

Specific fruit trees

Avocado

Avocado

The avocado, which originated from South America, has grown in Kenya for many years since the Portuguese introduced it. Fruits are of various sizes, shapes, and colour and can weigh up to 700 g. The fruits are nutritious, with high protein and oil content. Avocado oil, used in the cosmetic industry and also in manufacturing baby foods, can be extracted from the fruit.

Varieties

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- Fuerte and Hass are the main export varieties suitable for high-altitude areas.
- Others are Reed, Booth 8, Tonnage, Simmonds and Pinkerton.
- Tonnage and Simmonds are adapted to warm lowland areas while the others do well in midland and highland areas.

Rootstock varieties

- Puebla is recommended.
- Fuerte, G6, G7 and Duke can also be used.

Ecological requirements

- Avocados do well in lower midland to lower Highland zones. Altitudes of 1200 to 2200 m are ideal.
- Some varieties are adapted to warm, low-altitude areas of 0 to 1200 m above sea level.
- Temperatures should be in the range of 16 to 24 °C.
- High temperatures (> 30°C) and direct sunshine can sunburn and damage exposed fruit.

Rainfall

- 1200 mm of annual rainfall is optimal for good production; a minimum of 750 to 1000 mm is necessary.
- Climatic conditions with alternating dry and rainy seasons are best.

Soils

- Soils should be at least 1.2 m deep and be high in oxygen content.
- They should be well drained.
- Heavy or waterlogged soils are unsuitable because avocado plants are sensitive to excessive soil moisture and high salinity.

Cultural practices

- Remove the brownish peel from the seed, as it can be contaminated with fungus.
- Cut off approximately the top 1/4 of the seed to make it germinate faster.
- To avoid fungus infections, dip seeds in 50 °C warm water for 5 minutes or dip in systemic fungicide solution.
- Plant seed in containers. Grow the rootstock directly in the container. Common container size is 7 x 9 inches (18 x 23 cm). Fill the container to 2/3 with soil mixture, put in the prepared seed, and cover with soil. Seed germinates in 2 to 3 weeks.
- Seeds can also be planted directly on the farm and grafted later.
- Cleft grafting with scion of an improved cultivar is the most common method. Grafting is done from January to March, before mother trees flower, and at any time of the year as long as desired scions are available. With good management, graft in May to June, and you can then plant with the October rains.
- Sources for scions are farms with established, well-managed trees of the desired cultivars or farms with mother tree blocks.
- In a hot climate, pluck off all the leaf petioles and tie the grafting tape up to the top of the scion, leaving only the tip buds open. This method prevents the scion from drying. It is not common to cover avocado scion with a cap.
- Shade and water the grafted avocado trees frequently.
- The trees are ready to plant about 4 months after grafting.
- If you do not have irrigation, plant in the October–November short rains or the April–May long rains.

Banana

Banana

Banana originated in Southeast Asia. It is an important food and cash crop in Kenya. The false stem can be used as animal feed.

Varieties

- ? *Local cultivars:* Muraru, Kiganda, Bogoyo, Sukari and others. They are adapted to various agroecological zones. They can be eaten as a dessert or cooked.
- ? *Improved cultivars:* Apple, Gross Michel, Kampala, Dwarf Cavendish, Giant Cavendish, Williams, Grand Nain, Valery, Paz, Poyo and Lacatan.
- ? *Tall varieties:* Poyo and Lacatan.
- ? *Medium varieties:* Valery, Williams.

Ecological requirements

Altitude

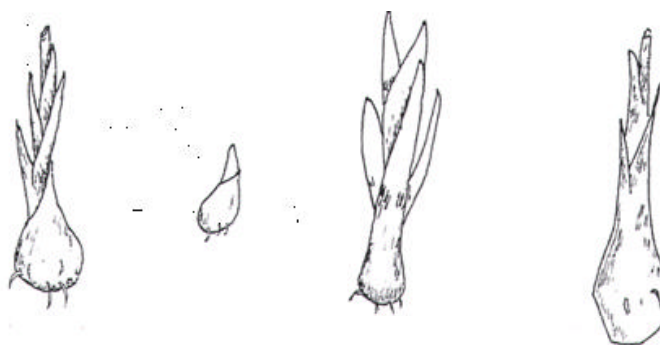
- ? Bananas grow from sea level up to elevations of 1800 m.
- ? Temperatures should average 20 to 30 °C. Below 10–12 °C, plant growth is retarded.

Rainfall

- ? Minimum annual rainfall should be 1400 mm per year, and it should be well distributed.
- ? Plants need a constant supply of moisture.
- ? Soils should be well drained, deep and rich in humus.

Propagation steps

- ? Suckers are commonly used to propagate bananas.
- ? Use:
 - ? *maiden suckers, with thin leaves (expect first yield in the first year)*
 - ? *sword suckers, with thin leaves (expect first yield in about 18 months)*
 - ? *peepers (expect first yield after 2 years, easy to transport)*
- ? Do not use water suckers, with broad leaves, in banana propagation. The survival rate after planting is low.



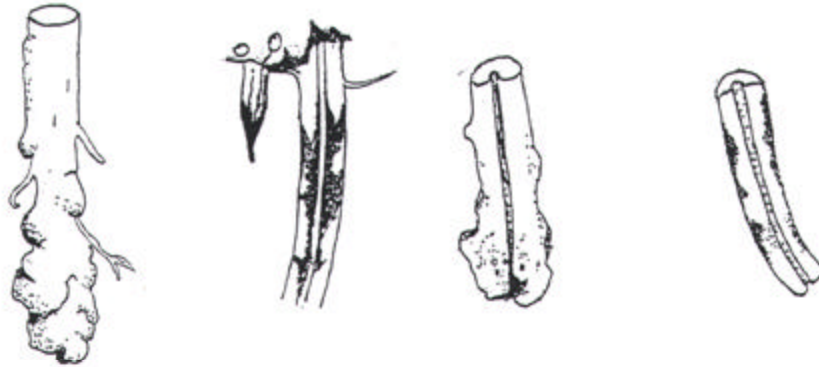
Different types of banana suckers—maiden, sword, peeper, water sucker

Selecting the suckers

- ? Select from a healthy mother plant, without any symptoms of banana weevils, nematodes, or other pests and diseases.
- ? Possibly use suckers from certified mother trees.
- ? Suckers should originate from heavy bearing mother plants.
- ? The mother plant should have all desirable characters, such as typical appearance and shape.
- ? The suckers should be 1 to 2 m tall (except peeper suckers).
- ? The diameter of the sucker at the bottom should be between 15 and 25 cm.
- ? The suckers should have well-developed, strong roots.

Digging out the sucker

- ? Scoop away the soil between the mother plant and the selected sucker.
- ? Separate the sucker from the main stool by using a strong, sharp pole or a special, flat iron digger.
- ? Avoid any damage to the roots and stem of the sucker.
- ? Check for symptoms of nematodes or banana weevils on the roots. Discard suspected suckers and do not propagate from an affected mother plant. Nematodes are detected by the dark colour of some roots. You can split the roots and check the interior; if the inside is black in colour as well, it is a symptom of nematodes.



Symptoms of nematodes on banana roots

- ? Banana weevils are identified by larger black holes in the sucker. Discard the infested sucker and do not transfer to your farm.
- ? Reduce the number of leaves before transporting or planting. Cut off the outer leaves with a sharp knife, leaving the inner sprouting leaves.
- ? Transport under moist conditions. Cover the suckers with shading materials and sprinkle water on the roots.
- ? The suckers can be stored for 3 to 5 days if they are placed in a hole and covered with mud.
- ? You should plant within at least a week. Otherwise some suckers might lose viability and will die after they are planted.

Prophylactic treatment for nematodes and banana weevil

None of the three methods of treating for nematodes or banana weevil are popular with farmers. But as nematodes are harmful, applying any of them or combining the chemical and the physical treatment is recommended.

Paring

Slice off the outer part of the sucker bottom. Remove all roots and some parts of the stem with a sharp knife. In case of a slight infection with nematodes that is not yet visible, eradicate the sucker immediately.

Dipping

Dip the banana suckers in a nematicide solution, which will kill the nematodes. This method is more costly than paring.

Hot water treatment

Dip the bottom and roots of the suckers in warm water (50 °C) for 10 min. This treatment does not harm the sucker but reduces the danger of nematode infection.

Planting bananas on the farm

Size of planting hole (length x width x depth):

- ? under dry conditions: 90 x 90 x 60 cm (3 x 3 x 2 feet)
- ? under wet conditions: 60 x 60 x 60 cm (2 x 2 x 2 feet)
- ? the bigger the planting hole, the better the production of bananas

Common spacing:

- ? for tall varieties: 5 x 5 m (plant to plant x row to row)
- ? for dwarf varieties: 3 x 3 m (plant to plant x row to row)

Planting time

- ? If possible, plant bananas in October–November.
- ? Bananas require a frequent supply of water and do not do well in a cold climate.
- ? If you plant with the rains in October–November, your suckers will establish roots and soon benefit from a second rainy season in April–May, before the beginning of the cold period in June–July.

After digging the planting hole

- ? Fill the planting hole only up to 2/3 with a mixture of
 - ? 2 to 4 bucketfuls of farmyard manure
 - ? fertile topsoil or compost
- ? To avoid nematode problems, add 100 g nematicide (Furadan) to the soil mixture. Mix it in very well with all the soil media.
- ? Plant the banana sucker in the centre of the hole. Leave the upper part of the hole empty. Water with 4 to 5 bucketfuls of water for each sucker.
- ? The banana stool needs some free space to establish itself in the first season. Cover the upper 1/3 of the planting hole with mulch and organic matter slowly in the next 3 to 4 months. The sucker will find its favourite position in the planting hole.
- ? Bananas need permanent water but cannot withstand waterlogging over a long period. If planting bananas in dry conditions, micro water catchments are favourable (see module 7 on fruit tree establishment).
- ? Bananas are easily damaged by wind. If your plot is affected by strong winds, establish a windbreak before planting the bananas.
- ? Bananas intercrop well with coffee and often are planted on contour lines (fanya juu). Plant them on the contour furrows.

Managing and maintaining the bananas stools

- ? The recently planted suckers need regular watering.
- ? Mulching is common in banana production.
- ? Shallow weeding is important, as bananas have a shallow root system. Preferably use a fork hoe. With an ordinary hoe, do not dig deep in the soil, just scratch the weeds off from the topsoil. Do not disturb the roots.
- ? Ring weeding is done according to the size of the banana stool, approximately 60 cm (2 ft) around the stool.
- ? Leave the depression in the planting hole, then fill it slowly with organic matter or compost over 3 to 4 months after planting.
- ? Allow 1 flowering or fruiting stem and 3 suckers of different size for continuous banana production. If you leave more suckers, the banana stool will produce stems and leaves but fewer fruits.
- ? Discard suckers exceeding the 3 selected ones. Always discard water suckers.
- ? Prop the plant as the fruits develop and the weight of the bunch increases. Support the fruiting stem with a wooden pole to prevent the whole stem from breaking.



Established banana with 1 fruiting stem, 3 suckers and supporting pole

Harvesting

- ? Two people should work together to harvest heavy bunches or tall cultivars. This avoids bruising the banana fingers by rough handling.
- ? Bananas ripen and change to yellow colour if stored in a dark, well-aerated place.
- ? Cut off the stem with a clean cut at ground level after harvesting the bunch.
- ? Cover the cut with soil, so the banana weevil cannot easily enter.

Fertilizer application

- ? Apply 2 to 4 bucketfuls of manure per stem per year.
- ? Use a fork hoe to incorporate fertilizer in the topsoil, shallowly and carefully.
- ? Emphasize that applying manure is preferable to applying commercial fertilizer.
- ? Apply the manure at the drip line of the outer diameter of the canopy instead of to the stem.

Post-harvest handling

- ? Banana fruits are ready for harvesting 90 to 150 days after the fingers begin to develop.
- ? The fingers are considered mature for harvesting when they are 3/4 round (75% maturity) and still green.
- ? At least two people are needed during harvesting, one to do the cutting and the other to support the bunch so that it does not fall to the ground.
- ? Always keep harvested bunches in the shade.
- ? Pack in boxes lined with banana leaves.
- ? Cut up bunches into hands or transport them whole.
- ? Take care that bunches do not come into contact with each other.
- ? Generally, transport, wash and pack banana hands rather than whole bunches because this reduces physical damage.
- ? Ripening is increased when bunches are packed in closed chambers with restricted air circulation.
- ? It a common practice to induce ripening so that the fruits become yellow faster.

Banana pests

Pest/Description and damage

Banana silvering thrips (Plate 1 & 2)

- ? The adults are dark brown with 2 pairs of wings.
- ? The thrips feed on the skin of the fruit, producing silvery patches which later turn brown and cover the whole fruit.
- ? Young fruits may crack and do not get yellow when ripe.
- ? The damage to the fruit is of little importance in the local market but may be a serious for the export market.

Banana weevil (Plates 3 & 4)

- ? The adult beetle is dark brown to black, hard shelled and can be recognised by the snout.
- ? The adults are sluggish and look dead when touched, hide during the day and come out at night to feed and lay eggs.
- ? They feed on dead banana plants, newly cut stems, and other decaying plant material near the base of banana plants.
- ? The larvae are cream-coloured and without legs and feed on the corms making irregular tunnels at ground level.
- ? The pupa develops in the tunnels.
- ? Leaves of attacked plants turn yellow, wither and die prematurely. Heavy infestations may kill young plants while older plants are easily blown over by the wind. This pest is distributed mostly by infested corms, and causes major damage in neglected plants.

Pest management

- ? Chemical control is sensible for high-grade banana production, and should be done as soon as the insect numbers increase or plant damage is observed.
- ? Whenever chemicals are used, observe pre-harvest interval.
- ? Use clean, uninfected plant material. This can be obtained by cutting off the roots and outer layers of the corm and checking if there are tunnels or feeding injuries.
- ? Do not leave prepared planting material in the field overnight, since the beetles may lay eggs in it.
- ? After harvest, cut stems close to the ground and cover the cut face with a layer of earth to prevent the weevil from entering.
- ? Cut harvested stems in small pieces to enable them to rot as soon as possible.
- ? Keep the base of the stems free of weeds.
- ? Trap the weevils by placing old stem pieces facing down between the plants. Trapped beetles can be collected by hand from the pieces or the traps can be also treated with insecticides.

Disease/Symptoms**Disease Management***Fusarium wilt (Panama Disease)*

(Plates 5 & 6)

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| <ul style="list-style-type: none"> ? Diseased leaves turn yellow from the margins, dry up and later collapse leaving a skirt of dead leaves draped around the plant. ? Stems of affected plants split longitudinally and when cut across the vessels exhibit purplish stains. ? Decayed stems smell of rotten fish when cut. ? Corms when cut show brown or black lines running through the tissues. ? Roots of diseased plants usually turn black and rot. | <ul style="list-style-type: none"> ? Obtain suckers from farms/areas where disease has not been observed ? All suckers should be pared and treated by dipping in a solution of benomyl. ? Uproot and burn all diseased plants. ? Do not plant suckers from affected to non-affected farms/areas. ? Avoid injuring the roots during weeding or other farm operations ? Avoid planting bananas in poorly drained soils ? Add plenty of manure when planting suckers. ? Irrigate the plants during drought. ? <i>Gros Michel, Bokoboko</i> and <i>Muraru</i> varieties are susceptible to the disease. Use resistant varieties: <i>Kisigame (Shisikame; Linyole), Ikiganda, Manyoke, Sukari, Chinese Dwarf, Cabou, Somali, Kimalindi, Kigumi, Pikipiki</i> or <i>Gatumia</i>. |
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Banana nematodes (Plates 7-9)

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| <ul style="list-style-type: none"> ? Diseased plants have yellow leaves and are generally stunted. ? Affected plants later topple especially during wet, windy weather. ? Roots of diseased plants when split appear red-brown to black. | <ul style="list-style-type: none"> ? Use healthy nematode-free suckers for planting. ? Do not replant new bananas on old banana land for 12 months. Uproot any volunteer plants. ? Do not plant cover crops such as maize, cowpea, and sorghum as these are hosts of the nematode. ? Pare roots and discoloured tissues from corms and treat with phenamiphos (Nemacur 5% G) or immerse in hot water (50° C) for 20 minutes. ? If nematodes are a serious problem, apply nematicides in the planting holes. Repeat spot applications every 4 months. ? Observe pre-harvest intervals when using nematicides. |
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Cigar End Rot (Plate 10)

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| <ul style="list-style-type: none"> ? A dry rot with an ashy grey appearance resembling a burnt-out cigar affecting a few centimetres of the tip. ? The pulp eventually undergoes a dry rot and becomes fibrous. | <ul style="list-style-type: none"> ? Remove by hand or a brush dried floral parts from fruit tips 8-11 days after fruit bunch emergence. ? Remove and burn all excess dried leaves and other dead plant tissue from the field. ? Maintain proper spacing between plants by pruning excess suckers |
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Cashew nut

Cashew nut

Cashew, a native of Brazil, grows along the coastal belt. The nut kernels are used in the confectionery food industry. Juice from the apple is used in preparing vinegar and wine, and it is a rich source of vitamin C. The nutshell liquid is used as a valuable oil by-product.

Varieties

Selections have been made at the coast and high-performing cultivars are being propagated.

The selected cultivars available at the Kenya Agricultural Research Institute, Mtwapa station, include A 41, A 47A, A75-83, A 81 and A 100.

Ecological requirements

- ? Altitude: Cashew trees do well at altitudes between 0 and 1200 m.
- ? Cashew nuts can also grow in areas like Kisumu and Embu.
- ? Rainfall should be a minimum of 900 mm per annum; 1500 mm is better.
- ? Cashew does well in drier areas. Humid conditions encourage disease.
- ? Soils should be deep and well drained; sandy or sandy loam are recommended.

Propagating from seed

- ? Cashew is commonly propagated from seed, although plants propagated from seed show a lot of variation from the mother trees.
- ? Select seeds only from healthy and high-yielding trees.
- ? Put the seeds in a bucket of salty water, and use only the seeds that sink to the bottom of the container.
- ? Seeds can be planted directly in the field or in containers.

Vegetative propagation

- ? Air layering and wedge grafting are the most common methods of vegetative propagation.
- ? For grafting, sow seeds directly into the field or in containers.
- ? Air layer on plants that are high yielding.

Field establishment

- ? Prepare holes 60 x 60 x 60 cm before the planting season.
- ? Space the holes at 12 x 12 m, 12 x 14 m or 14 x 14 m. The wider spacing is better to avoid overcrowding the trees.
- ? For direct planting, sow 3 to 4 seeds per hole. They will germinate in 10 to 12 days.
- ? Thin out the plants after 3 to 4 months, leaving only the healthy plants.
- ? Grafting can be done after plants have been thinned at a height of 15 to 20 cm.

Field management

- ? Stake all the plants left in the field and keep them weed free.
- ? Remove all side branches up to a height of 1 m.
- ? Cut or pinch the main stem at 80 to 90 cm to allow side branches to develop.
- ? Only 3 or 4 main branches should be left.
- ? Apply manure to encourage healthy growth and improved nut yield.

Harvesting and post-harvest handling

- ? Trees start to bear after 2½ to 3 years. Commercial yields are obtained 8 to 10 years after planting.
- ? Nuts are harvested between November and March. Each tree yields approximately 25 kg of nuts per year. Selected trees at Mtwapa can yield 40 to 78 kg of nuts per tree per year.
- ? Nuts fall from the tree when they mature. Then remove the attached apple.
- ? Pick the nuts once a week during the dry season and daily during the wet season.
- ? Dry nuts in the open. Dry nuts can store for up to 2 years.

Roasting the nuts

- ? Soak nuts in water and then roast to discharge the shell oil.
- ? Roast the nuts in perforated cylinders, which are placed above an open fire.
- ? Remove the kernels from the nuts with a mallet.
- ? Grade the nuts according to size and quality and then pack them.

Cashew pests

Pest/Description and damage

Pest management

Cashew helopeltis (Plates 1-5)

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| <ul style="list-style-type: none"> ? This is the most important pest of cashew and has very long legs and antennae. ? Young bugs are red or yellow, while the adults are orange-brown with transparent wings. ? These insects avoid direct sunlight. ? The damage typically called 'dieback', involves withering of the inflorescence or shoot, which turn brown/black. ? Heavy infestations retard trees, reduce fruit formation and lead to die back of young twigs. Secondary branching is stimulated, which is also very susceptible to attack. ? Seriously infested trees appear burnt. ????? Developing apples and nuts shrivel and dry up or are reduced in size. | <ul style="list-style-type: none"> ? Do not shade seedlings in the nursery. ? Avoid waterlogged or infertile soils since <i>Helopeltis</i> damage is normally worse on crops on these soils. ? Introduce weaver ants (majimoto), which deter the bugs. These ant nests can be transferring in the same way as for control of the coconut bug (see coconut pests), by connecting trees with ropes and by intercropping cashew with other plants favoured by these ants such as guava, citrus, soursop. ? Inspect fields regularly during the periods of flush growth. Crops near to the forest need especial attention. If necessary, sprays should be applied to the infested area only. Do not spray in hot sunshine when the bugs are sheltering. ? Young cashew trees, up to five years old, may need regular treatment to avoid stunting and delay in the onset of cropping. Control can be obtained by spraying with pyrethroids such as lambda-cyhalothrin (Karate E. C). |
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The coconut bug

It is an important pest of coconuts, but also attacks cashew, sucking on developing fruits lowering the value of the nuts.

For description and management see coconut pests.

Cashew nut diseases

Powdery Mildew

(It is caused by fungus *Oidium anacardii*. Symptoms and disease management are similar to mango powdery mildew).

Blossom Blight (Refer to mango blossom blight/anthracnose).

Citrus

Citrus

The family of citrus fruits is commonly divided into the following groups:

	Variety	Altitude (m)
Grapefruit	Marsh seedless	0–1500
	Red Blush	0–1500
	Duncun	0–1500
	Thomson	1000–1500
Lemon	Eureka	1000–1500
	Lisbon	1000–1500
	Villafranca	1000–1500
	Rough lemon	0–1500
Lime	Mexican	0–1000
	Tahiti	1000–1500
	Bearss	1000–1500
Mandarin	Satsuma	0–1500
	Kara	0–1500
Sweet orange	Washington	1000–1800
	Navel/Valencia	0–1500
	Hamlin	0–1500
	Pineapple	0–1500
Tangerine	Clementine	
	Dancy	

Ecological requirements

- ? Temperatures at which citrus fruits grow well are between 25 and 32 C.
- ? The orange colour of the fruit develops at a temperature of 14 C coupled with low humidity. These conditions are prevalent at altitudes above 1000 m.
- ? Fruits raised at altitudes below 1200 m remain green even when they ripen.
- ? Rainfall of 1000 to 1850 mm a year that is well distributed is suitable for citrus. Water requirement reaches a peak at the time between flowering and ripening.
- ? Citrus are intolerant of strong dry winds, and if a windbreak is not provided the top branches may suffer from dieback.
- ? Soils should be deep, light, loamy and fertile.
- ? Avoid waterlogged and saline soils.
- ? Poor, shallow or rocky soils are not suitable for growing citrus.

Establishment

Recommended rootstock

- ? Rough lemon
- ? Cleopatra mandarin
- ? Troyer/Carrizo citrange
- ? Rangpur lime

Seeds, planting and budding

- ? Select only clean seeds extracted from freshly picked fruits of the above varieties.
- ? Seeds perform better when planted soon after they are extracted.
- ? Plant seeds in seedbeds or containers, 7 x 9 inches (approx. 18 x 23 cm). Seeds germinate in 2 to 3 weeks.
- ? Water the seeds regularly, preferably twice a day, until they germinate.
- ? Plants are ready for budding when they reach pencil thickness or 6 to 8 months after germination. T-budding with bud wood from a selected variety is the most common method.
- ? Do the budding during the warm months. Avoid budding during cold periods and during dry conditions.
- ? Budded plants are ready for transplanting 4 to 6 months after budding.
- ? Alternatively, obtain budded plants from a registered fruit nursery. These young plants are ready for direct planting in the field.

Planting in the field

- ? Plant in the field at the onset of the rains.
- ? Clear the field and dig holes 60 x 60 x 60 cm well before the onset of the rains.
- ? At planting, use well-rotted manure mixed with topsoil.

Spacing

- ? Limes and lemons are planted at a spacing of 4 x 5 m.
- ? Oranges, grapefruits, mandarins and tangerines are planted at 5 x 6 m or 7 x 8 m. The wider spacing is good for a low level of management.
- ? Plants should be given adequate water immediately after planting. Mulching helps conserve moisture.

Tree management

- ? Keep the fruit trees free of weeds.
- ? Maintain a single stem up to a height of 80 cm.
- ? Remove all side branches below this height.
- ? Pinch or break the top branch at a height of 90 cm to encourage side branching.
- ? Allow 3 to 5 shoots to develop as branches. Select 3 to 4 of the strong branches growing outwards to form the framework of the tree.
- ? Remove any other side branches, including those growing inwards.
- ? Ensure that all diseased and dead branches are removed regularly.

Manure and fertilizer

- ? Apply farmyard manure at the rate of 1 or 2 debes per tree. Incorporate the manure well into the soil. Increase the manure by 1 debe every year.
- ? The following rates of CAN per tree are recommended: 1st year 100 g, 2nd year 250 g, 3rd year 400 g, 4th year 550 g, 5th year 700 g.

Yields

- ? Budded citrus fruits start to flower very early but fruits should be allowed to form only in the 3rd year. Remove all flowers that develop before then. Flowering begins at the onset of rains.
- ? Commercial yields start 4 to 5 years after transplanting.
- ? You can expect the following yield ranges per tree:
 - ? oranges 90–130 kg
 - ? lemons 130–180 kg

Harvesting and post-harvest handling

- ? Harvest fruits when they are mature. Mature fruits change colour.
- ? In low-altitude areas where fruit remains green, it is necessary to test a few fruits for ripeness.
- ? Harvest the fruits using a sharp knife, taking care not to injure or bruise the fruit.
- ? Fruits can also be plucked. However, plucking causes the stem to break close to the fruit and increases the chances of it becoming infected.
- ? Wash, sort and grade fruits under shade. Discard deformed and irregularly shaped fruits.
- ? Pack fruits in crates. Use crates to transport the fruits from the field and to the market.

Citrus pests

Pest/Description and damage

Scales

- ? They are small motionless insects that appear to be fixed on the plant.
- ? Scales suck sap mainly on all plant parts, resulting in discoloration of foliage, poor growth and branch dieback.
- ? There are many species of scales on citrus, which differ in shape and colour. There are two main groups: hard (armoured) and soft (naked) scales.
- ? Soft scales often secrete honeydew, cause growth of sooty mould and attract ants.
- ? Fruit and leaves are then heavily coated with sooty mould giving turning them black.

The citrus woolly whitefly

- ? This pest was recently introduced into Kenya. The adults resemble small white moths, covered with mealy white wax.
- ? The eggs are laid on the lower surface of young leaves.
- ? The young stages resemble soft scale insects and have a woolly appearance.
- ? They produce large amounts of honeydew that leads to the growth sooty mould on the infested trees.
- ? This leads to defoliation, loss of fruits and dwarfing of the tress.
- ? Small, mottled fruits are produced.

Citrus blackfly

- ? The adult resembles a tiny greyish moth.
- ? The eggs are usually laid in a spiral in the lower surface of the leaves.
- ? The young stages are shiny black scale-like insects surrounded by a white fringe of wax.
- ? They produce large amounts of honeydew, causing the growth of sooty-mould that covers all infested plants parts.

Pest management

- ? Natural enemies normally control scales. These natural enemies should not be killed.
 - ? Ant control is important since they may hamper the activity of natural enemies. However, weaver ants do protect citrus trees from other pests (see the coconut bug).
 - ? Undesirable ants can be controlled by banding the stems with grease, or by spraying stems, not leaves three times a year with diazinon.
 - ? Chemical control is possible with light mineral oils, at low concentrations, mixed with other insecticides. At high concentrations mineral oils are harmful to the plants.
 - ? Sprays should be directed towards young stages of the scales.
 - ? Oil sprays should be carried out after picking and not during flowering or periods of excessive heat or drought.
 - ? To protect natural enemies, alternate tree rows can be sprayed each season.
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- ? Its natural enemies in the area of origin keep the woolly white fly under control. The most effective parasitic wasp has recently being introduced in Kenya and is giving good control of this pest.
 - ? The use of pesticides should be avoided since it may affect the efficacy of this parasitic wasp.
 - ? Chemical control is not economically feasible. Pesticides are often inefficient since the larvae are covered by wax. When effective, pest resurgence commonly occurs within a few weeks after application.
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- ? The citrus black fly is effectively controlled by natural enemies
 - ? If needed careful application of insecticides of infested trees is recommended. Spraying should be directed to the lower leaf surface. Effective insecticides include dimethoate, diazinon, malathion and permethrin.
 - ? Plant material from infested sources should be completely defoliated and the branches dipped in a dimethoate solution before planting.

Citrus Aphids

- ? Citrus aphids are brown to black in colour, and maybe winged or wingless.
 - ? They feed on new growth and blossoms, thus high numbers are found on the leaf surface during flushing and stems of young shoots die back.
 - ? Attacked leaves are curled and distorted. Flower buds are damaged or drop.
 - ? These aphids secrete large amounts of honey dew. Leaves and fruits may turn black due to the growth of sooty mould.
 - ? Symptoms can be severe on flush growth during dry periods following rainy spells.
 - ? The black citrus aphid transmits tristeza and other virus diseases.
- ? Natural enemies, such as ladybird beetles, hoverflies and several parasitic wasps, normally control citrus aphids. Control of ants may increase the efficiency of natural enemies.
 - ? Monitor aphid population particularly at each flush and controlled if necessary.
 - ? Insecticides should be applied only when heavy aphid populations are developing on the new flush.
 - ? Insecticide application should be directed towards infested shoots especially on the underside of the leaves.
 - ? If chemical control is necessary, selective products which protect natural enemies, such as endosulfan.

Citrus psyllid

- ? This insect prefers cool climates and it is found in Kenya only at elevations above 900 m.
 - ? The body is yellow; the wings are large and clear with distinct venation.
 - ? The adults jump and fly short distances when disturbed.
 - ? Tiny orange-yellow eggs are laid on the edges of and main veins of tender young leaves.
 - ? The immature stages only develop in young leaves.
 - ? Young foliage may be severely deformed, and flush growth depressed, but the tree is not seriously affected.
 - ? The citrus psyllid is important as vector of the greening disease, which is a serious citrus disease.
- ? Several natural enemies attack this insect pest, but they are usually of little importance at the start of the major flushing time. But they may drastically reduce the psyllid population.
 - ? Chemical control methods are only necessary during periods of heavy flush. Effective chemicals include dimethoate (Rogor 40 EC) soil drenching or bark painting with monocrotophos or methamidophos. In the nursery, sprays should be directed towards the lower surface and be repeated every 7-10 days during the flushing period. In the orchard drenching with dimethoate is effective. This method cannot be used in rough lemon. Alternatively sprays may be applied, but have to be repeated every 7-10 days during the flushing period.
 - ? Strictly observe pre-harvest intervals when ever using pesticides.

Citrus thrips

- ? Citrus thrips small insects translucent orange-yellow in colour.
 - ? Young stages are wingless, but adults have two pairs of narrow fringed wings.
 - ? Commercial damage is caused by larvae and adults, which feed on young fruits, producing brown blemishes on the rind.
 - ? Typical damage is the presence of rings of brown russet marks around the stem of the fruit.
 - ? The damage is cosmetic but affects the marketability of the fruits. However, new shoots can be severely damaged.
 - ? In severe infestation, the leaves are deformed. Young twigs are retarded and misshapen while young leaves are underdeveloped and drop when touched.
- ? Thrips should be controlled with selective insecticides to avoid the increase of other pests.

False codling moth

- ? The moth is brownish in colour and flies only at night.
- ? It lays single eggs on leaves and fruits. The initial symptom on the fruit is a circular spot with a tiny dark centre where the insect entered the fruit.
- ? The caterpillar bores into the fruits causing premature ripening and fruit-drop.
- ? Infested fruits should be removed twice a week.
- ? Bury all fallen fruits at least 50 cm deep, or dump in a drum with water mixed with a little used oil. The fruits should be left in the drum for at least one week.
- ? Remove host plants such as wild castor from around the orchard.

Fruit flies

- ? The flies are brown-yellow-black and the wings show yellow and brown markings.
- ? The female fly lays eggs within the skin of ripening fruits.
- ? Spots develop on the skin where eggs were laid and the hatching larvae enter the fruit.
- ? The spots on immature fruits are yellow or brownish but in older fruits soft rotting follow.
- ? Maggots can be found feeding and burrow through the pulp in a fruit. The attacked area becomes soft turns brown and decays. In citrus fruits the larva usually dies.
- ? Attacked fruits decay as a result of secondary infections.
- ? Collect and destroy affected fruits still on the tree twice a week.
- ? No fruit should remain on the ground or on the tree at the end of the picking season.
- ? Bait sprays consisting of an insecticide mixed with sugar (molasses) or protein hydrolysate should be applied in large drops and sprayed on every second or third tree.
- ? Only part of the foliage needs to be covered. Alternatively Fenthion can be sprayed without bait.
- ? Start spraying before fruits turn yellow and repeat 10 days later. No sprays should be applied within 14 days of picking.

Orange dog

- ? The caterpillars are white/brown or green in colour feed on the edges of leaves.
- ? The adult is a yellow/brown butterfly common during rainy season and lays whitish/grey eggs mainly on the underside of old leaves.
- ? They can cause extensive damage to young plants especially in citrus nurseries where their feeding can cause complete defoliation of a plant.
- ? Several natural enemies such as parasitic wasp, attack the caterpillars. In addition several birds feed on these caterpillars.
- ? Hand picking of the caterpillars and destruction of the eggs usually provides satisfactory control on small trees provided the plants are regularly checked.

Mites

- ? Mites are more abundant during the hot dry season. The citrus rust mite is wide spread in warm locations being a serious pest.
- ? Commonly found in developing and leaf buds.
- ? Damage under the bracts causes the death of the buds. Flower-bud development is reduced, growth is retarded, branches become stunted and misshapen, and rosette-shaped leaves are formed.
- ? The fruits, particularly in lemon are deformed. Almost all deformed fruits fall off at an early stage of development.
- ? Even light infestations may cause damage and control measures should be applied on time and regularly.
- ? Spots decrease the market value of the fruit. They also provide entry for fungus.
- ? Damaged fruits lose moisture rapidly and do not keep well.
- ? Infestation on ripe fruits causes light yellow or silver discoloration.
- ? Numerous natural enemies such as predatory thrips, ladybirds, and predatory mites normally attack red spider mites. In unsprayed orchards the natural enemies normally control mites.
- ? The bud and the rust mites are not well controlled by natural enemies and chemical control is necessary.
- ? Don't use sulphur s since it kills beneficial insects. Apply Aldicarb to the soil.

Citrus diseases

Disease/Symptoms*Citrus greening disease*

- ? Bacteria cause the disease.
- ? In Kenya, citrus greening disease occurs in the cool highland areas (altitude of 800 m and above).
- ? It is transmitted by the adult citrus psylla and through the use of bud wood from diseased trees.
- ? It causes stunting; leaf and fruit drop, and twig dieback. Only one or a few branches are affected while the rest of the tree appears normal and produces healthy fruit.
- ? Affected fruits are reduced in size, are of poor quality, lopsided, start to colour from the fruit branch instead of the opposite end, as is the case with healthy fruits, and drop prematurely.
- ? Seed abortion occurs in seedy varieties.
- ? Diseased leaves turn yellow along the veins and develop a blotchy, mottled appearance.
- ? Leaves on diseased terminal twigs are small, upright and show a variety of chlorotic patterns similar to zinc deficiency symptoms. Leaf drop is common in diseased orchards.
- ? Diseased trees are irregularly distributed within an orchard, and excessive and out-of-season blooming frequently occurs.

Fruit and Leaf Spot

- ? Caused by fungi. The leaves develop circular, mostly solitary spots up to 10 mm in diameter.
- ? The spots are usually surrounded by a prominent yellow halo. Sometimes, the centre of old spots falls out creating a shot-hole effect. Infected leaves may drop.
- ? Spots on fruits are flat, circular, generally solitary and surrounded by a yellow halo.
- ? On young fruits symptoms often commence as nipple-like swellings without a halo.

Disease Management

- ? Use bud wood from disease-free trees. Take bud wood only from greening-free areas such as the Coast.
- ? Practise strict control of citrus psylla in nurseries and in orchards.
- ? Remove trees with more than 50% infection from the field.
- ? Prune greening infected branches from trees with less than 50% infection.
- ? Nurseries should be established only in areas below 800 m above sea level.

- ? Remove fallen diseased leaves and fruits from the orchard.
- ? Avoid overlap of cropping by picking all the fruits at the end of season.
- ? Effective fungicides include benomyl (Benlate 50 WP), flusilazole (Punch 40 EC), chlorothalonil (Daconil 2787 75 WP), copper hydroxide (Kocide DF) and propineb (Antracol 75 WP).
- ? Concentrate spraying on developing fruits throughout the rainy season. Fruits of more than 40 mm in diameter need not be treated if extended periods of wetness do not prevail. Observe pre-harvest intervals when fungicides are used.

Gummosis and Root Rot

- ? Caused by fungi. Gummosis is a rotting of bark anywhere on the tree.
- ? An early symptom of gummosis is the sap oozing from small cracks in the infected bark giving the tree a bleeding appearance.
- ? Citrus gum may be washed off during heavy rains. The bark stays firm, dries, and eventually cracks and falls off.
- ? Nursery trees and young orchard trees can be rapidly girdled and killed. Root rot causes a slow decline of the scion top.
- ? The foliage yellows and drop, and twigs die back often with a crop of small fruit still hanging from bare branches.
- ? The feeder roots are destroyed when the root cortex is attacked, turns soft and separates giving the root system a stringy appearance.
- ? Start nurseries on virgin land.
- ? Treat citrus seed with hot water at 52°C for 10 minutes.
- ? Soil drenches of metalaxyl or fosetyl-AI are useful for preventing *Phytophthora* diseases in the nursery.
- ? Use resistant or tolerant rootstocks. Trifoliolate orange rootstock is resistant. Swingle citrumelo and Cleopatra mandarin are tolerant. Troyer citrange, Carrizo citrange and Rangpur lime are tolerant to bark infection.
- ? Bud seedlings at a height of 25 cm and above, which will keep the bud union well above ground level.
- ? Avoid transplanting on heavy or poorly drained soils.
- ? Do not heap soil around the tree base.
- ? Avoid basin and flood irrigation. Do not over irrigate and ensure water does not contact the scion portion of the trunk.
- ? Avoid injuries to roots and trunks when cultivating.
- ? Early stages of root rot infection could be controlled by soil drenches of fosetyl-AI and metalaxyl.
- ? Gummosis could be halted by bark surgery before 50% of the trunk is affected. Scrape away dead bark tissue, remove about 10 mm margin of healthy tissue and paint the wound with a slurry of metalaxyl or fosetyl-AI.
- ? Replant sites should be treated with either of the two fungicides prior to planting.
- ? Pre-harvest intervals must be strictly observed whenever fungicides are used.

Coconut

Coconut

The coconut palm is an important tree along the Kenyan coast, where it has been grown for centuries. It is a multipurpose tree: the leaves are used in roofing and making baskets; the Immature nuts are consumed as juice; ripe coconuts are used for copra and for making cooking oil, margarine soap and coconut cake; the husks are used for making coir; and the trunks for building and firewood. The palms are also tapped for wine.

Varieties

Three distinct types exist in Kenya:

- ? East African Tall
- ? Pemba Dwarf
- ? hybrids

Ecological requirements

- ? Altitude: Coconuts grow best below 1200 m.
- ? Rainfall: Coconuts require an average of 1250 mm a year. Rainfall below 1000 mm is not suitable nor are areas with pronounced dry spells.
- ? Soils: Coconut can tolerate a wide of soil types but ideally the soils should be deep and well drained.

Establishment

- ? Coconuts are grown only from seed nuts.
- ? Cut selected nuts at angle on the stem end to remove the husk and facilitate germination.
- ? Plant nuts in seedbeds in rows 45 cm apart. Bury the nuts just below the topsoil.
- ? The nuts need sufficient watering until they germinate, which can take up to 45 days.
- ? Plant out seedlings after 1 year, when they have 3 to 4 leaves. Plant at the beginning of the rains.
- ? Place the seedlings 30 cm deep in holes that have been prepared before the growing season begins. The holes should be 60 x 60 x 60 cm.

Management

- ? Protect the seedlings from stray animals.
- ? Clear all weeds. Weed the basins around the trees regularly and keep the plants mulched.
- ? Coconuts can be interplanted with annual crops until the trees start to flower.
- ? Remove all dead branches and immature fallen fruits. Burn them away from the field.
- ? Mature trees require very little management.
- ? Applying manure to the plant is beneficial.

Harvesting and post-harvest handling

- ? Coconut harvesting starts 4 years after planting.
- ? Harvesting is done continuously throughout the year.
- ? A tree can yield 40 to 60 nuts per year.
- ? Nuts must be fully ripe for copra production and making desiccated coconut.

Coconut pests

Pest Description and damage***The coconut bug (Plates 1-4)***

- ? Adult bugs are brown in colour, densely mottled, and can grow up to a length of 14 mm.
- ? Adults and nymphs suck on flowers and developing fruits, causing them to drop or to develop cracks and sunken lesions.
- ? Attacked young coconuts develop scars and excrete gum. Many of the affected nuts fall off.
- ? Nuts older than 3 months at the time of attack may not be aborted but remain small and have scars.
- ? Nuts which abort naturally without been attacked by the coconut bug do not show scars.
- ? Damage is usually less serious in intercropped coconuts.
- ? The bug also feeds on cashew, cocoa and guava.

The rhinoceros beetle. (Plates 5-8)

- ? The beetle is about 5 cm long, dark brown to black in colour with a horn on the head, hence its common name.
- ? The adult flies at night to palms and bores into the spear leaf, cutting and chewing the young unopened leaves. The leaves continue to develop and when they unfold show the characteristic V-shape damage.
- ? If the whole growing point is eaten, the palm usually dies, particularly young palms less than four years old.
- ? It is a serious pest in plantations where field sanitation is neglected.
- ? The larvae develop in rotten coconut logs, and in other decaying material.

Coconut mite (Plates 9 & 10)

- ? The coconut mite is tiny and difficult to see with the naked eye appears like fine dust.
- ? It attacks and damages the upper part of nutlets under the sepals, on nutlets up to an age of 6 months and it is severe during the dry season.
- ? Attacked nutless may fall or have a scarred skin, which often splits. In coconuts with light scarring on the husk, the nut inside is not seriously affected, but in heavily scarred coconuts there is significant damage to the nut.

Pest management

- ? The red fire ant or weaver ant is a valuable predator of this pest. This ant chases away or kills coconut bugs. A good control is achieved if more than 60% of palms are colonised by the red weaver ant.
- ? Keep bushes, which are hosts for weaver ants in the surroundings of coconut fields.
- ? Intercrop coconuts with plants favoured by weaver ants such as citrus, soursop and guava.
- ? Transfer weaver ant nests into the field by collecting nests from bushes around and placing them into coconut plants or other host plants in the field. Ants coming from different bushes and placed on the same tree will fight, and kill each other.
- ? Pesticides should be used only when necessary. Collect about 100 nutlets from the ground and remove the sepals. If more than 35 show signs of bug attack spraying is advisable.
- ? Use Endosulfan (Thiodan) or cypermethrin (Ambush), but the former is preferred because it is less dangerous to weaver ants.

- ? Dead palms should be felled, chopped and removed to destroy the breeding site. If logs cannot be removed, the decaying end should be checked for beetle larvae and destroyed regularly.
- ? The beetles can be controlled in young plants by hooking. An iron rod of 30 cm long with a hook at the end is pushed into the tunnel, bored by the beetle while feeding. If the beetle is still inside, it will be hooked out.

- ? Control is not necessary since there is no significant economic damage.

Termites

- ? Termites can be a serious problem for coconut palms, particularly seedlings which are still in the nursery or which have just been planted into the field.
- ? Termites live in the soil in hills, construct tunnels from their hills to palms and feed on all parts of young coconut palms.
- ? Damage occurs mainly during the dry season.
- ? Prepare nurseries in areas without termites.
- ? Raising seedlings in polythene bags may help to avoid attack by termites.
- ? Traditional methods for termite control include:
 - a. Flooding mounds
 - b. Digging mounds and removing the queens
 - c. Suffocating the colony by burning and
 - d. Mound poisoning.

Custard apple

Custard apple

Custard apple is a common name used for soursop, sweetsop (sugar apple) and cherimoya.

Soursop

- ? Does well in warm areas at altitudes up to 1400 m.
- ? Mature tree grows up to a height of 8–10 m.
- ? Fruits are green with average weights of 2 kg and are covered with sharp spines.
- ? The fruit pulp has a woody, fibrous texture, acidic in flavour. It is rich in vitamins B and C. It is used in flavouring ice creams and cold drinks.

Sweetsop

- ? Commonly found in the coastal areas up to elevations up to 1100 m. It is drought tolerant.
- ? The fruits are heart shaped, up to 10 cm in diameter, yellow-green in colour with thick skin, white pulp, and a sweet and pleasant flavour.
- ? They are consumed mostly as a dessert but can be used in ice cream and milk shakes.
- ? Mature tree is about 5 or 6 m high.

Cherimoya

- ? Cherimoya grows at altitudes between 1400 and 2200 m.
- ? The fruit pulp is sweet and mildly acidic.
- ? The tree can reach a height of 7 m.

Varieties

There are no named varieties or cultivars of soursop or sweetsop in Kenya. Named varieties of cherimoya include McPherson, Delicosa, Bays, Haes and Pink Mammoth.

Ecological requirements

Custard apples are adapted to a wide range of ecological conditions, as specified above. Soils should not be waterlogged.

Establishment

- ? Seed propagation is the common method.
- ? Cleft grafting has been successful. Grafted plants bear fruits after only 3–4 years.
- ? Spacing:
 - ? *soursop* – 6 x 7 m
 - ? *sweetsop* – 5 x 6 m
 - ? *cherimoya* – 7 x 8 m

Management

Yields can be improved up to 30% with hand pollination, which improves the fruit set.

Harvesting and post-harvest handling

- ? Soursop yields 8 to 9 tonnes per hectare by the 6th year.
- ? Sweetsop can yield around 60 fruits per tree per year.
- ? Although some fruits have a thick skin, fruits should be handled with care to avoid bruising. Bruised areas usually turn black.
- ? Harvest the fruits using a knife and place them gently in crates or baskets.
- ? Keep harvested fruit in the shade.

Guava

Guava

Guava, a hardy tree about 8 to 10 m in height, is found both cultivated and growing wild. The fruit skin colour is green to bright yellow; flesh colour ranges through white, yellow, pink, salmon, orange and red. Fruit flavour may be sweet or highly acidic.

The fruits are eaten fresh and are processed into jams, jellies, paste, juice and other canned products.

Varieties

Many superior cultivars have been introduced into the country, including—

- ? cultivars with high sugar content, such as Malherbe, Fan Retief, Hong Kong Pink and Ruby X Supreme
- ? cultivars with acidic fruits, such as Potallo, Beaumont, WK-11-26 and Kahua Kula

Ecological requirements

- ? Altitude: Trees do well at altitudes from sea level to 2000 m.
- ? Rainfall: A minimum of 900 mm a year is desirable, but the tree tolerates both marked dry spells and waterlogging.
- ? Trees can grow in a wide range of soil types, from sandy to heavy loam. Shallow, gravelly and rocky soils can be accommodated but at the detriment of sustained production.

Establishment

Guava plants are commonly propagated from seeds; however, vegetative propagation techniques such as air layering, grafting and budding are highly encouraged.

Vegetative propagation is mainly done by air layering.

Seed planting

- ? Select seeds from healthy, outstanding mother plants of a known variety.
- ? The fruits should be fresh and ripe. The seeds are easier to remove when fruits are allowed to ferment for a few days in a container filled with water.
- ? Wash the seeds in fresh water to remove all the flesh.
- ? The seeds can be either dried or planted immediately.
- ? Sow the seeds in a seedbed, containers or directly to the field. If planted directly, sow 3 to 4 seeds per hole.

Grafting

- ? The seeds germinate in 1 to 4 weeks and are ready for grafting in 3 to 4 months, when they reach a thickness of 1 cm.
- ? Cleft grafting is the method most commonly used. Avoid grafting during the cold season.
- ? Plants are ready for planting out 2 to 3 months after they have been grafted.

Spacing in the field

- ? Space at 4 x 5 m when under high management or in dry areas. With low management, spacing of 5 x 6 m or 6 x 7 m is recommended.
- ? Planting holes should be dug 60 x 60 x 60 cm.
- ? When planting grafted seedlings, position the graft union 30 cm above the ground. Plant the seedling at the same depth as it was in the nursery.
- ? Fill the planting hole completely with soil.

Management

- ? Train young trees to single stems. After the stem reaches a height of 60 cm, prune to leave only 5 well-spaced side branches.
- ? Prune every season after harvest to enhance flowering. Remove all dry wood and branches.
- ? Prune trees to promote new vegetative growth and flowering.
- ? Keep young trees weed free. Large trees tend to have no weeds under them.
- ? If available, apply fertilizer at the rate of 1.5 to 2.0 kg CAN and 1.5 kg super phosphate for a fully grown tree.
- ? Apply farmyard manure at the rate of 2 debes per year, before the rains, and incorporate it into the soil.

Harvesting and yields

- ? Grafted trees start bearing after 2 years.
- ? Commercial yields are obtained in the 6th year.
- ? Ungrafted plants take up to 2 years before flowering and fruits take 3 to 4 months to mature.
- ? Two flowering seasons occur in Kenya—during March–April and October–November. Flowering coincides with the rains.
- ? Yields of between 47 to 52 tonnes per hectare have been obtained in Kenya.

Post-harvest handling

- ? Fruits are ready for harvest when the skin colour starts to change from green.
- ? Guavas have a very delicate skin that is easily damaged. Avoid mechanical bruising.
- ? Use shallow containers when harvesting and transporting the fruits.
- ? Keep harvested fruits in the shade.

Guava pests

Pest description and damage

Fruit flies (Plate 1)

- ? Fruit Flies are the most serious pests of guava. The flies are 4-7 mm long, brightly coloured, usually brown-yellow-black patterns; wings are spotted or banded with yellow and brown margins.
- ? Eggs are laid into the maturing fruit, where they hatch into small maggots.
- ? The maggots are creamy-white, up to 6 mm long and have no legs. The maggots burrow through the pulp, making them unsuitable for human consumption.
- ? Maggots emerge from the soil to pupate in the soil.

Mealy bugs (Plate 2)

- ? Mealy bugs are small (about 3mm long), elongated-oval insects with pale pink coloured, soft bodies mostly covered with a waxy secretion.
- ? They secrete honeydew, a sticky substance on which a black fungus (sooty mould) grows.
- ? Ants are attracted by the honeydew, which hampers the activities of the natural enemies such as ladybird beetles and parasitic wasps.

Scales

- ? Soft and armoured scales are often found in low numbers on guava trees.

The false codling moth

(Refer to citrus pests)

The coconut bug

- ? This bug is a major pest of coconuts, but also attacks other fruit trees such as avocado and guava. They are found in the coastal areas of Kenya and Tanzania.

?????For description and management refer to pest of coconuts.

Pest management

- ? Remove and destroy rotten fruits from the ground regularly. These fruits can be chopped up or buried at least 50 cm deep.
- ? Apply bait sprays consisting of insecticide mixed with sugar/molasses on every 2nd or 3rd tree.

- ? Parasitic wasps and predatory beetles usually control mealy bugs.
- ? Avoid unnecessary use of chemicals that kill natural enemies.

- ? Natural enemies can effectively control scales.
- ? Avoid unnecessary use of chemicals that kill natural enemies.

Guava diseases

No major diseases have been reported in East Africa.

Macadamia

Macadamia

Macadamia is considered one of the best edible nuts in the world. It is used in confectionery, cakes, ice cream and cookies. The kernel is the edible part, which is enclosed in a hard shell surrounded by a green husk.

The crop is adapted to lower tea zones and coffee areas.

Varieties

- ? The two main species are *Macadamia integrifolia* and *Macadamia tetraphylla*, but there are many natural crosses.
- ? The smooth-shell cultivars are preferred in the market as they have higher oil content and are low in sugar.

Characteristic	<i>Macadamia integrifolia</i>	<i>Macadamia tetraphylla</i>
Shell	smooth	rough
Nut	round or nearly round	slightly elliptical
Leaf margin	smooth	jagged toothed
Full-grown leaf	3 leaves per node	4 leaves per node

Recommended cultivars selected in Kenya:

- ? for altitudes between 1500 and 1650 m
 - ? for altitudes above 1650 m
- MRG 2, KMB 4, EMB 2, MRG 25, TTW 2
MFU 23, MRU 24, MRU 25, KMB 25

Ecological requirements

- ? Altitude and temperature: The best growing areas are at elevations of 1500 to 1900 m with an annual mean temperatures of 17.5 to 21 °C.
- ? Rainfall: The trees require a minimum of 1000 mm a year.
- ? Soils: The trees can grow in a variety of soils. Fertile and loose soils allow good root development. Avoid shallow, murrum and waterlogged areas.

Establishment

- ? Macadamia trees can be raised from seeds that are picked up from the ground.
- ? Rough-shelled varieties (*M. tetraphylla*) are commonly used as rootstock.
- ? Select large seeds from healthy, high-yielding trees. Prepare selected seeds for planting immediately after picking.
- ? Soak seeds in water for 24 hours before sowing.
- ? Sow seeds with the white spot on the seed facing down.
- ? Seeds can be sown in containers or directly in the field.
- ? The seeds will germinate in 1 to 3 months.

Vegetative propagation

- ? Seedlings can be grafted or budded in the field, seedbed or containers.
- ? Cleft grafting is commonly used. However, chip budding can also be used.
- ? Success in grafting and budding of macadamia is low because the stem is hardwood.
- ? Covering the seedlings with a polythene sheet increases the success rate of grafting or budding. However, some space should be left between the sheet and the plants. The tunnels increase the warmth around the plants that makes the propagation successful.
- ? Graft or bud the seedlings after 12 to 15 months when they are 1.0 to 1.5 cm in diameter. Do not allow any side branches to develop before grafting or budding.

Planting in the field

- ? Grafted or budded seedlings are ready for transplanting after 6 to 10 months.
- ? Dig holes 60 x 60 x 60 cm before planting. Space holes at 8 x 9 m or 9 x 10 m.
- ? Use well-rotted manure mixed with topsoil during planting at the rate of 1 debe per hole.

Tree management

- ? Weed and mulch the tree basins regularly.
- ? Remove all side branches until the plant reaches a height of 1 m.
- ? Prune to ensure there is a central leader with only wide-angled branches at various levels.
- ? Cut the central leader at 60 cm to allow the first two side branches to develop.
- ? Another framework is recommended at shoulder height. All the branches should be at an angle wider than 45°.
- ? Remove all side shoots other than those at the levels described above.

Manure and fertilizer

- ? Apply 1 or 2 deces of manure every year from the 2nd year onwards.
- ? Apply manure before the rains begin.
- ? Apply sulphate of ammonia fertilizer at the rate of 200 g per plant per year.

Harvesting and post-harvest handling

- ? Trees start producing nuts in the 5th year. Mature nuts normally drop from the trees.
- ? The harvesting season lasts from October to March. Keep the area under the trees free of weeds and debris.
- ? Collect fallen nuts once a week. Remove the husks within 1 to 2 days before storage.
- ? Yield of a 5-year-old tree is about 3 kg; yield increases to about 55 kg per tree per year by the 15th year.

Mango

Mango

The mango originated in Southeast Asia. It is eaten fresh as a dessert and used in manufacturing juice, jams and other preserves.

Varieties

- ? coastal cultivars: Ngowe, Boribo, Batawi
- ? improved cultivars: Van Dyke, Haden, Tommy Atkins, Kent, Keith
- ? other varieties: Sensation, Irwin, Zill

When selecting varieties to plant, consider the time of maturity, as different varieties are early, medium and late maturing.

Ecological requirements

- ? Altitude: Mangoes grow well from sea level up to altitudes of 1800 m.
- ? Temperature: Between 20 and 30 C. Below 15 C, growth slows and fruit quality lessens.
- ? Eye-catching varieties do well up to 1800 m. When apple variety fruits mature, they may develop a rust appearance in areas above 1200 m.
- ? Rainfall: Mangoes grow with a minimum annual rainfall of 500 mm. However, 850 to 1000 mm is needed to sustain fruit production. A dry spell of 40 to 60 days is required to trigger flowering.
- ? Once established, mangoes require very little water.
- ? Soils: Deep fertile soils are preferred. Mangoes cannot tolerate waterlogging.

Establishment

Propagation steps in the nursery

- ? Use fresh seed, available from December to March and some in July.
- ? Peel the husk off and plant the inner seed only. Germination will be faster.
- ? Plant seed in seedbed. Seed germinates in 2 to 3 weeks; then prick out.
- ? Direct seeding can also be done on the farm, with grafting to be done later.
- ? Transplant into container when germinated. Common container size is 7 x 9 inches (approx. 18 x 23 cm).
- ? Cleft grafting with the scion of an improved cultivar is the most common method. Grafting is done from January to February, before mother trees flower and at any time of the year as long as desired scions are available.
- ? Some sources for scions: Thika, prison farms, Mtwapa, Kamurugu, Embu, or any farm with desired cultivars.
- ? In a moderate climate (not extremely hot), cover scion and grafting union with transparent cap.
- ? In a hot climate, take off all the leaf petioles completely very close to the scion's bark and tie the grafting tape up to the top of the scion, leave only the tip bud open. This method prevents heat from accumulating under the plastic cap recommended for moderate climates.
- ? Shade the grafted plants and water frequently.
- ? Grafted seedlings are ready to plant about 4 months after grafting.
- ? Planting seasons without irrigation: October–November, short rains; April–May, long rains

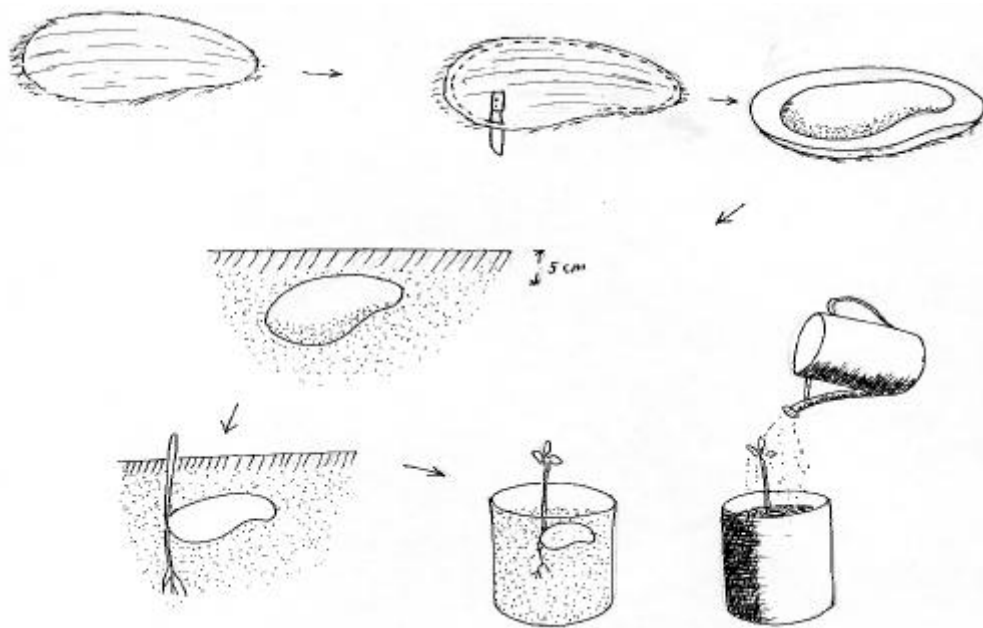
Preferable rootstock seed

Sabre, Peach, Dodo—or any outstanding local mango trees

Planting improved mango trees in the farm

Size of planting hole (length x width x depth):

- ? under dry conditions: 90 x 90 x 60 cm (3 x 3 x 2 ft)
- ? under wet conditions: 60 x 60 x 60 cm (2 x 2 x 2 ft)



Propagation of improved mango cultivars

Common spacing

- ? for extensive management: 12 x 12 m (plant to plant x row to row)
- ? for intensive management: 8 x 10 m (plant to plant x row to row)
- ? Make the grafting union at 30 cm (1 ft) above ground level. Plant the tree at the same depth as it was in the container.
- ? Fill the planting hole completely with soil if you plant during the rainy season. Do not leave space in the hole, as heavy rains will damage the tree and cover it with soil.
- ? Establish water catchments before end of the rainy season.
- ? Watering during dry season is necessary for 2 to 3 years.
- ? Mulch in areas without termites, but keep the stem free of mulch.
- ? Ring weed according to diameter of tree canopy.

Tree management

Formative pruning of young trees

- ? Maintain only a single stem up to 75 cm (2.5 ft).
- ? Remove all side shoots below that height. Use a secateur or sharp knife.
- ? Do not allow any sprouts below the graft union.
- ? Pinch off the leader (break over the top branch) at a height of 90 cm (3 ft). This is to induce the formation of lateral shoots (side branches).
- ? Allow 3 to 5 shoots (side branches) to develop.
- ? Maintain 3 to 4 of the shoots equally spaced around the single stem; prune off the weak ones.
- ? Force the shoots to grow in the desired directions by using sticks of timber or strings holding them away from the centre. This forms the scaffold branches (main branches) that are the supporting framework for the growing tree.
- ? Ensure an open scaffold system of growth (open crown).

Pruning of established trees

- ? Remove dead and diseased branches.
- ? Maintain the scaffold branches (main branches and open crown).

Annual application of farmyard manure

- ? Until first yield: 1 bucketful per year around the drip line.
- ? In subsequent years: 2 bucketfuls per year are recommended.
- ? Emphasize that applying manure is preferable to applying commercial fertilizer.
- ? Apply manure at the drip line, at the outer diameter of the canopy rather than to the stem.

Post-harvest handling

- ? A mature mango fruit has well-developed shoulders (region around the fruit stem), or when cut open, 50% of the fruit has changed from greenish white to yellow-orange.
- ? The colour change may not be the same for all varieties so it is advisable to observe the ripening pattern for each cultivar.
- ? Mango fruits should be picked by hand or harvested with the aid of a picking device attached to the end of a long pole. The device consists of a pair of string-operated knives and a collecting bag.
- ? Cut the fruit from the tree, leaving a long stalk of about 3 cm to prevent latex flow that spoils fruit quality. Cut the stalk back to 0.5–1 cm during packing.
- ? Wash fruits, using hot water where possible at 55 °C for 5 minutes to kill disease-causing agents. Do not use chemicals on harvested fruits.
- ? Sort and store fruits according to variety, colour and size.
- ? Transport in boxes or crates to avoid any physical damage.

Mango pests

Pest/Description and damage

Pest management

Fruit flies (Plates 1 & 2)

- | | |
|---|--|
| <ul style="list-style-type: none"> ? The flies are brightly coloured, usually brown-yellow-black patterns. The wings are spotted or banded with yellow and brown margins. ? The eggs are laid under the surface of the fruit skin. After hatching the maggots penetrate the flesh and destroy the fruits from inside, causing fruit rot. ? Infested parts of the fruit become soft and have premature colouring. | <ul style="list-style-type: none"> ? Collect and destroy all fallen fruits by burying or burning. Bury the fallen fruits at least 50 cm deep in the soil, thus the larvae cannot reach the surface. ? Harvest mangoes just before they get ripe. ? Bait trapping have proven effective. ? Heavy attacks may be treated with bait sprays, consisting of an insecticide mixed with sugar (or molasses). A number of insecticides provide good control of fruit flies. Some of them include deltamethrin (Decis), diazinon (Bazudin), dimethoate (Rogor). Observe pre-harvest intervals whenever using pesticides |
|---|--|

Mango weevil (Plates 3 & 4)

- | | |
|--|--|
| <ul style="list-style-type: none"> ? The mango weevil is greyish brown in colour. They are well camouflaged on the bark of the trees and pretend to be dead when touched or disturbed. The female beetle lays single eggs into young fruits, causing small dark marks. ? The larva, which is white with brown heads and has no legs, burrows through the flesh into the seeds where it feeds until pupation, destroying the seed. ? The external signs of fruit damage on the fruit are not very noticeable. ? The adult emerges by tunneling through the flesh into the open leaving a hole in the fruit skin. This tunnel turns hard and whitish in colour and renders the fruit unmarketable. | <ul style="list-style-type: none"> ? Orchard sanitation is very important to manage this weevil. ? Keep orchard free of fallen fruits and plant debris by collecting and burying or burning the fruits once or twice a week. ? Chemical control by spraying when fruits are forming is very effective. Use Decis, diazenon or dimethoate. |
|--|--|

Mango gallfly

- | | |
|--|---|
| <ul style="list-style-type: none"> ? The mango gallfly is a very small insect that lay eggs in young leaves. ? The larva feeds on the leaves, which develops a small gall (pimple). ? Young leaves may be covered with galls. Heavy infestations may lead to premature leaf drop. | <ul style="list-style-type: none"> ? Parasitic wasps usually control mango gallflies and no control measures are needed. |
|--|---|

Mango white scales (Plates 5 & 6)

- ? The mango scales are reddish brown with a round, white covering.
- ? They infest young twigs, leaves and fruits.
- ???? Infested spots on the fruit skin turn yellow and become depressed, making the fruit less attractive.
- ? Natural enemies usually control mango scales, and no chemical control is needed, except for fruits for the export market.

Mango diseases

Disease/Symptoms**Disease Management***Powdery Mildew (Plates 7-9)*

- ? Caused by a fungus, which infects only young tender tissues.
- ? The entire flower panicle is coated with white powdery growth of the fungus, which then dries and dies. Flowers are shed without fruit forming.
- ? Infected fruit turns brown, may crack and usually drops at pea size.
- ???? Typical white powdery patches are formed on young leaves, which later curl and deform.
- ? Mango varieties vary in susceptibility to the disease: Kent is highly susceptible; Haden and Keitt are moderately susceptible; and Sensation and Tommy Atkins are resistant.
- ? A spray of powdered kelp at bud break will often control the disease. Sodium bicarbonate sprays are also effective.
- ? A number of fungicides provide good control of powdery mildew. They include bupirimate (Nimrod 25% EC), dinocap (Karathane 57% WP), sulphur (Thiovit), triadimefon (Bayleton 5% WP), and triadimenol (Bayfidan 25% EC).
- ? Sprays should be applied before bud break or at the first appearance of mildew. Observe pre-harvest intervals when using fungicides. Spray at intervals of 10-14 days until fruit set.

Blossom Blight and Anthracnose (Plates 10 & 11)

- ? Blossom blight is caused by a fungus and appears as small black or brown spots on the flower panicle. The spots then enlarge and can blacken and kill the entire panicle.
- ? Young leaves are similarly affected but the spots remain small and often the centre drops out.
- ? Pin size black or brown spots develop on the young fruit. As the fruit ripens, black, slightly sunken spots, often with a central pinkish area develop.
- ? Sometimes, where many fungus spores are washed onto the fruit from diseased pedicles, a black tear-staining symptom develops.
- ? Anthracnose is particularly important post-harvest resulting in black rot of the flesh.
- ? Prune dead branches and twigs and remove from the orchard.
- ? Variety Tommy Atkins has been reported to be resistant to anthracnose.
- ? Use fungicides where the diseases are repeatedly observed and are serious. Effective fungicides include copper hydroxide, and copper oxychloride. Apply 1st spray when the panicles appear but before the flowers open. A 2nd spray should be applied at fruit-set, and thereafter every 2 to 3 weeks up to 2 weeks before harvest.
- ? Where feasible, fruits should be stored at 10 C –12 C.

Papaya

Papaya

The papaya is an important fruit in Kenya, although it is a native of tropical America. The fruits are consumed fresh when ripe. Unripe fruit is a rich source of papain, an enzyme used to tenderize meat, to ease digestion and to clarify beer. Fruits can be used to make wine or jam and can also be stewed when immature.

Male and female plants

It is important to note that there are sex variations in papaya (also known as pawpaw).

- ? Papaya plants are either dioecious (male or female) or hermaphroditic (have both male and female flowers on the same plant).
- ? Which characteristics a plant has can be differentiated only after it has flowered.
- ? In the female plant, the flowers are short stalked and are borne on the upper part of the trunk.
- ? In the male plant, the flowers are stalkless and borne in clusters on long, hanging compound spikes.
- ? Only the female flowers bear fruit.

Cultivars and varieties

The most important papaya varieties include—

- ? Honey Dew an Indian variety, bears medium-sized fruits
- ? Kiru a Tanzanian selection that bears large fruits
- ? Mountain grows at high altitudes, bears small fruits used for jams and preserves
- ? Solo-Sunrise a Hawaiian variety that bears small round fruits. Plants are hermaphrodite. It is popular in both export and local markets.

Ecological requirements

- ? Papaya does well in warm and hot climates, at altitudes below 2100 m.
- ? Solo-Sunrise does best and produces good quality fruits at altitudes below 1500 m.
- ? Rainfall should be above 1000 mm a year and well distributed.
- ? Low relative humidity is good for producing papaya fruits of high quality.
- ? The plants are susceptible to frost.
- ? The soils should be deep, well drained and capable of retaining moisture.
- ? The tree generally does not tolerate waterlogged soils, which lead to leaf and fruit drop.

Management

Raising seedlings in seedbed

- ? Prepare either raised or sunken seedbeds.
- ? Water the beds thoroughly before and after sowing until seeds germinate.
- ? Sow seeds at a depth of 1 cm in rows that are 15 cm apart.
- ? Seeds will germinate within 3 weeks. Continue watering until they are ready for transplanting.
- ? Transplant seedlings into containers 1 week after they emerge.

Seedlings in containers

- ? Sow 2 to 3 seeds in each container.

Direct planting

- ? Sow 6 seeds per planting hole.
- ? Thin to 4 plants after germination and later to 1 plant per hole after it is possible to establish the sex of the seedlings.
- ? For hermaphrodite varieties, plant 2 seeds per hole and thin to 1 seedling per hole after 1 month.

Transplanting from containers

- ? Transplant seedlings to the field in 4 to 5 weeks, when they are 10 to 20 cm in height.
- ? Young plants have higher survival rates than older plants.

Establishment

Dig planting holes 60 x 60 x 60 cm.

Spacing

- ? Dig holes 2.5 m x 3 m apart.
- ? In drier areas, space at 2 m x 3 m.
- ? Plant the seedling at the same depth as it was in the nursery or container.

Establishing seedlings

- ? Plant 4 seedlings per hole for varieties that have male and female flowers on different plants.
- ? For hermaphrodite varieties, plant 1 seedling per hole.

Need for pollinators

- ? Plants that have male and female flowers on different plants need to be placed near each other.
- ? Most of the male plants should be removed as they bear no fruits. Leave 1 male plant for every 25 to 100 females to serve as a pollinator.
- ? Flowering starts 6 to 8 months, after which female plants can be identified and selected.
- ? Keep the plants weed free.
- ? Watering is necessary in the early months of development. Mulching is recommended.
- ? The trees can be intercropped with low annual crops like capsicum, bean, onion.
- ? Papaya may be planted as an intercrop between young citrus or mango.
- ? Papaya has a commercial life of about 5 years, after which the trees need to be replaced.

Manure and fertilizer

- ? Apply manure at the rate of 2 debes per tree before the rains begin every year.
- ? Apply the manure around the plant basin and incorporate it well into the soil.
- ? If possible, apply a split application of 60 g CAN per tree at the beginning of the long and the short rains.

Harvesting and post-harvest handling

- ? Papaya plants start flowering after 6 to 8 months and fruits are ready for harvesting 8 to 10 months after trees have been planted.
- ? Papaya fruits are available throughout the year, provided the trees get enough water. Yields per tree vary. From 30 even up to 150 fruits per tree per year can be obtained.
- ? Harvest fruits when at least 2 yellow stripes appear seen between the ridges of the fruit. Fruits picked before they show any external colour change will not develop good flavour or ripen properly.
- ? As the skin is thin and delicate, fruits must be handled carefully to avoid bruising or any mechanical damage. Wounds on the fruit lead to rotting.
- ? Select ripe fruits and cut them from the tree using a curved knife.
- ? Leave a stem 0.5 to 1.0 cm long on the fruit. The stem can later be reduced when packing the fruits.
- ? Avoid letting latex from the plant flow on the fruit.
- ? Pad harvesting crates and place the fruits gently in them.
- ? Sort, clean and grade fruits for the market.

Common pests

- ?thrips
- ?mites

Common diseases

- ?anthracnose
- ?powdery mildew
- ?papaya mosaic
- ?black leaf spots

Papaya pests

Pest/Description and damage**Aphids**

- ? Aphids are small, pear-shaped soft insects, and may be winged or wingless.
- ? They are dark grey, dull black in colour or light to dark green in colour.
- ? Occur in small colonies sucking sap of young tissue, and may cause dieback of the affected tissue.
- ? Aphids are important vectors, which transmit viral diseases, particularly the papaya mosaic virus.
- ? The aphids are also found on other crops such as cucurbits, potatoes and tobacco.

Fruit flies

- ? The flies are 4-7 mm long, brightly coloured, usually brown-yellow-black patterns and have spotted or banded wings with yellow and brown margins.
- ? The flies lay eggs under the surface of the fruit skin. Most of the eggs die due to the latex secreted when green fruits are punctured when the flies are laying their eggs.
- ? Developing larvae cause rotting of ripening fruits.

Red spider mites

- ? The mites are tiny and brownish-red in colour.
 - ? They have needle-like mouthparts, which puncture plant tissue and cause scarring and discoloration of fruits.
 - ? Infested leaves show yellow patches on the upper surface, particularly between main veins and leaf stalk.
- ????? Serious infestations occur during long dry periods.

Pest management

- ? Natural enemies keep aphids under control. However, few aphids are enough to transmit mosaic virus, and monitoring and control of aphids in the nursery is important.
 - ? Use chemicals like alpha-cypermethrin (Fastac), and pirimicarb (Aficida, Phamton, Pirimor). Observe pre-harvest intervals whenever used.
 - ? Avoid planting cucurbits, potatoes and tobacco near papaya fields.
- ? Keep field free of all debris including fallen fruits.

- ? Natural enemies normally keep red spider mites under control. It normally becomes a pest following injudicious use of pesticides.
- ????? Indiscriminate use of chemicals results in mite build-up.

Papaya diseases

Disease/Symptoms***Powdery Mildew: (Plate 1)***

- ? Caused by a fungus. Light yellowish green patches on young crown either leaf surfaces covered with a white powdery growth.
- ? Leaves become chlorotic and drop off.
- ? Fruits develop circular, white patches on the surface. As the fruits develop, the white mould disappears leaving grey-scarred areas.
- ? The disease is particularly severe on immature tissue.

Black Speckle (Plate 2)

- ? Caused by a fungus.
- ? It develops as small black spots develop on both fruit and mature leaves. Young leaves in the crown of the tree are not affected.
- ? Diseased leaves wilt and drop.
- ? Fruit infection is superficial, and the black spots are restricted to the outer surface layer.

Foot Rot

- ? Caused by fungi. Older leaves form yellow, collapse, become necrotic and then hang limply around the trunk before falling.
- ? Young crown-leaves wilt and often trees stay for months with a few, small, yellow leaves around the crown.
- ? Trees are very prone to drought and are easily blown over while a soft, wet decay extends towards the trunk.
- ? The fungi can also cause damping-off of seedlings and trunk rot of mature trees.

Ring-Spot: (Plate 3).

- ? Caused by papaya ring-spot virus
- ? Leaves develop yellow mosaic pattern.
- ? Diseased leaves become malformed.
- ? Fruits develop characteristic line patterns, which form rings and remain green when fruit ripens.
- ? The virus spread by aphids and it is also mechanically transmitted.

Disease Management

- ? Collect and destroy fallen diseased leaves.
- ? Sprays of wettable sulphur could provide good control in severe cases. Sulphur should not be applied when it is too hot as it may cause leaf scorch.

Practice field sanitation: collect and destroy diseased fallen leaves.

- ? Raise seedlings in disease-free seedbeds. Plant seedlings from disease-free nurseries.
- ? Choose well-drained soils for papaya growing. Construct drains to remove excess water from papaya fields.
- ? Do not replant with papaya on fields where foot rot has previously occurred.
- ? Take care to avoid introduction of the foot rot fungi into clean areas.
- ? Avoid damaging trunks during cultivation.

- ? Practice field sanitation/hygiene.
- ? Control aphids in the nurseries and field.
- ? Do not interplant papaya with cucurbits.
- ? Avoid mechanical injury to papaya trees.

Passion fruit

Passion fruit

Varieties

- ? The purple passion fruit is the most important. It is mainly grown for juice extraction and to a lesser extent for the fresh market.
- ? The yellow passion fruit is grown in warm, low-altitude areas. It is also used as rootstock since it is tolerant to soilborne diseases.
- ? Other varieties are
 - ? *Banana passion fruit*
 - ? *Maracuja*

Ecological requirements

- ? Passion fruit does well in warm to cool areas, with average temperatures of 18 to 25 °C.
- ? An altitude of 1200 m is good for passion fruit.

Soils and rainfall

- ? Soils should be fertile.
- ? Well-distributed rainfall of 1500 to 2000 mm per year is required. In areas with a distinct dry season, the crop has to be irrigated.

Cultural practices

- ? Passion fruits are usually raised from seed taken from healthy plants.
- ? Grafting is recommended. Plants grafted on disease-resistant rootstock have a longer life span.

Raising seedlings

- ? Extract seeds from healthy fresh fruits selected from plants known to perform well. Be sure to select a good variety. Pick fruits from the vine, and avoid fruits fallen on the ground.
- ? Use yellow passion fruit seeds if grafting is to be done.
- ? Soak seeds for 24 hours to stimulate germination.
- ? Sow seeds in seedbeds or in containers, 7 seeds per container.
- ? The seeds germinate in 2 to 3 weeks.
- ? Select and remove the weak plants.
- ? Plant out seedlings when they are 20 to 30 cm high.

Raising rootstocks for grafting

- ? Yellow passion fruit is recommended as rootstock.
- ? Extract seeds from healthy fruits and sow in seedbed or containers.
- ? Seedlings are ready for grafting when they are 30 to 40 cm high.
- ? Select the scions from purple passion fruit mother plants that are healthy and high yielding.
- ? Cleft grafting is the common method used in passion fruit.
- ? Cut off the top 10 cm of rootstock that has attained the correct height.
- ? Grow the grafted plants under shade for 3 weeks before planting them out in the field.
- ? Remove all shoots growing from the rootstock below the graft union.

Trellising

A trellis is needed to support the vines. Make your trellis before planting the seedlings out or before the plants start climbing. Make it of wooden posts 2.7 m high and 15 cm in diameter.

- ? Place the posts in holes 60 cm deep and 6 m apart in a row. Lay posts across each planting row.
- ? Anchor the end posts firmly in the ground.
- ? Stretch a single strand of wire tightly across the top of the posts. You can use sisal twine, but it does not last long.
- ? Use support strong enough to carry the weight of the plants.

Planting out

- ? Plant seedlings out during the onset of the rains.
- ? Prepare holes 60 x 60 x 60 cm in advance. Space the holes at 2 x 3 m.

Training the plants

Train the shoots to climb the trellis.

- ? Encourage the vines to climb along the wire. Tie a piece of sisal twine from the base of the young plant to the top of the trellis. The shoots will climb up the twine.
- ? Direct the shoots of the plants in opposite directions when they reach the wire at the top of the posts.
- ? Lateral branches will form, hanging downwards from the wire.

Managing the vines

- ? Prune regularly to allow the branches to hang down freely.
- ? Disentangle any branches that cross each other's path. This will make it much easier for light to penetrate through the shoots. Do this every 2 weeks.
- ? Remove shoots that hang too close to the ground. Cut them off 15 cm above ground level.
- ? After the fruit is harvested, cut back the branches that had fruits to allow new shoots to develop.

Manure and fertilizer

- ? Apply manure at planting and 1 to 2 times every year before the rains begin. The manure should be well incorporated into the soil.
- ? Apply 150 g of CAN per plant at the beginning of each rainy season, that is, apply 300 g of CAN per plant per year.

Harvesting and post-harvest handling

- ? Passion fruit plants flower 6 to 8 months after transplanting. Grafted plants start flowering early and produce more fruits in the first 12 months.
- ? For the local fresh market or for processing, allow the fruits to drop to the ground.
- ? For the export market, pick the fruits from the vines.
- ? Mature fruits change colour from green to purple.
- ? Take care not to bruise the fruits when picking them.

Passion fruit pests

Pest/Description and damage*Aphids*

- ? Aphids are green in colour and suck sap from tissues.
- ? Severe attack leads to stunted growth when the tips of shoots are covered with aphids.
- ? Aphids transmit viruses particularly the woodiness virus.

Leaf miners (Plate 1)

- ? Leaf miner adults are small flies black and yellow in colour.
- ? They feed and lay eggs on the upper-side of leaves making tiny punctures.
- ? Small yellow maggots feed on the leaf tissue leaving irregular tunnels through the leaf affecting development of flowers and fruits.

Mealy bugs (Plate 2)

- ? Mealy bugs are small soft-bodied, oval insects covered with a white, mealy secretion. They suck sap from all parts of the plant causing discoloration, dieback, leaf/fruit fall and retarded growth.
- ????Leaves and fruits are often have sooty mould.

Stink bugs (Plate 3)

- ? The bugs are flat, shield shaped insects, green or brownish green.
- ? They produce an unpleasant odour if disturbed.
- ? They suck sap from the plants causing death of leaves and shoots, wilting of the plants while fruits develop dark, depressed spots, which become hardened.

Thrips (Plate 4)

- ? Adult thrips are small, slender and usually winged.
- ? Wings are long, narrow and fringed with long hairs and, at rest, are tied dorsally along the body.
- ?? Thrips feed by piercing and sucking sap from leaves, flowers and young fruits, causing deformation and scarring fruits.

Pest management

- ? Preserve natural enemies by minimizing use of pesticides e.g., parasitic wasps, ladybird beetles, and lacewings.

?
Remove weeds in the vicinity of the crop.

- ? Parasitic wasps normally control leaf miners. Protect these beneficial wasps by avoiding use of pesticides.

?
Leaf miners develop resistance to insecticides quickly. Effective insecticides are very expensive.

- ? Natural enemies particularly parasitic wasps, ladybird beetles and lacewings normally control mealy bugs. Keep ants away from mealy bugs since they disturb the natural enemies.

?
Protect natural enemies by avoiding spraying of chemicals.

- ? Are difficult to control since they feed on many different plants.

?
Spray the crop with a mixture of crushed stinkbugs, mixed with water and a little liquid soap. This repels the bugs.

?
Plant tree hedges and plant barriers, which prevent the bugs from flying into the field.

- ? Predatory bugs attack thrips.

?
Insecticides do not give adequate control of these species of thrips.

????Use glue-coated boards orchard to trap adult thrips. A coat of clean engine oil can be use instead of glue.

Passion fruit diseases

Disease/Symptoms**Disease Management***Brown Spots*

- ? Cause spots on leaves, stems and fruits. The spots are yellow or brown in colour.
- ? Symptoms depend on the type of fungi infecting the plant.
- ?? Fruits have enlarged dark spots, which may appear greasy or wrinkled.

- ? Practice field sanitation: collect fallen diseased fruits, leaves and vines.
- ? Prune vines to remove dead and weak sections. This will allow better spray penetration as well as reduce humidity within the crop.
- ? If chemical intervention is necessary, use only products that are registered for passion fruit

Fusarium Wilt (Plate 5)

- ? Caused by a fungus.
- ? Leaves yellow and drop off.
- ? The collar region of the plant at the soil level turns brownish and vertically cracks.
- ? Vines wilt and eventually die. On dissection of the stem, vascular tissues show brown discolouration.

- ? Use yellow passion fruit, which is resistant to the wilt disease, as a rootstock and graft to purple passion fruit.
- ? Do not grow purple passion fruit on land where the disease has previously occurred.
- ? Use disease-free seed of purple passion fruit.
- ? Remove and destroy all infected crop residue from infected field.

Septoria Spot (Plate 6)

- ? Caused by a fungus.
- ? Appear as brown to black spots scattered over the leaf surface.
- ? Leaves fall and vines may be defoliated.
- ? Spots on stems are similar but elongated
- ? Fruits develop light brown spots studded with tiny, black dots often joining to cover large areas of the fruit.

- ? Practice field sanitation.
- ? Prune vines to remove all dead and any weak diseases plant parts.
- ?????Use copper sprays in serious infections.

Woodiness (Plate 7)

- ? Caused by the Cucumber Mosaic Virus
- ? Leaves exhibit light and dark-green mosaic pattern often with a light-yellow speckle.
- ? Leaves may be stunted, curled and discoloured. Fruits are small and misshapen with very thick, hard rind and small pulp cavity.
- ? The virus is spread from diseased to healthy vines by aphids.
- ? It is spread through diseased scion wood and mechanically on pruning implements.
- ? The virus has a wide host range including cucurbits, bananas and many weeds.

- ? Use seed to propagate passion fruit.
- ? Ensure that the source of scions is disease-free.
- ? Remove diseased vines from the field.
- ? Keep passion fruit fields weed-free.
- ? Avoid planting of bananas and cucurbits near fields of passion fruit.
- ?????Control aphids to suppress virus spread.

Temperate fruits

Temperate fruits

Temperate fruit trees are those normally grown in temperate environments, such as apples, pears and plums. Temperate fruits need a sufficient cold period for the plant to break bud dormancy and hence sprout and flower. The chilling requirement varies with the species. Defoliation has been shown to trigger the required dormancy in areas where chilling is not adequate.

Varieties

The following varieties are recommended:

- ? Apples: Anna, Golden Dorset, Winter Banana, Rome Beauty, Red Rome, Jonathan, Granny Smith, Grand, Sharps Early
- ? Pears: Keiffer, Packham Triumph, Smith Hybrid, Corsica
- ? Plums: Santa Rosa, Lethally, Golden King, Sun Gold, Ogden, Reuben

Ecological requirements

Altitude and temperature

- ? Temperate fruits do well at elevations between 1500 and 3000 m.
- ? The crops generally require winter dormancy conditions for flowers and leaf buds to develop and several hours of sunshine daily for fruits to develop and ripen.
- ? Cultivars with a low chilling requirement can do well in upper midland zones. The recommended varieties for Kenya have a low chilling requirement.

Rainfall

- ? Annual rainfall of 800 to 1100 mm is sufficient. The rainfall should occur during bud break, flowering, fruit set and development.
- ? Inadequate water supply during these periods results in low yields and inferior fruit quality.

Soils

- ? Temperate fruits prefer deep, well-drained soils with good water-retention capacity.
- ? Avoid heavy or very sandy soils.

Establishment

- ? Vegetative propagation methods of grafting, budding and cuttings are recommended if true type plants are to be raised.
- ? Rootstock used influences both the tree size and the length of time for fruit production to begin.

Apples

- ? Rootstocks are raised either through seed or by stooling.
- ? Use mother plants that are 1m in height. Cut the plant back to 30 cm.
- ? When new sprouts appear, cover the lower part of the rootstock with soil.
- ? Recommended for rootstock are MM106, MM4, M4, M7, M9 and M26.
- ? Rootstock can also be raised from seeds.
- ? Put the seeds between moist media for 60 to 90 days at 2 to 7 °C before sowing.
- ? Varieties for raising rootstock from seed include *Malus bocata*, Antanovka, Bitterfelder, Rome Beauty and Golden Delicious.
- ? Raise the seeds either in seedbeds or in containers.
- ? Rootstock can be grafted or budded. Wedge grafting and T-budding are the most commonly used.

Pears and plums

- ? Propagate plums by using hardwood cuttings.
- ? Obtain cuttings from branches during the dormant months of the tree.
- ? Use a rooting powder (Seradix) to promote rooting of the cuttings.
- ? Use sandy soil or other growth media that promote easy root production.
- ? Stool pears to raise rootstock. The recommended variety for this is Quince.

Spacing

Pears	Apples	Plums
3 x 2 m (dwarf trees)	4 x 5 m	4 x 5 m (regular pruning)
4 x 3 m (large trees)	3 x 4 m	5 x 6 m (standard management)

Pollinators

- ? Most apple trees are not self-pollinating and therefore require cross-pollination for adequate fruit set and development.
- ? For every 8 trees, there should be 1 pollinator tree, which can be Jonathan, Winter Banana or No. 28.
- ? Honey bees are the best-known insect pollinators and should be introduced.

Management

- ? Stake young plants, placing sticks on the windward side.
- ? Cut the trees at a height of 60 cm above ground level to stimulate branching.
- ? From the several shoots that grow after the cutting, select 3 or 4 strong branches and allow them to grow in different directions for one season.
- ? Cut these branches again at 20 to 30 cm during the next dormant phase.
- ? Prune again in the 3rd and 4th years to allow further secondary branches to develop. Very little pruning is needed in the 4th year as the tree is already shaped for bearing.
- ? It is possible to intercrop with annual crops such as vegetables.

Manure and fertilizer

- ? Apply manure at the rate of 1debe per tree per year.
- ? 3 years after planting, apply 150 g of CAN at the onset of the rains.
- ? Increase application at the rate of 125 g a year up to a maximum of 1.5 kg per tree per season.
- ? Apply DSP at the rate of 120 g per tree in the 2nd year and increase by 120 g a year.

Breaking dormancy

Dormancy in temperate fruits is essential for flower and leaf bud development. In areas where chilling is not sufficient, interventions are needed for fruit bearing. There are varieties that do not require much chilling. In addition, observe the following pointers:

- ? Hand defoliate the trees immediately or within 4 weeks after harvest.
- ? Withhold irrigation after harvest.
- ? Spray with chemicals in the first week of September, when the cool season is over. Common chemicals include DNOC (di-nitro-ortho-creasol) 5%, tar oil (Tropical Mortegg or Overmott) 5 to 7%, and Dormex. Chemicals are recommended for large-scale production.

Harvesting and yields

- ? You can obtain a crop in the 2nd year of establishment.
- ? Under Kenyan conditions, 2 cropping seasons per year are possible.
- ? Apples are ready for harvest 4 to 6 months after flowering. Yields can be up to 10 kg per tree in the 5th year and 16 to 20 kg per tree in the 10th year.
- ? Pears start to bear 3 to 5 years after establishment.
- ? Plums take 3 years and yield can reach 10 to 30 tonnes per hectare per year, depending on the variety and management.

Common pests

- ?woolly aphids
- ?red spider mites
- ?scales
- ?fruit flies
- ?birds

Common diseases

- ?apple scab
- ?powdery mildew
- ?root rot

Tamarillo

Tree tomato (tamarillo)

Tree tomato grows to a height of 3–6 m. Fruit is the size of a hen's egg and has a mild acidic flavour. It can be eaten fresh, stewed or made into jams and preserves.

Because the tree is small, the crop is ideal for establishing in areas with small farm holdings.

Varieties

Fruits are orange, red or purple.

Ecological requirements

- ? Altitude: Grows well above 1300 m elevation.
- ? Soils: Adapted to a wide range of soil types so long as they are not shallow or waterlogged.

Establishment

- ? The trees can be raised either through seed or using hardwood cuttings.
- ? Select and extract seeds from healthy and high-yielding plants.
- ? Sow the seeds either directly in the field or in seedbeds.

Propagation by grafting and cuttings

- ? Graft seedlings when they reach pencil thickness.
- ? Transplant seedlings grown in seedbeds into containers or plant out in the field 1 to 2 months after germination.
- ? Cleft grafting is commonly used for tree tomato.
- ? Select scions from mature, high-yielding mother plants of the desired cultivar.
- ? Use hardwood cuttings to propagate.
- ? Grow cuttings under humid conditions.

Management

The trees need little pruning but keep them weed free and mulched and apply manure in small quantities.

Harvesting and yield

- ? Tree starts bearing after 20 months and bears fruits all year round.
- ? Well-managed farms can realize yields of up to 15–20 kg per tree.
- ? Fruits are ready for harvesting when they reach egg size and change colour to either orange, red or purple.
- ? Handle the fruits with care and store them in crates.

White sapote

White sapote

The tree produces fruits that weigh about 160 g, are juicy with a distinct sweet flavour, rich in vitamin C, sugar, proteins and carbohydrates. Trees are medium size to large. Production is low and no fruits are currently available in the open markets.

Varieties

Existing cultivars include Sugar, Shevelle, Roos and Kubwa.

Ecological requirements

- ? Altitude: Does well at about 1000 to 2200 m.
- ? Soils: Does not tolerate shallow, wet or poorly aerated soils.
- ? Rainfall: Fairly drought tolerant.

Establishment

Can be raised as seedlings, which take 6 to 7 years to bear, as compared with grafted trees, which begin to yield after only 3 or 4 years.

Spacing: A planting distance of 7 x 8 m is recommended.

Management

- ? The trees need very little maintenance.
- ? Weeding and applying manure are beneficial to the plants.

Harvesting and yield

- ? The fruits mature for picking between September and January.
- ? Pick fruits while still firm and green. They will ripen to a yellow colour within a week.
- ? Yields of 22 to 31 kg per tree have been obtained from topworked trees 2½ years old.