USAID FIRMS PROJECT

Mango MUAVAN Program On-Farm Infrastructure-Design and Specifications

Mango Pack house Analysis

February, 2010

This publication was produced for review by the USAID. It was prepared by David Picha for an assignment commissioned by Chemonics International under the USAID Firms Project.

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Data Page

Contract Number:	GBTI II Task Order No. EEM-4-07-07-00008-00
Contractor Name:	Chemonics International, Inc.
Name of the Component:	Value Chain Development (VCD)
USAID Technical Office:	Office of the Economic Growth and Agriculture; USAID Pakistan
Date of Report:	February 26, 2010
Document Title:	Mango MUAVAN Program On-Farm Infrastructure-Design and Specifications
Author's Name:	David Picha
Photo Credits:	David Picha
Editing:	Saleem, M.
SOW Title and Work Plan & Action ID:	Action # 3232, SOW # 1093
Project Area:	Nationwide, Pakistan
Key Words:	Cold storage, Disease control, FIRMS Project, Harvest, Mango MUAVAN Program, Mango Processing Plant, Packinghouse, Pakistan, Pruning Tools, Retail supermarket sector

Abstract:

This report contains recommendations and suggestions for improving the postharvest practices of Pakistani mango growers/traders that will enable them to produce fruit of a considerably higher quality. Care in farming practices may lead to penetration of the European retail supermarket, which can open other international trading opportunities for the mango producers. For these purposes, FIRMS project has commissioned a support program by the name of ‘Mango MUAVAN program’.

Acronyms

AS/NZS	Australian/New Zealand Standard
ASTM	American Society for Testing and Materials
CRISP	Community Rehabilitation and Infrastructure Project
FIRMS Project	USAID/Pakistan funded project
GlobalGAP	Global Good Agricultural Practices
HP	Horsepower
ISO	International Organization for Standardisation
KV	Kilo Volt
KVA	Kilo Volt Ampere
MGA	Mango Growers Association
MoU	Memorandum of Understanding
PVC	Polyvinyl Chloride
SOW	Scope of Work
USAID	United States Agency for International Development

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Executive Summary

USAID FIRMS Project developed a support program, the “Mango MUAVAN Program” in cooperation with both private and public sector mango stakeholders. The idea is to make improvements in both pre-harvest production practices and postharvest care, which are necessary in order for Pakistani growers/exporters to penetrate the European retail market sector. Currently no such penetration exists but the retail trade trend shows great potential.

The objective of this report is to identify the packinghouse design and equipment needs for the GlobalGAP-certified producers, taking into account individual needs and production capacity of the different operations.

Lastly, a series of improvements/investments are recommended for adoption by export market-oriented mango growers.

1. Introduction

1.1 Background

Significant export market opportunities exist for those Pakistani mango growers/exporters that can provide consistent supplies of high quality fruit at competitive prices. Importers representing the major European retail supermarkets have expressed interest in receiving Pakistani mangoes during the 2010 harvest season. Shipments by both air and marine container are planned to multiple European destinations. However, it is recognized that improvements in both pre-harvest production practices and postharvest care are necessary in order for Pakistani growers/exporters to penetrate the European retail market sector. The FIRMS Project in cooperation with both private and public sector mango stakeholders has developed a support program, referred to as the 'Mango MUAVAN Program', to encourage greater exports to European supermarkets, as well as destinations in the Middle East, Asia, and North America. The retail supermarket trade represents the greatest growth potential for Pakistani mango exports. Currently, there is essentially no penetration of Pakistani mangoes in the European retail supermarket sector. The supermarket trade offers high volume trade opportunities for Pakistani mango exports. The necessary pre-requisites for penetration of this market segment include GlobalGAP certification, adherence to importer/retailer due diligence requirements, and high quality fruit arrival condition. Although Pakistan is one of the world's leading mango producing countries, there are few, if any, grower/exporter operations with the proper on-farm postharvest infrastructure and equipment required for providing the retail export market sector with consistent supplies of high quality mangoes. The MUAVAN Program is an attempt to help alleviate some of the existing constraints that mango growers face in trying to penetrate the supermarket trade abroad.

1.2 The MUAVAN program overview

Well-designed packinghouses with the proper equipment are needed by the Pakistani producers in order to penetrate the international retail supermarket sector. The objective of this assignment was to finalize the packinghouse design and equipment needs for the GlobalGAP-certified producers, taking into account individual needs and production capacity of the different operations. A series of improvements/investments are recommended for adoption by export market-oriented mango growers in each of the postharvest handling steps shown in figure 1.

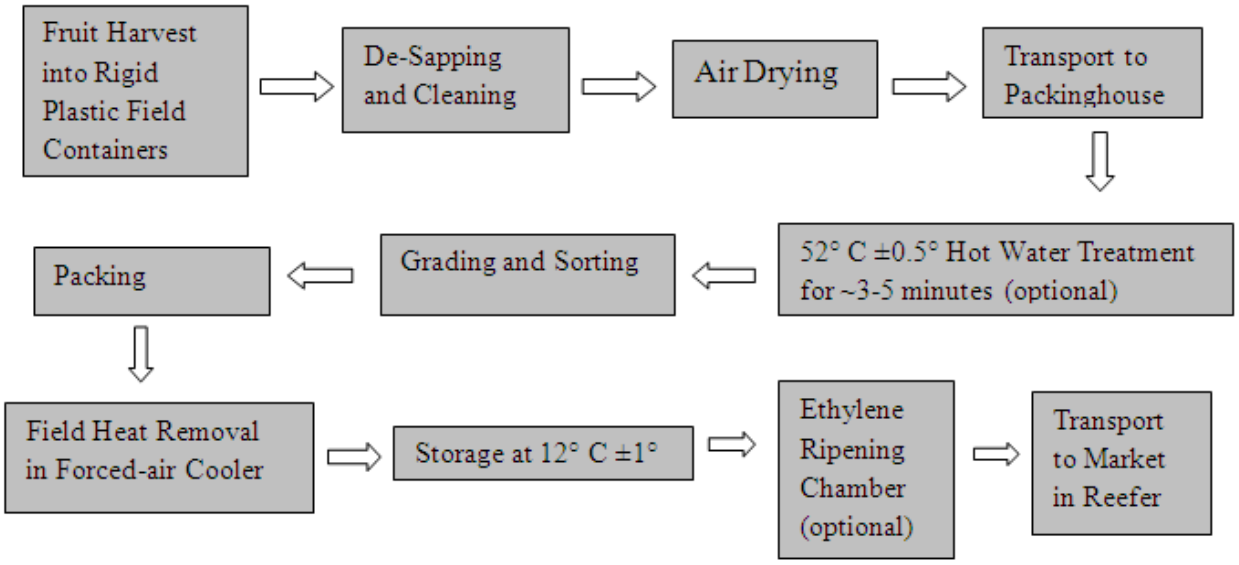


Figure 1: Postharvest Handling Steps

The objective of the FIRMS Project MUAVAN Program is to assist the mango growers and other private and public sector stakeholders with an appropriate technology and infrastructure improvement package, which will allow the Pakistan mango industry to be more competitive in the international market.

2. Specifications and Recommendations

Following are recommendations and detailed specifications for equipment and postharvest infrastructure improvement adoption by participating GlobalGAP-certified growers in the MUAVAN Program.

2.1 Pruning Tools and Harvest Aides

Proper tree pruning is necessary to allow for adequate foliar coverage of crop protectants and to facilitate harvesting. Appropriate pruning tools are needed to rejuvenate and reduce the height of excessively tall trees and maintain the proper canopy form. Inadequate pruning leads to lower fruit yields and higher incidence of disease. The recommended pruning tools include hand-held pruning shears, hand-held saws, and light-weight motorized saws.

Harvest aides are needed to facilitate picking of the fruit, while avoiding sap burn and bruise damage during the harvesting process. These include hand clippers, a lightweight harvest pole fitted with a nylon mesh fruit receiving basket, and strong well-ventilated plastic field crates.

The specifications of the harvest pole (shown below) include it being made out of bamboo or lightweight metal with an oval ring at the end. Two replaceable sharp blades fitted in the form of an inverted V should be mounted on upper end of the oval-shaped ring. A divider of 7.5 cm length is placed at the joining point of the blades. A 15.0 cm long holder measuring 5.5 cm at one end and 3.0 cm at the other is welded to the ring for fixing bamboo handle of desired length. The width of the ring is 12.5 cm at the center while the total length of the ring is 22.5 cm. A slight downward bend is given to the holder while welding it the ring. This helps for harvesting the fruits from upright branches. Nylon net is fixed to ring for collection of harvested fruits. This harvest aide eliminates the danger of fruit falling to the ground.

Strong, well-ventilated plastic field containers (shown below) are ideal for mango harvest. They should be capable of holding about 15 kg of fruit. In addition, they can be submerged with the fruit inside a hot water treatment tank.

2.2 De-Sapping and Fruit Washing

The recommended equipment for field de-sapping and fruit washing will vary according to the size of the farm, tree size, tree spacing, and vehicle access within the orchard. Latex flow from the pedicel can be stopped within a minute by cutting the pedicel in a dilute lime solution (0.5-1.0 % calcium hydroxide). This is generally followed by transferring the de-sapped fruit to a tank of potable water to remove the residual lime from the fruit surface. The de-sapping and washing tanks can be mounted on a movable frame body or put on a trailer and moved to different locations in the mango orchard. Positioning of stationary tanks adjacent to the packinghouse may be another option. Typically, the de-sapping and washing unit should include a stainless steel tank for the lime solution and another stainless steel tank for the potable wash water. However, some growers may prefer to de-sap in the field followed by washing of the fruit inside the packinghouse using an overhead spray wash and roller brushes. Those growers who opt to de-sap and wash the fruit in the field will also need metal or PVC racks for fruit drying. The dried fruit should then be gently transferred into well-ventilated plastic containers and transported to the packing-house facility.

The components of the de-sapping and wash system include 2 stainless steel tanks, a large potable water holding tank (i.e. 2000 liter polymeric tank), metal drying racks (8 x 4 feet), metal stands to support the field containers as the fruit is de-sapped, fans to accelerate fruit drying, and a diesel- or battery generator (2 KV) to power the fans.

2.3 Packinghouse Building

Proper postharvest care of mangoes intended to be sold in the export market requires an on-farm packinghouse building which contains appropriate equipment and infrastructure to properly prepare the fruit for market and allow for adequate cooling and cold storage. The necessary components of a well-designed packinghouse building include a fruit unloading/receiving area, followed by washing, hot water treatment, drying, sorting/sizing/grading, packing, forced-air cooling (blast chilling), cold storage, and a loading area.

Considerable time and effort has been spent discussing the packinghouse infrastructure and equipment needs with the existing and future GlobalGAP-certified mango operations. Based on these discussions, it is recommended that some flexibility be given to the individual mango operations in packinghouse infrastructure and equipment. A universal design is not appropriate for all operations, especially for the ones who already have a packinghouse building and some equipment. In addition, the financial situation differs for each operation. The amount of capital available to be committed for cost sharing and infrastructure/equipment investment varies between operations. Nevertheless, a common footprint design for the packinghouse was developed in joint discussions with the mango producers and CRISP. This design is

recommended to be adhered to in the MUAVAN Program, with some individual stakeholder flexibility allowed for the use of existing packinghouse infrastructure and choice among which equipment manufacture to procure from. There are a number of mango packinghouse equipment suppliers, all with different types of equipment and costs. The recommended packinghouse size, design, and equipment for the MUAVAN Program is based on a compromise between functionality and cost. The recommendations and specifications are based on in-depth discussions and information provided by the mango growers, equipment manufacturers, and CRISP. Gratitude is expressed to all the individuals who spent so much time and effort in providing information to help the FIRMS Project initiate a successful MUAVAN Program and future mango exports to the retail supermarket sector.

A 100 x 60 x 22 foot (L x W x H) packinghouse building is recommended for construction under the MUAVAN Program. It should have ample room for future expansion and the area allocated for the forced-air cooling (blast chiller) and cold storage rooms will be adjacent to the packinghouse. The cooling and cold storage should occupy 900 ft2 (30 feet long x 30 feet wide x 12 feet tall) and have additional space for product movement and loading (air corridor). It should also include a platform for the compressor and genset. A layout and schematic diagram of this packinghouse is illustrated in figure 2 and 3.

The estimated cost for construction of the packinghouse ranges from 500-600 rupees per ft2 if constructed by the grower (and/or his contractor) to a minimum of 1200-1500 rupees per ft2 if constructed by CRISP. A concern shared among all the growers was the possible additional costs to be incurred with a CRISP-constructed facility and the longer timeline needed for initiation and completion of a CRISP-constructed packinghouse.

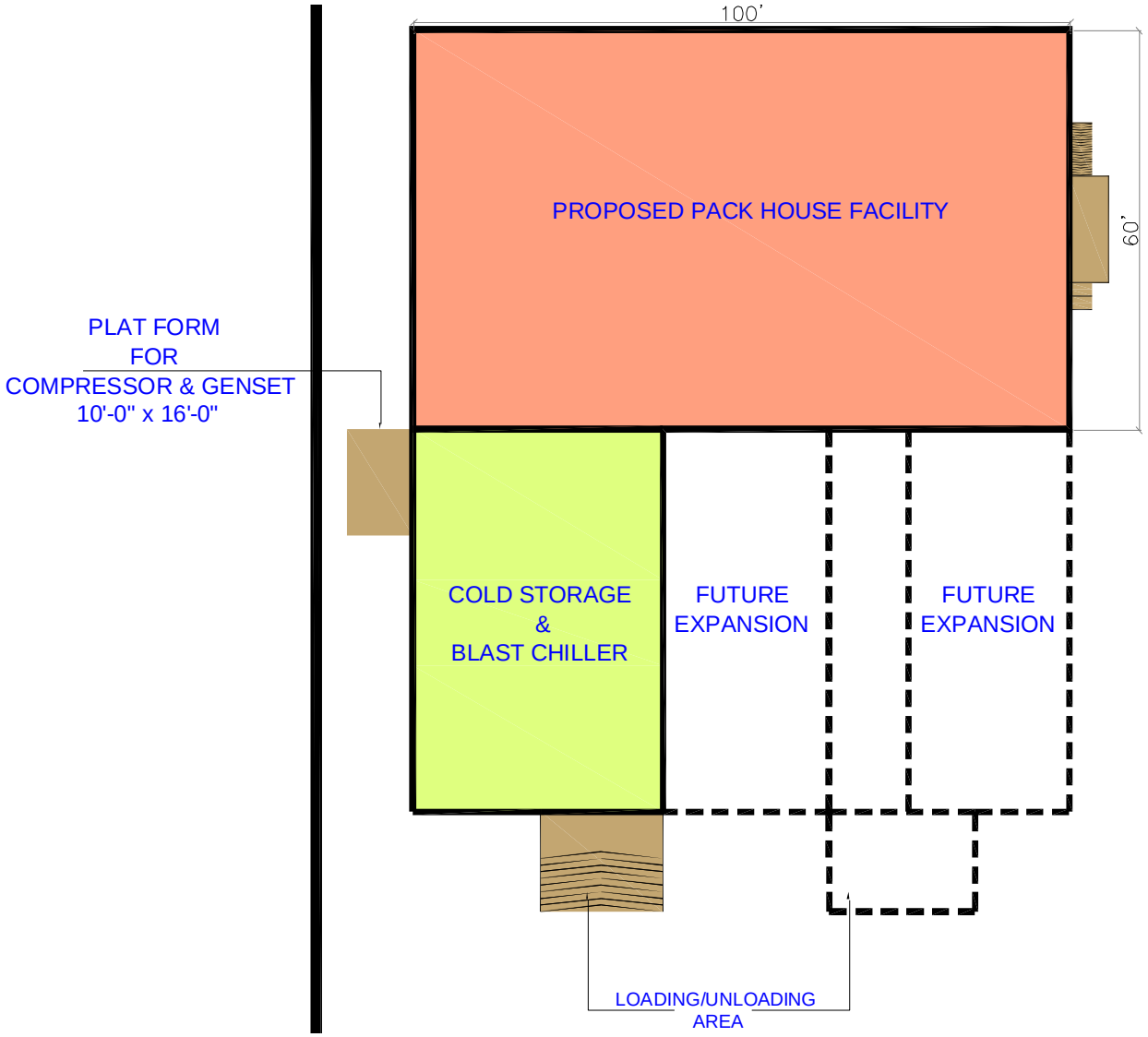


Figure 2: Recommended layout of mango packinghouse and cooling/cold storage facility

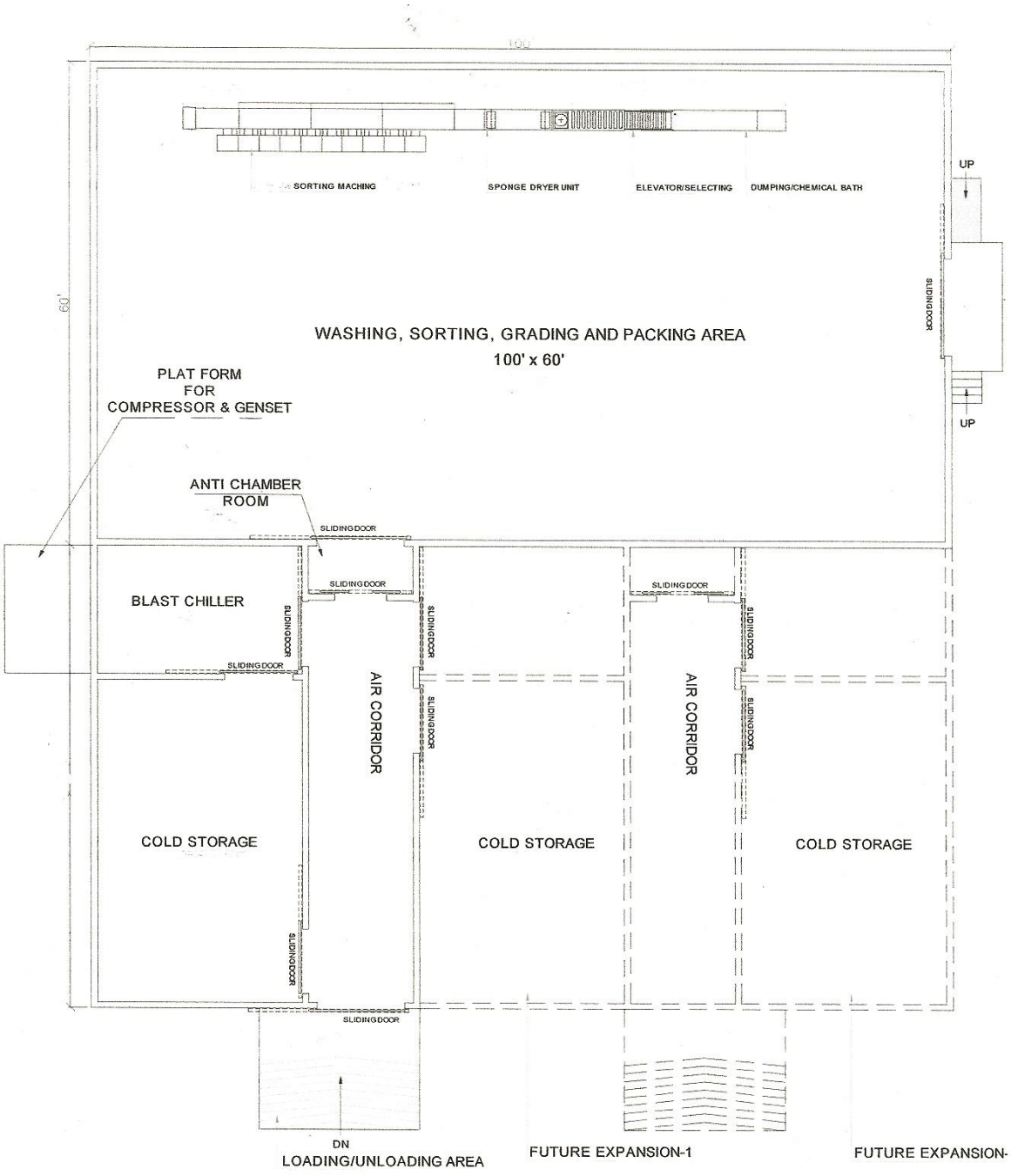


Figure 3: Schematic diagram of recommended mango packinghouse and cooling/cold storage facility

A slightly smaller packinghouse building should also be an option for smaller and more limited resource producers. The recommended size of this building is 66 x 60 x 22 foot (L x W x H). Like the larger packinghouse recommended above, this smaller building should have room for future expansion and the area allocated for cooling (blast chiller) and cold storage will be adjacent to the packinghouse. The cooling and cold storage area should occupy 30 x 30 x 12 feet and have additional space for product movement and loading. It will also include a platform

for the compressor and genset. A schematic diagram of this smaller packinghouse is illustrated below.

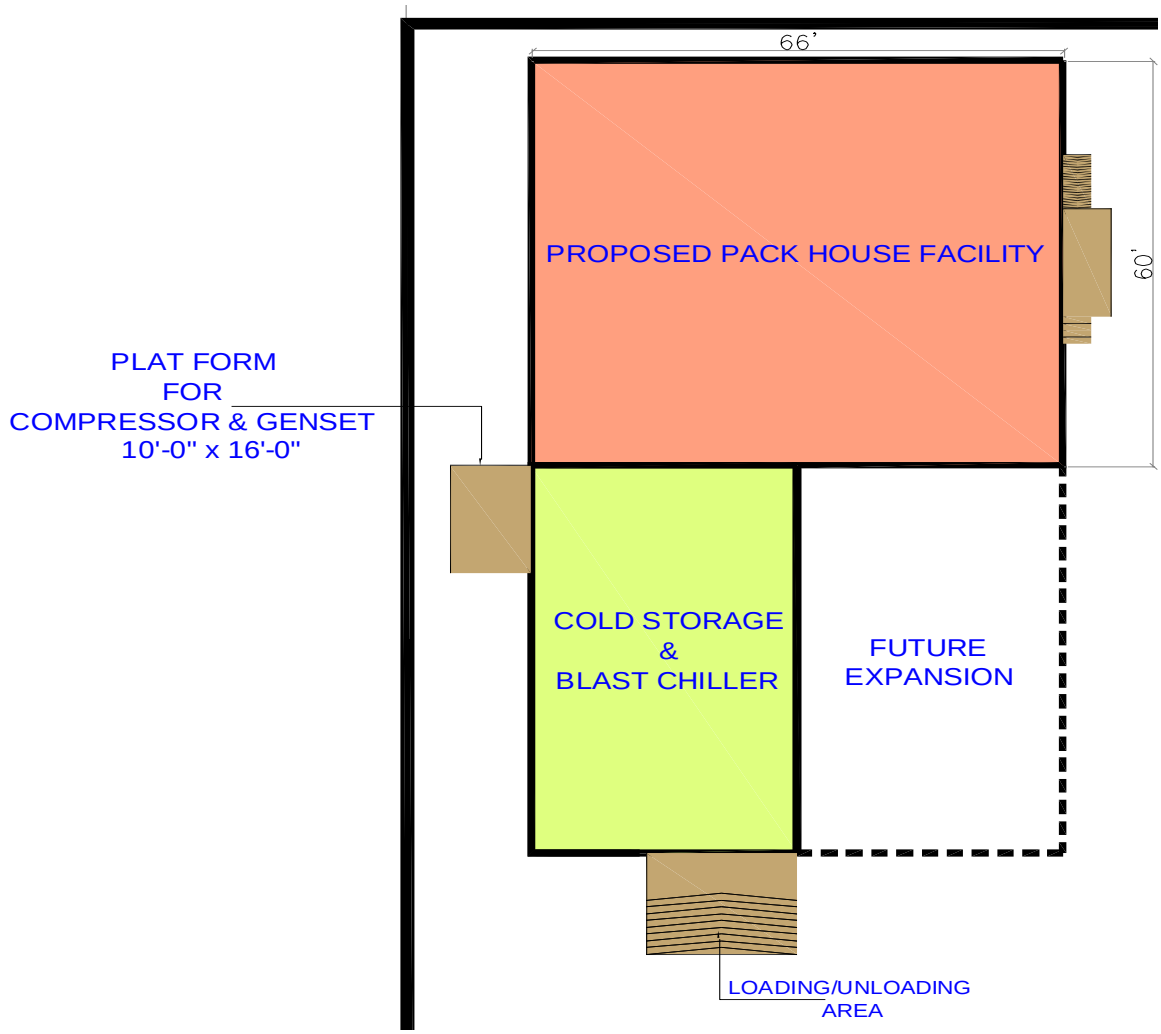


Figure 4: Layout of smaller-sized mango packinghouse and cooling/cold storage facility

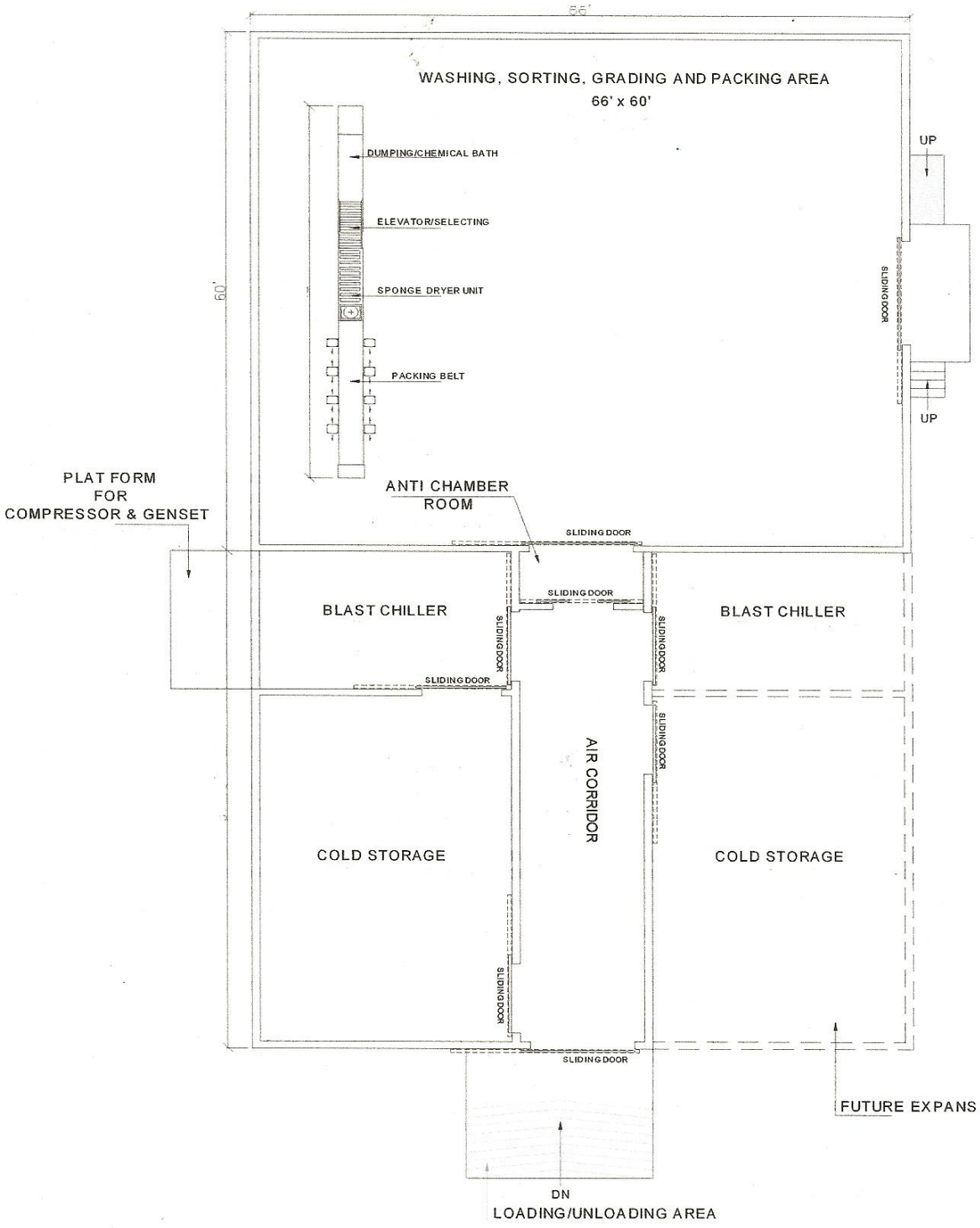


Figure 5: Schematic diagram of smaller-sized mango packinghouse and cooling/cold storage facility

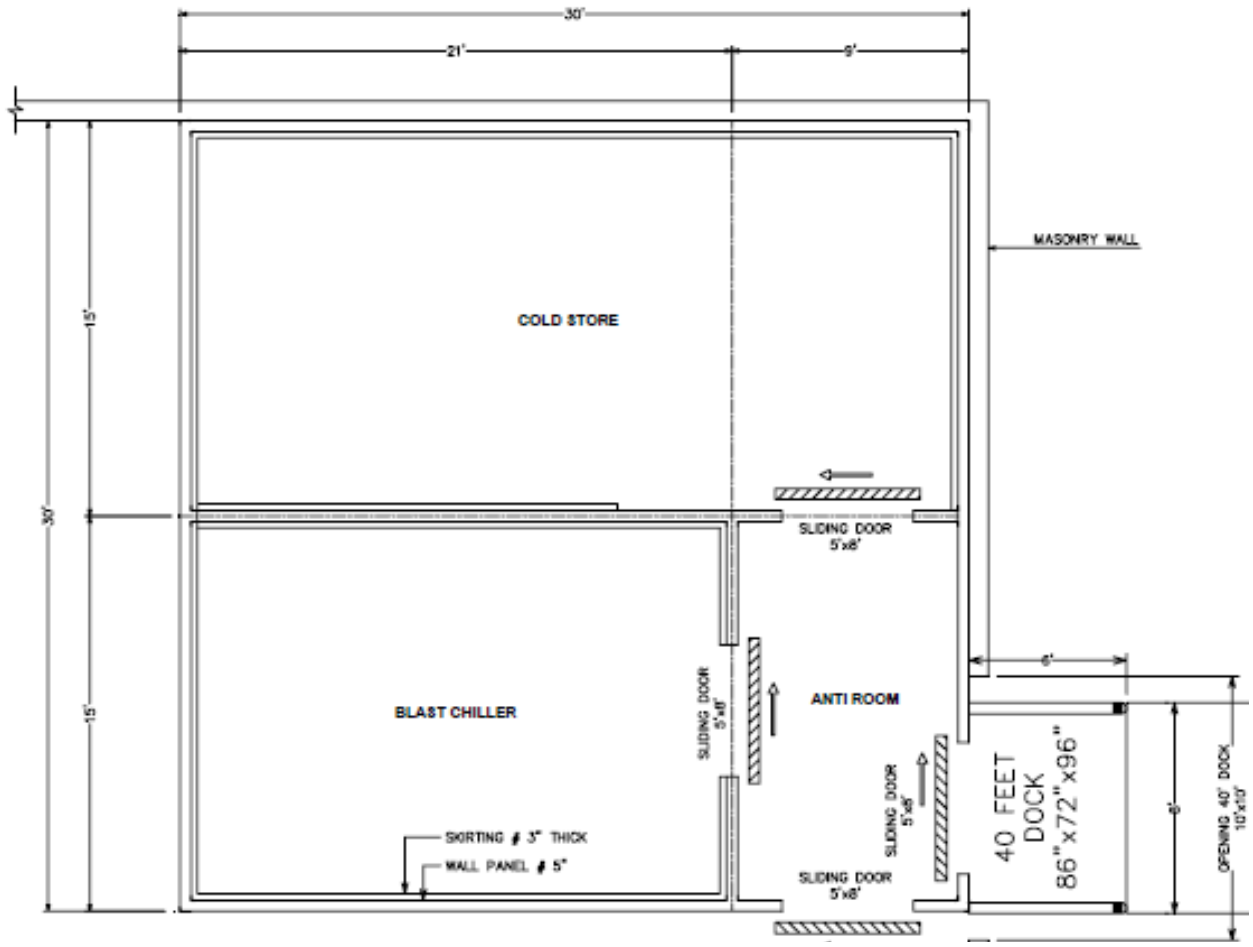


Figure 6: Alternate diagram of cooling/cold storage infrastructure next to packinghouse

2.4 Cooling and Cold Storage

Mango fruit require rapid removal of field heat followed by temporary storage at 12° C (± 1° C, depending on the specific variety) and 90-95% relative humidity. Improvement in on-farm postharvest cooling and cold storage infrastructure is critical to obtaining success in the export market. It is estimated that around 30% of the mango fruit harvested in Pakistan deteriorates prior to consumption due to inadequate postharvest care and lack of a cold chain.

Mango fruit temperature often exceeds 40° C at the time of harvest. Without cooling, the harvested fruit will soon become soft and succumb to rapid deterioration and decay. It is imperative to have proper cooling and cold storage near the production site in order to minimize the rate of ripening and maximize the fruit market life. However, there are currently no mango producing operations in Pakistan with adequate cooling and cold storage infrastructure.

Forced air cooling (i.e. blast chilling) is a fast and effective way to lower the temperature of the mango fruit after harvest. The technique consists of putting a warm product inside a cold room equipped with adequate refrigeration capacity and air flow to rapidly reduce the temperature of the product to its optimal storage temperature. In the case of mangoes, the optimal storage temperature for maximum market life of the fruit is 12° C ±1° C. During the forced air cooling process (illustrated in figure 7), cool air moves around and through the product, quickly lowering its pulp temperature. Adequate ventilation is needed on the sides of the packaging material to allow air flow through the package to the product being cooled. This cooling method is widely

adapted for use with nearly all fruit and vegetable crops. Following cooling, the mango fruit should be stored at 12° C, 90-95% relative humidity. This typically involves moving the palletized fruit with a hand jack or fork lift to an adjacent cold storage room.

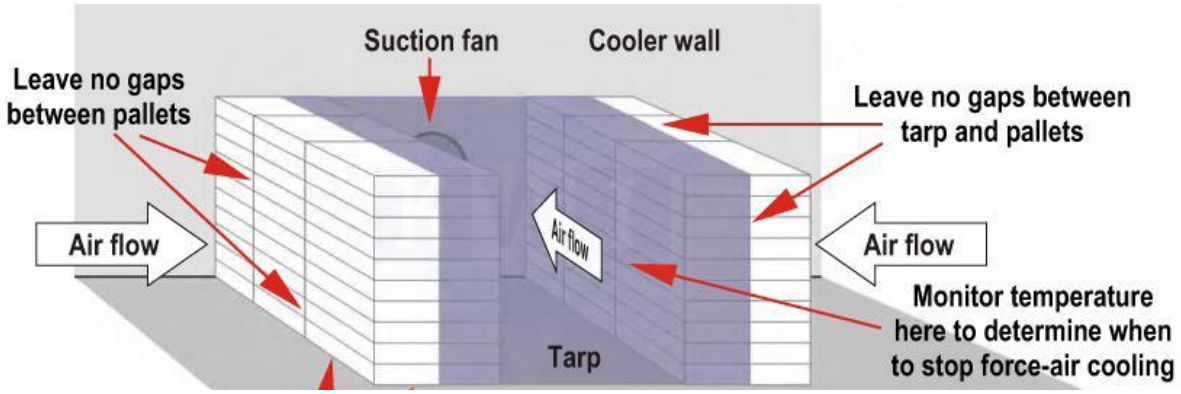


Figure 7: Forced Air Cooling Process

The Mango MUAVAN Program recommends sufficient on-farm cooling and cold storage capacity to force air cool 5 metric tons of mango fruit in 5 hours, from an initial pulp temperature of 45° C down to 12° C. The cooled mangoes should then be stored at 12° C. The MUAVAN Program recommends sufficient cold storage capacity to hold 25 tons of pre-cooled fruit at 12° C. A 40-foot marine container will hold between 22-24 tons of mango fruit, thus it is important to have enough cold storage capacity to fill a 40-foot container, or two 20-foot containers. The specifications for the forced air (blast chiller) room and adjacent cold storage room follow. The overall size of the combined forced air (blast chiller) room and adjacent cold storage room should be 30 feet long x 30 feet wide x 12 feet high. The estimated cost provided by several potential suppliers for the complete cooling and cold storage infrastructure was estimated to be approximately $67,000.

Forced Air (Blast Chiller) Cooling Room

Dimensions: 12 feet long x 30 feet wide x 12 feet high). Adequate refrigeration capacity to force-air cool 5 metric tons of mango fruit in 5 hours, from an initial pulp temperature of 45° C down to 12° C. This will require 415 volts, 50 Hz, 3-phase electricity.

Walls and Ceiling: Made of pre-fabricated polyurethane insulated galvanized steel sandwich panels. The insulated sandwich panels used for the 4 outer walls and ceiling should contain 4 to 6 inches in width of polyurethane foam, with a closed cell density of 40-42kg/m³, K-factor of 20.63mw/mK, and FCKW and HFCKW free. The metal cladding containing the polyurethane should be galvanized steel, 0.4–0.5mm thick, lightly profiled on both sides with tongue and groove, and covered with paint coating AS/NZS 2728, substrate AS1397. The coating on the painted sheets should be sealed with polyester-acrylic varnish with a thickness of 20µm on both sides. The thickness of the polyurethane insulation should be at least 6 inches for the outer walls and ceiling and 4 inches for partition walls between the forced-air (blast chiller room) and the cold storage room. The panels should be joined by tongue and groove joints spaced every 100 cm on each side of the panel to ensure airtight joints and locked by cam-locks, which are anchored into the rigid polyurethane foam during manufacturing of the panels.

Cold Storage Room

Dimensions: 18 feet long x 30 feet wide x 12 feet high. Adequate refrigeration capacity to store 25 tons of mangoes at 12° C.

Generator

The cooling and cold storage infrastructure will include a 50 horsepower, 3-phase, diesel-fueled, 380-400 volt 50 KVA generator. It will come complete with controls and be sound proof.

Condensing Units

The forced air cooler (blast chiller) will have two sets of 10 HP air-cooled condensing units with matching evaporators. The cold storage room will have one set of 5 HP air cooled condensing unit with matching evaporator. Each unit should be equipped with a new hermetic or semi-hermitic compressor motor manufactured by Copeland. Each unit should be supplied with a crankcase heater, liquid line with filter drier and sight glass, suction line with filter, receiver with fusible plug and shutoff valve, compressor start kit for single units, contactor for three phase units, and high / low pressure control. All condensing units are charged with R-22 coolant and are engineered to operate under an ambient temperature of 110° F. The evaporator unit should be constructed of a rust free aluminum housing consisting of scattered copper tubes expanded into corrugated aluminum fins for increased heat transfer. Medium temperature applications should have off-cycle defrosts using 220 volts fan motor. All evaporator units should be supplied with mounted TX valve, with the solenoid valve shipped separately.

Warranty

The manufacturer should provide a warranty to the original purchaser. The limited warranty should cover the following:

- the compressor(s) are covered for a period of 1 year from the first day of official handing over of the system;
- the operation of the refrigeration system will be protected against electrical malfunction, e.g. voltage surge etc;
- all other components of the refrigeration system are also covered for a period of 1 year from the date of official handling over of the system;
- insulated panels are covered for a period of 20 years

Fire Rating

The fire rating should meet flame retardancy requirements according to DIN 4102 Class B3 and according to ASTM D 1692 and ISO 3582 test (self-extinguishing foam). Total panel should be B2 classified.

Floor

The packinghouse owner will provide two layers of 50 mm thick injection molded expanded polystyrene board with the density of 32-35 kg/m prior to construction and the owner's civil contractor will lay a suitable layer of concrete.

Sliding Doors

Four single leaf manual sliding doors will be provided; with dimensions of 5 feet wide x 7 feet high. The doors should have the same finish and thickness as the walls and ceiling, complete with stainless steel fittings and accessories including rubber gaskets, internal safety release handles, door heaters and pressure port.

Pressure Valve

The rooms will be provided with a pressure relief valve to equalize internal and external pressure.

PVC Curtains

One set of PVC strips with stainless steel section will be supplied in front of each door, covering the full span of the door, in order to reduce warm air infiltration.

Accessories

Accessories will be provided including rivets, internal and external flashing, silicon and plastic buttons for cam locks.

Refer to appendix- 1 for domestic manufacturers of commercial cooling/cold storage units for fresh produce.

2.5 Hot Water Treatment for Disease Control

Postharvest market life of mangoes is significantly reduced by two commonly occurring fungal diseases, anthracnose (Colletotrichum gloeosporioides) and stem-end rot (Botryodiplodia theobromae). These two diseases are ubiquitous in Pakistan and require a multi-faceted control strategy. Appropriate timing and use of pre-harvest fungicides, proper tree pruning, and good field sanitation are all necessary to minimize the incidence and severity of these diseases. In addition, a postharvest hot water treatment can further reduce the amount of fruit decay caused by these two fungal organisms. The treatment protocol consists of submerging the fruit for a brief period (~3-5 minutes) in hot water (~52° C ±0.5° C). The treatment should be done as soon as possible, preferably the same day as harvest. It is very important to precisely control the water temperature while the fruit are being exposed to the hot water. If the water temperature rises above 54° C, the internal pulp tissue of certain varieties may be damaged. If the water temperature falls below 50° C, the thermal treatment may be ineffective in reducing fungal growth. Therefore, precise control and regulation of the water temperature is essential and requires good in-tank water circulation and heat transfer. It is recognized that further research is needed to determine the optimum temperature and time of exposure for maximum disease control in each mango variety.

The postharvest hot water treatment involves completely submerging the fruit inside a water tank. The fruit can be submerged while contained inside plastic crates or as loose fruit slowly moving underneath the surface of the water. The fruit can be manually put inside the hot water tank, followed by manual removal, or it can be exposed to the hot water after an initial overhead spray wash cleaning in an in-line conveyor process. Either treatment procedure is effective.

The postharvest treatment for disease control is very different in temperature and time of fruit exposure compared to the hot water treatment required as a phytosanitary treatment for insect control by certain countries. These two hot water treatment processes are distinct and should not be confused. The hot water treatment for disease control is not required by any importing country. It is only done to reduce the incidence of fruit decay upon arrival and during distribution to market in the importing country. It may not be necessary if rigorous pre-harvest disease control measures have been followed and proper cooling, cold chain maintenance, and postharvest care practices are applied.

The specifications and approximate cost of the recommended imported mango hot water treatment tank follows. The hot water tank should be made out of stainless steel and fitted with the appropriate heating elements and pumps for sufficient in-tank water circulation to maintain a 52° C water temperature ±0.5° C at all times. Thorough and uniform water circulation is essential inside the tank to avoid temperature gradients from forming. The water in the tank should be vigorously agitated during fruit submergence to prevent thermal gradients and uniformly distribute any added postharvest fungicide (i.e. prochloraz). The water must be heated with either electric or gas heating elements. The least complicated and most uniform heating elements are electric. They can be installed in the hot water tank along the bottom and perimeter, or external to the tank, in the form of a commercial hot water heater. If the electric

heating elements are installed inside the tank, it will be essential to protect and shield them from directly contacting the containers of mango fruit. Also, an experienced electrician and/or plumber will be needed to be hired to ensure the reliability and safety of the system. The location of the hot water tank in the packinghouse can be as a separate unit near the unloading area or as part of a continuous flow unit after the overhead spray wash and before the dryer.

Sensitive thermostats, temperature recorders, and sufficient heating elements are important to regulate and monitor the water temperature. Sufficient tank volume and precise temperature control is necessary since fruit at a lower temperature will be continually introduced into the hot water tank. The suggested specifications of the hot water tank should be at least 2.4 meters in length x 1.2 meters wide x 1.2 meters in height. A slightly larger volume tank may be advisable for more precise temperature control. The water temperature should be able to be maintained at a precise 52° C ±0.5° C throughout the tank once the mangoes are introduced. The tank should be made out of stainless steel. The dimensions of the hot water tank should be large enough to hold at least 12 field crates containing a minimum of 12.5 kg of fruit (150 kg total fruit weight). Typically, a 2 HP pump is used for in-tank water circulation, with at least eight heating elements (3 KV each) and temperature controller. If an in-line water treatment tank is used, a rubber or fabric blanket is used to keep the mango fruit submerged as they enter from one end of the tank and are discharged at the other end 3 minutes later. An inclined motorized conveyor assembly is generally used to move the fruit while submerged inside the tank. A lifting conveyor at the outlet end of the water tank discharges the fruit onto a series of sponge rollers inside a forced air-drying chamber. The motor (1 HP) speed should be adjustable to obtain the desired length of fruit exposure time.

The initial units will likely need to be imported or fabricated locally using the appropriate design and fine-tuning of the water circulation and temperature control. An Indian firm (Lele) manufactures an in-line hot water tank and mango feeder assembly (shown below) for a list price of $17,391. This price does not include the transport cost from India to packinghouse site in Pakistan. A schematic diagram of this unit is also illustrated in figure 8.

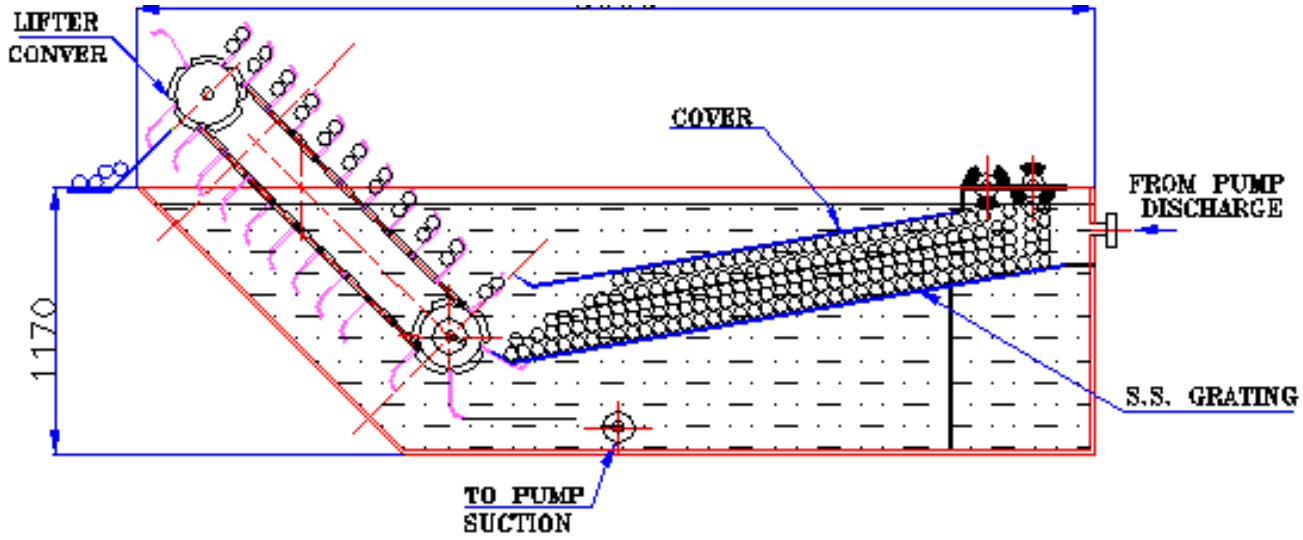


Figure 8: Schematic Diagram of Indian-made Mango Hot Water Tank and Fruit Feeder Assembly

There are no existing domestic models of hot water treatment units for mangoes in Pakistan. However, both [redacted] indicated they could fabricate such units and conform to the required temperature control requirements. The cost estimate provided by [redacted] was higher than the Indian-made unit. A schematic diagram of their unit is shown in figure 9.

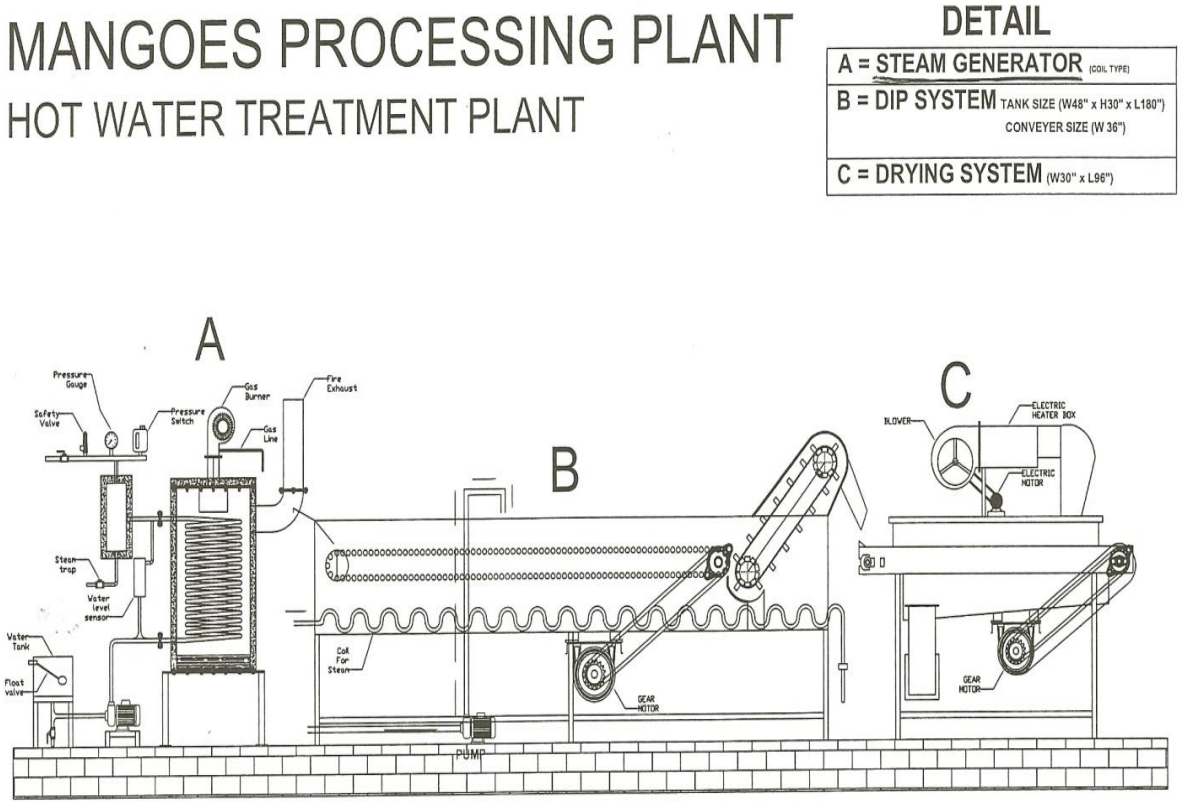


Figure 9: Mangoes Processing Plant

2.6 Sorting/ Sizing/ Grading Equipment

Various sorting and sizing systems can be used for grading mango fruit. The grading systems range from manual to highly sophisticated electronic color and weight sizing.

The simplest, most labor intensive, and slowest system is to use manual labor for the entire grading process. In this system, the de-sapped, washed, and dried mango fruit are brought to the packinghouse and manually placed into different cartons (typically 4-kg for export to European markets) based on fruit size (count). Empty cartons are placed next to the manual grader/packer, who receives the washed and dried fruit and hand selects each individual mango, followed by placing the fruit into the appropriate carton, based on size. Each worker must be knowledgeable about mango fruit defects, grades, sizes, and packing methods. Typically, an individual worker can manually grade and pack several hundred cartons per day.

Manual packing mangoes in single-layer export cartons

Semi-automatic sorting/sizing/grading equipment is available from a number of commercial vendors. In addition, these systems can often be fabricated in the shops of the producers and/or local manufacturing firms. The simplest semi-automatic grading systems for mangoes consist of a receiving elevator or conveyor belt for fruit manually dumped out of the field containers, followed by overhead spray washing and brushing of the fruit, drying by sponge rollers and/or fans, mechanical sizing, and manual packing. The sizing can be done by a series of roller sizers of increasing width, or by individual receiving cups which have load cells programmed to drop the individual fruit based on its weight. With both the roller sizers and individual cups, the fruit fall onto cushioned platforms or conveyor belts which move the fruit to accumulating areas, followed by hand packing of the fruit into the market container. Single line weight sizers are available which can grade about 1 ton of fruit per hour and multi-line weight sizers are available which can easily grade five or more tons of fruit per hour. It is recommended to use a grading system capable of separating the fruit into at least five and preferably up to eight different size categories.

Fully automated high volume sorting/sizing/grading equipment based on fruit color and weight is also commercially available, but the cost of such systems is typically well over several hundred thousand dollars and does not apply to any individual mango growing operation in Pakistan. However, such systems may become relevant to some individual grower/exporters in the future and may be applicable to large-scale fruit consolidators. Companies that manufacture these high volume electronic color/weight sizers include Greefa, MAF Roda, Aweta, and Durand Wayland.

The recommended sizing and grading equipment for FIRMS Project stakeholders is a semi-automated system capable of grading at least 1 ton of mango fruit per hour. Several options are appropriate, including a roller sizer, single-lane weight sizer, and dual-lane weight sizer. Currently, there are no domestic manufacturers of mango sizing/grading equipment in Pakistan. The initial units will likely need to be imported, after which reverse engineering of such units may be applied for domestic fabrication of the equipment. However, both [redacted] indicated they could fabricate a complete mango packing line. A schematic diagram of Technology International's system is shown below.

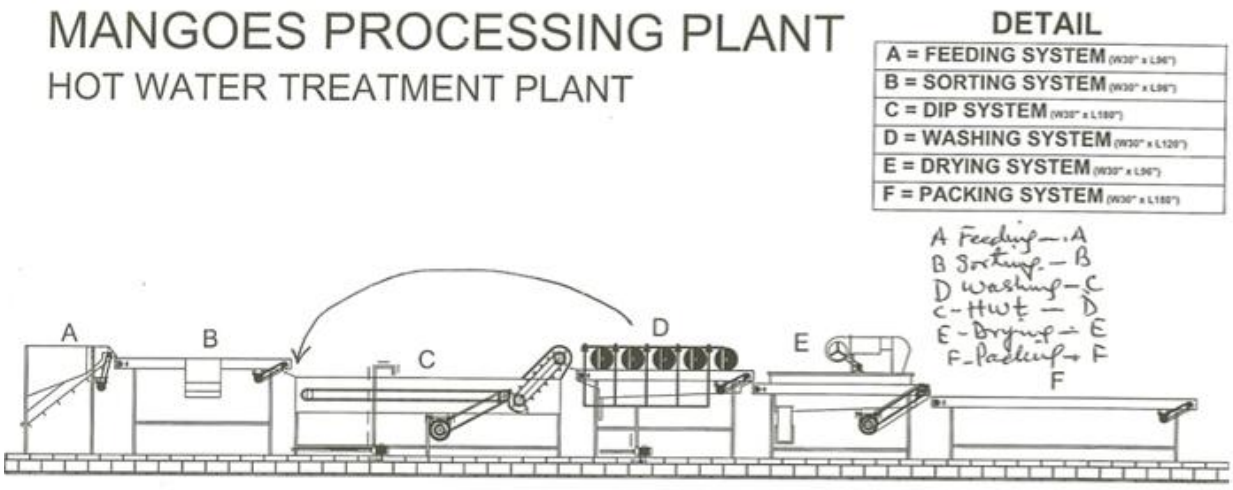


Figure 10: Technology International's Mangoes Processing Plant

The specifications and approximate cost of various imported mango sizing/grading systems is indicated below. The price does not include transport from the supplying country to the final packinghouse location. It is recommended that individual growing operations have the flexibility to decide which type of sizing/grading system is most appropriate for their individual operations. All of these systems are used in commercial mango growing and exporting operations worldwide. In addition, each sizing/grading system is able to be used with a wide diversity of fruit and vegetable crops. It is important to have this diverse product grading capability of the systems in order to allow for more year-round and/or multiple crop use. This economics of multi-purpose sizing/grading systems will be considerably more favorable compared to stand-alone mango graders, which would only be in use for several months of the year.

Kerian Speed Sizer

This U.S. firm manufactures roller-sizers designed to quickly and accurately separate mango fruit into nine different size categories. The equipment is easy to maintain, easy to adjust, and has a unique patented method of roller expansion. No other diameter fruit grader comes close to the precision of Kerian, because of continuous product rotate on and individually-driven heavy-duty rollers which maintain precise separation.

The recommended model to use for mango sizing is the Kerian X40, with MPVC rollers. The cost is $17,300. In addition a takeaway conveyor system will be needed, consisting of two 60-inch x 9-foot conveyors with up to 9 padded adjustable lanes. The cost for this takeaway conveyor system is $8,580. Also, 9 holding hoppers will be needed for each sizing lane. Each holding hopper costs $250, for a total cost of $2,250 for all 9 hoppers. Also, a loading hopper and feed elevator (30-inches wide x 5-feet long) with flighted belt will be needed to introduce the mango fruit onto the Model X40 Speed Sizer. The cost of this unit is $3,900. Finally, a custom spiral pattern loading assembly may be necessary to facilitate fruit loading onto the sizer. The cost of this assembly is $400. The total cost of the entire fruit loading, sizing, and takeaway conveyor system is $32,030 and is highly recommended for purchase. A schematic diagram of the unit is illustrated below.

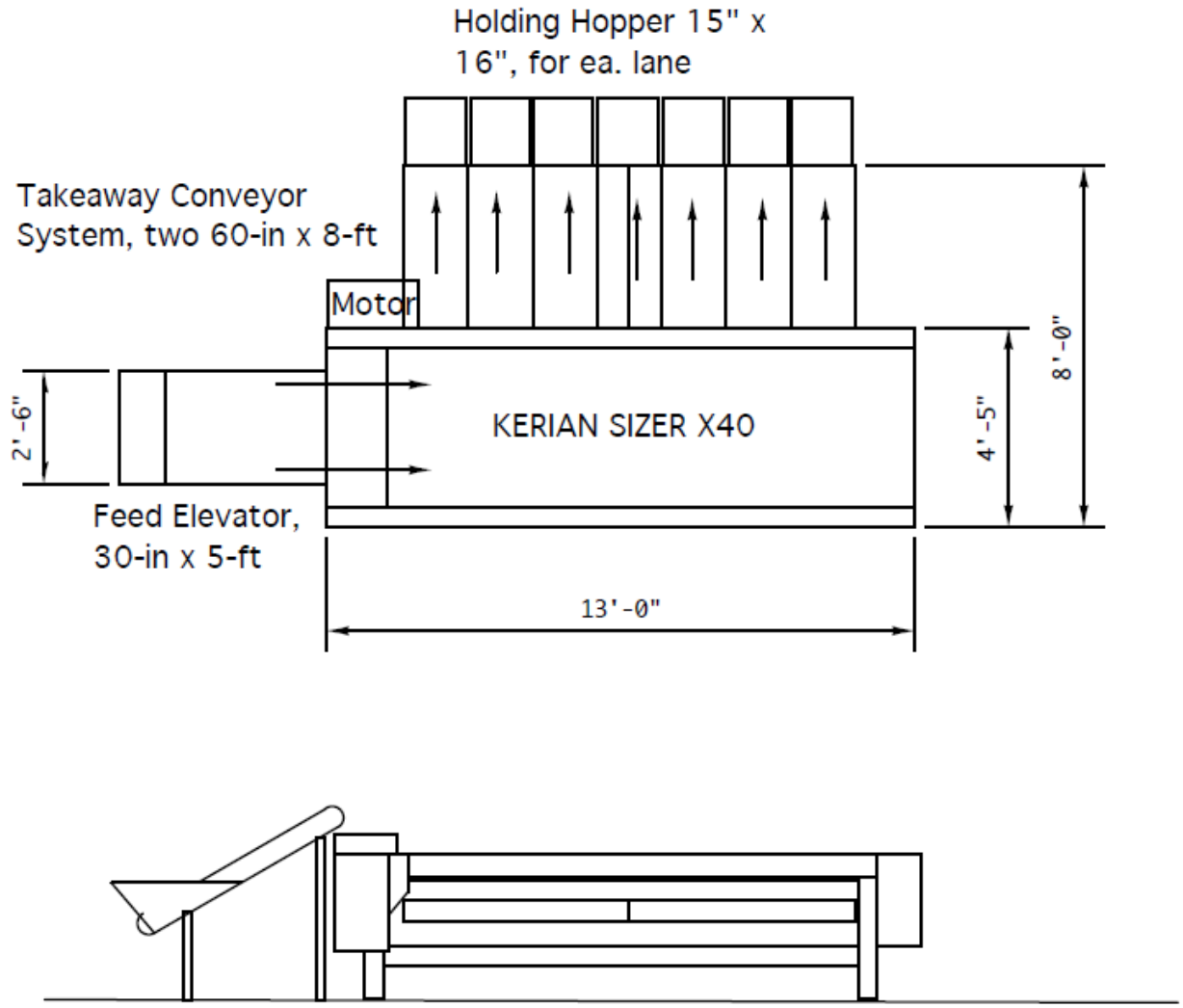
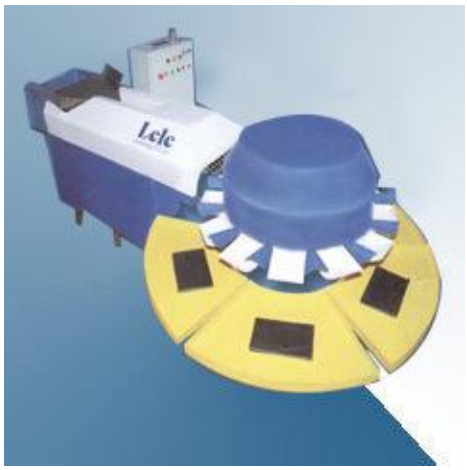


Figure 11: Systematic Diagram of the Conveyor Unit

Lele Weight Sizer

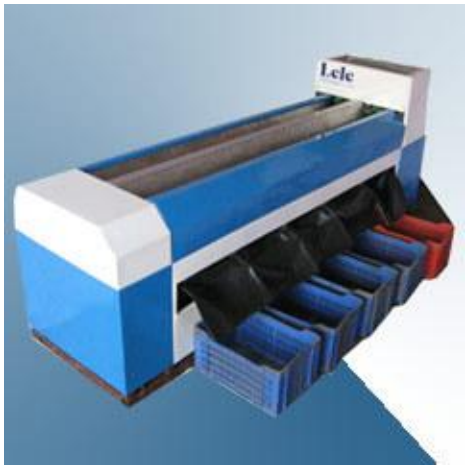
This Indian firm manufactures single and dual lane weight sizers designed to accurately separate mango fruit into either 4 or 8 different size categories. Each fruit is carried from the feeder elevator/belt to a receiving area in which the mango fruit are then singulated onto individual electronic load cell cups. The load cell of each cup registers the fruit weight, carries the mango a short distance in a circular motion, and drops the fruit onto the appropriate weight size receiving tray mounted on a rotating table. Two different options are available, a 4-lane sizer or an 8-lane sizer. The 4-lane sizer can grade up to 3,200 fruit per hour (≥ 1 ton/hour) and costs $7,608, while the 8-lane sizer costs $10,890. Each system uses a 1 horsepower (HP) motor and all parts coming in contact with the fruit are made of made of stainless steel or food grade material. The dimensions of the 4-lane weight sizer are 1 meter in height, 1.6 meters in width, and 2.6 meters in length. The dimensions of the 8-lane weight sizer are 1 meter in height, 2.0 meters in width, and 2.4 meters in length.



One lane Lele sizing machine capable of grading mangoes into 4 different sizes.

Lele also manufactures a two-lane electronic weight sizer (shown below) with a capacity of grading up to 8,000 fruit per hour into 8 different size categories. The machine is powered by a

5 HP motor and has dimensions of 6.8 m long x 1.2 m wide x 1.2 m high. The current price of this sizing unit is $30,000.



Two-lane electronic weight sizer.

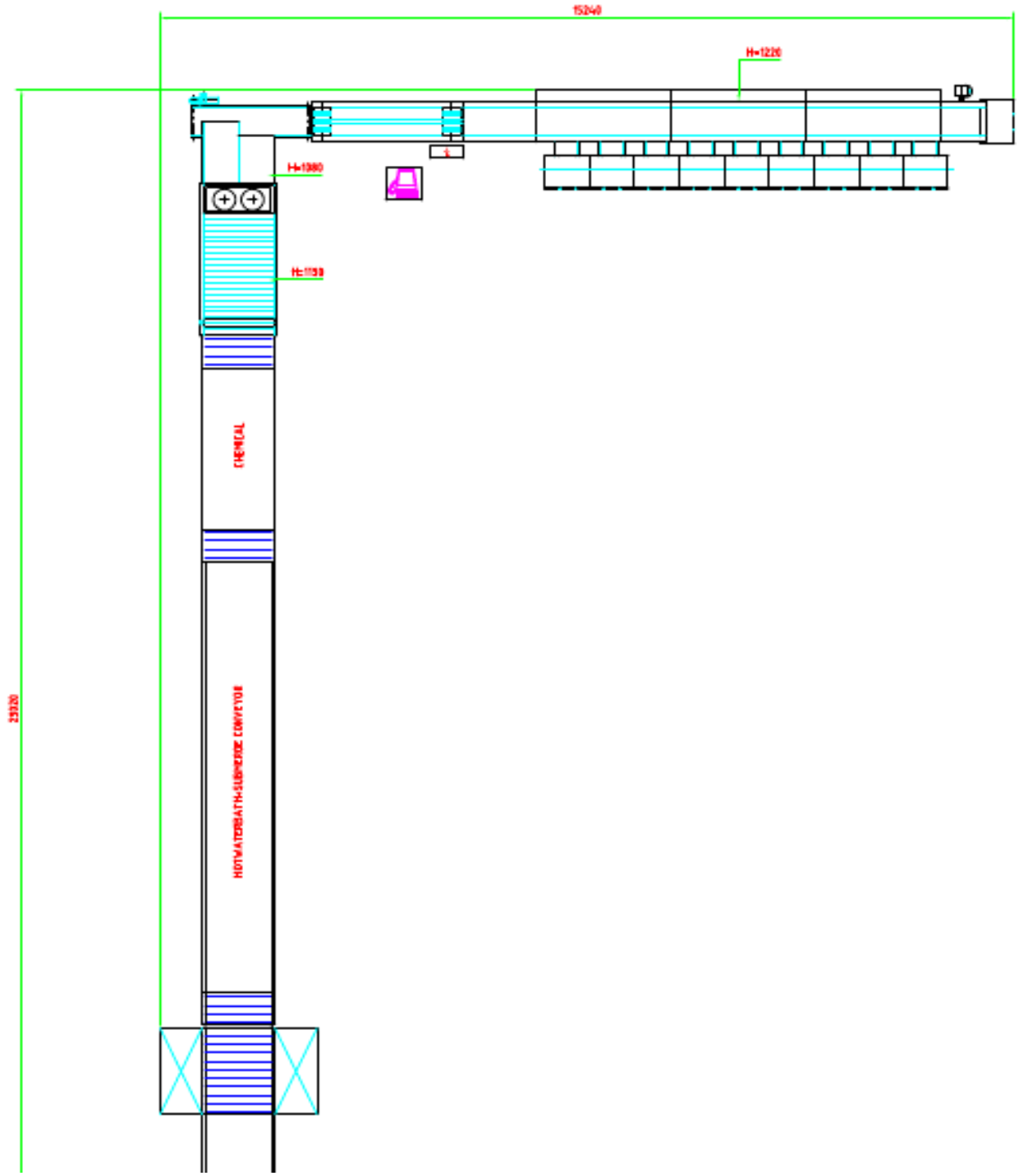
An additional feeder conveyor belt and in-line overhead fruit wash and dryer will be required. This conveyor unit is 3 meters in length x 1 meter wide x 1 meter high and is driven by a 0.5 HP geared motor. The cost of this component is $6,670. The drying unit is a 3.5 meter x 1.1 meter x 1.0 meter unit (L X W x H) hot air tunnel that is heated by six 1 KV heaters and a fan system. It requires 5 HP of electric power and the cost is $7,780.

Greefa Weight Sizer

This Dutch firm manufactures high performance multiple lane electronic color and weight sizers designed to accurately separate mango fruit into multiple size categories. Each fruit is carried from the feeder elevator/belt to a receiving area in which the mango fruit are then positioned onto individual load cell cups. The load cell of each cup registers the fruit weight, carries the mango a short distance in a linear direction, and deposits the fruit onto a receiving belt.

Their MSE type weight sizer is a tried and tested systems in which more than 1,000 have been sold worldwide. The maximum speed is 5 mangos per second per lane. The system is available with 2, 4, 6, 8 or 10 lanes and can separate the fruit into 9 different size grades. To sort mangos, one can choose between the MSE Combicup or MSE CXL models. Both sorting units have a special cup, which ensures that the mangos keep lying properly during transport along the system. Their Combicup type weight sizer is especially suited for smaller mangos, while the CXL is best for for larger varieties.

The most applicable Greefa sizer for Pakistan is the 2-lane system, with a capacity of sizing 2.5 tons of fruit per hour. Various components of the system are shown below, including the unloading and washing area and high-speed electronic weight sizer. A schematic diagram of the complete system is also illustrated. A complete grading system, including the receiving conveyor, overhead spray washer, hot water bath, drier, and 2-lane electronic weight sizer with a capacity of 2 tons per hour is list priced at €340,000. This includes delivery and installation in Pakistan. A similar system without the hot water tank for disease control is list priced at €165,000. The current and near term export volume of the GlobalGAP-certified mango farms in Pakistan would not economically justify purchase of these systems. However, as export volume expands in future years, purchase of one or more of these systems may be justified. Greefa equipment is distributed and sold in Pakistan by [redacted]



Several additional companies (i.e. Durand Wayland, Aweta, and MAF Roda) also manufacture high speed electronic weight sizers and complete packing line systems for mangoes. Their price ranges are on the high end and similar to Greefa for comparable systems. Therefore, due to cost they are not recommended for initial MUAVAN Program equipment purchase.

Table 1: GlobalGAP-Certified/Registered Mango Stakeholder Expressed Infrastructure and Equipment Needs within MUAVAN Program

		JDW Farms	Ali Tareen Farms	Asim Farms	Lutfabad Farms	Sarbuland Farms	Muzafarnagar Farms	Farms
Packing House	Requirement	No	No	No	Yes	Yes	Yes	Yes
	Size				50x60x22	50x60x22	100x60x22	100x60x22
	Specifications	None of the farms want CRISP building specifications/requirements. Want to go for a cheaper shed type construction						
Cold Storage	Requirement	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Size	22x40x14	22x40x14	22x40x14	22x40x14	22x40x14	22x40x14	22x40x14
	Refrigeration Capacity	25 tons	25 tons	25 tons	25 tons	25 tons	25 tons	25 tons
Blast Chiller	Requirement	Yes	yes	yes	yes	yes	yes	yes
	Size	25x20x14	25x20x14	25x20x14	25x20x14	25x20x14	25x20x14	25x20x14
	Capacity	1 ton/hour	1 ton/hour	1 ton/hour	1 ton/hour	1 ton/hour	1 ton/hour	1 ton/hour
	Specifications	Double Roofing	Double Roofing	Double Roofing	Double Roofing	Double Roofing	Double Roofing	Double Roofing
Treatment Plant	It was decided that the farmers will chose the most suitable option from among gas/petrol/diesel/electric versions from their portion of the cost sharing arrangement.							
Desapping Platform	Requirement	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Specifications	16'6"x7'4"x3'(height from ground)						
Processing Line	Requirement	Hotwater+Drier	Full line	Full line	Full line	Full line	Within project period but not this year	Within project period but not this year
Pallets	Required	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lifters	Requirement	Yes	Yes	Yes	Yes	Yes	Yes	Yes

3. Conclusion and Next Steps

3.1 Economic Benefit of FIRMS Project Postharvest Infrastructure Investment

The economic benefit of the MUAVAN Program postharvest infrastructure investment will be based on the additional revenue generated by domestic and export market mango sales, in addition to other fruit and vegetable products prepared, cooled, and stored utilizing the packinghouse equipment and cooling/cold storage infrastructure. The economic benefit will differ between individual operations. In addition, the postharvest market losses of mangoes and other fruit and vegetable products which utilize the new facilities can be expected to be reduced from a current average of 30% down to 10% or less.

The new postharvest infrastructure will have the capacity to hold 25 tons of mangoes (or other products). This is slightly more than amount of product needed to fill two 20-foot marine containers, or one 40-foot container. By the end of the FIRMS Project in 2013, it is anticipated the export market volume of mangoes to the retail supermarket trade in Europe and other countries will increase from essentially zero to 50 tons per week per GlobalGAP-certified operation. Assuming a 6-week harvest season per operation, this will amount to an additional 300 tons of mango exports. Current farm-gate purchase price for export quality mangoes is about 1 euro per kg (~$1.30/kg or $1,300/metric ton). Therefore, the economic benefit realized from the postharvest infrastructure investment for mangoes alone will be an estimated $390,000 per operation. The cost of procurement of the equipment and packinghouse infrastructure is estimated to be between $120,000-$150,000, of which FIRMS will provide a 50% cost share.

In addition to the positive economic benefit obtained from increased mango export volume, reduced postharvest market losses (from 30% down to 10%) for mangoes and other produce items run through the postharvest facilities will add to the economic benefit obtained from each facility.

3.2 Next Steps in the FIRMS Project Mango Sector Export Market Development Strategy

Proposed for David Picha and PSD Mango team

1. Writing of Mango Production Practice and Postharvest Care Technical Guides. Detailed and well-illustrated Pakistan-specific technical bulletins on all aspects of mango production, harvesting, and postharvest care. The specific topics to be covered are listed in the annex of the MUAVAN Program MOU.
2. Verification of Indian-manufactured mango packinghouse equipment quality for use in Pakistan.
3. Arrange Mango Study Tour to U.S. and/or Mexico.
4. Arrange Mango Technical Workshop and International Buyer Conference (Multan).
5. Collaboration with Dr. Amanullah Malik (FAU) and Dr. Mubarek Ali (Punjab Agricultural Research Board) on optimization of hot water treatment R & D work. Also test modified atmosphere permeable film carton/pallet overwrap treatments.
6. Coordination of mango trial shipment logistics during summer, 2010. Include Maersk {Controlled Atmosphere (3-5% O_2, 5% CO_2) and non-CA 20-foot reefer containers to

U.K.}, GlobalGAP-certified growers, PIA, Cargo Technology, E.U. importers, and PARAS irradiation facility.

7. Assessment of trial shipment fruit arrival quality in U.K. market.

4. Appendices

Appendix -1 Domestic Manufacturers of Commercial Cooling/Cold Storage Units for Fresh Produce

Appendix-2 List of Equipment Suppliers

Leading Mango Sorting/Sizing/Grading Equipment Suppliers

Kerian Machines Inc.

1709 Hwy 81 South

P.O. Box 311

Grafton, North Dakota, U.S.A. 58237

Telephone: 701-352-0480

Lele Chemiequip Pvt. Ltd
7, Mahadev Darshan, Ground Floor

Jeevan Vikas Kendra Marg, Koldongari, Andheri East
Mumbai 400069, Maharashtra, India

Telephone: 91-22-26826258

Greefa

Langstraat 12

4196 JB

Tricht, Netherlands

Telephone: 31-345-578-100

MAF Roda

546 Rue Gustave Jay

BP 112

82001 Montauban

France

Telephone: 33-05-3663-2770

Durand Wayland, Inc.
101 Durand Road
LaGrange, Georgia, U.S.A. 30241
Telephone: 706 882-8161

Aweta

Burgemeester Winkellaan 3

2631 HG Nootdorp

Netherlands

Telephone: 31-15-310-9961

Potential Domestic Packinghouse Equipment Manufacturers for Mangoes

[redacted]

[redacted]

USAID Firms Project

info@epfirms.com