

Good Nursery Practices: A Simple Guide



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About the World Agroforestry Centre

The World Agroforestry Centre is a non-profit research organisation whose vision is a rural transformation in the developing world resulting in a massive increase in the use of trees in rural landscapes by smallholder households for improved food security, nutrition, income, health, shelter, energy and environmental sustainability. We are one of the 15 centres of the Consultative Group on International Agricultural Research (CGIAR).

Headquartered in Nairobi, Kenya, we operate five regional offices located in Brazil, Cameroon, Indonesia, Kenya, and Malawi, and conduct research in eighteen other countries around the developing world. We receive our funding from over 50 different governments, private foundations, international organisations and regional development banks.

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Cover photo: Kisiwa primary school tree nursery and the students who take care of the nursery in Kenya.

Back photo: Participants at an ICRAF workshop visiting a Kenya Agriculture Research Institute tree nursery.

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Introduction

Agroforestry plays an important role in the socio-economic development of communities, as trees planted on farms provide timber, fuelwood, fodder, fruits, medicine, windbreaks, and a whole range of other economic and environmental benefits.

At present the need to plant trees on farms is on the increase. It is difficult, however, for smallholders to access – at the right time, in the right quantities and of high quality – the trees that they want to plant. In order to meet present and future demand for planting material, there is a need to promote on-farm and community tree nurseries. Such nurseries can be owned and managed by individual farmers, by self-help groups, by schools, by churches and/or by a range of other local institutions. They provide income-generating opportunities, act as models for further nursery development, provide seedlings more cheaply to planters, and can raise the particular species that local people are interested in.

In order for farmers and rural organisations to establish effective nurseries, it is important to provide nursery managers with the simple technical information they need for establishment and management of facilities. This is the role of this publication.

1.0 Establishing a tree nursery

1.1. Factors that influence location

Where to site a nursery is an important issue to consider before starting, because it influences the effort that will be required to maintain it, the way in which it will be managed, and the ease of access to users. Some of the factors to be considered in selecting the site for a nursery include the following:

- There should be a reliable supply of water, ideally being near a river or ponds, or where a water tank or a drum to store water is available
- The site should be accessible all year round, so that customers are able to get seedlings easily, and so that nursery staff can manage plants and transport mature seedlings to planting sites and/or markets
- Good soils and other planting materials such as sand should be available easily
- The site should be protected from strong winds and from livestock, should receive sun, and should be on a gentle slope to allow drainage

1.2. Factors that influence size

How big a nursery should be depends on many different factors, of which the following are most important:

- The space available for establishing the nursery. The land available on farms may only be small in area, but more space may be available in public land like school yards or church grounds
- Whether you will grow the seedlings in pots or in beds, and whether they will be raised from seed or from grafts, or from bare rooted cuttings, etc... This will influence the amount of space each plant needs. Remember that in a nursery additional space is required for keeping collected soil, sand and manure, and for mixing these materials
- The numbers of seedlings to be raised for personal use and for sale. When considering the size of the market for seedlings, it is better to start by being conservative in estimating what your market will be
- The amount of water that is available to maintain seedlings

1.3. Facilities and resources

When establishing a nursery, it is important to have somewhere to keep nursery tools safely and in good conditions. This does not have to be at the nursery itself, but could be in the house, school, church or other location.

The basic tools needed for a nursery include jembes, pangas, shovels, empty tins with small holes in the bottom (to substitute for a watering can), and kitchen knives for root pruning. If resources allow, then proper watering cans, wheelbarrows, pruning knives, knife sharpeners, soil sieves and shovels are also all useful

2.0 Nursery Site preparation

2.1. When to start raising seedlings: The time to start work in the nursery depends on when field planting is planned. It is important to allow sufficient time for seedlings to grow to a size where they will survive well in the field (normally 30 to 45 cm, though this depends on the species, where seedlings will be planted in farms, and how they will be managed). The initial labour needed to establish a nursery – in bed construction, soil collection, fencing, the procurement of tools, etc. – can take considerable effort but can be done some time in advance of raising seedlings. The sourcing of seeds or rootstocks that will be used to establish nursery plants (see below) will also often need to be done in advance.

2.2. Soil collection: The soil used to raise seedlings should be fertile and should drain well. Once a suitable collection site has been identified, clear the surface of weeds, leaves and other litter, then dig out the topsoil to a depth of about 10 cm deep. Remove any stones and roots, ideally by sieving. Then mix 2 parts of soil with 1 part of manure or compost and 1 part of sand (if available).

3.0 Nursery operations

Tree nursery operations involves various activities such as, seed sourcing, Seed bed preparation, Sowing seeds, Potting, Pricking Out, Shading, Watering, Weeding, root pruning, application of additional fertilizers or manure

3.1. Sourcing seed and pre-treatments

Sourcing tree seed: It is important to try and use good quality seed in planting. Seed can be collected from trees locally – from farms, forest or public land as long as one collects from at least more the 30 trees – or can be bought from suppliers. It is a good idea to collect seed with neighbours; then bulk this seed together and share it out. In this way, diversity is maintained in planted material, which is important in promoting good performance. When getting seed from a supplier, it is important to look at the seed and check that it appears to be of good quality, and hasn't been collected too early (is immature) or contains many empty seed. Before planting a lot of seed, it is a good idea to first check it's viability by seeing if it germinates well. Once you have an idea about viability, then it will be possible to estimate how many seed need to be planted to get a certain number of trees (for example, how many seed to plant in an individual pot).

Seeds can be bought from local seed dealers, from NGOs, and from institutions such as KEFRI and the Forest Department. More information on how to source seed can be obtained by getting in contact with your local seed centre, or by reading resources like ICRAF's Tree Seeds for Farmers Toolkit (referenced at the end of this guide).

Pre-treating seed: Sometimes it is important to treat seed before it is planted, in order to improve on the level, speed and uniformity of germination. These treatment methods can be used when seed does not otherwise germinate well.

The most common methods for pre-treatment are:

- (a) Soaking seed in hot water until the seeds look swollen. This is used for seeds of trees such as calliandra, most acacias, tamarind, leucaena and albizia. Procedure: boil water and pour it over seeds in a container. Allow to cool and leave the seed in the water until the seeds look swollen
- (b) Soaking seed in cold/cool water. This method is recommended for seeds that have soft seed coats such as sesbania, *tephrosia*, dalbergia species, gmelina, Gliricidia, sesbania and *Acacia augustissima*, etc.
The time for soaking varies between 12-48 hours, depending on the tree species.

Procedure:

- Soak the seeds in cold water which is 2 times its volume
- Remove all floating seeds

- Sow the remaining seeds at the bottom in containers in the nursery or direct sow directly in the field after

© Cracking the seed shell method

This method is used for tree species with a hard coat like melia (mukau), podo. Species, croton megalocarpus, etc. The cracking is done to allow water penetration for easy germination

Cracking is done using a sharp knife, a stone or a cracking machine

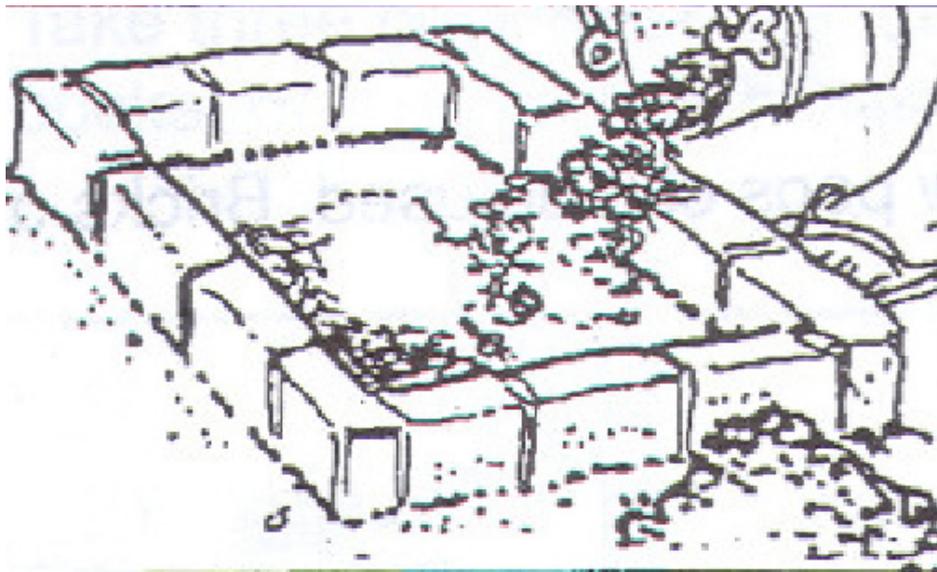
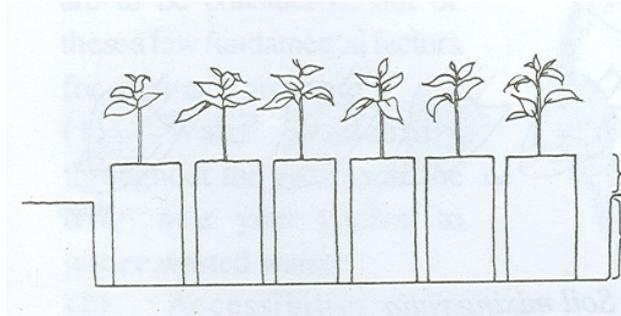
(d) Nicking-cut slightly the seed at one tip to allow water penetrate (Ref to the Tree Seed Toolkit for farmers)

Seeds such as *Croton megalocarpus*, Neem, Cassia spp. and Kei apple can be sown directly into the container. Fine and light seeds such as Eucalyptus, Casuarina are sown in transplant beds and later pricked out into containers. It is important that fine seed is mixed with sand and uniformly broadcast on the seedbed to avoid overcrowding that can lead to damping off. Do not sow the seed too deep in the soil; the depth of holes should depend on the size of the seeds (usually 5 mm to 1 cm). Sowing too deep is likely to prolong seed germination period or seeds may rot. Put a seed in each hole; gently cover with soil equal to the size of the seed itself. Water the pots. Make a light shade with grass (netting material) to cover the pots or the seed bed after sowing.

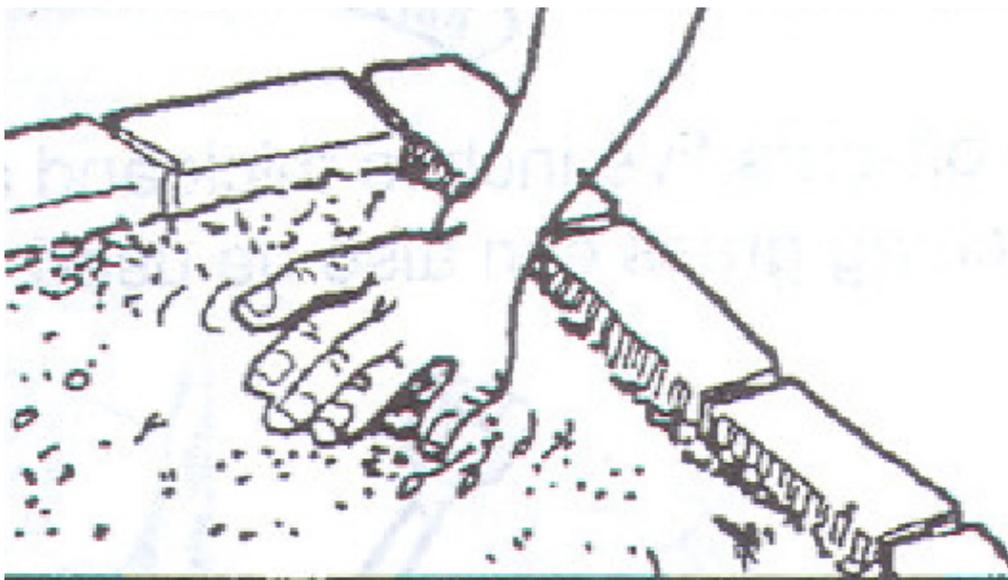
Water the sown seeds twice a day, early in the morning before 9.00 am and in the evening after 4.00 p.m. If this is not possible then water in the evening only since most of the water at this time is taken-up by the plant since there is very little evaporation

3.2. Seed bed preparation: nursery beds can be arranged in different ways. Potted seedlings can be raised on a flat bed, or can be set into a sunken bed, which is a basin like excavation of about 1 m by 1 m and about 10 cm deep. Such a structure holds seedlings together, and helps to conserve water in dry areas. Raised beds are used for establishing bare-rooted seedlings; as the sides of the bed can be broken down to reveal the roots of plants, ready for transplanting. Staking slats of wood into the ground in a square or rectangle with sides of about 1 m and then filling this structure with soil (mixed with sand if possible) makes a raised bed. Alternatively, the sides can be made from bricks or the like. It is normal to germinate small seeds such as e.g. blue gum (eucalyptus), sesbania or cypress in such seedbeds, to allow them to germinate before transferring small seedlings to pots or planting them directly.

An example of a sunken bed

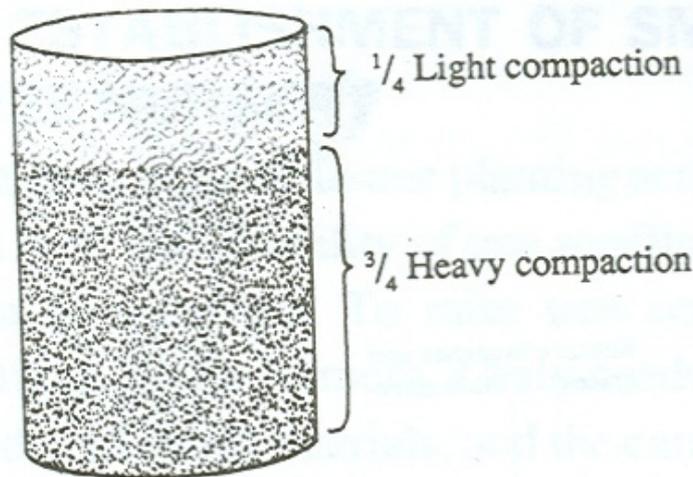


Filling a raised bed made form bricks with a mix of soil and manure



Levelling the soil of a raised bed, to a depth of about 2 cm from the top

3.3. Potting: Potting mixture (soil, sand and compost/manure) should be moistened and then pressed into containers to a depth of about three-quarters of the height of pots. Pots should then be topped up more loosely with mixture and pressed down lightly to about 2 cm below the top. Heavy compaction should be avoided at the top of pots because it will inhibit root penetration.



Before planting seed, containers should be watered lightly. Sometimes, more than one seed can be planted in a pot and then, if more than one germinate, seedlings can be removed to leave a single individual. This approach might be used if germination rate is expected to be quite low (see more below).

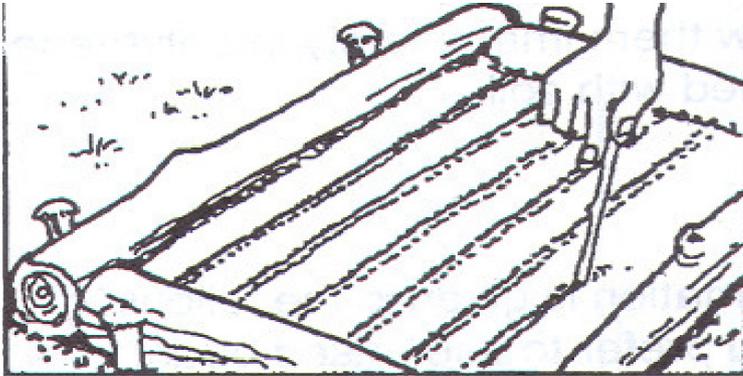
3.4. Sowing seed: When raising seedlings in pots it is normal to use polythene tubes that are around 10 cm in diameter and 20 cm deep, though the size of pots will depend on the species in question and the time that seedlings will be in the nursery. Instead of using plastic tubes, other locally available materials that can be used include small tins, milk packets, cardboard boxes, banana fibre containers, calabashes and clay pots.

It is better to use open-bottomed than closed containers, since this allows healthier root development and possible root pruning. If tins or other containers are being used, it is important that holes are made in the bottom to allow the movement of water.

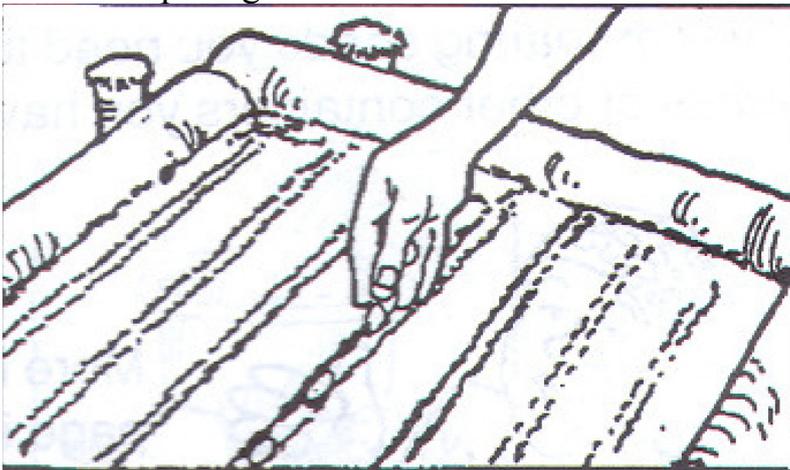
Seed sowing time depends on the species and the time it takes to attain size for planting out (30-45 cm). It is important the seeds are sown in time to enable the seedlings attain the recommended size (at least 30-45 cm in height). This should be attained before the onset of rains (April or November for Kenya).

When planting seed in nursery beds, use the procedure outlined in the drawings below

Sowing seeds in a seedbed: Draw lines 10 cm. apart or the width of your palm



Sow at the spacing of 10 cm. between seeds



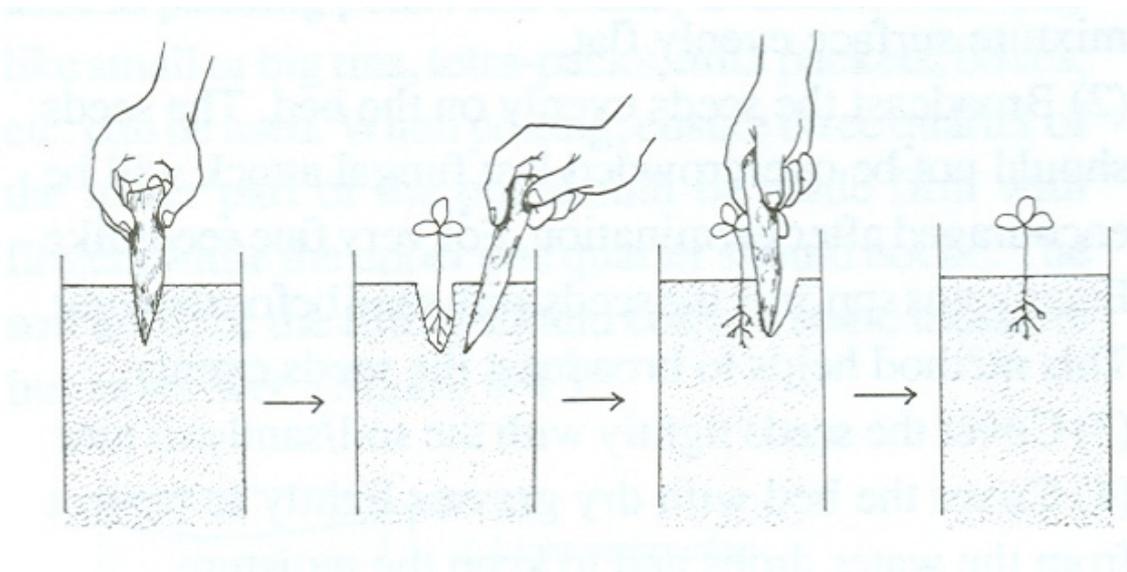
Cover the nursery with dry grass or maize stalk then water.



3.5. Pricking Out: This is the process of transferring young and tender seedlings from seedbeds into containers (pots). Pricking out should be carried out when the seedlings reach a height of 2 cm. This is usually about two weeks after sowing but depends on the species.

The pricking process:

- Water the seedbed and containers properly before commencing the operation
 - Ensure adequate shade is available
 - Take an empty container and fill with water to $\frac{3}{4}$ levels.
 - Hold the leaves of the seedlings and insert a pencil thick stick (dibble) underneath the root system to loosen the soil.
 - Pull out the seedlings gently and immediately put them in the container with water. Note that if the roots of the seedlings are kept under sunshine they lose water and may die.
 - Make a hole at the center of the pot using a stick.
 - If the roots are too long clip off the tip.
-
- Do not hold the stem of the seedling because they are tender and feeble – this may injure the seedlings.
 - Hold the stick in the tilting position and insert it in the soil about one centimeter away from the seedling to the same depth as the hole.
 - Push the soil towards the seedling to hold it tightly. This ensures that all the air pockets around the roots are closed.



- Using your fingers cover the hole you made.
- Water the containers properly once more after planting. Seedlings pricked out from same batch of the seed bed should be arranged in the same place.

3.6. Shading: Construct a shade to protect the seedlings from direct sunlight for two to three weeks after pricking out.

Use locally available materials such as grass, mats, or banana fibers for shade construction.

3.7. Watering: The regular supply of clean water is essential to plant growth. Plants are made out of more than 90% water. When grown in containers, nursery plants have only a limited volume of substrate and do not have the ability of mature trees to search for water from below the soil surface. The amount of water seedlings require depends on upon:-

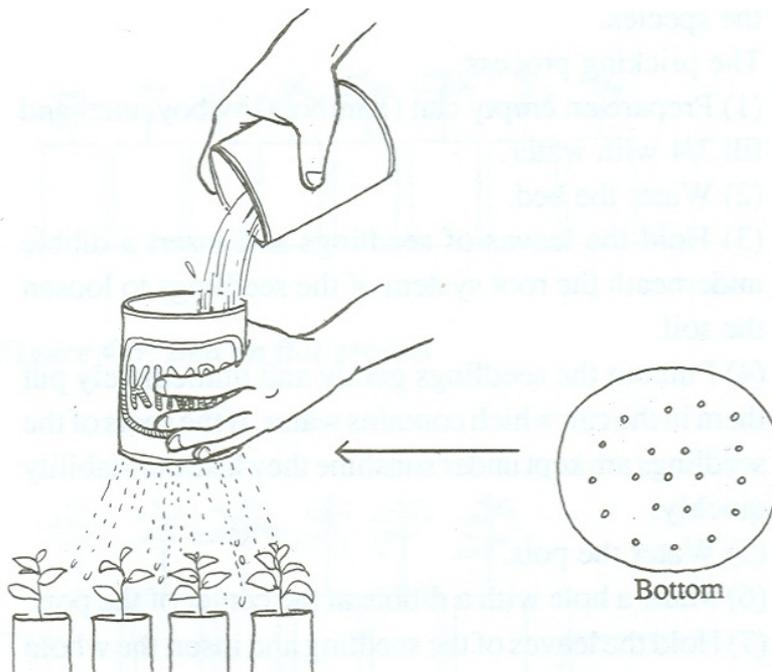
- **Seedling age.** More water is required after germination when the seedling is young and at pricking out but this requirement reduces as the seedling grows in age. The amount of water should be reduced four weeks before the seedlings are planted out. At that stage, the soil can be left to dry out completely and the plants to wilt for a day. The process should be repeated several times.
- **Amount of sunlight.** If the area is sunny, more water is needed and vice-versa. However, do not keep the area shady for too long to reduce water use.
- **Soil type.** A sandy soil loses water faster than a soil with high clay content hence need more frequent watering. However a clayish soil becomes hard and cracks if it dries out.

The substrate should be watered thoroughly so the water should be directed to the soil and not the leaves except to dust the soil lightly. A watering can or a hosepipe with a nozzle should be used to ensure uniform distribution water and one should water the whole bed and not just the plants in the centre of the bed. Low water pressure is good but one should ensure that water gets to the bottom of the container to avoid a dry and hard bottom, which will affect the growth of the roots as they get to the bottom of the container.

Water should be clean to ensure seedling health so water from such sources as kitchen waste should not be used. Too much water can damage the plants just as much as not enough water because of water logging which makes the roots not breathe

Avoid direct use of hosepipes while watering the seedlings as this may wash away the soil, Use a watering can or an empty tin with holes at the bottom

The image below shows how watering is done using a simple tin with holes at the bottom



This is used to reduce the power of water drops which cause soil erosion. It helps distribute water evenly. As already mentioned, watering in principle should be done twice a day early in the morning and late in the afternoon after 4.00 pm. when the sun is not strong. If this is not possible, then water once a day in the evening.

During rainy seasons, watering may be done once or not at all. Avoid under watering and over watering. Use adequate amount of water, e.g. 20 liters for 1,000 seedlings

3.8. Weeding: Weeds are a threat to healthy seedlings development. They compete with seedlings for nutrients, water and light hence they must be controlled.

With you hands or a dibble gently pullout unwanted growth (rouging) this should be done whenever weeds are observed.

Remove all the weeds around the beds with a jembe and don't leave any rubbish around unless you are sure that this can be converted to compost.

3.9. Application of additional fertilizers (Nutrition): Fertilizers or manure is applied when the seedlings show sign of weakness. The most common fertilizers are NPK and DAP.

It's important to note that manure from livestock can also be used. However weakness of the seedlings can be caused not only by insufficiency of the nutrient but also by pests and disease.

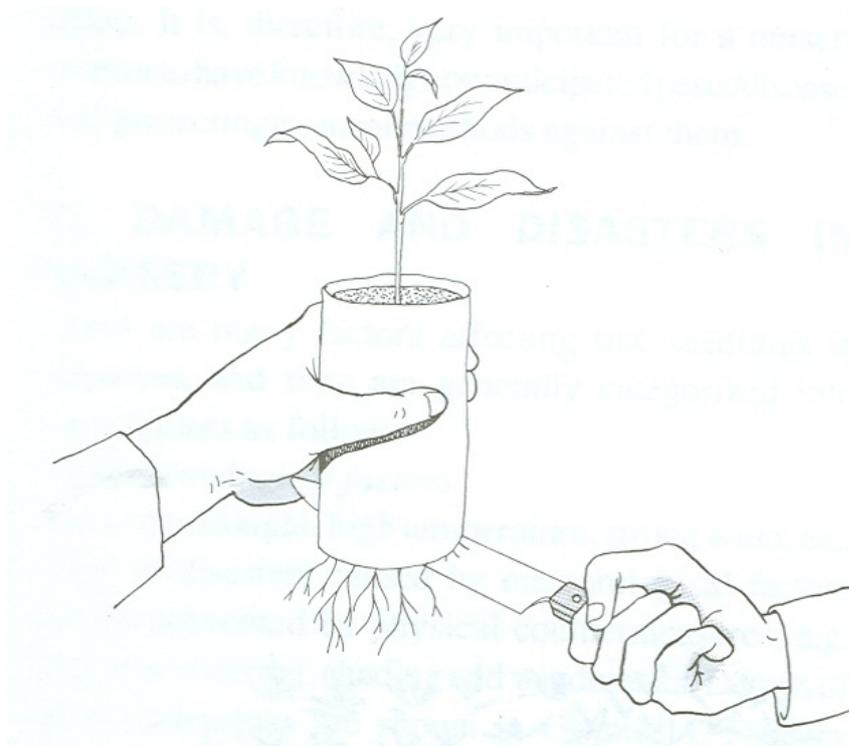
3.10. Root pruning: Root pruning is the cutting of roots to control root system development beyond the container.

Why root prune? When seedlings have reached to a certain size and their roots become longer than the depth of the pots. If the roots are left without pruning, they penetrate into the ground and develop the root systems there. Once the root system develops under the ground, it is hard to move the pots, and if the roots are cut when the seedling is old, the seedlings will be weakened; hence periodical root pruning is required before the root system reaches into the ground. The period and interval of pruning depends on different species and other conditions. Root pruning should be done regularly preferably every 2 –3 weeks. Prune when seedlings are the height of the span of your palm and when their roots have started to penetrate into the under surface

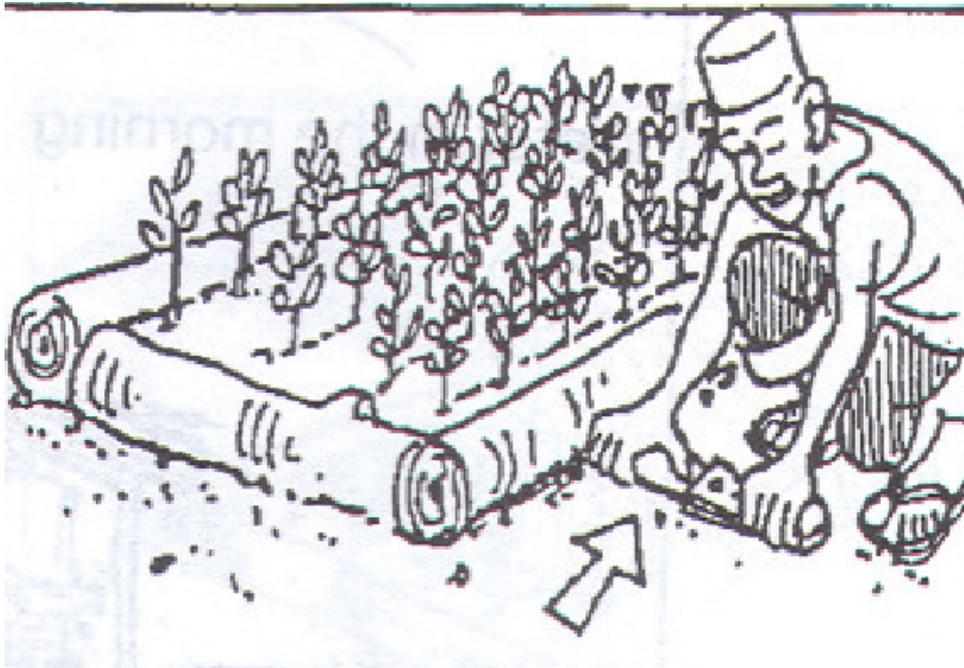
Procedure

- Water the seedlings properly before root pruning.
- Using a sharp knife or wire or scissors to cut the long roots underneath the container. You can also uplift the containers (wrenching) to cut overgrown roots.

The diagram below Illustrates root pruning using a knife; however when root pruning, the knife should face downwards while the plant being root pruned is place horizontally.



- Water the seedlings well after root pruning. This helps the plant withstand moisture stress.
- Note that to reduce root pruning, you can Place the seedlings on a bed of stones or on polythene sheet and this reduces root development.
- If the seedlings are in a raised bed, prune the roots by using a panga, knife or wire underneath the bed, soon after watering see below



3.11. Hardening off: Hardening up is to expose the seedlings to harsh conditions to make them strong so that they will be able to survive under harsh climate in the field after planting out. It is also a gradual preparation of seedlings for field conditions.

Hardening up process:

- When the seedlings grow and reach the planting size, the shade should be removed to exposure to more sunshine
- Reduction in watering intensity (quantity) and frequency-water twice a week and later once a week
- Before planting out, root pruning should be carried out frequently or re-arrangement of pots to allow more adoption to stress.

- Good preparation for out planting results in good field survival, therefore hardening off should be done 2 – 3 weeks before out planting time.

3.12. Postponing planting: If it's not possible to plant when the seedlings are ready for planting out (reached right size for planting-1.5 ft) or the seedling are not bought; cut the tips of the plant to suppress further growth so that they will not be overgrown during next season planting.

4.0 Seedling protection

Seedlings are delicate and susceptible to attack by various pests and diseases as well as weather conditions. Such damages can seriously weaken or kill the seedlings. It is important that the damages be dealt with immediately. Damage and disasters in the nursery may be categorized as below.

4.1. Weather conditions: This is damage caused by the adverse weather conditions. We can either regulate watering or shading to comply with prevailing weather conditions.

4.2. Human: This is the stealing and/or intentional damaging of seedlings by human beings. Fencing and security are such options to overcome this.

4.3. Livestock and wild animals: Livestock and wild animals browse or graze on seedlings. Fencing can offset this.

Rodents: Field mice/rates frequently cause serious damage to seedlings in the nursery as well as in the field by eating them. To control these, cleaning the nursery helps to reduce their population.

4.4. Insects: Termites are the most common recorded insects in the nursery. They eat the roots and stems of many tree species. Eucalyptus is particularly susceptible to termite attack.

Termite may be controlled by several methods;

- Putting a thin layer of ash (2-3 cm thickness) on the bed, where the pots or tubes of seedlings will be placed. However periodic application is required since ash cannot be effective for long
- Digging out the queen from nearby colonies (termite hills), use of plant extracts and chemicals in severe cases.
- Using chemicals such as Dieldrin and Aldrin
- If milk packs are used as pots wash the packs with soap water or solution of insecticide before use, otherwise termites may be attracted.

4.5. Fungal Disease

Although there are various diseases, which attack seedlings in the nursery, dumping off and wilt are described here since they are the most common fungal diseases in the country.

4.6. Damping Off: This is a fungal disease caused by *pythium* spp., *Rhizoctonia salani* and other various fungus. The severity of the attack usually increases with increase in soil moisture.

Dumping off can occur before germination, after germination and at pricking out.

The fungi attacks the seedlings at soil level and causes rotting of the part attacked consequently killing the seedling. Susceptible species include *Eucalyptus*, *Casuarina*, *Kei apples* etc.

Conditions favorable to spreading of the disease are;

- High sowing intensity
- Over watering
- Using soil with under-composed material
- Damaging the bark of tender seedlings

Control measures: Use of optimum sowing density, Use of appropriate quantity of water or not damaging the bark of seedlings

Types of Diseases:

- Wilting-This is a dying bark of the main shoot of a seedling. It is mainly caused by overcrowding. Separating the seedlings or immediate planting out can help control it.
- Powdery mildew-first small white powdery patches are formed on the leaf surface and later the whole surface of the leaf is covered with white powdery mycelial colonies. Damaged leaves gradually defoliate. This affects the growth of young seedlings. Control-fallen diseases leaves should be buried in soil or burned and the young seedlings sprayed with Benlate

5.0 Principles of plant propagation

Although trees are normally propagated from seed, for certain species it is better to propagate them vegetatively. This is especially important, when trees are of high value and/or do not propagate 'true to type'. Vegetative propagation is often used for fruit trees

5.1. Methods of Vegetative Propagation

Plants can reproduce one of two ways, sexually or asexually. Sexual reproduction is the natural combination of pollen and stamen to produce seeds. On the other hand asexual propagation, also known as vegetative propagation, is a human-assisted cloning of a plant. one of the most used method in propagation is grafting, other methods are, **budding** (used in oranges, the technique used are T-budding and patch budding), **cuttings** (depending on the species, cuttings can be taken from different parts of stock plant such as stem, leaves, roots or buds), **air-layering** (In this method, roots are induced on the stem of a plant using soil media or saw dust),

Division (In this method the shoots are separated from one other and planted as different establishment e.g. pyrethrum), **runners** (This is a method used in strawberry), **suckers** (Used in propagation of bananas and sugar cane),

Corms (a method of propagation used in flowers such as gladiolus), and **crown** (a method of propagation used in pineapples).

The method used depends on the type of plant being multiplied.

5.2. Grafting

Grafting is done to speed up period of maturity e. g. grafted fruits or nuts bears fruits much earlier-2-5 years after planting instead of 10-15 years. Grafting is also done to help in production of desired variety which may produce more fruits, tasty fruits, disease resistance plants or dwarf plants which are easy to harvest

In this propagation method, the root stock and scion are joined together to form a new union. This develops into a new plant. The upper portion is called the scion, and the lower portion or root is called stock or rootstock

Grafting is a method of plant propagation widely used in horticulture, where the tissues of one plant are encouraged to fuse with those of another. It is mostly used in propagation of trees and shrubs grown commercially. In most cases, one plant is selected for its roots, while the other plant is selected for its stem or leaves or flowers or fruits and is called the scion

5.2.1. Tools to undertake most grafting process:

- (a) Grafting knives-This has to be a sharp knife, which should be sterilized before use
- (b) Grafting wax-After the graft is made, some covering must be used to keep it drying out. Either hand wax or brush wax may be used. A

hand wax is most commonly used for home grafting. It is softened by the heat of the hand and can be easily applied.

- (c) Grafting tape-This is a special tape with a cloth backing that decomposes before girdling can occur. Electrical and masking tapes are also used. Masking tape is suitable where little pressure is required e.g. in the whip graft. Other materials used are polythene strips so long as they are sterilized. One can sterilize using domestic detergent such as jik.
- (d) Budding strips-Budding strips are elastic bands and look like a wide rubber band that has been cut open. Budding strips secure several types of grafts with small stocks and scions
- (e) Nails-Veneer and bridge grafts require long, thin nails. Half-inch nails are long enough for most grafts, except for bridge grafting, which may require $\frac{3}{4}$ inches nails. These help to hold the graft in place.
- (f) Chain saw- The chain saw is used to do top working of big trees.
- (g) Temporary shade-This is used to prevent newly grafted scions from rain water and wind. This could be shade nets, or rafters or loose thatch. This is also to protect the grafted seedlings from intensive sunshine.

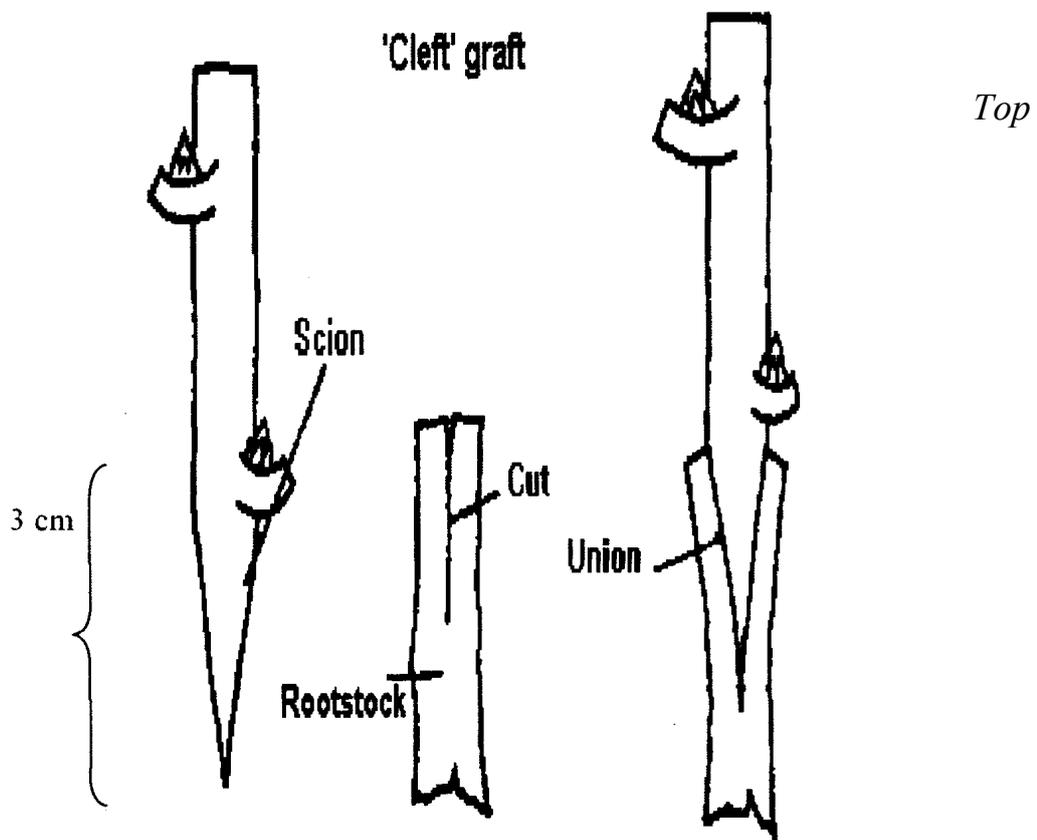
5.2.2. The grafting methods

Seedlings of desired species are produced in larger containers (20-25 cm) with a flat bottom. Alternatively big enough transplants can be used. Seeds from local varieties well adapted to climate and soil and also resistant to diseases should be used. The trees from which seed is collected have to be healthy and vigorous; the quality of their fruits does not matter. The seedlings are ready for grafting when their diameter at 40-60 cm height has approximately reached that of a pencil.

The best time for grafting is the second half of dry season. The scions to be grafted on to the seedling are collected from trees with a lot of good-quality fruit, such as genetically improved varieties are collected shortly before the grafting is to be carried out to avoid their drying out. For scion and seedling to unite, it is essential that a firm contact between the growing zones of the two is established. This zone is found just under the bark.

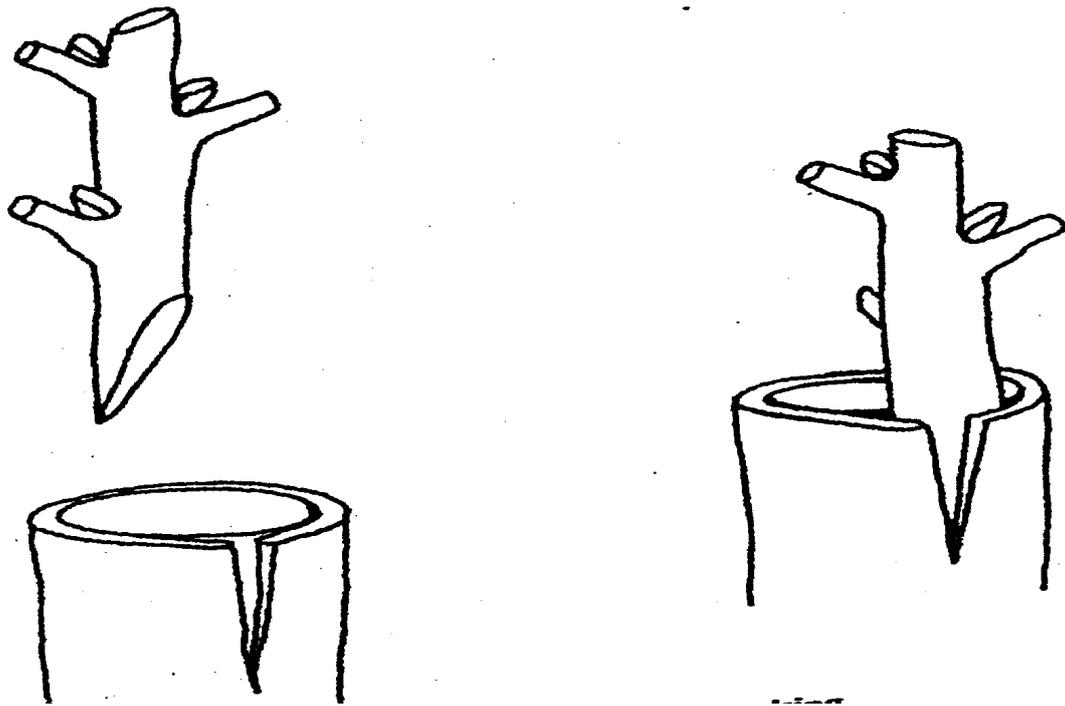
5.2.3. Types of Graft

(a) **Top Wedge or Cleft Grafting**-One of the simplest and most popular form of grafting. It's a method used in top working both flowering and fruiting trees. Cleft grafting may be performed on main stems or on lateral or scaffold branched. The rootstock used for cleft grafting should range from 1 to 4 inches in diameter and should be straight grained. The scion should be about 0.25 inch in diameter, straight and long enough to have at least three buds. Scions that are between 6 to 8 inches are usually the easiest to use. Make a 3 cm wedge cut into the scion, and a 3 cm cut into the rootstock. Ensure that all cut surfaces are smooth, then fit the scion and rootstock and align scion and rootstock cambium. Tie and wrap the graft union with plastic wrap. A plastic bag may be used to cover the scion and graft to prevent desiccation.



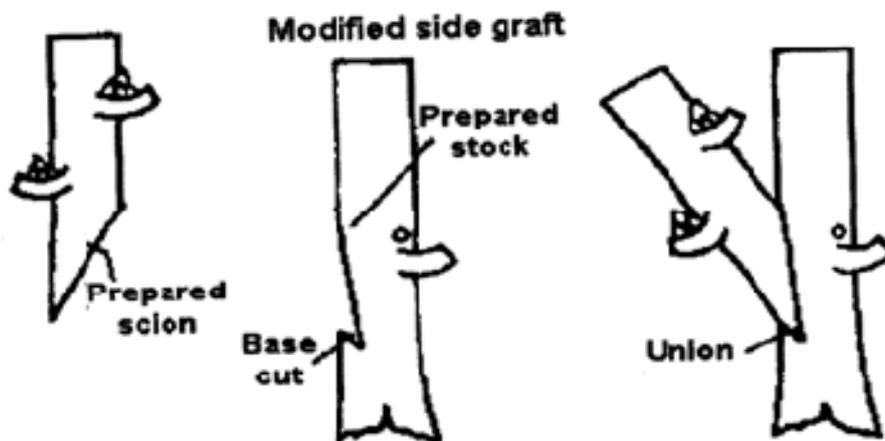
Wedge grafting method

(b) **Bark Graft**-Bark grafting is used primarily to top work flowering and fruiting trees. In contrast to cleft grafting, this technique can be applied to rootstock of larger diameter (4 to 12 inches).



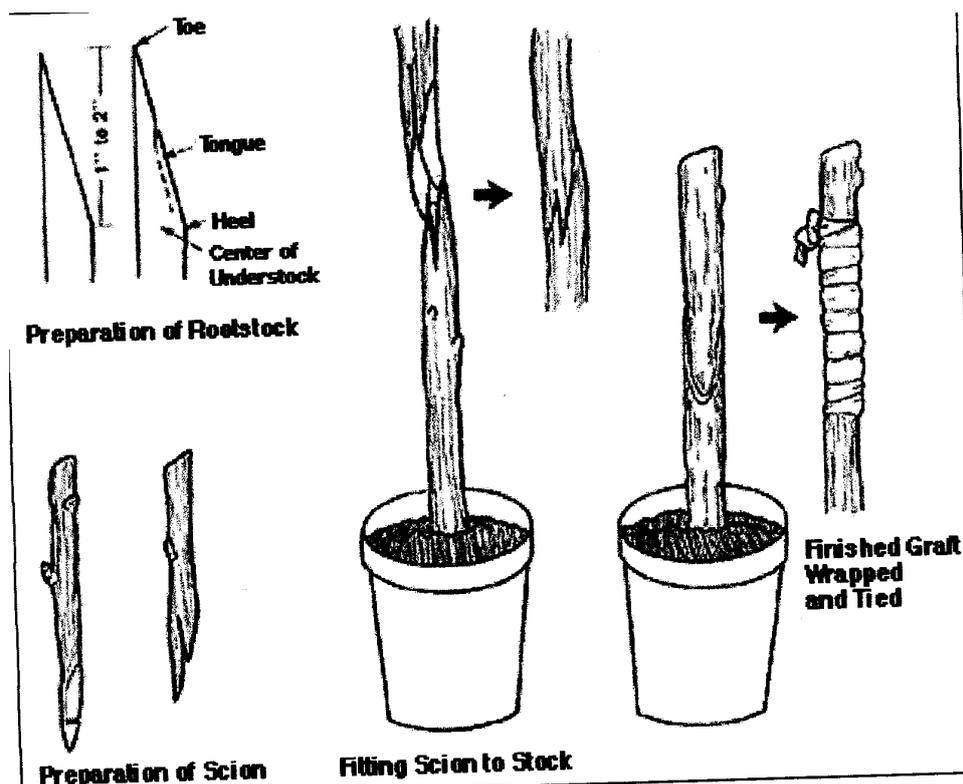
Bark grafting as practiced in top working

(c) Side-wedge Graft- This is done by; making a 5 cm sloping cut on one side of the scion (see the fig below), then making a 5 cm cut into the rootstock exposing the cambium(see the middle fig below) and then inserting the scion in to the rootstock (like shown below). One then ties the union tightly with a grafting tape



(d) Splice Graft-This is a grafting method used to join a scion onto the stem of a rootstock or onto an intact root piece. This simple method is usually applied to herbaceous materials that callus or “knit” easily or it is used on plants with a stem diameter of 0.5 inch or less. In splice grafting, both the stock and scion must be of the same diameter.

(e) Whip and Tongue Graft- In this graft both rootstock and scion should be of equal size and preferably not more than 0.5 inch in diameter. Make 1 to 2 inch slanting cut into the rootstock and a “tongue” cut 1 inch from centre of slant. Repeat this with scion (see 1st fig below), then fit the scion and rootstock and align scion and rootstock cambium (like in the fig below). Tie and wrap the graft union with plastic wrap. A plastic bag may be used to cover the scion and graft to prevent desiccation (see the last fig below)



Whip and tongue grafting method

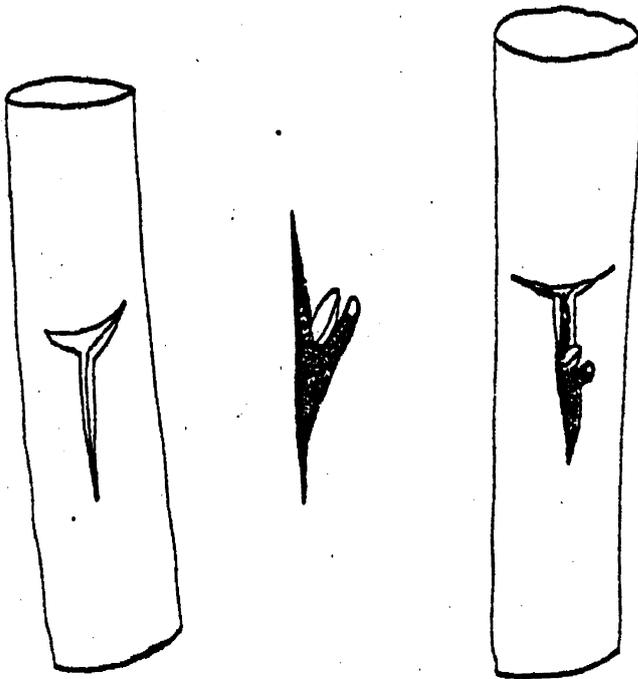
(f) Saddle Graft-The stock may be either field grown or potted. Both rootstock and scion should be the same diameter. For best results use saddle grafting on dormant stock and the root stock should not be more than 1 inch in diameter.

(g) Bridge Graft- This grafting method is used to “bridge” a diseased or damaged area of a plant, usually at or near the base of the trunk. Such damage commonly results from contacts with grading or lawn maintenance equipment or it may be caused by rodents, cold temperatures or disease organisms. The bridge graft provides support as well as a pipeline that allows water and nutrients to move across the damaged area.

(h) Inarch Graft-Inarching, like bridge grafting is used to bypass or support a damaged or weakened area of a plant stem. Unlike bridge grafting, the scion can be an existing shoot, sucker or water sprout that is already growing below and extending above the injury. The scion may also be a shoot of the same species as the injured plant growing on its own root systems next to the main trunk of the damaged tree.

(i) Approach Grafting-This is a form of grafting particularly suitable for difficult combination. Both scion and rootstock remain intact plant until a secure graft union has been formed, thus allowing both to use own vascular systems for assimilation and water uptake

(j) Budding-Budding is not a common practice in grafting many fruits but is mainly used for propagation of citrus. Most of budding should be done when the bark slips off easily from both scion and rootstock which is a time of high metabolic activity.



Budding of a fruit tree e.g. Citrus

6.0 Field planting-planting out

5.1 Introduction

A lot of trees have been planted all over the years e.g. in farms or public areas however, only a few survive; this is due to poor knowledge on- proper timing, technical aspects on proper tree planting and tending techniques. It's important to note that healthy seedlings cannot grow well or survive if not planted properly.

Natural regeneration of trees grows without any care, but their survival rate is generally very low and unstable. This section is developed to enable farmers, extension agents and tree nursery operators get guidance in proper tree planting and tending techniques for high survival rate. It's important to ensure that, seedlings to be planted are big enough (at least 1.5 ft high). Always remember to plant as soon as possible after you get the seedling from the nursery.

Do not plant trees too close to buildings and installations such as power (electricity) lines, water pipes or telephone posts.

Water the seedlings just before transporting from the nursery to the planting site; this water is to protect seedlings from drying up during the transportation.

Note: It is better to plant your seedling when it has rained for at least two weeks or when the soil is really soaked with water (if water penetration has reached a certain depth-30 cm from the surface), so that even if no more rain is available the plant can take off. Plants grow well if the soil is soaked before planting or if the rain continues after planting for two weeks.

5.2 Spacing:

Plants may be spaced at 3m by 3m or 5m by 5m or 6m by 6m or 8m by 8m or 10m by 10m (larger spacing is used for indigenous species or fruit tree species like Mangoes since these trees requires large spacing).

For hedges, the spacing can be 15cm between the plants or 30 cm between plants in a line to allow the fence grow faster.

5.3 Digging holes:

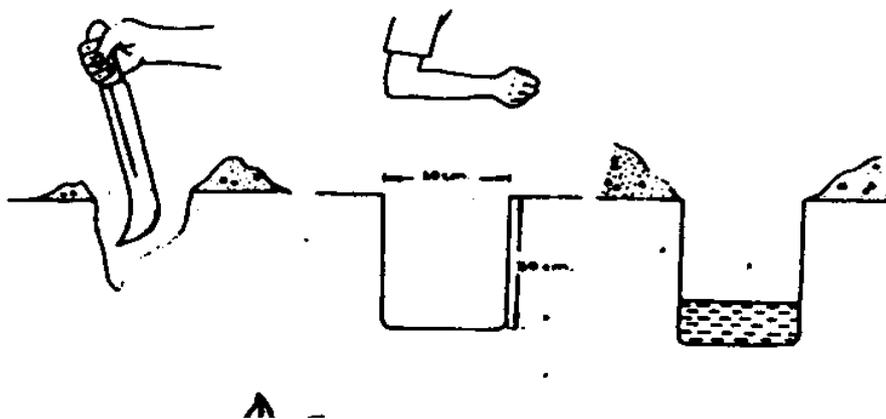
Planting holes should be dug before rainy season commences if possible since water collects in it and makes the survival easy even when rain is not much.

Dig a hole 30 cm x 30 cm (the distance from your wrist to your elbow) or 45 cm x 45 cm or 60 cm x 60 cm (especially in dry areas). However the size of the hole will also depend on the size of the seedling.

The purpose of planting hole is to soften the soil so that the roots of the tree can easily penetrate and the loose soil can catch and contain more moisture

5.4 Planting process:

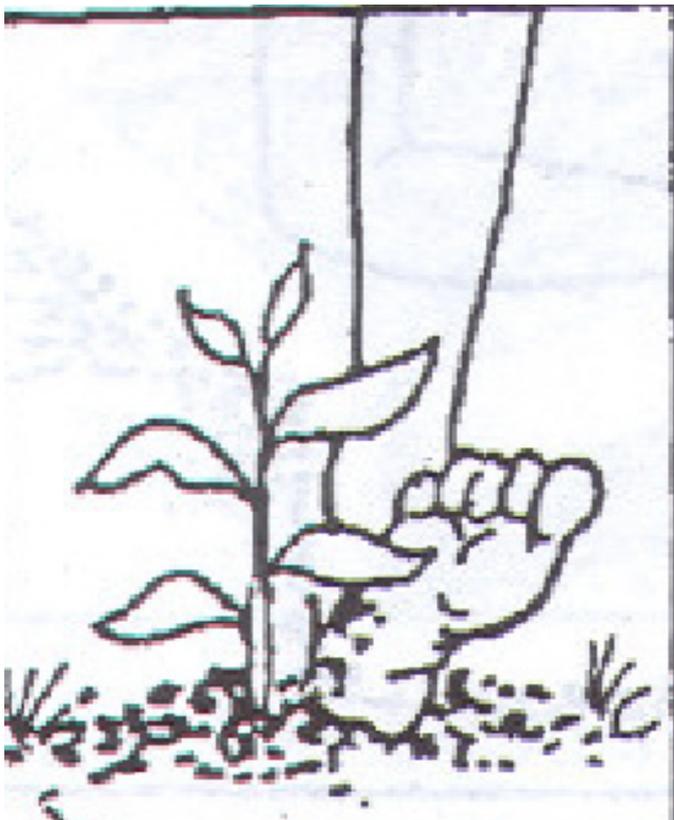
- Water the seedling before transporting them from the nursery to the planting site. This water is to protect the seedlings from drying up during the transportation.
- Transportation of seedlings-don't pile them up each other when transporting. Using boxes or bags are recommended if the planting site is far but always carry the seedlings upright. Transferring seedlings from the nursery to the field needs great care to avoid damaging them. If the seedlings were raised in polythene tubes or tins;
 - (a) Prepare a box or sack
 - (b) Chose strong seedlings
 - (c) Pack the seedlings by arranging them neatly, ready to transfer them to the field
- If ready to plant, re-fill $\frac{1}{4}$ Of the holes with wet top soil around the holes or with the soil removed when preparing the holes



Fill $\frac{1}{4}$ of hole with soil

- Remove the polythene bag or tube by tearing it while holding the seedling up-right
- If you the seedling was raised in a tin or any other container, bang it from the top slightly
- Remove the seedling from the tube with its soil by holding it under the stem

- Put the seedling in the hole and cover it with the top soil and then the sub soil
- Place the seedlings in the hole without removing the pot soil or bending roots
- Press down the soil nicely
- Fill the hole with top soil from the forest or the best soil you have nearby (from trees in the farm or collected around the banana base). This soil can be mixed with manure if possible to provide the plant with more nutrition.
- Use your hands to firm the soil carefully around the roots.
- Make sure the seedlings sits in the ground at the same level it sat in the container or nursery



When the hole is filled, tread gently with your feet to firm the soil. Firm it into the shape of a well or basin so that it catches rain water and holds water you put on it. Water the seedlings immediately after planting.



Water the seedling if the rain is not enough. If you plant in dry season, water two times a week-early morning and later in the evenings or at least once but in the evenings

- If the plant is not safe, build a fence of sticks or thorns around the seedling to protect the plant from goats and children

Note: Some tree species will need support. If a tree seems too weak or not very straight, place a strong stick in the ground close to the seedling and tie a piece of old plastic wrapper (sisal string can damage the seedling) between the stick and the seedling.

An example



5.5. Mulching

After planting the soil surface of the planting holes is covered with some materials (dry grass/leaves/twigs) to avoid evaporation or to help the plant retain water. This technique is called mulching. Note that small stones can also be used as covering Materials.

5.6. Water harvesting

To utilize rain water effectively, several types of micro-catchment are used to harvest the water effectively and conduct it to the seedlings.

- (a) Shallow trenches: V shaped trenches are dug to conduct the rain water to the planting holes
- (b) Divisions of the ground: This method is used where the rainfall is very scarce. Ground is divided by ridges and all the rain water is conducted to the plants

6. Direct sowing and planting cuttings in the field

Direct sowing or planting can be done for tree species like Sesbania, Albizia, Gliricidia and others used for live fencing, fodder and improving soil fertility.

Direct sowing is carried out as follows:

- Prepare the field by tilling the land and make lines
- Treat seeds as recommended (see page 9). Plant the seeds in lines and at recommended spacing (see page 25)

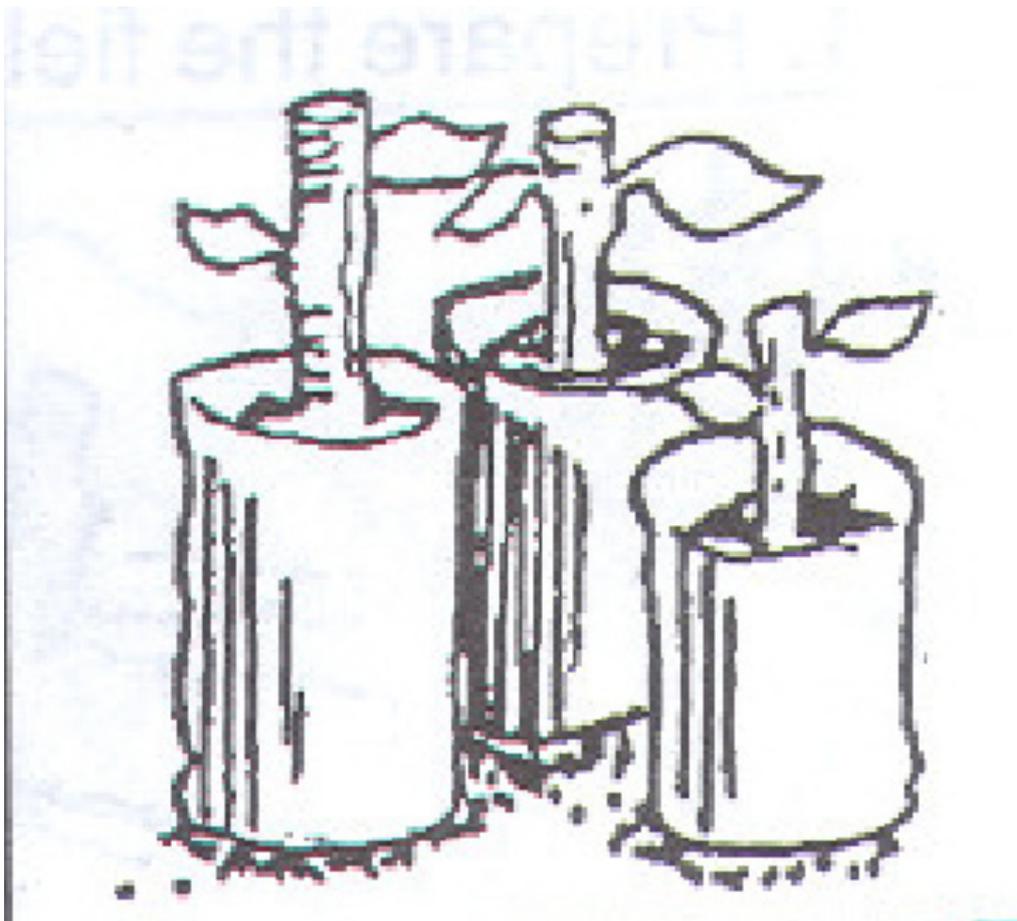
Planting stem/cuttings:

- Cut a stem from the mature branches of a tree like Gliricidia, Mulberry, Cassava, etc
- Put a mark to show the upper side
- Store the cuttings in the shade and water a little to quicken sprouting

Plant the cuttings in the soil with the upper mark showing without delay.



Place the cutting in the soil as shown in the above image



Cuttings can also be temporarily planted in polythene tubes for them to sprout before actual planting in the field

- Direct sowing of seeds or cutting planting should be done only when the rainy season has fully set in.
- Cuttings are well-suited when making a dense living hedge around the homestead, fodder bank or vegetable garden

Further reading

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Ruvuga S., Otsyina R, Bohringer A., Phalen A., (2002). Establishing and Managing your Own Tree Nursery, Makoka, Malawi: P.O. Box 134 Zomba. The World Agroforestry Centre (26 pages)



Essential tree nursery tools used by Kisiwa primary school student to run their nursery

The World Agroforestry Centre publishes a range of online resources that are available from its website (www.worldagroforestry.org) and that readers of this guide with Internet access may find useful. In particular, please see the following: The **Agroforestree Database** provides information on more than 500 tropical trees – including timbers, fruits, fodder providers and soil fertility improving species – that are of interest for planting by smallholders. The database includes information on where species grow, how they can be propagated and managed, their uses, and pests and diseases problems.

The **Tree Seed Suppliers Directory** provides information on the different suppliers of tree planting material. The database lists several thousand tree species, indicates where seed of these species can be obtained, and provides information on the quality of different seed sources. The Directory allows users to make more informed choices about the trees that they plant.

