Cultivating subtropical crops

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Foreword

PRESENTLY there is ample opportunity and good reason for emerging farmers in the warmer subtropical regions of South Africa, to become involved in fruit and nut production. Once established, the benefit of these high-value crops can be derived over many years, while intercropping with grain and vegetable cash crops can easily be practised.

The condensed information contained in this booklet could be very useful to small-scale farmers to improve their knowledge of cultivation practices, expand their income and in generating opportunities while also supporting agribusiness development in the country.

These crops are rich in proteins, carbohydrates, vitamins, minerals and beneficial oils which supply a considerable percentage of the daily nutrient requirements, and make an important contribution to a balanced diet. We sincerely hope that this production manual will be of great benefit to farmers and will furthermore motivate many others to also become involved in subtropical fruit and nut production.

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Avocados

Avocados are rich in protein, carbohydrates, vitamins and minerals while the oil content consists of polyunsaturated fatty acids. One half of a Fuerte fruit supplies a considerable percentage of the daily nutrient requirements and makes an important contribution to a balanced diet.

Buyer's guide

The quality of the trees grown in the nursery determines the success of an enterprise. Trees that received poor or incorrect treatment in the nursery will lag behind in the orchard, no matter how carefully the buyer tends them, and may die easily.

Container and root development

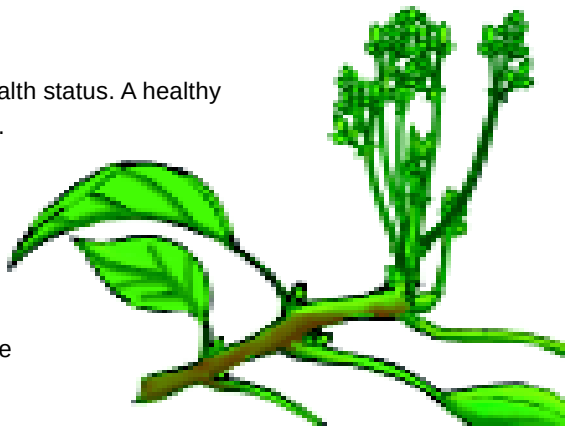
- The size of the containers in which the plants are grown, is important.
- The smaller the containers, the greater care will be needed after planting out the trees in the field to ensure their survival.
- The larger the container, the better the root system will have developed and the greater the chances of successful establishment.

Growth medium

- A clay soil mix tends to clog the drainage holes in plastic containers.
- Lighter soil mixes improve drainage and stimulate the development of the root system.
- Where mixes are too light, the soil is washed out easily through the drainage holes, resulting in exposure of the roots.

Foliage

- The foliage of a tree indicates its health status. A healthy tree has a glossy, dark-green colour.
- Deformed or discoloured leaves are an indication that the tree has not developed normally during the nursery period. It may also be a sign of disease.
- The leaves must be inspected for the presence of insect pests and any deficiency symptoms.



Graft union

- Any graft union that exhibits excessive thickening at the union, or large differences between rootstock and scion thickness, indicates incompatibility, a poor rootstock or a diseased scion.
- A first-grade tree should exhibit a smooth union, with few or no irregularities on the stem, either above or below the graft union.

Climatic requirements

The 3 best-known avocado races each has specific climatic requirements as a result of adapting to their original environment.

West Indian cultivars originated in the humid, tropical lowlands of Central America and are best adapted to continuous hot, humid conditions with a high summer rainfall. Like all avocado cultivars they are, however, extremely sensitive to drought and do not tolerate frost well (minimum temperature of 1,5 °C). The optimum temperature for growth is 25 to 28 °C. The humidity should preferably be above 60 %.

The ***Mexican races*** originated in the cool, subtropical highland forests of Mexico and mature trees can withstand temperatures of –4 to –5 °C. They should not be planted in areas prone to frost in August and September, because flowers are damaged easily by frost. A humidity range of 45 to 60 % should suffice. The optimum temperature for growth is 20 to 24 °C.

Guatemalan cultivars originated from the tropical highlands of Guatemala and require a cool, tropical climate without any extremes of temperature or humidity. The trees can withstand light frost, down to –2 °C, but the flowers are very sensitive to frost. High temperatures of about 38 °C, especially if combined with low humidity, could cause flower and fruit drop. A humidity level of 65 % or higher is required.

- The Fuerte cultivar, which is the most popularly grown cultivar in South Africa, is probably a natural ***hybrid*** between the Mexican and Guatemalan races and has a wider climatic tolerance (especially to cold) than the pure Guatemalan types.
- The minimum survival temperature is about –4 °C, but no frost is tolerated during flowering.
- The optimum growth temperature is 20 to 24 °C, and high temperatures, especially during flowering, are not tolerated well.
- It is more sensitive than others to unfavourable weather conditions during flowering. Hot, dry conditions could result in low yields because of fruit and flower drop.

Temperature

- Cool subtropical conditions with a mean daily temperature of 20 to 24 °C.
- Light frost can be tolerated, except during flowering and fruit set (August and September).
- For Fuerte, the daily mean temperature during flowering should preferably be above 18,5 °C, but definitely above 13 °C.

Humidity

- A high humidity is desirable, because it decreases stress conditions (particularly high temperature), that play an important role during flowering and fruit set.
- The mist-belt areas of South Africa are especially suitable in this regard. The humidity should exceed 50 % at 14:00.

Rainfall

All avocado cultivars grown commercially in South Africa are sensitive to water stress. An annual rainfall exceeding 1 000 mm is desirable, and it should be well distributed, with the only dry period in June and July. However, most of the suitable areas in South Africa experience a dry period during flowering, necessitating supplementary irrigation.

Wind

Avocados tend to have brittle branches that are damaged easily by wind. The majority of blemishes causing a downgrading of fruit most probably also result from wind damage.

From a climatological point of view, the best areas for commercial avocado production are therefore the cool, subtropical parts of Mpumalanga and the Limpopo Province as well as KwaZulu-Natal where the rainfall is fairly high and mist occurs frequently.

Soil requirements

A healthy avocado tree has a root system that can penetrate the soil to a depth of 1 m. Root rot *(Phytophthora cinnamomi)* can develop fairly quickly in poorly-drained soils. It is therefore essential to determine in advance the suitability of the soil for avocado production.

Methods of soil examination

Soil can only be examined by digging profile holes at least 1,5 m deep in areas where there are different soil characteristics. Even if the soil on the surface appears to be fairly homogeneous, it is still advisable to dig at least one profile hole per hectare.

In hilly areas holes must be dug in different positions along the slope to get an indication of the drainage properties of the area. For example, it may be necessary to dig drainage furrows in the lower-lying areas to prevent water from accumulating above the restricting layers.

Aspects of concern when digging a profile hole are colour, texture, structure, patches, concretions and stones, as well as soil depth.

Colour

- Only reddish-brown, red and dark-brown soils, particularly in the subsoil, are suitable.
- Temporary to permanent waterlogged conditions with concomitant root rot usually occur in yellow, grey, light-brown and white soils.
- Very dark and black soils usually have either a high clay content that could lead to poor root development, or a large percentage of organic matter that could result in excessively acid conditions and aluminium toxicity.

Texture

Avocados do best in soils with a clay content of between 20 and 40 %. If the clay content is below 20 %, the soil has a limited water-retention capacity and unless optimum irrigation is applied, the trees will sometimes suffer temporarily from drought.

A too high clay percentage makes irrigation difficult because overirrigation and high rainfall lead to oversaturation of the soil. This means that water drains away relatively slowly, which promotes root rot.

Structure

In soils with a moderate to strongly developed block structure, such as soils that can be broken into hard clods when dry, root development will be restricted. Ideal avocado soils display only small, fine cracks when a dry profile wall is examined.

Patches

If a light-coloured layer with many patches occurs within 1,8 m below the soil surface, root problems can be expected, especially with irrigation. Such a soil can be regarded as a moderate to high-risk avocado soil.

Concretions and stones

The same requirements concerning depth apply to black concretions (iron and manganese) in light-coloured soil. If concretions and stones occur as a type of gravel and form more than 30 % of the volume of a soil layer, the water-retention ability of that layer will be adversely affected, and irrigation practices will have to be adjusted accordingly.

Chemical soil properties

- Information on aspects such as pH (water), exchangeable quantities of sodium (Na) and the quantity of free lime present are obtained from chemical analyses of sampled soil from profile holes.
- The pH value (in water) of avocado soils should be between 5,0 and 7,0. Only at great cost and over a long period will it be possible to change pH values below 3,5 to make the soils suitable for avocado production.

Cultivars

Avocado growers should produce high yields of good-quality fruit, acceptable to the consumer. There is, however, no single cultivar that can fulfil all the requirements of the grower, the packer, the retailer and the consumer at the same time.

Fuerte

Good production potential

Flowering and harvesting months		
	Warm regions	**Cool regions**
Flowering:	June–September	July–October
Harvesting:	March–August	May–November

Tree characteristics

Tree growth habit: large and spreading

Hardiness: tolerates temperatures as low as –4 °C

General

Limitations: alternate bearing, sensitive to microclimate for fruit set

Comments: fruit set increased by a pollinator

Post-harvest storage: susceptible to physiological disorders during storage

Hass

Good production potential in cool areas. Fruit is smaller in warm areas

Flowering and harvesting months

	Warm regions	Cool regions
Flowering:	July–September	August–October
Harvesting:	June–October	August–December

Tree characteristics

Tree growth habit: fairly upright, slow grower
Hardiness: tolerates temperatures as low as –2 °C

General

Limitations: fruit becomes too small with age and in warm regions
Comments: susceptible to environmental factors
Post-harvest storage: good

Pinkerton

Consistent heavy bearer

Flowering and harvesting months

	Warm regions	Cool regions
Flowering:	September–October	
Harvesting:	June	July

Tree characteristics

Tree growth habit: moderately spreading
Hardiness: tolerates temperatures as low as –1 to –2 °C

General

Limitations: flowering and fruit set over extended period
Comments: fruit may develop internal disorders if picked when overmature
Post-harvest storage: pick at optimum maturity stage to avoid post-harvest problems

Ryan

Good production potential; bears heavily and fairly consistently

Flowering and harvesting months

	Warm regions	Cool regions
Harvesting:	September–December	November–February

Tree characteristics

Tree growth habit: fairly upright, medium grower
Hardiness: frost tolerant

General

Limitations: poor quality, fruit sometimes does not become soft
Comments: suitable for planting in drier inland areas
Post-harvest storage: average

Soil preparation

It is important to examine the soil for suitability regarding depth, drainage and compacted layers (see Methods of soil examination).

A representative sample of the proposed orchard must be taken for soil analysis. It is desirable to take the soil sample at least 9 months, but preferably 12 to 24 months prior to planting. This gives the farmer enough time to prepare the soil thoroughly, particularly if large quantities of lime are required.

Soil sampling

It is important that a sample represents a soil of homogeneous characteristics, i.e. where no visible differences in the soil occur. If there are differences regarding colour and texture in such a land, the land must be subdivided accordingly and separate samples taken of the different parts.

A soil auger or spade can be used for taking samples.

Depth of sampling

This should be from 0 to 0,3 m for topsoil and 0,3 to 0,5 m for the subsoil sample.

Number of samples

A sample must be made up of at least 10 subsamples (preferably more). The area represented by the complete sample should not exceed 3 ha.

Mixing and packaging

- The subsamples from a particular land must be pooled in a clean container (not a fertiliser bag) and mixed thoroughly.
- A 2-kg sample is taken from this, placed in a clean plastic bag or other suitable container and submitted for analysis.
- Every sample must be marked clearly. The name of the sender, number of the land and depth at which the sample was taken, must appear on the label.
- Attach the label to the outside of the container.

The analysis results will supply valuable information regarding fertilisers to be applied before planting. If required, lime or phosphate should be thoroughly worked into the soil before planting.

Method of soil preparation

The soil must be loosened as deep as possible before planting. In this case it will not be necessary to make large planting holes.

- If the soil is very acid, heavy lime applications may be necessary. About two-thirds of the recommended agricultural lime must be distributed over the entire area 12 months before planting, mixed into the topsoil by disking and ploughed in as deep as possible.

- Calcium (lime) moves very slowly in the soil, and should therefore be worked into the future root zone of the trees.
- A cover crop can then be planted and ploughed in 6 months later to increase the organic-matter content of the soil.
- The remaining lime and all the required phosphate must be applied and lightly worked in simultaneously. The trees are planted 3 months later.
- If soil samples have not been taken early enough to proceed as described, two thirds of the lime must be mixed with the soil and ploughed in deeply. Phosphate and the rest of the lime should then be distributed and worked into the soil lightly. If large quantities of lime are required, this must be applied at least 3 months before planting (as described), thoroughly mixed with the soil and then worked in deeply.
- If the soil depth is inadequate but still acceptable, it is recommended to make ridges of approximately 0,5 m high and about 3 m wide. The trees are then planted on these ridges.
- It is important not to fertilise recently-planted trees too soon. The trees must first become well established and start to grow vigorously before any fertiliser is applied. In most cases it would be advisable to wait a year. These applications must be very light. The fertiliser must be applied evenly and should not come into contact with the stem of the tree. Immediate irrigation is required.

Layout of orchard

An avocado orchard should be profitable within 7 to 10 years.

There are 3 patterns according to which trees can be arranged in an orchard:

- Rectangular (which leads to hedge-type tree rows)
- Square (which leads to a change of direction when thinning diagonally)
- Diamond-shaped (which also results in a change of direction of tree rows with every thinning).

If trees are spaced in such a way that no thinning will be necessary during the lifespan of the orchard, only slightly more than 50 % of the land is utilised. Effective land use therefore, means that the trees are initially spaced close together, to be thinned systematically and selectively at a later stage.

There is, however, no proof that any specific layout is the best. The choice of planting distance and the pattern of planting depends on the following factors:

- Cultivar
- Location of orchard (e.g. north or east facing)
- Soil type and depth
- Expected short and long-term production
- Access for machinery, depending on orchard practices
- Thinning practices.

The final decision must be based on economic principles, because each of the aspects mentioned has an influence on the ultimate economic value of an orchard.

Planting distance and planting pattern

The choice of a planting pattern (rectangular pattern discussed here) depends on the management practices followed.

- Early yields are maximised by planting trees close together in the row.
- Hedge-type tree rows are more suitable for installing a permanent irrigation system.
- Where implements are constantly used in orchards, the hedge-type layout is more suitable because access to the orchard is possible for a longer period of time than it is in a square layout. Traffic is also always moving in the same direction in such an orchard—an important point in orchards planted on a slope.
- The hedge-type tree-row layout minimises the effects of the loss of branches and trees in a row.

Interrow spacing

Economic considerations and access for implements determine interrow spacing of trees. Final distances of less than 10 m will necessitate thinning before the orchard is 10 years old. High-density plantings can therefore be planted at less than half the “final” distance on the understanding that trees in the semipermanent rows are removed timeously.

Planting and early care

- Avocado trees bought from a nursery should already have been hardened off.
- Plant the trees as soon as possible; if kept too long they may become root-bound or suffer from nutrient deficiencies.
- Do not place the trees in the sun because the containers will become hot and the roots could be burnt even before planting.
- Support the young trees with sturdy props as soon as possible after planting. Make sure that the stems are whitewashed.
- Remove the nursery tags and surplus graft strips after planting to prevent girdling.

Planting hole

- If the soil has been well prepared, big planting holes are unnecessary.
- If it is not possible to prepare the soil properly, a planting hole of 1 x 1 x 1 m should be made.
- A well-prepared orchard does not require extra fertiliser in the holes. The addition of especially poultry manure could easily burn the roots.
- Plant the trees to the same depth that they were in the planting bag.
- The trees should preferably be planted in a slightly-raised position so that water cannot collect in the basin.

Irrigation

- Young trees must be irrigated to ensure a uniform stand.
- Overirrigation is just as harmful as too little water.
- Examine the soil moisture content of the subsoil regularly to prevent overirrigation.

- Avocados are sensitive to moisture stress. In the nursery the trees would have been accustomed to regular water applications and still have a limited root system as a result of the small bag. It is therefore essential that the water reaches the limited and shallow root system.
- A small basin around the tree will ensure that the roots get enough water.
- Apply frequent light irrigations: 50 ℓ/tree/week and 100 ℓ as soon as the subsoil starts drying out, and then resume watering at 50 ℓ/week/tree.

Shade

- Where hardening off has been inadequate (in the nursery) temporary shade should be provided.
- Remember to whitewash the stems.
- Erect a frame covered with grass or shadenetting over the trees to protect the leaves. Remove the frame as soon as the leaves penetrate the grass because then they have become hardened off and need no further protection.
- Structures erected to protect the trees against animals, also provide shade.

Protection against animals

- Trees are often damaged by wild animals at night. A screen that will keep the animals out can be made by covering poles with chicken wire and building a tent-like structure around the trees.
- Termite control will be necessary during droughts.

Cover crops

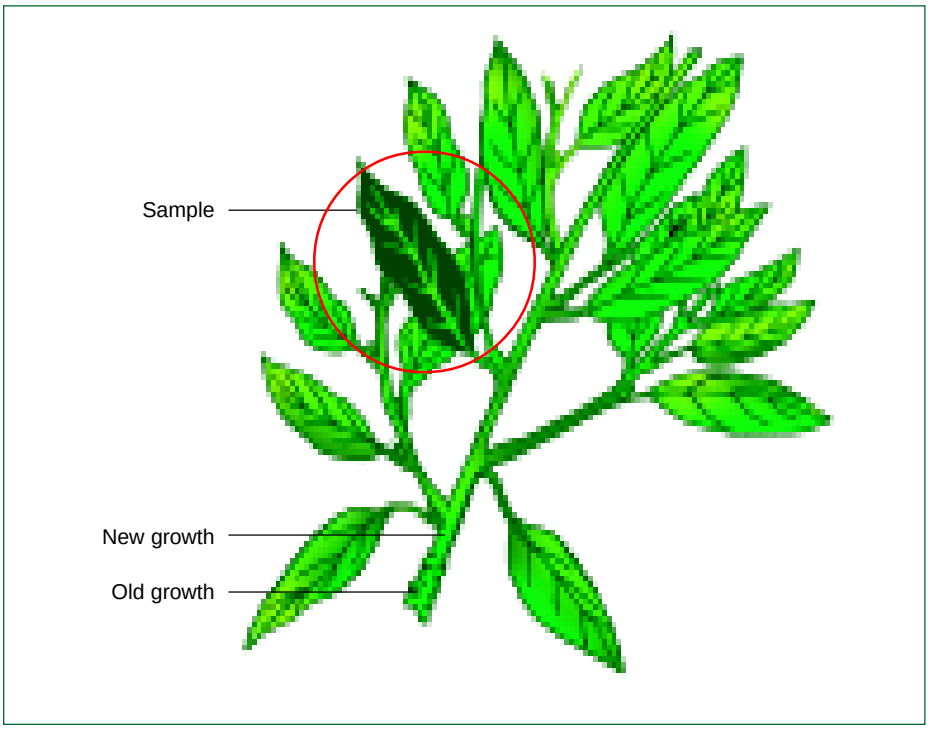
- During the early years of an orchard a cover crop will protect and maintain the soil until the trees start providing shade.
- A cover crop must not, however, compete with the trees and must be restricted to the strips between the tree rows.
- The drip area of the tree must be free of grass and other weeds and, if possible, this area should be covered with an organic mulch.
- Plastic covers are suitable for young trees, but irrigation management must then be very effective and accurate to prevent overirrigation.

Leaf analysis

Leaf analysis indicates the nutrient status of an orchard. The trees can be fertilised accordingly. Soil analysis, in addition to leaf analysis, increases the reliability of the recommendations made.

The following aspects of leaf sampling must be followed strictly:

- Samples of 6 to 8-month old avocado leaves must be taken during February to April. If they are not taken during this period, the fertilisation recommendations will not be reliable.
- The correct leaf must be sampled (see figure).



Sample the correct leaf

- When a leaf sample from a particular orchard is submitted for the first time, it must be accompanied by a soil sample. Thereafter, it would also be advisable to submit soil samples annually.
- When making fertilisation adjustments, the analysis results of both the soil and the leaf samples have to be considered.
- Only leaves from healthy trees must be sampled. They must not show any signs of sunburn, deficiencies, insect damage or disease.
- A leaf and soil sample must not represent an orchard of more than 3 ha. Should soil variations be apparent in such an orchard, separate leaf and soil samples must be taken.
- The sampling method is important:
  - Select approximately 20 healthy trees well distributed throughout the orchard, homogeneous in appearance and representative of the orchard.
  - Exceptionally good or poor trees must not be sampled.
  - The trees must be marked clearly, e.g. with paint, so that both the soil and leaf samples can be taken from the same marked trees every year.
- To obtain a meaningful fertilisation programme for a particular orchard, leaf samples must have been analysed for a period of at least 5 years.
- It is not always possible to rectify deficiencies, excesses, or imbalances within one season because it is a gradual process.

Fertilisation

- Do not fertilise young, transplanted avocado trees too soon, preferably only after one year. The trees must first become well established and grow vigorously.
- Never apply fertiliser against the stems of young trees. It must be spread evenly about 0,2 m from the stem to approximately 0,5 m outside the drip area of the tree.
- Each fertiliser application must be followed by a light, controlled irrigation.
- Fertilisers must not be worked into the soil.

Quantity of fertiliser per year per tree according to age (guidelines)

Age (years)	LAN (28 % N) (or equivalent) g	Superphosphate (11,3 % P) g	Potassium chloride (50 % K) g
1	150	200	150
2	300	400	300
3	450	600	450
4–5	600	900	600
6–7	800	1 200	800
8–9	1 000	1 500	1 000
10–12	1 200	1 800	1 200
Maximum	1 500	1 800	1 500

Time of application

Nitrogen and potassium

If fertiliser is applied in the first year, nitrogen (N) and potassium (K) must be divided into at least 4 applications and applied during the warm months. Thereafter the application times are as follows:

- N and K: 3 equal applications in July, December and April.
- P: December.

Zinc

Most soils are either naturally low in zinc or the zinc is not available. The following quantities should therefore be applied annually:

- Zinc oxide at 200 g/100 ℓ water, or
- NZN at 150 mℓ/100 ℓ water.

Boron

Many avocado orchards are also low in boron and the trees should be sprayed every year with 100 g borax or 75 g Solubor/100 ℓ water.

Irrigation

Avocado trees are very sensitive to waterlogged conditions as well as to drought stress.

The aim of irrigation is therefore to maintain the soil-moisture content between these two extremes, except in June and July when a drier period is required to stimulate flowering.

The purpose of avocado farming is to obtain optimum yield and reduced vegetative growth from an orchard.

- By applying half the calculated volume of water per tree after the moisture-stress period (June/July), new growth is retarded, competition with the young fruit is restricted and fewer fruit will abort.
- After fruit-set full irrigation is applied to encourage a flush for fruit growth.
- No fertiliser should be applied during flowering and early fruit-set, because it would also encourage vegetative growth, which competes with the young fruit for nutrients and water.

Irrigation systems

Light, frequent irrigations are necessary. A flood irrigation system is therefore not suitable. A sprinkler system, particulary dragline, is more suitable, especially if capital is limited. The best type for avocado orchards is undoubtedly one of the daily-flow types, preferably microjet irrigation.

Weed control

Weed control can be done by either mechanical or chemical methods.

Mechanical

There are 3 types of mechanical weed control:

Hand or mechanical slashing

Care should be taken when hand slashing is used not to cause injuries to the tree trunk. In time mechanical slashing will lead to compaction and ripping will have to be considered to promote root growth.

Disking

This method is not recommended as feeder roots are continually damaged and soil is compacted just below the depth of cultivation.

Ploughing and ripping

Both methods loosen the soil, especially heavy soils. These should, however, not be practised at intervals shorter than 2 years, because root growth will be arrested too often. Ploughing displaces the compacted layer to just below the depth of the plough while ripping can break up compacted layers if it is done when the soil is relatively hard and dry.

Chemical

Herbicides that control the entire weed spectrum in an orchard must be used. Therefore, the weed species and their relative abundance in the orchard should be determined before selecting a herbicide.

Cover crops and mulching

Cover crops are temporary crops, grown for the purpose of improving the soil, either as soil protection or to be disced in as green manure.

- The summer crop reduces soil temperature, thereby promoting avocado root growth. It also produces a mulch for winter and controls weeds.
- A cover crop prevents erosion and the loss of plant nutrients.
- A leguminous cover crop enhances the nitrogen content of the soil.
- Decayed cover crops increase the humus in the soil.
- The time of planting a cover crop depends on the needs of the tree and the supply of available moisture. In seasons where good rains are experienced, the cover crop should be planted early, but in periods of drought the trees will need all the available moisture in the soil, and planting should therefore be delayed.
- In young orchards it is possible to plough and prepare a seedbed between the tree rows, but as the trees grow older hand planting becomes the obvious method.

Kinds of cover crops

Cover crops can be divided into leguminous (nitrogen-fixing) and nonleguminous crops. Leguminous crops include various types of beans, while rye, oats, barley and buckwheat are examples of nonleguminous crops.

The following crops can be considered:

- Conditioning the soil before orchard establishment: velvet beans, soya-beans, sunnhemp, ration beans, lupins*, medics*, cowpeas.
- Planting after orchard establishment: velvet beans, soya-beans, ration beans, cowpeas, lupins*, medics, wheat, rye, barley, teff, vetches, desmodiums, groundnuts, buckwheat.

Pests

Avocado producers must be familiar with the insects that occur in orchards as pests. Most of these are controlled by natural enemies. The injudicious use of agrochemicals on avocado trees could, however, allow minor pests to develop into major economic risks.

Fruitflies

This pest has only recently gained economic importance in avocados. When the fruit is picked before it is ripe, the larvae never reach maturity. However, if the fruit remains on the tree for extended periods, as in the home garden, fruitflies may occasionally develop to maturity.

Female Natal fruitfly

Symptoms

- The Natal fruitfly attacks both young and older fruit.
- It lays its eggs just under the skin surface.
- When the fruit is about golfball size, a sting lesion appears as a slight puncture mark surrounded by white powdery exudate. As the fruit develops the lesion becomes dry and distinct star-shaped cracks in the skin surface occur.

* requiring winter irrigation

- When the surface layer of skin around the lesion are removed with a pocket knife, the underlying tissue will appear bruised and, on further dissection using a 10 x magnifying lens, longitudinal white eggs, about 0,5 to 1 mm in length, should be found clustered together.

Control

The few natural enemies of the fruitfly cannot control the problem effectively. There are 2 methods of control, namely:

- **Eradication of unwanted host plants**

  The Natal fruitfly also infests other host plants, such as bugweed or bugtree, bramble and wild-growing guavas which often constitute a significant proportion of the indigenous bush surrounding avocado orchards. These plants should be eradicated in an area of up to 200 m or more around the orchards. They should be cut down to 200 mm above the ground. A suitable herbicide should be applied as soon as the plants have regrown to about 0,5 m.

- **Baiting**

  Using poisoned bait to lure the flies should be considered if damage exceeds 5 %. The chemicals used in this process are, however, detrimental to the parasitoid-predator balance in the orchards.

Heart-shaped scale

- This insect grows to about 3 mm and has a reddish-brown colour. A white, woolly edge can be seen at the rear end of the adult female.
- The female lays cream-coloured eggs which are kept underneath the body in the white, woolly secretion. More than 200 eggs have been counted underneath one female at a single count.
- The young scales, known as crawlers, eventually become permanently fixed in one spot. In this way the new leaves become infested. There are 2 generations per year. The summer generation lasts 5 months and the winter generation 7 months. Crawlers are produced mainly during November and April.
- The scales occur on the back of avocado leaves where they suck the sap from the leaves.
- Fruit is never attacked, but the scales secrete considerable quantities of honeydew, landing on the leaves, branches and fruit on which sooty mould grows, causing a black discoloration of the plant and fruit and interfering with photosynthesis.
- Dust blown from dirt roads alongside avocado orchards settles on the trees, creating conditions that are unfavourable to the natural enemies of the scale. Therefore greater numbers of scales occur in such areas.
- The heaviest infestations occur on trees of the Hass cultivar.
- Wasps, ladybirds, larvae of a lacewing and a fly species (Cecidomyidae) play an important role in the biological control of this scale.
- As a result of the many natural enemies, chemical control is usually not necessary.

Diseases

Phytophthora *root rot*

Root rot, caused by *Phytophthora cinnamomi* occurs worldwide. Locally it is one of the most important avocado diseases and is found in all production areas, as well as home gardens. The severity of infection varies, but the potential loss is very big if no control measures are taken.

Symptoms

- When infected, the entire tree assumes a bare appearance.
- Leaves are smaller, paler in colour, turn yellow, wilt and then drop off.
- Tree growth is retarded and the fruit tends to remain small, showing symptoms of sunburn, as a result of a lack of foliar shading.
- Infected feeder roots turn black and become brittle as they die off.
- Where the disease is severe, virtually the entire feeder-root system may be destroyed and the tree dies as a result of water stress.

The pathogen

Dispersal of the pathogen requires free-moving water. It is therefore important to avoid planting avocados on soils that are prone to waterlogging. The fungus has a very wide host range, which includes papaya, granadilla, macadamia and various ornamental species. If possible, planting of avocados on lands previously used for alternate hosts should be avoided.

Control

- Avocados should not be established in areas where waterlogging is a problem.
- Planting material should be disease free.
- Irrigation should not leave water standing on the soil surface, particularly around the trunks. Sprinklers and microjets are therefore preferred to flood irrigation. Avoid over-irrigation.

Stem canker

This is another form of *Phytophthora* infection, but it may be caused by *P. citricola, P. cactorum* and *P. cinnamomi.*

Symptoms

- Discoloured bark, close to ground level. The brown discoloration extends into the wood.
- Infected trees normally pine away slowly, but may die off suddenly.

Control

- Do not cause injuries to the stems near ground level and avoid constant wetting of the stem.
- Where lesions occur, remove dead tissue and cover with a bituminous sealant.

Anthracnose

This is a pre as well as a post-harvest problem and can cause serious losses. It is present in most, if not all, production areas of the world.

Symptoms

- The most important symptom, economically, is fruit spotting.
- The lesions are brown in colour and may enlarge, coalesce and eventually cover large areas of the fruit surface. Such fruit often drops prematurely.
- The pulp beneath the lesions becomes soft and discoloured, rendering the fruit inedible.
- Where leaves are infected, a brown necrotic band spreads inwards from the margin, and in severe cases, it may spread through the petiole into the branch.
- Branches then show brown or purple lesions and may die off.
- Infected flowers turn red or brown and drop off later.

Control

A registered post-harvest dip is available specifically for anthracnose control. It should be applied in the packhouse. Control of *Cercospora* spot should also give good control of anthracnose.

Cercospora *spot*

This is a fruit-spotting disease, caused by the fungus *Pseudocercospora purpurea.*

Symptoms

- Brown fruit lesions, 3 to 5 mm^2 but irregular in shape, develop initially. The lesions dry out and crack, creating entry points for secondary pathogens.
- Individual spots are small (1 mm^2), brown and angular. They remain scattered or may coalesce.

Control

- Several chemicals are registered for use against this disease. These programmes will also help to control sooty mould.
- Always consult product labels before any chemicals are applied.

  Consult the latest issue of *A Guide for the Control of Plant Diseases* for information on chemical disease and pest control. It is obtainable from the Resource Centre, Directorate Agriculture Information Services, Private Bag X144, Pretoria 0001

Handling

Picking

- While the fruit is on the tree, it remains hard.
- It becomes soft and edible only after picking.
- A mature fruit ripens evenly. The edible part acquires a smooth, buttery texture and the peel shows no sign of shrivelling.
- Immature fruit, that is fruit picked too early, will not ripen properly and the skin will eventually become shrivelled.

Picking maturity

The maturity of the fruit is closely related to moisture content. The fruit is normally ready to be picked when it has a moisture content of about 80 % or less.

The following procedure may be applied to determine maturity:

- Pick a representative sample of fruit which has already attained the average mature size of the cultivar concerned.
- Store the fruit at room temperature until it ripens. An avocado is ripe when it yields slightly to light pressure applied on its entire surface.
- If these samples ripen within 8 to 10 days and do not shrivel, the fruit may be considered mature. Selective harvesting of similar fruit may then begin.
- If the fruit takes more than 10 to 12 days to ripen, the ripeness test may be repeated a week later.
- Experience is an important factor in determining the picking maturity. Not all the fruit on the tree will reach the same degree of maturity simultaneously.
- If there is any doubt, it is better to wait than to harvest prematurely.

Harvesting

Always handle fruit carefully during harvesting and packing because avocados are bruised and scratched easily.

Precautions

- Workers should wear cotton gloves when harvesting fruit, to ensure that their fingernails do not scratch the fruit.
- The fruit should be cut off and not pulled from the trees.
- A section of stalk, measuring 10 to 15 mm, may be left attached to the fruit.
- Healthy fruit should be carried in canvas picking bags. The bags must be clean inside. No more than 10 to 15 avocados should be carried in such a picking bag at one time.
- Fruit high in the tree may be reached by a tripod ladder, while even higher fruit may be harvested by means of a picking shoot. Use of suitable equipment will prevent unnecessary damage to the fruit, save labour, and will also be safer for workers.

Handling

- Fruit should be taken one by one from the picking bag, by hand, and placed in the trays.
- Take special care when transporting fruit to the packhouse.
- Trays containing fruit and awaiting transport should be kept in the shade under the trees. If there is not enough shade, the fruit should be covered with empty trays, placed upside down.
- Do not spread a tarpaulin over the trays, because it will hamper ventilation and cause the temperature underneath it to rise.
- Harvested fruit should be removed from the orchard as soon as possible.
- It is important to pack and dispatch the fruit to the market, or to place it in cold storage, on the day it is harvested.

Grading and packing

- It is important to take precautions against bruising.
- Persons handling the fruit must wear gloves.

- The tables on which the fruit is placed must be clean and smooth.
- Each fruit stem must be cut back with a sharp knife to a length of 6 to 12 mm.
- Grade fruit for export according to appearance. Fruit is suitable for export if it is virtually free of blemishes and has a regular shape. Fruit suitable for export is transferred to a different table.
- The fruit may now be treated with a suitable post-harvest fungicide and, after waxing, packed in a suitable box.

Cold storage

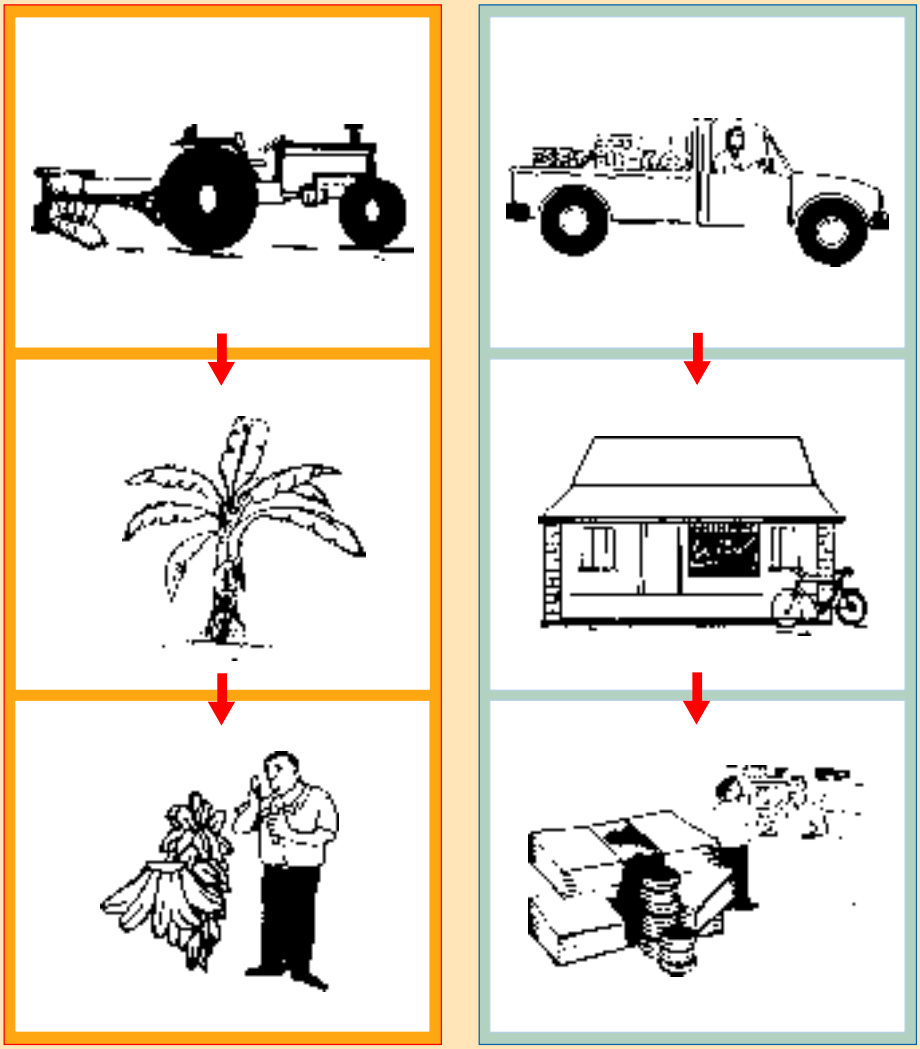
To delay ripening, fruit must be stored at a low temperature as soon as possible. The lower the temperature, the longer the fruit will take to ripen. However, storage temperatures that are too low will cause cold damage of fruit. A temperature of 5,5 °C is generally best. Early-maturing avocados may be kept at a slightly higher temperature while late-season fruit may be kept at a slightly lower temperature.

Bananas

Planning and production

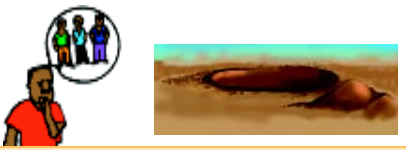
Plan your banana production well. Farming with bananas is farming for profit.

Farming = business



How do you plan?

Use a calendar or a year planner to organise your actions.

July	Do a soil analysis before planting—take soil samples to see if nematodes are present and which nutrients are lacking	 Soil analysis
September	Irrigate, plough and rip the field. Apply lime, potash and phosphate with ploughing	
November	Measure and start digging holes for planting	
December	Plant, fertilise, irrigate the plants and hoe the weeds	

What actions to plan

- Decide on a cultivar.
- Identify where your bananas can be marketed.
- Decide on size of land and spacing between plants.
- Obtain finance and buy inputs such as fertilisers and tissue culture plants.
- Buy land preparation equipment: tractors for ploughing, discing, etc.
- Plan labour.
- Buy and fetch planting material from a nursery.
- How to get rid of weeds.
- Maintain and upgrade irrigation equipment and plan irrigation scheduling.
- Desuckering of the banana plants and selection of ratoon suckers.
- Covering the bunches and propping the plants.
- Harvesting your bananas.
- How to utilise the income.

Preparing the land

Soil analysis for lime and phosphate is essential before planting.

- Add kraal manure or compost if available.
- Fertilise the soil using 4 bags of Supers fertiliser per hectare.
- Add 2 bags of lime if the pH is low on soil analysis.
- Plough.
- Rip the field after fertilising to loosen the soil deep.
- Spray herbicide or hoe if there are many weeds in the field.
- Measure the planting distance and dig holes for planting.

Planting

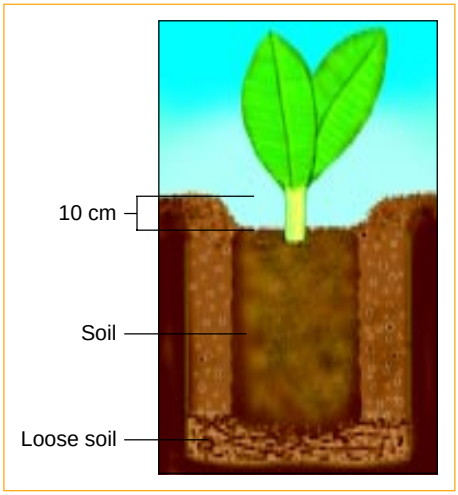
Bananas can be planted using 3 methods:

- Tissue culture plants
- Bits
- Suckers.

Planting method for tissue culture plants

Tissue culture plants are small plants which are grown from the tissue of the banana plant, in bags, and are ready for planting. For hygiene reasons, this is the preferred method for planting bananas.

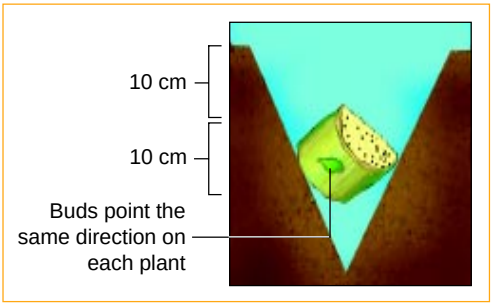
- Prepare for planting by digging holes. Add old kraal manure and put some loose soil back into the holes. Do not add more than 10 g of Supers into each planting hole.
- Remove the plastic bag before planting and place the plant in the hole. The soil in the bag must not break up.
- Fill the hole with soil round the plant and compact it.
- Check correct planting depth when planting.



Planting method for bits and suckers

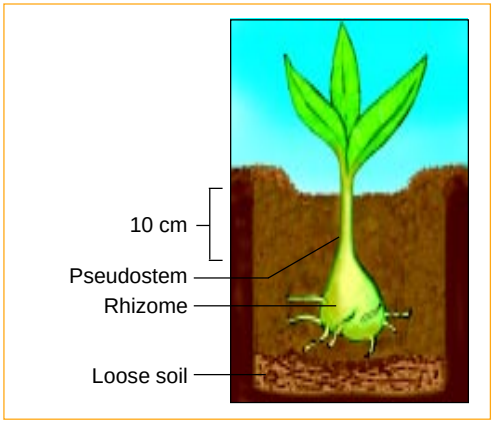
Bits are small portions of the banana plant cut from the rhizome (corm) of the plant and a bud is attached.

Suckers are shoots growing from the rhizome of banana plants and they grow into new plants.



Planting a bit

- When planting bits, the planting depth must be 10 cm and the bit also about 10 cm. Buds point the same direction on each plant.
- The planting method for suckers is the same as for planting tissue culture plants.



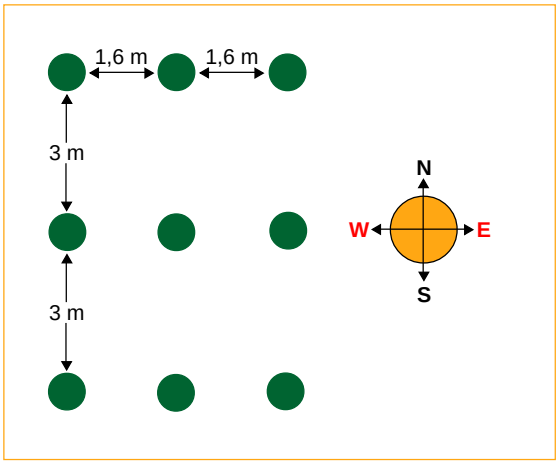
Planting a sucker

Spacing

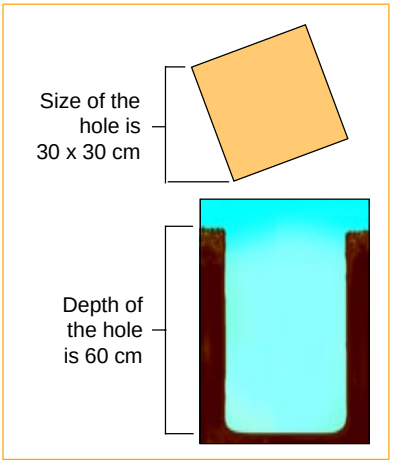
Space the rows 3 m apart and the plants 1,6 m in the row. The size of the hole must be 30 x 30 cm and the depth about 60 cm.

Dos and don'ts when planting

- Do not damage the plant or dislodge the soil when removing the bag—use a knife instead of a hoe.
- Do not plant too shallow or too deep and allow a space of 10 cm between the plant and the soill surface.
- Irrigate the banana plants after planting.



The direction of rows should be from west to east



The size of the hole

Fertilising

Make the soil fertile for the banana plants after planting by applying topdressing.

- **First topdressing**
  Apply first topdressing a month after planting (January).
  Use 2 bags of LAN fertiliser per hectare (50 g per plant).
- **Second topdressing**
  Apply second topdressing 3 months after planting (March).
  Use 2 bags of LAN fertiliser per hectare (50 g per plant) and 4 bags of KCl fertiliser per hectare (100 g per plant).

- **Third topdressing**

  Apply third topdressing 5 months after planting (May).
  Use 4 bags of KCl and 2 bags of LAN fertiliser per hectare.
- **Do not apply topdressing in June, July and in August.**
- **Nine months after planting**

  Topdress again 9 months after planting in September.

  Use 4 bags of KCl and 2 bags of LAN fertiliser per hectare.

- **Eleven months after planting**

  Topdress again 11 months after planting (November).

  Use 4 bags of KCl and 2 bags of LAN fertiliser per hectare.
- **Last topdressing**

  Apply the last topdressing in January .

  Use 4 bags of KCl and 2 bags of LAN fertiliser per hectare.

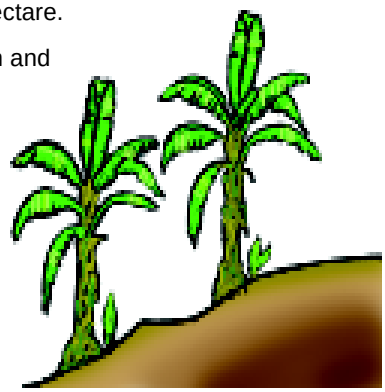
Make compost heaps from old vegetable leaves, chicken and kraal manure, which can supplement the fertiliser programme.

Desuckering

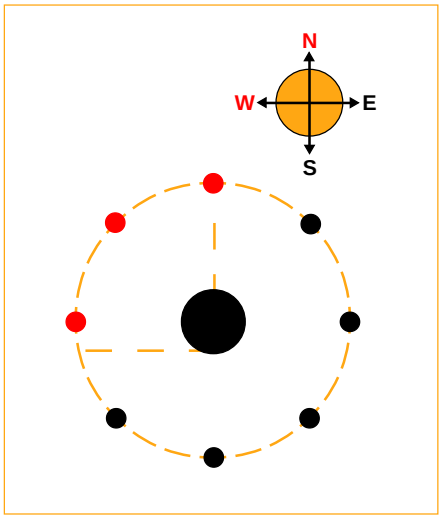
Desuckering means cutting off unwanted shoots from the stems of the mother banana plant.

- Use a knife to cut off the stems of the suckers which have grown to about 30 cm.
- When planting on a slope, always leave the suckers which are on the uphill side.
- Cut off all suckers which are on the north-western side of the banana plant. This is the side where the bunch hangs.
- After 5 months from planting, select only 1 vigorous sucker to carry the next bunch. Cut the remaining suckers.
- Continue removing unwanted suckers as they appear.
- Do not pour diesel over the stems of the suckers, water them instead.

NB: It is important to keep not more than 2 080 plants per hectare. Therefore, after harvesting only 1 sucker should be allowed to grow.



Leave suckers on the uphill side



Cut off all suckers which are on the north-western side of the banana plant

Irrigating

- Water the banana plants after planting.
- Irrigate newly-planted tissue culture banana plants every day for 2 weeks (15 minutes per irrigation) to protect leaves from heat stress.
- In the absence of rain, irrigation water should be applied on a “little and often” basis to banana plants.
- For heavy loamy soil apply 20 mm of water every 3 days in summer and every 8 days in winter. Find out the delivery rate of sprinkler nozzles.

Example:
Nozzle delivery = 3 mm per hour
For every irrigation, run the system for 20 hours divided by 3 hours
= 6 hours and 40 minutes ($^{20}/_{3}$ = 6 hours, 40 min)

- For light sandy soil apply 12 mm water every 2 days in summer and every 5 days in winter. Find out the delivery rate of sprinkler nozzles.

Example:
Nozzle delivery = 3 mm per hour
For every irrigation, run the system for 12 hours divided by 3 hours
= 4 hours ($^{12}/_{3}$ = 4 hours)

Bagging and removing leaves

- Cover the banana bunches with bags for protection against insects and wind. Remove lower hanging, yellow leaves from the plant.
- Covering the bananas will result in better quality bananas.
- Remove lower leaves from the banana plant as they get old because they can spread diseases and scratch the bunch.
- Use a knife to cut off old leaves from the banana plant—do not pull them.

- Old leaves can scratch and damage the fruit on the bunch. Cut off the old leaves and place them on the ground—they mulch the surface and increase nutrient content in the soil.
- Remember to give your banana plants support by propping the bunches with a rope and sticks.

Controlling weeds

Control weeds by using:

- chemical method
- hand method
- both methods.

Chemical sprays are used to kill the weeds—use only recommended chemicals and apply these strictly according to the instructions on the label.

Do not spray:

- too much
- the banana plants
- when it is windy.

When using chemical control, such as glyphosphate, protect all parts of the banana plant from spray drift.

Weeds are also killed by using a hoe or by hand, especially in the area near the plant to avoid chemical spray contact with the plants. Both methods can be used at the same time to kill weeds.

Pest and disease control

Control pests and diseases. Different pests and diseases require different treatments.

Thrips

Use chlorpyrifos pesticide once a month to kill thrips if they are present.

Nematodes

If they are present, kill them with Nemacur using 45 kg per hectare (20 g per plant).

Compost, kraal manure and chicken manure applied in ample quantities will also suppress nematodes. Tissue culture plants are free of nematodes.

Sigatoka

Spray with Dithane plus mineral oil.

Post-harvest decay

Dip the banana hands into Benlate solution (5 g Benlate per 10 ℓ water) to prevent post-harvest decay.

Harvesting

Harvest bananas when they are swollen and green but before they become ripe (plump and yellow).

Do not harvest

- too early (when the bananas are thin and dark green)
- too late (when they are thick and turning yellow).

Harvested too early ***Harvested at the right time*** ***Harvested too late***

Hang bunches in packhouse at a cool location

How to harvest

- Get at least 2 people to help you cut the banana pseudostem halfway across and halfway down.
- Let the plant fall down slowly and then remove the bunch from it by cutting the bunch stalk.
- Chop up the leaves and top part of the pseudostem and lay on the soil as a mulch.
- Carry the bunches to the trailer and put them next to each other (not on top of each other).

Dos and don'ts when harvesting

- Do not work alone, always work in pairs.
- Do not let the bunches fall to the ground.
- Do not pack the bunches on top of each other.
- Harvest early in the morning when the sun is not too hot.
- Do not leave cut bunches in the sun.
- Do not cut in the hot afternoon unless overcast.
- Build a packhouse in a cool location to hang bunches, remove hands, cut into clusters, pack into cartons and store (on southern side).

Marketing

Now your bananas are ready to be taken to different markets where they can be sold.

Selling bananas can generate income for a family

Local markets

You can sell your bananas on the streets or at a roadside stall.

Municipal markets

You can arrange with the nearest local market to sell your bananas.

Contracts

You can have contracts with supermarkets and chain stores which can buy and sell your bananas on a regular basis.

Home use

You can use some bananas for food security at home.

Citrus

The enjoyment from a home fruit garden depends largely on the condition and general appearance of the trees. Purchase young trees from a nursery that is registered with the South African Citrus Improvement Scheme. Trees should not be too old or too big, otherwise they are likely to be pot-bound.

Climatic requirements

- Citrus trees are subtropical in origin and cannot tolerate severe frosts. Citrus production in South Africa is therefore confined to areas with mild and almost frost-free winters where temperatures seldom (not more than once in several years) drop below –2 °C and almost never below –3 °C. The average minimum temperature for the coldest month should not be below 2 to 3 °C if no protection is provided.
- Moisture is also a limiting factor in citrus production. Because rainfall is often poorly distributed and in most cases deficient, it is necessary to supplement moisture by irrigation to ensure that moisture stress does not suppress growth and production.

Temperature prior to flowering

- Citrus (except lemons) require shorter days and cooler temperatures in winter for a normal production rhythm.
- Flowering should occur almost exclusively in spring, and these spring flowers should produce a large fruit crop 7 to 12 months later, depending on the cultivar. In more tropical areas the flowering pattern is much less clearly defined and main-season crops tend to be considerably smaller.
- In South Africa the winters are generally cold enough for good in-season crops (especially Valencias and grapefruit) to set.
- Navel trees, however, tend to set smaller crops in the warmer parts of the local citrus areas. The coldest month in most of the better navel areas tends to have a mean temperature of 12 to 13 °C. For the tree to become dormant, the mean temperature must be below 13 °C. Navels, therefore, need to approach dormancy in winter. The chances of producing consistently good crops diminishes progressively as the mean temperature for the coldest month rises above 14 °C.

Soil requirements

Citrus can be grown in a wide range of soil types provided they are well drained. Fertile, well-aerated soils with a pH of between 6 and 6,5 are ideal.

The growth, development and production of a plant depend on the physical characteristics of the soil such as drainage, density, texture, water-holding capacity, structure, soil depth, the homogeneity of the profile, erodibility, and the degree to which water can infiltrate the soil. These characteristics differ in the various soil types.

Physical soil properties determine the degree to which water is released for uptake by the plant roots, and the depth of the root system.

Influence of physical soil properties on the development of citrus trees

Root development

The roots of citrus trees normally grow to a depth of 1 m and spread to 2 m beyond the dripline of the tree.

Certain factors, such as a rock or gravel layer, a mottled clayey soil or a sandy mottled layer could, however, limit the normal spread of the roots.

If any limiting layers are found within 1 m of the soil surface, the effective soil depth for the development of plant roots will be restricted to the depth at which the upper boundary of the restrictive layer occurs. A greater effective depth will cause an increase in plant yield and growth, because a greater volume of soil can be exploited by the plant roots.

Root development can also be restricted by a low availability of water and nutrients.

Water supply

Water supplied through rain or irrigation is absorbed by the fine particles in the soil and is therefore available for absorption by plant roots.

Oversaturation or waterlogging occurs in soils that have a layer which restricts the drainage of water. Such layers can be identified by one or more of the following characteristics:

- Grey or yellowish-grey colour
- Abundant yellow-brown or reddish-brown mottles
- Soft and hardened mottles (concretions)
- Prismatic or columnary structure
- Strongly developed block structure
- Very clayey
- Stratified rock layers.

An ideal citrus soil will, in respect of optimum water provision, have the following characteristics:

- Red, yellow-brown or brown colour
- Clayey content of 10 to 40 %
- No clayey, mottled or structural layers within 1 m of the soil surface.

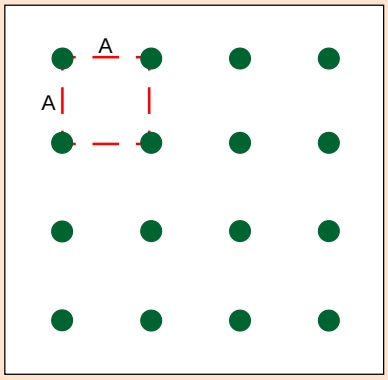
Layout of citrus orchards

Before planting an orchard it is advisable to provide irrigation facilities such as pipelines or concrete canals. At present the dragline sprinkler irrigation system and the basin system for flood irrigation are regarded as the most suitable for citrus orchards.

Planting systems

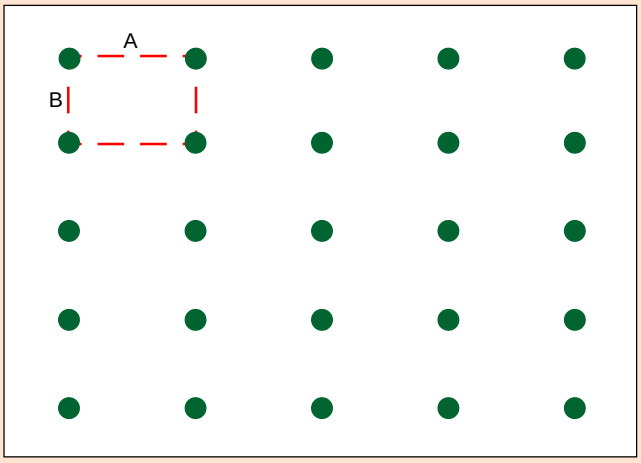
The square and rectangular planting systems applicable to citrus orchards are illustrated below.

With the exception of the square system, which is preferable where sprinkler irrigation is used, the rectangular system is at present favoured above other systems because the smaller planting distance in the tree rows increases the number of trees per hectare.



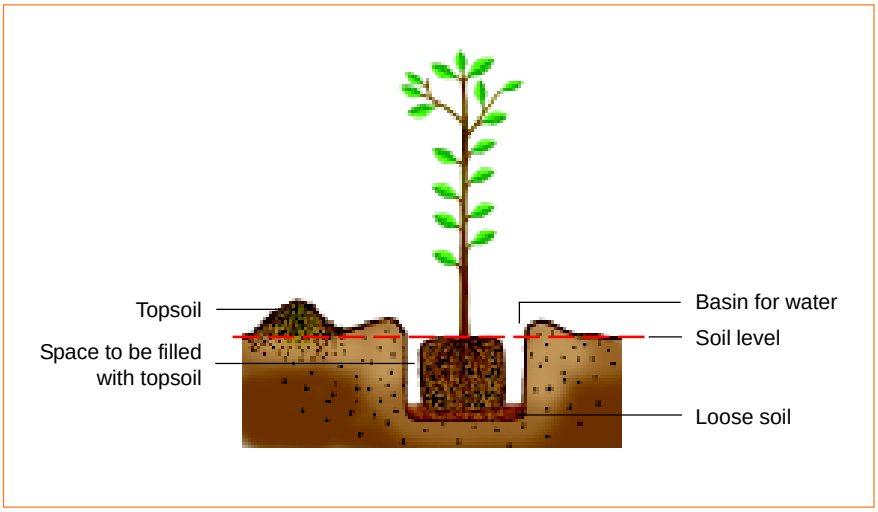
Valencias: A = 7,0 m
Navels: A = 7,0 m
Grapefruit: A = 7,0–8,0 m

Schematic illustration of the square planting system



Navels: A = 7,0 –7,5 m
B = 6,0–6,5 m
Valencias: A = 7,0 –7,5 m
B = 6,5–7,0 m
Grapefruit: A = 7,0–8,0 m
B = 6,0–7,0 m
Lemons: A = 6,0–7,0 m
B = 5,0–5,5 m

Schematic illustration of the rectangular planting system



Planting depth for citrus tree

Planting

- Early spring is the best time for transplanting. Planting holes of 0,5 x 0,5 x 0,5 m are prepared and the soil mixed well with 2 spadefuls of compost or kraal manure and 250 g of superphosphate.
- The young trees are planted to the same depth as they were in the nursery. Keep in mind that loose soil tends to compact. The bud union should be about 300 mm above the ground.
- Once the tree has been planted, the soil must be firmly tramped down. A basin for irrigation is made around the tree which must be thoroughly irrigated immediately after planting. Irrigate again the following day to seal any cracks in the soil.

Irrigation

During the first 6 months the trees should be irrigated twice a week and thereafter every 7 days. The irrigation basin should be gradually enlarged as the tree grows, so that it is always slightly bigger than the dripline of the tree. Be careful not to damage the fine superficial feeder roots.

The water required depends on weather conditions. Saturated and poorly-drained conditions could result in root rot, which will shorten the life of the trees. On the other hand, a shortage of water may have the following effects:

- Moisture stress during early spring while the tree is flowering, could result in excessive drop of flowers and fruitlets, and the resulting crop will be small. A serious drought followed by good rains could produce out-of-season flowering and fruit setting.
- A lack of moisture during October to January could result in acid fruit.

Do not wait for symptoms of water stress before applying water. A tree can suffer from stress well before any visible signs appear. A slight leaf wilt is a sign of a lack of water and this must be prevented.

If a sprinkler is used, about 30 mm of water must be applied every 7 days, depending on the weather.

Leaf sampling

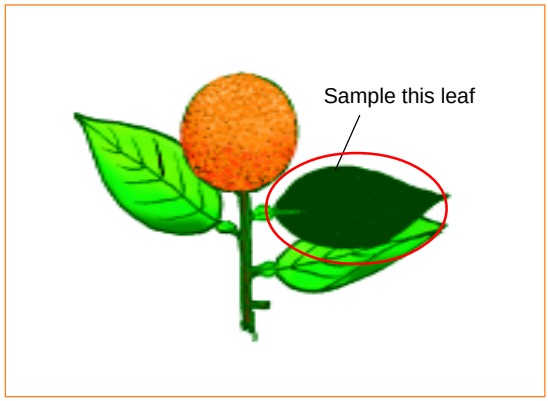
Leaf samples must be taken during the following periods:

- Easy peelers – end of February
- Navels and grapefruit – middle of March
- Midseasons and Valencias – middle of April

A leaf sample should represent an orchard smaller than 3 ha in which the soil is homogeneous. If soil variations occur, separate samples must be taken. To ensure that a good, representative sample is obtained, 3 to 4 leaves per tree from about 20 trees (60–80 leaves) should be sampled evenly through an orchard. Leaves should not be picked from the same side of the tree. Mature 5 to 7-month-old leaves are picked behind the fruit on the fruiting stem.

Important factors when sampling leaves:

- Different cultivars should be sampled separately.
- Leaf samples must only be taken from bearing trees.
- Leaves should preferably be sampled in the morning when the dew has dried off.
- Leaves must be free of sunburn, disease symptoms or insect damage.
- Leaves should be gathered in clean, new paper bags.
- The bag should be tightly sealed after sampling. If the samples cannot be delivered immediately, the bag should be kept in a refrigerator (not a freezer).
- Samples must be delivered to the laboratory for analysis within 2 days of sampling. Samples dispatched by post will not be suitable for analysis.
- Every sample must be accompanied by a completed questionnaire, as this information is important for recommendation purposes. Questionnaires are available from the Analysis Service, ITSC, Nelspruit.
- Leaf samples should be taken annually from the same trees (mark trees with paint).



Mature 5 to 7-month-old leaves behind fruit on fruiting stem are picked for leaf sampling

Soil analysis

- A soil-analysis report of a certain orchard can only be reliable if the soil samples which are analysed are representative of the particular orchard.
- Soil should be sampled at the same time as the leaves.
- It is important that the samples taken represent a homogeneous field or orchard.
- A soil analysis merely indicates the chemical composition of the soil; physical problems such as waterlogging and plough-soles can only be determined by means of profile holes.

Method of sampling

If a soil auger is not available, a spade may be used.

Depth

Topsoil: 0 to 200 or 300 mm

Subsoil: 300 to 500 mm

Number of samples

A sample must consist of at least 10 subsamples, representing an area of not more than 3 ha. Samples from different orchards should not be combined.

Sampling points

The samples should be taken evenly by moving diagonally from the corners through the orchard. Samples should be taken under the drip area of the trees (in tree basins).

Mixing and packing

- The subsamples taken from a certain orchard should be placed in a clean container (not a fertiliser bag) and thoroughly mixed.
- A sample of about 2 kg is taken from the composite sample and put into a strong, clean plastic bag.
- Every sample must be clearly marked.
- In addition to the name of the producer, the number of the orchard, sample number and the depth at which it was taken should be indicated on the label.
- Attach the label to the outside of the container. If placed inside the container it might become illegible.
- Send the sample to the nearest soil analysis laboratory.

Fertilisation

During the first year, nitrogen may be applied every 2 months. Any of the following nitrogen fertilisers may be applied:

- 6 applications of 25 g limestone ammonium nitrate (LAN 28 %) per tree per year

  OR
- 6 applications of 16 g urea (46 %) per tree per year

  OR
- 6 applications of 36 g ammonium sulphate (21 %) per tree per year (one matchbox full of fertiliser is roughly 36 g).

From the second year, nitrogen must be applied twice a year, half in July and half in March. Fertiliser should be spread evenly under the canopy of the tree and irrigated. Very deep irrigations will wash the fertiliser down too deeply and out of reach of the shallow feeder roots.

Phosphorus may be applied at any time of the year. One application should be sufficient. Potassium should also be applied once, early in spring.

The table indicates how the fertiliser requirements of growing citrus trees increase.

Fertiliser requirements of young citrus trees (kg/tree/year)

Age	Fertiliser mixtures		Type of fertiliser		
	3:1:5 (38)	5:1:5 (45)	LAN (28)	Supers (10,5)	Potassium chloride (50)
1	0,5	-	0,15	0,20	0,20
2	0,9	-	0,30	0,40	0,20
3	1,3	-	0,50	0,60	0,30
4	1,8	-	0,75	0,80	0,50
5-6	-	2,0	1,20	1,00	0,75
7-8	-	2,5	1,80	1,25	1,00
9+	-	3,0	2,10	1,50	1,50

It is often necessary to apply micronutrients. These elements are dissolved in water and applied as a spray onto the tree. Deficiencies of zinc, copper and manganese often occur and may be applied in 10 ℓ water at the following concentrations:

- 15 g zinc oxide
- 20 g copper oxychloride
- 20 g manganese sulphate.

The micronutrient solutions should be sprayed during early spring when the leaves are actively growing. A boron deficiency can be rectified by spreading 20 g borax per large tree under the canopy or by spraying with a solution of 10 g solubor/10 ℓ water.

Pruning

- Citrus trees are not usually pruned, although dead wood must be removed regularly.
- To avoid low branches reaching to the ground, trees are skirted soon after the crop is removed.
- Branches reaching to the ground hamper the removal of fruit lying underneath the tree, impede irrigation and promote ant infestation of the trees.
- When trees become too big and start growing into one another, pruning is recommended.

Control of pests, plant diseases and weeds

For information on the chemical control of insects, plant diseases and weeds consult the latest issues of:

- *A guide for the control of plant pests*
- *A guide for the control of plant diseases*
- *A guide to the use of herbicides*

These publications are published by the national Department of Agriculture and obtainable from the Resource Centre, Directorate Agricultural Information Services, Private Bag X144, Pretoria 0001.

Pests

The use of pesticides in the home garden should be restricted to a minimum. There is a balance between pests and their natural enemies. When pesticides are used injudiciously, this balance is disturbed and a vicious cycle is created. The result is that these few trees have to be sprayed regularly. Apart from the cost factor, this is dangerous because the amateur fruit producer does not normally use protective equipment such as gloves, overalls or respirators.

Ants

- Some of the most important insects to be controlled are the brown house ant and the pugnacious ant.
- To keep ants out of the trees, insecticides sold under various trade names can be applied around the tree trunks.
- Ant nests, particularly those of the pugnacious ant, underneath or near the trees can be treated with registered chemicals.

Red scale

Red scale is controlled satisfactorily by natural enemies, provided ants are kept out of the trees (see Ants).

Soft brown scale

Soft brown scale secretes a sticky substance, known as honeydew, on the leaves and fruit. The honeydew subsequently turns black as the result of sooty mould that grows on it. Soft brown scale is controlled very well by various parasitoids and predators, provided ants are kept out of the trees (see Ants).

Soft brown scale

Citrus thrips

Severe attacks by citrus thrips cause young shoots and leaves to become thickened and distorted. Developing apical shoots may turn black and fall off. During development the peels of young citrus fruit can also be blemished by citrus thrips. This mostly starts from the stem-end and may spread downwards extending over the rest of the fruit. However, it does not affect the eating quality of the fruit.

Orange dog

Orange dog is frequently a problem on young trees because it feeds mainly on the young leaves. The smaller caterpillars are black with yellow and those that are larger, green and brown. They can be identified by the unpleasant smell that is exuded when touched. They can be collected by hand and destroyed.

Citrus psylla

Citrus psylla is the vector and transmitter of a major citrus disease known as greening. (see Greening under Diseases). Citrus trees have 3 normal growth flushes during the year:

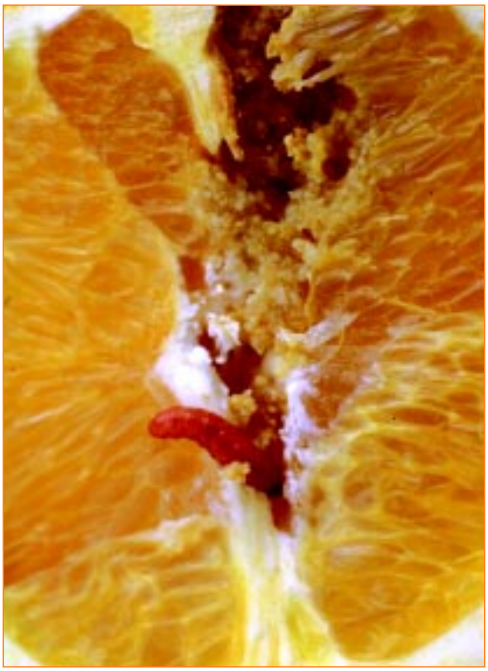
spring growth during August/September, followed by a second in November/December and the last during February/March. Lemons are, however, the exception since lemon trees form new leaves throughout the year. It is during these flushes that the trees are subject to psylla infestation. It is therefore important to examine the trees thoroughly during these periods to determine the degree of infestation and to organise control of the pest accordingly.

The female lays easily discernible orange-yellow eggs on the edges of young leaves. When the eggs hatch, the young nymphs move to the underside of the leaves where they establish themselves to feed and cause pock-like malformation of the leaves.

Control of the pest must be aimed at destroying the nymphs as soon as possible after they have hatched. Because all the eggs do not hatch simultaneously, it is essential to use a spray with a fairly long residual action.

Fruit flies

Fruit flies cause post-harvest decay on fruit. The normal control method is to apply a toxic bait to the leaves of the trees. Applications must commence in February and continue up to the end of the citrus season. The important period is from February until the end of June.



Larvae and eggs of the false codling moth

False codling moth

Larvae of this moth feed inside the fruit and cause decay. Remove and destroy all dropped and infested fruit from the trees weekly. Also remove all out-of-season oranges in November and again once the fruit has been harvested. Infested fruit serves as a source for reinfestation.

Citrus bud mite

This mite is exceptionally small and hides in the flower and axillary buds. It causes malformed growth points, flowers and fruit and also peculiarly shaped leaves. The growth of young trees is seriously hampered and yields can be reduced dramatically. Young citrus trees up to the age of 10 years, as well as older navel and lemon trees, should be sprayed once a year to control this pest.

Weeds

It is very important to keep the area under the canopy free of weeds. Nutgrass and quick-grass, especially, should not be tolerated. Weeds may be removed by hand. Be careful not to damage the shallow feeder roots or the trunk when spades or other tools are used. Wounds promote penetration of soil pathogens which cause root rot. Weeds also act as pathways for ants.

Diseases

Citrus black spot

This disease is common in the hot low-lying areas of Mpumalanga and KwaZulu-Natal and can be controlled effectively with chemical remedies.

Scab

Scab often occurs on rough lemon seedlings. The symptoms are a corky roughness on the leaves and young twigs. It can be controlled chemically.

Greening

It is an important disease which is prevalent in the relatively cooler, high-lying areas (above 600 m). Typical symptoms are yellowing of the leaves and malformed fruit. One side of the fruit along the central axis does not develop normally and remains smaller, resulting in asymmetrical fruit. The smaller side remains greenish while the rest of the fruit turns orange. The disease is caused by a bacterium for which no chemical treatment is available. It is transmitted by psylla (see Citrus psylla).

As greening is usually localised within one or two branches of the tree, it is advisable to cut out such branches. Saw them off as close to the trunk as possible. If the entire tree is affected, it would be better to remove and replace it.

Granadillas

The purple granadilla, also known as the purple passion fruit, is locally grown commercially as well as for home use.

Climatic requirements

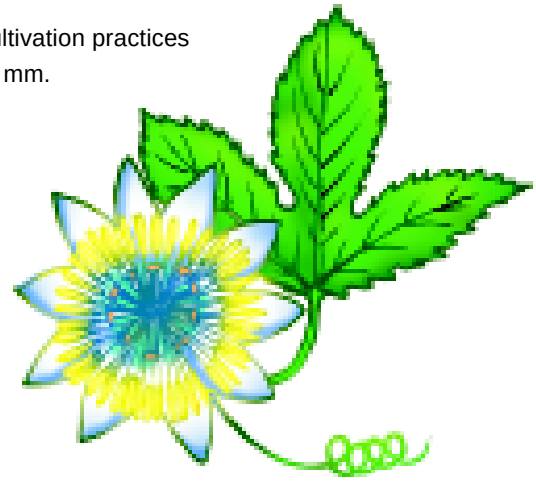
- Granadillas prefer moderate temperatures throughout the year.
- They are sensitive to severe frost (especially the purple granadilla).
- In hot areas, they should be planted on cool slopes and in cool areas on the warm northern slopes. The average maximum monthly temperature should not exceed 29 °C and the minimum should not fall below 5 °C.
- Granadillas prefer a high relative humidity and well-distributed rainfall of not less than 1 200 mm/year (irrigation can supplement low rainfall).

Soil requirements

Deep soil preparation is important because granadilla plants develop shallow root systems in compacted soils. Thorough soil preparation will also improve drainage. This is very important, because granadillas are sensitive to excessively wet soil conditions. It is best to avoid clay soils.

Soil preparation

Granadillas have deep root systems, therefore cultivation practices should be as deep as possible, not less than 800 mm.



Proper soil preparation ensures better:

- root development
- soil drainage (less runoff)
- utilisation of nutrients
- tolerance of diseases
- fruit size
- yield
- economic return over a longer period.

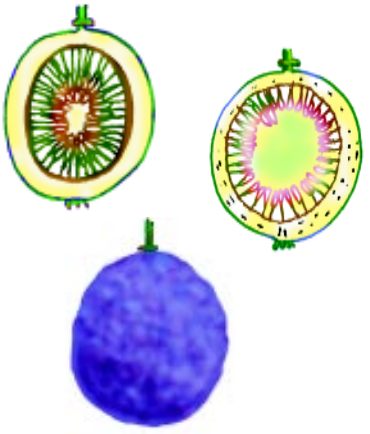
The following is important

- Examine the soil thoroughly.
- Add lime and phosphate to the root zone.
- Deep plough or rip.

Supply nutrients

- Calcium and phosphate (if necessary) should be incorporated into the soil during soil preparation.
- Lime should be applied before planting.

Seed



Granadillas are mostly grown from seedlings.

- When seed is used, be sure to use seed from ripe fruit selected from healthy plants.
- Scoop out the contents of a granadilla that has been cut through.
- Wash the contents to separate the seed and pulp.
- Dry the seed in the shade and sow it in seedling trays or planting bags filled with a well-prepared soil mixture.
- To enhance germination, the seed together with the pulp can be placed in a plastic container and allowed to ferment for 1 to 3 days.
  It is then thoroughly washed, dried and sown as soon as possible.
- Seed may be stored in closed containers at 13 °C for about 4 months.

Raising seedlings

All soil used in the nursery must be sterilised by fumigation or steam treatment, because the presence of rootknot nematodes can have a detrimental effect on the growth of the plants.

- Seed can be sown in trays or polyethylene bags (75–150 mm in diameter and 200 mm in height).
- If possible, sow 2 seeds per hole of the seedling tray or per bag and select the stronger of the two.
- Push a thin stake into the soil next to the emerged seedling so that it can be trained up the stake.
- Remove the developing side shoots regularly.
- The seedlings should be ready for transplanting when they reach a height of 300 to 400 mm.
- Select only seedlings for transplanting which have dark green leaves and are free of any symptoms of nematode or fungal disease infestations.

Transplanting

- The seedlings should be ready for transplanting about 3 to 6 months after sowing the seed.
- The optimum time for transplanting is during August/September.
- The yellow granadilla is more susceptible to cold than the purple granadilla and grafted plants should therefore not be planted in areas where frost occurs.

Planting distance

Generally plant spacings of 1 to 2 m are used. The average lifespan of a healthy granadilla plantation is about 3 years. Bearing in mind the effect of viruses and soil-borne diseases, plant spacing of about 1 m could ensure high production over the short term.

Trellising system

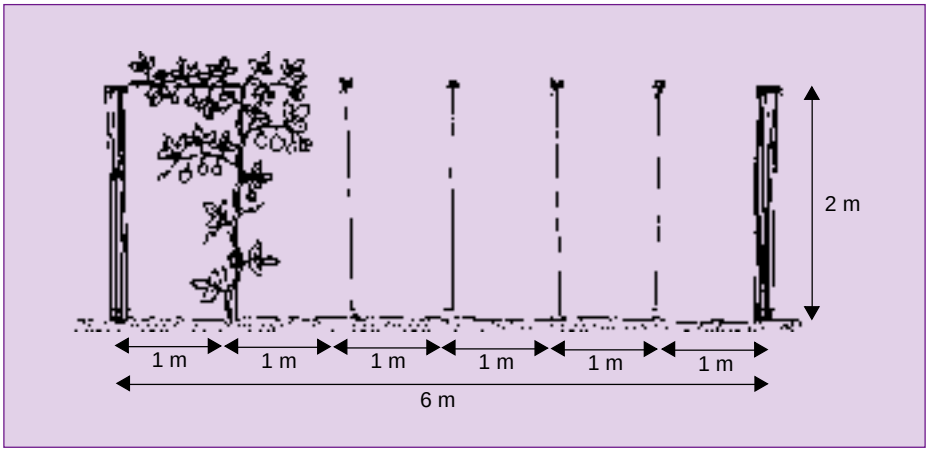
Erecting a trellising system is the main initial expense. A sturdy construction is necessary because the trellis has to support a heavy mass. The wooden posts must be solid and resistant to termites.

Construct it as follows:

Draw a single strand of 12-gauge wire (taut) about 2 m above the surface of the ground and along the tops of the wooden posts 2 m high and about 6 m apart along the row.

Training the plants

- The granadilla vines should be trained systematically so that the framework gets a good shape.
- Tie a selected leader of each plant loosely to a stake or train it up a string until it reaches the top wire. Remove all side shoots, but not the leaves.
- As soon as the main leader reaches the top wire, it is progressively wound loosely round the wire as it grows.



Constructing a trellising system

Pruning granadillas

Pruning or thinning out is necessary when the granadilla vine becomes unproductive. It is done mainly to:

- Stimulate new growth
- Promote healthy vine growth because light and air can now reach the inner parts, which discourages pests and diseases
- Remove all dead, old, injured and diseased parts of the vine
- Prevent vine overlap
- Facilitate spraying.

Severe pruning is not necessary if granadillas are grown on a short-term basis (12–18 months), because it can lower production.

Selective pruning

- The main leader is trained along the wire and the fruiting laterals are trained so that they hang down freely.
- Cut off all laterals at ground level if they start growing along the ground.

Severe pruning

- The main leader is trained along the wire and the laterals are trained to hang down.
- As soon as the laterals reach the ground, they are cut back just above ground level.
- After about 12 to 15 months all the laterals are cut back about 300 mm (or 4–6 nodes) from the main leader.
- The plants are usually pruned during July/August.
- To produce an out-of-season crop, the vines may be pruned during September/October.

Water requirements

- Well-distributed rainfall of about 1 000 to 1 200 mm/year is essential for commercial granadilla cultivation.
- The maximum water requirements are approximately 50 m^3/ha/day or 15 ℓ/plant/day in summer and approximately 25 m^3/ha/day or 8 ℓ/plant/day in winter.
- It is important to obtain an optimum soil-water status throughout the season.
- Avoid overirrigation because it could enhance the multiplication and distribution of fungi.

Fertilisation

The recommended fertiliser programme for granadillas is given in the table. These are only general guidelines and should be supported by soil and leaf analyses.

Fertilisation according to plant age (g/plant/year)

Age	LAN	Single superphosphate	KCl	K_2SO_4
1st year	250	150	150	180
2nd year	350	300	300	375
3rd year+	450	450	450	540

Time of application

July to August:	1/3 of the nitrogen + all the phosphate + 1/2 of the potash
December:	1/3 of the nitrogen + 1/2 of the potash
April:	1/3 of the nitrogen

Granadillas often have a zinc and boron deficiency.

- Zinc oxide can be added at 200 g/100 ℓ of water, or
- Solubor at 100 g/100 ℓ of water.

Spray especially new growth during spring.

Diseases

Major diseases affecting granadilla crops in South Africa include:

- **Damping off** of seedlings caused by fungi as a result of poor seedbed management.

  Control

  – Plant on a well-drained site in virgin soil, or sterilised soil or growth medium.

- **Foot rot** *(dikvoet)* where the base of the stem thickens, causing cracks in the soil surface through which numerous secondary organisms can enter, resulting in total rotting of the stem. Waterlogging and overirrigation increase the incidence of the disease.

  Control

  – Plant in well-drained soils.

- **Various viruses** causing symptoms such as spots, mosaics and distortion. It is usually very difficult to identify the specific virus involved.

  Control

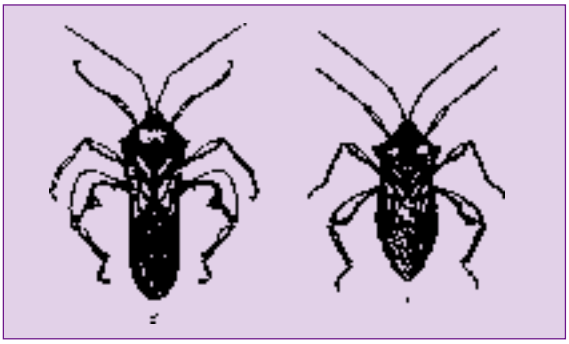
  – Affected shoots can be broken off the plant

  – Frequent washing of hands reduces transmission

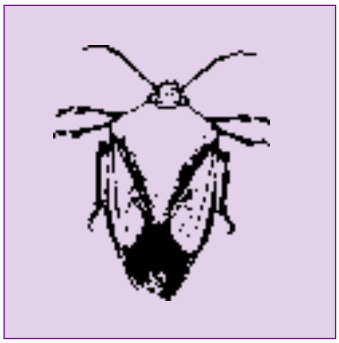
  – Wipe instruments with 10 % of a household bleach after pruning each plant.

Pests

Pests which frequently occur on granadillas include stinkbugs and tip wilters.



Male (left) and female (right) tip wilters



Stinkbug

Control

- Field inspections must be carried out frequently.
- Collecting insects by hand can help to control them.

Consult the latest issue of
***A guide for the control of plant pests* or**
A guide for the control of plant diseases
for information on chemical disease and pest control.

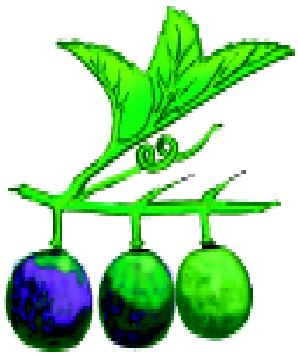
It is obtainable from the Resource Centre,
Directorate Agricultural Information Services
Private Bag X144,
Pretoria 0001

Harvesting

Depending on the time of transplanting, the first fruit is usually ready for harvesting 6 to 9 months after planting. At about 18 months after planting the crop should have reached its full bearing potential. Thereafter, there are 2 main crops annually, namely a summer crop from November to January and a smaller winter crop during June and July. In the Northern Province and Mpumalanga growers sometimes have a third crop during March and April. A limited quantity of fruit will, however, be available throughout the year.

When to pick the fruit

- Fruit for the fresh market is picked 2 to 3 times a week in summer when fully developed and with a light purple colour.
- Fruit should not have a deep purple colour when harvested, because it will arrive at the market in a shrivelled condition and will not have a good market value. A wax treatment protects the fruit from drying out and could delay the shrivelling process.
- During the cooler months fruit is harvested weekly.
- Fruit for processing can be harvested when it has reached a deep purple colour.
- Fruit should be harvested early in the morning.

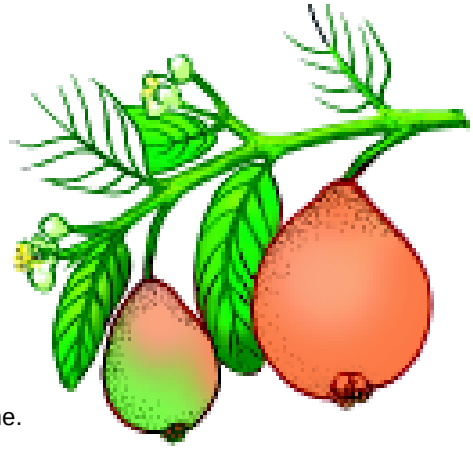


Guavas

The guava is a shrub or small tree which grows 2 to 8 m tall. When cultivated it is usually pruned back to about 2 to 3 m.

Trees that are not pruned, usually flower during October. When they are pruned, the period of full bloom is 10 to 12 weeks after pruning. Bees are the main pollinators, but self-pollination also occurs.

Fruit



- The fruit is a berry.
- Guavas vary in shape, from spherical to pyriform, and the size of the fruit varies from 25 to 100 mm in diameter.
- The flesh of the cultivar Fan Retief is orange-pink with a granular structure as a result of the many stone cells. There are numerous hard seeds embedded in the pulp.
- The period from flowering to ripening of the fruit is 20 to 28 weeks, depending on pruning time.

Climatic requirements

- Guavas are adapted to areas with hot summers and cool winters. In some areas an average monthly maximum temperature higher than 32 °C and a minimum temperature below 3 °C are regarded as restrictive for the cultivation of guavas.
- Temperatures of up to 45 °C can be tolerated, although the highest yields are usually recorded at mean temperatures of 23 to 28 °C.
- Optimum vegetative growth occurs between 15 and 28 °C.
- Approximately 3,5 to 6 months, depending on the cultivar, of mean summer temperatures higher than 16 °C are needed for the trees to flower and bear fruit successfully. The quality of the fruit becomes inferior when mean temperatures fall below 15 °C during the maturing stage.
- Guavas can be grown successfully from sea level up to an altitude of 1 500 m.
- The trees are also well adapted to both summer and winter rainfall conditions.
- They are more drought resistant than most tropical trees and grow best in areas with an annual rainfall of 1 000 to 1 500 mm. However, fruit production and quality are affected by extreme moisture conditions.
- If rainfall is inadequate, trees should be irrigated during dry periods, especially if there is fruit on the tree.

Soil requirements

- Guavas grow well in any type of soil. Because of its distribution on a wide variety of soil types, the guava tree is often regarded as a weed. The trees are frequently found along streams, brooks and rivers where they apparently thrive, despite periodic waterlogging and poor physical and soil chemical conditions.
- For sustained successful commercial cultivation of the crop, it is, however, better to plant the trees on fairly well-drained soils. Shallow soils or those containing compacted layers can, in the long term, have an adverse effect on growth and production.
- Guavas can be grown in soil that is not suitable for the production of most other subtropical fruit trees.

Cultivars

- Guava cultivars include Fan Retief, Frank Malherbe, Van Zyl, Rousseau, Du Preez, Fredene, Dimple, Jonelle, Welheim, Frederika and TSG 2. The latter is preferred because it is not susceptible to guava wilt disease.
- At present only Fan Retief is planted on a large scale. It is, however, very susceptible to guava wilt disease (*Acromonium* sp.) which is prevalent in guava plantings in Mpumalanga and the Northern Province. Frank Malherbe, which is used for canning, is the only other cultivar planted commercially, mainly in the Western Cape Province.

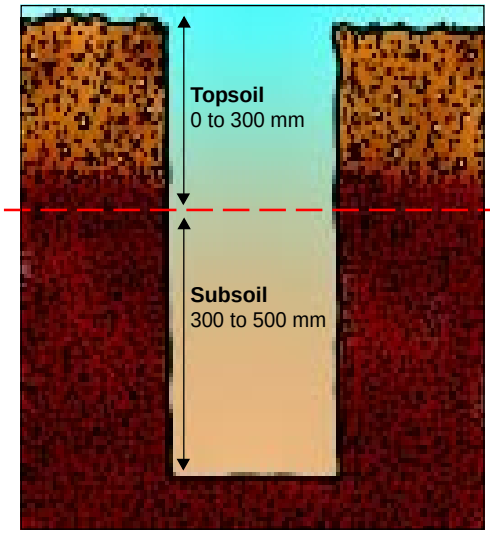
Soil preparation

- A guava planting is a long-term investment. It is therefore important to plan a new planting thoroughly and well in advance.
- The first and most important step is to examine soil suitability with respect to depth, drainage and compacted layers. The soil should be at least 800 mm deep. The physical suitability of a soil can only be evaluated by digging holes in the ground and examining the soil profile.
- If the soil, regarding physical properties, is suitable for growing guavas it is of vital importance to prepare it carefully and well in advance of planting.
- A representative sample of the proposed orchard must be taken for soil analysis. It is desirable to take the soil sample 9 months, but preferably 12 to 24 months, before planting. There will then be enough time to prepare the soil thoroughly, especially if large quantities of lime are required.

Soil sampling

- It is important that a sample should represent a soil of homogeneous characteristics, i.e. where no visible differences occur. If there are differences regarding soil colour and texture in such a land, the land must be subdivided accordingly and separate samples taken of the different areas.
- If a soil auger is not available, a spade can be used for taking samples.

- ***Depth of sampling:*** 0 to 300 mm for topsoil and 300 to 500 mm for subsoil samples.
- ***Number of samples:*** a sample should be made up of at least 10 subsamples (preferably more). The area represented by the sample should not exceed 3 ha.
- ***Distribution of sampling points:*** the samples must be taken evenly over the entire area.
- ***Mixing and packaging:*** the sub-samples from a particular land must be pooled in a clean container (not a fertiliser bag) and mixed thoroughly. A 2-kg sample is taken from this, placed in a clean bag or other suitable container and submitted for analysis.



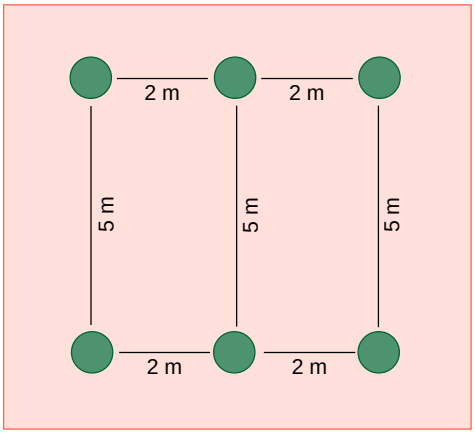
- Every sample must be marked clearly. The name of the sender, the number of the land and depth at which the sample was taken, must appear on the label. Attach the label to the outside of the container because it could become illegible on the inside.
- The analysis results will supply valuable information regarding the required types and quantities of fertiliser to be applied before planting. It is important that any lime or phosphate that is needed, be thoroughly worked into the soil before planting.
- The results will also facilitate the making of a preliminary fertilisation recommendation up to the stage when the trees are old enough for leaf analysis.
- The soil must be loosened as deep as possible before planting. In this case it will not be necessary to make large planting holes.

Method of soil preparation

- If the soil is very acid, heavy lime application may be necessary. In such a case two thirds of the recommended agricultural lime must be distributed over the entire area 12 months before planting, mixed into the topsoil by discing and then ploughed in as deep as possible. Because calcium (lime) moves slowly in the soil, it is essential to work it into the future root zone of the trees.
- A cover crop can then be planted and ploughed in 6 months later. This will help to increase the organic matter content of the soil. The remaining lime and all the required phosphate must be applied and lightly worked in simultaneously. The trees are planted 3 months later.
- If soil samples have not been taken early enough to proceed as described above, two thirds of the lime must be mixed with the soil and ploughed in deep; the phosphate and the rest of the lime are then distributed and worked in lightly. If large quantities of lime are required, these must be applied at least 3 months before planting (as described), thoroughly mixed with the soil and then worked in deep.

- Do not fertilise recently planted trees too soon. The trees must first become well established and grow vigorously before any fertiliser applications are made. In most cases it is advisable to wait a year. Such an application must be very light and the fertiliser must be applied evenly without coming into contact with the stem of the tree. Irrigation must be applied immediately.

Planting distance



- Planting patterns and distances are determined to ensure optimal fruit production at the earliest stage.
- The trees must remain healthy and productive and should therefore not be planted too close together or pruned too heavily.
- Planting distances must be wide enough for tractors, spraying machines and labourers to move easily between the trees.
- The recommended planting distance is 5 m between the rows and 2 m between the trees in the row. With this planting distance of 2 x 5 m a total of 1 000 trees can be planted per hectare.

Fertilisation

- Young trees should be well established and growing vigorously, preferably after about one year, before any applications are made.
- Never apply fertilisers against the trunks of young trees.
- Fertilisers must be spread evenly about 200 mm from the stem to about 500 mm from the drip area of the tree. Applications should be followed by a light, controlled irrigation or alternatively applications should be made during the rainy season.
- Fertilisers should not be worked into the soil.

As soon as the trees are established and start to grow, fertiliser should be applied frequently in quantities shown in Table 1.

TABLE 1. Quantity of fertiliser per tree per year according to age (g)

Age (year)	LAN (28 % N)	Superphosphate (10,5 % P)	Potassium chloride (50 % K)
1	75	50	40
2	150	100	80
3	225	150	120
4 and older	300	200	160

Nitrogen

- For the first 4 years the nitrogen should be divided into 4 equal applications *viz.* 2 weeks before pruning and then at two-monthly intervals.

- Thereafter apply nitrogen as follows:
  - one third 2 weeks before pruning
  - one third 4 weeks after pruning
  - one third 10 weeks after pruning.

Potassium and phosphate

Half the quantity of potassium and all the phosphate must be applied together with the first nitrogen application. The rest of the potassium must be applied 4 months later.

Zinc (Zn) and boron (ß) sprays

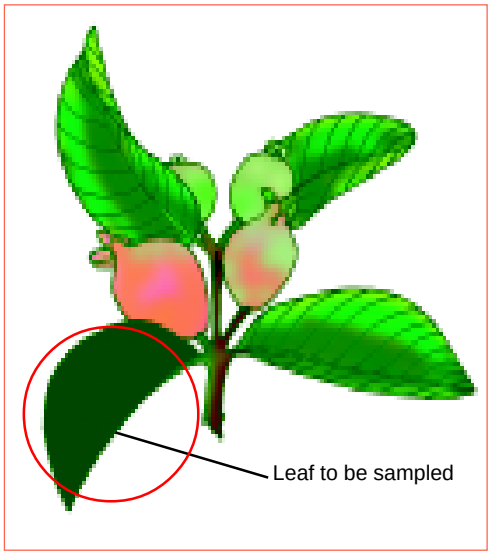
Because most soils are either naturally low in zinc or the zinc is not available, this element must be applied every year. The following substances and concentrations are recommended per 100 ℓ water:

- Zinc oxide at 200 g or
- NZN at 150 mℓ

Many guava orchards are also low in boron and it is desirable to spray the tree every 2 years with 100 g borax or 75 g Solubor/100 ℓ water.

Leaf analyses

The following instructions regarding leaf sampling for guava trees are important and should be strictly adhered to. Young, fully-developed leaves are sampled 5 months after pruning directly behind the largest fruit as indicated in the figure.



Time of sampling: five months after pruning. Sample leaf behind the largest fruit

- The time of sampling will normally be between January and March, depending on the time of pruning.
- The correct leaves must be sampled (see figure).
- When a leaf sample from a particular orchard is submitted for the first time, it must be accompanied by a soil sample. Thereafter, it would also be advisable to submit soil samples annually. When making fertilisation adjustments, it is essential to take into consideration the analysis results of the soil as well as the leaf samples.
- Only leaves taken from healthy trees must be sampled. The leaves must therefore show no signs of sunburn, deficiency, insect damage or disease.
- A leaf and soil sample should represent an area of not more than 3 ha.
- The recommended method is to select approximately 20 healthy trees that are well distributed throughout the orchard, homogeneous in appearance and representative of

the entire orchard. Exceptionally good or poor trees must not be sampled. The 20 selected trees must be marked clearly, for example with paint, so that the soil and leaf samples can be taken from the same marked trees every year.

Pruning

Tree pruning is an annual practice on guava farms in South Africa and is carried out for a number of reasons, namely to:

- direct or control growth, to obtain the desired tree shape and size
- encourage flower and fruit production to maximise production of high-quality fruit per unit area
- facilitate harvesting and to utilise the bearing area of the tree optimally
- obtain the desired leaf to fruit ratio
- optimise sunlight utilisation and air movement in the tree. Efficient sunlight utilisation is essential for obtaining optimal yield and high fruit quality. Insufficient sunlight will cause dieback of the fruiting branches. Inadequate air movement promotes fungal and insect pests within the tree
- effect rejuvenation by removing dead or excessive wood or shoots
- allow spraying and cultural practices to be applied more effectively
- extend the production period. The production season of guavas can be controlled by the time of pruning. If pruning is done later in the season, fruit will also be harvested later.

Pruning usually involves three basic techniques: thinning, heading back and pinching or tipping. Thinning involves the removal of entire branches at the point of origin. By thinning, the bulk of the plant is reduced without obviously altering its size or form. Heading back is the process of pruning to shorten branches. Heading back is usually used to induce production of flowers and fruit and to limit tree size. Pinching involves the removal of the growth tip of the stem. This action will stimulate the growth of side branches. These different techniques are usually combined to obtain the desired tree form.

Structuring of the tree during the first 2 years is essential for maximum sunlight utilisation. Limited sunlight penetration will adversely affect yield and fruit quality once the tree starts bearing.

Pruning is usually applied during September or October.

Diseases

Guava wilt disease

Guava wilt disease (GWD), caused by an *Acromonium* sp. and reported for the first time in 1981 in South Africa is present in most of the guava-producing areas of Mpumalanga and the Limpopo Province. As a result of this disease the total hectarage of guavas in the southern Lowveld of Mpumalanga has decreased by 80 % in the period 1982 to 1994. Restrictions have been placed on the transport of guava planting material in terms of existing plant quarantine legislation, and plant material may not be taken out of the affected areas.

Symptoms

- The first symptoms of the disease include wilting and yellowing or bronzing of the leaves.

- The tree can decline rapidly or relatively slowly. Where tree decline is rapid, the leaves tend to remain on the tree, but shrivel and become necrotic, so that the tree has a scorched appearance. Where tree decline is slow, the leaves drop naturally, eventually resulting in the complete defoliation of the tree. The development of fruit on such trees ceases and the fruit eventually becomes mummified.
- GWD is spread mainly through root infection and the movement of infected plant material. The disease is also spread by contaminated soil clinging to farm implements and lugboxes.
- The disease tends to spread more rapidly during summer than winter.

Control

No chemical control measures have been registered against GWD. Eradication is at present the only control measure. Eradication involves the removal of the diseased tree, the 2 adjacent trees within the row, and the trees in the adjacent rows on either side of the diseased tree.

Management practices in orchards should be kept to a minimum from December to February to prevent damage to the trees and spreading of the disease.

Pestalotia *branch dieback*

- This disease is caused by *Pestalotia psidicola,* and differs from GWD in that individual branches die back from the tips. The shoots usually die rapidly and the leaves remain attached to the shoots, giving the diseased shoots a scorched appearance.
- The only effective control measure is to remove the diseased branches and coat the pruning wounds with a fungicidal sealant.

Blossom-end rot

- Blossom-end rot is a major problem in the guava-producing areas of the Western Cape Province as well as in the cooler production areas of Mpumalanga and the Limpopo Province, mainly Brondal and White River.
- Copper oxychloride, captab and mancozeb are registered for control. Spraying programmes do not reduce the disease to a great extent and are therefore not cost effective.

Fruitflies

Fruitflies are a major pest in guavas in most production areas. Three types attack guavas in South Africa, namely the Natal fruitfly, Mediterranean fruitfly and the marula fruitfly. In the Lowveld, the Natal fruitfly is the most important of the three. They all cause the same type of damage and can be controlled in the same way.

Damage and symptoms

Female flies lay white, oblong eggs in groups just under the skin of mature, ripening fruit. A few days later the maggots hatch and feed on the fruit flesh. The maggots are creamy-white, reach a length of about 6 mm and have no legs. Pierced fruit is characterised by small holes in the skin surrounded by a bruise. Such fruit soon becomes soft, and can decay and drop early.

Control

Fruitflies can be controlled successfully by means of a combination of chemical control, pruning, the eradication of useless host plants and regular orchard sanitation.

A full cover spray with fenthion 500 g/ℓ EC at 100 mℓ/100 ℓ water 3 to 4 weeks before harvesting, followed by a second spray 10 days before harvesting gives good control. Three sprays are recommended for homegardens, namely 7 weeks, 4 weeks and 10 days before harvesting.

Pruning

By pruning guava trees, harvesting time can be shifted to a period when fruitfly populations are lower. In Levubu, where the normal harvesting time of unpruned trees is March/April, the main harvest time could be shifted to June/July by pruning in October. By pruning in November, harvesting time is moved to July/August. However, pruning does not replace chemical control because it only helps to shift the main harvesting time to a period when there are fewer flies.

Eradication of host plants

The fruit of some useless host plants serves as an ideal breeding place for fruitflies, and should be eradicated. They include:

- Bug tree *(Solanum mauritianum)* which occurs in large numbers in plantations and along streams or rivers. The Natal fruitfly feeds on this plant during winter and large numbers of flies hatch from the fruitlets in summer.
- Wild-growing guavas which are good hosts for the Natal and Mediterranean fruitfly. The trees usually grow in the vicinity of roads and footpaths because guava seeds are spread mainly by human activities.
- Bramble fruit shelter the larvae of the Natal fruitfly and these plants should be eradicated where they occur in the vicinity of guava orchards.

Orchard sanitation

Guavas and other fruit, including wild fruit that has dropped, should be collected weekly and destroyed because fruitfly maggots emerge from the fruit, pupate in the ground and reappear as adult flies. Such fruit can be chopped up with a hammermill or buried at least 450 mm deep.

Post-harvest handling

- The guava is a climacteric fruit. It can therefore be picked green and will ripen during as well as after storage or shipment.
- Although the ideal ripening and harvesting norms have not been determined conclusively, it appears that the fruit should be picked when a colour change occurs. This stage is referred to as the “adult green” stage.
- The fruit has a delicate skin which can be damaged easily. Mechanical damage increases the extent to which the fruit can be infected by fungi. Harvesting practices must, therefore, be directed to keep mechanical damage to an absolute minimum.
- Because of the high respiration rate of guava fruit, refrigeration is a very important aspect. The period between harvesting and refrigeration must, however, be kept as short as

possible. Attempts should be made to shift harvesting to the cooler part of the day and not to leave the fruit in the orchard unnecessarily. Picked fruit must not be exposed to the sun. The fruit is sensitive to low temperatures. The suitable storage temperature for guavas is approximately 5 °C.

- The standard export carton of which the dimensions have been adapted for pallet stacking and which are of variable height to allow for different fruit size, is also suitable for guavas.
- The fruit must be packed in a single layer to limit damage during transportation to a minimum. For the same reason, fruit should be packed firmly without bruising. It should be kept in mind that the aim of packaging is to protect the fruit as well as to create an attractive presentation of fruit on the market.
- If too many problems are experienced with the marketing of the fresh fruit, guavas can be processed in various ways. The fruit is especially suited to canning or processing into jams or dried guava rolls. Factories also purchase the fruit on a large scale for the manufacturing of guava juice and nectar.

Guava pulp

Use any ripe guavas (even the dropped ones underneath the tree which are in a good condition). Put the guavas in a pot and cover them with water. Boil the guavas until they are blanched (the skins crack and loosen). Prevent overcooking as it will result in a dark brown pulp instead of the desired pink-coloured pulp.

Remove the cooked guavas from the boiling water, place in a clean container and mash with a potato masher. The mashed guavas are then pressed through a strainer to separate the seeds from the pulp.

Throw away the pips and keep the pulp for guava rolls and guava juice. The pulp is highly perishable and should be used immediately or kept in a fridge for use at a later stage.

Making juice

Mix one cup of guava pulp, prepared in the first stage, with three cups of water and add sugar according to taste. The juice contains no preservatives and should be consumed immediately or kept in a fridge. This is a healthy drink with a high vitamin C content.

Making rolls

Open a piece of plastic. Cover the plastic with a thin layer of cooking oil, followed by a thin layer of guava pulp. The layer of cooking oil is to prevent the pulp from sticking to the plastic when it dries. Allow the pulp to dry in the sun for about one day. The dried guava rolls can be cut into pieces and covered in plastic for use at a later stage.

Bottling

Peel firm and ripe guavas and cut them in half. Remove all the bruised and damaged parts of the fruit.

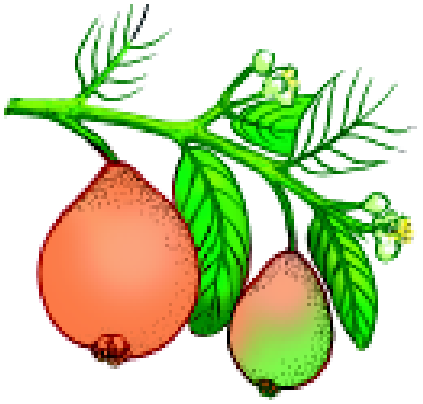
Prepare the syrup by dissolving one cup of sugar in two cups of water and bring to boiling point.

Place the peeled guavas in the boiled syrup and cook until froth starts to appear on top of the syrup or the pips start to loosen. Be careful not to overcook guavas. Overcooked guavas lose their pips.

Remove the labels from the glass bottles for the cooked guavas by soaking them in water. Sterilise the bottles by boiling in water for 30 minutes. All the bottles used must have metal caps and should not be cracked or chipped.

Remove the bottles from the boiling water and fill up to the rim with cooked guavas and syrup.

Remove all the air bubbles by inserting a knife against the inside of the bottles. Close the cap tightly and place the bottle upside down while it cools. This will ensure that the bottles seal properly. The bottles must be sealed tightly.



Litchis

Temperature and humidity

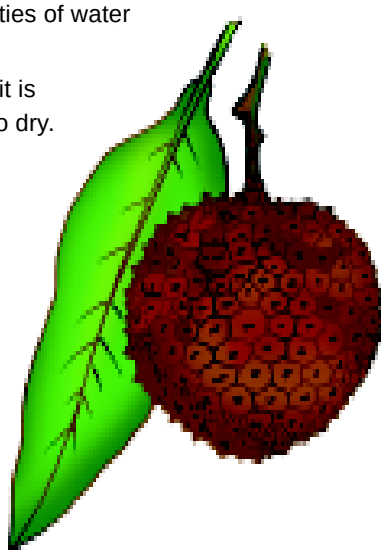
- The average maximum temperature in the litchi-producing areas of South Africa should be at least 23 °C during October and 24 °C during November, with a relative humidity of 50 % and higher.
- The average monthly minimum temperature in areas where litchis are produced should be above 6 °C. Areas where heavy frost occurs are not suitable for litchi production. It should, however, be cold and dry enough in winter to ensure good dormancy.
- The minimum temperature in some Lowveld areas (Malelane and Komatipoort) does not drop low enough in winter to give the trees the proper dormancy period. Trees can be forced into dormancy by withholding water/irrigation during the 3 coldest months of the year. Producers must, however, ensure that especially young trees do not dry out.

Soil

- Litchis grow very well, especially in sandy soil in the cooler subtropical areas.
- However, the trees also grow and produce well in clay soil in warmer areas.
- Litchis are well adapted to different soil types.

Water supply

- Because of the varying root distribution in different soils (deep in sandy soils, shallow in clay soils) water is very important for the optimum development of the plant.
- In sandy soils short irrigation cycles with small quantities of water are usually effective.
- In clay soils water is available for longer periods, but it is important that the soil does not become too wet or too dry.



Drainage

- Poorly-drained soil or soil with impenetrable layers shallower than 1 m below the surface is not suitable for litchis.
- Although gravelly or rocky soils drain well, these do not supply enough water to the trees because of poor waterholding capacity. Good irrigation practices, such as wetting the soil more frequently with small quantities of water will make these soils more suitable.

Cultivars

Litchis were originally imported from China, India, Taiwan and Florida, USA. Cultivars grown in South Africa are divided into the following groups:

Mauritius group

This group is usually planted locally as well as abroad and produces satisfactory yields and fruit of good quality, e.g. H.L.H. Mauritius, Muzaffarpur, Late Large Red, Hazipur, Saharanpur and Rose-Scented.

Chinese group

These trees produce very poor yields, but the fruit is of excellent quality and has a high percentage of chicken-tongue seeds. Cultivars include Haak Yip, Shang Shou Huai, Kontand, Glutinous Rice and Three Months Red.

Madras group

These trees bear colourful red fruit, but fruit quality is poor. Cultivars include Kafri, Shorts Seedless, Johnstone's Favourite, Emmerson, Durbhanga, Maries, Mooragusha, Madras 19, Hazipur/Saharanpur, Red McLean, Brewster and Bedana.

Tree quality

- A good air-layer tree has a single erect stem. The first scaffold branches should branch horizontally at a height of about 200 mm. Any acute forks that branch lower than 200 mm should be avoided.
- In grafted trees the graft-union height should be about 200 mm from the ground so that the first scaffold branches can branch at 300 mm. The graft union must be strongly attached and nurserymen must remove the grafting strip so that girdling cannot occur.

Aftercare of grafted trees

Trees can also be propagated by means of grafting.

- Weekly aftercare is very important and suckers and wild shoots that develop on the rootstock below the graft wound must be removed.
- After 5 to 6 weeks the buds start swelling and growing. A small cut can then be made through the plastic next to the bud. The bud grows through this cut, but the plastic strip must not be removed too soon. Once the first new growth has hardened off, the strip can be removed.
- Grafted trees have a better root system than trees developed from air layers and therefore show rapid initial growth. Air layering is, however, preferred to grafting because of a better end product.

Soil sampling

A representative soil sample should be taken for analysis. A soil sample must represent a homogeneous area where there are no visible soil differences. If there are colour or texture

differences the land should be subdivided and separate samples of the different parts should be taken. Use a spade to take the samples.

How deep?

- Take soil samples up to 300 mm below the soil surface.
- Take subsoil samples from 300 to 500 mm below the soil surface.

How many?

- A sample should consist of not less than 10 subsamples.
- The area represented by the sample should not exceed 3 ha.

Where?

The samples must be taken evenly over the entire area.

Mixing and packing

- Mix the subsamples of a particular land thoroughly in a clean container (not a fertiliser bag). Keep the topsoil (0–300 mm) separate from the subsoil (300–500 mm).
- A 2-kg sample of this mixture is then packed into clean plastic bags or suitable containers. Use separate containers for the top and subsoil.
- Put a label on the outside of the container to prevent it from becoming illegible. On the label must appear:
  - Your name
  - The number of the land
  - The depth at which the sample was taken.

Results

The results will provide valuable information on the type and quantity of fertilisation that should be applied before planting. Remember to incorporate the required quantity of lime about 6 to 12 months before planting if a large quantity is required and phosphate about 3 months before planting.

Soil preparation

- Examine the soil for suitability in respect of depth, drainage and compacted layers. It should preferably be 1 to 2 m deep.
- Prepare the soil according to the results of the soil analysis, especially when large quantities of lime are required.
- If the soil is suitable for litchi production, it must be prepared well in advance.
- Before planting, the soil must be tilled as deep and as thoroughly as possible so that it will not be necessary to make the planting holes too big.
- If the soil is very acid, heavy lime applications may be necessary. Two-thirds of the recommended quantity of lime must be scattered over the planting area, mixed with the topsoil and then ploughed in as deep as possible, at least 9 to 12 months before planting. Calcium (lime) moves very slowly downwards into the soil and must therefore be worked in to the depth of the root zone.

- A cover crop can then be planted and ploughed in about 6 months later to improve the organic matter content of the soil. The remaining lime (one third) and all the required phosphate must be scattered and incorporated at the same time. The trees can be planted 3 months later.
- If a lighter lime application (2–4 t/ha) is required, the lime can be worked into the soil at least 3 months before planting and phosphate 1 month before planting.

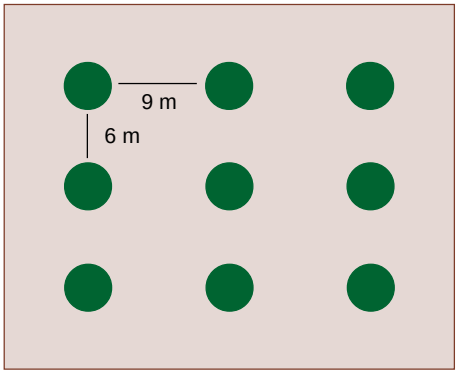
Planting

Remember that litchi trees have a long life and become large.

- Trees should be planted far apart to eliminate competition and to prevent branches of adjoining trees from growing into each other.
- The entire outer area of the tree must be exposed to sunlight and air movement.

Planting distance

A 25-year-old tree can reach a crown diameter of 12 m. If trees are widely spaced and later become uncontrollably big an economic yield will not be possible. If the trees are to be spaced closely together, size must be controlled from the start by pruning. Try to plant as many controllable trees as possible per hectare. A planting distance of 9 x 6 m is recommended for semi-intensive plantings.



The ideal planting distance is 9 x 6 m

Planting the trees

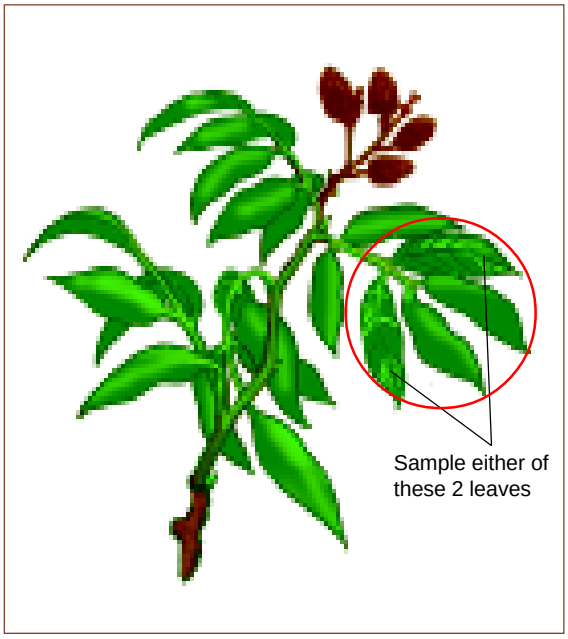
- Litchi trees can be transplanted any time of the year, but the best time is during spring or at the beginning of the rainy season.
- Planting holes should be square (in deep-ploughed soil 300 x 500 mm and in nonploughed soil 1 x 1 m).
- Mix the topsoil with compost and put it back into the bottom of the hole.
- When planting the tree, remove the container and loosen the soil around the roots without damaging the roots.
- After planting, compress the soil slightly by standing on it.
- Wet the soil around the tree immediately after planting.
- Place a mulch around the newly-transplanted tree.
- Irrigate young trees regularly after planting. They must never suffer from a water shortage or too wet conditions.

Leaf analysis

Leaf analysis is the only technique according to which sensible fertilisation can be applied to a specific planting. The following aspects are important:

- The correct time for sampling is from mid-September to mid-November.
- The correct leaf must be sampled (see figure).

- The first leaf sample of a specific planting must be accompanied by a soil sample.
- A leaf and soil sample must represent a planting of not more than 3 ha.
- The sampling method is important:
  - Select about 20 healthy trees, well distributed throughout the planting.
  - The trees must be of homogeneous appearance and representative of the average trees in the planting.
  - Sample 4 leaves per tree.
  - Do not take samples from obviously good or weak trees.



Taking samples of leaves

Fertilisation

Do not fertilise newly-transplanted trees too soon. Fertiliser should only be applied about 1 year after transplanting. The applications must be very light and broadcast evenly, but not against the stems of the trees. Irrigate after applying fertiliser.

Application and quantities

- Fertiliser should be broadcast evenly about 0,2 m from the stem to 0,5 m outside the drip area of the tree.
- Irrigate lightly immediately after application. Fertilisers must not be worked into the soil.
- As soon as the trees are established and start growing, fertiliser must be applied regularly according to the quantities given in the table.

Time of application

Quantity of fertiliser per tree per year according to age (g)

Age years	LAN 28 % N	Superphosphate	Potassium chloride
1	200	250	50
2–3	500	250	100
4–5	1 000	250	200
6–7	1 500	500	300
8–9	2 000	500	400
10–11	2 500	750	500
12–13	3 000	750	750
14–15	3 500	1 000	1 000
15 and older	4 000	1 000	1 000

Remember:

This is only a guideline; correct fertilisation can only be applied according to the soil analysis for young trees and soil and leaf analyses for fruit-bearing trees.

Nitrogen (N)

First year

– divide the nitrogen fertiliser into 8 equal monthly applications of 25 g each and apply during summer (September to April).

Second to fifth year

– divide the nitrogen fertiliser into 5 equal applications and apply during summer (September to April).

Sixth year and older

– half of the nitrogen fertiliser is applied immediately before flowering and the remainder just after harvesting.

Phosphate (P)

All the phosphate is applied immediately after harvesting.

Potassium (K)

Half of the potassium fertiliser is applied just before flowering and the remainder after harvesting.

Zinc (Zn) and boron (B)

Zinc must be applied at least 4 times a year. The following substances and concentrations are recommended per 100 ℓ of water:

- Zinc oxide at 200 g or
- NZN at 150 mℓ or
- Agri-zinc at 50 mℓ.

Spray the trees from soon after planting with 100 g borax or 75 g Solubor/100 ℓ water every 2 years.

Organic fertiliser

Kraal or chicken manure can be used as additional fertiliser at 2 or 1 kg respectively per mature (10 years) tree, spread evenly in the drip area. However, if no other fertiliser is available, kraal manure can be applied as follows:

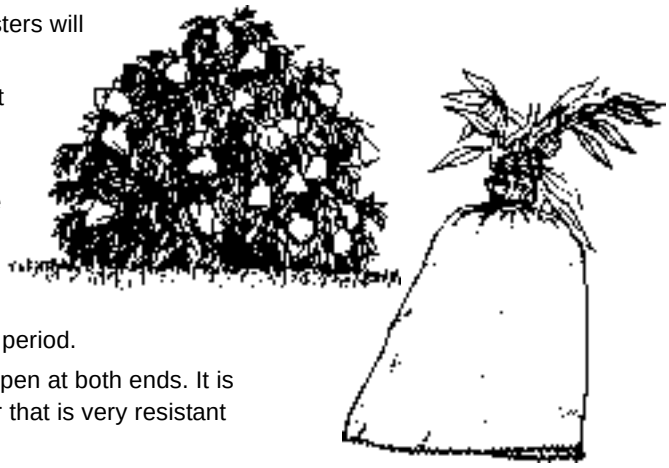
Tree age (years)	Kraal manure (kg/tree/year)	Time of application
1	5	± 1 kg every 6 weeks from September to April
2–3 4–5	15 25	Give 5 equal dressings between September and April
6–7 8–9 10–11 12–13 Maximum	40 55 70 80 100	Give ½ the quantity before blossoming and the remainder after harvesting

Water requirements

- Litchi trees need regular watering and therefore it is essential that enough water must be available from the flowering stage until after the February/March flush following the harvest.
- Because the edible portion of the litchi fruit has a water content of 86 %, the availability of water remains important during the development period.
- A water shortage will delay development of the fruit and adversely affect the size, mass and quality of the litchis.
- Irrigation must continue after harvesting to ensure that a normal growth flush occurs during February/March, just before the beginning of the dormant period.
- During dormancy (April to July) irrigation should be reduced, but the tree should not suffer drought.
- Young trees that are not producing yet are irrigated throughout the year.
- Producers normally stop irrigating the trees during the coldest months of the year (June and July) so that they can have a proper dormancy period. In areas where it is never very cold, irrigation should stop to force the trees into dormancy.

Covering litchi fruit clusters

- Covering the fruit with paperbags prevents damage from fruitflies and litchi moths, as well as sunburn and cracking.
- The best time for covering the clusters will vary from one locality to the next.
- Paperbags are at present the most suitable and also the cheapest covering material.
- The fruit develops a very attractive red colour inside the paperbags.
- Covering the fruit also extends the harvest period because fruit can be left on the tree for a longer period.
- The paperbag at present used is open at both ends. It is made from reinforced brown paper that is very resistant to the elements.



- The fruit must, however, be covered in the correct way and during the right time of the day (not early in the morning or immediately after rain), because of the risk of decay when covered while still wet. Spray against litchi moth and fruitflies just before covering.
- Remove all the leaves on the cluster stem before covering.
- Do not put more than 25 litchis in one bag.
- The bags must be fixed to hang to an angle to allow water to flow out.
- Both sides of the bag must be closed and, if necessary, a small opening must be left for rainwater to run out. The open ends can easily and quickly be stapled together.
- The paperbags will even keep fruit bats and birds away.
- Another advantage is that the fruit is handled less during harvesting and this limits damage caused by rough handling.
- When removed carefully, the bag can be used for another season.

Insect pests

Important pests include bark borers, litchi moth and fruitflies. Consult your nearest extension officer about ways to control these insects.

Litchi moth

Harvesting

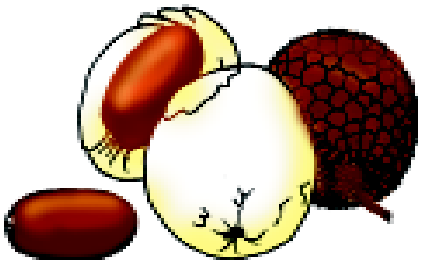
- The stage of maturity at which fruit is harvested is one of the most important factors that determine the ultimate quality at the point of sale.
- Litchis do not develop further after picking. The fruit must therefore remain on the tree until quite ripe.
- Litchis harvested too early have an unattractive colour and have a sour taste.

When are litchis ripe?

Ripe fruit has an average mass of between 21 and 25 g. Fruit with a mass of at least 21 g is therefore ready for harvesting during a normal season.

Packing

Litchis are packed as loose fruit and all unnecessary twigs or stems must be removed to ensure neat packing.



Mangoes

Mangoes are grown over a wide area in South Africa. However, the main production areas are in the Limpopo Province with the Letsitele valley/Tzaneen, Hoedspruit/Phalaborwa, Letsitele/Lower Letaba and the Trichardtsdal/Ofcolaco areas accounting for 60 % of total production. In Mpumalanga the Onderberg/Malelane region is the most important mango-production area.

Climatic requirements

- Mango trees can tolerate a wide range of climatic conditions.
- The crop is successfully cultivated under conditions which vary from very hot, very humid to cool and dry, to very hot and arid.
- The trees can survive in swampy conditions for an extended period of time, but will also survive in areas with an annual rainfall of less than 300 mm and temperatures as high as 45 °C.

Temperature

- The average minimum temperature during the winter should preferably be above 5 °C.
- Low temperatures when the trees are in full bloom, can cause the fruit to develop to approximately golf-ball size, turn yellow and then be aborted. Large numbers of these fruit result in a reduction in yield.
- Mango trees will grow and produce well in areas with very high temperatures (45 °C). However, when the maximum temperature exceeds 46 °C vegetative growth ceases, especially if it is accompanied by low humidity.
- For optimum growth and production, the average maximum temperature should be between 27 and 36 °C.
- Certain cultivars are less tolerant to high temperatures and low humidity, and the fruit will show symptoms of sunburn (Sensation, Edward, Isis, Fascell and Keitt). Cultivars with a high tolerance include Neldica, Tommy Atkins, Irwin, Lilley, Lippens, Chené, Kent, Ceriese, Kensington, Jubilee, Palmer and Zillate.

Humidity and rainfall

In South Africa the average relative humidity should preferably be 55 % or less, from October until the fruit is harvested.

The rainfall should also preferably not exceed the following:

September:	50 mm	October:	85 mm
November:	110 mm	December:	140 mm
January:	140 mm	February:	140 mm

The relative humidity and rainfall described here are ideal for the development of disease-free fruit, but unsuitable for optimum production. Where mangoes are produced under such low-rainfall conditions irrigation is of vital importance.

Wind

- Wind (even moderate winds) could cause scratch marks on fruit. Harmful fungi and bacteria can enter the fruit through these wounds. Fruit with such marks are unacceptable for marketing.
- Stronger winds will cause fruit loss, resulting in lower yields.
- Certain cultivars, such as Zill, Haden and Kent, are prone to a greater extent to fruit loss under windy conditions than others.
- Damage by wind can be minimised by:
  - Avoiding very windy areas.
  - Establishing windbreaks such as artificial structures or fast-growing trees on the upwind side of prevailing winds. It is advisable to establish mango orchards in such a manner that the rows run diagonally to the prevailing wind direction to avoid creating a funnel effect.
  - Prune the non-bearing flower panicles as soon as it is evident that these will not bear any fruit, because when they become dry and hard, they cause scratch marks on the fruit.

Elevation

In the tropical and subtropical regions, mangoes grow well at altitudes ranging from sea level to 1 200 m. However, production decreases at higher altitudes. In South Africa it is generally accepted that mango production above altitudes of 600 m is not commercially viable.

Soil requirements

Mango trees grow and produce well on various soil types. The tree often develops a fairly strong taproot shortly after planting. This taproot can continue growing until it reaches the soil water-table, and under favourable conditions can penetrate the soil to a depth of 6 m. However, most of the roots responsible for nutrient uptake are found in the top 500 mm of soil, with the largest concentrations in the top 250 mm. Depending on the conditions under which the mango is grown, i.e. dryland or under irrigation, the response to the soil type will vary.

Soil requirements for cultivation under irrigation

Drainage

- Mango trees grow best on a slight slope which enables runoff of excess water and prevents waterlogging. Depressions or basins are poorly drained and plantings on these sites should be avoided. The roots will turn black and become desiccated in oversaturated soils as a result of a lack of aeration. Under such conditions the parts of the plant above the ground will wilt and show symptoms of chlorosis.
- Mango trees do not grow and produce well in soils with impermeable layers (mottled layers, usually with a light grey of white colour, hard banks, compacted layers of stratified rocks).
- They also do not thrive on very steep slopes because excessive drainage in this case could lead to water shortages and soil erosion.

Soil depth

Under irrigation, mangoes grow well in soils with an unimpeded depth of more than 1 m. If irrigation scheduling is well planned, there should be no problem on soil with a depth of 750 mm, provided that any soil or rocky layers that restrict root growth to a depth of 750 mm allow excess water to drain easily. If not, a temporary shallow soil water-table could develop above this layer, with resulting damage to the trees.

Texture

The ideal soil texture for mango cultivation under irrigation is a sandy loam or loam (with a clay content of 15 to 25 %), but soils with a clay content of up to 50 % are also suitable.

Soil structure

- The ideal soil has a fairly loose, brittle, crumbly structure.
- Compact or strongly-developed soil structures prevent effective water infiltration and root penetration. These soils are normally associated with a high clay content in the subsoil.

Water

- Allowing the soil to dry out for 2 or 3 months before the flowering stage will promote good flower formation. This phenomenon is attributed to a simultaneous stimulation of vegetative growth during the autumn months which, in turn, influences flower formation in spring.
- Fruit drop as well as the size and quality of mango fruit seems to be influenced by irrigation at certain times. Irrigation during the developmental stage of the fruit is essential to prevent fruit drop and to promote the development of young fruit. Additional irrigation from fruit set to ripening results in a considerable improvement in both fruit size and quality.

Soil requirements for cultivation under dryland conditions

In some areas moisture losses through transpiration and evaporation are so low (because of humidity, temperature and rainfall conditions) that the soil remains moist enough throughout the year to prevent wilting of the trees. Mangoes can then be grown under dryland conditions,

provided the soil has the ability to retain moisture that can be available to the plants in drier periods. These soils have a depth of at least 600 mm and a clay content of between 15 and 30 %. Soils with a lower or higher clay content will not be able to supply sufficient moisture to the plants.

Suitability of soil types for mango cultivation

- Hutton, Clovelly and Oakleaf are suitable for cultivation under irrigation.
- Hutton, Bainsvlei, Clovelly, Avalon and Oakleaf are suitable for dryland conditions.

Chemical requirements

Soil pH

Mango trees grow best in soils with pH values of 6 to 7,2. If the soil-exchangeable aluminium (Al) is not more than 30 ppm, soils with a pH of 5,5 or higher may be used.

At pH values lower or higher than 6 to 7,2 the trees may suffer trace-element deficiencies, especially phosphate and potassium.

Trace elements

- A minimum calcium content of 200 ppm is desirable.
- The ideal potassium status is from 80 to 200 ppm.
- A phosphate content of at least 20 ppm is required.

Soil preparation

Proper soil preparation is very important because it will last for the lifetime of the plantation.

The most important advantages are:

- Better root development
- Improved soil drainage and reduced runoff
- Improved water penetration (rain and irrigation)
- Better utilisation of nutrients
- Greater tolerance towards diseases
- Larger fruit size
- Increased yield
- Prolonged economic lifespan.

Components of soil preparation

The most important components of soil preparation are:

- Proper examination of the soil (physical and chemical)
- Supplying lime and phosphate into the root zone
- Deep plough or rip cultivation
- Construction of ridges if necessary.

Soil examination

This process determines the most effective way to prepare the soil.

A soil examination should supply the following information:

- Soil type
- Soil strength (compaction)
- Soil texture
- Soil depth
- Drainage capacity of the soil.

A chemical analysis is necessary to determine lime or phosphate requirements. Soils where mangoes are to be planted should be sampled at least 9 months prior to planting.

Supplying nutrients

- Calcium and phosphate move very slowly downwards in soils. If there is a shortage of one of these elements, especially in the subsoil, it should be incorporated into the soil during soil preparation because there will not be a chance to plough it in afterwards.
- If it is necessary to rip the soil, lime should be ploughed in beforehand.

Buying nursery trees

The prospective buyer should have a close look at the trees and select only those of good quality by inspecting the foliage and flowers, internodes, graft unions as well as soil mixture and root system.

Foliage and flowers

- The foliage of a nursery tree should be glossy and green, giving a general appearance of good health.
- If the trees are flowering in the nursery, make sure that there are no symptoms of blossom malformation.

Internodes

- Long internodes are an indication of a vigorous, healthy tree.
- Avoid plants with compressed internodes and a rosette of leaves at the shoot apex, because it is an indication of a zinc deficiency.

Graft union

- An abnormal graft union indicates incompatibility, a poor rootstock or a diseased scion. A first-grade tree should have a few leaves on the rootstock below the graft union.
- Trees should have a uniform appearance and should all be grafted at approximately the same height.

Soil mixture, container and root system

- Soil mixture and container size play important roles in the production of high-quality trees.
- A mixture with a high clay content limits drainage and results in restricted root respiration and growth.

- Small containers cause the trees to become prematurely root-bound. The tree may appear healthy, but restricted root growth in the nursery will adversely affect growth in the orchard.
- The bark or growth medium should be a mixture of well-rotted compost, sand and loam which will provide good drainage and allow strong root growth.
- Containers of at least 175 x 150 x 450 mm (about 10 ℓ) are recommended for use in mango nurseries.

Cultivars

Important characteristics include time of ripening, internal quality, external appearance, fruit size, resistance to bacterial black spot and other diseases, tree size and consistent yields. None of the existing cultivars is totally resistant to bacterial black spot.

Tommy Atkins

- Early cultivar
- Large fruit (450–700 g) with an ovoid to slightly shape and an attractive skin colour
- Shelf life is good and the cultivar is tolerant to bacterial black spot and anthracnose
- Trees are of average size and produce regular high yields
- Fruit is not entirely fibreless, has a watery taste and is susceptible to internal breakdown, jelly seed and stem-end rot
- Because of its attractive external appearance good prices are realised on both local and export markets
- The cultivar is recommended for planting in all production areas

Zill

- Early cultivar which tends to produce low yields
- Fruit is fibreless, of good quality, medium sized, with a mass of 230 to 400 g and an oval to ovate shape. The fruit develops a good colour only under very hot conditions
- Trees are large and grow vigorously
- Zill is susceptible to physiological disorders such as jelly seed and does not store well.
- Main advantages are: an early cultivar and good taste
- It is recommended for planting in early areas
- Zill can be marketed locally or exported from areas where external colour develops well
- New Zill orchards are no longer being established on a large scale

Kensington

- Early midseason cultivar with little support in South Africa
- Good resistance to bacterial black spot

- Trees are vigorous and give consistently high yields
- Fruit size is medium to large (> 450 g). Fully-ripe fruit has an unattractive yellow colour with slightly orange cheeks
- Shelf life is good
- Physiological disorders such as jelly seed are rare

Irwin

- Early midseason cultivar but not suitable for all the production areas
- Trees are dwarfed to some extent and give consistently good yields
- Fruit is elongated, of average size (340–450 g), with an attractive colour and can be stored for long periods, but is slightly fibrous
- Irwin is highly susceptible to black spot and the fruit tends to split in areas with high humidity
- Recommended only for hot, dry areas

Neldica

- Early cultivar which ripens at the same time as Zill and Tommy Atkins
- Fruit shape is slightly elongated and round. Skin colour is a very attractive red, pale red and yellow. The fruit is large (400–500 g) with limited fibres around the seed
- It shows great tolerance to bacterial black spot at Messina but not at Nelspruit. It is not susceptible to scorch
- The trees are moderately vigorous
- Recommended for hot, dry areas and is suitable for both local and export markets

Kent

- Trees are large and give consistently satisfactory yields
- Harvesting period is classified as late midseason
- Fruit is large (500–700 g) with a rounded base, fibreless and the internal quality is very good. The skin colour in cooler, humid areas, is often poorly developed
- Kent is considered as one of the best tasting mangoes
- Highly susceptible to bacterial black spot and is only recommended for hot, dry areas

Heidi

- Late cultivar
- Fruit size varies from medium to large (450–600 g). The fruit is round, slightly elongated with flat sides. The skin colour is very attractive and appears purple, red and yellow when ripe
- Excellent taste and the fruit is fibreless
- Good tolerance to black spot, even under conditions of moderate to severe disease prevalence
- Trees have a compact growth habit and are slightly dwarfed
- Leaves are typically long and very narrow
- Widely recommended although susceptible to sunburn in hot, dry areas
- Fruit size can be reduced to some extent in very hot regions
- Suitable for both local and the export markets

Sensation

- Late cultivar and a consistently good producer
- Fruit is fibreless with an attractive colour. Fruit size is small (200–350 g). If left on the tree until it develops a yellow colour, it tends to develop jelly seed
- Trees are dwarfed and can therefore be planted at higher densities than most other cultivars
- Grown for both the local and export markets
- In late areas there is the benefit of good prices realised at that time
- Trees should receive nitrogen fertiliser immediately after harvest to ensure an adequate post-harvest flush
- A disadvantage of this cultivar is that the fruit ripens unevenly, which necessitates selective harvesting. In very late areas Sensation tends to bear alternately
- The cultivar shows tolerance to bacterial black spot and is recommended for all areas

Keitt

- Keitt is the latest of all the recommended cultivars
- The fruit size is medium to large (400–500 g). The fruit is fibreless, oval with rounded base. Skin colour often poor. The fruit has an exceptional keeping quality and can be left on the trees long after normal harvest time without the risk of jelly seed developing
- The trees are of medium size and the growth habit is characteristically open and appears somewhat disorderly with slender ranky branches
- The cultivar is highly susceptible to bacterial black spot and is only recommended for very hot and dry areas

Orchard planting

Tree spacing

Guidelines for mango planting distances

Cultivar	Standard semi-intensive planting (a degree of manipulation is still necessary) (m)	Intensive planting (for specific training system, manipulation techniques, rootstocks and soil types) (m)
Sensation	5 x 2,5	5 x 1,5
Tommy Atkins	6 x 3	5 x 2
Heidi	6 x 3	5 x 2
Keitt	6 x 3	5 x 2,5
Kent	6 x 3	5 x 2

Rootstock, soil and climate must be taken into account and adaptations made accordingly

Planting time

Although mango orchards are planted throughout the year (especially in the warmer production regions) the best time is August to September after the risk of cold weather has passed.

Planting procedure

- After proper soil preparation the holes for planting should be large enough for the bag containing the tree to fit inside. Cut the bags open before planting to ensure that the trees have well-developed root systems and the roots are undamaged.
- Irrigation systems should already be installed before planting the trees.
- As soon as active growth is observed after planting, each tree should receive 4 applications of 25 g LAN at intervals of 6 weeks, i.e. a total of 100 g for the first year.
- A groundcover should be established in the work-row between the tree rows just after planting.

Irrigation

Mangoes are to some extent drought resistant, but will not achieve optimum growth if they do not receive sufficient water (especially during the fruit-developing phase). Correct irrigation is very important for maximum production in most mango producing areas of the country.

Water requirements

The annual water requirement (with no rainfall) of mature mango trees is 11 000 m^3/ha/year. Some degree of stress during flower bud development (May to July) is, however, advantageous. Water usage of trees subjected to water stress during flower-bud development is 9 500 m^3/ha/year.

The seasonal water usage of trees not subject to water stress, varies from 20 to 44 m^3/ha/day from June to November respectively.

Liming and fertilisation

Preplant preparation

Soils to be used for cultivation of mangoes should be sampled at least 9 months prior to planting. The correct quantity of lime should be applied according to soil analysis.

Established orchards

Recommendations for macronutrient fertilisers differ for trees under irrigation and those grown under dryland conditions. However, application of micronutrients, (generally foliar), are the same for both conditions.

Macronutrients for mangoes under irrigation

During the first 4 years, nitrogen (N) can be applied as 4 equal instalments in July, October, January and April. Thereafter, with fruit-bearing trees, N application will depend on cultivar and climatic variables which influence the seasonal stage at which the fruit is ready for harvest, i.e. early, mid or late season (December/January, February or March respectively). An orchard may, however, be ready for harvest at various stages in different seasons. Depending on the season of bearing, general times and rates of fertilisation are given in the table.

Application after August may induce excessive vegetative growth to the detriment of fruit set and development and is therefore undesirable.

Time and rate of N application

	Proportion of N to be applied		
Harvesting time	**After harvest**	**March**	**May to August[1]**
December/January (early season)	1/2	1/4	1/4
February/March (mid/late season)	3/4		1/4

[1]Stage at which flower panicle begins to shoot

Application time of other macronutrients (primarily K and P) is not as critical as N. However, to minimise the risk of rootburn these nutrients should be applied in between applications of N. Potassium (K) fertilisers, because of their high solubility, should be split into the same number of applications as N. Phosphorus (P) sources, on the other hand, have comparatively low solubilities and can all be applied at the panicle stage, as can additional lime or gypsum.

Macronutrients for mangoes under dryland conditions

Producers are advised to apply half of the fertiliser following harvest and the rest in March, i.e. the rainy season. Potassium should be applied at least a month later after the post-harvest N application, because simultaneous application with N could induce fertiliser burn. Phosphorus, lime and/or gypsum can be applied at the same time during the off-season winter months.

Micronutrients

Micronutrients are essential to all plants and include Zn, B, Mn, Fe, Cu and Mo. Soils suitable for mango production are generally low in zinc (Zn) and boron (B). It is therefore important to supplement these elements according to leaf analyses. Nutrients can be applied by means of foliar spray once a month after harvest while trees are flushing, at blossom break, at fruit set and once a month after fruit set up to 1 month before harvest. Zinc and boron are compatible and can be sprayed simultaneously, preferably during cooler times of the day.

Lime and fertiliser placement

Requirements for mango trees of different ages are provided in the table below.

General fertilisation according to tree age in g/tree/year (in absence of leaf and soil analyses)

Year	Nitrogen (N)	Phosphorus (P)	Potassium (K)
1	70	25	200
2–3	140	50	200
4–5	210	75	250
6–7	280	100	375
8–9	350	125	500
10 or more	420	150	625

- Prior to planting, lime must be mechanically incorporated into the entire soil volume in which root growth is expected.
- In established orchards, mechanical incorporation is not practical and under such conditions, gypsum should be applied. While gypsum is not a liming material and has no neutralising power, it may lead to a significant reduction in Al in the subsoil.
- Following sufficient time for lime to neutralise soil acidity (preferably about 6 months), P can similarly be incorporated into the soil by ploughing or discing. Most soils in mango areas of South Africa do not, however, have P deficiency problems.
- Nitrogen and potassium fertilisers should be applied as topdressings once trees are properly established and growing vigorously, preferably after 1 year.
- Nutrients should only be applied to the drip/irrigated area of a tree. Fertiliser close to the roots could result in scorching.
- Plants cannot absorb nutrients from a dry soil.
- Micronutrients B, Cu, Fe, Mn, Mo and Zn are essential for all plants.
- Boron deficiency results from excessive leaching, overliming and excessively dry weather. Deficiencies can be prevented by preplant soil application of 50 g Solubor/tree (levels of 100 g could be phytotoxic).

Concentrations of micronutrients to be used for foliar applications to mangoes are presented in the table. A single spray should be used for minor deficiencies while 2 or 3 sprays should be applied where major deficiencies occur.

Recommended concentrations for foliar sprays

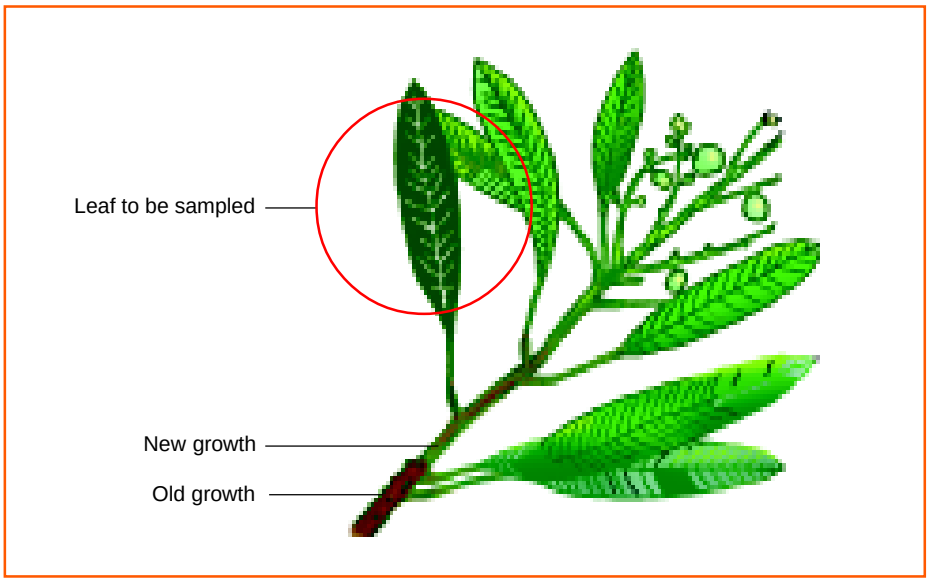
Deficient nutrient	Treatment
B	Solubor at 300 g/100 ℓ water
Cu	Copper oxychloride at 200 g/100 ℓ water
Fe	Fe-chelate/sulphate applied as specified
Mn	$MnSo_4$ at 200 g/100 ℓ water
Zn	ZnO at 200 g/100 ℓ or NZN at 150 mℓ/100 ℓ water or as specified

Leaf and soil analyses

The aim of leaf and soil analyses is to determine the nutrient status of mango trees or suitability of a soil for the production of mangoes.

Leaf sampling

- A single leaf or soil sample should be representative of an area not greater than 3 ha. However, if there are soil variations separate leaf and soil samples must be taken and the orchard management adapted accordingly.
- The time of leaf sampling as well as leaf position, is very important and is shown in the figure. Leaf analysis is only applicable for producing mango trees (normally a tree age of 5 years and older).
- Select about 20 healthy trees by walking diagonally from the corners through the orchard (see figure on p 72). The trees should be homogeneous in appearance and representative of the orchard.



Sample 7-months-old fully developed hardened-off leaves from fruit-bearing twigs

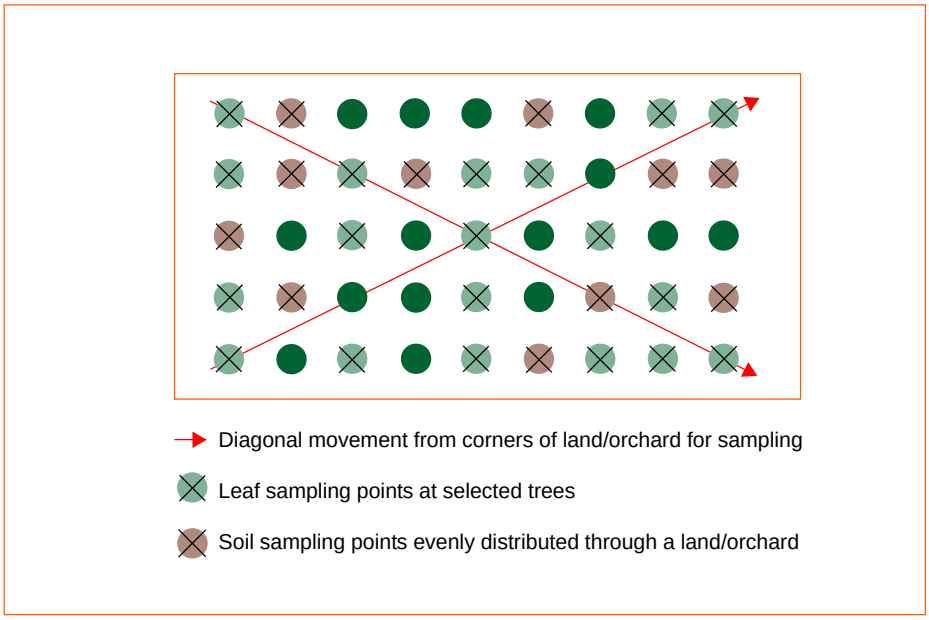
- Exceptionally good or poor trees must not be sampled.
- The 20 selected trees must be clearly marked, for example with paint, so that both the soil and leaf samples can be taken from the same trees every year.
- Where possible, pick 4 leaves from alternate sides of the tree at about shoulder height. Eighty leaves per sample should be sufficient.
- Different cultivars should be sampled separately.
- Leaves sampled must be free of sunburn, disease and insect damage.
- Leaf samples should be collected in the morning, after the dew has dried off.
- Leaf samples should not be taken if trees are under stress, i.e. drought or high temperatures. After a heavy downpour, wait at least 2 weeks before taking samples.
- After sampling, leaves should be placed in clean, perforated or open plastic bags.
- If samples cannot be delivered immediately (within 48 hours), they can be stored in a refrigerator and should be transported in a cooler bag. The sample must be accompanied by the relevant orchard information including previous production figures, tree age and fertiliser programmes of the past. Any problems concerning the specific orchard, such as small fruit, should be mentioned.

Soil sampling

Sampling depth	Topsoil 0–300 mm Subsoil 300–600 mm

Number of samples

A sample comprises of a combination of at least 10 subsamples. A composite sample should not represent more than 3 ha. Samples from different orchards or lands should not be combined.



Taking representative soil and leaf samples

Distribution of sampling points

Take samples by walking diagonally from the corner through the orchard or land. In an established orchard, topsoil and subsoil samples should be taken at the same trees selected for leaf sampling. Soil samples must be taken under the canopy of trees in the middle between the stem and the drip area perimeter.

Method of sampling

Clear the soil surface 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. The top and subsoil samples are taken by removing a core of soil from the top 0 to 300 mm and then from 300 to 600 mm soil depth, respectively.

Packaging of samples

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

Topsoil and subsoil must be packed separately and the depth of sampling, orchard/land must be indicated clearly.

Weed control

Weeds are usually controlled between rows in an orchard by means of mechanical mowing with a rotary cutter (slasher driven by a tractor).

Chemical mowing, where herbicides are used, can be applied at low concentrations as an alternative. The idea is not to kill all the weeds but to slow down growth. Chemical control is normally followed by mechanical mowing. The advantage of this method is that mechanical mowing is limited, resulting in less traffic in the orchard.

Diseases

Anthracnose

It is an important post-harvest fungal disease which affects all mango cultivars to varying degrees. Because the disease is rain-linked, the fruit will be less affected in warm areas where it matures early and where it does not hang on the trees throughout the entire rainy season.

Symptoms

Small brown-black spots appear on the leaves, which could later enlarge and coalesce to form large blackened irregular patches, usually with a faint yellow halo. The tissue will die and later fall out.

Control

During wet periods control measures are important, especially when the trees are in bloom, to prevent losses as a result of blossom blight and also during fruit development to reduce post-harvest problems. Specific sprays for anthracnose are not usually necessary because the fungus is controlled by the fungicide programme followed for powdery mildew and bacterial black spot.

Powdery mildew

This is a fungal disease found in all mango-growing areas and in the case of all cultivars. It is usually a lesser problem in areas with warm winters. If not controlled properly, it could cause crop losses of 80 to 90 %.

Symptoms

Infection starts as isolated white powdery patches on young tissue of the shoots, leaves, flowers or fruit. Once a certain stage of maturity is reached, the fruit is no longer susceptible.

Infected flowers fail to open and drop from the inflorescence without fruit formation. On fruit which has started to form, mildew causes skin cracking and corky tissue on fruit infected at about pea size. Younger fruit will drop. After the fruit matures beyond marble size there is no longer a risk.

White powdery patches can occur on young leaves which then curl and become distorted. As the leaf matures and the fungus disappears, brown patches remain. Mature leaves are not susceptible.

Control

Various fungicides are registered for effective control.

Bacterial black spot

Symptoms

Bacterial black spot is a rain-related disease.

Fruit lesions begin as water-soaked spots which later become raised and black, cracking open to exude

a gum-containing bacterium. There is often a tear-stain pattern where the gum has washed down the fruit and started a number of new lesions. Infection of small fruit and especially the fruit stalk will cause fruit drop.

Control

Copper sprays are the only method of combating the disease and are not always successful when disease prevalence is high. One or two post-harvest copper sprays to cover the post-harvest flush and final stage of the rainy season are effective in reducing inoculum pressure during the following summer.

Malformation

It is a fungal disease which is spread by grafting and buying infected trees from nurseries. Blossom malformation is easy to control, but if left unchecked can devastate an orchard.

Symptoms

Affected flowers look like cauliflower heads. The axes of the panicles are shorter and thicker than normal, branch more often, and a profusion of enlarged flowers is produced. These panicles develop more slowly than normal, retaining their green colour but the flowers are mostly sterile.

Control

The disease can be eliminated by breaking off affected panicles and putting them in black plastic refuse bags and allowing these to ‘cook’ in the sun for a day or two, or by burning. If this is done every year the incidence of the disease becomes insignificant.

Pests

Fruitflies

Mangoes can be severely damaged by female fruitflies laying eggs in the fruit and by the maggots (larvae) which then develop in the flesh of the fruit.

Control

Successful fruitfly control in mango orchards depends on a combination of the following:

- Eradication of invaders (host plants such as bug tree and brambles)
- Orchard and yard sanitation by removing on a regular basis all mangoes and other fruit that have dropped in the orchard or yard and destroying these immediately
- The use of traps to determine when a population build-up occurs. By making weekly counts of the number of flies in the traps, a sudden increase in the population can be detected and chemical control can commence
- Regular poison bait applications. Chemical control of adult fruitflies in mango orchards is based on weekly applications of a poison bait on the trees. The poison bait contains a mixture of insecticide plus a lure plus water.

Ingredients of a poison bait for fruitflies

Insecticide/100 ℓ water	Lure/100 ℓ water
50 g trichlorfon SP or 175 mℓ mercaptothion EC or 300 g mercaptothion WP (Hymlure)	250 mℓ protein hydrolysate (417 g/ℓ) (Nasiman) or 250 mℓ protein hydrolysate (500 g/ℓ) (Buminal) or Dilute 1:1 and use 400 mℓ protein hydrolysate (750 g/kg) or 400 mℓ protein hydrolysate (425 g/ℓ) (Hymlure ready)

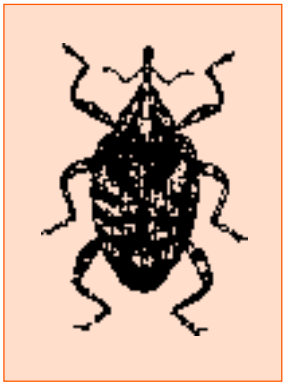
Consult the latest issue of *A guide for the control of plant pests* or *A guide for the control of plant diseases* for further information on poison baits. This publication is available from the Resource Centre, Directorate Agricultural Information Services, Private Bag X144, Pretoria 0001.

The poison bait is applied to the tree in the form of large-droplet sprays at a rate of 250 to 1 000 mℓ/tree, depending on tree size. It is not necessary to wet the whole tree; a section on one side of the tree will be adequate.

Apply poison bait as soon as fly counts in the traps show a sudden increase. Poison baits should be applied long before the fruit starts colouring. A 10-day safety period must, however, elapse between the time of final application and harvesting.

Mango weevil

The mango weevil is present in all the mango producing regions of South Africa and is spread through the transportation of infested fruit. As the weevil develops inside the mango seed, it can be transported inadvertently from one place to another. No alternative host plants are known.



Mango weevil

Tip wilter

Symptoms

The symptoms are most apparent in the seed. Infestation is also evident as small, dark marks on the fruit skin where the female weevil laid her eggs. With cultivars ripening towards the end of February and later, the weevil which developed in the seed, feeds through the fruit skin to the outside, resulting in an unattractive hole in the fruit. The pest status of the mango weevil has consequently increased.

Control

Dropped fruit in the orchard or discarded seeds left lying around are the major sources of infestation. Fruit should be buried at least 600 mm deep or finely chopped with a hammer-mill. The most important period for orchard sanitation is during January and February as most weevils have by then become adults and could escape from the seeds.

Tip wilter

Tip wilters can be a serious pest on young mango trees of up to 4 years old. They are black, about 25 mm long and live on plant sap. In mango trees, they concentrate on young, new flush, leaf veins or flower stalks. Plant tissue dies off at the feeding points. Host plants include weeds, vegetables, ornamental plants, granadillas, citrus and also mangoes. Tip wilters secrete a repugnant odour when disturbed. They can cause considerable growth retardation, but are of minor importance on large trees.

Control

Hand collection on a regular basis.

Harvesting

Achar fruit

Many growers have peach mango trees or other fibrous types. The fruit is harvested while still relatively small. The seed should not be allowed to harden because this causes rejection by the factories. Fibreless types can be used for achar and this often comprises small fruit that would otherwise drop naturally, or fruit where pollination was unsuccessful and the fruit is seedless and likely to drop (mules).

Local market

If fruit is to be marketed locally, it can be allowed to mature for longer periods on the tree. This will give it a better colour and flavour. However, if the fruit is left on the tree for too long, it will drop in a process known as spontaneous ripening.

Export

Only the best-quality fruit is suitable for export, as it has to undergo transport and cold storage for 28 days in order to reach foreign markets by sea. Fruit picked too green will never ripen properly whereas overripe fruit will spoil as a result of softening and the development of various diseases. It is therefore important to start picking at the correct stage.

Maturity

Maturity describes the stage of internal fruit development. A fruit is considered mature when it has reached the stage at which, after harvest and ripening, its eating quality will appeal to the consumer. Mango fruit is harvested at the so-called mature-green stage. This is the stage of physiological maturity at which ripening will occur, while still allowing time for handling and marketing. Maturity can be measured by using a colour chart and must not be confused with ripeness.

Ripening

Ripening is the process which transforms a mature fruit into an attractive edible one.

Ripeness is quite distinct from maturity. A mango may be mature, but not ripe. It is only ripe when it is ready to eat.

A mature mango will ripen properly, whereas an immature one will not. The stage of maturity at picking will affect the speed of ripening, and the final quality of the edible fruit. When the fruit is removed from the tree several days before the onset of ripening, it is initially hard and green. The fruit progressively softens, changes colour and develops an aroma at a rate determined by the storage conditions and the maturity of the fruit at harvest.

If fruit in a carton is of mixed maturity, it will be difficult to recommend a suitable storage temperature.

Handling (orchard to packhouse)

- Fruit should be handled with extreme care. Excessive tree height is a distinct disadvantage. Pickers should keep their fingernails short to prevent fruit damage. The use of linen-type gloves is not advisable because the stem-end latex exudation would later cause the gloves to become abrasive.
- Each picker should be provided with a soft rag which should be rinsed frequently in a bucket of water to which a detergent has been added. The rag is then used to wipe off and neutralise most of the latex (the juice exuding from the stem).
- Latex, under some circumstances, can cause severe scorch marks on the skin of the mango. Placing the fruit on the ground to drain off latex is not recommended, as this can lead to post-harvest diseases.
- It is wise to pick mangoes selectively for export by sea, because the fruit will only be reaching the consumer after a long time lapse. Because fruit size is all-important for export mangoes, pickers should be provided with rings fashioned from wire, to assist them in determining the minimum size.
- Fruit should be carefully placed in non-abrasive containers and attention should be given to the prevention of sunburn (keep lugboxes in the shade).

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 °C, production is only recommended in areas where the average daily minimum temperature during midwinter never drops below 5 °C.
- Ideally, night temperatures should not drop below 12 °C.

  The optimum temperature range for papayas is between 25 and 28 °C.
- Temperatures higher than 36 °C and lower than 17 °C for extended periods of time will adversely affect the growth of the trees.
- At average day temperatures (± 23 °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.

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 %).

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.

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.
- 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 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.

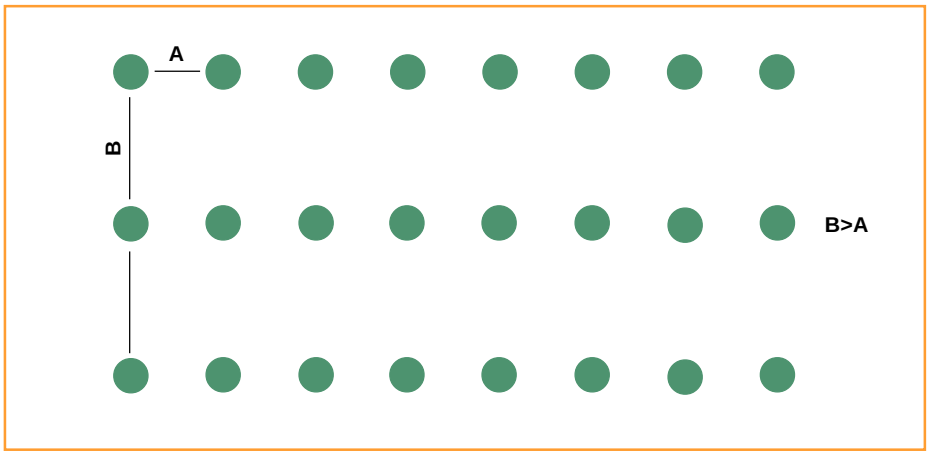
- For export, small fruit (300–500 g) with an outstanding shelf life is required. Presently Sunrise Solo, Baixinho and to a lesser extent Af-1, are suitable for export.
- Chainstores require fruit with a good shelf life and for prepacks, fruit not bigger than 1 200 g. The Tainung varieties as well as 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 Fl-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 Fl-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.



Schematic illustration of the rectangular planting system

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.

Orchard orientation

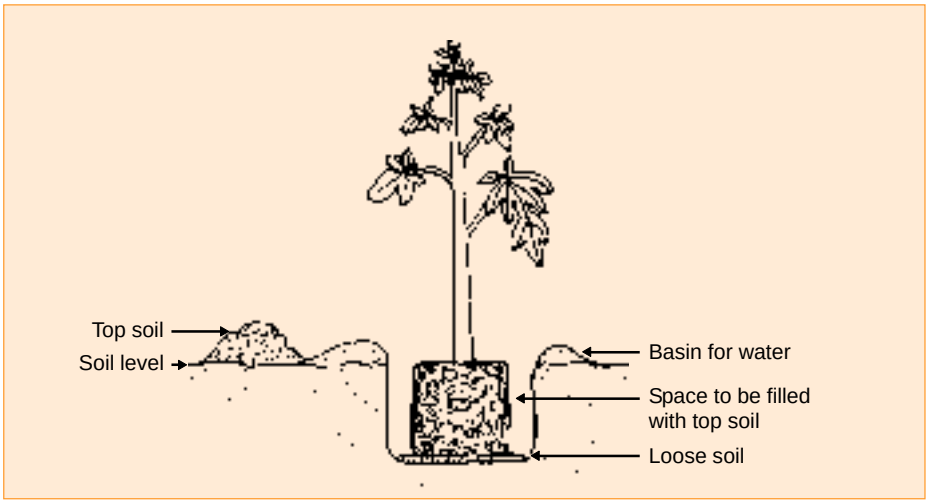
For optimal interception of sunlight orchard rows should run north/south. This orientation gives a more even distribution of light on both sides of the trees than in the case of trees planted in an east/west direction. In cases where a north/south orientation is not possible the producer should allow 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.



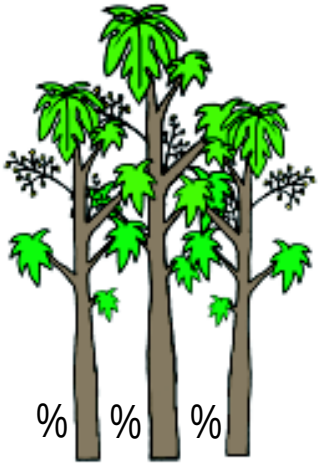
Planting a papaya tree

Preparing the planting positions

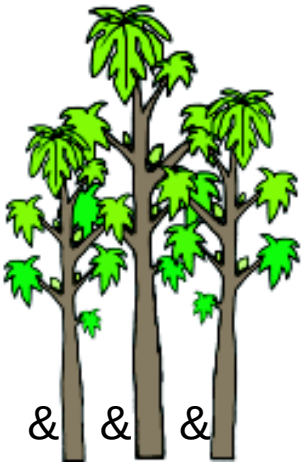
- Because the young papaya plants are not in very large bags, a small hole made with a spade at each planting position is all that is needed.
- At each planting position remove one spadeful of soil which should leave a hole approximately 200 x 200 x 200 mm.
- Just before the plants are planted out the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

Planting

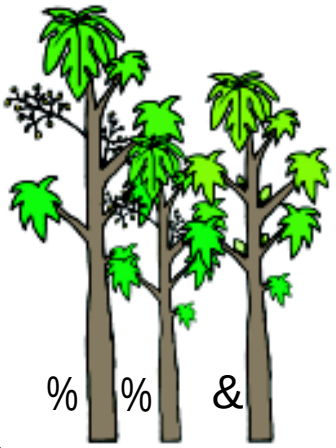
- Make a slit in the plastic bag down one side to remove the bag and place the plant in the hole. Do not break up and loosen the roots because this will cause the plants to lodge later.
- If there is more than one plant in a bag do not separate them for the same reason.
- Rake in the soil from around 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.

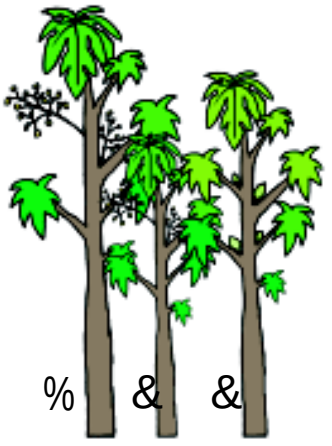


When there are only male trees at a planting position, select the earliest flowering male and cut down the others at soil level or slightly below



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

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.

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

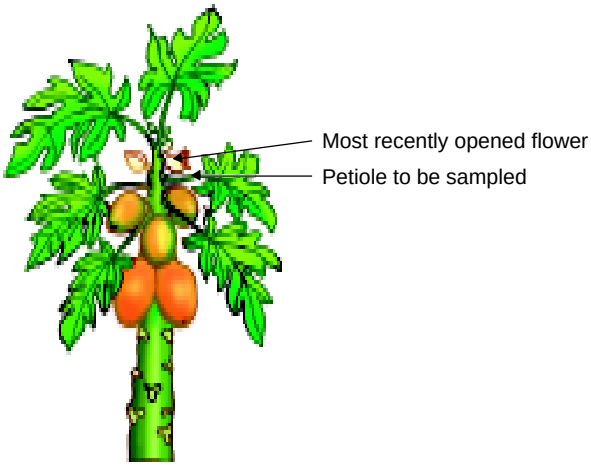
Time of year	Litres/tree/day
Establishment	6–13
First autumn	6–13
First winter	4– 9
First spring	9–17
First summer	13–26
Second autumn	9–17
Second winter	6–13
Second spring	13–26
Second summer	17–34

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.



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

- 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.

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.

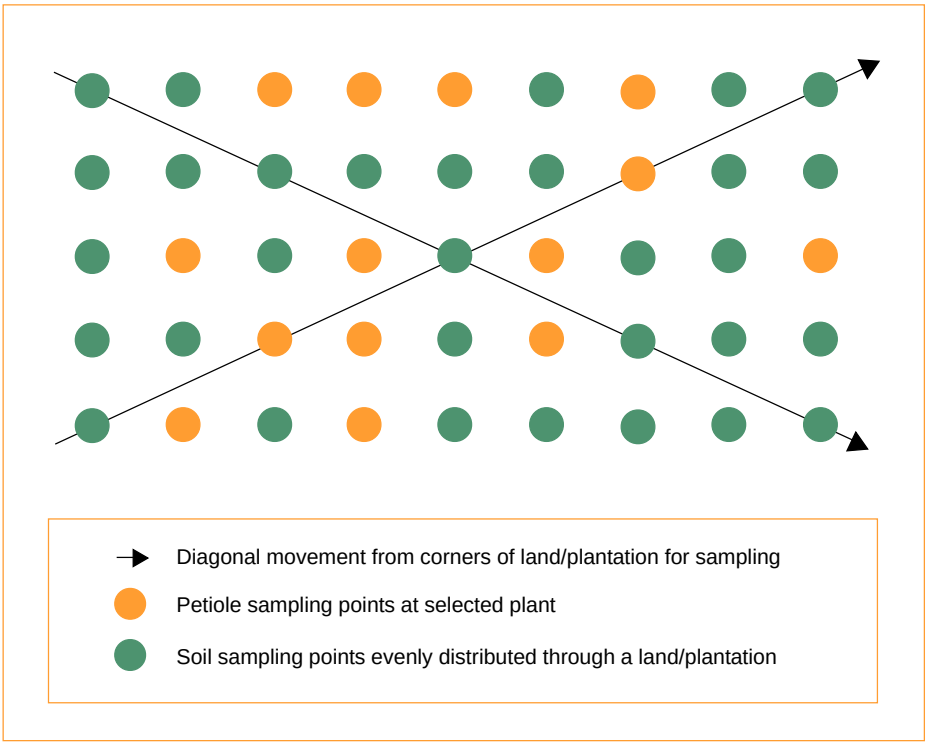
If a soil tube or auger is not available a spade can be used, and two buckets, for the top and subsoil respectively.

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.



Taking representative soil and leaf samples in a block

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.

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.

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 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 m² 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/m² 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/m² 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_2O) 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.

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.

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 watersource 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.

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.

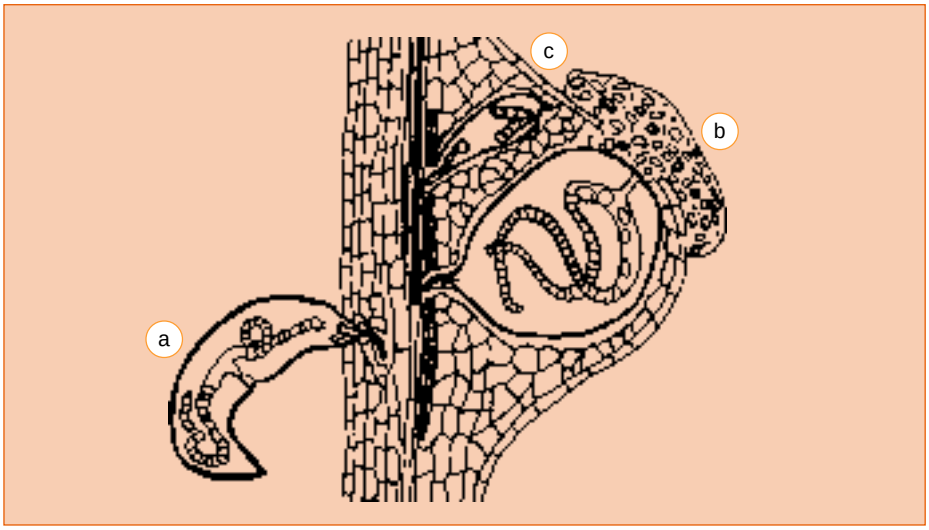
Control measures for papaya diseases

- **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.

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.



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

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.

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 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
- Chainstores
- Export
- Greengrocers
- Roadstalls
- 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.

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.

Pineapples

The main producing areas of pineapples in South Africa are Northern KwaZulu-Natal and the Eastern Cape and, on a smaller scale, the Limpopo Province. It is one of the most important subtropical crops cultivated in the country.

As it is indigenous to the tropics, the crop requires areas where the climate is warm, humid and free from extreme temperatures (25 °C being optimal). These areas have a great potential for pineapple production.

There are 5 major pineapple groups grown throughout the world. Two of these, Cayenne and Queen, are widely cultivated in South Africa.

Cayenne and Queen cultivars

The **Smooth Cayenne** cultivar is used for both canning (75 % of which is exported) and as fresh fruit. The **Queen**, because of its high sugar content and unsuitable canning qualities, is cultivated only for fresh consumption. However, because production of the Queen pineapple is more costly, fresh consumption is shifting towards the Cayenne.

Cayenne plants and the fruit are normally larger than that of the Queen, with succulent yellow fruit. Queen fruit has a golden yellow colour and is less juicy.

Planting requirements

Pineapples can be grown in a variety of soil types but prefer mildly acid soils (pH 5,5–6,5). However, there are certain requirements for successful pineapple production, which include:

Preparing the soil

- Remove trees, stumps and stones
- Subsoil (rip) to a depth of 800 to 900 mm under dry conditions
- Disc, plough and till the soil a number of times, to achieve a fine tilth, for effective plant rooting
- Ridge the soil for better drainage, temperature and to improve aeration
- Have soil samples analysed at least 6 months before planting to determine fertilisation and fumigation requirements

Planting material

Unlike many other crops grown from seed, pineapples are grown by planting various parts of the plant according to the cultivar, where it is going to be produced, and the cultivation methods practised in the area.

Although crowns are mostly used as planting material for the Cayenne cultivar, they are considered uneconomical for the Queen cultivar because of the length of time they take to bear.

Suckers are planted in the case of Queen pineapple production. Slips bear sooner than crowns but they require a great deal of labour (to break them out and to remove the small fruit attached to their bases). Stumps are generally used when no other planting material is available.

A crown or top

Planting time

Plant pineapples between July and December.

Why?

- For rapid growth and uniform stand
- The temperature during this time ranges from satisfactory to ideal

Do not plant between February and April.

Why?

- Temperatures become progressively lower
- Retarded growth, poor and uneven stand

Farm planning, selection of soils and land layout

Consider the following factors when designing the layout of the land where you are going to plant pineapples as they will affect production:

- **Climate—**is it warm, humid and frost free? The occurrence and intensity of rainfall should also be considered
- **Soil type—**clayey loams or sandy soils are ideal for planting
- **Natural obstacles—**rocky outcrops and vleis
- **Soil conservation—**unprepared soil usually results in poor plant uniformity, root development and weed control
- **Position of windbreaks—**to protect soil and crops
- **Topography—**gentle slopes will require a layout different from that for steep slopes. Steep slopes are more difficult to manage and cultivate (more powerful machinery is required)

The aims in the layout of a pineapple land are to:

- control water runoff and thereby limit soil erosion
- facilitate good drainage and prevent root and heart rot
- uniform distribution of sunlight to all plants
- have roads allowing machinery easy access to the pineapple plants (to expedite harvesting and spraying).

Planting

Planting is done by hand, with or without the aid of a planting machine. Use of the latter results in uniform, neat plantations.

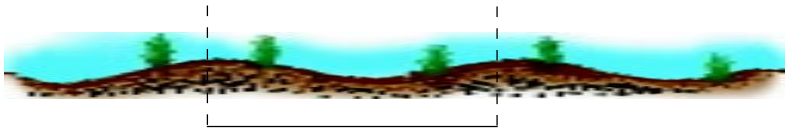
Plant spacing

Spacing from ridge centre to ridge centre: 1,5 m.

Each ridge must carry a double row of plants.

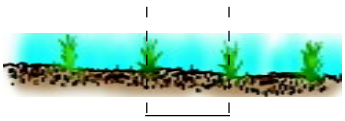
Spacing between rows should be 600 mm.

Spacing between the plants in the row: 300 mm.



1,5 m
Spacing from ridge centre to ridge centre

600 mm
Spacing between rows



300 mm
Spacing between plants in the row

Weed control

For the control of most broad-leaved weeds and annual grasses, contact herbicides can be used.

Apply pre-emergence herbicides immediately after planting the pineapples, before root development and weed emergence.

The herbicide should be applied according to the type of soil:

- Initial weedkiller application (spray)
  - 3–5 kg bromacil/ha: low rate for sandy soils
  - 3–5 ℓ diuron/ha: low rate for sandy soils
  - 5–6 ℓ atrazine/ha: where euphorbia is a problem
  - 3–4 ℓ ametryn/ha: if weeds are already present
- Booster applications (at 12 months interval)
  - 2 ℓ diuron/ha
  - 2 kg bromacil/ha: at grower's discretion
  - 4–6 ℓ atrazine/ha: if euphorbia is present
  - 3–4 ℓ ametryn/ha: if weeds are already present

Pest and disease control

Effective control measures are available for the most important pests and diseases. Pesticides used to control soil pests and diseases should be incorporated into the soil before ridging, with booster applications if required.

Pests above the soil level are usually controlled by spraying with a foliar pesticide during the period when the pests are most active.

Always read the label on the pesticide containers.

Why?

- To know if pH sensitive or biodegradable, i.e. whether it breaks down rapidly in direct sunlight
- To find out how to get the desired control with minimum impact on the environment
- For the safety of workers

Fertilisation

Use the following fertilisers

Hand applied fertiliser:	ammonium sulphate 100 N (sulphate of ammonia) —10 pockets/ha
Phosphate:	drilled into the ridges 0–300 kg/ha (Saaifos and zinc)
Potassium:	broadcast before ridging 0–400 kg/ha (potassium chloride)
Mixture:	drilled/broadcast 0–600 kg/ha (0:1:6 + Mg/Zn)

Forcing agents

With the use of forcing agents, the pineapples can be made to bear fruit at virtually any time of the year.

Why?

- It initiates flowering, shortens crop cycle and increases yield
- It ensures uniform, complete and concentrated cropping

Fruit colouring or yellowing

Fruiting agents can also be applied to colour fruit, by spraying or brushing onto fruit. This ensures uniform colouring of the fruit in a plantation.

Irrigation

The pineapple plant is able to utilise rainwater and even dew very effectively. Therefore, the heavy dew that occurs in the coastal regions is so valuable to pineapples that irrigation may not even be necessary. Supplementary irrigation could, however, sometimes be essential and of great value.

Harvesting

Harvesting should be done 7 to 14 days after yellowing. It is labour intensive because workers walk in the space between ridges to pick the fruit by hand, loading it into baskets, or onto a boom harvester.

After harvesting the crowns are broken off (not twisted) and left on top of the plants in the field or are placed in bags to be collected at a later date for planting.

Make sure that the fruit is not too green or too ripe when harvested, not bruised or damaged and that it is not affected to a large extent by any physiological problems.

Cashews

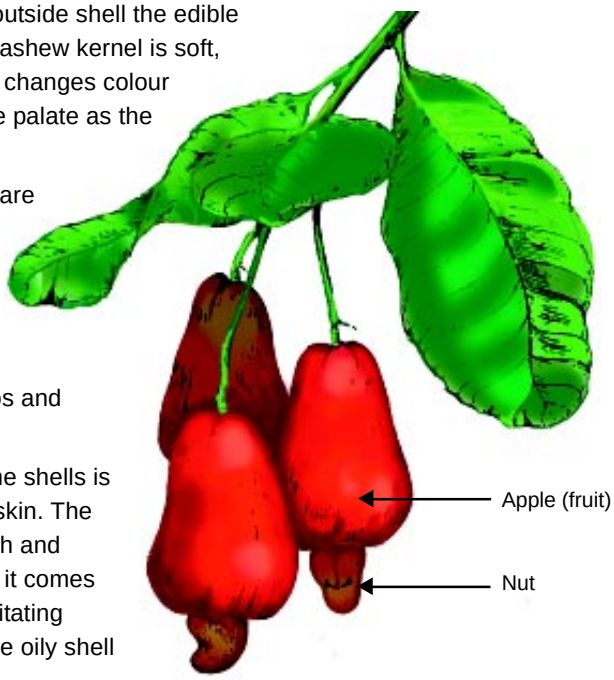
The tree

The cashew-nut tree is a fast grower and an evergreen tropical tree. It grows to a height of 12 m. Blossoming takes place between November and January. Seedling trees flower in the third year after planting. The fruit ripens fully within 2 months.

The fruit (nut)

The nut is attached to the lower portion of the cashew apple which is conically shaped. The cashew nut (seed) hangs at the bottom of the apple, and is c-shaped.

The cashew seed has within the outside shell the edible kernel or nut. In its raw form the cashew kernel is soft, white and meaty. When roasted it changes colour and taste. Salted, it appeals to the palate as the most delicious nut.



Cashew apples and cashew nuts are excellent sources of nutrition. The cashew apple contains five times more vitamin C than an orange and contains more calcium, iron and vitamin B1 than other fruit such as citrus, avocados and bananas.

Cashew shell oil extracted from the shells is caustic and causes burns on the skin. The mucuous membranes of the mouth and throat are severely affected when it comes into contact with shell oil or the irritating fumes emitted during roasting. The oily shell liquid has many uses.

Climatic requirements

- Cashew trees are genuinely tropical and very frost sensitive.
- The trees grow in a wide spectrum of climatic regions between the 25 °N and S latitudes.
- Although the cashew can withstand high temperatures, a monthly mean of 25 °C is regarded as optimal.

- Yearly rainfall of 1 000 mm is sufficient for production but 1 500 to 2 000 mm can be regarded as optimal.
- The cashew tree has a well-developed root system and can tolerate drought conditions. Rain during the flowering season causes flower abortion due to anthracnose and mildew.
- During harvesting, while nuts are on the ground, rain and overcast weather causes the nuts to rot or start germinating.
- Nuts germinate within 4 days when lying on wet soil.

Trees grow well at Pongola, Hluhluwe, Mtubatuba and Makhathini where the climate can be described as warm-subtropical. The Natal coastal region north of Empangeni as well as the Pongola valley are suitable areas for cashew production. Regions in the interior, such as Malelane and Hoedspruit, with warm summers and winters are also suitable. In other subtropical regions of South Africa, where the absolute minimum temperature falls below 7 °C, commercial plantings will be at a high risk.

Soil requirements

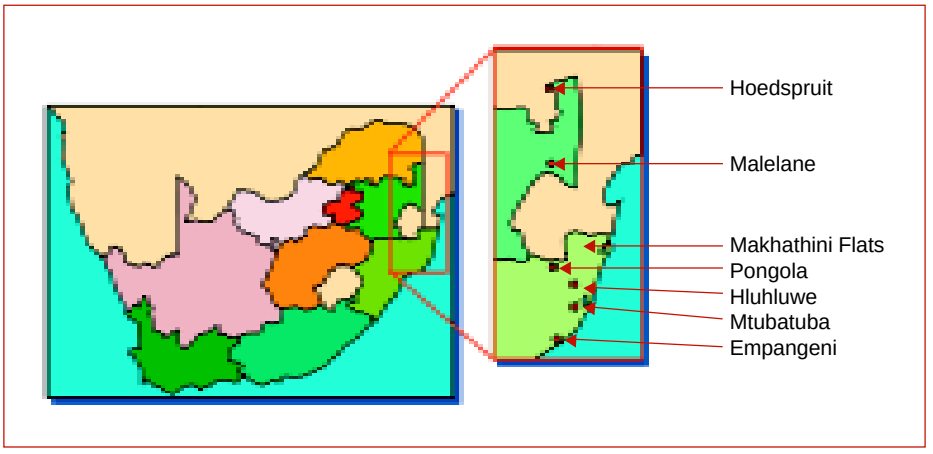
The cashew is a strong plant that is renowned for growing in soils, especially sandy soils, that are generally unsuitable for other fruit trees. For the best production deep, well-drained sandy or sandy-loam soil is recommended. Cashew trees will not grow in poorly-drained soils.

Establishment

Self-pollination and cross-pollination play an important role in the formation of cashew seed. Seedlings therefore show great variation and no “true to type” trees can be grown from seed.

Selected trees should preferably be multiplied by grafting or air layering because vegetative propagation will ensure the best production and quality. Trees that are precocious bearers and grow vigorously are selected.

Nuts should weigh between 8 and 9 g with a density of not less than 1,0.

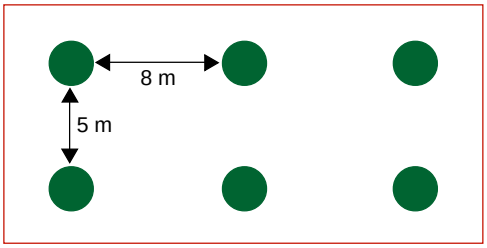


Areas where cashew trees grow well

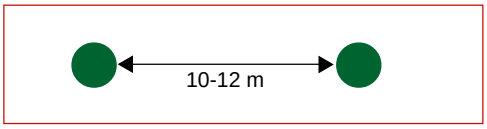
Trees with yellow to grey-brown apples have exhibited the most resistance against anthracnose and are associated with the best production.

Planting

Fresh seeds that sink in water are planted in an upright position in a planting bag containing a loose, sterilised soil mixture. Three to four seeds can be planted directly in the planting hole. The weakest ones are thinned out later and the strongest left to develop further. The seedlings are very susceptible to *Phytophthora* root rot.
The plant bags should be 350 to 400 mm deep, as the tap-root grows very fast and bends around as soon as it touches the bottom.



Planting distances of 8 x 5 m are recommended in the first 3 years



Permanent planting distance of 10 to 12 m is recommended

Grafting

Two grafting techniques, namely side grafting and wedge grafting are practised with success. Grafting should commence as soon as possible (seedlings of 3–4 months old) and planted out in the orchard to prevent the tap-root from bending.

Seedlings

Cashew seedlings are grown under shade (45 %) and hardened off before planting in the orchard. It is very important not to disturb the root system during planting. Young trees should be supported for the first 2 to 3 years so that wind will not blow the plants over.

Planting distance

Planting distances of 8 x 5 m are recommended. The trees grow vigorously in the first 3 years and as soon as the crowns touch each other alternate trees should be removed until the permanent planting distance of 10 to 12 m is reached. Branches hanging on the ground should be removed because they interfere with harvesting. In other parts of the world cashew trees bear well, in spite of the little attention devoted to the orchards.

Growth and production of cashew trees can be enhanced by establishing clonal orchards, and improving fertilising and irrigation practices

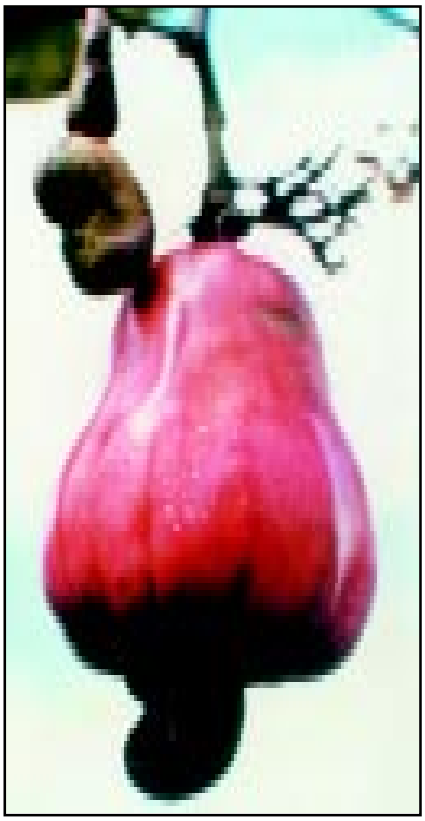
Fertilisation

The application of nitrogen and phosphate are important. Approximately 75 g LAN and 200 g superphosphate per year age of the tree is applied annually with a maximum of 750 g LAN and 2 kg superphosphate. Cashew trees are subject to zinc deficiency that can be treated with 200 g zinc oxide/100 ℓ water applied as a leaf spray.

Flowering to harvest time

Flowering is affected by weather conditions and also varies from tree to tree, but continues for a period of 3 months. High temperatures lead to earlier flowering. Both male and bisexual flowers are borne on one cluster. The flowers are very susceptible to mildew and control thereof on the leaves and flowers is a prerequisite for good production.

Pollination is mostly by insects. After pollination it takes 6 to 8 weeks for the fruit to develop. The nut develops first while the apple develops and enlarges only 2 weeks before fruit fall. Nuts should be harvested as soon as possible, especially under wet conditions and should be dried before storage.



The cashew apple (fruit) and nut

Irrigation

Irrigation is important during establishment of young trees because it doubles the growth tempo of young trees in a dry season. Due to the deep root system the trees can survive several months without irrigation. Mature trees should receive 1 800 ℓ of water per tree every 2 weeks.

Weed control

Grass strips in the inter-rows between the tree lines are ideal to prevent erosion and should be cut regularly.

Processing

The objective of cashew processing is to extract the healthy, tasty kernel from the raw nut in the shell. Most modern factories are designed to obtain the maximum number of whole nuts and as much shell oil as possible. Processing can be subdivided into a series of steps.

Drying

Harvested nuts are dried in the sun for a few days. Properly dried nuts can be stored for 2 years before being shelled. Nuts are roasted to discharge the caustic shell oil and acrid fumes. Hand shelling is impossible if the shell oil has not been removed previously. Kernels must be protected from contamination by the shell oil because it would cause blisters in the mouth and throat when eaten. Before the nuts are roasted they must be soaked in water—the moisture in the shell facilitates the rupturing of the cells containing shell oil and retaining it in the shell. Moisture makes the kernel slightly rubbery and limits breakage of the kernels. The easiest method to wet the shells is to heap the nuts into big piles and to use sprinklers intermittently. Steam may also be used.

The simplest roasting method is to heat the nuts for about a minute in an open pan with holes. Acid fumes are released and if the nuts should catch fire the flames can be doused with water. A more efficient method is to use a slanting perforated cylinder that is rotated above a fire. The shell oil flows through the holes in the cylinder and is collected in a catch through. After the roasting process the nuts are dumped into ash or sawdust to remove the excess shell oil still clinging to the shells.

Shelling

This is the most difficult operation in cashew processing. In India shelling is mostly done by cheap female labour. Shelling is carried out by using special wooden mallets and pieces of bent wire, at a rate of about 200 nuts per hour.

Mechanical shelling methods are difficult to design because of the irregular shape of the nut, hardness of the shell and brittleness of the kernel. In some mechanical processing plants compressed air is used to crack the nuts. The latest Windmer and Ernst method is to cut a groove around the shell and to place the shells in a modified centrifuge fitted with metal plates. The nuts are thrown against the plates and cracked by centrifugal forces when the machine spins. It is possible to obtain 85 % whole kernels with this method.

Removal of the testa

Before the thin, papery seed coat (testa) can be removed, the kernels must be dried. Nuts are dried on big racks in an oven at 70 °C. The testa becomes dry and brittle and is easily removed. The remaining traces of membrane are removed with bamboo knives. Modern factories use electronic machines to detect nuts with pieces of remaining testa which are then sorted and cleaned by hand.

Grading

Kernels, whole and broken, are sorted into 6 grading schedules. There is only a small demand for broken or dark and unevenly roasted kernels.

Packaging

- Kernels are dried to 3 % moisture content before they are packed.
- Drying is necessary to extend shelf life and prevent fungal and other infections.
- Dried kernels do not become rancid.
- Nut kernels of export quality are vacuum packed in tins.

By-products

Shell oil represents about a quarter of the mass of an unshelled nut and approximately equal to that of the kernel. This fluid, that is not an oil as the term “shell oil” indicates, but a mixture of anacardic acid and cardol is the main by-product.

There are more than 200 registered patents of different uses of shell oil. One of the most important uses is in the manufacture of brake linings. Shell oil is used in the manufacture of numerous materials that have to be resistant to heat, friction, acids and caustic products, for example clutch plates, special isolators, varnish and plastic materials. The wood is

insect repellent and used in making book cases and packing crates. The gum is a replacement for gum arabic and used as insect repellent glue in book bindings. In the nut and the apple, a compound has been found that combats tooth decay.

The apple is highly perishable but very healthy. It can be eaten fresh or juiced. Syrup, wine, brandy, gin, preserved fruit, pickles and glazed fruit are also made from the cashew apple. In Brazil, fresh cashew-apples are packed in trays and marketed in retail fresh produce outlets.

The indigenous people in cashew-producing regions use different parts of the plant such as the leaves, bark, gum, wood, juice and roots for the preparation of local medicines or insect-repellent mixtures. The bark is rich in tannins and is used in leather tanning. The papery seed coat around the kernel can serve as cattle feed.

Exports

India earns more than 200 million dollars a year by exporting 40 to 50 thousand tonnes of cashew kernels and the country's tradelinks are spread over 40 countries. Cashew is a craze in the United States which is by far the largest buyer. The other major purchasers are the EEC countries, Japan, Australia, Canada, Hong Kong, Singapore and the countries in the Middle East.

Cashew is an excellent choice to grow around the house as a shade tree with healthy fruit (apple) and nuts.

Nuts determined the eating habits of prehistoric people. Along with berries and brook water, nuts followed humanity to civilisation. Cashew nuts are packed with proteins, fats and vitamins to a high degree.

Proteins, the tissue builders in our system, constitute a large proportion of cashew contents. The cashew kernel contains 21 % of vegetable protein. Nutritionally they stand on a par with milk, eggs and meat. It also contains a high concentration of much-needed amino acids.

Coconuts

The coconut palm

"The coconut is God's gift to man. He sleeps in the shade of the palm, is awakened when the nut falls, drinks the milk, and eats the meat.

He then feeds the rest of the meat to the chickens and cattle, which produce eggs, milk and meat.

The leaves provide thatch for the roof and walls for his coconut hut and are also woven into hats, baskets and mats".

Palm trees are mainly found in tropical areas. They are often used as ornamental plants (landscaping), and many varieties are of very great economic importance. Apart from their fruit, stems and leaves being manufactured on a large scale, they also provide food and shelter for many inhabitants of tropical countries.

The coconut palm has various uses and is grown over a wide geographical area. The importance of coconuts are often underestimated not taking into account the fact that millions of people in tropical regions depend upon coconut plantations for their livelihoods. In these parts of the world most coconuts grow wild and are not strictly seasonal. A large proportion of the crop is used to supply food, drink and energy (firewood).

The most important uses of coconuts are:

- whole coconuts (tender green as well as the dry mature nuts)
- copra (the dried kernel of the nuts used for shredding and pressing oil)
- coconut oil (extracted from copra)
- coir (fibre of the husks)
- desiccated shredded coconut
- coconut skim milk and coconut protein.

Description of the coconut palm

- Coconuts *(Cocos nucifera)* are the most important of the cultivated palms and more widely distributed than any other palm.
- They are monocotyledonous, with no tap root, and have a swollen base.
- The coconut has long (3,6–6,1 m) fern-like leaves, with ribbon-like leaflets.
- The trunk or stem is branchless and grows to a height of 18 to 30 m, bearing at its summit a crown of leaves. The leaf stalk encircles the trunk and supports the weight of the bunch of nuts. The cluster of nuts weighs 148 to 246 kg.
- The fruit is ovoid in shape and consists of 4 parts: about 35 % husk, 12 % shell, 28 % flesh (edible) and 15 % water.

Temperature and humidity

- There are many coconut varieties. Some of them even grow well in areas where cooler weather occurs at times.
- The trees prefer a high humidity and are therefore usually grown near the coast. In the tropics, however, they grow well in areas away from the coast even at an altitude of 700 m.
- Short, cold periods, even if frost does not occur, is the most limiting factor to coconut growing.
- Ideally, the temperature should range from 24 to 29 °C. At the Burgershall Research Station, 60 km from Nelspruit, there is an orchard of bearing coconut palms where the temperature drops to 6 °C without any obvious damage to the palms.
- When the annual rainfall is below 1 240 mm, the trees must be irrigated and moisture conservation practices be used.
- Sandy loam soils in areas with a very high rainfall give the best results.
- The plants tolerate wind quite well and serve as good windbreaks.

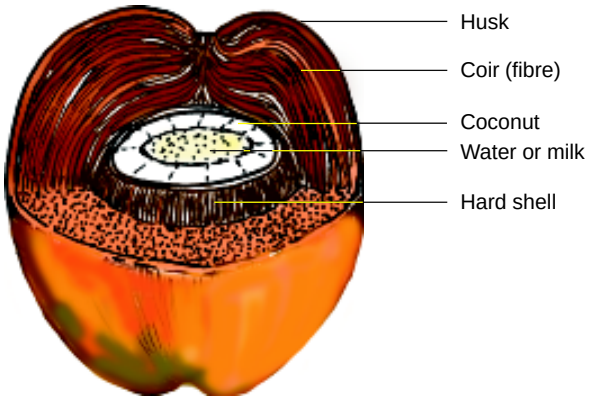
The tall coconut

This is the common or typical coconut. In selecting seed, strains or varieties long established in any location tend to be best adapted to the specific location. Therefore, palms become adapted to drought, high rainfall, alkaline soil, or show resistance to various insects and diseases.

The dwarf palm

Short in stature but sterner of stuff than its taller brother, the dwarf palm is less susceptible to disease. Dwarf varieties start bearing earlier than the tall varieties. They will often flower in the third or fourth year after planting. There are many varieties of dwarfs and they tend to come fairly true to seed because the shedding of pollen by the male and female flower overlaps by almost a week.

Hybrids between tall and dwarf types have exhibited marked hybrid vigour.



Components of a coconut

Propagation

- The first step in propagating the coconut is to select seed from parents with superior qualities, not only heavy producers, but also with the greatest quantity of good copra per unit. The nuts should be mature when they are harvested for planting, but should not be completely dried out.
- The coconut is propagated by seed (nuts) only. Ripe nuts can be planted in their permanent positions, but they germinate better when they are first grown in seed beds consisting of well-drained sandy soil with decomposed organic matter.
- The nuts are set in the soil just deep enough to cover them, each on its side with the stem end which contains three “eyes” slightly more raised.
- If the seedbeds are kept reasonably moist the nuts will germinate within a month. A sprout will emerge from one of the eyes and in time produce leaves and roots while still attached to the nut. Very little upright stem is produced at first and the growth is cabbage-like for a while. Later a single stem develops which grows to a tall height, bearing leaves only in the top.
- The seedling is best transplanted when it has 3 to 4 leaves. The complete plant, with nut attached, is carefully lifted and set in a well-prepared hole rich in organic matter and deep enough to cover the coconut hull. Watering is important to settle each plant. The usual spacing is 10 m between plants.
- The plants will grow fairly rapidly if weeds around each plant are always removed. The first flowers can be expected in 4 to 5 years. Many palms become 80 years old.

The crop

- Usually about 60 fruit are carried by a bearing palm at one time, all being of different ages, because each flower generally produces up to 10 fruit. Pollination is mainly by insects.
- The fruit matures after 12 to 15 months. Fully mature fruit fall from the tree on their own.

Fertilising

It is general practice in India to bury coconut husks, which are rich in potash, between rows of coconut trees. Most growers use organic manure regularly, consisting of about 25 to 55 kg cow dung, green leaves, ash compost, fish manure and bone meal per tree. In addition, up to 4 kg of 8:8:16 chemical fertiliser is used. Small farmers use proportionally more organic fertilisers, resulting from home composting, than large farmers.

Interplanting

Coconut plantings are usually interplanted to row crops such as ground nuts, peas and other annual crops. These afford income and do not harm the coconuts. The returns per hectare could be boosted by intensive utilisation of suitable intercrops before young trees come into production.

Marketing

There are many ways to market coconuts.

- Firstly, marketing varies according to the product, namely fresh coconuts, desiccated coconuts, copra, coir, novelty or speciality products, or other.
- Secondly, marketing according to the size of the operation—growing coconuts as a small sideline enterprise, supplementary to other cash crops, or a large plantation as a major source of income.

Generally the marketing of coconuts falls into one of the following categories:

- In areas where the trees are grown mainly as a subsistence crop, most of the coconuts are consumed at home.
- In areas where coconuts are a supplementary cash crop, they are delivered to local assembly points and marketed along with those of neighbours.
- Some growers are also processors of copra, coir, toddy, desiccated coconut, charcoal or novelty items, in which they process not only their own production, but buy some from their neighbours.
- Some growers supply raw material to large processors of copra, copra meal, coconut oil, desiccated coconut, charcoal or other products. In this case coconuts are the main cash crop, and they are grown under contract with the processors.
- In Florida, Hawaii and other areas frequented by tourists, whole coconuts, coconut husks, coconut shells and dozens of coconut products are sold by the roadside.

Harvesting energy from the coconut palm

After the nuts have been harvested and the milk and copra have been removed, one is left with a great deal of combustible material in the form of husks, shells and oil that remains in the shells. When the leaf petioles fall from the tree they may be gathered for heating too.

The energy content of these waste products compares well with conventional firewood. The waste may also be converted into charcoal.

Macadamias

Macadamias can be produced successfully in areas where avocados, papayas, mangoes and bananas do well.

The trees flower during spring from August to September. The further development of the fruit lasts 31 weeks.

Select high-quality nursery trees by inspecting the:

- plant container and roots
- soil mixture
- leaves
- internodes
- graft union
- shape of the tree.

Plant container and roots

The size of the container is very important. If the container is too small, the tree becomes pot-bound and the tap-root might be distorted. The tree may appear healthy in the nursery, but has little chance of reaching its full potential in the orchard. The weakened root system cannot provide the growing tree with sufficient water and nutrients.

Distorted root systems

Climatic and soil requirements

Soil

Most soil types are suitable for the production of macadamias, provided they are well drained and have no restrictive layers in the top 1 m of the soil. Poorly-drained clay soils are not suitable.

Temperature

The ideal temperature for macadamias is between 16 and 25 °C. Although the trees can survive when temperatures drop below 3 °C, they should not be regarded as frost resistant.

Height above sea level

Height above sea level influences nut quality and production. Production declines dramatically above 600 m. Above 640 m growth is slower and trees take longer to produce.

Cultivars suitable in areas between 600 and 640 m above sea level are Mauka, Kau and Keaau.

Cultivars recommended nearer to the coast, 90 to 300 m above sea level, are Purvis, Makai and Keaau.

Cultivars

The cultivars recommended are: Keaau, Kakea, Kau, Purvis, Pahala, Mauka and Makai. They are regarded as superior to Nelmak 1 and Nelmak 2 for commercial processing and marketing. Their oil content is usually higher than 73 % and the sugar content is low enough to ensure an even, cream colour after the nuts have been baked. Under ideal circumstances the crack-out percentage will be higher than 40 %.

Soil preparation

- If the physical properties of the soil, namely depth (0,8–1,0 m), drainage, etc are suitable for growing macadamias, the soil must be prepared carefully and well in advance.
- The soil must be loosened as deeply as possible. It should then not be necessary to make large planting holes.
- If the soil in the planting holes is compacted, the roots could become rootbound.
- An investigation should be done after the planting of macadamia trees to ensure that root growth is not restricted.
- Do not fertilise recently planted trees. They must first become well established and grow vigorously. It is wise to wait one year before applying fertiliser.

Planting distances

- Macadamia cultivars have different growth patterns. They are usually either spreading or upright growers.
- The size of each cultivar's drip area (surface area below leaf canopy) depends on the altitude, soil type, rootstock, rainfall, temperature and relative humidity.
- The planting distance for each cultivar will therefore differ from place to place. Various guidelines can be followed with respect to spreading and upright growers.

Tree shape of some macadamia trees

Cultivar	Tree shape
Keauhou	Spreading (umbrella)
Kakea	Spreading (broad)
Keaau	Upright (broad-upright)
Ikaika	Spreading (broad-upright)
Kau	Upright (upright)
Mauka	Upright (broad-upright)
Makai	Spreading (umbrella)

As soon as the competition for light becomes too great, production will decrease.

To allow for tractors to move between the trees, the hedgerow planting system is used. With this system:

- Upright growers are planted 3,5 m apart within the row with 7 m between rows.
- Spreading cultivars are planted 10 m apart within the row with 6 m between the rows.

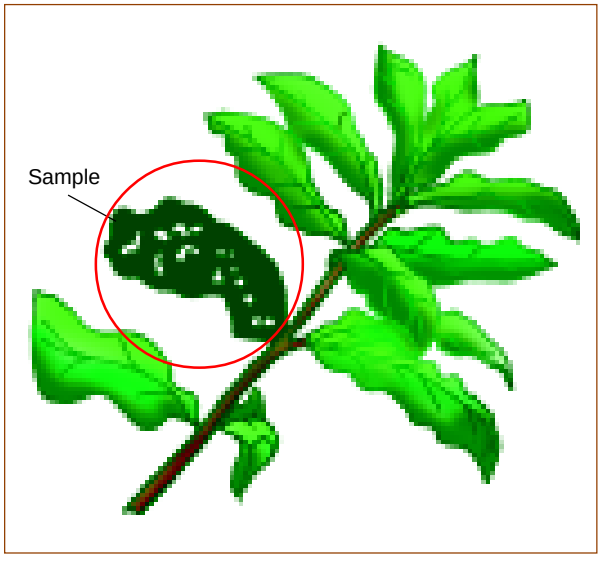
Intercropping

Other crops are sometimes cultivated between young macadamia trees. There are 3 main aspects to be considered before planting an intercrop.

- Cultivation of the intercrop could damage or adversely affect the growth of the tree or injure roots and should be avoided.
- Tall-growing plants could crowd out or overshadow the young macadamia trees and should not be planted.
- No other crops should be planted between bearing macadamia trees. Once this stage has been reached, the macadamia trees should receive the attention and treatment necessary to ensure maximum growth and production.

Leaf analysis

- Macadamia leaf samples must be taken during October and November. The time of sampling is critical. The correct leaf must be sampled.
- When submitting a leaf sample from a particular orchard for the first time, it must be accompanied by a soil sample. Thereafter it is advisable to send in soil samples annually. It is essential to consider the results of both soil and leave samples when making fertilisation adjustments.



The leaf that should be sampled

- Only leaves from healthy plants must be sampled. They must be free from sunburn, insect damage or any deficiency symptoms or signs of disease.

Method of sampling

- Select approximately 20 healthy trees, well distributed throughout the orchard, homogeneous in appearance, and representative of the orchard as a whole.
- The selected trees must be clearly marked with, for instance, paint. In this way it is possible to take soil samples at the same places and leaf samples from the same tree every year.
- Four leaves are taken from alternate sides of the trees giving a sample of 80 leaves.

Fertilisation

Do not fertilise young, transplanted trees too soon. They must first become well established and start growing vigorously before any applications are made, preferably after at least 1 year.

Never apply fertilisers against the stem of young trees.

Fertiliser must be broadcast evenly from about 0,2 m from the stem to about 0,5 m outside the drip area of the tree.

Macadamia trees are very sensitive to root damage, therefore each fertiliser application must be followed by a light, controlled irrigation.

Fertilisers must not be worked into the soil.

When the trees are established and start growing, fertiliser must be applied regularly according to the table.

Quantity of fertiliser according to age (kg/tree/year)

Tree age (years)	LAN 28 %	Superphosphate	Potassium chloride
1	0,2	0,2	0,1
2	0,4	0,2	0,3
3–5	0,6	0,3	0,5
6–8	1,0	0,5	0,5
9–11	1,5	0,75	0,75
12–14	2,0	1,0	1,0
15+	3,75	1,35	1,25

Zinc and boron sprays

Because most soils are naturally low in zinc, or the zinc is not available, this element must be applied every year. The following concentrations are recommended:

- Zinc oxide at 200 g/100 ℓ water, or
- NZN at 150 mℓ/100 ℓ water.

Many macadamia orchards are also low in boron and it is desirable to spray the trees every 2 years with 100 g borax or 75 g solubor/100 ℓ water right from the start.

Irrigation

Water stress often limits tree growth, as well as the set, growth and quality of macadamia nuts. It is important to know how much water to apply and when to apply it if it does not rain.

Water requirements

The approximate water requirements for macadamia trees (mm/month)

Tree age												
Years	**Month**											
	Aug.	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**March**	**Apr.**	**May**	**Jun.**	**Jul.**
5	16	20	24	27	29	29	24	21	14	9	9	9
10	46	57	69	77	81	81	67	59	38	26	26	26

These values are only guidelines for water use throughout the season.

Diseases and pests

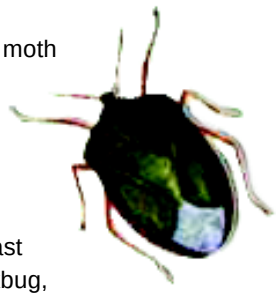
Phytophthora *root rot*

This disease usually occurs as a result of mechanical damage causing injury. These areas usually become infected. Trees suffering some kind of stress such as drought conditions may also get the disease.

Nut borer

Nut borer is the common name for the larvae of 4 types of moths that can either burrow into the green husks of macadamia nuts or feed on the kernels. The damage can easily be recognised, but the moths are small and inconspicuous and seldom seen in an orchard.

- Adult larvae are about 10 mm long and pale red or grey.
- An infested nut can be recognised by a small hole in the husk which is surrounded by excreta.
- Affected nuts, especially young developing nuts, usually drop as a result of damage to the husks.
- Susceptibility to attack by moth larvae differs among cultivars because of hardness and thickness of the shell.
- No insecticide is at present registered against nut borer. It can, however, be limited by planting fairly resistant cultivars such as Nelmak 1, Nelmak 2 and the Hawaiian cultivars.
- A natural enemy that plays a role in the control of false codling moth is the parasite *Trichogrammatoidea lutea,* which parasitises the eggs of the moth.



Stinkbugs

Stinkbugs are the most important pest on macadamias in South Africa. Damage is caused by a stinkbug complex comprising at least 20 different types. The most important types are: two-spotted stinkbug,

green vegetable stinkbug, coconut stinkbug, small green stinkbug, spotted stinkbug, yellow-edged stinkbug and yellow-spotted stinkbug.

Stinkbugs can cause crop losses of up to 80 %.

Damage

Most stinkbugs have 4 generations per year and each generation causes a different type of damage to the nuts.

- The first generation is the spring generation (August to September), and occurs during or after flowering. This generation can cause extensive flower and/or fruit drop of small macadamia fruit.
- The second generation is the summer generation (December). Damage occurs during fruit development or just before the fruit reaches mature size. Once the fruit has reached mature size, it remains on the tree even after stinkbugs have fed on it. When harvesting, these nuts will have large, sunken lesions on the kernels.
- The third generation, the autumn generation (February to March), is normally the largest. This generation feeds on the nuts before and during harvest. Although it causes lesions on the nut kernel, no fruit drop occurs. The size of the lesions depends on the type of stinkbug. The coconut, two-spotted, yellow-spotted, and spotted stinkbugs are capable of inflicting damage late in the season because of their longer mouthparts. Less trouble is experienced from other stinkbugs during autumn.
- The fourth generation stinkbugs (winter) do not normally cause problems because most nuts have been harvested and stinkbugs are not very active during this season. The damage evident at the end of the season (stung nut kernels) is inflicted from December to harvest. The hardness of the shell does not limit stinkbug feeding. Nuts must therefore be protected against stinkbugs throughout the year from flowering until harvest.

Control

Stinkbugs can be controlled chemically.

The shaking method is used to monitor the number of stinkbugs, especially the winter and spring generations when morning temperatures are low.

- Ten trees must be chosen weekly at random per control unit/block (a unit is not larger than 5 ha). All the lower branches which can be reached on each tree must be shaken and the stinkbugs counted.
- Trees must be shaken before the temperature exceeds 18 °C, otherwise the stinkbugs will fly away when the branches are shaken. The economic threshold value (in other words the level at which economic damage to harvest occurs) for this method is an average of 0,7 stinkbugs per tree.

There are also other signs which may indicate the presence of stinkbugs:

- An excessive number of fruit on the ground during spring and summer.
- Feeding marks (small brown or black sting marks) on the inside of the green shell.
- Egg masses on tree stems. Unparasitised eggs should be destroyed while those that have been parasitised should be left on the tree so that the parasites can hatch. Whenever chemical control is necessary pesticides should be applied judiciously. At present cypermethrin and endosulfan are the only active ingredients registered for use against stinkbugs.

- Cypermethrin is applied as a full cover spray at 20 mℓ/100 ℓ water.
- Endosulfan can be applied at 120 mℓ/100 ℓ water when the shaking method of monitoring shows 0,7 stinkbugs per tree. It has a residual effect of a few days compared to cypermethrin which has relatively long residual effects. Endosulfan can therefore be used until the end of the production season for the control of stinkbugs.

Recommended guidelines

- Monitor for stinkbugs before applying any pesticide.
- Spray cypermethrin after flowering to reduce the original population size.
- Follow up with an endosulfan treatment if the number of stinkbugs in the orchard warrants it.

Harvesting, storage and processing

- Macadamia nuts drop from trees when they are mature and are then collected from the ground.
- The main crop is usually collected from March to July.
- The area underneath the trees must be clear. Grass, old leaves, branches and other debris must be removed.
- The nuts must be collected regularly, at least once a week.
- Nuts remaining under the trees for too long lose quality and are susceptible to damage by mould, rats and other rodents.
- During the main harvesting period the branches may be shaken to loosen the nuts. Never pick immature nuts.

Removal of husks

The green husks around the nuts must be removed as soon as possible after harvesting.

Drying

- Freshly harvested, dehusked nuts contain 25 % moisture and must be dried before they are stored in bulk.
- Wire frames containing 3 layers of nuts are used for drying.
- Air must circulate freely between the frames to prevent mould. A fan may be used.
- The nuts could also be sundried, but if the freshly harvested nuts are exposed to the sun immediately, the shells may crack. These cracks provide access to insects when the nuts are stored.
- If the nuts are not dried, but immediately stored in bags or other containers, fungal growth could occur.

Storage

- The hard, undamaged shells offer adequate protection against insects during storage. The kernels of shelled nuts are, however, susceptible to infestation.
- Because insects can infest stored nuts, the necessary preventive precautions should be taken.

- A reasonable degree of insect control is possible if packhouses and storage areas are kept absolutely clean.
- The shell offers total protection against insect damage and if nuts are to be stored for any length of time, it would be best to store them unshelled. Before they are stored, any cracked or broken nuts should be removed because cracks in the shell will provide access to insects.
- Because shelled nuts are susceptible to insect damage, they can only be successfully kept in cold storage. The nuts should be packed into cartons as soon as possible after shelling. They can then immediately be placed in a cold store at 0 to –4 °C. Cold storage prevents fungal growth and rancidity. This method is also recommended for the long-term storage of unshelled nuts.

Shelling

- For successful shelling, the nuts should be dried to a moisture content of about 1,5 % to ensure that kernels shrink away from the shells. Therefore, nuts should be dried before shelling. The final drying takes place in large containers through which hot air is circulated.
- The macadamia nut has a very hard shell, but is easily cracked mechanically between rotating steel rollers. A nutcracker or shelling machine works on the principle that nuts are cracked between a rotating steel roller and a fixed plate. The distance between the roller and the plate is adjustable according to the grading size of the nuts. The kernels of the nuts that have been properly dried, drop from the shells when the nuts are cracked.

Packaging

The fried or roasted nuts are packed in airtight bottles, tins or plastic containers for consignment and marketing.

Pecans

Pecan-nut trees are fast growers and can become very tall. The nut has a high nutritional value because it is rich in protein, vitamins, carbohydrates and nut oil.

Nut size and kernel development

Factors causing poorly filled nuts:

- A general water shortage
- Limited carbohydrate reserve
- Early leaf-drop (caused by scab disease or inadequate fertilisation)
- Zinc deficiency
- General tree starvation
- Unfavourable weather conditions such as cool summers.

Climatic requirements

- The pecan-nut tree is well adapted to subtropical areas.
- It also grows well in areas with short, cold winters and long, very hot summers.
- Low temperatures and even frost during June to August are required for successful budding and flower formation.
- During the summer months (October to April) the tree requires high temperatures for fruit growth.
- Trees are successfully established in valleys and along rivers where the winter temperature is low and frost occurs.
- In the subtropical areas only cultivars that are tolerant to scab should be planted since humidity is very high along rivers, in valleys and in low-lying areas.

Temperature

The average monthly maximum temperature should be higher than 28 °C during summer and lower than 23 °C in winter.

The average monthly minimum temperature during the summer must rise above 16 °C, but drop below 8 °C in winter.

Humidity and rainfall

High humidity and rainfall are ideal for the development of scab.

The most suitable production areas are therefore those with short, cold winters and long, hot summers, with no early or late frost and a humidity below 55 % during the greater part of the growing season.

Soil requirements

The pecan-nut tree performs best in a fertile, well-drained, deep soil with a loose to medium texture.

Cultivars

To produce pecan nuts successfully and profitably, it is essential to plant cultivars that comply with the high standards concerning adaptability to an area, disease tolerance, production, kernel percentage, nut size and shape, appearance and taste of the kernels.

Tolerance to scab

- Scab is a fungal disease that can spread rapidly in areas with a high summer rainfall and humidity.
- It can be controlled with fungicides, but the long-term solution is to plant cultivars with a high degree of natural resistance to the disease.

The following cultivars are resistant to scab and can be produced in all production areas: Moore (Bester), Barton, Ukulinga, Shoshoni (also areas with a high rainfall and humidity).

Soil preparation

Examine the soil regarding depth, drainage and compacted layers.

- The soil should be at least 2 m deep.
- The physical suitability of a soil can only be evaluated by digging holes in the ground and examining the soil profile.
- If these properties are suitable for growing pecans, the soil should be prepared carefully and well in advance of planting.

Soil sampling

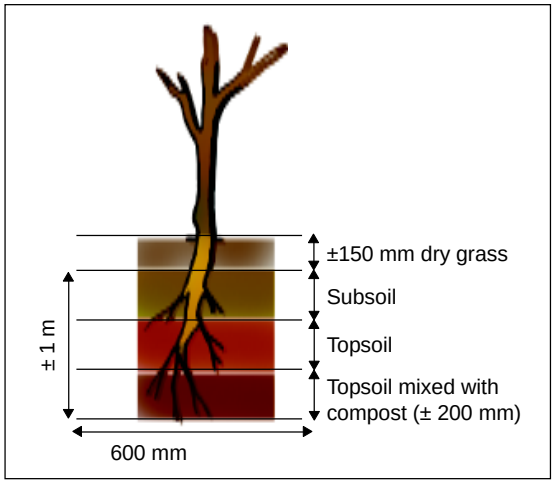
A representative sample of the proposed orchard must be taken for soil analysis. This sample should be taken 12 to 24 months, or at least 9 months, before planting. This gives the farmer ample time to thoroughly prepare the soil, particularly if large quantities of lime are required.

Method of soil preparation

If the soil is very acid, heavy lime applications may be necessary. In such a case two-thirds of the recommended agricultural lime must be distributed over the entire area 12 months before planting, mixed into the topsoil by disking, and then ploughed in as deeply as possible. Because calcium (lime) moves very slowly in the soil, it is essential to work it into the future root zone of the trees.

A cover crop can then be planted and ploughed in 6 months later. This will increase the organic matter content of the soil. The remaining lime and all the required phosphate must be applied and lightly worked in simultaneously. The trees can then be planted 3 months later.

If soil samples have not been taken early enough to proceed as described, two-thirds of the lime must be mixed with the soil and ploughed in deeply; the phosphate and the rest of the lime are then distributed and worked in lightly. If large quantities of lime are required, this must be applied at least 3 months before planting, thoroughly mixed with the soil and worked in deeply.



Planting method

Planting

The pecan-nut tree is deciduous and can therefore only be transplanted during the winter. The best results are obtained when establishing orchards with trees planted during July and August.

Nursery trees

- The pecan tree has a long, strong tap-root system.
- The tap root has to be cut at a length of 1 m with a sharp spade. The tree should then be carefully removed from the soil and immediately taken to a shed or shady place. Cover the roots with wet sawdust or any other suitable damp material to prevent them from drying out.
- Inspect the trees carefully, and discard those with bent roots.

Planting in orchards

- Loosen the topsoil to a depth of 1 m before planting.
- The depth of the hole must be deeper than 1 m, or at least 200 mm deeper than the length of the tap-root.
- Some loose soil should be replaced, so that the cut end of the tap root is in loose soil. This promotes vertical root growth during the first season of establishment.
- Well-rotted compost (plant material) can be added to the hole.
- Zinc fertiliser (22 % Zn) should be added (0,5 kg/ hole) and mixed well with the topsoil. No other fertiliser should be applied at planting.
- Plant the tree at exactly the same depth in the orchard as it was in the nursery. If it is planted too shallow, the root collar will be exposed to the sun, causing sunburn and eventual die-back or stunted growth.

Aftercare

- Newly planted trees must be irrigated immediately. Thereafter, irrigation should be applied carefully, because too much water given before the tree starts growing, may cause the roots to rot.
- They should be treated against possible termite attacks by timeously destroying all termite nests in the vicinity.
- The trees should be white-washed to prevent sunburn damage. It is advisable to put a straw mulch around the base of the young tree for better moisture conservation and to

protect the roots against high temperatures. After planting, the trees must be topped to encourage branching to form a framework. A height of 1 m is recommended.

- Inspect young trees regularly during the first season after planting.

Fertilisation

- Do not fertilise young, transplanted trees too soon. They must first become well established and start growing vigorously.
- The first application should only be made one year after planting. Never apply fertilisers against the stems of the young trees.
- Immediate irrigation is important.

Fertilisers

- Fertilisers should be spread evenly about 0,2 m from the stem to about 0,5 m outside the drip area of the tree.
- Each fertiliser application must be followed by a light, controlled irrigation. Fertilisers must not be worked in.
- Once the trees are established and start growing, fertilisers should be applied regularly according to the table.

Annual application of fertilisers for pecan-nut trees

Application	LAN	Superphosphate	Potassium chloride
g/tree/year	250	300	100
Maximum application: kg/tree/year	4,5	3	2

Time of application

- August: $^1/_2$ of the LAN + all the superphosphate
- October: $^1/_2$ of the LAN + all the potassium chloride

Zinc

Since most soils are low in zinc or the zinc is not available, this element must be added every year. Spray with 150 mℓ NZN or 200 g zinc oxide/100 ℓ water when the leaf buds are 50 mm long. Repeat at least 3 times at intervals of 2 to 3 weeks. It may be necessary in some cases to spray as many as 5 times.

Boron

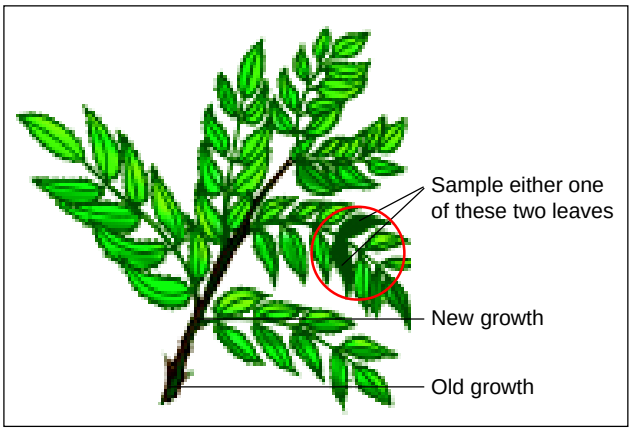
Many orchards are low in boron. The trees should be sprayed every 2 years with 100 g borax or 75 g Solubor/100 ℓ water from the start.

Leaf and soil analyses

Soil and climatic differences as well as cultural practices greatly affect the quantities of fertilisation that have to be applied.

Soil and leaf analyses give an excellent indication of the actual requirements of a particular planting. If is therefore recommended that, when the trees reach fruit-bearing stage, full use

be made of a soil and leaf analysis service. This will make it possible to obtain an accurate and complete fertiliser programme for every planting.



Pecan leaf sample

Leaf analysis

- Leaf analysis determines the concentrations of specific elements in the plant. Adequate, inadequate or excessive quantities of nutrients could be present in the plant.
- It is therefore possible to determine the nutrient status of an orchard and to fertilise accordingly.
- Limiting factors that must be taken into account are weather conditions, irrigation water and soil. In the latter case the most important requirements are usually good depth and drainage, correct pH and the absence of high salt concentrations in both the soil and the irrigation water.

Sampling

- Leaf samples should be taken during the first 2 weeks of January.
- The right leaf must be sampled (see figure). Sample 4 leaves per tree.
- A soil sample must accompany the first leaf sample.
- It is advisable to have soil analyses done every year.
- Leaves for analysis must only be taken from healthy trees and must be free of sunburn, deficiency symptoms, insect damage and disease.
- A leaf and soil sample must represent a planting of not more than 3 ha.

Method

- Select about 20 trees, spread throughout the planting, that are homogeneous in appearance and are representative of the p lanting.
- Strikingly good or poor trees should not be sampled.
- The 20 pre-selected trees must be clearly marked, for example with a spot of paint on the stem. Leaf and soil samples are then taken annually at the same marked trees.
- The fertilisation programme can then be adapted according to the analysis results. Adjustments to the previous programme, according to leaf and soil analyses, can only be done effectively if the previous applications are known.
- A rational fertilisation programme for a specific planting can only be obtained if the leaf samples are analysed annually for a period of at least 5 years. The situation cannot always be rectified in a single season, since it is a gradual process.

Irrigation

Rainfall in South Africa is often insufficient and does not satisfy the water requirements of pecan-nut trees for optimal production. Additional irrigation is usually necessary during the critical growth stage.

The pecan-nut tree has a deep-tap root system, but for optimum irrigation purposes it will be adequate to supply the top 1 m with water.

Recommended wetting area based on tree age

Age (years)	Diameter (m) of wetting zone	Wetting area (m^2)
1–2	2,0	3
3–5	3,0	7
6–10	4,5	16
11–15	6,5	33
15+	8,0	50

Pruning

Scaffolds

- To obtain a well-balanced tree, all scaffolds must develop evenly around the main stem, about 300 to 360 mm apart.
- Scaffolds must be pruned back during the second, third and fourth seasons. The primary bud is not removed so that the scaffold can continue growing upwards and outwards.
- Primary buds are only removed on the leader shoot to form scaffolds.

Summer pruning

- Scaffolds are pruned in summer (Nov/Dec) by removing 100 to 200 mm of the growth. This forces a branch to develop numerous lateral branches which can bear fruit during the same year in which they were pruned.
- Summer pruning dwarfs a tree and will increase production considerably during the first 10 years.
- After 10 to 15 years the producer can start pruning adult trees, especially if they begin crowding one another.
- The young tree must be shaped from the day it is planted.
- Control the growth that follows pruning.

Rejuvenation pruning

Many old trees with declining production and nut quality can be stimulated to more active growth and increased nut production by pruning. By completely pruning back a big tree, the production of 1 or 2 years is lost, but later new growth and the resultant increase in the production of nuts with improved quality compensate for this.

Growth regulants

A registered plant growth regulant will control excessive vegetative growth. This substance must be applied strictly according to the directions on the label. If pruned trees are treated, the concentration of the recommended dosage must be reduced by half.

Diseases

Scab

- Scab is caused by a fungus and is the most important disease in pecan nuts in South Africa.

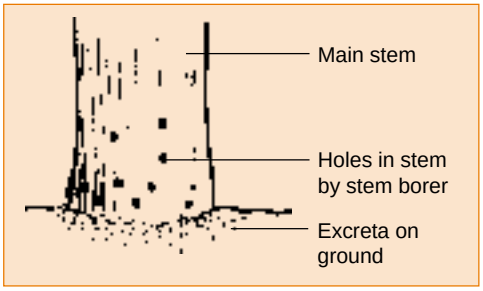
- Early symptoms are the appearance of numerous small, brown to black spots, especially on the underside of the leaves. The spots become larger and merge until the entire leaf turns black. Immature leaves drop off.
- Similar spots are visible on the shuck of the nut (see figure). Such nuts suffer from delayed development and they are misshapen. Immature nuts may drop off and have no commercial value.

- The fungus winters on branches and old shucks that have dropped. Fungal spores rapidly develop in spring and are spread by wind and rain. New spring growth on the trees is infected when the leaf surfaces are wet, especially after rain.
- Susceptibility for the disease varies in different cultivars. Ukulinga, Shoshoni, Moore and Barton are regarded as highly tolerant, while Mohawk, Wichita and Chocktaw are susceptible.

Pests

Pecan nut stem borer

- This stem borer is sporadically observed on pecan-nut trees.
- The first sign of infestation is red-brown granular excretions around the base of the trunk. This discharge comes from the pink coloured larvae which have burrowed into the trunk and branches of the trees.



Damage caused by stem borer

- The tunnels vary in size according to the age of the larvae and can be up to pencil thickness. Numerous tunnels occur in a single tree trunk.
- Young larvae hatch from the middle of December until the end of February. The larvae reach their maximum size of approximately 40 mm during spring and early summer. At this stage the larvae become inactive and change into pupae in the tunnels. The pupal stage lasts approximately 6 weeks and it appears that only 1 generation occurs per year. The larvae remain in the trunk for about 11 months.

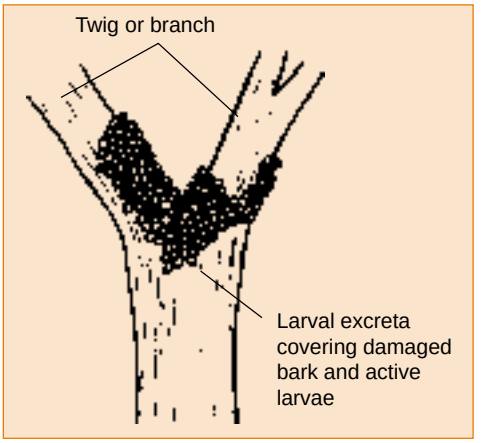
Control

- Good chemical control of the larvae in the tunnels can be obtained. By removing larval excreta around the stem just after spraying, the producer can later determine whether some of the tunnels were skipped during spraying.
- In young trees a piece of soft wire can be used to kill the larvae in the tunnels. This method, although primitive, is very effective and must be undertaken during winter when the tunnels and the excreta are more noticeable around the stem of the tree.

Bark borer

- Larvae of bark borer feed on the living bark of pecan-nut trees, especially in young plantings. They later bore into the hard wood.
- Penetration is usually where branches are formed and can occur in branches of any thickness.
- The holes in the branches that serve as shelter for the larvae, are about 70 mm long and 5 mm in diameter when the larvae reach maximum size.

- Feeding marks on the bark are covered with larval excreta spun together with threads in such a way that the larvae can move freely underneath the threads. As the larva feeds, this “house” of spun threads and excreta becomes bigger and could be found around a branch. Although infested trees do not die, the branch is ring-barked and it could die back.



Damage caused by bark borer

Control

- Good control can be achieved with a registered chemical, even if only the lesions on the branches are treated.
- It is not necessary to remove the excreta from the branches before spraying.
- Spraying of the entire tree is not recommended.

Parasitic plants in pecan-nut trees

Parasitic plants, *Tapinanthus* spp. (bird-lime), occur in most pecan-nut producing areas of South Africa. These plants have no root system and parasitise the host plant. They debilitate the tree and reduce the bearing area.

The plants, with their red and yellow flowers, are easily seen in the tops of pecan trees, especially during winter and September.

Control

There is no chemical control method for these parasitic plants. The only way is to prune the parasitic plants. The branch on which the bird-lime grows must be cut off and removed from the orchard.

Harvesting

Depending on the area, pecan nuts usually ripen from April to July. As soon as the nut is physiologically ripe, the green husk becomes dry, cracks open and the nut drops out.

In South Africa the nuts are mainly collected manually from under the trees.

A certain percentage of the nuts, for various reasons, do not drop. These nuts are called stickers and must be shaken from the trees. If a very large percentage of the nuts are stickers, it may be because of poorly filled nuts, scab or other factors such as irrigation and fertilisation.

Storage

The nuts can be stored at room temperature for as long as 6 months before they are marketed. Shelled nuts realise a much higher price than unshelled nuts, but the processing equipment is very expensive and most producers market cooperatively or through a processor. After processing the nuts are usually packed in vacuum-sealed packages, which means that they can be stored for a very long time.

Coffee

Temperature

The optimum temperature range for coffee in South Africa is 26 °C (mean maximum), 32 °C (absolute maximum) and 12 °C (mean minimum) 4 °C (absolute minimum). Although this crop can tolerate temperatures well outside this range, excessive temperature variation usually affects the crop and the coffee bush detrimentally. Coffee cannot tolerate frost and should be planted well above the frost line. The effect of frost can be minimised by planting on broad ridges and by mulching.

Altitude

The optimum range is between 900 to 1 200 m.

Humidity

A minumum humidity (14:00) of 40 % must be maintained during the warmest months.

Rainfall

Coffee is sensitive to water shortages and adequate well-distributed precipitation of about 1 500 mm/year should occur. Rainfall also influences flowering and coffee should therefore be produced in areas with adequate spring rains. A dry period during winter (June–August) is important for flowering.

Wind

High winds have a negative effect on growth because it increases evapo-transpiration and causes tree breakage.

Nurseries

Arabica coffee is essentially grown as seedlings. No or very few plants are clonally produced, i.e. either *via* tissue culture laboratories or cuttings.

- Seed must be obtained from registered growers.
- Old seed germinates very poorly and care should be taken that seed of 3 months or younger is used.
- Between 1,5 and 2 kg of seed should be sufficient to establish 1 hectare.
- Minimum bag or sleeve size should be 150 x 250 mm.
- The nursery site must be well away from frosty areas.
- Use only well-sterilised potting mixtures. Well-drained sandy loam mixes are preferred.
- If not commercially available, potting mixtures can be made as follows:
  - wheelbarrow of topsoil
  - 2 shovels of well-composted manure
  - 1 tin (440 g) of single superphosphate
  - 1 tin compound fertiliser
  - apply lime if pH is too low—pH should be 5,5 to 6.
- Broadspectrum granular insecticides could be incorporated into the mixture to protect seedlings against certain root pests.
- Seed should be planted not deeper than 6 mm with the centre cut facing downwards.
- Cover lightly with mulch and monitor frequently.
- Fresh seed takes 8 weeks to germinate.

Clearing and land preparation

Choice of site

- Soil depth not less than 1,5 m.
- Good drainage.
- Soil texture—sandy loam soils are ideal.
- Frost free.
- Proximity to irrigation.
- Aspect: north and west-facing slopes are warmer and drier—more stress. South-facing slopes are generally cooler—less stress and higher-quality coffee.

Cultivars

Variety	Type	Rust resistance	Cup quality	Yield potential
SL 28 + 34	Tall	Nil	Good	Good
Catimor 129	Semi-dwarf	Semi-resistant	Fair	Good
Catimor 128	Semi-dwarf	Semi-resistant	Fair	Good
F6	Dwarf	Resistant	Fair	Fair
Yellow Catuai	Semi-dwarf	Nil	Fair	Good
Red Catuai	Semi-dwarf	Low	Fair	Good
Caturra	Semi-dwarf	Nil	Fair	Fair
Ruiru 11	Dwarf-tall	Resistant	Fair	Good

Layout of orchard

Within-row spacing and arrangement

- Conventional varieties can be planted at 2,4 m spacing provided that 2 plants are planted in the same planting hole (cova).
- Dwarf varieties can be planted at 2,0 m spacing depending on the number of plants per cova.

Between-row spacing

- If a small orchard tractor is used: 3 m (conventional varieties), 2,57 m (dwarf varieties).
- Hand spraying: 2,57 m (conventional varieties), 2,25 m (dwarf varieties).
- Dwarf varieties can be planted 0,4 m closer than conventional varieties.

Cova system

Benefits from planting more than one plant per cova:

- Smaller yields/tree, therefore stress is reduced.
- Mutual protection of trees results in favourable conditions for growth during early stages.
- Leaves function and photosynthesise more effectively under conditions of dim light.
- Less higher order shoots are produced. Such trees are also more open which facilitates management.

Planting and early care

Planting hole

- Young plants require loose soil for optimal development. The size of the hole should be 0,45 x 0,45 x 0,45 m.
- The top 200 mm of soil should be kept separate—only topsoil should be used for refilling holes.
- Best results are obtained by planting out early in the season.
- Planting should preferably take place during cool, wet conditions.
- Planting out can be done during the mornings and/or afternoons.

Irrigation

Dryland planting: 10 ℓ of water per station before planting and 5 ℓ immediately afterwards.

Apply 3 to 5 ℓ every 4 to 10 days until rain sets in.

During very hot periods the irrigation interval should not exceed 4 days.

Irrigation: 50 mm should be applied before planting followed by 25 mm afterwards.

Irrigation interval: 25 mm every 10 days.

Other important husbandry practices

- Mix recommended fertiliser and lime well with topsoil in the planting hole. This should be done long before planting to allow the soil to settle.
- Recommended fertiliser: 30 to 60 g single supers and 30 to 60 g compound fertiliser which is high in phosphates.

- Soil in the planting bags should be soaked well before planting out.
- The taproot should be examined and if bent, it should be cut just above the bend.
- The upper surface of the soil in the bag should be 25 mm above soil surface.
- Make a large basin around the plant, but keep frost protection in mind.
- Apply contact insecticides to the soil on a regular basis if white grubs or dusty surface beetles are prevalent.
- The soil around the plant should be firmed by hand.

Inter-row cropping

Although the principle of inter-row cropping is controversial it is advisable in the following circumstances, namely to:

- assist financially before coffee comes into bearing
- bind soils and protect against erosion
- supply on-farm crop residue for mulch.

Types of cover crops: burley tobacco, groundnuts, soya-beans, field beans, maize and bananas.

Leaf and soil analyses

Combining information from both soil and foliar analyses is probably the most effective approach in understanding soil:plant nutrient relationships.

- Leaves should be sampled during full bloom in October/November by collecting the fourth pair, counting from the first fully-opened leaf at the tip of a primary branch from the midcanopy of the cropping region of the tree.
- Do not count the first pair if they are less than 20 mm long and take only leaves that are free from insect and/or pathogen damage.
- Take four pairs of leaves from each tree and sample at least 10 trees, i.e. 80 leaves.
- Soil samples should ideally be a composite sample which comprises many subsamples taken from the area which will be planted.
- Each composite sample must consist of at least 10 subsamples—increase this number if the field has recently been ploughed or if it is relatively large.
- Do not sample near termite mounds, antbear holes, contour ridges, drains, gravelly patches and sites previously used for stacking of fertiliser, compost or crop residue.
- Samples should be taken after the rains and when the soil has dried out.
- Every sample must be marked clearly, preferably with a label on the outside of the bag. Clean, new bags should be used—do not use a fertiliser bag.

Both leaf and soil analyses should be done well before planting.

Fertilisation

Time of application

- Only commence fertilising 1 to 2 months after planting out.
- For established plants, apply fertiliser annually in August/September.

- Fertiliser should also be regularly applied in small quantities rather than big lumps. In a small farmer situation fertiliser should ideally be applied bimonthly.
- Never apply fertiliser against the stems of young trees. It must be spread evenly about 0,2 m from the stem to approximately 0,5 m outside the drip area of the tree.

Quantity of fertiliser per year per tree according to age (guidelines)

Age years	LAN (28 % N) g	Super-phosphate (10,5 % P) g	Potassium chloride (52 % K) g
1	150–180	100	80
2	300–360	200	160
3 and older	450–550	300	250

Nitrogen

- Nitrogen is the most limiting element in coffee production.
- The application of nitrogen to supplement reserves in the soil will increase growth, prevent leaf fall and thereby maintain the photosynthetic area.

Potassium

- In most areas suitable for coffee production in South Africa, soils have adequate levels of potassium. However, when soils become deficient, symptoms can be severe. This further underlines the importance of regular soil and leaf sampling.
- Potassium deficiencies normally coincide with setting of a heavy crop. Interveinal chlorosis (similar to iron deficiency)—small necrotic areas appear on the leaf margins and these rapidly extend to the centre of the lamina and to each other. Eventually these lesions coalesce and defoliation results, very often along the entire length of a lateral.
- Potassium and nitrogen should be applied in equal parts from September to April in 6 to 8 applications.

Zinc

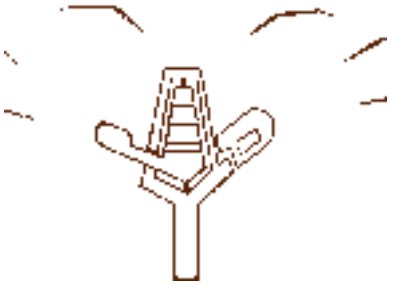
- Zinc is deficient in many soils, but over application can lead to a reduction in yield. It should therefore only be supplied when necessary.
- Deficiency symptoms include: interveinal chlorosis on the terminal growth—main veins remain dark green and rosetting of lateral branches. The shortening of internodes and smaller leaves (deficiency of this element) is also known as little leaf disease.
- Two remedial foliar sprays are recommended with zinc oxide (3 kg/ha) during November and February annually.
- A spreader/sticker should always be added to the suspension.

Boron

- Boron is needed for cell division and is not very mobile in the internal parts of the tree.
- Deficiency symptoms include: newly-formed leaves remain small, the leaf margin is irregular and asymetrical and the length of internodes is reduced.

- Not all the leaves on a lateral may be affected and symptoms can easily be confused with damage by antestia beetles and windchafing.
- Boron foliar sprays can be applied at the beginning of the main flowering period and towards the end of this period to rectify any possible deficiencies.

Irrigation



The main purpose of irrigation is to supplement rainfall. The majority of coffee roots is confined to the top 300 mm of the soil. With-holding irrigation during the winter months can induce more uniform flowering which will later impact on the labour needed to harvest the crop.

Irrigation systems

Cost and the volume of water needed should be considered when deciding which system to use.

Hose and basin

Advantages: cheap and effective when used with mulch.

Disadvantages: high labour costs, only operational in daylight hours and poor water distribution.

Drag-hose sprinkler system

Advantages: easy to operate and maintain, low cost and no clogging.

Disadvantages: high labour inputs, lower efficiency (than drip or micros) and wind may affect water distribution.

Drip irrigation

Advantages: increased efficiency (low evaporation), lower costs and efficient fertiliser application.

Disadvantages: clogging, high capital costs and need high levels of maintenance.

Microjet

Advantages: lower management, larger root surface wetting and less susceptible to clogging.

Disadvantages: high evaporation and costs.

Weed control

- Coffee yields can be severely reduced by weeds.
- Weeds normally compete for water, nutrients and light.
- Mulch is the ideal form of weed control, but it is seldom sufficient.
- Mechanical and chemical control is not sufficient as the former can lead to erosion and the latter to build-up of resistant weeds.

- An integrated weed control programme, including the following aspects, should rather be considered:
  - Topography
  - Soil type
  - Water availability.
- Irrigation method is important.
- Weed control should start early in the season before planting.
- Weeds must be controlled within a radius of 0,5 m from the main stem.
- During early stages and to facilitate establishment, mulch could be placed around the young seedling. Mulch should not be placed closer than 100 mm from the main stem.
- Weeds growing close to the main stem should be removed by hand. Coffee has a very shallow system of feeder roots and this practice will prevent root damage.
- As plants mature and leaves accumulate beneath them, weeding should become less problematic.

Mulching

- In its natural habitat, coffee grows on a bed of forest litter. Its root system is therefore adapted to function optimally under such conditions.
- By mulching, commercial growers try to simulate natural conditions as closely as possible.
- Mulching also has a dramatic, positive effect on yield in unshaded coffee.

Advantages

- Reduced soil erosion
- Improved soil moisture retention
- Builds up soil fertility
- Weed control
- Moderation of excessive soil temperatures (insulation).

Disadvantages

- Can lead to insect damage to stems of young coffee
- Can be a potential fire hazard
- Risk of frost is increased

Types of mulch

- *Grassland: up to 6 t/ha*
- Crop residue: 8 to 12 ha soya-bean or wheat = 1 ha coffee
- Napier grass: 50 to 70 t of dry grass per year/ha which is sufficient for 1,52 ha coffee

Pests

Coffee is attacked by a number of insects which have the potential to seriously disrupt production. Management of coffee insects is therefore critical and the following insects must be monitored very closely.

White stem borer

Symptoms

- Wilting of the leaves.
- Yellowing (chlorosis) of leaves.
- Wood shavings and frass, which resembles sawdust, gather in piles under the bushes and next to the stems.

If uncontrolled this insect will destroy an entire plantatior This beetle is endemic to Africa south of the equator, and all plantations will have problems with it sooner or later.

Control

- Eggs are laid on weak plants, therefore any factor that limits plant stress will also increase the plant's inherent natural resistance to the pest.
- Chemical control can only be applied from December to February when adult beetles are active. No chemical is currently registered against this pest, but the following have been tested with success in the field.
  - Stem treatments with a chemical with a long residual action. It will also help if the loose flaky bark is removed superficially.
  - Full-cover sprays with most insecticides will kill adult beetles.
- Removal of all plants showing symptoms of stem borer attack (sanitation).
- Larvae can be killed by pushing a metal spike down their tunnels. The success of this approach will be measured by the volume of frass that accumulates after each control intervention.

Antestia stink bug

Symptoms

- Multiple branching.
- Blackened flowers.
- Hollow coffee cherries (floaters).
- Zebra beans—low density.

Control

- Monitor bushes every week by shaking branches and by counting number of antestia stink bugs that are collected. Visual monitoring alone is not reliable as these bugs are very well camouflaged.
- Antestia bugs can be sprayed with contact insecticides. However, these insecticides are usually detrimental to the ecology of a coffee plantation and could cause flare-ups of other less important insects.
- In the absence of any control measures, the bug population will increase fast and economic damage will ensue.

Leafminer

Symptoms

- Dark brown dead patches on the upper surface of the leaves.
- On close inspection H-shaped white silken cocoons are often found on the underside of the leaves.
- If branches are shaken early in the morning the tiny grey-white moths will be observed.
- Severe outbreaks of leafminer usually coincide with heavy foliar spraying and could cause total defoliation.

Control

- This insect is usually under very good biological control. By following an integrated insect control programme, problems should be minimal. However, look out for these insects during weekly routine scouting.
- There is a range of effective insecticides registered to control this insect. Contact insecticides should only be applied when the moths are active and systemic insecticides early in the season, especially in areas with a history of leafminer infestation.

Coffee berry moth

Symptoms

- Coffee berries are usually spinned together with white silk, the berries eventually turn black.
- Upon closer inspection holes (± 4 mm in diameter) will be noticed in the fruit. This fruit contains a larva of the berry moth and most fruit in the cluster is usually destroyed.

Control

- This insect is usually under very good biological control. By following an integrated insect control programme problems should be minimal.
- Various contact insecticides are registered.

Coffee berry moth

Diseases

Only one of the major coffee diseases occur locally, namely coffee leaf rust.

Coffee leaf rust

Symptoms

- Bright orange spore masses on the underside of the leaves
- Necrotic lesions on some leaves distantly resembling damage by leafminer feeding
- Defoliation

Control

- Plant resistant Catimor varieties.
- A range of contact and systemic fungicides are available for the control of this pathogen.

Cercospora *spot*

Symptoms

- Smooth, round, dark brown lesions on the upper surface of the leaves.
- In severe cases necrotic lesions become visible on the fruit and can lead to significant crop losses.

Control

Locally this disease is only serious under conditions of high humidity.

Standard copper oxychloride sprays are normally effective to control this fungus.

Handling of coffee

Picking

- Ripe coffee (blood red fruit) is easy to pick, produces an end product of superior quality and is also easier to pulp than green or partially green fruit.
- Fruit must be harvested by twisting it from the fruit stalk using the fore-finger and thumb.The stalk should remain on the branch. Nodes which are picked this way may flower again during the following season. Fruit without the stalk is also considerably easier to pulp.
- Picking should start from the centre of the bush (using both hands). Picked fruit should be placed in picking bags immediately.

- The base of plants should be checked for fallen fruit after the pickers had completed their rounds. Dropped fruit can harbour pests and diseases.

Processing

- The golden rule is that quality coffee is grown in the field. Processing can never improve quality.
- Essentially coffee can be produced *via* a dry or a wet process. The wet process produces high quality washed mild Arabicas and the dry process so-called “mbuni” types of coffee. Mbuni coffee is produced by air drying coffee cherries. This type of processing results in coffee of noticeable lower quality and price. It is, however, possible for small farmers to produce high quality washed mild Arabicas.
- Processing of coffee, i.e. to the final green bean stage, requires extensive investment in capital equipment and expertise. However, to maintain quality it is essential for the small grower to do the early stages of processing on the farm.

Pulping

- Cost-effective hand-operated pulpers are available on the market. These machines can pulp significant volumes of coffee berries and it is suggested that a prospective small farmer should consider acquiring one.
- If the farming enterprise is very small and the cost of a pulper is not warranted, the fruit can be pulped by hand.
- Only ripe red fruit should be used.
- The fruit should be immersed in water, the ones that float are probably affected by antestia bugs and one or both of the beans are hollow.
- This fruit should be kept separate. Fruit that sinks is normally of higher quality.
- The fruit should be squeezed between the thumb and forefinger, this should normally produce two beans.

Fermenting

The function is to remove the mucilage from the beans.

- The moist coffee should be stored in a specially prepared tank.
- In the case of small volumes a large drum should suffice.
- The coffee should be covered by plastic sheeting to prevent desiccation of the outer layer of beans.
- Coffee should be turned regularly.
- The time it takes for the process to be completed depends on temperature and enzyme activity. Normally it takes between 12 and 28 hours.
- The beans are ready if they feel gritty and should be washed and dried immediately.

Drying

- Drying should take place in the sun and preferably on shade netting which will facilitate quick air drying.
- Skin dry as quickly as possible.
- Turn coffee every hour and every half hour between 12:00 and 15:00.
- Always cover at night to protect against dew.
- Bag at 10 to 12 % moisture—beans are greyish blue if the hard “hull” is removed.

Hulling and grading

This should preferably take place at a coffee mill.

Roasting and packaging

Roasting is not a simple process, therefore, the following should always be considered:

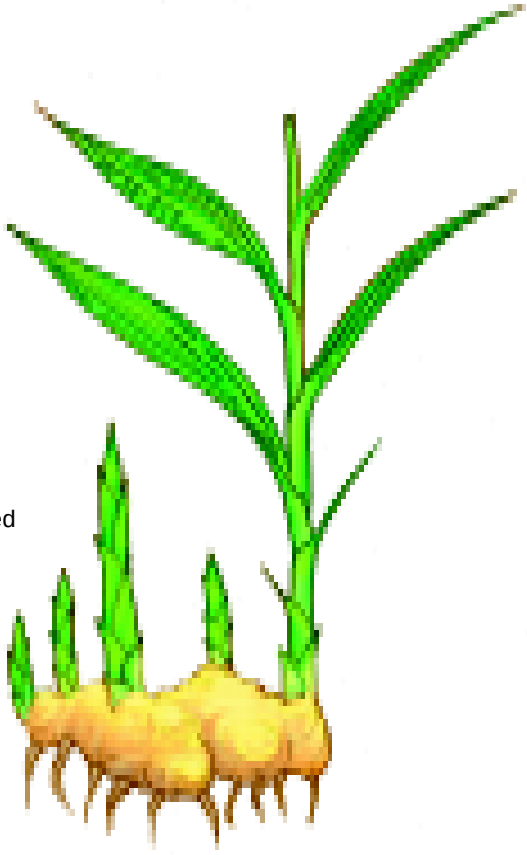
- Roasting time and temperature.
- Uniformity of roast and quality of beans.
- Roasted coffee immediately begins to oxidise and has to be stored in airtight containers or in the freezer.

Ginger

Ginger is a perennial plant that is cultivated as an annual crop. After a growing period of 8 to 9 months the above-ground growth dies off (June/July). If the underground creeping stems (rhizomes) are not harvested, they start growing again as soon as soil temperature increases (October/November).

Climatic requirements

- High summer temperatures with a high humidity and rainfall are essential.
- Sunburn of the young, tender shoots can be a problem during the hot summer months, but it can be solved by water cooling (see Irrigation and cooling).



Soil requirements

- For successful ginger cultivation, the soil must be loose and crumbly to promote development of the rhizomes.
- Gravel soils and soils with hard, compacted layers are not suitable.
- The topsoil should preferably have a depth of 250 mm, be loose and crumbly with a high organic-matter content.
- The soil pH should be between 6 and 6,5. A pH of slightly below 6 is acceptable, but it should not be above 6,5.
- The soil should be well drained and have a good water-holding capacity, because ginger has a high water requirement but the plants do not grow well in wet soils.
- Red and yellow-brown soils with a clay content of between 15 and 50 % seem to be the most suitable.
- Ginger is usually cultivated on ridges to improve drainage and aeration in clay soils. This also ensures loose, friable soil with little resistance to root penetration.

Establishment

Soil preparation

- High applications of organic matter are necessary for successful ginger production. Up to 70 t kraal manure, 100 t bagasse or 24 t chicken manure/ha are recommended.
- If a reasonable quantity of lime (4 t or more) has been recommended, about one half of it, together with half of the organic matter, can be thoroughly incorporated into the soil by October/November. A cover crop such as lupins or velvet beans which produces a great quantity of organic matter may then be planted. At this stage it may be necessary to apply some of the required phosphate.
- By June the following year the cover crop is thoroughly chopped up, mixed with the rest of the organic matter, and incorporated into the soil. It may be necessary to till the soil 3 or 4 times to obtain a suitable seedbed. The soil can then be left undisturbed until at least 2 weeks before planting when it must be fumigated for nematodes.
- Fumigate soil at a depth of 400 mm with EDB at 60 ℓ/ha and seal soil surface to control nematodes. Do not plant within 14 days of fumigation. The soil can be ridged at a later stage.

Planting material

The rhizome is broken into smaller pieces which are used as planting material. The most suitable planting material is seed pieces of 50 to 80 g. Old seed pieces from the previous season may also be planted.

Planting time

- Ginger can be planted from the beginning of September to mid-October. The crop must be well established before November and December when high temperatures can damage the young plants.
- The crop may be planted without a shade covering, although shading does have advantages, especially in preventing sunburn. A dense plant population has the advantage that the plants shade each other, and it also suppresses weed growth.

Planting distance

- Seed pieces are planted in 2 or 3 furrows.
- The furrows must be approximately 150 mm deep, with 720 mm between the rows.
- The seed pieces are planted about 180 mm apart in the row. Using seed pieces of 50 g each, approximately 4 t of planting material/ha are used, resulting in more or less 77 200 plants/ha.

Fertilisation

Organic fertilisation, especially chicken manure, should be applied in large quantities.

A soil analysis should be done in good time to correct the soil pH. Soil analysis will also determine whether it is necessary to apply phosphorus or potassium. Lime, phosphate and potassium may, if necessary, be mixed well with the top 300 mm of the topsoil to create ideal growing conditions.

Phosphorus and potassium fertiliser can be applied according to the soil analysis shown in the table.

Phosphorus (P) and potassium (K) fertilisation

Soil phosphorus (resin extraction) ppm	Super-phosphate kg/ha	Soil potassium ppm	Potassium chloride kg/ha
20 +	0	250 +	0
16–20	250	200–250	200
11–15	500	150–199	300
6–10	750	100–149	400
0–5	1 000	50–99	500
		< 50	600

Ginger requires approximately 220 to 280 kg nitrogen/ha/season or 1 000 kg LAN. Chicken manure contains about 3,5 % N, 2 % P and 2 % K. Therefore, for every ton of chicken manure applied, the equivalent of 125 kg LAN, 190 kg superphosphate and 40 kg potassium chloride is applied. These quantities must be subtracted from those given for phosphorus, potassium and nitrogen.

Time of application

Lime, phosphate and potassium must be spread on the lands and incorporated before planting. Altogether 220 to 280 kg N/ha must be applied as follows:

- At planting time 10 % of the total quantity (25 kg N/ha).
- After emergence (about a month later) 25 kg N/ha is applied every month from October to the end of December.
- The rest (about 60 % of the total) is applied from January to April, at intervals of 3 to 4 weeks at approximately 25 kg N/ha per application.

If chicken manure is applied, further nitrogen applications will probably not be necessary until January.

Trace elements

Trace elements play an important role in the cultivation of ginger. Because it is a fast-growing crop requiring soil with a high organic matter and phosphate content and a reasonable quantity of calcium, the availability of trace elements could pose a problem. As zinc, copper, boron and even manganese deficiencies may develop, the situation must be kept under close surveillance. Preventive applications may be given, but leaf analysis at an early stage is the only method of determining a deficiency so that timely control measures may be taken.

Zinc (Zn)

Spray the leaves with a suspension of 200 g zinc oxide/100 ℓ water or a solution of 50 ℓ agri-zinc/100 mℓ water. Three sprayings of 4 kg zinc oxide or 1 ℓ agri-zinc/ha/spraying from 6 weeks after planting should be sufficient. Spraying should be done every 2 weeks.

Copper (Cu)

In this case a suspension of 200 g of a fixed copper such as copper oxychloride (50 % Cu) per 100 ℓ water is used. Note: copper oxychloride and agri-zinc are immiscible (may not be used in the same spray).

Manganese (Mn)

It is recommended that the leaves be sprayed with manganese sulphate at 200 g/100 ℓ water.

Boron (B)

Spray the leaves with a solution of 100 g solubor/100 ℓ water. Three sprayings of 2 kg solubor/ha/spraying may be given fortnightly from 6 weeks after planting.

Miscibility

- Zinc oxide, copper oxychloride, solubor and manganese sulphate are **miscible** and can be used in the same spray.
- Solubor, agri-zinc and manganese sulphate are also **miscible** and can be used in the same spray.
- Copper oxychloride and agri-zinc are **immiscible** and may not be used in the same spray.
- Potassium nitrate and other trace elements are **immiscible** and may not be used in the same spray.

Leaf analysis

This technique is very valuable for determining deficiencies and excesses concerning the nutrient elements. In the case of a fast-growing crop such as ginger, the samples must be taken as early as possible so that there will still be time to make adjustments. This is especially important in the case of elements like phosphorus which takes time to be absorbed.

Sampling

At 15 weeks after planting (8-leaf stage) the entire third leaf from the top is sampled. A total sample of between 30 and 50 leaves, from plants that are well distributed over the land, should be sufficient and representative.

Norms

The norms used are given in the table.

Leaf norms for fertiliser recommendations

Element	Optimum	Deficiencies
P	0,2–0,4 %	-
K	3,0–4,0 %	-
Ca	0,7–1,2 %	< 0,07 %
Mg	0,5–0,8 %	-
B	25–110 ppm	< 20 ppm
Mn	125–250 ppm	< 22 ppm
Fe	100–160 ppm	< 35 ppm
Zn	30–45 ppm	< 20 ppm
Cu	8–10 ppm	< 4 ppm
N	3,4–3,7 %	-

Irrigation and cooling

Ginger is a tropical crop cultivated under subtropical conditions. High summer temperatures and low humidity are characteristic of the subtropics and cause sunburn of the young ginger shoots and leaves. The problem can be solved by cooling the plants by means of overhead irrigation (evaporative cooling).

- Irrigate only when the temperature rises above certain limits at different times of the year:
  - From October to the end of December when the temperature rises above 28 °C
  - From January to the end of March, when the temperature rises above 30 °C
- A temperature sensor activates the overhead irrigation system to spray and cool the plants for 1,5 minutes every 6 minutes.
- The soil-water status is monitored by tensiometers and the ginger is irrigated at night to keep evaporation of the irrigation water to a minimum.
- It is essential that the sprayers supply the water at a very slow rate, namely about 2,0 to 3,0 mm/hour.

Diseases and pests

In South Africa ginger is attacked by only a few serious diseases and pests. Contact your nearest extension officer or the ARC-ITSC for further information.

Harvesting

The time of harvesting is determined by the purpose for which the ginger is grown. Ginger for preserving is harvested early, before too much fibre has developed.

Early ginger

Early ginger is harvested more or less from the beginning to the end of February. The plants are lifted by hand and the green leaves, stems and roots broken off. A potato lifter bruises the rhizomes, making it unsuitable for preserving. Flowering is an indication that it is already too late to harvest early ginger.

Midseason ginger

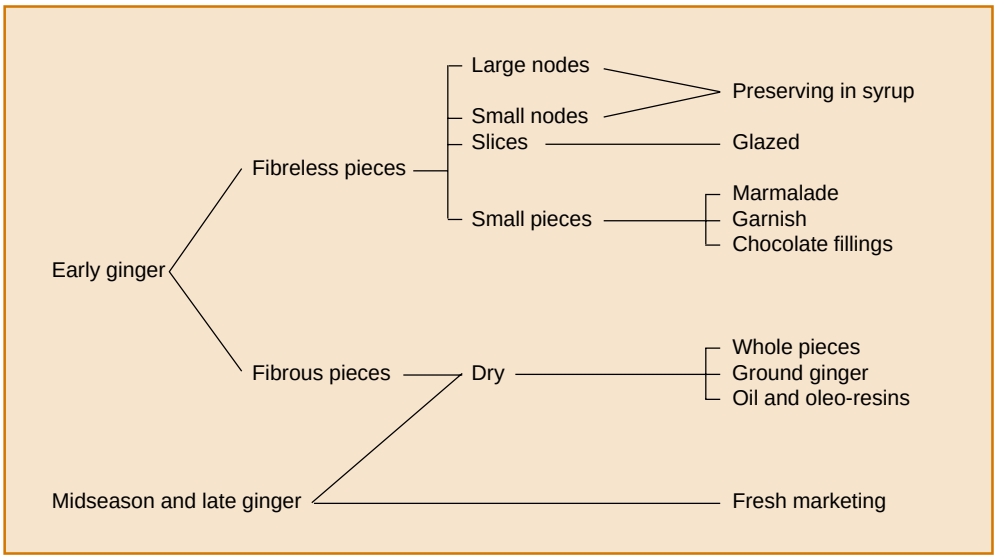
This ginger is harvested from approximately 1 April to 1 June and is used to prepare whole pieces of dried ginger. It is harvested while the plants still have green leaves. To facilitate mechanical harvesting with a potato lifter, the leaves may be chopped off beforehand with a rotary cutter. After harvesting the green stubble is removed manually.

Late ginger

Late ginger is harvested from June to August after the leaves on the plants have died. Harvesting may continue until just before the buds begin sprouting with the onset of warm weather in September/October.

Processing

The processing method is determined by the purpose for which the ginger is eventually to be used (see figure).



Schematic presentation of the processing of ginger

Early ginger (March)

The harvesting period is very short—about 30 days—as fibre builds up at about 1 % per day. The harvested rhizomes are thoroughly washed in water. They are then kept in bowls containing a saline solution until required for further processing. This period may last up to a year. The fibreless ginger is used mainly for preserving in syrup.

Midseason ginger (April/June)

Midseason ginger is suitable for fresh marketing. The largest pieces, from which the necks are cut off, are first grade and the smaller pieces second grade. Small pieces are dried, either peeled or unpeeled, and sold as dried ginger. Waste pieces are dried and ground.

Late ginger (July/August)

Late-harvested ginger is also marketed fresh, or otherwise cut up, dried and/or ground to be used as a spice. To make sure that as little as possible of the volatile oils are lost, the ginger must be dried slowly at a temperature below 50 °C and a relative humidity of 6 to 10 %. The oil and oleo-resin content is at its highest (about 2 %) in late ginger and the typical citral flavour is very strong at this time. Ginger oil is further used for seasoning and flavouring various drinks and dishes. The rhizome also contains a proteolytic enzyme that can be used as meat tenderiser.

Yield

There is a difference between yields obtained in ideal circumstances on small trial plots and the average yield obtained in practice by the farmer.

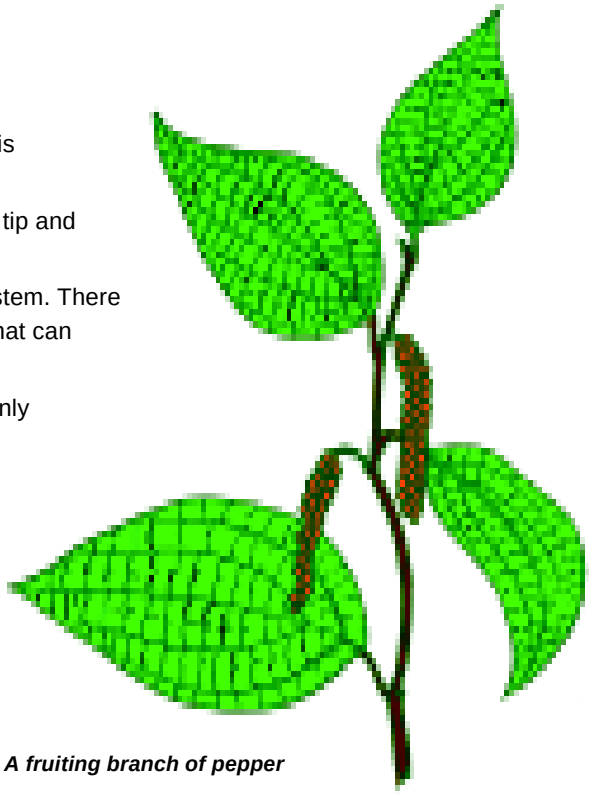
In trials conducted at the Burgershall Research Station, yields 10 to 15 times exceeding the mass of the planting material were obtained, so that 5 t of planting material yielded a harvest of about 50 t/ha.

Pepper

Pepper is a tropical plant that grows in hot humid areas with a high rainfall. Locally it can only be grown in the Lowveld and along the northern coastal areas of KwaZulu-Natal.

Botanical characteristics

- The pepper plant is an evergreen perennial. It attaches itself to trees or trellises by means of aerial roots and is not a parasitic plant.
- The leaves are oblong, pointed at the tip and arranged alternately.
- Pepper plants have a shallow root system. There are usually a few major lateral roots that can penetrate the soil to a depth of 2 m.
- The white flowers are minute and mainly hermaphroditic (both sexes in one flower). The flowers converge in oblong spikes which later form clusters.
- The pepper plant has 3 types of runners:
  - the main stem (primary runner) forms the permanent stem from which other runners develop
  - the secondary runners are round, long shoots with lengthy internodes. They climb to a considerable height and later droop downwards
  - tertiary runners are short, sturdier branches that spread horizontally from the axis of primary and secondary runners.
- Flowers and clusters always develop opposite a leaf and only on tertiary wood.
- Fruit: round berries, 4 to 10 mm in diameter and converge in oblong clusters. Each berry has a single spherical seed of 3 to 6 mm, encapsuled by the fruit flesh.



A fruiting branch of pepper

Climatic and soil requirements

- Pepper is a tropical plant and cannot tolerate frost. It will not grow where the temperature drops below 12 °C. A moderate winter climate is essential.
- Pepper plants need about 2 000 mm rain annually. In South Africa the rainfall must be supplemented by irrigation.
- The soil should have a good structure and water-holding capacity. Drainage must be good to prevent root rot.
- The pH should be 5,5 to 6,0.
- The red dolerite soils of KwaZulu-Natal and the red andesite soils of the Soutpansberg are best for growing pepper plants.
- A high humus content is advantageous.

Propagation

- Propagation is usually by means of cuttings.
- One or two-leaf cuttings are taken only from secondary runners during September.
- Cuttings are rooted in mistbeds and transplanted into the land after 9 months.

Spacing

Spacing between the rows is 3 m and between the plants 2 m, which gives 1 666 plants/ha.

Trellising

Because pepper is a climbing vine, provision must be made for supports. Treated poles must be used, because the expected lifetime of the plants is 20 years. No shade is needed when planting pepper, because too much shade will result in yield reduction.

Fertilisation

- Pepper plants react very well to organic fertilisation. Kraal manure can, therefore, be used at about 5 kg/plant/year. If kraal manure is applied or if the soil pH is slightly high (6,5), ammonium sulphate can be used as nitrogen source. About 600 g per mature plant per year at a rate of 100 g per application is required. Plants only respond well to nitrogen when the soil has a high level of potassium.
- Magnesium must be applied in the form of magnesium sulphate at about 750 g per plant. If the soil is too acid 500 to 1 000 g dolomitic lime can be applied every 2 years.
- A general directive for the fertilisation of pepper is:
  - 700 g LAN per year per plant, divided into 7 applications
  - 500 g superphosphate in a single application
  - 450 g potassium chloride, divided into 2 or 3 applications.

Mulching

Pepper plants have a shallow root system. The use of an organic soil cover is therefore very beneficial. It keeps the soil damp for longer periods and dramatically reduces temperature fluctuations between day and night.

Irrigation

- Overhead irrigation is preferred to flood irrigation.
- The most effective irrigation system consists of permanent plastic microjets.
- The rainfall must be supplemented by irrigation to about 2 000 mm/year.

Pruning and maintenance

Pepper plants are pruned to

- get stronger plants
- reduce wild growth of the runners
- keep the plants at a certain height
- stimulate the growth of lateral fruit-bearing branches.

When the plants are not pruned, the secondary runners will show dense growth and suppress the tertiary runners, with a resultant loss in yield. Young plants are only allowed to retain 3 main runners. To strengthen these runners, they must be pruned back to 7 internodes. The long secondary runners hanging from the top must be pruned every year.

Yield

- After flowering, it takes about 9 months before the ripe berries can be picked.
- They ripen over a period of 2 to 3 months.
- The berries are green at first, turning yellow and then red when fully ripe. The berries are harvested every 7 to 14 days.

The first commercial yield from cuttings is harvested from the third year and the maximum yield from the seventh year. The harvesting time in South Africa is from November to January.

The table shows the harvesting calendar of all the main pepper producing countries.

Harvesting *calendar of pepper

Type	Origin	Months **Jan.–Dec.											
		1	2	3	4	5	6	7	8	9	10	11	12
Black	Brazil								———				
	India	———	———	———									———
	Indonesia								———	———	———		
	Madagascar						———	———	———	———	———	———	
	Malaysia						———	———	———				
White	Brazil								———	———			
	Indonesia									———	———	———	
	Malaysia						———	———					

*Approximate periods
** 1 = Jan.
12 = Dec.

Processing

Three types of pepper are available in the trade:

- white pepper
- black pepper
- preserved green pepper (in brine).

Preparation of white pepper

- The berries must be picked when they are ripe or red, and then fermented to remove the flesh surrounding the peppercorns. The fruit flesh ferments by means of bacterial fermentation.
- The peppercorns are then washed repeatedly, until the clean greyish-brown peppercorns remain. They are then dried in the sun for 12 hours.
- The colour must be cream to white and the moisture content 12 to 15 %. From 100 kg of ripe berries about 28 kg (28 %) dry white pepper can be produced.

Preparation of black pepper

- The clusters are harvested while still green, but mature.
- These are immersed in almost boiling water for a few minutes after which they turn dark brown to black.
- The berries are then dried in the sun for 16 to 20 hours.
- The skin of the berries shrinks, giving the peppercorn a wrinkled appearance.
- From 100 kg of green berries about 35 kg (35 %) dry black pepper can be produced.

Diseases

The main problem with the cultivation of pepper is root rot, caused by *Phytophthora*. Symptoms of root rot are wilting of the leaves and discoloration of the stem bark. *Phytophthora* is a soil fungus which flourishes in wet and poorly-drained soils. It will attack the roots, leaves, branches and the berries of the plant. Affected plants usually die off within 10 days.

Pests

Pepper is subject to root damage caused by several plant parasitic nematodes. The most important of these are the burrowing nematode *(Radopholus similis)*, the root-knot nematode *(Meloidogyne* sp.), the spiral nematode *(Helicotylenchus* sp.), the ring and the dagger nematode.

Nematode control should start in the nursery and cuttings should only be rooted and transplanted into nematode-free soil.

Burrowing nematode

Uses

Worldwide about 75 % of black pepper is used domestically and 25 % of white pepper. The meat-processing industry uses about 35 to 40 % of the world production. Dried seeds of pepper contain 2 % volatile oil, which is used in sausages and table sauces.

Quality

The degree of dryness may not exceed 12 to 15 % moisture. Imported pepper is subject to strict standards (see table).

Requirements for imported pepper

	White pepper	Black pepper
Nonvolatile ether extract	6,5 %	6,5 %
Ash content	2,5 %	7,6 %
Foreign ingredients	None	None