

The Ultimate

Pawpaw Production Guide

From Planting to Marketing



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Edition



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The Writers Forward

This guide is written to help starters make their first steps in commercial pawpaw production and to help improve production for those who have been doing pawpaw farming.

It is a simple, easy to follow guide that provides step by step directions right from land preparation to post harvest operations. Details provided here reflect practical aspects as recorded on the farm.

Considerations have been made to the varying conditions in different parts of the world. The writer has therefore made efforts to customize information to fit conditions of different places.

This guide, despite providing information in modern intensive farming, has a bias on organic farming. It is the practice of Richfarm Kenya and the belief of the author that organic farming is not only sustainable but the ultimate solution to food security and environmental conservation.

Constant revision of the information and practices provided here will be done in subsequent publications to provide updated information.

Regards,

Evans Mfani.

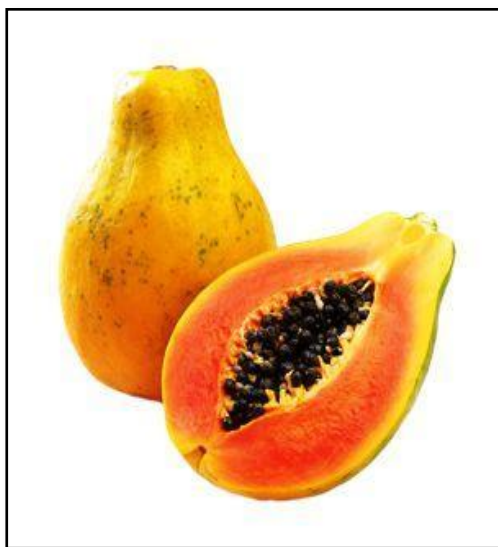
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The Ultimate Pawpaw Production Guide

Introduction

Pawpaw, also known as papaya or Papita (*Carica papaya* for those who love scientific names,) originated from tropical America specifically Mexico and Costa Rica.



However, due to its high commercial and nutritional value, fast growth and high yields, the crop spread fast and has become a very popular fruit grown in most tropical regions including Africa and Asia. The crop also matures fast producing fruits in less than a year and continues to produce for a long period.

Today, India leads in the production of Pawpaw with an annual production of over 3 million tonnes. Other major producers of the crop include Brazil, Mexico, Thailand, Philippines, China, Peru, Thailand and Nigeria.

Kenya is fast catching up and should soon start exporting significant amounts to put it on the world map.

Uses and Benefits of Pawpaw

1. Foods

Apart from its fruit being eaten raw, the crop has a wide variety of other uses. Green unripe pawpaw fruits can be cooked and eaten, usually in curries, salads, and stews. In Indonesia, the unripe green fruits and young leaves are boiled and use as part of *lalab* salad. A vegetable dish can also be made using flower buds fried with chillies and green tomatoes. In some parts of Asia, the young leaves of the pawpaw are steamed and eaten like spinach.

The ripe Pawpaw fruit can also be processed to make a variety of products such as jams, juice and ice cream. It can also be consumed as a dried fruit.

The black seeds of the pawpaw are also edible. They have a sharp spicy taste which makes them to be used as a substitute for black pepper when ground.

Pawpaw fruit contains about 88.8% water, 9.8 % carbohydrate, 0.8% fibre, 0.6% protein, and 0.1% fat. It also contains 16% more vitamin C than oranges and is a good source of vitamin A. Consumption of the fruit is aids digestion because of the papain content.

2. Papain and pectin



Papain is a white, milky and sticky liquid (latex) obtained from green pawpaw fruits the tree. It is collected by making incisions in the fruits or tree. The latex, which is dried under the sun or in an oven can be ground and sold in powdered form. It is used in a variety of industries including in beer clarifiers, meat tenderizers, and in making of other products. Pawpaws also have a relatively high amount of pectin, which can be used to make jellies. The

fruits are a source of flavouring used in candies, jellies, preserves, and ice cream.

3. Traditional medicine

In some parts of the world, pawpaw leaves are dried and ground and used to prepare a beverage just like tea which has been used as a treatment for malaria. Even though there have not been any scientific studies on this treatment, it has been successful. Papain powder is also used today in making digestion and wound debridement aids and tooth-cleaning powders. While there is only limited documented information on the medicinal value of pawpaw, there is a lot of evidence for healing various diseases and wounds.

According to the Journal of Medicinal Plants Studies “*Traditional and Medicinal Uses of Carica Pawpaw*” published on Plants Journal, Pawpaw is a powerhouse of nutrients which give it a wide range of medicinal properties. It is a rich source of threes powerful antioxidant vitamin C, vitamin A and vitamin E; the minerals, magnesium and potassium; the B vitamin pantothenic acid and folate and fiber.

In addition to all this, it contains a digestive enzyme-papaintha effectively treats causes of trauma, allergies and sports injuries. All the nutrients of pawpaw as a whole improve cardiovascular system, protect against heart diseases, heart attacks, strokes and prevent colon cancer. The fruit is an excellent source of beta carotene that prevents damage caused by free radicals that may cause some forms of cancer. It is reported that it helps in the prevention of diabetic heart disease.

Pawpaw lowers high cholesterol levels as it is a good source of fiber. Pawpaw effectively treats and improves all types of digestive and abdominal disorders. It is a medicine for dyspepsia, hyperacidity, dysentery and constipation.

Pawpaw helps in the digestion of proteins as it is a rich source of proteolytic enzymes. Even papain-a digestive enzyme found in pawpaw is extracted, dried as a powder and used as an aid in digestion. Ripe fruit consumed regularly helps in habitual constipation. It is also reported that pawpaw prevents premature aging. It may be that it works because a poor digestion does not provide enough nutrients to our body.

4. Other industrial uses

Papain is also used in the manufacture of chewing gum, cosmetics, for degumming natural silk and to give shrink resistance to wool. It is also used in pharmaceutical industries, textile and garment cleaning paper and adhesive manufacture, sewage disposal etc.



Different papain products in the market

Varieties of Pawpaw

There are many varieties of the pawpaw today. In this guide, we will discuss only the main ones available in Kenya and whose seeds and seedlings you can get from Richfarm Kenya today. It is worth noting that more varieties, especially the hybrid varieties are continuously being developed. We shall do our best to keep this document updated on the varieties that come up and their benefits and characteristics. The following are the major pawpaw varieties grown in Kenya.

1. Calina Papaya IPB9



This variety was imported into Kenya from Indonesia. Its outstanding characteristic is that it is a pure dwarf: it starts bearing fruits at only 30cm high. It matures very fast such that if you planted it in a hot area with sufficient water for irrigation, you harvest your first fruit in under 6 months.

Calina papaya fruits are large and oval weighing about 0.5 to 1.2 kgs. They have a very appealing red colour inside and are very sweet as well. Most of the fresh fruit vendors in town love it because of its large size that allows them to slice it and sell in parts. Can you also imagine how attractive a bowl of fruit pudding would look like with the bright red chops of this pawpaw?

This variety may not have as good keeping quality as solo sunrise but it is still a darling for fruit exporters. With good management, each tree of this variety will give you more than 50 fruits in a year.

One advantage that farmers of Calina papaya IPB9 variety have is that they can space the trees a bit more closely (1.5 meters from plant to plant) hence ending up with about 1350 trees in an acre. You know what that means? Of course more yield per acre hence more money in the pocket.

2. Solo Sunrise



This is one variety that has been loved by everyone who has tried pawpaw farming in Kenya. It was first imported by KALRO and propagated in their farm in Baringo. It fast spread throughout the country with many farmers taking it up in Meru, Machakos and Makeni. Today, it is the most common in the country and its largest propagator, Richfarm Kenya, has distributed seeds to as far as Zambia.

Solo sunrise pawpaw tree matures fast and starts bearing fruits after only 6 months. At this age, the tree is about 1 meter tall. As it sets fruits, more flowers develop on the growing crown and by the time the tree is a year old, it would be carrying over 60 fruits. The production is continuous and the tree will give you more than 100 fruits in the second year of production.

The fruits are small and pear-shaped, with a red flesh and very sweet taste. Each fruit weighs about 250 to 300 grams, ideal for one person to eat in one sitting. The fruits have excellent keeping quality since a ripe fruit can be kept for 14 days without going bad. This is why it is the best variety to farm if you are targeting the export market.

3. Red Lady

This is another great variety originating from the Philippines. It is high yielding giving up to 100 fruits in the second year after transplanting. Although it takes a bit longer to mature (9 months on average), it has a long productive lifespan and can give you fruits year in, year out for more than 5 years.

Red lady pawpaw fruits are oval in shape, obviously red and sweet but a bit smaller than those of Calina papaya IPB9. They weigh 400 to 650 grams on average.

I should have mentioned by now that it is a self pollinating variety just like the other two we have discussed above. That means as a farmer, you do not have the burden of keeping male trees that do not produce fruits in your orchard.



The Hybrid Red-Lady variety Pawpaw

Cultivation of Pawpaw

Climatic and soil requirements

Pawpaw is a tropical plant adapted to warm or hot temperature conditions. Even in the tropical lands, it grows best in low altitude areas and the fruit production and quality declines with increase in height above sea level. The optimum altitude is less than 1200 metres above the sea level. Pawpaw is very sensitive to frost. The optimum temperatures for growing it range between 25 and 30° C (77 and 86°F) and a minimum temperature of 16° C (60.8°F).

The crop is also adversely affected by strong winds. It can only tolerate moderate winds if well rooted. It grows better in sheltered conditions but with full sunshine. In places that experience very strong winds, pawpaw can be grown if wind breakers are erected. However, such windbreakers should not compromise the intensity and duration of sunshine that the crops receive.

Pawpaw grows well on many types of soil. The pH and drainage are the most important aspects of the soil that should be considered. The suitable soil pH value is between 6 and 7.

Well drained or sandy loam soils with adequate organic matter are most suitable for the pawpaw cultivation. If the drainage is poor and the crops remain in water-logged conditions for 24 to 48 hours, the plants may die from root rot. Because of this, sticky clay and calcareous soils are not good for growing pawpaw as rain water may accumulate in the soil even from a few hours of rain. However, pawpaws can still be grown in such area if higher raised beds and drainage ditches are used.

Note that maintaining pawpaw crops on the same field for a long time may result to poor growth which makes the crops susceptible to diseases. However, with proper application of artificial or organic fertilizers you can replenish the soil nutrients and ensure a high crop yield is maintained. We will cover this in detail later under caring for pawpaw trees.

Seedling propagation

1. Seed sources

Pawpaw seedlings are commercially propagated directly from seeds or by tissue culture. The most common practice is the use of seeds. You will need about 20 grams of seeds to germinate seedlings for 1 acre. It is advisable to purchase certified seeds from dependable sources to give you a high germination rate and seedlings free of diseases.

To get seeds certified by KALRO in Kenya, you can call Evans on 0724698357. He mainly supplies Solo Sunrise seeds whose trees do not have males meaning all the trees bear fruits.

2. Sowing seeds

In Kenya, pawpaw can be planted any time. However, seedlings establish better in the farms during the rainy season. Therefore, you should time your sowing of seeds in the nursery such that the seedlings will be ready at the onset of the rains. The seeds usually take 14 to 28 days to germinate, after which you should take care of them in the nursery for about 2 months. So, essentially, you should sow your seeds approximately 3 months before the time of transplanting.

The best practice is to raise the seedlings in nursery beds that is about 1 metre wide and 10 centimetres high or in pots, polythene bags or a seedling tray. The seeds are first soaked for 24-48 hours in an optimiser (you can get this from an agro-vet shop or ask them of any solution they have for breaking seed dormancy).



Pawpaw seedlings in a nursery

Whichever method you choose, the seeds should be sown only 1 cm deep.

a) Using plastic containers

Plastic bags or soft plastic pots that are about 10 cm wide and 8 to 10 cm high is can be used in raising seedlings. Drainage holes are usually made on the sides and bottom of the containers which are then fill with the mixture of sandy loam virgin soil. One or two seeds should be sown in each container and the top covered with well prepared compost or light soils. This is done to keep the soil warm and wet till the seedlings germinate. The site of the bag or pot should be changed if the roots of seedling penetrate into the soil. This is done to make the seedlings produce more roots hence become healthier.

b) Seedling Tray sowing

The use of plastic seedling trays is a new way of seedling propagation being used to obtain healthy seedlings. It has an advantage in that the seedlings can be easily transported and transplanted without much interference with the roots. The tray should have large cups and the ideal ones are trays with 20 holes. When using this method, fill up the holes with sandy loam virgin soil or preferably coco-peat or peat-moss and sow 1 or 2 seeds in each hole and cover them lightly such that they are only about 1 cm beneath the surface.

c) Nursery seedbed

When a nursery bed is used, the seeds should be sown in rows that are 10 cm apart. The seedbed should then be covered in a small layer of fine compost. You should then irrigate the seedbed lightly everyday in the morning hours. The nursery beds are covered with polythene sheets to protect the seedlings.

Rule of thumb

As a rule of thumb, you must ensure that the soil in which you sow the seeds is light and well drained. To achieve this, mix your soil with at fine sand in the ratio of 2:1 (for every 2 units of soil add 1 unit of sand).

During the germination period, a greenhouse or a tunnel can be used for purposes of controlling aphid, viral infection and protecting the seedlings from heavy rain and strong wind. This also helps in maintaining optimum temperatures and humidity levels. For better aeration, the film should be covered during the cool night or heavy rain period and opened in the warm day time.

With proper care and favourable climatic conditions, the seedlings should start emerging from the 14th day. The optimum temperature for seed germination is 21 to 27°C. At a height of about 15 to 20 cm, the tall healthy seedlings are chosen for planting.

3. Transplanting seedlings

Transplanting should be done when the seedling attain a height of 10 to 15 cm. Pawpaws grow very fast and should attain a height of about 30 cm within the first month of transplanting.



Young transplanted Pawpaw seedlings

However, if the pot system was used to germinate the seedlings and the container is large enough, more time can be given for the plants to attain a height of up to 30 to 40 cm. Older and bigger seedlings have greater chances of surviving and growing into stronger healthier trees compared to younger seedlings. The seedlings should be transplanted onto well prepared land and spaced as instructed below to give maximum yield.

a) Land preparation

The existing vegetation should be cleared to pave way for ploughing. Soil samples from the land should then be collected and analyzed to determine if there are any problems. This analysis can be done by local commercial laboratories familiar with the soils of your area or by other established agricultural research institutions in your area. Based on analysis results, the laboratory or institution gives recommendations on adjusting soil pH and the amounts of other soil nutrients.

The land should be ploughed and harrowed twice to create a loose crumbly soil texture. This ensures that the soil is well aerated and also improves drainage. An elevated bed along which the rows of pawpaw would be planted is made by ploughing on both sides. This will ensure proper irrigation and drainage. Organic fertilizer and manure should be spread and incorporated in the soil during land preparation.

Planting pawpaw in a land that has not been previously used for growing the crop (virgin land) is preferred because such land usually has low disease and insect pressure. It is very difficult to find such lands today. However, fields in which pawpaw has recently been grown can be treated and used to successfully grow the crop.

Non-virgin lands generally have high levels of *Phytophthora palmivora* spores due to the decomposition of infected pawpaw fruits, trunks, and root residues. In such lands the “virgin soil” technique can be used. The technique involves the use of about ½ cubic foot of “virgin” soil (soil not previously planted with pawpaw) placed in each planting hole. This soil allows the seedling roots to grow in a fungus-free environment until the seedlings are old enough to withstand fungal infection as the roots extend beyond the “virgin soil” zone. Otherwise, the land would require a fallow period of 3–5 years before planting another pawpaw crop.

b) Transplanting and Spacing

Transplanting should typically be done on a cool day or late afternoon to minimize transplanting shock. The seedlings should be fully watered one day before transplanting. Drill the planting hole about 45 cm in diameter and 30 cm in depth and fill it with soil that has been mixed with compost.

While planting, you should take care not to plant too deep such that part of the stem is covered in soil. If this happens, collar-rot disease may affect the buried part of the stem. You should water your crop immediately after transplanting.

Black and white plastic mulching film can be used on the transplanting beds. This is done in order to:

- (a) Reduce the loss of water and fertilizer nutrient
- (b) Control weed
- (c) Repel the winged aphids
- (d) Decrease virus infection at young stage
- (e) Decrease bed soil erosion.

c) Plant sex selection

The three varieties we discussed above are self pollinated. That means that each flower has both the male and female parts and pollinates itself. Such varieties have all the trees bearing fruits and are the best for commercial purposes since the farmer doesn’t have to deal with the male burden.

However, some of the available commercial varieties have plants that are dioecious (separate male and female plants). That requires that the farmer does proper sex selection to come up with a productive orchard.

Determining the sex of a pawpaw plant prior to flowering is practically impossible. Therefore you will have to grow two to three seedlings in each hole until flowering then eliminate some of the plants to get the required female to male ratio. You need one male tree for 8 female trees.

Female flowers are borne along the trunk and can be identified by that location and the presence of a miniature pawpaw fruit (ovary) inside the base of the flower petals. Male flowers are borne in long sprays that originate along the trunk. Each spray is much-branched with inch-long, trumpet-shaped, male flowers that do not have an ovary. The much desired hermaphroditic flowers are practically identical to the females but contain both an ovary (female organ) and pollen sacs (male organ); they are self-pollinating.



Female pawpaw flower



Hermaphrodite pawpaw flower

Plant sex selection is also guided by market preferences. For example, seeds from Solo varieties produce plants of two reproductive types: female and hermaphrodite. Although there is no difference in the eating quality of fruits from these two flower types, the commercial market prefers the pear-shaped fruits produced by hermaphrodite plants over the rounder fruits of the female plants.

In addition, female plants require cross pollination to produce fruit, and there can be gaps in production when pollination does not occur. It is therefore preferred to have hermaphrodite plants and this is the other reason why plant sex selection is paramount.

d) Thinning

Thinning is done to reduce competition for nutrients among the plants and to retain enough plants to ensure that a hermaphrodite plant is finally obtained in each hole or the right male-to-female ratio is obtained. We have said that 2 to 4 seedlings should be planted in each hole. This is because most of the standard commercial gynodioecious cultivars have a sex segregation ratio of 2:1 (two hermaphrodite plants for each female plant). Therefore having 2 to 4 seedlings in a hole ensures more than 97% chance of retaining one hermaphroditic plant. Thinning is done at the flowering stage, when all the other trees are cut off at ground level leaving one hermaphrodite plant. Most of the commercial cultivars begin to flower at approximately 6 to 8 months.

You can intercrop your pawpaws with newly-planted long term fruit trees such as oranges. Short term crop such as corns or vegetables may also be considered but this is not necessary.

4. Caring for Pawpaw Trees

Pawpaw is a sensitive crop and for maximum production especially in commercial farming, strict management practices are essential. The pawpaw crop management practices that must be observed are:

a) Weed control

You should start weeding your crop at the young stage while they are still in the nursery beds. Weeding should be done frequently and lightly. Deep tillage to the soil should be avoided since pawpaws have shallow roots.

Before transplanting, irrigate fields to germinate weed seeds and then spray the weeds with a systemic herbicide (e.g., Roundup®). If this is done twice, most weed seeds in the surface soil will be eliminated. After transplanting, hand weeding is recommended around the young seedlings. Herbicides should be used with caution. Contact herbicides are preferred over systemic herbicides at the young stages, although both may damage the pawpaw plants.

It is advisable to shield the young plants when spraying. Older pawpaw plants with woody trunks are more tolerant of glyphosate-based systemic herbicides such as Roundup, but care in herbicide application should be emphasized. Herbicide applications are usually limited to a bimonthly or quarterly interval in mature orchards, where the plant shade reduces weed growth.

Mulching the field with plastic films before transplanting or with rice / sugarcane straws before or within a few days after transplanting is a very effective and recommended method that you can use to control the weeds, soil erosion and water loss.

b) Irrigation

Although pawpaws have a considerable level of drought resistance, they will not achieve optimum growth and yield if they do not receive sufficient water, especially during flowering and fruit development stages. Pawpaw plants that lack sufficient water may drop flowers, leaves and young fruit and produce small fruits of low sugar content. Correct irrigation is therefore important in areas that receive low rainfall. In such areas, irrigation should be provided via drip-type or mini-sprinkler irrigation systems.

Water requirements vary according to weather conditions, soil type and the developmental stage of pawpaw. It is therefore important to monitor soil moisture levels and schedule irrigation appropriately. Plants growing in sandy or rocky soils that are well drained and do not hold much water should be watered every day during hot, dry conditions and less often during cool parts of the year. Plants growing in soil with a capacity to hold water, such as loams and sandy loams, should not be overwatered and therefore should be watered at 3 to 4 day intervals.

c) Application of fertilizers

Before establishing a pawpaw plantation, a representative soil sample must be taken from the entire field and analyzed. The soil analysis results will indicate the types and quantities of minerals needed before planting. Soil analysis should also be done within the course of pawpaw growing to find out the availability of nutrients in the soil.

Pawpaw trees need continuous fertilization since fruiting is continuous after the tree attains maturity. Fertilizer should be applied at the base of each tree. If you are using drip irrigation, the drip line can also be used as a guide for placing the fertilizer.

Chlorine-free fertilizers should be used since the pawpaw plant is very sensitive to the chemical. One week after transplanting, apply about 28g of high phosphate fertilizer, for example N:P:K 12:24:12, to each plant. Thereafter, about 57g of high nitrogen fertilizer, for example 20:10:10 should be applied every week per plant.

Potassium is very important during the flowering and fruit setting stages of the pawpaw plant. Therefore, at the first sight of flowers, you should apply 144g of high potassium fertilizer (such as N:P:K 12:12:17+2) per plant. This application should continue being done every month.

You should also apply foliar fertilizer containing trace elements especially Boron every month. Foliar fertilizers help in ensuring good fruit quality. Other trace elements include manganese and zinc which may be applied to the ground in soils with a low pH (7 or less) and through foliar fertilizers for plants growing in high pH soils.

Organic fertilizers can also be used for growing pawpaw. It is recommended that you apply 10 tons of compost or manure per hectare (or 1 kg per square meter) before planting or when forming beds. The same amount should be applied every year for adult plants. A few handfuls can also be sprinkled at the base of each plant every month. 10 to 20 kg of dry manure should be applied per tree every year.

Farm manure should, however, be analysed before it is used on pawpaw because manure, such as poultry manure, has a high phosphorous content, which can be detrimental to plants and induces micronutrient deficiencies if excessive quantities are applied. However, poultry manure can be useful on very sandy soils if phosphorous uptake is very poor and the plants lack vigour. Remember also that over-application of manure and other organic fertilisers can result in soft fruit which is not desirable especially for export or canning industry.

It is important to note that pawpaw is grown under many different environmental and soil conditions, and therefore it is difficult to have any one fertilizer practice that fits all conditions. Plant tissue analysis is useful in determining the nutritional status of growing plants at different stages of development. This permits modification of fertilizer programs to maximize yield and improve fertilizer use efficiency.

d) Pest and disease control

Even though pawpaw plants are considerably tolerant to pests and diseases, they are not totally free. A number of pests and diseases attack pawpaws and these vary depending on the prevailing environmental conditions.

A combination of cultural and biological pest and disease control practices is what we would recommend. However, severe cases may require that you use chemical control. If this be the case, please refer to your local recommendation for chemical control from established agricultural institutions.

The following are the most common diseases and their control measures.

i) Pawpaw Ring Spot Virus (PRSV) and Pawpaw Leaf-Distortion Mosaic Virus (PLDMV)

The PRSV causes vein-banding (bands of lighter colour (mostly yellow) occur along the main veins of leaves), mottling (appearance of irregular spots on leaves and petiole) or distortion of leaves. It may also cause water soaking streaks on leaves and petioles and ring spots appear on fruits or even on leaves.

The virus stunts the plants and drastically reduces the size of fruits, sugar content, and distorts the normally sweet taste. Some infected plants will bear fruits but with a reduced production. The disease spreads very fast and has become the limiting factor in pawpaw production in many areas of the world.

The PLDMV virus induces characteristics rosettes (light coloured rose-shaped spots) on leaves with slender stems on the crown top. The fruit has the same markings but there are bumpy swellings around the ring spots. As the disease progresses, the lobes of the leaves become distorted and leaf size is greatly reduced.

Both viruses are transmitted by sap (via mechanical means) or aphids. No evidence has been found that they are seed transmitted. However, seed from small, pear-shaped Solo-type fruits produce seedlings that seem to be more susceptible to this virus than those obtained from seeds of larger, elongated, oval-shaped fruits.

Prevention and Control:

- Grow the tolerant varieties such as the Solo and Red Lady varieties.
- Grow the seedlings and trees under the net house or screen house.
- Transplant at a time when there are relatively few winged aphids around and protect the seedling with transplant cylindrical plastic film and supports.
- Inter-crop pawpaw with barrier crop such as corn, but never host crops such as cucurbit. (May sow the corn seed one month after transplanting)
- Mulch with silver and black plastic film to deter winged aphids from visiting young seedling.
- Immediately eradicate and bury the whole infected plant once found
- Do not touch the healthy plants if hand or foot is contaminated with infected plant

- Control the aphids
- Practice cross protection with specific mild strain, but it often breaks down after a few months, losing its effectiveness.
- Pawpaw tree may be treated as an annual crop and requires replanting every year in order to cut down on virus infection in the area where virus occurs seriously.

ii) Damping-off

This disease mainly affects seedlings and is caused by a complex of fungi, among them Pythium, Phytophthora, Alternaria, Rhizoctonia and Fusarium. The fungi live in the soil.

The disease is favoured by high humidity and soil moisture levels especially in hot areas, poor drainage, deep sowing, thick sowing (crowded trees), poor soil aeration, high nitrogen in the soil and sunshine shortage. Infected seedlings will wilt, fall and then die.

Preventions and Control:

- Use virgin soil or sterilize the soil with steam at 180°F (82.3°C) for 30 minutes or fumigate with methyl bromide (see manufactures recommendations)
- Improve above mentioned environmental conditions to be favourable to the seedlings.
- Protect with plastic film from rain water.

iii) Phytophthora Fruit Rot

This disease is caused by soil-borne fungi of the Phytophthora and/or Pythium groups. It mainly occurs in the hot and humid season, especially after typhoon attacks. It induces root rot on young and adult plants, which finally wilt or die. It also may cause large lesions and white mould appears on the fruit and then the fruit drops.

Preventions and Control:

- Rotate with other crops.
- Select well drained soil.
- Avoid harming the roots.
- Control the snails and ants.
- Remove and deeply bury the diseased fruits.
- Spray 80% Mancozeb (Dithane M - 45) W.P. at 1:400 weekly.

iv) Powdery Mildew (*Oidium caricae*)

It is characterised by white and gray powder-like mould that appears on the leaves, petioles, stem and young fruits in early spring season

(around 18-22° C). It stunts the plant, induces leaf dropping, or may cause the tree not to set fruit.

Preventions and Control:

Spray one of the following fungicides with the sticker at 10-14 intervals.

1. 50% benomyl (benlate) W.P. 1:3000
2. 70% wettable sulfur at 1:400
3. 10.5% Penconazole E.C.1: 2000 phytotoxic to seedling.
4. 50% Binapacryl W.P 1:2000 phytotoxic to seedling.
5. 18.6% Triforine E.C. 1:1000 phytotoxic to seedling.
6. 19.5% Dinocap W.P.1:1500 phytotoxic to seedling.

Caution should be taken since the above mentioned chemicals may injure pawpaw at high temperature or/and when used in high concentration.

v) Anthracnose

It is caused by Colletotrichum, Gloeaporides, Glomerella or Cingulata fungi. It attacks the petioles and fruits and its symptoms mainly appear on the mature fruit and thus shorten its shelf life. The symptoms are usually round, water soaked lesions which if enlarged, will be slightly sunken. The fungus frequently produces light-orange masses of spores in the central lesion.

Preventions and Control:

- Weekly spray 80% Mancozeb (Dithane M -45) W.P. 1:400 with spreader/sticker.
- Treat the harvested fruits with hot water at 49°C for 20 minutes, then dip in the cool water for 20 minutes and then dry it.

vi) Black Spot

It is caused by Asperisporium caricae or Caercoospora pawpaw fungi. The leaf spots are greyish-white, roughly circular to irregular in shape. Heavily infected leaves turn yellow and dry up. The spots on fruit are tiny water-soaked, turning black and corky. This disease is more serious in wet and cool places at hill side.

Preventions and Control:

- Please refer to “Anthracnose” control.

vii) Root Rot

It causes root decay, leaf yellowing, and failing plant after raining. It also kills young seedlings in the nursery.

Preventions and Control:

- Rotating pawpaw with other crops
- Maintaining good drainage on the field and nursery

- Staking
- Sterilization of the nursery bed with formaldehyde two weeks before sowing or treating the seeds with thiram (TMTD) or captan.

viii) Collar Rot, Foot Rot (*Pythium aphanidermatum*)

Symptoms include swelling, cracking and rotting of the stem, when it comes in contact with water during the rainy season.

Preventions and Control:

- Please refer to “Damping-off” control.

ix) Stem-end Rot (*Ascochyta* sp. And other fungi)

A dry, firm, dark rot usually occurs after picking. It starts at the stem-end and extends into the fruit.

Preventions and Control:

- Pick the fruits with part of peduncle.

x) Rhizopus Fruit Rot

It is caused by *Rhizopus stolonifer*. The fungus invades injured mature fruit only. It causes soft rot and produces masses of visible black sporangia; leakage of cell fluids from the rotting fruit will also occur.

Preventions and Control:

- Be careful when picking, transporting and packing to avoid bruising or injuring the fruit.
- Heat treatment to kill the pathogen.
- Remove and destroy the rotting fruit in the packing sheds.

xi) Black Rot (*Erwinia cypripedii*)

The symptom mainly appears on the top of the stem. It primarily causes water-soak, then turns to black and leaves start falling. New shoots may be infected and finally the plant dies.

Occasionally the symptoms of water-soaked lesions are found on the leaves and petioles and will turn to brown angular and necrotic spots. The bacteria may also invade the flesh, inducing brown spots and decay leading to bad odour.

Preventions and Control:

- Eradicate the severely infected plant.
- Cut the infected portion of the stem under sunny day, then paste with sulphur to develop the new shoot.
- The seriously infected plantation should be destroyed.

xii) Boron Deficiency.

This physiological problem is common in the sandy or gravel soil during dry cool season. Latex could be found on the surface of immature fruits. Gall-like malformation of the fruit is also found in the severe plantation. The fruits are hard and not easy to get ripe, become tasteless and lose their commercial value.

Preventions and Control:

- Use more organic manure
- Dissolve Borax in hot water, then spray 0.25% Borax or Boric acid solution on the leaves at the beginning of dry season at 2-3 weeks intervals.
- Apply 2.5-5g Borax per plant (5-10kg/ha) along with other fertilizers by side dressing at the beginning of dry season.

xiii) Nematode Diseases

1. Reniform Nematode (*Rotylenchulus Reniformis*)

The young female nematode penetrates the root, causing stunting of the trees which are stressed and wilt more readily than the healthy ones. Fruits of affected trees are smaller and may become tasteless as well.

2. Root-knot Nematode (*Meloidogyne sp.*)

It causes swelling or retardation of the root and stunting of the plants.

Preventions and Control:

- Rotate the pawpaw crop
- Control with nematocide.

xiv) Mites

1. Spider Mites: Carmine Mite (*Tetranychus cinnabarinus*)

It infests widely on many kinds of plants and more seriously on pawpaw. The leaves become matted with webbing. There are two types of spider mites: Citrus Red Mite (*Panonychus citri*) and Texas Citrus Mite (*Eutetranychus banksi*). The outbreaks of both mites occur only periodically, usually during the fall, causing matted but not prominent webbing, and inducing bleached punctures on leaves. The premature leaves drop and the plants become weak. The damage may widely spread rapidly.

2. False Spider Mites

These are red and black flat mite (*Brevipalpus phoenicis*). They cause corky scarring of pawpaw fruit and reduce its market value. The mites are found on the stem and advances onto the petioles and fruits.

3. Tuckerellid Mites:

They are also known as twelve-tails Tuckerellid (*Tuckerella pavoniformis*): It is minor pest. Their symptom is similar to that caused by red and black flat mite.

4. Tarsonemid Mite:

They are also known as broad mite (*Hemitarsonemus latus*). It damages the seedlings and young plant greatly, causing stunted and distorted leaves. In a serious situation, the rosette leaves will appear, and the growing tips may be aborted.

Preventions and Control:

- Use fungicide such as Binapacryl, Trifornine, Dinocap used for powdery mildew control. This is also effective on spider or false spider mites. Spray 25% Morestan W.P. at 1:1000~1500 or 50% plictran W.P. at 1:2500~3000 at 10-15 days intervals.
- For Tarsonemid Mite, spray 75% wettable sulphur at 1:300 on the top of stem at 10-15 days intervals until normal new leaves occur.

Notice that too high concentration or/and high temperature may cause plant injury. Also, do not use the same chemical continuously because if you do, the mites may become tolerant to pesticide.

xv) Aphids (*Myzus persicae*, *Aphis spp....etc.*)

Aphids suck young leaves causing them to become curled and crinkled, and even defoliate, especially at seedling stage. Some aphids also transmit the virus diseases

xvi) Red Scale (*Aonideilla inornata*).

It mainly infests stem after flowering and then spreads to the fruits.

Prevention and control:

- Spray one of the following pesticides at 7-10 days intervals.
 1. 33% Formothion E.C. at 1:660
 2. 50% Malathion E.C. at 1:500-1000
 3. 44% Methidation E.C. at 1:1000
 4. 40% Methidation E.C. at 1:800

The above pesticides are also effective to control aphids and some other insects of Pawpaw.

xvii) Other Insects:

Scales, thrips, beetles, stink bug, leaf hopper, moths, mealy bug, and white fly are minor insects, but may occasionally cause certain damage to pawpaw.

Prevention and control:

- Keeping the plantation relatively free of weeds can control aphids, leaf hopper and thrips outbreaks to a large extent.
- Harvest all the fruits at the mature-green stage, and then pick dispose of all soft ripen and infested fruits promptly to prevent fruit fly infestation and reproduction within the plantation.
- Select the proper insecticide to control the outbreaks of certain insects.
- Biological Control: Apply the eggs of Mallad basalis walker (20-60 eggs/ plant or 100,000 eggs/hectare) to control mites, aphids, white flies if the pawpaw is grown in the screen house.

xviii) Snail and Slug:

They feed on young plants, shoots, or flower buds in humid place. They can also transmit the pathogen of phytophthora fruit rot.

Prevention and control:

- Collect the snails in the evening and at dawn and properly dispose them off.
- Protect seedlings with big plastic cylinder film after transplanting. (This may also protect from virus infection)
- Apply “Arttitox” 10-15 granules each square meter.

Note: The information on pests and diseases provided here is based on research and field observations. Variations in local condition may affect the information and suggestions contained above and for which the company should not be held liable. In case of doubt, it is recommended to carry out ordinary trial production in order to test local growing condition in different seasons and area.

e) Other Management Practices for pawpaw crop

- Removing suckers:** Suckers are the side shoots of the stem. All suckers should be removed as soon as possible to avoid damaging the maturing fruits. Generally suckers are not strongly attached to the main stem of the plant and can easily break off when allowed to bear fruit.
- Orchard sanitation:** This involves the removal of all old or dead leaves from the plant. Leaves, petioles and fruits that have been infected by diseases must also be removed and destroyed away from the orchard. Malformed fruits and the ones that are too small for the market must also be removed. Care must be taken when performing these practices to avoid transmitting the virus mechanically from infected plant to others.

- iii) **Plant support:** When plants bear very heavy fruits especially on an inclined field, they must be supported to prevent the stem from breaking. This should also be done in areas that frequently experience storms. The plant is supported with ropes tied on pegs fixed firmly on the ground or by propping using poles of wood or bamboo. Use two poles by forming an X placed along the centre of gravity of the plant to avoid hurting the plant.

- iv) **Hand pollination:** It is advisable to pollinate the plants by hand to increase the fruit setting and the percentage of large and normal fruits. This is actually necessary when growing pawpaws under a net house.

Harvesting

When to harvest

Generally, pawpaw fruits will mature and be ready for harvesting around the ninth month after seed sowing. However, in hotter regions, the plants develop faster while it takes a little longer for them to mature in cooler areas.

Pawpaw fruits to be used as vegetable (fruits for cooking) are harvested while still green but mature. You will know mature fruits when its papain turns from being milky to almost a colourless liquid.

The most popular product of pawpaw is the ripe fruits which are harvested when yellow colour traces start appearing on the green fruit. It is advisable to harvest the fruits when about 25% or $\frac{1}{4}$ of the fruit surface turns yellow or orange (Never

squeeze the fruit to determine if it is ripe). Remember that overripe fruits are not good for the export market since they go bad along the way. However, fruits being grown for the local market can be left to ripen more on the trees since this increases fruit quality and sugar content. In the peak season the fruits can be harvested 2 to 3 times a week and at least once a week during the rest of the season.



Pawpaw ready for harvesting

How to remove fruits from trees

Pawpaw fruits are delicate and a lot of care should be taken while handling them during the harvest to avoid bruising them. There are two ways of removing the fruit from the tree:

- i) Hold on the fruit and twist it until it snaps
- ii) Cut the peduncle with a sharp knife.

Never drop fruits to the ground or use poles to snap the fruit from the tree. Pawpaw fruits are delicate and should be handled with utmost care to avoid bruising them. If the trees are very tall, use a ladder to reach and pick the fruits by hand.

Alternatively use the specialized implement for harvesting pawpaws that are inaccessible by hand due to tree height. The implement 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.

Sorting and cleaning fruits for packaging

The harvested fruits should be placed gently on baskets with soft padding and delivered to the packinghouse within 2-4 hours from harvest. Heavily bruised, damaged, over-ripe or old fruits and those that have been affected by diseases are sorted out and discarded.

Wash and treat the healthy quality fruits by dipping them in hot water (for about 10 minutes in water that is approximately 52°C). Allow the washed fruits to dry in air under a shade. Do not expose the harvested fruits to direct sunshine.

Packaging and transportation

Ripe pawpaws are best transported in wooden or hard plastic fruit crates. The fruit crates hold them firmly so that they do not move and bump against each other during transit to the market. Sometimes paper fillers can also be used to ensure that the fruits are firm in the crate. It is advisable to wrap each fruit in paper before packing if the product is for export.

The bottom of the crate should be filled with shredded paper to cushion the fruits. Before packing, the peduncle should be cut to about 5 mm and the fruits packed in one layer with the peduncle facing the bottom so that the papain drains and gets absorbed by the shredded paper. The field crates containing the fruits should be left in shaded conditions protected from the sun and rain. You should never use mesh bags, sacks or baskets for pawpaw transport due to the high susceptibility to bruising the fruit.



Pawpaw ready for harvesting

Marketing

Markets of pawpaw are domestic, export and processing plants. There are fruit traders and consolidators who buy from farmers and transport them the cities and major towns where for retailers sell them in the local markets.

Some farmers have also entered into growers marketing contract with big fruit processors and exporters who play an important role in connecting the small growers to large markets locally and internationally. Other growers have their own market outlets formed by a group of organised small growers.

Prices of pawpaw vary according to variety and the supply and demand situation. While pawpaw has a big export demand, it is difficult for the small farmers to have access to these markets because of the stringent requirements and huge capital outlay required. However, by making use of government agencies involved in marketing of agricultural produce, small farmers can get access to the huge international market.

Economic importance of Pawpaw

Brazil is the main producer and trader of pawpaw in the world. As trade has increased new producers have appeared in the international market from the country and many other parts of the world. With the development of better cultivation and post-harvest technologies, pawpaw is becoming a new star in the world's tropical fruit market. It therefore is a potential major income earner in many parts of the world where commercial farming of the crop has not been practiced.

Estimated Costs and Earnings

Let's now seize this great opportunity and establish solid ventures in pawpaw farming. To help us do this, here are figures of estimated costs and profits. Please note that these are only estimates and figures may vary, though with a small margin, from place to place.

For this purpose, let us consider one acre of Solo Sunrise, till the first harvest:

Costs:

Ploughing	4,000
Preparing planting holes (labour)	10,000
Manure	15,000
Seedlings (1100)	66,000
Planting (labour)	3,000
Irrigation and pests and disease control	30,000
Total	<u>128,000</u>

Note: You can significantly reduce production costs by buying seeds instead of seedlings. Seedlings for an acre cost between Ksh.5,000 to Ksh.20,000 depending on variety.

Earnings

Pawpaws have 2 high and 2 low seasons in a year.

During the high season each tree gives approximately one kilo of fruits per week giving about one ton (**1,000** kgs) of fruits per acre per week.

During the low season, each tree produces a little less than a kilo of fruits giving approximately **600** kgs per week from one acre of Solo Sunrise.

In total, one acre of solo sunrise pawpaw gives between 30 to 40 tons of fruits in a year.

1 kg of pawpaw sells for between Ksh.30 to Ksh.60 depending on market and quality of fruits.

Therefore, the total earnings in a year of production of pawpaw range between Ksh.**900,000** to Ksh.**2,400,000**.

Important contacts:

To help you establish your pawpaw plantation in Kenya, the following people have immense knowledge in seedling propagation, orchard management and marketing:

1. Evans Nthiga 0724698357 – Farmer and supplier of seeds and seedlings.
2. Pius Rioba 0724076390 – Agronomist and consultant
3. Jane Lyomu 0735847672 – Agro-vet and plant protection specialist.

List of exporters

NAME	ADDRESS	EMAIL ADDRESS	CONTACT
Kenya Fresh Produce Exporters	P.O. Box 16845-00620 Nairobi	info@kenyafresh.co.ke	Tel: 254 20826267/8 Fax: 254 20826268
Kenya Horticultural Exporters (1977)	P.O. Box 11097-00400 Nairobi	khe@khekenya.com info@khekenya.com	Tel: 254 20650300-1 Fax: 254 20650303
Africa Fresh Produce Investment	P.O. Box 54964-00200 Nairobi	info@africafreshproduce.com	Tel : 020 2077030
Al Haq Trading Enterprises Ltd	P.O. Box 87445 Mombasa	alhaqenter@hotmail.com	Tel: 041 2228073
Benvar Estates Limited	P.O. Box 53-00621 Nairobi, Kenya	info@bcf.co.ke	Tel: 254-67-26002/25037, 254-20-827009
Fresco Produce Ltd	P.O. Box 1702-00200 Nairobi	finance@frescoproduce.co.ke	Tel: 254 202044375, Fax: 254 202044374 Mob: 254 0722 764395,0733773807
Sunny Fields Ltd	P.O. Box 7264-00200 Nairobi		Tel:0722727930, 0734675008 Fax:22709/352266
Sunripe (1976) Ltd	P.O. Box 41852-00100 Nairobi	info@sunripe.co.ke	Tel: 020-822518/822879 Fax: 020-822709/3542266
Wilham (k) ltd	P.O. Box 49125. Nairobi	operations@eaga.co.ke	Tel: 02822017/822025 Fax: 20 822155
Canken	P.O. Box 9333 - 30100 Eldoret	canken@cankencargo.com	Tel. 0532026652
Selina Wamucii Ltd.	P.O. BOX 35037 – 00100 Nairobi.	http://www.selinawamucii.com/farmers-program/	

Other guides in this series

1. [The Guide to Grapes Production in Kenya](#)
2. [The Strawberry Production Guide For Kenya](#)
3. [Passion Fruit Production Guide For Kenya](#)