The logistics have to be worked out for the circulation, transportation and responsibility, but they would probably be “owned” by the grower associations.

Photo 11. Plastic “milk” crate currently used by most exporters

Photo 12. 13 kg capacity solid base field crate (L 50 x W 33 x H 28.5cm)

Photo 13. 18 kg capacity ventilated field crate (L 55 x W 38 x H 33 cm)

The author cannot make recommendations as to the number of crates required nor the final design selection. This will depend on the volume of fruit harvested by the grower groups chosen and the amount of funds available for purchase of crates.

Note: From an overall quality perspective the Haitian mango would probably not meet Grade 2 if US commercial specifications are used for "mango in general". This is not surprising given the production conditions and present handling. Luckily, the Haitian mango is categorized somewhat different from the majority of mangos in the market and is judged separately. Problems will occur for Haiti however if a competing country begins producing the same variety under normal commercial production systems with the resulting improvement in overall quality and possibly lower costs. Improvements have to be made somewhere along the chain.

4.4. Postharvest Handling Systems: Packing Plants

4.4.1. Packing Plant Observations

There appears to be a wide range of designs and processes used by the exporters in the plants themselves.

- The exporters reject fruit that do not meet the required quality on receiving at the packing plant. There are no written quality specifications. In effect, the majority of the losses that have occurred up to this point do not directly affect the exporters as they do not pay for the fruit. They have however lost the opportunity of exporting. Some exporting companies have seen the benefit of working in the production areas, which helps to increase the delivered exportable volume to the packing plants.
- Fruit maturity is judged by eye and experience; some exporters randomly cut the fruit – white pulp will cause full rejection. Others selectively judge the fruit maturity. This is particularly a problem in early season fruit as growers harvest early to obtain income and the exporters buy early to ensure a presence in the field and in some cases, in the market. It is in most cases however, detrimental to all.
- Two plants visited were designed with the required materials flow for efficiency and fruit quality maintenance; the other three plants visited were not.
- Food safety systems were not considered a priority by most and were definitely not possible in some plants. USDA inspectors are present only to supervise the hot water treatment and are not involved in implementing or ensuring food safety or HACCP programs.
- Most of the exporters talked to consider their fruit to be of good or the best quality.
- Cold rooms where used, were operated at low humidity, because of the believed effect on anthracnose development. Temperatures were adequate (10^{o} to 12^{o}C). These low humidity conditions also increase water loss and shriveling which tend to be increased by the hot water treatment.
- Bins and plastic crates are used by the exporters. The crates are the "milk type" – square with high ventilation on all sides. The vented base can and does cause some mechanical damage particularly if the fruit is softening. Most were dirty. The fruit is loaded in the crate in no particular fashion (Photo 14).
- Fruit are size graded by eye and packed by count into the cartons (Photo 15). Cartons appear to be either 4.0 or 4.5 kg net weight. No weighing scales were seen in the packhouses.

- Some exporters hold the fruit in open cartons to enable ripening to commence (Photo 16); the fruit are then re-checked prior to carton closure just prior to shipping. Fruit with insufficient ripeness or over-ripe is removed from the carton and replaced. Damaged or diseased fruit are also removed. Some exporters hold under ambient conditions, while one was using 20°C but with low humidity. Problems include the multiple handling, the inefficiency of the whole system and cartons sitting on top of fruit causing further mechanical damage.

Photo 14. Plastic "milk" crate used in packing facilities.

Photo 15. Fruit are normally size graded by eye for packing

Photo 16. After packing, cartons are left open and fruit allowed to ripen before shipping

- When fruit is palletized for sea shipment the carton ventilation and the pallet design have to be compatible. In some cartons they were not. If the air vents in the base of the carton are covered by the wooden slat of the pallet, air will not travel through up the column of the cartons – cooling will not occur. Some pallet bases were being covered with cardboard to prevent the cartons from slipping through the slats; this would result in zero air flow through the cartons in the container and very limited cooling or temperature control. Fruit would be hot and probably at a more advanced ripening stage on arrival.
- While exporters appear to be grading by ripeness stage, none of the companies were labeling the cartons so the importers could easily identify the pallets with more advanced fruit – and sell first.

4.4.2. Packing Plant Recommendations

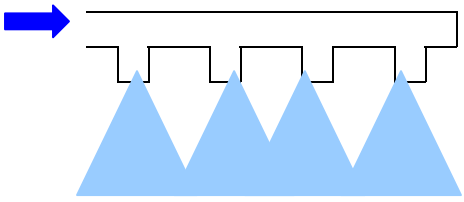
Improvements are possible and implementation will have to take into account the improvements in productivity and reductions in quality loss to determine the return of investment. In this particular case, the importing market is not the main drive for change – increased exporter profitability by reduction of costs, increased productivity or increased available volume are the driving factors. The exception will eventually be with food safety systems that may begin to be demanded by certain buyers for selected markets. General and specific recommendations are as follows:

- If field crates are used from the tree onwards with delivery direct to the plant, at least two individual fruit handling steps will be removed at this point. Delivery and off-loading at the plant will also be improved both in terms of the fruit quality and in terms of labor costs. Rejections can be expected to be reduced by at least 25% over the loose handling system.
- Fruit harvest maturity will likely continue to be judged on experience and by cutting the fruit. Where water tanks are used, exporters may want to consider using a 1 to 2% salt solution to "float" the immature mangoes to the top. This would need to be checked as varieties do behave differently. Some immature fruit do sink. Growers need to be

encouraged to leave the fruit on the tree and begin harvesting when at least 4 or 5 fruits begin to ripen (although difficult).

- Plant design and layout in some operations can be significantly improved. This would require investment in time and assistance to the exporter to find the best ways for each operation. This should be carried out under Phase II. Similarly, the basic food safety and HACCP pre-requisite systems can begin to be implemented this season, particularly those that directly affect cost, productivity or management information systems. Other HACCP requirements and systems can be implemented in the second season.
- Cold rooms for fresh fruit, including mangoes, should be operated at 85 to 90% relative humidity. Anthracnose is a postharvest disease that begins in the field. The fungal spores are present in the fruit in the field – they do not infect the fruit after harvest. The disease begins to develop only as the fruit begin to ripen and as conditions allow. Low humidity will reduce the development, but so will low temperatures. If the fruit is held under ambient conditions to ripen, anthracnose will also develop if present. No information is available on weight loss so no cost benefit can be given for increasing the humidity. This information needs to be obtained. Low cost manifolds can be built with spray nozzles (size 2.5 to 3.5) that can be used to humidify a cold or ripening room (Figure 2).

Figure 2. Spray Manifold for Raising Humidity



Humidification Manifold. 0.5" PVC tubing with T-joints to attach "full cone" spray nozzles (size 2.5 to 3.5). Manifold placed at 45^{o} angle, 3 to 4' in front of blowers on ceiling.

- Plastic crates are needed at all stages. While the milk type crate is not considered the best for handling purposes because of the mechanical damage, it does appear to offer benefits in terms of the weight when full and is relatively inexpensive. Standard plastic field crates weight between 13 and 18 kg when full, while the milk crate probably weighs less than 10 kg when full; this makes it easy for handling for both sexes. Cost benefits are also found: less than $3 for the milk crate compared to $6 to $9 for the standard field crates – less investment cost and lower unit replacement costs if lost or broken.
- At present, plastic crates are simply filled with fruit. Normally the fruit are placed in the crates with the stem facing down and the shoulders on the second layer resting between the bases of 2 fruit below (Photos 17 & 18). A quick test with this method showed that almost 30% more fruit could be placed in the same crate. Three crates with the standard random fill were equivalent of two crates "placed" filled. This reduces the number of crates needed and could have a major effect of the hot water treatment throughput, increasing the amount of fruit per treatment by at least 20% - thus increasing productivity with very little change and no investment. This method of filling the crates applies throughout the **entire** handling chain, direct from the tree onwards.


Photo 17. Random fill in crates


Photo 18. "Place" filling increasing the weight of fruit in the crate

- Size grading by eye probably results in the exporters "giving away" between 5 and about 10% of the fruit. The buyer wants a minimum of 4 kg or 4.5 kgs as stated on the box. Normally the exporter packs the required net weight, plus 5% extra to account for possible weight loss. This is not being done as neither the fruit nor the packed carton is being weighed. The fruit is being sold with a specific count and a full box. Experience with mangos and papaya has shown that with this system some cartons will be above and some below the required net weight – the majority however are above as the carton has to be "full". This extra weight can total up to 10% ie. if 100 are shipped today, by improving the size grading 110 can be shipped tomorrow from the exact same fruit. The main problem is the fruit are graded by count and graded by eye by apparent SIZE not by WEIGHT. Previous experience has shown that providing scales to packers for weighing individual fruit can reduce this variation. Low cost weighing machines may also be considered. Note: some resistance may occur from buyers selling into the ethnic market where "full" boxes are more important than achieving the net weight. In this case – reduce the box size.
- Checks should be made as to whether exporters receive additional NET income for the 4.5 kg carton as opposed to the 4.0 kg. It is probably worthwhile moving or converting all to 4.0 kgs.
- Ripening under ambient conditions prior to shipment will continue to be inefficient and cause quality problems as the packed fruit is harvested at different harvest maturities and thus they will ripen at different rates. These different rates are longer and more pronounced in the early season and less so as the season progresses. The standard answer to this problem is to force ripen the fruit using ethylene gas treatment at 20^{o}C for 24 hours. All the fruit will begin to ripen together and reduce the variation. This requires a ripening room and some basic ripening equipment. Some exporters could do this with existing facilities. This would improve productivity and reduce some rejections. Small-scale trials should be carried out.
- For palletization exporters should ensure a standard pallet design is used for their cartons to facilitate vertical air movement through the boxes.

5. Other Follow-up Work – Processing

As only 30% of the mango crop is being exported, local market sales absorb most of the remainder with some being processed. Most fresh produce industries of this nature are supported by processing operations. The processors utilize the second grade product that cannot be exported in the fresh state. They do not normally take third grade product as this type of fruit will not provide a first grade processed product. There are two or three companies buying mango for processing into juices, concentrates and sauces, with all at present being sold locally.

There is good potential for expansion with adequate product development, production support with procedures, costing, etc., market research, market development.

6. Draft Mango Quality and Postharvest Handling Bulletins

The following draft bulletins were drawn up. They need to be formatted (design, layout and color) according to HAP Project standard formats. These are for discussion and can/should be expanded on with input from the producers and exporters. It should be remembered that full agreement between all parties will not be possible particularly where certain areas are subjective.

Growers - Mango Fresh Fruit Standards

Quality Criteria

Growers need to be aware of the final consumer requirements as quality begins in the field. The quality of the fruit cannot be increased after harvest – it can only be maintained. The activities of the growers during harvesting and handling therefore play an important role in the quality of the fruit that exporters can ship. These are principally the harvest maturity, the harvesting techniques and transport to the collection points or the packing plant. Import market requirements state that mangoes on arrival should be:

- Firm with fruit, beginning to ripen
- Uniform shape
- Free of diseases
- Free of decay, sunscald, cracks, bruises, latex stains
- Free of insect and mechanical damage
- Conform to the weight and size specifications.

Harvest Maturity

Control of harvest maturity is essential to ensure good quality fruit on consumption. Immature fruit do not ripen properly and do not develop the required flavor. Mangoes shipped immature reduce prices and cause damage in the market place. All fruit for sea and air shipments should be fully mature fruit.

- Fully mature: Shoulder in line with stem, the apex rounded not pointed, firm and green. The pulp next to the seed should be yellow and the seed hard and fully developed.
- Immature: Both shoulders below the stem and the apex pointed. The pulp is white to pale yellow and the seed soft and not completely developed.

Fruits should not be harvested showing any signs of ripening as indicated by yellow peel color development and softening, particularly at the base of the fruit. Ripe fruits are highly susceptible to bruising and mechanical damage during handling and transport. Immature fruits should not be shipped.

Harvesting

Mangos never mature simultaneously, so fruits are harvested from individual trees on several occasions throughout the season.

Mangoes should be harvested by hand from the ground, where possible, by snapping the mango from the stem. Fully mature fruit will detach easily, whereas half- mature will not. At least 1 to 2 cm of stem should be left attached to the fruit. This method helps to keep the fruit clean from the latex exudation and staining and also reduces the entrance of fungus. If the fruit is harvested without the stem, latex will flow and immediately cover the bag and the fruit. While this can be limited immediately after harvest by placing the fruit stem-down on the ground, problems can occur with soil contamination. If field crates are available for transport, the fruit is placed directly into the field crate at a 45^{o} angle with the stem intact and pointing downwards. The fruit is then not handled again until it reaches the packing station.

If field crates are not available and sacks are used, the fruit should sill be harvested with the stem intact. The stem should be removed by snapping and the fruit placed in a bucket of water with 0.01% chlorine for 2 to 3 minutes. If no chlorine is available, the water has to be changed regularly to avoid build-up of fungal spores. The fruit should then be dried or allowed to dry before placing in sacks. If no water is available the fruit should be placed stem down on green banana leaves and allowed to drain for at least five minutes before placing in sacks.

Plastic field crates are preferred; bags, sacks and buckets are to be avoided, as these result in mechanical damage and bruising. Grading should be done in the field to remove immature, undersized, damaged, bruised, scarred or ripe fruit. Harvested mangoes should not be left in direct sunlight, wind or rain, either in the field or during transport from the field to the pack house.

Collection Centers

Under the best conditions, the fruit are transported from the field to the collection center in field crates. The minimum amount of handling is needed during delivery from the field to collection centers. Multiple handling, piling in heaps, holding in un-ventilated places and exposure to sun and rain will reduce the quality and the shelf-life of the fruit.

Collection centers can be basic facilities comprising simply of a compacted floor and a covered roof. A wash tank and grading tables are the minimum equipment requirements. Wash tanks should be fiberglass not concrete or metal and tables made of wood with foam and plastic covering.

Transport

Most of the fresh mechanical damage is caused by multiple handling, bulk loading on trucks and pick up trucks, the use of sacks and baskets, and overloading. People and spares tires sitting on the top of the fruit do not help. Filed creates have to be used and the crates covered with a tarpaulin; closed trucks should not be used due to heat build up. There is no other solution to this problem. The best solution is for crates to be used from the filed to the collection centers and then in the same crates directly to the packing facility.

Crates will not only reduce mechanical damage but also improve efficiencies and productivity for loading and unloading.

Growers - Export Mango Quality Guidelines

Harvest Maturity

- Harvested fruit should be fully mature, with one of the shoulders raised alongside the stem, the apex rounded and the internal pulp pale yellow in color.
- Immature fruit should not be harvested and are not suitable for export as they do not ripen properly.

Minimum harvest maturity

Immature fruit at harvest

External Quality

- Small blemishes & healed scars are permitted to a maximum of 5% in any one area & a maximum of 10% of the entire fruit.
- Multiple handling, sacks, loose loading on pick-up and dropping or throwing the fruit all cause damage. They result in rejection before or at the market place.

Acceptable condition

Acceptable scarring damage

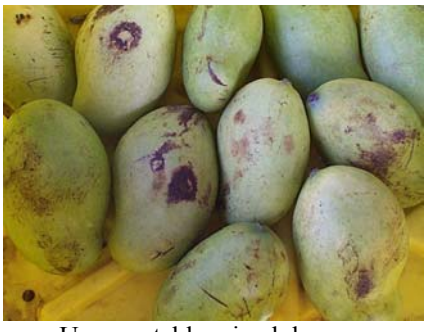
External Quality

- Skin damage in harvested fruit covering more than 10% of the total surface should not be delivered to the exporters, as they will be rejected. This includes fruit to fruit scaring, leaf scarring, branch scarring and rain stains.

On-tree scarring damage

Unacceptable scarring damage

Rain stains



Unacceptable mixed damage

Fresh mechanical damage

Exporters - Mango Fresh Fruit Standards

Quality Criteria

Market requirements state that mangoes on arrival should be:

- Firm with fruit, beginning to ripen
- Minimum sugar content of 10%
- Uniform Shape
- Free of diseases
- Free of decay, sunscald, cracks, bruises, latex stains
- Free of insect and fresh mechanical damage
- Conform to the weight and size specifications.

Harvest Maturity

Control of harvest maturity is essential to ensure good quality fruit on consumption. Immature fruit do not ripen properly and do not develop the required flavor. Mangoes shipped immature reduce prices and cause damage in the market place. All fruit for sea and air shipments should be fully mature fruit.

- Fully mature: Shoulder in line with stem, the apex rounded not pointed, firm and green. The pulp next to the seed should be yellow and the seed hard and fully developed.
- Immature: Both shoulders below the stem and the apex pointed. The pulp is white to pale yellow and the seed soft and not completely developed.

Fruits should not be harvested showing any signs of ripening as indicated by yellow peel color development and softening, particularly at the base of the fruit. Ripe fruits are highly susceptible to bruising and mechanical damage during handling and transport. Immature fruits should not be shipped.

Condition on Shipment

After hot water treatment and packing the fruit should be:

- Physiologically Mature
- Commencing ripening with 30 to 50% yellow coloration for sea shipment and up to 80% yellow coloration for shipments by air
- Firm fruit particularly on the shoulders; the base may show slight softening
- Pulp color: yellow – orange
- No disease development

Grading

All fruit should be graded in each carton (4.0 and 4.5 Kg net weights) according to:

- Size giving range of counts from 8 to 12's:

Count	4.0 Kg	4.5 kg
8's	440 g to540 g	519 g to 600 g
10's	360 g to 440 g	410 g to 500g
12's	300 g to 360 g	340 g to 410 g
14's	250 g to 300 g	290 g to 340 g

- Ripeness stages

Fruits in each carton should be at the same ripeness stage as follows:

Stage 1: 25 to 50% yellow peel coloration
Stage 2: 50 to 75% yellow peel coloration
Stage 3: more than 75% yellow peel coloration

Packing

- Single layer, ventilated, self-locking fiberboard cartons.
- Carton Strength: 250 to 300 lb/in^2
- Individual labels in fruit will assist in product identification.

Carton external dimensions

Suggested external dimensions are length 40 cm x width 30 cm x height 12 cm

Ripening

If further ripening is required before shipment the fruit should be held at 20^o to 25^{o}C and treated with 100ppm ethylene for 24 hours.

Pre-cooling and Storage

If pre-cooling is used the forced air system is preferred as this is a faster system (up to 2 hours) than normal room cooling and results in an increased shelf-life. Normal cold room cooling is a slower process, taking up to 24 hours.

Temperatures in cold rooms should be set at 55^{o}C (12.6^{o}C); lower temperatures may cause chilling injury. The relative humidity should be maintained around 90%; lower humidity will result in water loss (and weight loss) and shriveling of the fruit. Cartons and pallets should not be placed directly against cold room walls as air will not circulate properly.

Shipping Container Conditions

Container temperature should be set at 12^{o}C. Ventilation should be set at a minimum of 25% open, and up to 50% open if Stage 2 ripe fruit (50 to 75% yellow) are shipped. The minimum amount of space should be left between pallets and the final open space at the end of the container should be covered. Drain plugs near the doors should be opened. It is recommended to place two temperature recorders inside of marked cartons placed in the middle of a pallet at both the front and rear of the container. This will be more representative of the fruit temperatures, rather than the simple air temperature which is measured when the recorder is placed on the wall of the container near the doors.

Approximate Storage and Shelf-life

These are dependent on various factors including the stage of ripeness, the cooling procedures, the time of harvest in the season and cold chain maintenance. The maximum that can be obtained is normally up to 14 days.

Export Mango Quality Guidelines

Harvest Maturity

- Harvested fruit should be fully mature, with one of the shoulders raised alongside the stem, the apex rounded and the internal pulp pale yellow in color.
- Immature fruit should not be accepted as they are not suitable for export as they do not ripen properly.

Minimum harvest maturity

Immature fruit at harvest

External Quality

- Depending on market conditions, small blemishes & healed scars maybe permitted up to a maximum of 5% in any one area & a maximum of 10% overall.
- Multiple handling, sacks, loose loading on pick-up and dropping or throwing the fruit all cause damage. They result in rejection before or at the market place.

Acceptable condition

Acceptable scarring damage

External Quality

- Skin damage in harvested fruit covering more than 10% of the total surface should not be accepted and hot water treated, as they will be rejected. This includes fruit to fruit scaring, leaf scarring, branch scarring and rain stains.

Unacceptable scarring damage

Unacceptable scarring damage

Avoid fruit transport loose

Placed pack in crates

Packed fruit is uniform in size & ripeness

Fruit at 25% ripeness color stage

Fruit at 50% ripeness color stage

Fruit at 75% ripeness color stage