

# Cultivating papayas



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# Papayas

***Papaya trees are fast growing and have an upright growth pattern. In tropical conditions they flower within 6 months after planting and will continue flowering throughout the year.***

***In subtropical conditions, however, growth and flower production will cease when the night temperature drops below 12 °C.***

## Climatic requirements

- Although a mature papaya tree can withstand a temperature of  $-2\text{ °C}$ , production is only recommended in areas where the average daily minimum temperature during midwinter never drops below  $5\text{ °C}$ .
- Ideally, night temperatures should not drop below  $12\text{ °C}$ .
- The optimum temperature range for papayas is between  $25$  and  $28\text{ °C}$ .
- Temperatures higher than  $36\text{ °C}$  and lower than  $17\text{ °C}$  for extended periods of time will adversely affect the growth of the trees.
- At average day temperatures ( $\pm 23\text{ °C}$ ) it will take about 6 months from flowering for the fruit to mature.
- The lower the temperatures the longer it will take for the fruit to mature and the other way round. After the winter (August–October) the trees are in a recovering stage and few flowers are produced.
- Production normally peaks from September to November.



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## Soil requirements and preparation

Papayas grow and produce well on a wide variety of soil types. The tree often develops a fairly strong taproot shortly after planting. The root system can, under favourable conditions, penetrate the soil to a depth of 2 m, but most of the roots responsible for nutrient uptake are found in the top 500 mm of soil, with the largest concentration in the top 250 mm.

### *Soil requirements for cultivation under irrigation*

#### **DRAINAGE**

- Papayas grow best on soil with a slight slope, because it enables the runoff or drainage of excess water and therefore prevents waterlogging.
- Papaya roots will die off in oversaturated and poorly drained soils such as depressions or basins as a result of a lack of aeration.
- Impermeable layers in the soil adversely affect growth and production of the plant and can lead to infection with root diseases.

#### **SOIL DEPTH**

Under irrigation, papayas grow optimally in soils with an unimpeded depth of more than 1 m. However, if irrigation is well planned and managed, there should be no problem on soil with an unimpeded depth of 750 mm, provided that no drainage problems occur at that depth.

#### **TEXTURE**

The ideal soil texture for papaya cultivation under irrigation is a sandy loam or loam soil (i.e. with a clay content of 15 to 30 %), but soils with a clay content of up to 50 % are also suitable.

In very sandy soils temporary oversaturated conditions could also occur if soil compaction or impermeable layers limit drainage. Sandy soils (< 10 % clay) normally have a very low water-holding capacity and nutrient status. A mulch or application of organic material can greatly increase the potential of such a soil.

It is, however, recommendable to seek expert advice before any type of organic material is worked into the soil.

#### **SOIL STRUCTURE**

The ideal soil has a fairly loose, brittle, crumbly structure. A compact or strongly developed soil structure will adversely affect water infiltration and root penetration. These soils are normally associated with a very high clay content in the subsoil (> 50 %).

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## SOIL pH (WATER)

- Papayas grow best in soils with pH (water) values of 6 to 6,5. If the soil exchangeable aluminium (Al) is not more than 30 ppm, soils with a pH (water) of 5,5 or higher may be used.
- At lower or higher pH (water) values than the range 5,5 to 7,2 plants may suffer from trace element, phosphate or potassium deficiencies.

## SOIL PREPARATION

Proper soil preparation will ensure optimal conditions for root growth which can last for the lifespan of the plantation and has the following advantages:

- Better root development
- Improved soil drainage and less runoff
- More effective utilisation of irrigation and rainfall
- Better utilisation of nutrients
- Greater tolerance toward diseases
- Improved fruit size
- Increase in yield
- Prolonged economic lifespan.

The components of soil preparation include:

- Complete examination of the soil (physical and chemical)
- Supplying the required lime, phosphate and other elements as recommended in the preplant soil analysis
- Deep plough or rip
- Building of ridges if necessary.

## SUPPLYING NUTRIENTS

- Calcium and phosphate are elements which move very slowly downwards in soils. Should there be a shortage of one of these elements, especially in the subsoil, it should be incorporated during soil preparation. If lime needs to be applied, it should be incorporated into the soil 6 months to a year before planting.
- If it is necessary to rip the soil, lime should be ploughed in beforehand and then ripped afterwards.
- Some producers prefer to plant a cover crop as a source of organic material. In such cases the crop must be planted about 6 months before the actual soil preparation action.

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## Propagation of seedlings

Papayas can be propagated by seed. Growing seedlings is the easiest and most economical way to propagate papayas. The short life of a papaya orchard (less than 4 years) and the number of trees per hectare makes the cost of planting material a critically important economic factor.

### *Seed germination*

- There are about 60 seeds/g of dry papaya seed.
- Seed can be sown directly in seedling trays or planting bags and thinned to the required number of plants per bag or it can be germinated in special containers and transplanted within 14 days after germination (two-leaf stage). The advantage of the latter is that the germination trays can be moved to a warm spot during the night.
- The number of seeds planted in a container (seedling tray, cell or planting bag) will depend on the germination vigour and the cultivar. In general, more seeds will be planted per container than needed and plants are then thinned.
- Plant about 6 seeds/bag and leave all the plants. Thinning will be done in the land when the plants start to flower and sexing can be done.
- For hermaphroditic cultivars, plant 2 seeds/container. The extra plants should be transplanted into empty containers within 2 weeks after germination. The plants should not be transplanted deeper than they were (only the white part of the stem should be covered by the medium).
- Provide shade during germination to prevent the seeds from drying out. The shade must be removed soon after germination because papaya plants develop poorly if shaded. The Brazilians build a small “roof” of palm leaves over the planting bags containing the seed. As the seeds start to germinate the palm leaves are progressively removed to allow more sunlight. At the four-leaf stage the palm leaves are removed so that the plants can grow in full sunlight. The same effect can be achieved by using shade netting.

### *Growth medium*

- A good potting medium must drain well and be free of soil-borne diseases.
- Composted pine-bark from a reliable source can be used without fumigation. The medium usually contains adequate levels of phosphorus and potassium, but is low in available nitrogen. It can also have a very low pH. Fertilisation and correcting of the pH can be done according to the results of the soil analysis.

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- Fill the bags with the compost 2 to 4 weeks before sowing and irrigate regularly. Do not sow in a dry medium because it will result in poor and uneven germination.
  - As a general rule 0,5 g of LAN is applied per planting bag just before germination. In practice this means an application of a few granules of LAN in every bag when the first seedlings start to emerge. Thereafter the seedlings are irrigated weekly using a balanced water-soluble fertiliser with high nitrogen content.

### *Soil mix*

- Equal parts of a sandy soil and compost or equal parts of a loam soil, sand and compost can be used as a growth medium in the bags.
- If soil is used, sterilisation is necessary.
- The growth medium should be analysed to correct deficiencies. The planting bags must be filled and irrigated well in advance of sowing. Any free water must drain away within 30 seconds after application.

### *Damping off*

Seedlings sometimes develop water-soaked spots at the soil line and topple over. This often occurs in warm, wet conditions and is caused by various fungi. To prevent further plant losses, decrease the interval of irrigation and time the irrigation so that the top layer of soil dries out before the next irrigation. A fungicide drench can be used. Do not, however, use a copper-based fungicide because copper is very toxic to young papaya plants.

The generally recommended containers for the production of papaya seedlings are black polyethylene bags. If one seedling per bag is required, a bag of 75 x 150 mm can be used.

### *Time of planting*

- In the tropics a papaya tree will start to flower within 6 months after planting and will continue to do so for the rest of the plant's lifetime.
- Different planting times will have an effect on the size of the tree when the first fruit sets.
- The best planting time for papayas is February/March.
- The plants will then mature before and during winter, but the growth will be retarded, so that when the plants start to flower in October the flowers will be nearer to the

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- ground, enabling the harvesting of more papayas from the trees without using ladders.
  - An advantage of March to August plantings is that the first crop is harvested from more mature trees, giving better quality fruit, and in particular, a higher sugar content.
  - For plantings in March/April seeds are sown in January/February.

## Cultivars

The target market is the most important consideration when choosing a cultivar.

- For export, small fruit (300–500 g) with an outstanding shelf life is required. Presently Sunrise Solo, Baixinho and to a lesser extent Af-1, are suitable for export.
- Chainstores require fruit with a good shelf life and for prepacks, fruit not bigger than 1 200 g. The Tainung varieties as well as Sunrise Solo are suitable for this purpose.
- The fresh produce markets and farm stalls prefer bigger fruit such as the Tainung varieties and Hortus Gold types such as FI-2.
- In general the hermaphroditic cultivars, such as Sunrise Solo, are not suitable for cooler production areas with mean minimum temperatures lower than 12 °C during the winter.
- For the cooler, frost-free areas, dioecious (separate male and female trees) cultivars such as FI-2 are recommended.

## Layout of orchards

The producer often has to consider nonprofitable male trees as part of the overall layout of an orchard. A growing demand for agricultural land, increasing land prices and production costs, all put pressure on the producer to increase the per hectare yield as well as the quality of the crop.

### *Planting density*

- Because of the characteristic shape of the papaya tree, it is important that the trees be spaced in such a way that they do not interfere with each other's ability to grow or intercept light needed for photosynthesis.
- The table lists the number of trees per hectare based on various combinations of between-tree and between-row spacings for the rectangular planting system.

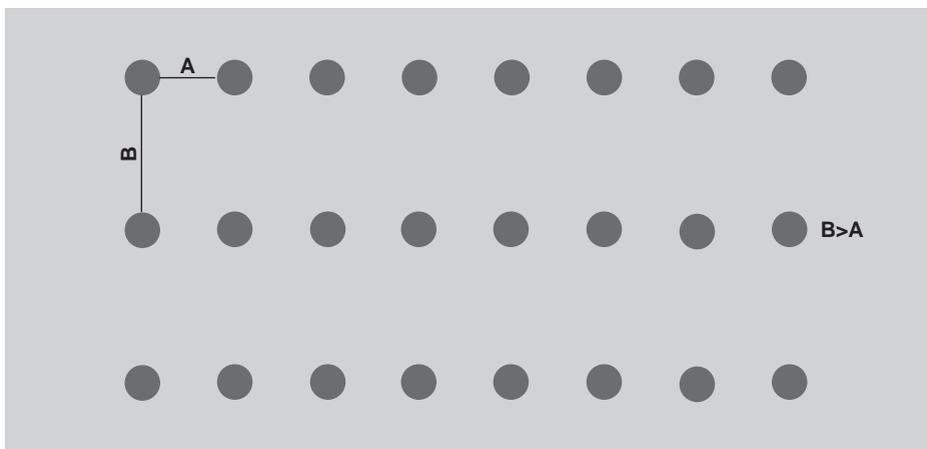
- Plant density will also depend on the slope to be planted. When planting on steep slopes it is advisable to contact the engineering division of either the Department of Agriculture tel [(012) 842 4279] or the ARC-Institute for Agricultural Engineering in Pretoria [(012) 842 4000]. They will be able to assist the producer with the proper planning of contours to control runoff. Uncontrolled runoff can cause erosion (loss of top soil), exposure and drying of roots, as well as damage to roads and infrastructure.

**The number of trees to be planted per hectare (rectangular system) on variations of the planting distance**

Planting distance between rows (m)	Between trees			
	1,0	1,5	2,0	2,5
3,0	3 333	2 222	1 666	1 333
2,5	4 000	2 666	2 000	1 600
2,0	–	3 333	2 500	

*Planting systems*

There are various planting systems. The rectangular system is, however, one of the more popular systems and can be adapted according to the spacing of the trees in the row. With this system adjacent trees within the row are not expected to touch one another even when they are fully grown. It also allows for adequate space between rows for orchard implements.



**Schematic illustration of the rectangular planting system**

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## *Orchard orientation*

For optimal interception of sunlight orchard rows should run north/south. This orientation gives a more even distribution of light on both sides of the trees than in the case of trees planted in an east/west direction. In cases where a north/south orientation is not possible the producer should allow for wider spacing of the trees to promote greater light penetration and air movement (not very critical in the case of papaya because of its tree form).

## **Planting papayas**

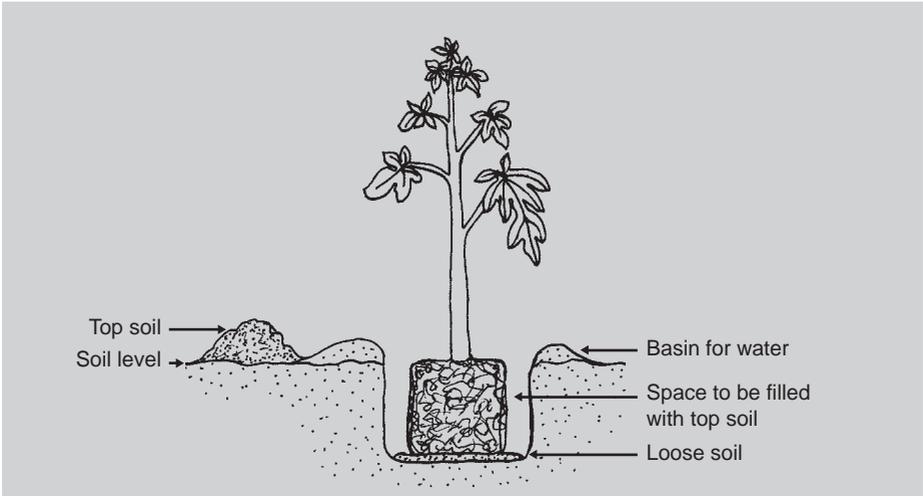
- Young papaya plants are ready to be planted out in the open when they are about 200 mm tall, measured from the base of the stem to the growing point.
- Papaya seedlings are usually planted in small 150 mm tall bags.
- If the plants are allowed to continue growing in the bags they will have to be transplanted, because the roots of a healthy plant should fill the bag space when the plant is 200 mm tall. Economically this is the best way as the plants are then strong enough to survive in the open.

## *When to plant*

- The best time is during late summer and autumn (February to April), except in areas where winter temperatures drop below 6 °C. In these areas they should be planted from late spring to midsummer (October to January) so that the plants are reasonably mature before the onset of winter.
- In most parts of South Africa, a late summer planting is ideal, giving the plant the opportunity to mature to the flowering phase (September to December).
- Plants planted in late spring to midsummer will also begin to flower in September, but will be much taller than those planted in late summer, which will mean a shorter economic lifespan.

## *Preparing the planting positions*

- Because the young papaya plants are not in very large bags, a small hole made with a spade at each planting position is all that is needed.
- At each planting position remove one spadeful of soil which should leave a hole approximately 200 x 200 x 200 mm.
- Just before the plants are planted out the holes are filled with water to cool the soil and to promote good contact between the roots and the soil.



***Planting a papaya tree***

### *Planting*

- Make a slit in the plastic bag down one side to remove the bag and place the plant in the hole. Do not break up and loosen the roots because this will cause the plants to lodge later.
- If there is more than one plant in a bag do not separate them for the same reason.
- Rake in the soil from around the hole to cover the roots and growth medium, but be careful not to pile too much soil around the stem of the plant.
- A good guideline is that you should be able to see the growth medium that
- was in the bag. In other words the surface of the growth medium should be level with the soil surface.
- The young papaya trees should, as far as possible, be planted in an upright position.
- If not planted in this position, the tree will continue its slanting growth habit for the rest of its lifespan. The base of the stem of the adult tree will then lie on the ground and the upper two thirds of the stem will form a flattened C shape, with the growing tip pointing straight upwards.
- As the tree ages the increased weight will cause larger parts of the stem to lie on the ground, blocking movement in between rows (rows need to be clear to facilitate weed control and harvesting).

- A young plant lying on its side is also more susceptible to fungal diseases and sunburn.

### **Important!**

- ◆ ***Do not plant the papaya tree deeper than it was planted in the bag***
- ◆ ***Plant the tree upright***

### *How many plants per hole?*

This will depend on the type of papaya, e.g. dioecious (separate male and female trees), hermaphroditic (self-pollinating) or tissue-cultured plants.

- Dioecious plants: Because only the female trees will bear fruit, it is important to have the minimum number of male trees in a planting (1 male to every 25 females). For this reason 3 to 5 plants are usually grown in a single bag and treated as one plant when planting out. If there is one seedling only per bag, then three separate plants are planted in each hole, as close together as possible.
- Hermaphroditic plants: With hermaphroditic plants (cultivars such as Sunrise Solo and Tainung) each plant has the potential to bear fruit, therefore only one plant per hole needs to be planted.
- Tissue-culture plants: These plants are clones of a selected plant and are usually all female (if dioecious) or hermaphroditic. One plant per hole is generally planted. A few cloned males are usually placed strategically to ensure pollination.

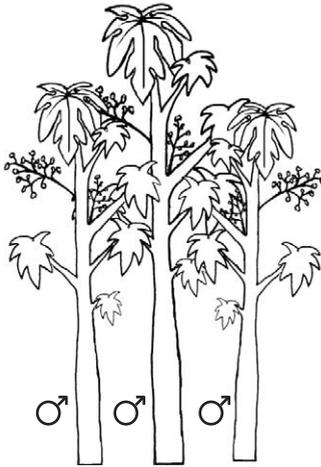
### *Post-planting care*

#### **FERTILISATION AND WATERING**

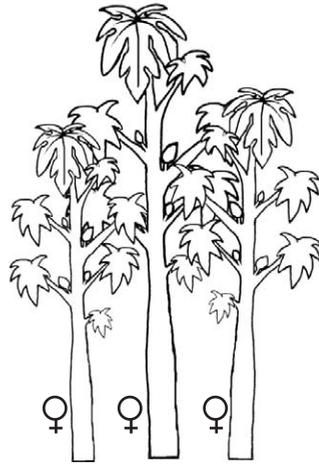
- Apply approximately 40 g LAN immediately after planting around the base of each plant. Frequent and thorough watering is necessary in the weeks following planting, especially during midsummer.
- Once established, papaya trees are reasonably hardy.
- Mulching is advisable but not always necessary.
- Where evaporation is excessive, mulching is recommended and any mulch may be used.

#### **THINNING**

Thinning can be done as soon as the sex of trees can be determined at about 6 to 9 months after planting.



*When there are only male trees at a planting position, select the earliest flowering male and cut down the others at soil level or slightly below*



*When there are only female trees at a planting position, select the earliest flowering female, and cut down the others in the same way*



*When there are both female and male trees at a planting position, the earliest flowering female is usually selected. If a male is needed at this position, then a male must be selected and the others cut down. Where hermaphroditic seedlings have been planted with more than one plant per planting position, the earliest flowering plant, and/or the plant that appears most true to type is/are selected*



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## SUCKERS

- All suckers on the stem below the fruit and between the fruit are removed because they could damage the maturing fruit.
- Suckers near the top of the tree are sometimes kept if the growing point of the tree dies.
- Generally suckers are not strongly attached to the main stem of the plant and can easily break off when allowed to bear fruit.

### *Economic lifespan*

Three years is usually the maximum lifespan of a planting. Generally, after the second harvesting season, the plants become too tall for easy harvesting. A papaya planting is usually replaced every 2 to 3 years.

## Irrigation

Although papayas are to some extent drought resistant, they will not achieve optimum growth or yield if they do not receive sufficient water (especially during the fruit development phase). Correct irrigation is therefore important.

### *Water requirements*

Timing and volume of irrigation vary according to weather conditions, soil type and time of year. It is therefore important to monitor soil moisture levels and schedule irrigation. General guidelines for the total water requirements (rainfall included) of papaya trees are given in the table.

#### **Water requirements of papaya trees**

<b>Time of year</b>	<b>Litres/tree/day</b>
Establishment	6–13
First autumn	6–13
First winter	4– 9
First spring	9–17
First summer	13–26
Second autumn	9–17
Second winter	6–13
Second spring	13–26
Second summer	17–34

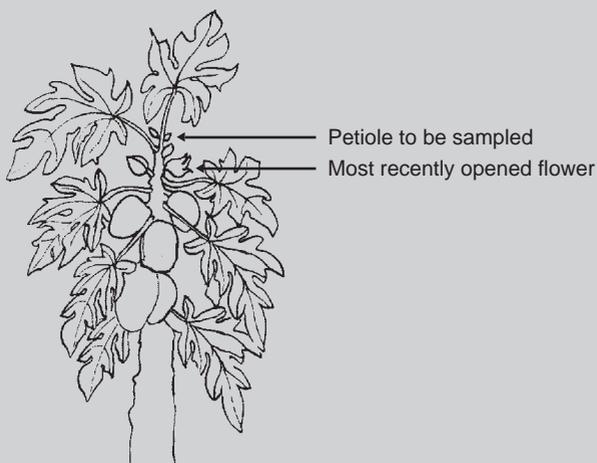
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## Fertilisation

- Fertilisation is an important aspect of papaya cultivation.
- The success of a fertilisation programme will depend on good leaf-sampling techniques, the correct utilisation of soil and foliar nutrients, and good fertilisation practices.
- Before establishing a papaya plantation, a representative soil sample must be taken.
- With a very acid soil (low pH) a sample should be taken at least 9 months prior to planting so that a lime application can be made in time, because it takes at least 6 months for the soil to stabilise.
- The soil analysis results will indicate the types and quantities of fertilisation needed before planting, e.g. lime, phosphate and potassium.
- A soil analysis after planting will indicate the availability of nutrients in the soil.
- A petiole sample provides information on the uptake of nutrients by the plant.
- The correct procedure for soil and leaf-petiole sampling is a prerequisite for accurate analytical results.

### *Petiole sampling*

- As a guideline a petiole sample should be representative of an area not larger than 3 ha. However, should soil variations be apparent in such a plantation, separate soil and leaf samples must be taken.
- The time of petiole sampling as well as the position is critical. Sample the petiole of the youngest fully-expanded mature leaf beneath the most recently opened flower during November. It is important to note that the sample does not include the leaf.
- Select approximately 10 to 20 healthy plants by walking diagonally through the plantation. The plants should be homogeneous in appearance and representative of the plantation. Selected plants should be marked so that samples can be taken from the same sites every year.
- Petiole samples should be collected in the morning after the dew has dried off. Samples should not be taken if plants are under stress as a result of drought, disease or high temperatures. After heavy rainfall, wait at least 2 weeks before taking samples.
- Place the petiole samples in a clean, perforated or open plastic bag. Dispatch to the analytical laboratory within 48 hours after sampling. Keep the samples cool (not frozen) after sampling and during transportation.



***Sampling position of the petiole of the youngest fully expanded mature leaf beneath the most recently opened flower***

### ***Soil sampling***

A soil analysis will only indicate the chemical composition of the soil. Physical problems, such as impermeable layers and soil compaction, can only be identified when test pits are made in the particular area.

If a soil tube or auger is not available a spade can be used, and two buckets, for the top and subsoil respectively.

Sampling depth:

Topsoil 0–300 mm

Subsoil 300–600 mm

### **NUMBER OF SAMPLES**

A sample consists of a combination of at least 10 subsamples. A composite sample should represent no more than 3 ha. Samples from different plantations or lands should not be combined.

### **DISTRIBUTION OF SAMPLING POINTS**

To obtain a proportionate distribution of samples, samples should be taken by walking diagonally from the corners through the orchard or land. In an established orchard, a topsoil and subsoil sample should be taken at the same plants selected

for leaf sampling. Take soil samples about 300 to 500 mm from plant stems within the fertilisation zone of the plant.

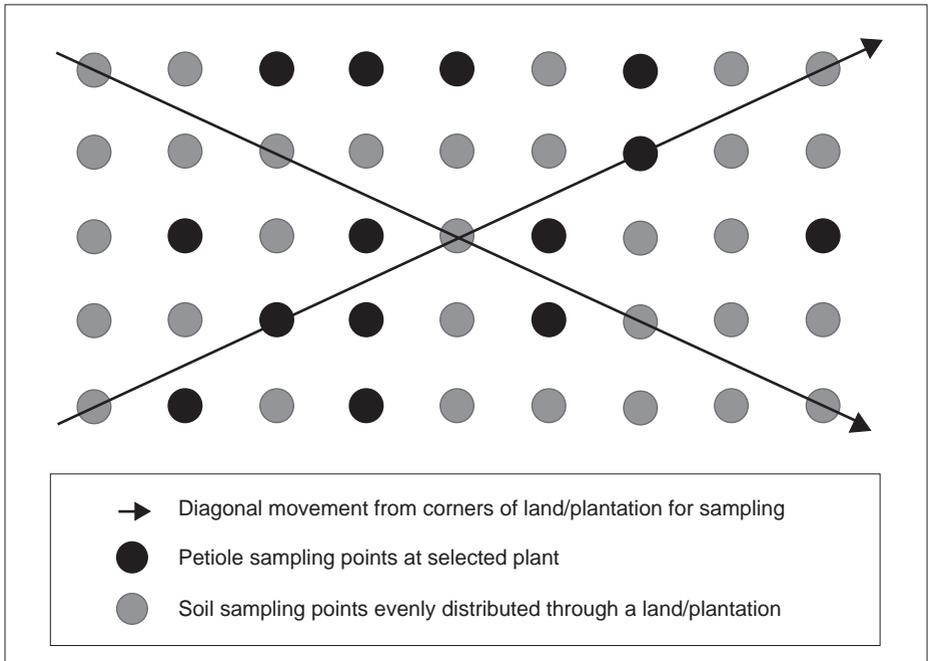
### METHOD OF SAMPLING

Before a soil sample is taken the soil surface must be cleared of debris, leaves and fertiliser. A soil sample must not be taken too soon after fertilising because this will contaminate the soil sample and lead to an incorrect analysis.

### PACKAGING OF SAMPLES

Subsamples from an orchard or land should be combined in the respective bucket (not fertiliser bags) and mixed thoroughly. A sample of about 2 kg is taken from the composite sample and dispatched in a clean, strong plastic bag.

Top and subsoil must be packed separately and the depth of sampling, the plantation or land must be indicated clearly. Information which must accompany the samples are the address and telephone number of the consignee, and it must be stated clearly whether recommendations are required. The same applies for soil sampling in established plantations.



### *Taking representative soil and leaf samples in a block*

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## *Nutrients*

### **LIME**

Lime, normally dolomitic lime, supplies the soil with the important nutrients, calcium and magnesium, and reduces soil acidity and potentially toxic elements such as aluminium as well as manganese. The quantity of lime required will depend on the pH, aluminium (extractable acidity) and the clay content of a soil. Because lime moves slowly in the soil, it must be broadcast and incorporated into the soil to a depth of at least 500 mm before planting. After planting annual maintenance lime applications of about 1 to 2 t/ha are necessary to avoid reacidification of the soil caused by acidifying fertilisers, rainfall and irrigation. Apply early in the season but not within 3 weeks of nitrogen applications.

### **PHOSPHORUS**

Phosphorus (P) is an important nutrient for papayas because moderate applications at the vegetative stage of the plant will encourage an active root system, stimulate vegetative growth and enhance flower initiation as well as fruit set. However, P fertilisation remains in the soil for a long time and because the P requirements of papaya plants are relatively small, growers must avoid overapplication of this element. Overapplication can induce an iron and a zinc deficiency and has negative consequences on yield and fruit quality. Because P fertiliser moves relatively slowly in the soil, a preplant phosphorus application is essential. A single superphosphate which also contains sulphur, is normally recommended as a broadcast application and incorporated into the soil about 1 to 3 months before planting. Other frequent sources of P, such as MAP (mono ammonium phosphate) and DAP (double ammonium phosphate) are recommended on alkaline soils (pH >7,5) where uptake of P can be a problem. An annual maintenance application of 450 g superphosphate during spring from the second year after planting is recommended. If, however, soil and petiole sampling indicate that these levels are high, P fertilisation should be reduced or stopped.

### **NITROGEN**

Nitrogen (N) is most important for increasing yields. However, overapplication will cause the plants to produce a large number of smaller sized fruit. Overapplication is also associated with soft fruit, which has serious implications in the shipment of papayas from the field to the packing plant and eventually to the market and the consumer.

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The most frequent source of nitrogen fertiliser is LAN (28 % N) (limestone ammonium nitrate), urea (46 % N) and ASN (27 % N) (ammonium sulphate nitrate). LAN is recommended in most cases, except on alkaline soils (pH >7–7,5) where ASN is more suitable. Urea is also used frequently and is suitable for soils that are not too acid or alkaline, or too sandy.

Once papaya plants are established and growing actively, apply 60 g LAN every 6 weeks during the first year. Thereafter apply 120 g LAN every 2 months during the active growing period (between about September and April). During cold winters, when root activity is inhibited, foliar application of urea at 5 g/l can also promote growth and fruit set.

### **ORGANIC FERTILISER**

- Organic fertiliser such as kraal manure improves the physical and biological properties of the soil.
- Farm manure should, however, be analysed before it is used on papaya because manure, such as poultry manure, has a high P 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 P uptake is very poor and the plants lack vigour.
- If well-decomposed kraal manure is available, a preplant application of about 5 to 10 t/ha can be incorporated into the soil.
- For mature plants kraal manure could be applied at 10 to 20 kg/tree as a supplement to inorganic fertiliser.
- Keep in mind that overapplication of manure/organic fertiliser can result in soft fruit, especially if applied during spring.
- Do not apply manure within 300 mm of the trunk.

### **FERTILISER MIXES**

Fertiliser mixes are described by their ratio of nitrogen:phosphorus:potassium (N:P:K), for example a 3:1:5 (30) mixture will contain 10 g N/100 g of fertiliser. No single mix can be recommended for papaya because the N:P:K ratios will depend on soil and petiole analyses. However, on a soil with a high P content a 1:0:1 (47) mix at 70 g/application/plant during the first year can be used if potassium is required.

### **POTASSIUM**

An adequate supply of potassium (K) is necessary for the development of roots, stem, leaves and fruit of papaya plants as well as for fruit quality and size. Excessive supply

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of potassium will reduce the uptake of calcium, magnesium and boron, which can have a negative effect on fruit quality.

Potassium is recommended as a preplant soil application if the K levels in the soil are low. As a guideline, maintenance K applications of 150 g potassium chloride (KCl) or 180 g potassium sulphate ( $K_2SO_4$ ) per tree per year during the first year and 200 g KCl or 240 g  $K_2SO_4$  during the second year are recommended. Apply about 40 % of the fertiliser during the vegetative phase and 60 % during the fruit growth and development phase. Two to 3 applications should be sufficient on most soils. Further adjustments must be made according to petiole K levels. On certain heavy soils where the Ca + Mg/K ratios are very high, higher K-fertiliser applications will be required to maintain optimum levels.

## MICRONUTRIENTS

Boron deficiencies occur frequently on soils in South Africa. Papaya plants with a boron deficiency have lumpy fruit, reduced fruit set and show poor growth. To prevent deficiency, boron fertilisation must be incorporated into the fertilisation programme from the onset. Apply 10 g borax or 5 g Solubor 1 month after planting, spread evenly over 1 m<sup>2</sup> at each planting site. Do not apply within 200 mm of plant stems. Excess boron is extremely toxic, especially on sandier soils. Should petiole boron levels show a boron deficiency, apply 2 or 3 foliar sprays of Solubor at a concentration of 100 g Solubor dissolved in 100 ℓ of water. Wet the spring-growth leaves to the point of runoff at 3 to 4 week intervals.

Even when boron petiole levels are within the norm an annual maintenance boron foliar spray is recommended during spring. If levels remain low, a soil application of 20 to 25 g borax/m<sup>2</sup> per site for a mature plant is recommended.

If a petiole analysis indicates a zinc deficiency, apply a foliar application of NZN (nitrozinc) at 150 ml/100 ℓ water or zinc oxide at 150 g/100 ℓ water on young leaf growth during spring. A soil application of zinc sulphate monohydrate at 3 g/m<sup>2</sup> spread evenly under the canopy and outside the dripline for a distance of 300 mm can be given if foliar sprays are not effective.

Manganese (Mn) and iron (Fe) deficiencies can occur on alkaline soils with a pH (H<sub>2</sub>O) above 7. If petiole levels indicate deficiencies of these nutrients, apply a foliar spray of manganese sulphate at 200 g/100 ℓ water during spring.

Iron deficiencies can be rectified by applying iron chelate (Libfer SP) according to the manufacturer's recommendations.

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## Orchard floor management

Weeds have much the same requirements for growth as crop plants and compete with crop plants for soil moisture, soil nutrients, light and carbon dioxide. Soil temperature can also be affected. The lateral water distribution from micro-irrigation systems is often obstructed, resulting in ineffective irrigation.

### *Chemical weed control*

When using chemicals, the producer should have a sound knowledge of weeds, the advantages and disadvantages of the different chemicals and of the correct application method.

Herbicides that are applied after the plants have emerged, can reach them through contact with the leaves (contact or scorch chemicals), or they can be taken up and spread throughout the plant by means of translocation (systemic chemicals). Herbicide can also be applied to the soil (pre-emergence or residual chemicals) where it inhibits germination of seed, or it can be taken up through the weed roots and be spread by translocation (systemic).

### *Mechanical weed control*

Weeds under the trees can be controlled mechanically by hand hoeing. Disadvantages of these practices include damage to tree stems, shallow roots and to irrigation equipment and it is normally labour intensive.

In the case of a tramline planting (with a working row area which allows tractor movement), mechanical mowing by means of a rotary cutter (slasher driven by a tractor) can be used. Mechanical hoeing with a disk plough is not recommended because of damage to the soil structure and tree roots. Implement traffic near the drip area must be avoided because most feeder roots occur in the top 400 mm of the soil. Traffic near this area causes soil compaction.

### *Mulches*

Various organic as well as inorganic mulches can be used in tree orchards. Organic mulches include straw, sawdust, woodchips and groundnut shells. Some of the advantages of mulching are that weed growth is suppressed, soil moisture conserved, soil temperature stabilised and the soil structure is improved. The result is usually better root development (especially near the surface), enhanced vegetative growth and increased yields.

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## *Orchard sanitation*

- The implementation of a thorough orchard sanitation programme can limit the incidence of leaf and fruit diseases. Old and dead leaves must be removed from the plants, without damaging the fruit. Leaves and spoilt fruit must be removed from the orchard and be destroyed elsewhere.
- Malformed and small unmarketable fruit, as well as secondary and tertiary small fruit on flower bunches where there is an inclination to displace each other, must carefully be removed at an early stage.

## **Diseases**

### *Damping off of seedlings*

Damping off can occur at the pre-emergence stage, in which case seedlings do not emerge, or post-emergence where seedlings will fall over and die from a constriction on the stem (often brown) at soil level. The disease is caused by a complex of fungi, among them *Pythium*, *Phytophthora*, *Alternaria*, *Rhizoctonia* and *Fusarium*.

Factors which favour damping off are excessive water or fertiliser, heavy soils, overcrowded seedbeds, in fact anything which contributes to wet, high-humidity conditions and lush, soft plants. Cleanliness concerning the nursery and the water-source is of prime importance. Registered chemicals can be used for seed treatment and these and other chemicals can be used as drench treatments or mixed with the growth medium.

### *Powdery mildew*

Powdery mildews are responsible for a considerable degree of defoliation, leaf distortion and fruit scarring. The mildews are particularly severe during the dry winter months and early spring in South Africa.

Disease development can be limited by direct contact with water, e.g. rain. Most of the powdery mildew species are not active during the summer months when temperatures are too high for the fungi.

### *Black spot*

Black spot causes a reduction in plant vigour, resulting in lower yields of small, poor-quality fruit.

The first symptoms appear on the lower side of older leaves as small round water-soaked lesions. The lesions increase in size to 4 to 5 mm in diameter and develop a black velvety appearance. Chlorotic lesions appear on the upper side of the leaf.

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On fruit, the first sign of the disease is the appearance of small water-soaked lesions, approximately 1 mm in diameter on the exposed side of the fruit and these follow the same progression as on leaves.

### *Root rot*

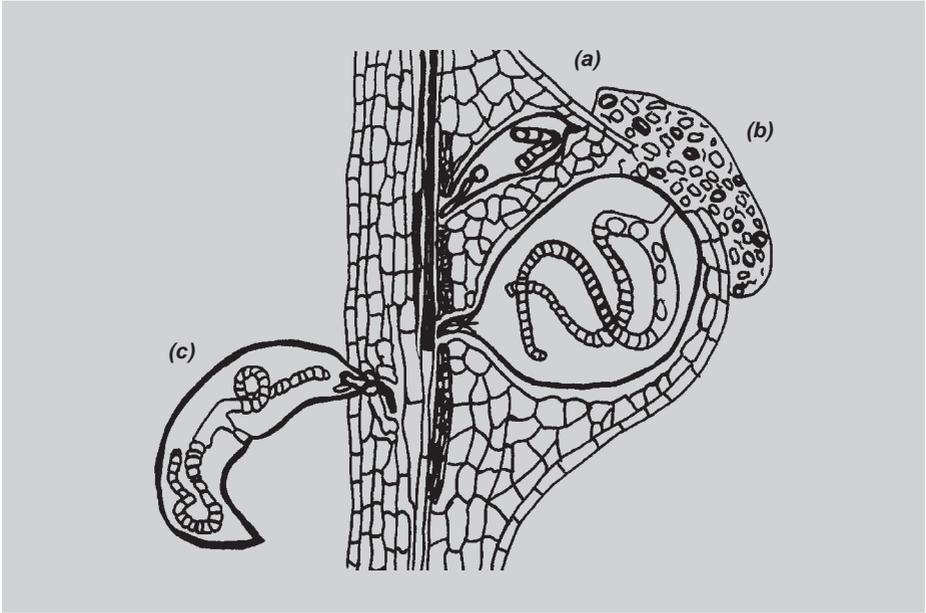
This disease is caused by soil-borne fungi of the *Phytophthora* and/or *Pythium* groups. Infection first occurs on the roots or stem base. The above-ground symptoms can easily be recognised: the older leaves first wilt, droop and then die. This process proceeds progressively up the stem until only a few leaves remain at the top of the tree, or the tree dies. A soft, rotted cavity is often found at the base of the stem. Affected plants are easily blown or pushed over.

### *Virus diseases*

- Cucumber mosaic virus is occasionally found. Leaves have a mosaic of paler and darker green areas and can be distorted. Most suspect cases presented for diagnostic purposes have proved to be powdery mildew (see above).
- Presumed tomato spotted wilt virus causes small green circles on the yellow surface of ripening fruit. It is seen frequently, but appears to have little effect on yield and quality.
- Viruses can be transferred mechanically as well as by seed and insect vectors such as aphids. Nothing can be done once a plant is infected. Prevention is therefore the only cure. Infected plants should be destroyed because they act as sources of infection to other plants.

### *Control measures for papaya diseases*

- **Powdery mildew** on papayas can be controlled by a wettable sulphur which is the only registered product for this purpose. The recommended dose is 300 g/100 ℓ water. Apply when first symptoms are noticed and repeat at two-week intervals.
- **Black spot** can be controlled by the registered product containing mancozeb at 200 g/100 ℓ water, applied from flowering at 28 day intervals. If the disease becomes more severe the intervals can be shortened to 14 days.
- No chemical is registered for the control of **root rot** on papaya. It can be prevented by good soil drainage and by avoiding mechanical damage to the roots or stem base.



**Line drawing depicting the relative feeding positions of reniform nematode (a) and rootknot nematode adult (b) and juvenile (c) in root tissue**

## Pests

### *Nematodes*

In South Africa the main economic damage is caused by species belonging to 2 genera, namely *Meloidogyne* (rootknot nematodes) and *Rotylenchulus* (reniform nematode). Both groups contain exclusively endoparasitic species which penetrate roots completely to feed on cortical or stelar root tissue after causing extensive cellular changes.

The more important rootknot nematode species occurring in papayas are *M. javanica* and *M. incognita*. Both these species are widespread in the subtropical regions of South Africa and occur on many alternate hosts, e.g. banana, ginger, litchi, tobacco, vegetables and various broad-leaf weed species.

Symptoms of rootknot nematode damage to papaya roots are very conspicuous as a result of the often massive galls of 25 mm in diameter that are formed. Other symptoms of rootknot nematode infestations are sparse foliage and small leaves exposing fruit to sunburn damage. The risk of root rot and toppling of plants is also aggravated in the presence of the rootknot nematode.

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## CONTROL

- Effective control of nematode infestations in the nursery and clean propagation material are very important factors.
- Planting bags should be free of nematodes.
- If soil or sand is added to the growth medium, the medium should be sterilised with methyl bromide or steam. Composted bark and peatmoss are usually free of pathogenic nematodes.

## Harvesting

All the major cultivars produced for fresh fruit are suitable for the local market. These include cultivars such as Hortus Gold types, Sunrise Solo, AF-1 and the Tainung types.

At this stage it is suggested that only the Sunrise Solo cultivar be exported. This pertains to exports by both sea and air.

### *When to harvest*

The fruit should be harvested at the 'yellow break' stage. That is, the first streak of yellow should have appeared. This is a good indication that the fruit is physiologically mature and will ripen. Although a degree of variation may be tolerated as to the above with regard to locally-marketed fruit, especially if the fruit is ripened before packing, export fruit should be sorted strictly to conform to a narrow range of external colouration.

### *Harvesting procedure*

Papayas must be handled with great care to prevent cuts and bruises. In the peak season the fruit should be harvested about 3 times a week. During the rest of the season the physiologically mature fruit should be identified through regular scouting.

The fruit should be harvested with a 20 mm portion of stem attached and must be packed carefully in a single layer in a lugbox with the stem-end resting on the bottom. The bottom of the lugbox should be covered with paper wool or other noncontaminant material which will absorb latex. Latex should therefore be allowed to drain from the stem-end onto the paper wool where it will be absorbed. Care should be taken not to have any latex dripping onto the fruit during harvesting. The paper lining should be removed on a daily basis and replaced with clean lining. A soft synthetic lining may also be used on the sides of the lugboxes to prevent the grid from damaging the fruit. Bulk bins should only be used if the outward

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appearance of the fruit is less important, e.g. minimal processing. Even in the latter case care should be taken to prevent deep bruising.

Harvesters must take care not to cut into the fruit being harvested or adjacent fruit. The effect of handling the fruit, especially dropping and catching, in the case of tall plants should also be monitored closely.

When transporting the lugboxes to the packing shed, the papayas must not be subjected to excessive bumping. It is recommended that a vehicle with appropriate suspension be used for this purpose.

### *Packing*

Upon arrival at the packing shed the stem should be cut to a length of approximately 5 mm and the fruit washed in a disinfectant solution. The latter may consist of a 0,5 % solution of a household hypochlorite preparation in water (e.g. 500 ml of this preparation in 100 l of water).

Packaging requirements vary according to the requirements of the client and the intended market:

- Farmers supplying department stores prepack their fruit in punnets which are marked attractively and packed in lugboxes provided by the client.
- Fruit destined for municipal markets is packed in fresh fruit boxes. Individual fruit should be wrapped in a sheet of polystyrene wrapping or netting.
- In the case of export fruit, the boxes will have to be sturdy to last for the journey. The boxes should therefore be made from good-quality cardboard and end pieces should be inserted.

### **Marketing**

Grow what you can sell. Selling the fruit profitably needs special considerations. A marketing plan is therefore essential. The type of market will dictate the cultivars.

The possible markets for papaya fruit are:

- The national markets
- Chain stores
- Export
- Greengrocers
- Roadstalls

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- The bakkie market
  - Processing:
    - Fresh fruit salad
    - Juice
    - Drying, conventional and agar-impregnated cube.

It is advisable to focus on a particular market and make the most of it. This is true, particularly for the new grower. All markets, however, demand **quality** and **consistency**.

### *National markets*

- The national markets are probably the biggest single outlet and because these markets are operated by professional marketers it is relatively easy for newcomers to enter the market.
- The most important considerations are the choice of the particular market(s) and agent(s).
- It is important to establish good relations with the marketing agent because he is in a position to advise his clients regarding prices and requirements of the market.

### *Chainstores*

- Most chainstores will only accept producers with the proven ability to supply the quantity and quality required by the store.
- Rigid standards will apply regarding cultivar, ripeness, packaging, blemishes and other quality characteristics. In some cases, for instance organically grown produce, pre and post-harvested practices will also be prescribed.
- The new papaya grower is advised to utilise other markets and establish himself as a grower before seeking entrance to this market directly. It is possible to enter the market indirectly through packers who will give advice regarding cultivars and cultural practices. The packers pack and sell the fruit to the chainstores on behalf of their clients.

### *Greengrocers*

Smaller growers are able to produce high-quality fruit and can supply directly to greengrocers on a regular basis.

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## *Roadstalls*

Essentially the same requirements as for supplying greengrocers, but more attention should be given to an eye-catching display. Usually consumers in this market prefer bigger fruit.

## *Bakkie market*

This market is of very little importance in the papaya industry. Papayas are not regarded as an essential food item and the fruit cannot withstand the rough handling of produce in this market.

## *Processing*

Processing is expensive and usually requires more than one middleman, the factory and often a wholesaler. This will almost invariably mean a low price to the producer.



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