Production and Handling of Solo Papaya

Fintrac Inc.
Centro de Desarrollo de Agronegocios
(financed by USAID)

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Photo1: Land and Bed Preparation

Photo 2: Land and Bed Preparation

Papaya will grow in most soils. Good drainage is the most important factor when choosing location. The pH values can range from a low of 5.5 to a high of 8.0. The land chosen should not have too much slope as hydraulic lifting equipment could be used later on for harvesting and there might be a danger of roll-over. Aspect should not interfere with growth. Where possible, it is best to plant at right angles to the prevailing winds, but care must be taken if the land slopes. Where possible, bed across the contour but allowing a slight slope to prevent standing water in the beds after heavy rains. Soil erosion prevention is more important than wind direction when planning the row direction.

- When a suitable location has been chosen, cultivation should be done as follows.
- Deep rip with a parabolic type ripper both ways. Plough both ways using heavy discs.
- Refine with discs or a rotary tiller. The seedbed must be fine enough for direct planting.
- You then make continuous beds with a molding tool or bedder. For double row planting the following spacing can be used.

See Photos 1 and 2 and Figures 1 and 2 below.

Figure 1. Side view of beds

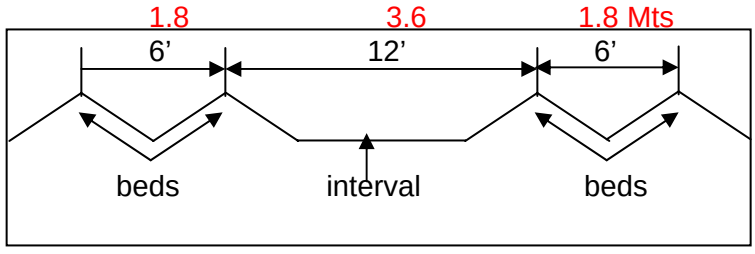
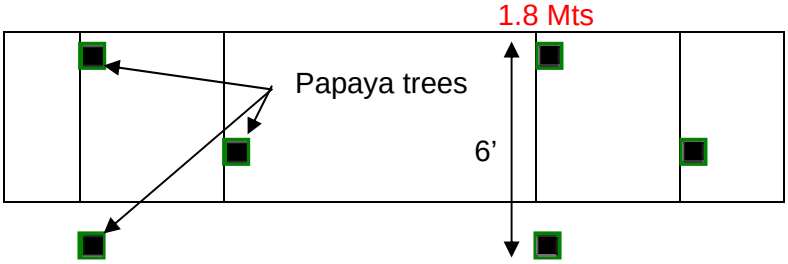


Figure 2. Plan of layout



Plant population of 2,058 plants per hectare.
The papaya should be grown using drip irrigation. It is not recommended to use other types of irrigation. The growers should choose the type and make of the drip irrigation system that best suites local conditions and suppliers. The system that is chosen must be capable of applying at least 40 liters of water / tree / day during dry conditions.
30 liters/tree/day

3. Seed Preparation

The preparation of the seed is simple and can be done in the field. The seed is soaked in a water, fungicide and fertilizer solution. Benlate as the fungicide and soluble 20:20:20 fertilizer is recommended. There are other fungicides that can be used, but trials should be carried out to determine if there are any adverse effects on germination.

The mixing rate should be as follows:

- A 20-litre bucket with 15 liters of clean water.
- For this quantity of water use 100g of 20:20:20 fertilizer, a water pH neutralizer and 15g of B*enlate WP (fungicide)*.
- An insecticide can also be used if there is a problem with ants. For ants you can use *Furadan 25 ml* (*insecticide*) in the fertilizer and fungicide solution at the prescribed seed-dressing rate on the label.

Photo 3: Seed Treatment with Insecticide

Photo 4: Plantlet Production in Trays

(ALL PERSONS MUST USE THE CORRECT PROTECTIVE CLOTHING WHEN HANDLING OR MIXING THESE PESTICIDES)

If ants are a problem, the seeds can be pre-germinated by laying them out on a damp surface in the shade, such as newspaper. Germination takes 7 -12 days; when the radicle appears, direct planting can be made using the same process as above.

If mice are a problem, bait some corn soaked in a suitable insecticide and placed throughout the field in small well-marked plastic containers.

Plantlets can also be used with seedling trays - one seed per hole. 1" x 1" x 1.5 or 2" deep cells and peat moss media. The time from planting to the development of two sets of true leaves (about 3" tall) is around 20 days. Care has to be taken to avoid the bending of the tap root.

4. Planting

4.1. Direct Seeding

After the irrigation has been installed and tested, planting can start. The irrigation needs to be run for a few hours prior to planting. Wet seeds should not be planted in a dry seedbed. By each dripper dig three small holes about 6 cm apart and as close as possible to the drippers. The holes should be about 2-3 cm deep.

Place three to five seeds in each hole, cover and press the soil down firmly. Enough irrigation should be done to keep the soil around the seeds damp but not too wet. It is recommended that water is applied for a few minutes every two to three hours(its better to apply water twice a day for 30 minutes). Fifteen day aster the papaya has germinated you have to thin to one plant per hole. Always leave the most vigorous.

Photo ?: Direct Seeding in Three Holes

Photo ?: Direct Seeding

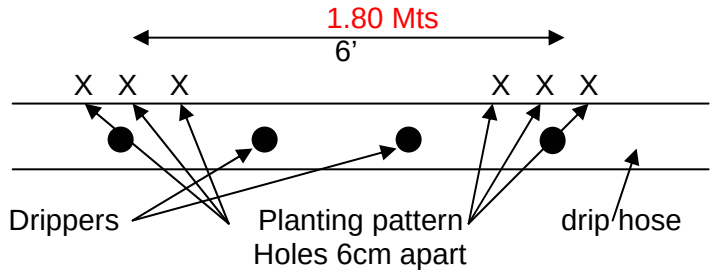
4.2. Plantlets

When you are going to transplant your papaya crop you have to irrigate your beds before transplant to avoid any stress. Use the same procedure as seed for placement of the plantlets. Use starter solution for each hole before placing your plantlets (Boletin Tecnico # 1) Place one plantlet per hole and compact the soil around it to avoid air pockets. Irrigate the plantlets twice a day for 30 minutes for 3 to 5 days depending on the weather. Plantlets should be treated with Trichoderma sp. In the greenhouse to have them protected form the start (Boletin Tecnico # 30).

Photo ?: Three Plantlets per Position

Photo ?: Leaf Curl after Transplant

Fig 3 planting diagram:



5. Germination

I think this section should be part of direct seeding.

With direct seeding, germination should start after ten days, but may take up to sixteen days. Use twelve days as the average. After planting check that seeds are being protected from ants. Dig up a few planting spots and check seeds for damage. You may have to do a spraying of the field if seed treatment has not been effective against insects. If there is no germination present a large range of insecticides can be used. The choice can be selected based on the problem being experienced. If there is young papaya seedlings there must be caution. After the papayas have germinated a drench treatment with Trichoderma sp. has to be done to protect the plants from any soil born desease (Boletin Tecnico #30).

Papaya are very susceptible to chemical damage. *Malathion WP*, *Dimethoate, Pegasus 500 SC, Sevin 5 dust, Lannate* and *Agrimek 018 EC*. have been used as insecticides without problems.

If there are other chemicals that can be considered **ENSURE THAT THE EFFECTS ARE FIRST TESTED ON A FEW TREES**. Table 1 lists the active ingredients for each product.

Table 1. Insecticides

Brand Name	Active Ingredient (A.I)
Malathion 25 WP	Dimethyl - phosphorodithioate
Dimethoate	S-Methylcarbamoylmethyl
Pegasus 500 SC	Diafenthiuron
Sevin 5 dust	Naphthyl methylcarbamate
Lannate	Methomyl
Agrimek 018 EC	Avermectin B1

ALL CHEMICALS RECOMMENDED IN THIS GUIDE MUST FIRST HAVE APPROVAL FOR USE WITH THE APPROPRIATE GOVERNMENT OR PESTICIDE CONTROL AGENCIES WITHIN THE COUNTRY.

6. Weed Control

After germination the young seedlings grow very quickly. At this young stage they are susceptible to most cutting type insects, such as crickets, caterpillars etc.

The care in the first few weeks after germination is the most difficult. Try and keep the perimeters clean of bush, as these areas will host many pests. It is very important also to keep the field clean of any weeds. The young papaya must not be competing against weeds. If there is a grass problem, then a specific grass herbicide (Select, Fusilade, Post or Nabu) can be used without the young papayas being affected.

Experience has shown that *Roundup* (*glyphosate*) is the best form of total weed control. The technique used is a sprayman with a knapsack sprayer carefully spraying the beds. The young papaya trees should be covered with a small bucket or empty can to be protected from the spray. *Roundup* kills small papaya trees. Enough trees should be covered in an area on a bed in case the chemical drifts. It has been very successful and if done well will keep the fields clean.

Plastic mulch can also be used. Some of advantages are that the weed problem is minimized and water is conserved. The mulch must be the black and white type and must be strong enough to last for a least one year. Cut out one problem. A problem found is that if the orchard is in a very dry area, when rain does fall, the trees do not fully benefit from it.

Photos ? & ?: Field & Border Cleanliness - Free from Weeds

If there are gaps where there has been no germination at all, they can be supplied by using seedlings from another spot. The aim is to have a minimum of three plants per spot. When moving the plants, try and dig up a group of seedlings at once. Use a small hand spade and try not to disturb the roots.

7. Months 0 to 3

After two true leaves have appeared a routine spray program can be started. Use *dimethoate* (*systemic insecticide and acaricide*) every seven days at the lowest recommended dosage on the bottle. This will keep away many of the problematic insects like aphids, thrips, white flies and mites. **This should be done until there is first flowering (12-14 weeks).** Also, mix in with the insecticide a 20:20:20 soluble fertilizer with a basic micronutrient base. The application of this

Photos ?? & ?: One Month Old Plants

mixture is usually done with a knap-sack sprayer at an approximate rate of 200 liters of the mixture per acre (200 Liters/Ha at 1 and up to 500 liters/Ha at 12 weeks). The fertilizer should be mixed at a rate of 45 grams per 200 liters of water.

There should not be any fungal problems at this stage. However, occasionally you can get a dampening off. This is usually caused by soil borne fungi and can be treated with most systemic fungicides. This problem is usually promoted by over watering. If you have to use a systemic fungicide only treat the plants that are affected and the ones around it. Ten days after the last chemical treatment retreat with Trichoderma sp. these same plants to keep them protected.

During the first two mouths after germination the trees grow very quickly. The biggest threat to the papaya plants is competition from weeds. It is vital that the fields are kept clean. Spraying of the insecticide and foliar fertilizer should now be done with a motorized blower or an orchard blower behind a tractor. A pH regulator and sticker-spreader should always be added to the spraying solution. Fertilizing should be done according to the attached schedule.

At the first sign of blossom, which starts approximately 12 weeks after germination you must **stop using** *dimethoate*. Malathion WP must be used as the replacement insecticide (address of the seller) . Liquid Malathion 50EC was tried with out any problem but always be careful using it.

DO NOT USE MALATHION LIQUID AS IT CAN CAUSE FLOWER DROP.

8. Gender Determination and Thinning Out

Photos ? & ?: Hermaphrodite and Female Flowers (Left & Right, Respectively)

Photos ? & ?: Tree Pruning to Leave the Hermaphrodite Tree

With solo varieties the first flowers usually appear 12 to 14 weeks after germination. Successful germination and field management should give you three plants at each planting spot that are roughly the same size. Most markets have grown to prefer the shape of the fruit that is produced by the hermaphrodite plant. They are pear shaped and average 300 to 500 grams. The female fruit tend to be slightly larger with a big seed cavity. The flower forms at the base of each leaf stem and is attached to the trunk. It is very simple to distinguish which is hermaphrodite and which is female by the shape of the flower. The female flower is wider at the base and is pointed at the tip. The hermaphrodite flower is thin at the base getting wider in the middle where there is an indentation. It then gets wider again and gradually decreases back to a point. A flower of both the genders at 4 weeks is approximately 20mm long.

When you have determined the tree that you want you carefully cut the remaining plants leaving one at each spot. Occasionally one of the three plants maybe bigger and could be a female. You must cut out the big female and give the two smaller plants a chance to flower. Hopefully one will be a hermaphrodite. Selected trees should be removed with a machete as close to the ground as possible, taking care not to damage the tree which will remain. In general, after tree thinning, approximately 5% of the plantation will be female trees – 95% will be hermaphrodite.
It is conducive to thin out as quickly as you can recognize the flowers to reduce competition. Male papaya trees do not produce fruit. The male tree flowers profusely, its flowers are on long stems and are easily recognized.

9. Months 4 Onwards

Photos ? & ?: Five and Six Month Old Trees (Left & Right, Respectively)

8.1. Fungicides

At blossom start using a fungicide with a spray rotation: *Mancozeb WP, Champion, Benlate WP, Topsin M and Ridomil MZ* have all been used with success. The brand names and the active ingredients are given in Table 2.

Table 2. Fungicides

Brand Name	Active Ingredient (AI)
Mancozeb. WP	Ethylene-bisdithiocarbamate.
Champion.	Copper hydroxide.
Benlate WP Benomyl)	Benzimidazol-2-carbomate
Topsin M	Thiophanate-methyl
Ridomil MZ	Metalaxyl-mancozeb.0

Note: Copper has for years been thought to cause flower drop in papaya. Trials have been done using copper hydroxide and there have been no problems. Copper Oxychloride has not been tried, therefore it is not recommended.

With anthracnose during the wet season, if sprays are not carried out properly, then the leaves on the inside rows touching will all become infected and drop off.

The *mancozeb* or *champion* are the two contact fungicides used. If problems persist *Benlate* or *Topsin* is used as the systemic fungicides

Most of these are compatible. For example, mix mancozeb with the malathion and with foliar fertilizer. Dimethoate should used on it's own.

8.2. Spraying

Spraying should be carried out using a motorized air assisted sprayer when they are young. When the trees reach 6 months, an orchard sprayer should be used eg. FMC, Hardy Degania 500 (L). Almost all the chemicals are contact and therefore need air assisted spraying to reach under and inside the canopies. This is very important during wet season. Stickers and pH adjusters should not be forgotten.

Photos ? & ?: Spraying of Young Plants and 7 Month Old Plants (Left & Right, Respectively)

Always calibrate your personnel and equipment with fluorescent ink once a month at least. Boletin Tecnico #22

10. Pests and Diseases

10.1. Leaf Hopper (*Empoasca papayae* & *E. stevensi*)

Affects the papaya trees all year round. Symptoms include a crab-claw appearance of the leaf, followed by chlorosis around the edge of the leaf, then the whole leaf turns yellow, then brown and then drops off. During this period there is no fruit set. If serious, the tree can die. The symptoms are due to the phytotoxicity of the saliva of the leaf hopper.

Leaf hopper is also believed to be the transmitter of bunch top which can destroy the entire crop.

Leaf hopper control is carried out by first maintaining weeds and grasses in a 20 to 30 m perimeter and inside the field. There should be no weeds, grasses nor beans. Chemical control can be with dimethoate when the plants are young – before flowering. It is possible that after flowering it will cause flower abortion (although this is not confirmed). If used, it can only be used up to 21 days before harvesting (leaf hopper cycle is 21 days). Malathion can be used to control leaf hopper for at least for three weeks – but will only be effective if all the control components are present: weed control and good application methods. You also have to remember that Malathion is a contact insecticide and the leafhoppers are underneath the leaf so if you don't have a good coverage of the leafs you will not control the leafhopper.

Photos ? & ?: Symptoms of Leaf Hopper Damage

10.2. Red Spider Mites (*Tetranychus sp.*)

Red spider mites are usually only a problem in dry conditions. Mites are probably the biggest pest problem. Symptoms are firstly a yellowing along the leaf vein, normally at the base. Wherever the mites have protection and if not controlled, the affected areas will start dying and within 1 to 2 weeks the entire leaf will die. They also affect the crown leaves, the flowers and the fruit. On the fruit, at the base within the cracks, a browning effect will develop which is unattractive for sale. In addition, the sides of the fruit will show a grayish/brownish rough surface.

Control is carried out with abamectin, Pegasus does have some control, Malathion controls and Sulfur also has some control. But remember Malathion and sulfur are contact products you have to cover the underneath of the leaf completely to obtain good control.

10.3. White Fly

White fly can affects the trees all year round. They gather under the soft crown leaves and when population increases the leaves become opaque. They can encourage sooty mould around the crown and on the fruit in the column.

Malathion will help control; lannate is the most effective but should used only under severe conditions.

10.4. Phytophthora

Phytophthora affect the papaya trees all year round, but is usually worse during the wet season. The disease is usually a secondary problem caused by burning of the trunk with herbicides or mechanical damage (eg. machete when weeding). Trees are more susceptible when they are young as the trunk is still green with no lignin formation. Gramoxone and contact type chemicals tend to be more damaging.

Symptoms are a bubbling/oozing from the base of the trunk in contact with the soil, which turns brown and then black and rings the entire trunk.

To control, the dirt from the trunk needs to be scraped away and then painted (yes a brush) with a strong solution/thick paste of mancozeb or ridomyl MZ (Can't remember the mix 1 KG/5 Lts I think) . If necessary, it may have to be reapplied.

Photos ? & ?: Phytophthora Damage

10.5. Anthracnose (*Colletotrichum gloesporiodes*)

Anthracnose affect the papaya trees all year round, but is usually worse during the wet season. Symptoms are small oily looking spots on the leaf, usually the lower leaves first. The spot is about 2 mm diameter, dark in color with a yellow halo. The center will die and become brown and will cause premature leaf drop. If not controlled, it will go up to the crown of the tree. If the leaves drop then they can take the fruit with them.

Cleanliness of the field and spraying of fungicides will control anthracnose. Mancozeb and champion (copper hydroxide) should be used. If conditions are severe, benlate or topsin (systemics) can be used. If not controlled in the field, anthracnose will affects the fruit after harvest and will develop as the fruit ripens.

10.6. Thrips (These are pest should go before deseases)

Thrips are normally more problematic in the wet season. They can be seen on the outside of the un-opened flowers by the presence of a small brown mark, usually the entry point. If the flower is open, the thrips can be seen. At this point it is normally too late and the fruit will be already damaged.

Usually, field cleanliness and weekly Malathion sprays should control thrips and yes god coverage is necessary.

10.7. Bunchy Top

Said to be caused by leaf hopper transmission of a phytoplasma. Symptoms include shorter internodes, contraction of the crown, chlorosis and abnormal leaf bending and shorter petioles.

Control is the same as leaf hopper control. Affected tree should be cut out, removed from the field and destroyed.

This picture looks more like leafhopper

Photos ? & ?: Trees Affected by Bunchy Top

10.8. Ring Spot Virus

If not controlled, ring spot virus will destroy are complete plantation. It is present in many countries but this has not prevented the expansion of papaya production in these countries and some of them are world leaders in production. The virus affects plants in all stages of growth, from seedlings through to the mature bearing trees. The fruit from affected trees are unmarketable due to their appearance and unpleasant flavor.

In seedlings, the leaves of affected plants are yellowish with puckering and mosaic patterns and are malformed and distorted. Similar symptoms are shown in the mature plants, where they will taper off in a “sword shape” pattern and die slowly. The symptoms are also shown on the fruit as concentric circles and semi-circles on the skin, which are yellowish on mature fruit. The skin surface is normally rough and the fruit flavor is unpleasant.

Aphids (*Aphis gossipi* and *Myzus perisic*) have been identified as the insects that transfer the virus from plant to plant. Other crops, including cucumber, pumpkin and squash can also harbor the virus.

Prevention and control is carried out by not introducing plants or seedlings from other farms, ensuring the seedlings are disease free, not planting cucumber, squash or pumpkin near to the papaya, weed control and field sanitation, and with approved insecticides for control of the carriers. If symptoms are shown, the tree should be cut out, removed, buried or burned.

Fields have to be monitored continuously for aphids and changes in color and shape of the papaya leaves.

Photos ? & ?: Trees with Virus Symptoms

Photos ? & ?: Trees and Fruit with Virus Symptoms (Maradol)

10.9. Catface

Symptoms are the deformation of the fruit with the appearance of a “cat face”. The problem is caused by stress conditions during flowering such as high temperature, low temperature, sudden temperature changes, fertility changes, water status, excess nitrogen, etc. This results in uneven pollination which causes the deformation when the fruit development.

10.10. EPA Approved Chemicals

A list of the approved chemicals with allowed maximum residue levels provided by the US EPA is given in Table 3. This is may change and is available from the EPA web site at http://www.epa.gov/pesticides/food/viewtols.htm

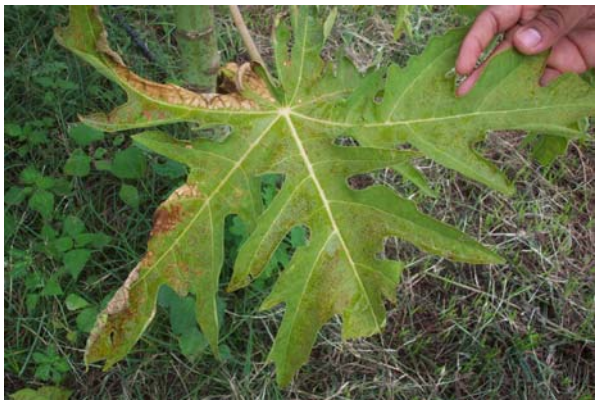
Table 3. EPA Chemical Tolerances List for Papaya

Chemical Name	Crop	PPM	CFR
3-Carbamyl-2,4,5-trichlorobenzoic acid	PAPAYA	-	180.1110
Azoxystrobin	PAPAYA	2.0	180.507
Benomyl	PAPAYA	3.0	180.294B
Chlorothalonil	PAPAYA	15.0	180.275
Diuron	PAPAYA	0.5	180.106
Fenbutatin oxide	PAPAYA	2.0	180.362
Ferbam	PAPAYA	7.0	180.114
Glyphosate and its metabolites	PAPAYA	0.2	180.364
Glyphosate and its metabolites	PAPAYA, MOUNTAIN	0.2	180.364
Malathion	PAPAYA	1.0	180.111
Mancozeb	PAPAYA, EDIBLE PULP (NO PEEL)	0.0	180.176
Mancozeb	PAPAYA, WHOLE	10	180.176
Maneb	PAPAYA	10.0	180.110
Metalaxyl	PAPAYA	0.1	180.408
Methyl bromide	PAPAYA (POST-H)	20.0	180.123
Oryzalin	PAPAYA	0.05	180.304
Oxyfluorfen	PAPAYA	0.05	180.381
Paraquat dichloride	PAPAYA	0.05	180.205
Permethrin	PAPAYA, WHOLE	1.0	180.378
Phosphine	PAPAYA	0.01	180.225
Spinosad	PAPAYA	0.3	180.495
Thiabendazole	PAPAYA (POST-H)	5.0	180.242

11. Field Hygiene

Field cleanliness is important in order to reduce pest and disease pressures. This applies to both weeds and fallen fruit. In addition, the fruit fly protocol requires that all fallen fruit and ripe fruit be removed from the fields. This should be done on at least a weekly basis.

12. Spray Damage



Papaya trees are very susceptible to chemical damage eg. over-spraying, Gramoxone and oil based chemicals. Initial symptoms are upward roll of the leaves, followed by leathery feel to the leaf, chlorosis then browning, and leaf drop.

13. Scouting for Pests and Diseases

Daily scouting is preferable, but it should be carried out at least twice a week.

Scouts need to look for discoloration of crown leaves, check leaves for signs of mites, white fly and leaf hopper. In an ideal situation sticky traps should be used. At present, no scientific thresholds have been developed, and controls are used based on experience. Field should be divided into sections and if pest or disease pressure is present, then the affected field section is sprayed.

Procedures should be followed as given in the Fintrac CDA Production Bulletin # 17.

14. Fruit Pruning

While several countries may recommend fruit thinning, it is **NOT** recommended with the solo papaya. When there is over population of fruit there will be natural fruit drop. If the tree is in excellent condition it can have up to five marketable fruit per node.

On the initial fruit set, it is normal to have only one fruit per node and sometime misshapen. Within 6 weeks of flowering start to get two flowers per node.

15. Sex Changes

A papaya tree can change sex. A tree producing hermaphrodite fruit can change to produce female fruit during stress conditions (eg. high temperature, low temperature, etc). When conditions revert to normal, the sex will change back again.

16. Side Shoot Pruning

This should be before since you have to start doing it at 4 to 5 moths into the crop.
These are the shoots that appear right above the leaf node above the fruit. These should be pruned continuously and never left to grow more than 3". The side shoots will stop about 8 weeks after the start of fruiting. As the tree ages, shooting will occur on the side of the trunk on the old leaf nodes.

17. Fertilization

A fertilization calendar is provided in Table 1. This calendar should be followed with weekly fertigation throughout the life of the crop and by foliar applications. Foliar applications are mainly to apply the micronutrients. If the calendar is not followed, problems can occur such as poor flowering (adequate potassium), poor shelf life (during rainy months the fruit is softer due to lower potassium and calcium), catface (excess nitrogen). Papaya requires boron. If boron levels are insufficient, the fruit tip will have the appearance of a navel orange with a belly button appearance and deformed fruit.

Overall, there is limited published information available on papaya nutrition.

18. Postharvest Handling

Papaya fruits are sensitive to poor quality outturns and high post-harvest losses if harvesting, treatments and handling techniques are inadequate or inappropriate. From harvest, a shelf-life of four to six days under tropical conditions and up to three weeks at low temperature storage can be achieved with the correct harvest maturities, disease control measures, handling techniques and storage conditions.

18.1. Harvest Maturity

Papaya fruits should be harvested when the color of the skin changes from dark green to light green and when one yellow streak begins development from the base upwards. Fruits in this condition will continue to ripen normally after harvest. Those fruits harvested before this stage will fail to show complete ripening, and those harvested after, are more susceptible to damage and bruising during handling. The papaya protocol for exports to the US state that no fruit should be left on the trees with more than 25% color (2 stripes).

18.2. Harvesting

Papaya are harvested manually by hand from the ground, and as the trees grow, with specialized harvesting platforms or ladders. Specialized harvesting tools can be used buy they are not preferred. When harvesting by hand, the fruit is rotated and the peduncle snaps off against the tree. Avoid pulling the fruit from the tree as the peduncle can break next to the fruit preventing trimming.

The specialized implement for harvesting of fruit inaccessible by hand due to tree height, comprises of a long pole, a small circular hoop at the top, a small mesh bag attached to the hoop, and a horizontal blade above the hoop and the bag. The blade is positioned below the

peduncle of the fruit and the pole moved upwards; the fruit is detached from the tree and then drops gently into the mesh bag below the hoop at the top of the pole.

After harvest, the fruit are placed in single layers into shallow, light colored field crates, preferably containing a foam layer for cushioning. Care should be taken to avoid mechanical damage from fruit to fruit rubbing occurs during transport to the packing facilities. Fruit should never be thrown or dropped. Field crates containing the fruit should be held under shaded conditions protected from the sun and rain, while awaiting collection for delivery to a packing facility. Mesh bags, sacks or baskets are unacceptable for papaya transport due to the high susceptibility to bruising. Care should be taken during transport in field crates to minimize the movement of fruit. Avoid delays in transporting the fruit from the field to the packhouse.

18.3. Export Grading and Packing

Packing facilities should meet food safety requirements and the US phytosanitary requirements where exports are to be made to the USA. Initial classification and washing should be carried out as soon as possible after harvest. Fruit should be outgraded if they show signs of fresh mechanical damage, disease, over-maturity, cat face, oversized, small size, etc. Depending on the market tolerances, fruit will also be rejected based on scarring levels, insect damage and shape.

At the same time the fruit is being classified, the stem should be removed with a sharp knife, flush to the neck of the fruit. They should then be placed in a water wash tank to remove latex and debris. Chlorinated water should be used at 100 to 150 ppm. For exports to the USA, the papaya protocol requires that the fruit be treated in hot water at 49^{o}C for 20 minutes. This should be carried out after the initial washing process. After hot water treatment the fruit should be cooled in ambient water prior to packing.

If anthracnose is a problem, then depending on the market, the fruit can be treated with 0.05% thiabendazole solution (0.5 g active ingredient per liter). Importing and exporting country legislation on the application of fungicides should be consulted prior to any postharvest fungicide treatment.

Washing, treatment and grading can be carried out using mechanized or manual systems, depending on the volumes of fruits. Grading in each carton is required in terms of size, sex (shape) and stage of ripeness. Only hermaphrodite fruit should be packed in cartons for export; all fruits must be of a similar size in each carton resulting in a range of counts, and separations must be made for the degree of ripeness. Carton net weights are dependent on the importer, ranging from 3.5 to 4 kg (8 to 9 lbs), and must not be overfilled during packing. The count categories are essentially weight categories, with all fruit in an individual carton falling within a weight range. These are given in section 18.2.

18.4. Packaging

Single layer, one-piece self-locking or two-piece full telescopic fiberboard carton; bursting strength - 250 lb/in^2. Ventilation holes must be provided to allow for both horizontal and vertical cooling. Internal packaging material can include shredded paper in the base of the carton and individual tissue wraps for each or alternate fruit. Individual labels can be attached to the fruit for appearance and recognition.

Example carton external dimensions: 39.5 x 29.5 x 10.5 cms (L x W x H).

Cartons should be labeled with the count, stage of ripeness and the traceability code.

18.5. Storage and Transportation

Short term storage can be carried out at 10^{o} to 12^{o}C and 85 to 95% relative humidity. If air shipments are to be made, cold storage is not recommended to the lack of a continuous cold chain.

Sea-shipment of papaya is possible when fruits are shipped at the optimum harvest maturity, with one or two yellow streaks. Fruit should be pre-cooled and conditions set at 10^{o} to 12^{o}C and 85 to 95% relative humidity (25% ventilation), in refrigerated holds or reefer containers. Pre-harvest and post-harvest disease control is critical with sea-shipment, particularly anthracnose and Phytophthora. Color development during sea-shipment usually increases from 10% to 40% during 10 days at 12^{o}C, and will develop further during the customs, clearance and delivery period on arrival. Where possible containers should be delivered to the buyer to ensure cold chain maintenance.

Fruit harvested and placed to ripen at the recommended harvest stage (one yellow stripe) will ripen to 60 to 70% yellow coloration within four to six days under ambient tropical conditions (25^{o} to 28^{o}C). Fruit transferred to low temperature storage (10^{o} to 12^{o}C), when harvested at the one-stripe stage, will store successfully for 14 to 21 days if post-harvest disease incidence can be controlled. When harvested at more advanced stages of ripening, the storage life will be significantly reduced.

18.6. Potential Post-harvest Losses

Papaya is particularly susceptible to post-harvest losses as a result of high susceptibility to bruising and disease infection. Careful handling must be employed during harvesting, handling and shipping, and the relevant disease control measures employed.

Mechanical Damage: damage to the skin immediately after harvest, as a result of the harvesting implement, dropping into crates, over-filling of crates and excess movement of fruit during in-field transport, will result in latex staining, punctures, scars and bruises. During ripening, bruised areas will develop into dark soft regions which become affected by secondary microbial infection. Similar effects can occur as a result of poor handling during washing, grading and packing. Damage can be reduced by taking protective measures throughout the handling procedures. Staff should be trained with harvesting techniques, foam should be included in the base of field crates and crates should contain only one layer of fruit. Stems are to be removed in the field to prevent puncturing or scratching of adjacent fruit. Vehicles used to transport the fruit from the field to packhouse should be driven slowly and with care. During handling in the packhouse, fruits should never be thrown or dropped and in automated operations, all machinery should be padded where possible. Palletized systems of produce movement in packhouse operations are preferable, both with field crates and with the final packed product.

Pathological Factors: Anthracnose (*Colletotrichum gloespoirides L*.) disease is prevalent during long term storage and with humid orchard conditions, inappropriate pre-harvest disease control or poor orchard hygiene. The presence of the disease is characterized by small black or light brown spots which gradually enlarge and may coalesce and sink. Anthracnose can be controlled or reduced by pre-harvest sprays. Post-harvest control where pre-harvest sprays are in operation should include a cold-water dip or spray containing 0.05% Thiabendazole and surfactant (importing and exporting country legislation should be checked prior to use).

Phytophthora: The disease can be prevalent during long-term storage at low temperature if orchard control systems are not in operation. Phytophthora is characterized by circular translucent lesions which develop with grey surface mycelium, and is particularly apparent around the peduncle.

Low Temperature: Storage of unripe papaya below temperatures of 10^{o}C will result in chilling injury. The symptoms are indicated by surface pitting, discoloration of the peel and the flesh, incomplete ripening, poor flavor and increased susceptibility to disease incidence. Ripe papayas will store successfully at lower temperatures, but transport of ripe fruit (more than 50% yellow color) is not recommended due to the susceptibility to mechanical damage and bruising.

19. Quality Specifications

19.1. Characteristics

Yellow/green peel, deep orange/yellow flesh. Hermaphrodite fruit should be pear-shaped and female fruit uniformly round; only hermaphrodite fruit should be used for export to the USA, Canada or the EU. All fruit should appear fresh with no shrivelling, discoloration or non-uniform ripening.

19.2. Size

Different sized fruit are separated and packed according to weight, resulting in different "counts". The following weight range is used for a 4 kg net weight carton:

- small: 12 to 15 count (260 to 330 g)
- medium: 8 to 12 count (360 to 500 g)
- large: 4 to 8 count (570 to 1000 g)

19.3. Condition

- No latex stains or surface debris
- No wounds from harvesting or handling, including punctures, scratches and bruises
- No scars or residues from insect or spray damage
- No fruit above the required color stage for shipment

19.4. Market Requirements

- All markets: small and medium hermaphrodite fruit are preferred with 50 to 70% yellow coloration on arrival at the importer. Small female fruit are acceptable to some importers.
- Selected markets and importers require medium and large fruit, particularly for ethnic or catering markets. Hermaphrodite fruit are preferred due to the large cavity size and susceptibility to damage shown with large female fruits.

20. Good Agricultural Practices / HACCP and Record Keeping

The buyers in the export markets demand that Good Agricultural Practices are followed in the field and that a HACCP program is implemented. Full traceability of the fruit in each carton is required back to the production area and history. The critical control points and standard sanitary operating procedures require continuous monitoring. Key training programs should be in place covering areas such as pesticide handling and application and staff hygiene. Each production and packing operation should keep full records of all activities carried out. Examples of selected forms are given in Annex 1.

21. Productivity

Projections are based on production of 2 fruit/tree/week with a plant life cycle of 26 months.

- 136 fruits/tree/life cycle.
- Average 400 g / fruit = 54 kgs/tree/cycle.
- With 2,058 / hectare = 112 tonnes fruit/hectare/production cycle.

Some 8 month old trees will have fruit available for harvesting – with 1 fruit/5 trees. By month 9, all trees should have fruit for harvest. Peak production will be months 11 to 16, after which it will reduce. Normally there are peaks and troughs during the year due to weather conditions. Volumes are usually up in April and May, then down slightly June to August, then up again September to November. This may vary depending on the temperature and weather conditions.

Production volumes estimates are given in Table 2. These have been developed on a uniform production basis until actual commercial production numbers and trends are available.

22. Cost of Production

Solo papaya costs around $?? / hectare to establish and produce until the first harvests. A cost breakdown sin given in Table 3.

Table 1. Fertilization Program for Drip Irrigation							
		Area Mz:	1.43	Area Ha:	1.00	Date:	1-Jan-02
Week	Days after Planting	Date	Ammonium Nitrate (Lbs)	DAP (Lbs)	KCl (Lbs)	Magnesium Sulphate (Lbs)	Calcium Nitrate (Lbs)
1	7	8-Jan-02	15	32	24		
2	14	15-Jan-02	17	36	28		
3	21	22-Jan-02	19	40	31		
4	28	29-Jan-02	21	44	34		
5	35	5-Feb-02	23	49	37	10	5
6	42	12-Feb-02	25	53	41	10	5
7	49	19-Feb-02	27	57	44	10	5
8	56	26-Feb-02	30	61	47	10	5
9	63	5-Mar-02	32	66	50	10	5
10	70	12-Mar-02	34	70	54	10	5
11	77	19-Mar-02	36	74	57	8	3
12	84	26-Mar-02	38	78	60	8	3
13	91	2-Apr-02	40	83	63	8	3
14	98	9-Apr-02	42	87	67	8	3
15	105	16-Apr-02	44	91	70	8	3
16	112	23-Apr-02	46	95	73	8	3
17	119	30-Apr-02	48	100	76	8	3
18	126	7-May-02	65	36	70	8	3
19	133	14-May-02	65	36	70	8	3
20	140	21-May-02	65	36	70	8	3
21	147	28-May-02	65	36	70	8	3
22	154	4-Jun-02	65	36	70	8	3
23	161	11-Jun-02	65	36	70	8	3
24	168	18-Jun-02	65	36	70	8	3
25	175	25-Jun-02	65	36	70	8	3
26	182	2-Jul-02	65	36	70	8	3
27	189	9-Jul-02	65	36	70	8	3
28	196	16-Jul-02	65	36	70	8	3
29	203	23-Jul-02	65	36	70	8	3
30	210	30-Jul-02	65	36	70	8	3
31	217	6-Aug-02	65	36	70	8	3
32	224	13-Aug-02	65	36	70	8	3
33	231	20-Aug-02	65	36	70	8	3
34	238	27-Aug-02	65	36	70	8	3
35	245	3-Sep-02	86	47	93	8	3
36	252	10-Sep-02	86	47	93	8	3
37	259	17-Sep-02	86	47	93	8	3

Table 1. Fertilization Program for Drip Irrigation							
		Area Mz:	**1.43**	**Area Ha:**	1.00	**Date:**	1-Jan-02
Week	**Days after Planting**	**Date**	**Ammonium Nitrate (Lbs)**	**DAP (Lbs)**	**KCl (Lbs)**	**Magnesium Sulphate (Lbs)**	**Calcium Nitrate (Lbs)**
38	266	24-Sep-02	86	47	93	8	3
39	273	1-Oct-02	86	47	93	8	3
40	280	8-Oct-02	86	47	93	8	3
41	287	15-Oct-02	86	47	93	8	3
42	294	22-Oct-02	86	47	93	8	3
43	301	29-Oct-02	86	47	93	8	3
44	308	5-Nov-02	86	47	93	8	3
45	315	12-Nov-02	86	47	93	8	3
46	322	19-Nov-02	86	47	93	8	3
47	329	26-Nov-02	86	47	93	8	3
48	336	3-Dec-02	86	47	93	8	3
49	343	10-Dec-02	86	47	93	8	3
50	350	17-Dec-02	86	47	93	8	3
51	357	24-Dec-02	86	47	93	8	3
52	364	31-Dec-02	86	47	93	8	3
		Total	**3,186**	**2,581**	**3,728**	**396**	**153**

Table 2. Projected Production Volumes

Table 3. Cost of Production Estimates

FIELD MANAGEMENT: CHEMICAL & FERTILIZER APPLICATIONS

Crop:	**PAPAYA**	**Month:**			
Farm:		**Field #:**		**Area (acres):**	
Planting Date:		**Field Age (months):**		**Predicted Harvest:**	

Date	Trade Name	% AI	Application Details		Harvest Interval	Earliest Harvest	Actual Harvest	Applied by	Comments
			Rate of Use	Water Volume					

WEEKLY FIELD EQUIPMENT MAINTENANCE Records
Units: SPRAY EQUIPMENT

DATE:

Unit	Checked By:	Tank Clean (ed)	Hoses	Nozzles	Fan Belts	Bearings	Chassis	Bolts	PTO Shaft	Other
							n/a		n/a	
							n/a		n/a	
							n/a		n/a	

Write "Checked" when inspected, and OK if acceptable – if not, state subsequent activity as a result of the inspection.
N/a = not applicable to this piece if equipment

MONTHLY PESTICIDE EQUIPMENT CALIBRATION & CHECKS

Equipment Identification:						YEAR:						
	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Operator Name:												
Sprayer Undamaged												
Nozzle(s)												
Diaphragm												
Flow Rate (L / min)												
Drive / Walk Pace (min / 100m)												
Swath Width (m)												
Volume (L / Hectare)												
Overalls												
Mask & Filter												
Goggles / Visor												
Initials of Checker / Date:												
Faults found / Repairs carried out: *(Carried out in the last week of each month)*												

CROP SCOUTING RECORD

Crop:	PAPAYA	**Farm:**		**Field:**		**Area (Hect)**	
Density:		**Planting Date:**		**Predicted Harvest:**			

Date	Tree Age	Pest / Disease		Beneficial Organism		Weather	Disease Risk/ Action Recommended	Scout Sign.	Manager Sign.
		Type	Level	Type	Level				

PACKING HOUSE DISPATCH COVER SHEET

Date:						
Customer:						
Order #:						
Airline:						
AWB #:						
Box Net Weight (kg)						
Fruit Size	**Total Amount (boxes)**	**Amount of Boxes & Trace Code (box end label)**				
6's						
7's						
8's						
9's						
10's						
11's						
12's						
13's						
14's						
TOTAL QUANTITY						
Signed:						
Dispatch Driver:						
Vehicle:						
Drivers Remarks:						

PACKINGHOUSE QUALITY AUDIT FORM

Date:		**Customer:**	
Farm / Field:		**Box Net Weight (kg)**	…… kg

Invoice #:		**Trace Code:**	

Box Weight Sampling (kg)							
1		**4**		**7**		**10**	
2		**5**		**8**		**11**	
3		**6**		**9**		**12**	

COUNT		**Individual Fruit Sampling – Weights (g)**			
		7's: 3.5 kg range: 480-535 g		**4.0 kg range: 550-640 g**	
# of Cartons:					
Brix %					
Pulp Temp (C)					
		8's: 3.5 kg range: 435-475 g		**4.0 kg range: 485-550 g**	
# of Cartons:					
Brix %					
Pulp Temp (C)					
		9's: 3.5 kg range: 380-430 g		**4.0 kg range: 435-485 g**	
# of Cartons:					
Brix %					
Pulp Temp (C)					
		10's: 3.5 kg range: 325-375 g		**4.0 kg range: 10's 385-435 g**	
# of Cartons:					
Brix %					
Pulp Temp (C)					
		12's: 3.5 kg range: 260-320 g		**4.0 kg range: 310-385 g**	
# of Cartons:					
Brix %					
Pulp Temp (C)					
		13's: 3.5 kg range: 225-255 g		**4.0 kg range: 275-310 g**	
# of Cartons:					
Brix %					
Pulp Temp (C)					
				14's: 4.0 kg range: 225-255 g	
# of Cartons:					
Brix %					
Pulp Temp (C)					
TOTAL # OF CARTONS					