Technical guidelines on tropical fruit tree management in Ethiopia









October 2010

Giuseppe De Bac

Project GCP/ETH/073/ITA

NURSERY CARE AND GRAFTING

The success of failure of an orchard is largely dependent on how well the propagating and growing of fruit trees has been done in the early stage, therefore proper nursery care is crucial.





An individual grower in most of the cases does not produce his own plants, although if nursery plants are not available, it will be forced by the circumstances to do so.

The nursery should be located in an area which is climatically suitable for the species being grown.

Nursery requires deep, well drained soil for growing seedlings in suitable conditions, preferably in polyethylene bags.

A reliable water source that guarantee water all year round is necessary.

After the site has been selected, propagation structure should be erected.

After the layout is complete, areas to be used for propagation beds and filed areas for the production of filed stock (plants grown in the ground as opposed to those grown in plastic plant bags or other containers) should be tested for nematodes and, if necessary, fumigated with methyl bromide, EDB (ethylene dibromide), or some other fumigant. Even if nematodes are not a problem, the fumigation of nursery beds is desirable as a control for soil-borne disease and insects.

A simple shade structure can be constructed by using poles to support a roof of wire mesh upon which a thin layer of thatching grass or a black shade net is tied to give filtered sunlight beneath. This type of structure (especially if also provided with grass walls) can be used to propagate many species of fruit crops and can also be used for growing newly transplanted stock. Poles should be treated with a wood preservative to prevent rotting and termite damage. Creosote may be used below ground level but should not be used above ground as it gives off fumes which are toxic to plants. Copper-containing preservatives such as copper naphthenate are ideal if they are available. If these materials are not obtainable, soak the bottom of the poles in paraffin (kerosene) so that the poles are protected to 15cm above the soil level.

Potting soils

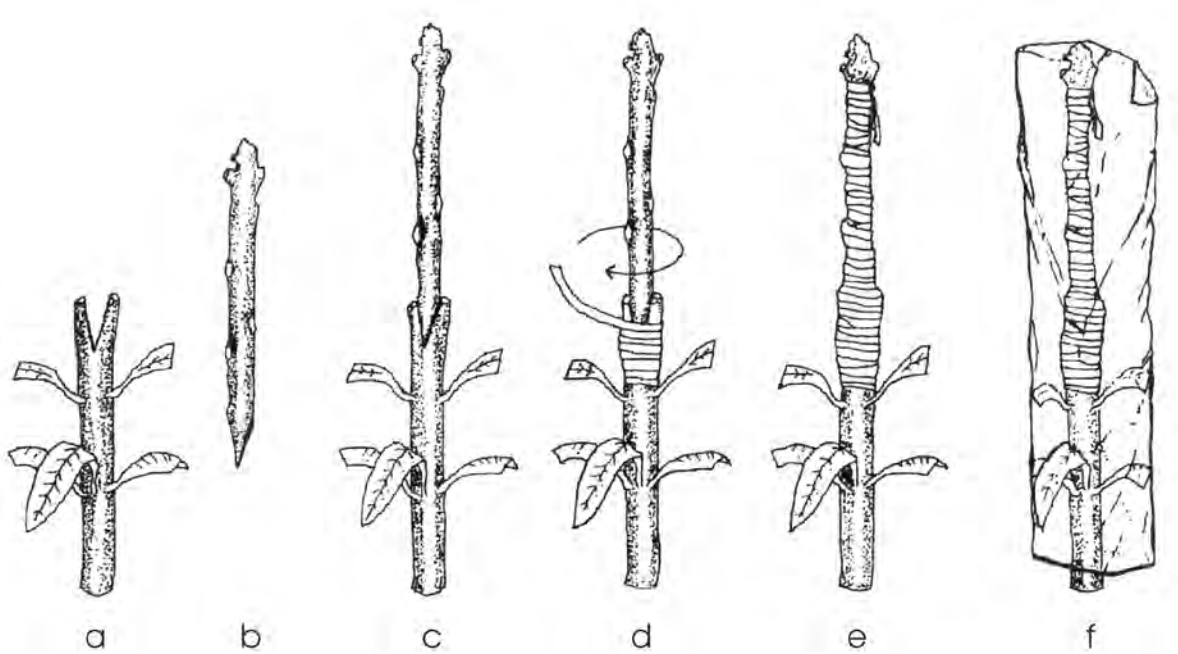
Good quality potting soil mixes for containers is a must to growth successfully a seedling. The first prerequisite is to guarantee a media free from nematode, insects and pathogens. To do so, it is always recommended to kill the pathogen using fumigation (chemicals) or high temperatures (heat) through “solarisation” (put 20cm layer of soil mix under a plastic thin foil and under the sun), or heating a drum full of soil with firewood.

The soil mix should therefore ideally be taken from virgin land (forest) it should be rich in organic matter and should also have a good percentage of sand which can improve drainage and aeration.
However, the best soils for a potting mix are sandy loams taken from the top 15cm below a grass cover.
To obtain good quality mango and avocado trees, seedlings are generally grafted in their early stage, using cleft technique;

But what is grafting, and why it is useful.
Grafting is a form of propagation, which involves the union of two separate woody pieces.

The upper part is the “scion”, which combines with the “stock” (lower part). The stock and the scion must belong to the same species or to the same family, to guarantee success in the “union”. Grafting is executed to combine the quality of two plants. It could be done to ameliorate the quality of a plant and strengthen the plants against diseases.
If propagation is carried out by seeds there is no guarantee that the desired character will appear in the offspring.
When grafting is successful, the quality of the plants from which the scion is taken are enhanced by the vigour of the plant which serves as the rootstock.
Hereunder listed are the main common grafting techniques for mango and avocado propagation:

Cleft grafting. The steps in cleft grafting are as follows: (see Fig.).



Wipe any soil or debris adhering to the stem of the stock.

a. Cut back the stock to the point where there is active growth or where the bark easily separates from the wood. Leave 2 or more leaves intact below the cut.
   Cut the stock down the centre deep enough to hold the wedge.
b. Choose a scion with a diameter as big as the stock.
c. Cut the scion to a length of 10-15 cm.
d. Shape its base into a short wedge (about 2-3 cm).
e. Insert the scion to the stock with care to line up the junction between bark and wood of the two.
f. Tie the graft with , grafting tape
g. Cover the union with grafting wax or waterproof material



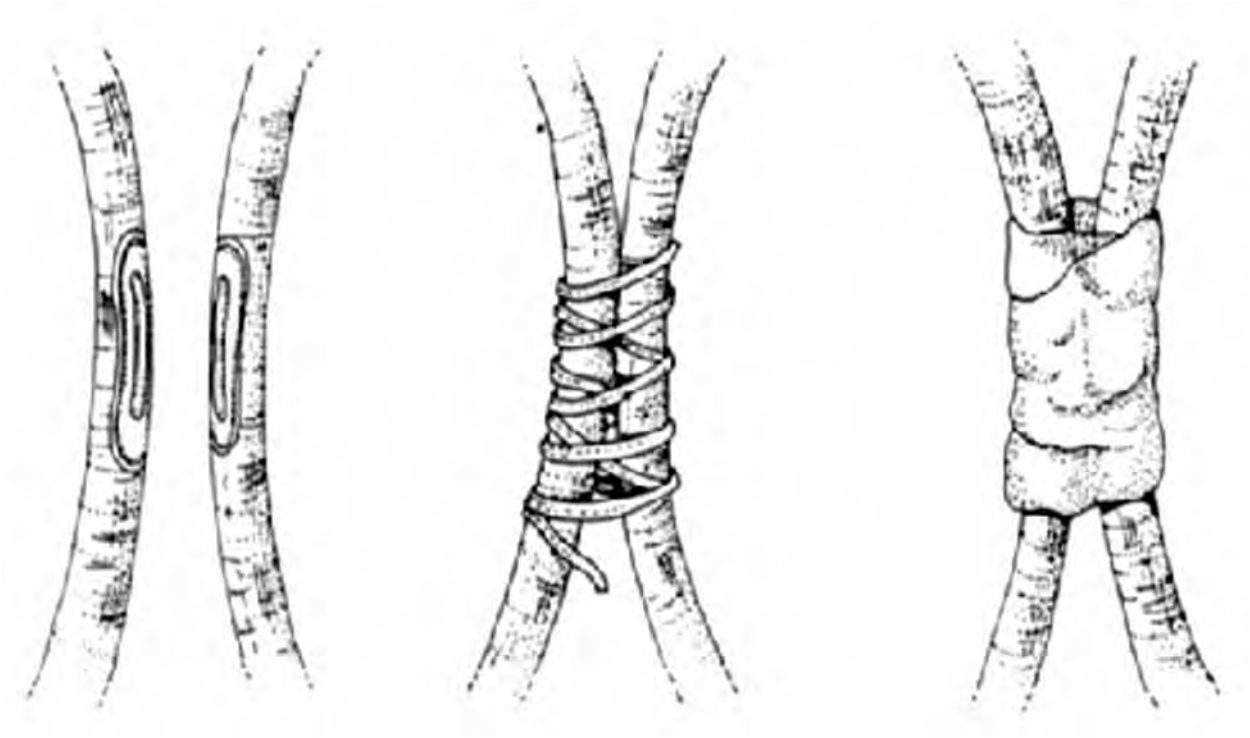












APPROACH GRAFTING TECHNIQUE-

In this grafting technique scion is not cut from its root so that when the union of the two parts is carried out photosynthesis process continue on both scion and stock until the graft has healed.

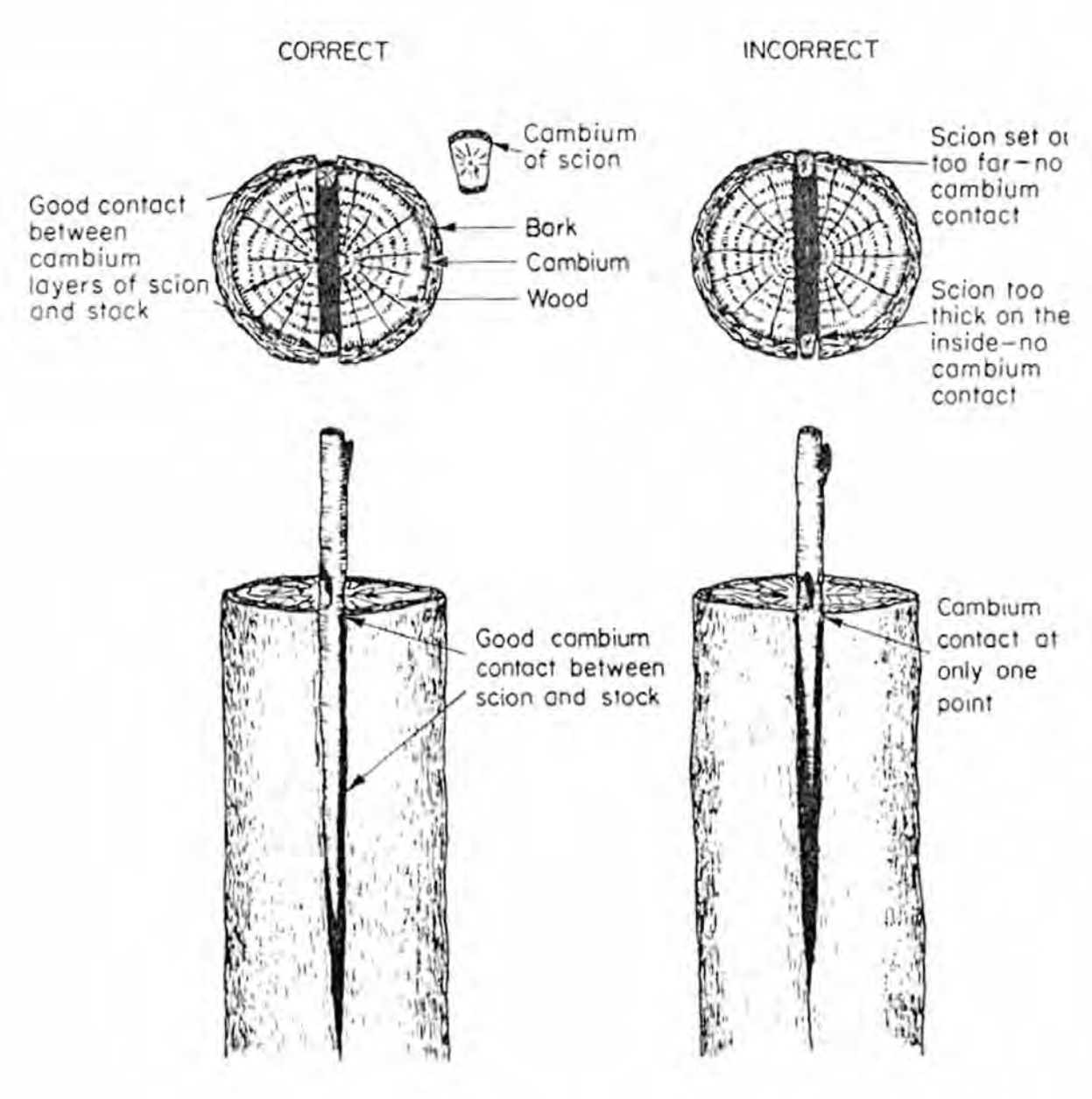
STEPS:

- thin layer of bark is shaved off on both scion and stock.
- the stock and scion are joined
- the graft is tied and covered with grafting wax or other waterproof material
- after the graft has healed the scion is separated from its root by cutting just below the graft and the remaining shoots of the stock is cut.

Top Working

It is used on mature plants which are to be change in a different cultivar; this method should be limited to stock branches about 2.5, 10cm in diameter and to species with fairly straight-grained wood that will split evenly. Cleft grafting can be done any time during the dormant season (dry season), but the chances for a good union are best if the work is done just before the active growth has initiated (just before raining season) and buds of the stock are beginning to swell. In making the cleft graft for top working the proper placement of the scions is very important. (See figure below).

The scions should be made from one year-old wood. The scion is made by cutting a long, gradually tapering wedge. Preparing the stock it is important to split the stub deeply (even split). Two scions are inserted in the stub, one at each end of the split. The scions must be carefully placed so the cambium layers match.



CROP MANAGEMENT OF SOME TROPICAL FRUIT TREES



Avocado *(Persea Americana)*

Description of some varieties introduced in Ethiopia and presently available

Cultivars A

Hass: high yielding. Resistant to main pests and diseases. Not presenting a marked bi-ennial fruiting behaviour. Fruit size variable; oil % in the fruit: medium, month to ripen: 9, seed size: small; cold tolerance: medium

Pinkerton: high yielding; fruit size; medium; oil % in the fruit: high; month to ripen: 6-8; seed size: big; cold tolerance: medium

Cultivars B

Fuerte: a Mexican Guatemalan cross; medium yielding, fruit size , small to medium; oil % high; month to ripen 5-6;seed size : tolerant to frost

Bacon: high yielding; medium size fruit; oil % high; tolerant to cold -5°C

Ettinger: A Mexican Guatemalan cross, resistant to cold -6°C

Nabal: Guatemalan type, big size fruit; suitable for warm climate

Nursery care

Seeds should be harvested from selected tree (not picked from the ground) and after removal of the pulp, care should be taken, in planting them as soon as possible in the nursery in order to avoid drying out.

It is common the infection of Phytophthora cinnamoni (avocado root rot) and to eliminate this fungus seeds should be sunk in hot water at 50^{0}C for 30 minutes before planting.

Germination of the seed is hastened by removing the brown seed coats and cutting a thin slice from the apical and basal end of each seed before planting.

The seed coat can be removed by wetting the seeds and allowing them to dry in the sun. The seed should be placed in the soil with the large basal end down, just deep enough to cover the tips. Seedling should be ready for grafting after 5 -6 months.

The propagation by seed-for rootstocks production it is a necessary step before grafting with improved varieties (taken from well identified mother plants).

Shade

In the nursery the seedlings are kept under partial shade. They should have been hardened before delivery. Where hardening has been inadequate it is advisable to protect the seedlings with temporary shade. As mentioned before, the stems should be white-washed. The leaves can also be protected by erecting a frame over the trees and covering this with grass or shade net. Once the leaves have penetrated with grass or shade net. Once the leaves have penetrated the grass they are hardened and need no further protection.

Transplanting

The plant hole

Prior to planting, a hole should staked out and holes which are at least twice the diameter of the root ball must be dug.
Top soil should be placed in one pile and subsoil in another.

The hole should then be refilled with a mixture of 50 % top soil and 50 % of well rotten manure, compost, or other decomposed organic matter. If this system is executed fertilizer application can be avoided during the first year of plant growth.
The hole should be allowed to settle for two-three weeks before planting.

Container grown plants should be removed from their pots and any circling roots should be cut off in several places or loosen them. Soil is removed from the prepared holes and any stakes should be inserted firmly into the planting hole (to give support to the tree for the first two years); the plants are then set and covered to the same depth that they were growing in the container.

If the soil has been well prepared and is still loose at planting, big planting holes are unnecessary. Where it is not possible to prepare the soil properly, a plant hole of mx1mx1m should be made. A well prepared orchard does not require extra fertiliser in the holes. The addition of fresh manure, especially poultry manure, could be dangerous for the young tree since the roots could be easily burned. Avocado trees should be planted to the same depth as they were in the planting bag. This is particularly important in the case of clonal rootstocks where collar rot develops if the trees are planted too deep, while roots are burnt by the sun if the tree is planted too shallow.. The trees should preferably be planted in a slightly raised position so that water cannot collect in the basin around the stem.

A few other factors are also important during the early establishment stage of an avocado orchard.

Planting the seedling, some additional tips!

Avocado trees bought from a nursery should already have been hardened. Plant the trees as soon as possible after receiving them. Do not place the trees in the sun since the containers become hot and could burn the roots before planting.

Never keep the trees too long before planting ; they are made ready for planting while still in the nursery. If they are kept much longer they may become root-bound, develop long shoots in uncontrolled shade and suffer from nutrient deficiencies.






NABAL


PINKERTO-
N

The young trees should be supported with sturdy props as soon as possible after planting. Trees topple over and expose the underside of the leaves and tender stems to the sun will undoubtedly suffer sunburn. Remove the nursery tags and surplus graft strips after planting to prevent girdling.

It is often necessary to erect structures to protect the trees against animals, and the same structures can be used to provide shade.

The most important and critical period in the life of a tree is the first year, so that special care should be taken in water the plant and guarantee good sanitary condition, to be free from insect and disease .infestations.
The attack of termites could cause severe damage in young trees, in this respect is recommended to spray the base of the plant and the surrounding soil with a persistent insecticide (lindane or chlordane).
Mulching is a suggested practise for young plantations to control weeds and maintain moisture in the soil. The thickness of the mulch should be at least 10cm and should be placed in an area 1-3m around the tree but not touching the trunk itself.

Tillage, weed control and cover crops
During the early years of an orchard it is desirable to plant a cover crop to protect and maintain the soil until the trees can cover it with shade. Such a crop must not, however compete with the trees and must be restricted to the strip between the tree rows. The drip area of the tree must be free of grass and other weeds and. If possible, this area should be covered with an organic mulch. Plastic covers are suitable for young trees, but irrigation management must then be very accurate so that the trees are not over- irrigated.

Fertilisation
Young trees must be fertilised very judiciously since their roots could easily be burnt.

Apply three times in the first year 50g / tree of Urea and DAP
In the second year double the doses
In the following year continue to apply fertilizers especially before flowering and during fruiting stage

Irrigation of young trees is important to ensure a uniform stand. Although over-irrigation is decidedly harmful, too little water can also cause damage. Symptoms of over and under irrigation are virtually identical. Regular examination of soil moisture in the subsoil is important to prevent over irrigation. Avocados are sensitive to moisture stress. In addition, in the nursery the trees would have been accustomed to regular water applications

and they also still have a limited root system as a result of the limited soil volume in the nursery bag. It is therefore essential to ensure that the water reaches the limited and shallow root system. A SMALL BASIN AROUND THE TREE WILL HELP TO ENSURE THAT THE ROOT SYSTEM GETS ENOUGH WATER.

Some Additional TIPS for establishment of a private small nursery!

Step to be taken;

1. select a virgin plot close to a water source
2. select an area of ¼ lima and provide shade with construction of frame of local wood and banana leaves.
3. Mulch the area in order to avoid growth of weeds and assure a good drainage of water
4. Polyethylene bags with holes at the bottom (drainage and air should pass through !!) should be available for sowing
5. Fill bags with black virgin soil
6. Plant good quality mother trees

Why a mother orchard is crucial?

Because planting of mother trees can assure a continuous source of good quality propagation material.

Site selection for establishment of mother orchard

Plot should be located	close by water source	
	Well drained land	
Soil must be	rich in organic matter and deep	(no rocks or stones around)
Spacing	6 meters X 6 meters	



MANGO *(Mangifera indica)*

Economic importance and distribution

The mango is generally considered to be one of the most important fruits of tropical regions. In most tropical regions fruit is grown only for local consumption but it is produced for export in India, Hawaii, Mexico, Brazil and parts of Africa. In Africa, the mango has become naturalised due to germinating discarded seeds and grows wild in most inhabited areas.

Recommendation for Mango seed collection and propagation

Mango may be propagated both by sexual (seed) and asexual (vegetable) means. The latter is preferred since trees grown from seeds (1) take a longer time to bear, (2) grow excessively large, and (3) are difficult to manage. Besides, asexually propagated plants are true-to-type.

Mango seeds could be either polyembryonic (with one or more apomictic embryos) or monoembryonic.

Some clonal cultivar can be multiplied from apomictic seedlings but is almost impossible to distinguish between the nucellar seedlings and the sexually produced seedling.

Clonal cultivars are propagated mainly by grafting or budding onto seedlings rootstocks.







Seeds should be obtained from uniform trees and polyembryonic type are preferred.
In fact, it is recommended that scions be grafted onto seedlings from a polyembryonic cultivar so that the mature tress will be uniform.
The seeds should be depulped than dried and prior planting cutting both ends of the fibrous husk and peeling it off, then sown within a week for optimum germination
Seeds should be sown in nursery beds about 5cm apart and 1-2cm deep, with concave side down.

Sowing the seeds with concave side up will cause unnatural growth of the roots see photo above (left image).
Sowing flat may cause crooked stems and roots.
The seedbeds as shown in this photo should be raised (10-15cm above ground level), well-drained, partially shaded and made up of sandy loam soil. Seeds will germinate in 2-4 weeks after sowing, with about 80% germination on the 25th day. If there is a need, the seedbeds should be watered.
Seedlings should be watered regularly and fertilized with about 1/4-1/2 tsp
Ammonium sulphate a month after planting and every 2-3 months thereafter. At the start, shade should be provided.

The seeds of polyembryonic types are usually planted in seedbeds, 30-45cm deep , containing a light media since the seeds will produce several seedlings. The sexual seedlings will be the most vigorous and emerging from each seed and should be discarded .
The relative shallow seedbed is used because when the taproot strikes the bottom of the seedbed will turn sideways thus eliminating apical dominance and causing the root above to branch. This increase the easy of transplanting when the seedlings have reached the



proper stage, that usually is when seedlings have between five and six reddish leaves will be ready to be transplanted.
The seedlings are lifted, separated and the tips of crooked taproots cut off.
They are then transplanted into individual containers or planting pockets to be grafted when they reach an appropriate size.

Polyethylene containers should measure 15cm in diameter and 20-25cm deep. They should be perforated adequately for good drainage. A good growing medium consists of 1/3 sand, 1/3 soil, and 1/3 compost (or well-rotten manure). Seedlings may be maintained in these container for about one year without being seriously pot bound.
Seedlings can be grafted when the stem diameter is roughly 1cm or pencil size which is reached when they are almost 6 months old.
Selection and preparation of scion. The source of scion should be a regular bearer of large and thin-seeded fruits. Collect mature shoots with well-developed terminal buds and wrap them in either moist paper towels or sphagnum moss. Keep them in polyethylene bags in a cool shady place.

Most common varieties of Mango available in Ethiopia:

Kent

The tree is vigorous, with a compact growth habit. It produce high yield and large fruits, with oval shape. The palatability is excellent, with rich sweet flavour. The skin colour is greenish-yellow with some rer blush when ripe. The flesh is fibreless.
The seed is monoembryonic.



Keitt variety





Kent variety



Apple variety

Keitt

The tree is also vigorous but a bit smaller than Kent. Fruit production is large and consistent. The fruit shape is oval with a slight beak at the bottom which differentiates its shape. Skin colour is green with some light red blush. The flesh is fibreless with monoembryonic seed.

The fruit has a good disease resistance.



Tommy Atkins

Very popular for the trade, thanks to its longer shelf life. The tree habit is compact. The yield is high. Fruit is oval compact with characteristic stunning purplish colour. The flesh is fibreless, with no very high sugar content and sweet flavour.

Apple Mango

Originally from the Far East. The tree is compact, the yield quite good, the fruit has an attractive flavour, fibreless flesh, small seed and round shape from which it is named Although there are many ways of propagating mango by grafting , cleft grafting is the most successful and popular under local conditions.

Shade

In the nursery the seedlings are kept under partial shade. They should have been hardened before delivery. Where hardening has been inadequate it is advisable to protect the trees with temporary shade. As mentioned before, the stems should be white-washed. The leaves can also be protected by erecting a frame over the trees and covering this

with grass or shade net. Once the leaves have penetrated with grass or shade net. Once the leaves have penetrated the grass they are hardened and need no further protection. It is often necessary to erect structures to protect the trees against animals, and the same structures can be used to provide shade.

Transplanting

The plant hole
Prior to planting, a hole should staked out and holes which are at least twice the diameter of the root ball must be dug.
Top soil should be placed in one pile and subsoil in another.

The hole should then be refilled with a mixture of 50 % top soil and 50 % of well rotten manure, compost, or other decomposed organic matter. If this system is executed fertilizer application can be avoided during the first year of plant growth.
The hole should be allowed to settle for two-three weeks before planting.

Container grown plants should be removed from their pots and any circling roots should be cut off in several places or loosen them. Soil is removed from the prepared holes and any stakes should be inserted firmly into the planting hole (to give support to the tree for the first two years); the plants are then set and covered to the same depth that they were growing in the container.

If the soil has been well prepared and is still loose at planting, big planting holes are unnecessary. Where it is not possible to prepare the soil properly, a plant hole of mx1mx1m should be made. A well prepared orchard does not require extra fertiliser in the holes. The addition of fresh manure, especially poultry manure, could be dangerous for the young tree since the roots could be easily burned. Mango trees should be planted to the same depth as they were in the planting bag. This is particularly important in the case of clonal rootstocks where collar rot develops if the trees are planted too deep, while roots are burnt by the sun if the tree is planted too shallow.. The trees should preferably be planted in a slightly raised position so that water cannot collect in the basin around the stem.
A few other factors are also important during the early establishment stage of an avocado orchard.

Planting the seedling
Mango seedlings bought from a nursery should already have been hardened. Plant the trees as soon as possible after receiving them. Do not place the trees in the sun since the containers become hot and could burn the roots before planting.

Never keep the trees too long before planting ; they are made ready for planting while still in the nursery. If they are kept much longer they may become root-bound, develop long shoots in uncontrolled shade and suffer from nutrient deficiencies.
The young trees should be supported with sturdy props as soon as possible after planting. Trees topple over and expose the underside of the leaves and tender stems to the sun will undoubtedly suffer sunburn. Remove the nursery tags and surplus graft strips after planting to prevent girdling.

The most important and critical period in the life of a tree is the first year, so that special care should be taken in water the plant and guarantee good sanitary condition, to be free from insect and disease infestations.
The attack of termites could cause severe damage in young trees, in this respect is recommended to spray the base of the plant and the surrounding soil with a persistent insecticide (lindane or chlordane).
Mulching is a suggested practise for young plantations to control weeds and maintain moisture in the soil. The thickness of the mulch should be at least 10cm and should be placed in an area 1-3m around the tree but not touching the trunk itself.

Protection against animals

Many farmers find that wild buck damage their trees at night. A practical solution is to erect a screen that will keep the animals out. This can be made by covering poles with chicken wire and building a “tepee”-like structure around the trees. Termite control will be necessary during drought.

Tillage, weed control and cover crops

During the early years of an orchard it is desirable to plant a cover crop to protect and maintain the soil until the trees can cover it with shade. Such a crop must not, however compete with the trees and must be restricted to the strip between the tree rows. The drip area of the tree must be free of grass and other weeds and. If possible, this area should be covered with an organic mulch. Plastic covers are suitable for young trees, but irrigation management must then be very accurate so that the trees are not over- irrigated.

Fertilisation

Young trees must be fertilised very judiciously since their roots could easily be burnt.

Apply three times in the first year 50g / tree of Urea and DAP
In the second year double the doses

In the following year continue to apply fertilizers especially before flowering and during fruiting stage Irrigation of young trees is important to ensure a uniform stand. Although over-irrigation is decidedly harmful, too little water can also cause damage. Symptoms of over and under irrigation are virtually identical. Regular examination of soil moisture in the subsoil is important to prevent over irrigation. Avocados are sensitive to moisture stress. In addition, in the nursery the trees would have been accustomed to regular water applications and they also still have a limited root system as a result of the limited soil volume in the nursery bag. It is therefore essential to ensure that the water reaches the limited and shallow root system. A small basin around the tree will help to ensure that the root system gets enough water.

Harvesting and handling

As fruits ripen they will naturally abscise and in many areas fruits are commonly gathered from the ground. Fruits which are to be transported to market should be cut from the tree when they have reached full size to prevent bruising by striking the ground.

Pests and diseases

The primary insect pests of mangoes are the mosquito-back (Helopeltis spp.) and the mango stone weevil (Sternochetus spp.).

Helopeltis spp. are sucking insects which feed on fruits and on young shoots which then die back, causing vigorous secondary branching and subsequent twigginess. The mango stone weevil feeds on the mango seed, often destroying the fruit in the process. Helopeltis spp. is controlled by spraying with carbaryl while the disposal of fallen fruit in the field is the best method of controlling the mango stone weevil. Mealybugs, fruit flies, scale, and mites can also be serious mango pests.

The two most serious fungal diseases of mangoes are powdery mildew(Oidium mcrngiferae) and anthracnose (Colletotrichum gloeosporioides), both of which are most prevalent in wet weather. Anthracnose causes leaf spots, flower blights, and fruit discolouration and rot.

Powdery mildew responds well to sulphur sprays and both diseases can be controlled with benomyl sprays.



PAPAYA *(Carica papaya)*

The fruit is a berry with a green rind which changes to yellow in most cultivars when ripe. The inside flesh is yellow or occasionally orange, and seeds are black located in a central cavity in the fruit and surrounded by a gelatinous material.

The fruit has an high content of beta-carotene (vitamin A) and vitamin C.

Importance and distribution

Papayas are locally important throughout the tropics where they thrive in frost-free areas below 1500m in elevation. Little fresh fruit is exported since it is highly perishable and requires careful handling to reach distant markets in a saleable condition.

Environment and soils

The papaya succeeds on a wide range of soil types providing that drainage is good. A windbreak is advisable if the area is subject to high winds since the plants are susceptible to breakage. Papayas are tolerant of drought once established but in areas with a pronounced dry season little fruit will be set except during the wet season. Irrigation will increase yields in low rainfall areas but has a disadvantage in that, if irrigation is excessive, the flavour of the fruits may be poor. Flood and furrow irrigation are the most common methods used.

Propagation

Propagation by seed is the most practical method. Seeds can germinate in 2-3 weeks and can be sown in flats of soil or in seedbeds.
The seeds germinate equally well if extracted both from a stored or fresh fruit.
The plant selected should be a superior cultivar hermaphrodite
When the seedlings are 10 cm tall they are transplanted.



Maradol Variety

A method of starting the seedlings without disturbing the roots is to plant 4-8 seeds in a container and then thin to two to four of the strongest when they are about 10cm tall. Then at this stage they can be transplanted in the field without disturbing the roots.
Young papaya seedlings are very susceptible to damping-off organisms so the soil in which seeds are sown should be sterilised.

Papaya Transplanting in the field

As soon as papaya has reached the proper size the seedlings should be transplanted with four seedlings in each planting station 3mx3m. The plants are then thinned to one after flowering and the sex has been detected.
Papaya are primarily dioecious although hermaphrodite forms which bear perfect flowers are common in some cultivars (Solo).Generally one male tree every twelve (12) female is recommended for dioecious plants (with male and female flowers on different plants). For hermaphrodites cultivars male trees are not necessary and can be discarded. Within this type of plants the “Solo”cultivar , which is the most important and stable hermaphrodite commercial cultivar, seeds should be obtained only from hermaphrodite plants which have been self pollinated or cross pollinated with an other hermaphrodite.
Male trees can be recognised bearing a long pendulous inflorescence on which small fruit occasionally can be formed.
Female plants have sessile and larger flowers on the trunk. The flower have large functional pistil (female part of a flower, see drawing) without stamens (male part of a flower, see drawing). The five petals are free from one other. The female tree is extremely stable, always producing pistillate (female) flowers.
Hermaphroditic plants have not sexual stability. Normally produce bisexual flowers on a relatively short inflorescence. The petals are fused for one-half to three fourths of their length, forming a rigid tube.
Hermaphrodite trees are sexually variable . In fact cool night in winter can induce carpelloidy of the stamens (the male part of the flower undergo a modification of the original structure). The result is that the plants produce misshapen fruits. Solo cultivar from Hawaii, Maradol from Cuba/Mexico and Red Lady from US are the only one which have acceptable sexual stability. These varieties have been introduced in Ethiopia during the implementation of project GCP/ETH/073/ITA.

Fertilizers

Papayas are very responsive to fertilizer and yields can be significantly improved by proper fertilization. Since the fruit is formed in the axles of the leaves, plants must be kept growing continually for maximum yield. About 0.9-1.4 kg of Urea and DAP fertilizer or equivalent per year per tree divided into three applications is recommended.

Pests and diseases Few insect pests seriously damage papayas but damage by diseases can be severe and often accounts for the short life of the tree. Seedlings are very susceptible to damping off and older plants are susceptible to root and collar rots. All of these diseases are most serious in waterlogged soils, therefore the importance of good drainage cannot be under-estimated. Perhaps the most potentially serious disease is bunchy top caused by a virus transmitted by homopterous insects.

Control

Bunchy top-infected plants yield little or no fruit and should be removed to prevent spread of the virus to healthy plants.

Root-knot nematodes can also be a serious problem, especially in sandy soils. If moisture and fertility levels are high, plants will produce fairly well despite nematode infection. However, under dry, hot conditions severe yield reductions can be expected.

Control

The application of mulch around the base of the tree is often beneficial in reducing nematode populations.

Anthracnose (Colletotrichum gloeosporioides) causes spotting of the fruits which renders them unusable. Powdery mildew on the leaves may also be a problem.

Control

Fixed copper or benomyl sprays will control both of these diseases.

The crop cycle

Papayas are usually spaced 2.7m apart with up to four seedlings at each ranting station. These are thinned to one in each location after flowering has begun and the sex of the plants has been determined. One male tree for every 12 female trees is necessary for pollination in dioecious cultivars. In hermaphrodite cultivars male trees are unnecessary. Papaya trees begin to bear very quickly after planting and will generally produce ripe fruit within a year, with the exception of ‘Solo’ which may take up to 18 months. Trees should be maintained with only one main stem and will generally continue to produce profitable crops for between two and three years. After three years yield usually begins to decline and the fruits are borne too high on the tree for easy picking. At this stage it is best to remove the trees and replant. A nematode-resistant crop should be planted for a season or two before rotating back into papayas. Yields vary tremendously, but 30 fruits per tree year is considered to be a minimum acceptable yield in many areas.

Harvesting and handling

Fruit is harvested at the first signs of yellowing if it is to be sent to distant markets; it may remain on the tree a day or two longer if intended for local markets. Papayas should be stored at temperatures between 10°C and 13°C for maximum storage life. Lower temperatures will cause chilling injury and fruits will fail to ripen properly. Since the skin is extremely delicate, very careful handling is necessary. A post-harvest thiobendazole dip will aid in anthracnose control (damage of fruit).

Maradol Variety is recommended for Ethiopia

The plant has a dwarf habit, generally it does not grow taller than 2 meters, it bear big oval fruits of 1Kg to 1,5 Kg (see picture below).

It generally produce 66% of hermaphrodite plants, 33 % of females and 1 % of the other forms 1%.

The fruits which ripen in about 9-10 months from planting have a sweet flavor with flesh of orange to red colour, rich in vitamin A and vitamin C.



Papaya





CITRUS

Citrus trees vary in size from the 3-5m tall to 10m for grapefruit.
The dark green leaves are ovate and vary in having narrow-winged petiole in oranges and limes, and wingless petioles in most lemon cultivars.



The trees flower during the wet warm periods.
The main species of cultivated citrus are the sweet oranges (Citrus sinensis), the lemon (C. limon), the grapefruit (C. paradisi), the pummelo (C. maxima), the lime (C. aurantifolia), the mandarin, also known as tangerine (C. reticulata). There are various hybrid like Tangor (tangerine x sweet orange), Tangelo (tangerine x grapefruit)

Citrus are at the present the major fruit in the subtropical regions. Citrus can be produced in the tropics although fruit quality is sometimes inferior in colour , yellow to that produced in subtropical region (orange colour, where cooler months induce the pigmentation of fruit).

Citrus-propagation by seed

Seed should be extracted from flesh fruit picked from the tree (from June throughout the dry season) rather than from the ground in order to minimise Phytophthora infection. When the fruit has been cut the pulp should be squeezed in a sieve and the seeds washed. The seed should not be dry out or germination will be reduced.. After extraction it is advisable to soak the seed in hot water at 47^0C for 10 minutes to kill any fungus which adhere to the coat. Seeds should be planted in the germination boxes, 3-5cm deep and covered with sand or other light material which will not compact. The soil should be kept permanently moist to favourite germination and after emergence when the seedlings are 10cm high the frequency of watering should diminish but the quantity increased. Seedlings can be transplanted into individual containers when they are 20-60cm high which occur after six-nine months.

The budding should be done when the diameter of the plant liner has reach about 1.25cm. The best bud should be taken from an healthy tree from an upper portion of a branch (just below the last flush of growth).

Herewith under outlined are some of the major characteristic of some “budded”citrus varieties grown and introduced in North Wollo and Tigray project area:

Oranges

Introduction

They could be devised in two main group, sweet oranges and common oranges. The sweet oranges include the subgroup of Navels which have the distinctive characteristic of having a small secondary fruit imbedded in the apex of the primary fruit.

The group of common orange are thus named to distinguish them from the Navels.

Hereunder listed are the main varieties which are being grown in Ethiopia and introduced by the project GCP/ETH/073/ITA in Tigray and North Wollo

Sweet orange (Citrus sinensis)

Navel and Navelina

Bahianinha: originally from a bud mutation on the Bahia(washington). It is a medium size fruit not prone to alternate bearing as are the other navels. They take their name from a Navel protuberance at the end, which contain a tiny embryonic fruit. They have tick skins, and juicy sweet flesh.

The flesh is seedless.

Lane Late

It has a lower juice and sugar content than Washington Navel. The fruits are not as round as Washington Navel and the yield is bit lower than other Navels. It also alternate bearing.

Common orange (Citrus sinensis)

Valencia

It is the most important commercial variety in the world. It is originated from China and taken to Europe by Spanish voyagers. This variety is ideal for the tropics, very flexible adaptability, suitable for altitude in Ethiopia that goes from 1500 up to 2500 it has a thin skin with a slightly pebby ring, the flesh is bright orange and extremely juicy, with very few seeds.

Hamlin

Originated in Florida. The fruit is small to medium bright orange when mature. Very fleshy pulp good for processing. It has few seeds and it is low in acidity.

Lemon (Citrus lemon)

Eureka

The most popular in the tropics . Very vigorous, good quality fruits, few seeds, elongated shape, smooth skin. The yield is high, it keep producing all year round.

Femminello Zagara Bianca

Originally from Italy. Very good yield, the tree can continuously fruiting. The fruit size is big, flesh is juicy. In Ethiopia produce well from 1500 up to 2200 meters, but it can also be grown ad higher altitudes.

Femminello Siracusano

Italian origin. Very high yields. Good quality. Produce very early. Trials in Ethiopia confirmed production in the second year from introduction.

Lunario

Italian selection. It produce all year round but has a lower yield than Femminello. Quality of the juice is good, quite sweet, presence of citric acid is low.

Lime (Citrus aurantifolia)

Related to lemon. Round-oval shape and small size fruit. Skin is green. More sensitive than lemon tree to cold. Very acidic juice. It could be grown in Ethiopia up to 2000 meters.

Mandarine (Citrus reticulata)
Related to orange, smaller in size, sweeter than orange, easy to peel and easy to split in segments. Could be grown in Ethiopia from 1500 up to 2400 meters.

Tardivo di Ciaculli
It is an endemic variety of Sicily, and it is not a result of breeding.
It has a strong unique aroma, high sugar content, thin smooth skin.

Clementine
Variety of mandarin. It is now days the most important commercial variety of Mandarins, it is almost seedless.

Recommendation for early care of citrus trees

Care of containerised citrus trees
Plants should not been watered too often; as a rule if tree is wilting in the early morning or evening they need water; Wilting at midday is natural. Wherever possible use borehole water which is generally free of phytophthora. If river water is used it must be assumed that it is infected; in this respect it is suggested to drench the pots with a 1% solution of Captan before planting out.

If the tree are going to be kept for more then one month before transplanting, the following chemical treatment programme is recommended:

Nutrifol	spray once every two weeks
Captan	Drench the solution once a month

Care after transplantation in the field

Irrigation
Frequent light irrigation are recommended. It is essential to assure that the water that is being applied get to the root system. In this respect it is better to check the moisture contents of the soil (digging with the hand).

Sucker control
Suckers will grow out of the rootstock. Suckers must be removed otherwise they may overgrow the scion variety.

Weed control
Weeds should be controlled in an area 2m in diameter around the base of each tree.

Weed control can be accomplished through cultivation or with herbicides (see Appendix). After the weeds have been killed, a thick mulch will prevent new weed growth and will also conserve moisture. The area between rows is best grassed and mowed so that erosion is minimized.

Pruning

Citrus require little pruning and, in fact, pruning will reduce yield. Early tipping of main branches may, however, be required to develop a balanced tree form. In later stages of growth, only branches which touch the ground should be removed, otherwise lower branches should be allowed to remain to protect the trunk from sunscald. Other pruning consists of removing diseased or crossed branches and removing vigorous suckers which occasion- ally grow up through the centre of the tree or from below the graft union.

Harvesting and handling

Maturity of citrus fruit is indicated by colour changes in the rind. In cool tropical areas good colour will develop. However, in the lowland tropics fruit may remain green at maturity. Though the lack of colouring decreases the attractiveness of the fruit, flavour is unaffected. If degreening is desired, fruit can be treated with ethylene after harvest to destroy the chlorophyll in the rind and allow the underlying colour to show. Citrus fruits are harvested by clipping or pulling fruit from the tree. Mandarins, lemons, and limes are clipped while others are pulled with a slight twisting motion. Fruit should be handled carefully to prevent bruising and pickers should wear gloves to minimize damage to the rind. After picking, fruit should be graded, washed, and kept as cool as possible until consumed or sold. Damaged fruit should be discarded or used immediately. Ideal storage temperature is between 4°C and 6°C.

Pest and disease control

Thrips, Aphids, leaf miners	Melathion, Karate, Decis
Grey mites	Acaricide
Ants, termites	Chlordane, Lindane

• Stem treatment with Azodrin or Citrimet once every six weeks is very useful to prevent psylla, thrips and aphids attacks.

Fertilization

First year:	Urea and DAP	three application 100g/tree from August to March
Second year:	Urea and DAP	same timing but double doses

Propagation

The usual method of citrus propagation is by budding virus-free clones onto suitable (compatible) rootstocks. In addition, many citrus species can be propagated by semi-hardwood cuttings or leaf-bud cuttings (cuttings containing a section of stem with one leaf and its axillary bud). Cutting grafts may also be used for propagation. They are scions grafted to rootstock cuttings and then placed in a propagating frame. The graft heals at the same time that rooting occurs. Except for psorosis virus, transmissible diseases do not occur in seedlings unless transmitted by insect vectors or diseased budwood.

Other citrus species

Lemon *(Citrus limon)*

Lemons are used primarily for processing into lemonade and squash. They are widely grown in the tropics but grow best at moderate elevations. The most common cultivars are 'Rough Lemon', 'Eureka', 'Lisbon', 'Villa Franca', and 'Meyer'. The cultivar 'Meyer' produces a more thick-skinned, sweeter fruit than the other cultivars. There is some indication that it is also, better adapted to low elevations than many other cultivars.

Lime *(Citrus aurantifolia)*

Limes are commonly cultivated in the tropics both for their juice and as a flavouring for other foods. Like the lemon, they are not generally eaten fresh. They are the only truly tropical citrus and are well-suited to- low elevations. Trees are small and bushy and can therefore be',spaced as close as 5m x 5m. There are two groups of limes: (a) diploid limes called Key limes, Mexican limes or West Indian limes, and (b) triploid limes including 'Tahiti', 'Persian', and 'Bearss'. Diploid limes are small, seeded, thin-skinned and juicy while triploid limes are the size of lemons,' seedless and have a slightly thicker rind. Triploid limes grow better at high elevations than do diploid limes. Limes are especially perishable so they must be handled with care. They will store for four weeks at 4°C.

Grapefruit *(Citrus paradisi)*

Like limes, grapefruits are adapted to low elevations where the climate is hot. They will not have good quality where the weather is cool. Grapefruit trees are larger than most other citrus so they should be planted 8-10m apart. Important cultivars are 'Duncan' (seedy), 'Marsh Seedlm', "Mompson, (seedless, pink flesh), 'Foster' (seedy, pink flesh), and 'Hohn Garner' similar to 'Duncan' but with only five seeds).

Pummelo *(Citrus maxima)*

Pummelos or shaddocks are grapefruit-like fruits which are important primarily in South-east Asia although they are also grown to some degree in other areas. They are a vari-

able group ranging from fruits which are practically inedible to those whose quality rivals the grapefruit. Fruits are large, thick skinned, and have firmer flesh and less juice than the grapefruit. Most cultivars are yellow although some have a pink to red flesh. Purnmelos are less cold tolerant than grapefruit and like grapefruit tolerate high temperatures well. Trees tend to be large (5-10m) though size varies from clone to clone.'Culture is similar to the grapefruit.

Mandarin *(Citrus. reticulata)*

This citrus group include tangerines or naarchis. Usually all the cultivars with loose skin are included in this group. Those fruit are very appreciated for their flavour and their and easy pealing. In addition they are the advantage of high contents of Vitamin A comparing to other citrus species.

The fruits once harvested spoil very quickly.

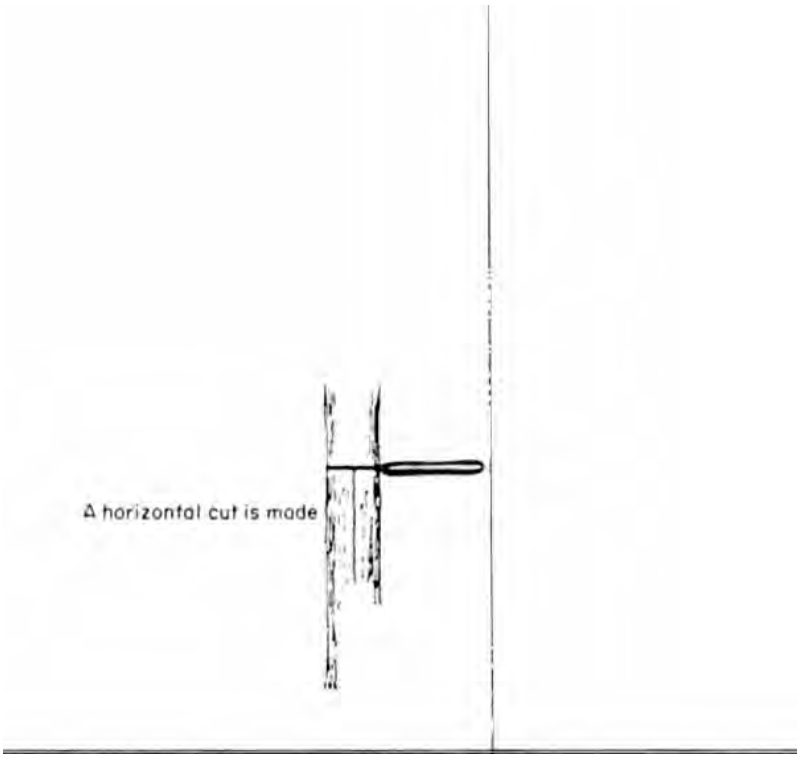
The plant does not perform well in very hot climate so that moderate elevation (over 800 m) are an advantage in the tropical condition.

STEPS IN T-BUDDING TECHNIQUE - RECOMMENDED FOR CITRUS STOCK

A vertical cut about 2.5cm long is made in the stock.



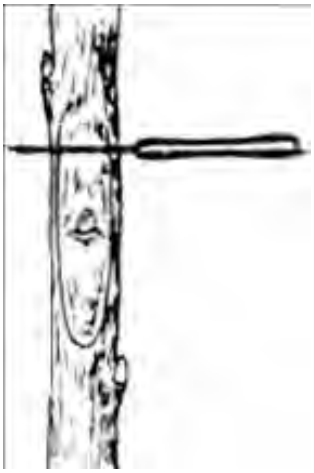
Through the bark about one third the distance around the stock with the knife is given a slight twist to open the two flops of bark



PREPARING THE BUD



Through the bark about one third the distance around the stock with the knife is given a slight twist to open the two flops of bark
Starting. about 1.2 cm below the bud, a slicing cut is made under and about 2.5 cm (I in.) beyond the bud.



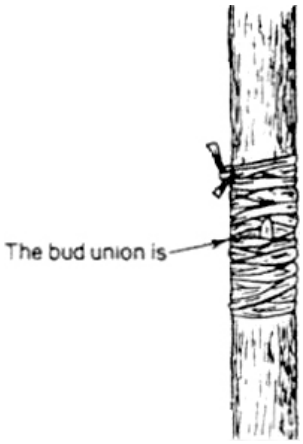
About 2 cm (3/4 in.) above the bud a horizontal cut is made through the bark and into the wood, permitting the removal of the bud piece.
side view
The shield piece is inserted , by pushing it downward under the two flops of bark



INSERTING THE BUD INTO THE STOCK



Bud union



The bud union is tightly tied with some wrapping material







GUAVA

Propagation: normally by seeds. The guava seed keep high viability even after long storage.

Seed should be extracted from flesh fruit picked from the tree (from June throughout the dry season) rather than from the ground in order to minimise fungus infection. When the fruit has been cut the pulp should be squeezed in a sieve and the seeds washed. Seeds should be planted in wooden germination boxes, 3-5 cm deep and covered with sand or other light material, which will not compact. The soil should be kept permanently moist to favourite germination and after emergence when the seedlings are 10 cm high the frequency of watering should diminish but the quantity increased. Seedlings can be transplanted into individual containers when they are 20-60 cm high which occur after six-nine months.

Spacing 6 X 5

The crop cycle:

Guava trees usually begin to bear from one to three years after planting.

Pruning of lower branches is suggested

Harvest: fruits should be picked when they begin to turn yellow and will ripen off the plant.

www.unitedprinters.biz

This manual presents the basic principles of fruit nursery and crop management.
It is addressed to technicians and extention officers operating in the horticulture sector but could also be a valuable concise reference for farmers and University students.