KENYA / JAPAN

SOCIAL FORESTRY TRAINING PROJECT

PILOT FOREST SUB-PROJECT

NURSERY MANUAL

TIVA NURSERY

E.M KYALO
(NURSERY OFFICER)

M. NAMI
(JAPANESE NURSERY EXPERT)

May 1997

KENYA / JAPAN

SOCIAL FORESTRY TRAINING PROJECT

PILOT FOREST SUB-PROJECT

NURSERY MANUAL

TIVA NURSERY

E.M KYALO
(NURSERY OFFICER)

MINAMI
(JAPANESE NURSERY EXPERT)

MAY, 1997

Acknowledgement

I wish to extend my gratitudes and appreciation to the various individuals or parties who in one way or another contributed to the successful preparation of this manual.

I am particularly indebted to the Kenya/Japan Social Forestry training project (SFTP) for their support.

Special thank goes to Benard Muok Pilot Forest Manager and Minami (Japanese Nursery expert and Miyagi (Team leader) for their technical advice and editing of the manual.

I wish not to forget all the nursery staff for having assisted in collecting , all the relevant datas used in this manual.

Finally, I wish to extend special thanks to all those who were involved in typing and retyping of the manual, Beth, Ann, Josephine and Agnes for their excellent job.

Table of contents

Appendix

1:0 Introduction

Tiva tree nursery is one of the sections of the Pilot Forest scheme of the Kenya/Japan Social Forestry Training Project. It is located in Kwa-vonza location Kitui district. The nursery was started 1987. The project is within a semi-arid region and receives average annual bimodal rainfall ranging from 500-700mm. The long rains come in March-April and short rains October-November. Temperatures are high ranging between 22-33°C . Most of the soils here are shallow with murram. The nursery covers about one hectare. The objective of this section is to develop appropriate nursery techniques for ASAL and to collect tree seeds and produce high quality seedlings.

This manual has been prepared with emphasis on management of small to large scale nurseries in arid and semi-arid areas. The main subject of the manual is plant propagation, seed collection and handling, germination techniques and nursery records. Other nursery management are included, such as site selection, layout, seed extraction and identification of good mother trees.

It is the author's hope that this manual will be of great help to those involved in raising tree seedlings in government, NGOs, groups or private nurseries.

2.0 Setting up a Tree Nursery

What is a tree nursery and why is it needed ?

A nursery is an area where young plants can grow with special care and protection. It produces seedlings for afforestation and tree planting. Seedlings are usually needed in large numbers and young trees of most species do not survive if directly grown on the plantation site. It is therefore easier and cheaper to raise seedlings in one place- the nursery - and plant them when they need less care and protection.

The purpose of the nursery, therefore is to grow seedlings
- of the required species
- of the right size and of high quality at the beginning of the planting season.
- sufficient numbers for the intended tree planting programme.

2.1 SITTING THE NURSERY

When selecting the nursery site, it is essential to consider the following factors:

(a) Factors important for seedling growth
- availability of water
- good soil
- availability of manure
- sunshine
- materials used (e.g. pots)

(b) Factors important for nursery management
- Location
- accessibility
- size
- ownership

(a) Factors important for seedlings growth

Water - A guaranteed water supply all year round is absolutely essential because seedlings have to be watered once or twice every day especially in arid and semi-arid areas. The quality of water also must be considered since very few tree species can tolerate saline water.

The distance between the water source and the nursery is important, since carrying water over long distances to the nursery is difficult and time consuming.

Water requirement for nursery stock will not only vary with the location of the nursery, the time of the year, but also the stage of the seedlings and the production method. As a thumb rule potted stock requires about 40 litre -1000 seedlings (4 "to 5" pots).

Soil - For potted plants the soil of the nursery site itself is not important, however, suitable potting soil should be available close to the nursery.

Topography - The nursery should not be exposed to too much winds such as those prevailing on hilltops, not prone to flooding or severe frost as may occur in valley bottoms. Relatively flat land is most suitable, ideally with 1 % -2 % slope to allow gentle drainage.

If flat land is not available, terraces can be constructed and the site should receive sunlight for the major part of the day. For more exposed nurseries, shading may be desirable to avoid excessive heating.

Materials :- To condition soil texture, water holding capacity, drainage and fertility, it is convenient if sand or fine gravel and humus, forest soil or turf are available close to the nursery. Also fencing materials should be available.

(b) Factors important for nursery management

Location -The nursery should be close to the planting area to minimise transport and handling shock of the seedlings which may result to low survival to most species.

Access - The nursery should be situated at an area accessible at all times, preferably close to the road, or member of the nursery (if group nursery).

Size - The size of the nursery are will depend on : - the number of seedlings required for planting.

- The time it takes to produce seedlings of the desired size and species in the nursery
- The size of the containers used. Some seedlings particularly fruit trees, ornamental are grown in big pots thus require more space than those grown in small pots.

The list below show the approximate space required for various pot sizes used in the nursery.

Pots sizes/poly bags

Number of seedlings	Seed bed	4" pots	5"x9" pots	7"x9 pots	9"x10 pots	Total area required
100 forest trees	$0.5m^2$	$4m^2$				$4.5\ m^2$
1000 fruit tree from seeds (guava, passion, mango) etc.	$2m^2$	------	6.5			$8.5m^2$
1000 fruit trees from seed	$2m^2$	-------	-------	12.5 m^2		$14.5m^2$
100 Avocado/mango	$4m^2$				$21m^2$	$25m^2$

- When starting a nursery for the above restored target, additional space for the mother orchard and future expansion should be added.

2.2 Basic facilities

A nursery must have :-

(a) access roads and paths
(b) Fence
(c) shelter for tools, material and workers
(d) a soil dump
(e) seed bed
(f) pot beds
(g) shading and shelter for plants.

In addition it may have : -

(h) wind breaks
(I) a composts area
(j) a working shed
(k) seed extraction area

(a) Accesses roads and paths

The sitting of the nursery should minimize the need for transport of materials and seedlings with vehicles because this can be expensive nuture. for easy collection of seedlings . If possible the nursery should be located where vehicles can pass and allow visitors reach the nursery.

(b) Fencing

Before putting anything on the ground, fencing should be done to protect the nursery against browsing and trampling animals. Different materials can be used in fencing the nursery and this depends on availability of fencing materials and capability of the people running the nursery. The fencing materials range from dead (e.g. wire, sticks, thorny branches, palm leaves, stone wall) to live (e.g. *Dovyalis caffra*, hedges, Acacias, Euphorbia etc.) .

(c) Shelter for tools, material and workers

As a shelter for workers and to keep tools, and materials in a dry and safe place, a simple hut should be constructed from materials locally available. (pole, sisal, mud, etc. in the local style. Even the nursery can be placed under tree shade.

(d) A soil dump

The production of potted seedlings requires large amounts of soils, sand and manure or fertilizer depending on availability of the same . Space is needed to store these materials within the nursery where they can be mixed and the pots filled.

(e) Seed beds

Seed bed is a container, or a designed place purposely prepared for germination of seeds. There are various types of seed beds. There is sunken seedbed and raised bed. Sunken seedbed is constructed through digging the land surface (about 20cm) and soil removed is replaced with germination media. Then there is raised seedbed which is constructed through the use of side support materials, to form the frame that will contain the soil from being washed away by water.
Those side supporting materials, can be timber, banana stems or other readily available materials on the environment, such as , timber off cuts, split logs. bricks, large stones or even concrete blocks provided they can form a frame that is least 20cm (8") height.

Seedbed should be level to prevent water from running off and washing away soil, seed or mulch. To obtain optimum condition for good seed germination, the seedbed should consists of :-

(i) Gravel to ensure good drainage
(ii) Humus -rich soil holding water
(iii) Sand to ensure easy germination and pricking.

The germination media should be changed more often to avoid soil born diseases

(f) Potbeds

Beds 1m wide and 5-10m long are most convenient and if the beds are wider weeding and watering the centre is more difficult. If sloppy areas, the beds should be along the contour. Between the beds, access paths are required for transport, weeding, watering, pruning etc.

(g) Shading

Young seedlings need to be shaded from the sun especially in ASALS areas. Shades can be made from locally available materials, such as sorghum, millet, grass, poly sheets, nets etc. Shades should allow some sunlight to pass through for better seedlings growth.

(h) Wind break

Seedlings should be protected against strong wind, through establishment of shrubs on the prevailing wind direction.

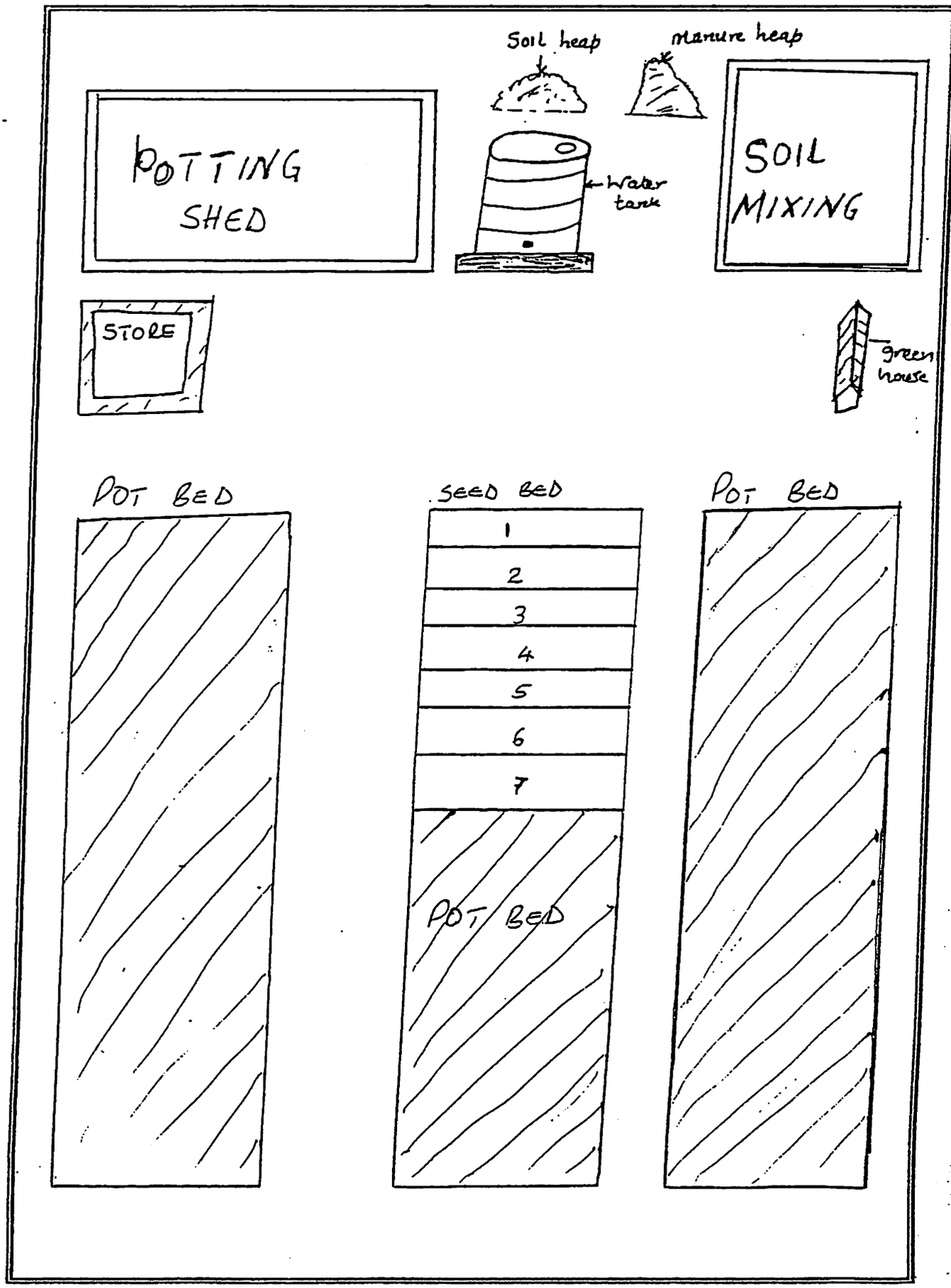
(i) A seed extraction area / shed

Different seeds are collected in different forms i.e. fruits, cones, pots, capsules and they have to be extracted before sowing for better germination. It is therefore important, to construct a shed where the extraction can be done.

2.3 Nursery layout

Once a site is selected a plan should be made of how to construct the new nursery. This done through a simple sketch. Trees within the compound are marked as well as the contour access roads, water points. By doing this it is easier to utilize the area in the best possible way.

NURSERY LAYOUT



2.4 Tools Required

The following tools should always be available for use at any given time. It is the responsibility of the nursery manager to find out how many of each will be required depending on financial status of the nursery owner. Before the establishment of the nursery, the required tools ought to be ready. These tools include :- wheel barrows, shovels, jembes, pangas, rakes , slashers, watering cans, prunning knives, sharpening files, soil sieves, jerricans, polythene tubes, tetrapacks, tins strings, pointed wooded stick (pricking) , bucket, budding knives, disinfectant, fungicides, labels, measuring tape, paint, brush, sharpening stones.

Uses of the tools:-

(1)	Wheel barrow	-Ferrying soil/water or any other materials.
(2)	Shovels	-Moving earth, for sieving soil and mixing soil
(3)	Jembes	-to break up soil or digging /weeding
(4)	Pangas	-for cutting pegs, fencing materials
(5)	Rakes	-for levelling the soil and collecting unwanted materials in the nursery
(6)	Slashers	-for cutting down grass
(7)	Watering cans	-for watering sown seeds and seedlings
(8)	Prunning knives	-for prunning seedlings roots, planted seedlings, knipping seeds.
(9)	Sharpening files	-for sharpening pangas, jembes.
(10)	Soil sieves	-for sieving soil /manure
(11)	Polythene tubes/ Tetrapacks/Tins	-for putting soil for seedlings
(12)	Strings	-for alighting potted tubes
(13)	Jerrycans	-for fetching water / this can be mental, plastic of various sizes
(14)	Pointed wooden sticks	-for pricking out

3.0 SEED COLLECTION AND HANDLING

Most planting stock is raised from seed. Successful raising and growing of trees depend on:-
-The right kind of seed (provenance)
-Good quality
-Sufficient amount
-Available at the right time.

Seed can be obtained from distributors or collected locally. In many countries, forest seed centres have been established by the forest service, universities or research institutions. Sometimes seeds are sold by commercial firms or are available from other nurseries or projects. Any seed distribution must provide information of the species, provenance, collection time and probably from what type of parents tree. For one to be good seed collector, one must be conversant with flowering, fruiting and maturity time for different tree species. The seed should only be collected when they are mature or ripe. Most of species, change colour of their fruits, pods, capsules, when they are mature for harvesting, from green to brown. Seeds should not be collected from isolated or deformed trees in order to get good characteristics like vigorous growth, pole strainghtness and high above grown biomass for fodder.

When collecting seeds , it is important for the seed collection team to keep records of collection sites, collection dates, specifying soil types or any other details which may be useful for future reference. Also it is useful to do some germination tests after in order to check viability of the collected seeds.

3.1 Mother tree.

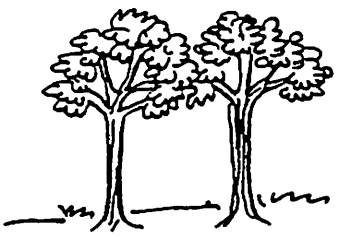
Good parent trees are important because the seedlings will be similar to the tree from which collected. Big, straight and vigorously growing trees will normally give straight and vigorously growing seedlings. Form of the tree desired depend on intended purpose.

3.2 Seed extraction

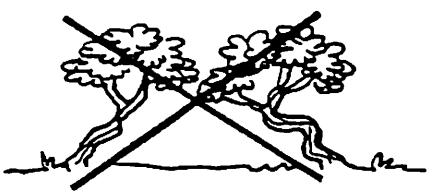
Most seeds collected are contained in cones, fruits or pods. The seeds must therefore be extracted from their cones or fruits. Seed of most species can be extracted by :-

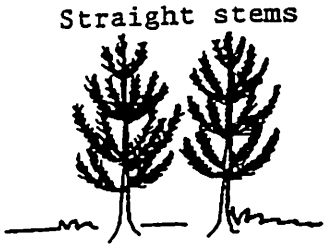
(a) Sun-drying e.g. *Eucalyptus, Casuarina sp.*
(b) Termites e.g. *Prosopis, parksisonic, terminalia sp.*
(c) Pounding e.g. *Acacia species*
(d) Beating e.g. *Acacia species, cassia sp. Leuceana species etc.*
(e) Washing e.g. *(Dovyalis caffra, Balanites, carica papaya, Azadirachta indica* etc.).
(f) Machine e.g. (mostly used to extract seeds with hard nuts such as *mellia volkensii, macadamia).*

THE RIGHT PARENT TREE

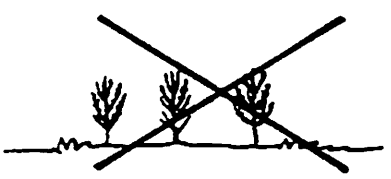


Straight stems

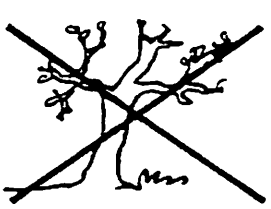




Fast growth

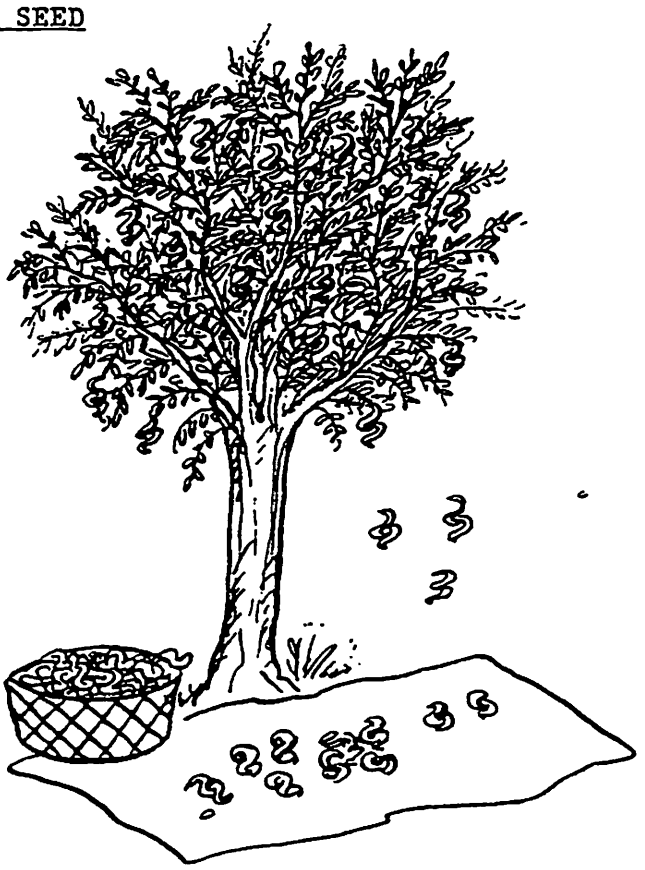


Leaf production
Dense foliage (fodder trees)



COLLECTION OF SEED

Picking or cutting



Spreading cloth under the tree

3.2.1 SUN -DRYING

Grevillea robusta seeds are taken out from the capsules open when dried for 3-4 days in the sun. The collected fruits are exposed to the sun by spreading in thin layer on a polythene, canvas or trays.

3.2.2. BEATING

Pods are therefore collected from the trees as soon as they change colour from green to brown and start splitting from one end. The collected pods are sun dried for 3 -4 days after which they are put in sacks between abit and tossed around to extract the high loss of seeds because pods split open by explosive mechanism and throw out the seeds. For *Cassia spectabilis, Delonix regia* and *Jacaranda mimosifolia* whose pods are very hard, extraction is done by opening the pods by a knife. The pods are dried for 5-7 days before seeds are extracted. The seeds are then dried for 2-3 days in the sun. The nut of *Croton megalocarpus* is broken using a stone or hammer to extract the seeds. The seeds are then dried for 3-4 days.

The seeds of *Acacia albida, A. gerradii, A. polyacantha, A. senegal, A. tortilis, Acrocarpus flaxinifolia, Albizia anthelminitica, Caesalpinis decapitala, Cassia siamea, Leucaena leucocephala, Parkinsonia aculeata, Sesbania grandiflora* and *Sesbania sesban* are thrown out when the pods splint open.

3.2.3 POUNDING.

The pods of *Acacia nilotica, A. tortilis and piliostigma thorningii* are dried for 5-7 days put in a mortar and winnowed to get the seeds. The seeds are dried for 5 days before storing or sowing. In the case of *Melia volkensii* , the ripe fruits are collected, depulped using a mortar and pestle after which the seeds are washed and sun dried for one week. The seeds of *Balanites aegyptiaca* and *Tamaridus indica* are collected from the tree, put in a large basin with water and sand. The pulp is removed by rubbing the fruits against the sand by use of hand. The seeds are then washed and dried for one week.

3.2.4 TERMITES EXTRACTION

The pods of prosopis juliflora are heaped 10cm high on metal sheet. They are then covered with a layer of grass and then soil. The heap is then watered and left for few days.

Pods will be attacked by termites which consume the pulp and the grass leaving the seeds. The soil is removed after 2 weeks and the seed washed and dried for 2-3 days. The seeds of *Melia azadirachta, Newtonia hildebrabdtii, Terminalia brownii, Terminalia mentalis , Terminalia prunioides* after being collected are directly stored.

3.3 Cleaning and sorting

Cleaning and sorting are necessary for good germination and protection against pests and diseases. What should be removed are dirt, immature light seeds and seeds that are rotten, broken, damaged by insects or infested by diseases. They should be removed by hand or sorting machine.

3.4 Drying

Although there are several methods of seed drying, sun drying is the most common. The seeds should not be directly exposed to naked flames. The dying of seed should be gradual over several days and the seed should be turned every few hours. When the seed is dry, it may be packed in clean, air and moisture tight containers such as polythene bags.

3.5 Seed testing

Seed tests are very important to verify the seed quality, vigour and monitoring seed condition from collection through handling to storage. All collected seeds must be tested before storage or dispatch for purity percent, seed weight , moisture content and germination capacity.

Seed testing label.

No. of species	
Species name	
Type of pre-treatment	
Date sown	
Date of first germination	
Date of last germination	
No. of plots sown directly	
No. of pots germination	
Germination percentage	

3.6 Storage

For most species cool and dry storage in a dark place is best. Some species can be stored for several years without much loss of viability but some will loss the potential of germination within a month. Those species which can be stored for longer period include- *Acacia species , Eucalyptus, Melia volkensii* and many others those which can lose their viability within a short period include -*Azadirachta indica, Dovyalis caffra.*

Seeds for storage must be dry enough and if possible cool storage (refrigerator) can be the best for storing seeds for longer period. For those with small scale, nurseries, they can store their seeds in bottles, jars, boxes, Tins , paper bags and even plastics.

3.7 Estimate of seed requirement

The amount of seed required depend on the number of the seedlings needed for planting and the capacity of the seed to germinate and grow into a healthy seedling. One can calculate the amount of seeds in kg as :-

Amount = 125 N/PW+E

Where N= No. of seedlings required for planting
P = Germination rate or plant per cent
W= No. of seeds per kg.
125 = A factor that adds a 25% reserve
E = An extra quantity if some of the seeds are not good.

Example of calculation of seeds required

Amount (in kg)= 125xN/PW+E

- For the species A planting target 30ha.
  planting density 2000 seedlings/ha.
- Number of plants required (N) = 30x2000
  =60,000 seedlings
- Germination rate 20% (P).
- Number of seed/kg (W) = 3,000
- 15 % will get damaged during storage & development (E)
- Amount (in kg) including 20 % reserve =

$$\frac{125 \times 60{,}000 \times 15}{100 \times 30{,}000 \quad 100} = 30.15\text{kg}$$

4.0 PROPAGATION

Propagation of plants is fundamental occupation of man-kind, agriculture and nursery industry. Its study has three different aspects : the art, the science and the knowledge.

- Art of propagation - Requires knowledge of the mathematical manipulation and technical skills. These take a certain amount of practice and experience to master.

- Science of propagation - Relates a knowledge of plant growth and structure. This helps the propagator to understand why he does the things, he does , how to do them better and cope with unexpected problems.

- Propagation knowledge - Relates the propagation methods selected to the response of the different kinds of plants produced.

- There are two basic types of plants propagation. Sexual (by seed) and a sexual (vegetative). Each of these methods has its advantages and limitations. The function of any plant propagation technique is to preserve a particular characteristic of a plant or group of plant that are important to man

4.1 Sexual or seed propagation

Propagation by seed is the primary method of plant multiplication and remains the principal way of raising the majority & tropical seedlings. The origin of seed is due to sexual function in plants, which is part of the process of pollination and fertilization. Seed propagation require careful management of germination requirements or various seeds.

Advantages of seed propagation

- Cheap and convenient method of large number of plants.
- Easy and convenient to distribute
- Off springs raised from seeds are more robust.
- Deep anchoring root system is produced (taproot)
- Most seeds do not retain viruses occurring in the parent

Disadvantages

- Some species are difficult to germinate e.g. Mellia volkensii
- Slow to reach maturity (e.g. Dalbergia melanoxylon).
- Seedlings do not always have all characteristics of the parent tree

4.2 A sexual propagation (vegetative)

Most trees raised from seeds bear fruit that is inferior to that produced by the parent (mother) tree. The most convenient method which result in the transfer of the characteristic of propagation. This methods retain in full all characteristic of parent tree throughout their period of growth.

Vegetative propagation is the real basis of horticulture, enabling plant raisers not only to aim at perfection by selecting but also to preserve at will any advance achieved.
Most common species propagated vegetatively in ASALS include :- Ficus benjamin, Mangoes (grafts), oranges (grafts), prosopis juliflora, (cuttings/ grafts) strawberry etc. In vegetative propagation one can use suckers, cuttings, or even grafting.

Advantages of a sexual propagation
- Period of maturity for plants is shortened.
- Retention of characteristics of mother trees.

Disadvantages
- Easy transmission of diseases from parents tree young plants.
- Young trees not deep anchored as there is no tap root

4.2.1 GRAFTING AND BUDDING

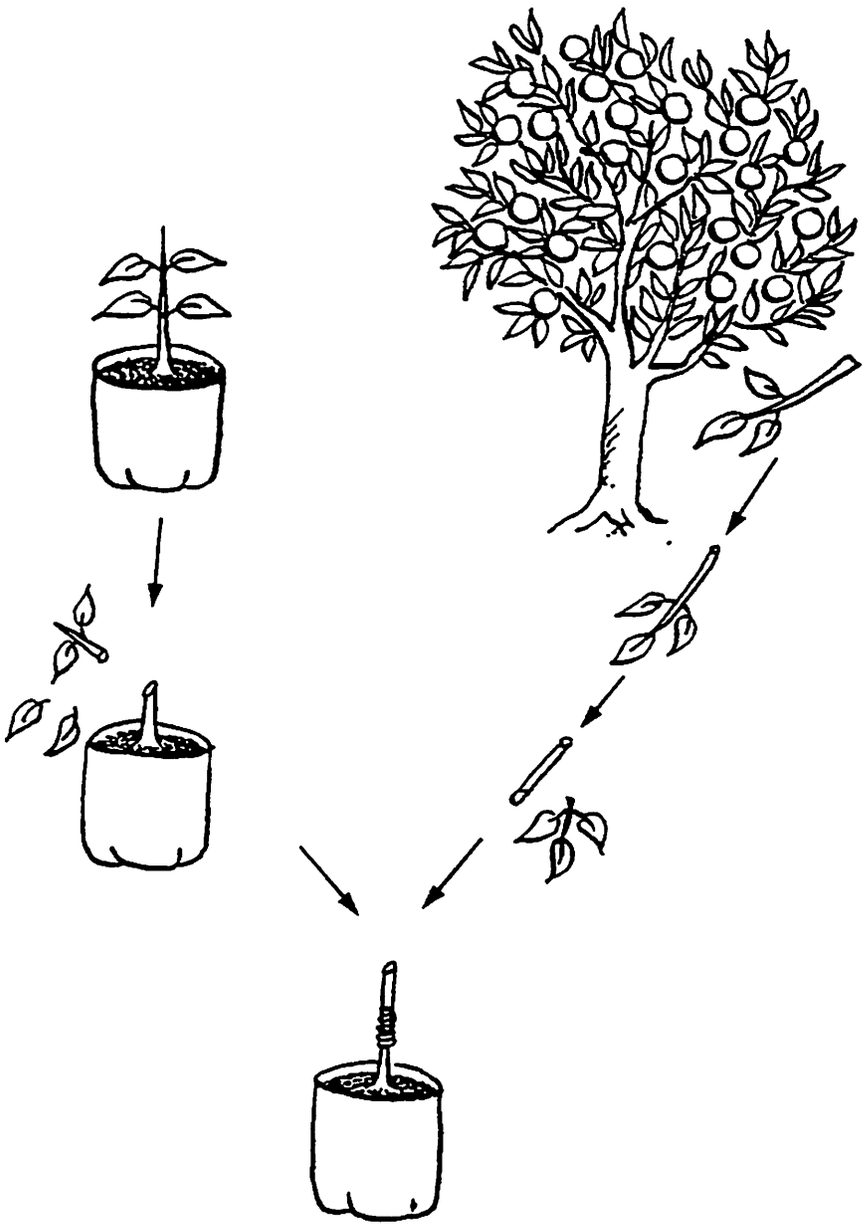
Grafting is the art of joining part of plants together in such a manner that they will unite continue their growth as one plant. The part of the graft combination, which is to become the upper portion or top of the new plant is termed as the scion (scion) and the part which is to become the lower portion is the root stock. All methods of joining plants are properly termed grafting, but when the scion part is a small piece of bark (and some times wood) contain a single bud , the operation is termed budding

Reasons for grafting and budding

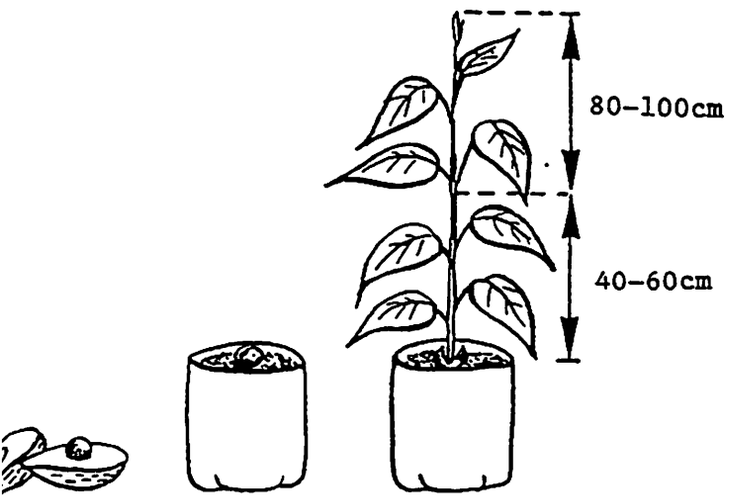
- Propagate clones that cannot be conveniently reproduced by cutting , layers, divisions or other a sexual means.

- Obtaining benefits of certain root stocks. In some instances, varieties can easily be propagated by cuttings or seeds, yet grafting or budding is preferred on certain rootstocks are available root characteristics not obtained when the scion variety is on its own roots. Far many plant species , root stocks are available which tolerate unfavourable conditions, such as heavy, wet soils which resists soil borne diseases or pests some stocks, particularly in citrus, leave a profound effect on the size and quality of the fruit of the scion variety.

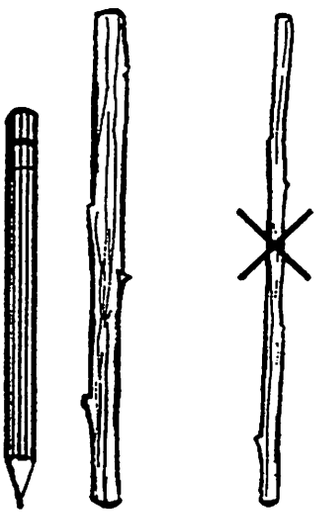
6. GROWING GRAFTED FRUIT TREE SEEDLINGS



HOW TO GRAFT

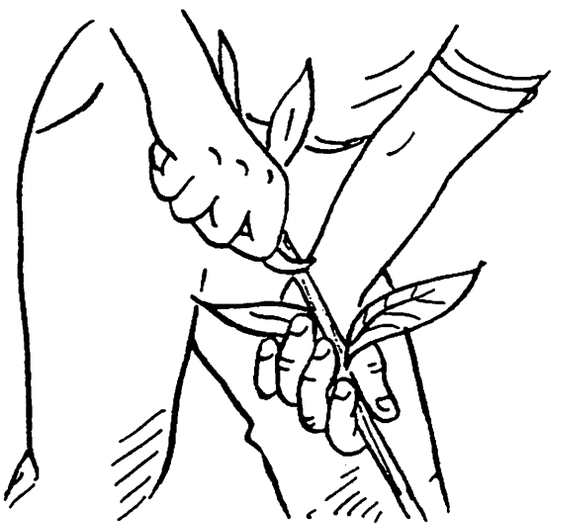


Seedlings are ready for grafting

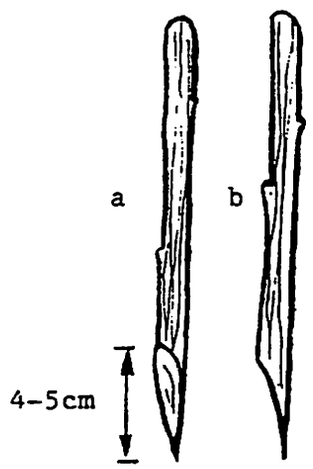


Correct: diameter of a pencil

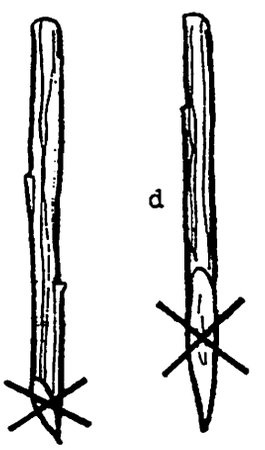
Oblique cut on the scion



Oblique cut on the seedling

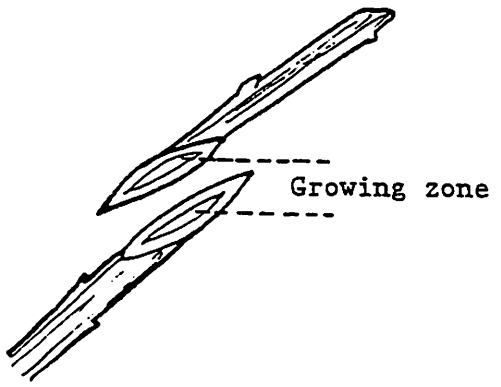


Correct cut

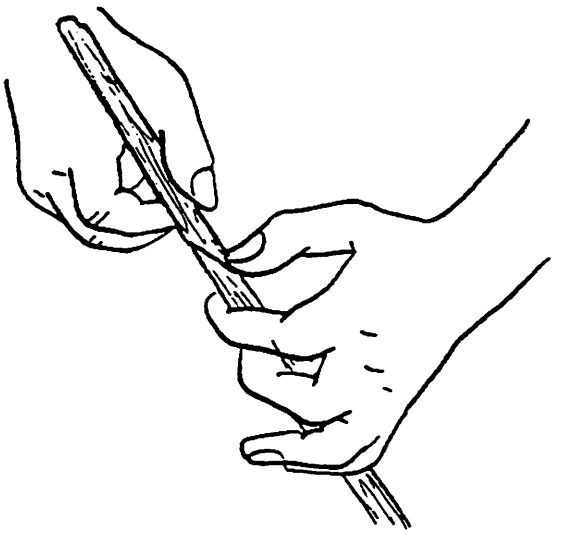


False

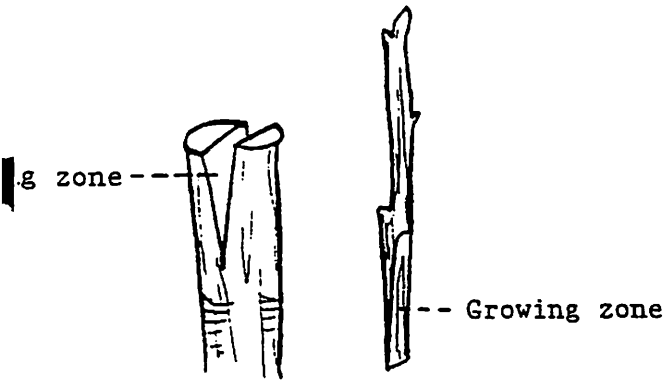
HOW TO GRAFT



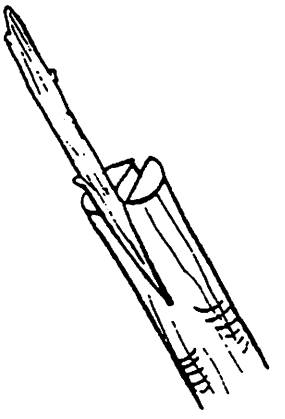
Method 1: sideways



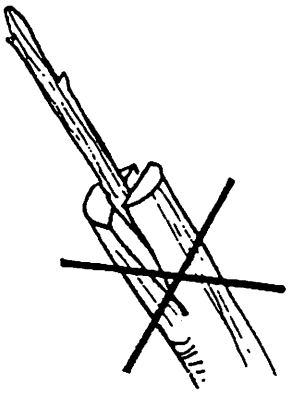
The two surfaces are laid on to each other



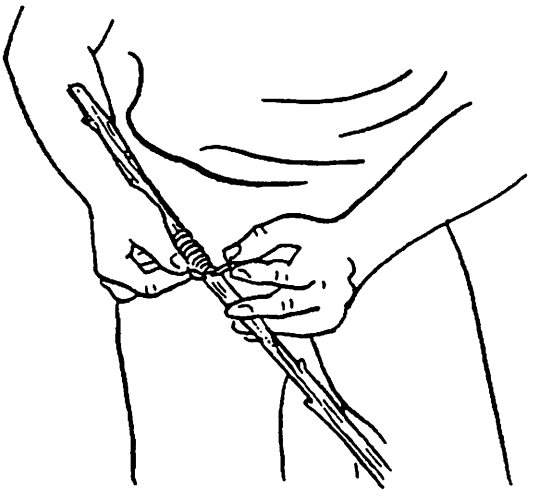
Method 2: slot



Correct: firm contact of two growing zones on one side



False



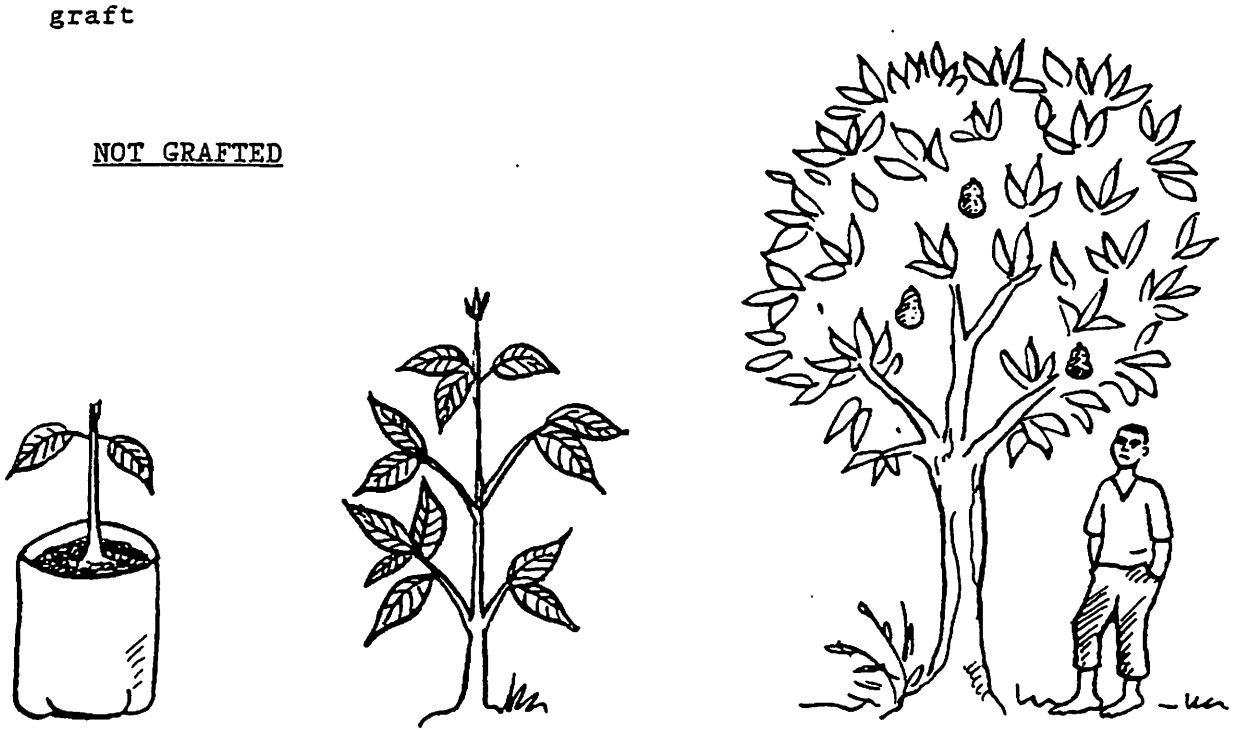
Scion and seedling are tied together

GRAFTING

GRAFTED

Seedling with graft → 3rd year → 10th year

NOT GRAFTED



Seedling → 3rd year → 10th year

FORMATION OF THE GRAFT UNION

The sequence of events is as follows:-

(a) Freshly cut scion tissue capable of meristematic activity is brought into secure, intimate contact with similar freshly cut stock tissue in such a manner that the cambial regions of both are in close proximity.

(b) The outer exposed layers of the cells in the cambial region of both scion and stock produce parenchyma cells which soon intermingle and interlock.

Methods of grafting:-

(a) Whip or tongue graft
(b) Splice grafting
(c) Side tongue grafting

The variation of the methods in marked by different cuttings type both the root stock and the scion. Below see the demonstration of a simple grafting technique.

4.3.0 Process of seed Germination

Seed germination can be inhabited (blocked) by:-
- Non developed embryos
- Dormancy
- Physical causes
- Hard sheet
- Fat in and around the seed coat

To overcome the above, the following pre-treatment of seeds are necessary to stimulate the germination :- mechanical, hot water & cold water.

4.3.1 Mechanical treatment:-

Scarification :- A process of manual breaking, cuttings or scratching the cover of the seed. The reason for scarification is to crack the seeds so that water and gases can enter. When cracking, one should avoid exposing the inner part of the seed embryo. Common ASAL species which are mechanically pre-treated before sowing:-

1. *Mellia volkensii*
2. *Acacia nilotica*
3. *Terminalia brownii*
4. *Acacia tortilis*
5. *Terminalia mentalis*
6. *Terminalia prunioides*
7. *Acacia gerradii*
8. *Acacia nubica*
9. *Zyziphurse mauritania*
10. *Faidharbia albida*
11. *Adansonia digitata*
12. *Acrocarpus flaxnifolia*
13. *Acacia seyal*

Seedbed sowing and direct growing - Seed propagation can either be achieved through seedbed or direct sowing.

Seedbed sowing - Most seed propagation method is done through seedbed. Propagation by seed though is mostly applied to those seeds which are small in size, and require easy germination media e.g. sand.

Common species raised through seedbed in ASALs include :-
1. *Azadiratch indica*
2. *Eucalyptus species*
3. *Causuarina species*
4. *Prosopis species*
5. *Acacia species*
6. *Mellia volkensii*
7. *Dalbergia melanoxylon*
8. *Terminalia species*
9. *Passion fruits*
10. *Psidium guajava*
11. *Cassia species*
12. *Chlorophora exelsa*
13. *Dovyalis caffra*

Direct sowing

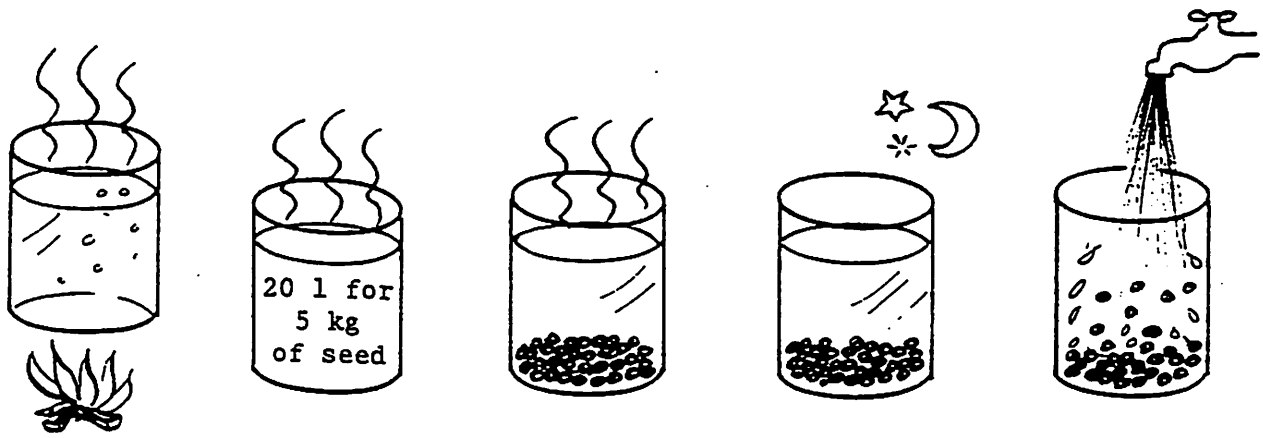
Seeds which have high germination ability and big in size can be directly sown to the pot, tin, or any other container.

Some of those species include:- *Croton species, Tarmarindus indica, Cassia species, Balanites eagyptiaca delonix regia, Mangifera indica, pawpaws* etc.

4.3.2. **Hot water**

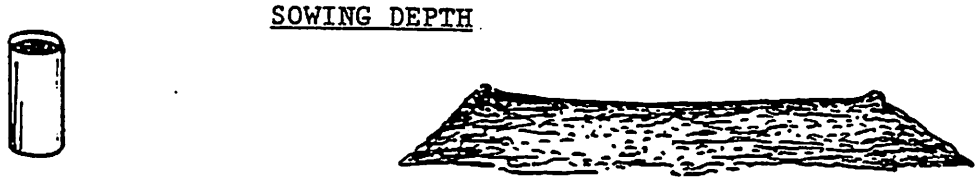
Soaking seeds in hot water helps overcome seed coat dormancy, soften seeds and stimulate germination. The seeds should be planted immediately after the hot water treatment. In hot water pre-treatment, seeds are exposed to temperatures ranging from 60 °C to 100°C . Different seed types are soaked for different times, ranging from 2 min to about 30min. Others are soaked in lukewarm water overnight. The below Asal species are pre-treated with hot water.

HOT WATER TREATMENT



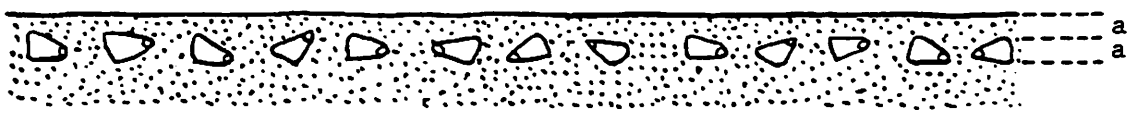
Boil water | Take off the fire | Immerse seed | Cool overnight | Rinse

SOWING DEPTH

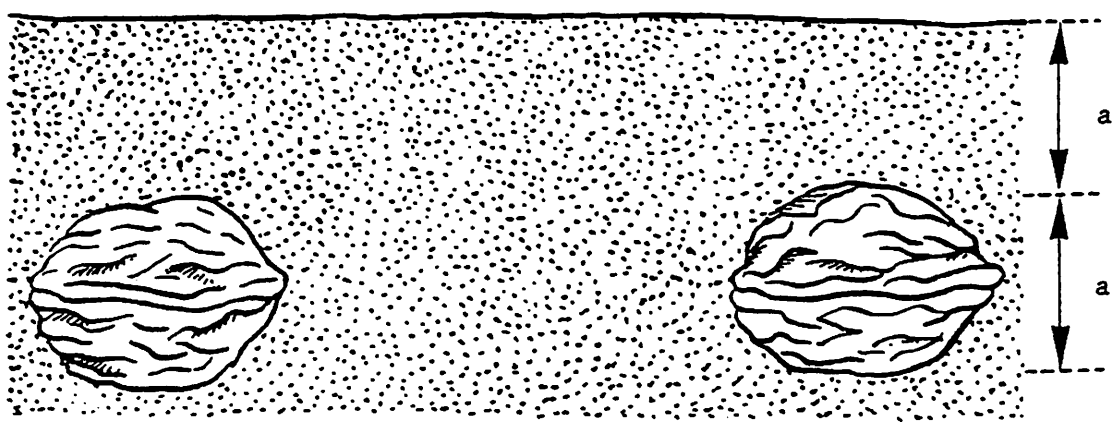


For pots and seedbeds

Eucalyptus



Pinus



Big seeds, e.g. Juglans

SPECIES	TEMPERATURE	TIME (Soaked)
1. Cassia siamea	60 °C	20 min
2. Cassia spectabilis	80 °C	10 min
3. Tarmarindus indica	60 °C	3 min
4. Acacia polyacantha	80 °C	20 min
5. Prosopis juliflora	80 °C	15 min
6. Acacia holoicelica	60 °C	7 min
7. Acacia xanthophlea	80 °C	15 min
8. Caesalpinia decapitulata	60 °C	3 min
9. Parkinsonia aculeata	60 °C	2 min
10. Leuceana leucocephala	80 °C	15 min
11. Delonix ragia	60 °C	15 min
12. Phoenix reclinata	80 °C	3 min
13. Terminalia spinosa	80 °C	15 min
14. Terminalia mentalis	80 °C	2 min
15. Acacia abbyssinica	80 °C	2 min
16. Acacia holoicericea	80 °C	7 min
17. Acacia mearnsii	80 °C	until cool
18. Acacia polyacantha	80 °C	2 min
19. Bombax rhodognaphalon	80 °C	20 min
20. Caesalpinia decapelata.	60 °C	

4.3.3 **Cold water**

Cold water soaking of seeds of some species, just above freezing is sometimes used in conditioning for germination. Most of the species which are germinated through cold water, can be sown without any pre-treatment but to achieve uniform and faster germination, seeds can be soaked mostly overnight.

The below species can be pre-treated with cold water:-

1. *Acacia senegal*
2. *Acacia melifera*
3. *Acacia presipica*
4. *Albizia anthelmintica*
5. *Albizia lebbeck*
6. *Berchemia discolor*
7. *Gnelina arborea*
8. *Albizia amara*
9. *ETC*

There are other species which require no pre-treatment before sowing. These include:-

1. *Balanites eagyptiaca*
2. *Dalbergia melanoxylon*
3. *Cordia ovalis*
4. *Schinus molle*
5. *Eucalyptus camaldulensis*
6. *Grevillea robusta*
7. *Croton megalocarpus*
8. *Mangifera indica*
9. *Psidium guajava*
10. *Moringa oleifera*
11. *Dovyalis caffra*
12. *Carica papaya*
13. *Azadirachta indica*
14. *Casuarina equistifolia*
19. *Newtonis hilderbratii*
18. *Vitex dimiana*
15. *Jacaranda mimosifolia*
16. *Passion fruits*
17. *Ficus benjami*

In order to improve the percentage of germination and the quality of the seedlings,

- Never sow seeds thickly - this can be avoided by mixing seeds with fine sand, twice the amount of sand to seed.
- Full shade should always be provided for seedbeds, including the shading of the sunny side of the seedbed. After an even germination has been obtained, the shade can be reduced to $^3/_4$ shade.

5.0 SOIL COLLECTION AND MIXING

5.1 Selection of collection site

Good growing medium can be collected from different places depending on location of the nursery and capability of the nursery management. Soil can be collected from planted and natural forests, uneroded areas or any other area where soil contain humus. Decomposed leaves in the forests, make planting media good for seedlings growth, aeration, drainage. Objective of any good growing medium is to produce a quality plant by providing an ideal environment for root growth and adequate base for anchoring plants. Soil should be collected within 15" deep (top soil).

SOURCES OF SOIL

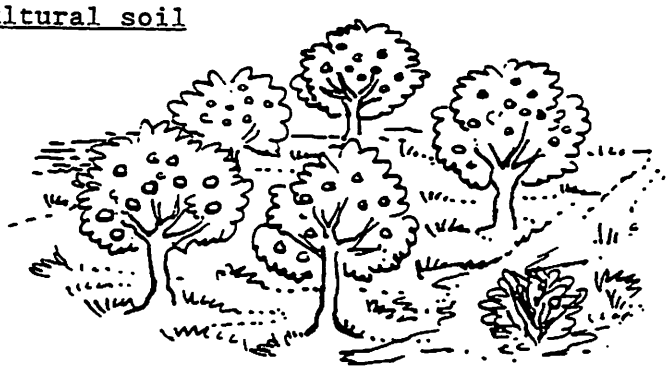
Humus-rich soil

Under trees

In forest

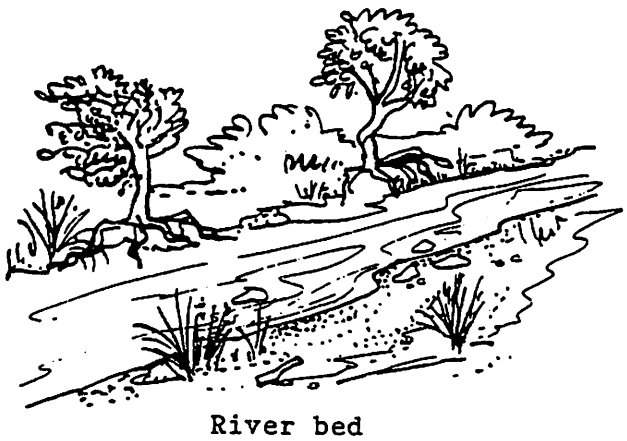
Agricultural soil

Fields



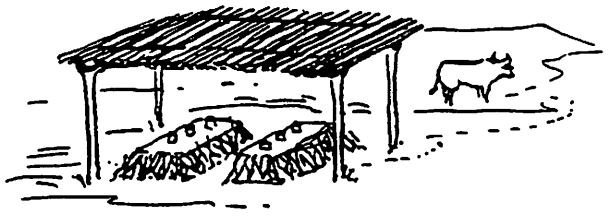
Gardens, orchards, fallow land

Sand



River bed

Compost, manure, peat



5.2 Soil mixing

Soil for filling containers should be sieved (if contain lumps) mixed with manure and if possible sand. Forest soil can be potted without mixing with other materials because it is rich in humus, good aeration and has good drainage capacity. For Tiva Nursery, the below mixing ratio is used:-

- 4 parts of virgin top soil
- 1 part of animal manure

This mixture can be applied by both small scale and large scale nurseries. It is easier and cheaper than using undisturbed forest soil (which may be far) or use of fertilizer which are expensive . Other applicable ratios include :-

- 5 virgin to soil
- 2 part decomposed manure (animals manure)
- 1 part coarse sand.

5.3 Potting

The process of putting growing medium onto the container is termed as 'potting' . It is important to avoid potting using soil infected with nematodes or soil borne diseases as this may affect seedlings. If prepared soil mixture is dry, give the heap a good watering turning 3 to 4 times before using . This is important because the mechanical state of the soil can be badly upset, if watered and then packed into bags immediately afterwards. Filling polythene tubing is difficult at first. Place initial amount of soil and firm the soil at the bottom . Fill to about half the tube and only compact the lightly. Gentle firming will ensure that growth can occur. Line the filled tube straight, well arrange tubes will facilitate work at the time of transplanting , root prunning, weeding and also clearing. Air pockets should be avoided when filling the containers.

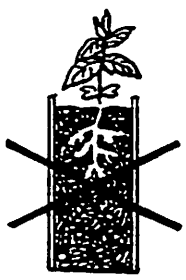
5.4 Pot arrangement

Potted containers should be arranged in straight lines to ease movement within them. Pots can either be arranged in a sunken beds or flat beds. The pots are placed in the beds in an upright position. They should not be squeezed but maintain their round shape and space should be left for rain and excess water to drain off easily. Inclined pot arrangement will encourage root distortion of the seedlings.

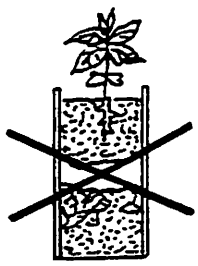
6.0 NURSERY ACTIVITIES

FILLING POTS

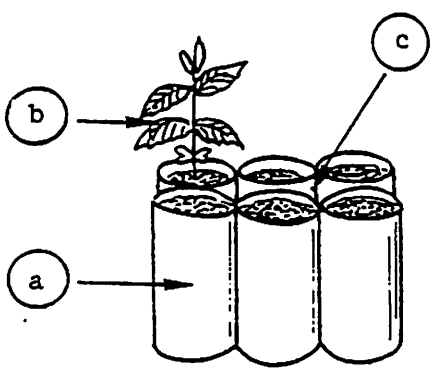
Correct



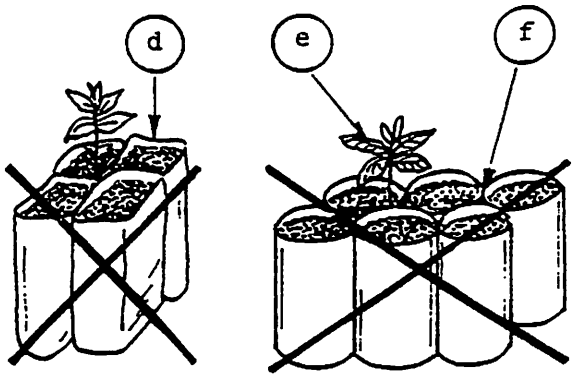
False:
too compact



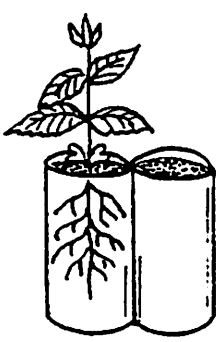
False:
air pockets



Correct:
(a) Pots are not deformed
(b) Seedling in centre of pot
(c) Pots placed in straight rows leaving space for draining



False:
(d) Pots are deformed
(e) Seedling not placed in centre
(f) Pots placed too densely, insufficient space for drainage



Correct:
pot upright -
roots will develop well

False:
pots inclined -
roots distorted

6.1 Pricking out:-

Pricking out is the act of transplanting germinated seedlings from the germination media to the pots. Most species are transplanted when they attain two (2) leaves. Others are transplanted at 3 to 5 weeks after germination and it is very important to organize necessary containers before hand.

When pricking out the following aspects are important to note:-

(a) Never grasp the seedling by the collar (stem). Always hold it by the seed leaves. This is because it will check the growth of the seedling for several weeks due to the brushing if the outer stem tissues and the brushed tissues may become the entry points for damping off fungi.

(b) Always cut the young taproot back by about 1/3 of its length to avoid taproot being coiled into a U-shape when transplanted as the root system will not develop fully.

(c) Ensure that seedlings are well " firmed" in the soil upon transplanting. This is because the young taproot possesses few if any feeder roots and so, the soil must be closely pressed to the root to enable it to absorb the soil moisture held between the soil particles.

(d) Never over water seedlings which have just been transplanted . It is important only to maintain constant moisture in the soil.

6.2 Watering

Watering is very important in the nursery operations and should be done with maximum care . Watering cans, hoses, buckets or debes are adequate for small scale nurseries. When watering tender seedlings by splashing water from buckets, debe or guards care must be taken to avoid speel off the soil. Tender, newly emerged seedlings can be watered by dipping a dense broom or brush or bundle of grass into a container of water, and a low height above them. Watering should be done twice a day. In the mornings and late evenings.

- Frequency of seedlings watering can also be dictated by weather conditions. When sun is not hot, watering can be done once.

6.3 Shading

Shading is required to protect seedlings from sun scorch and excessive water loss (evatraspiration) Some species are tolerant and can be grown without shade but sufficient water should be applied to them. Shading for seedbeds and seedlings can be fashioned out of palm leaves (or mats) thatch (grass) bamboo, nets, or any other material that does not disintegrate too readily, completely opaque materials (for example metal sheeting) should be avoided as too deep shade interferes with the growth of trees. On the other hand , the shade of tall trees may not be sufficient if the mid-day sun reaches the seedlings.
-Shading should gradually be reduced as the seedlings grow.

6.4 Root prunning.

The ideal nursery seedling, regardless of how they are raised (whether in container or in transplant beds) require well developed, fibrous root mass. Root density is far more important than root length in terms of ensuring seedlings survival.

In order to promote fibrous rooting and to avoid long tap roots (that break when lifting the seedlings) or even worse,
(spiral) roots, the roots of the seedlings must be pruned periodically, usually once every 1-2 weeks. With seedlings standing directly on the soil the roots protruding from the tubes can be eliminated by lifting the tubes and breaking the rootlet. Alternatively the tubes can be kept on a hard surface and root growth outside the tube thus prevented. Or the tubes can be lifted and the roots pruned with shears or prunning knives.

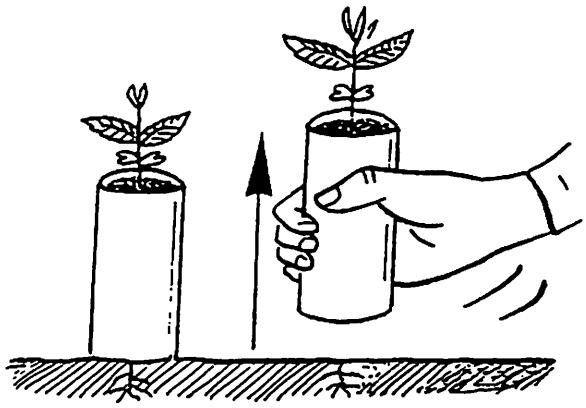
With seedlings growing in beds (swazilandbeds), a wire or a panga is run under the bed at ground level so as to prevent root growth from the bed to the underlying soil. Roots are also pruned horizontally by slicing the soil with a panga or a knife, so as to make 'cube' around the seedling.

One disadvantages of seedlings grown in a tin cans, is that their roots, having nowhere to go , are more likely to spiral at the bottom.

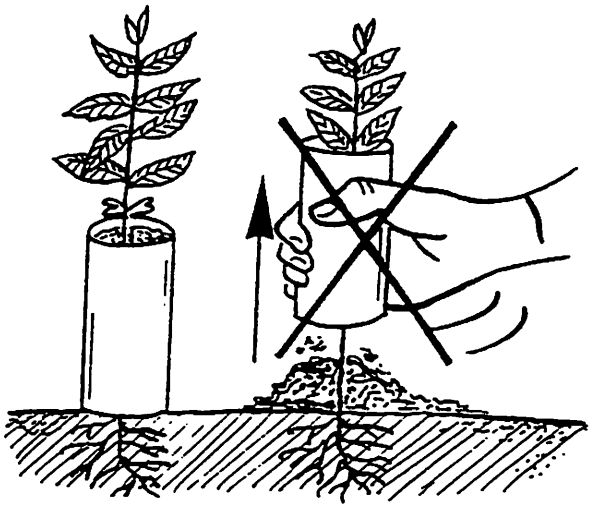
6.5 **Weeding.**

Nursery beds and seedlings containers must be weeded at regular intervals. Aggressive weeds can easily kill or greatly weaken tree seedlings. Failure to weed regularly results in deeply rooted weeds which are then hard to extract without damaging the tree seedlings. Weeds growing in the containers and seedbeds can be uprooted wisely.

ROOT PRUNING OF POTTED SEEDLINGS

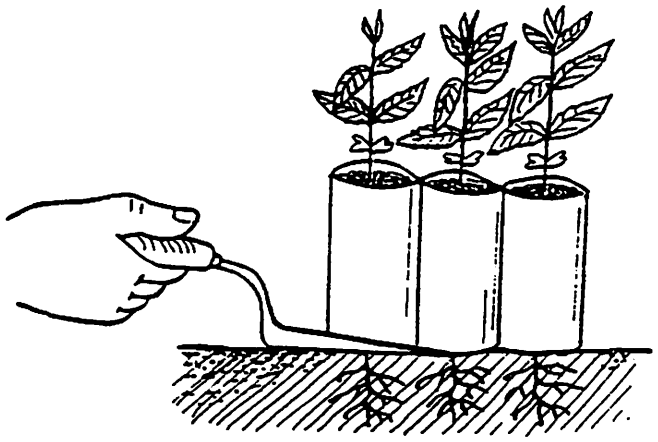


Correct: timing permits "shocking"

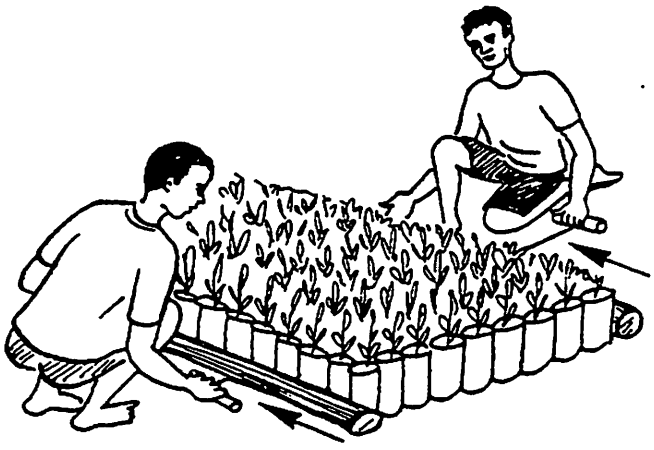


False: roots are too long

Root pruning with pruning shears



Root pruning with trowel



Root pruning with wire (e.g. piano wire)

6.6 Hardening -up

Having grown a good stocky seedlings, with fibrous root system, the next step is to " toughen it up" so that it is ready for the shock of field planting. This is not difficult, five or six weeks before the proposed planting date, gradually withhold water and increase root prunning . Bring your nursery stock almost to a standstill, physiologically. The seedling should fare well in the field.

7.0 NURSERY RECORDS.

To provide information about the performance, costs and productivity of the nursery, as well as to improve planning and its operations in the future a number of records have to be kept in the nursery.

These records include:-

(a) Workers attendance sheets and payrolls
(b) Store inventories records
(c) Delivery records
(d) Nursery inventories (seedlings production record)
(e) Meteorological data record
(f) Plant development record
(g) Seed collection and handling records
(h) Seedlings distribution record.

7.1 Workers attendance/ payroll

Workers attendance and payroll record is very important as it controls the unnecessary costs. This record is quite effective especially if the workers are paid on days worked (casuals) and payment confusions is avoided. Nursery costs represent a considerable part of the overall cost and a planning person incharge of the nursery has to be cost- conscious.

7.2 Store inventories

Each nursery manager should ensure that proper record of the nursery tools and facilities are well kept. It is from that the manager will be able to know what is missing and what is required for better nursery operations.

7.3 Delivery record

This record shows how many seedlings of each species left in the nursery, their quality, the dates of delivery and who received the plants and to which site they were sent. By having this kind of record, the nursery manager will be able to control unwarranted disappearance of seedlings from the nursery.

7.4 Nursery inventory record

For the planning and preparation of planting work, one has to know how many seedlings of the different species will be available . This information should be collected every month.

7.5 Meteorological record

It is important for every nursery to collect Meteorological data which will help to determine why different tree planting seasons will come up with different survival percentage for tree species . The data will include:- rainfall and temperatures.

7.6 Plant development record

Successful nursery work depends to a large extent on experience, with behaviour and particular problems of each species produced under the conditions of the nursery in question . This record will ensure all the information collected will enable any new personnel to benefits from experience already acquired. Systematic recording in writing is highly recommended. After a short period, it will be possible to see from the records:-

- How long it take for a species to grow to the right planting size.
- How much seeds are needed to produce the required number of plants
- How long the seed of a species takes to germinate and whether it germinates all at the same time over large period. This helps to plan labour requirements over the season.
- Which species need more or less watering and shading, special precautions against pests/ diseases.

7.7 Seed collection and handling records

People involved in seed collection must keep records of the following:-

- Collection site (provenance) this will provide information which will enable the nursery man to know whether the seeds can grow in a particular ecological zone.
- Date of collection - To confirm the viability of the seeds and when they are ready for collection.
- Mother tree- this will tell the plants morphology.
- Seed pre-treatment - this will contain information of how seed from different species are pre-treated for better germination

7.8 Growing schedules:-

For each species grown, it is possible to develop a growing schedules.

- A growing schedules is a chart of operation to be done for each species planted as a function of calendar date from seed preparation to shipment from the nursery.
- All growing schedules should have the following attributes:-

(a) It should define the days between which the crop will be in the nursery.
(b) It should show the complete cycle from seed to crop maturity
(c) The length of each segment of the growing stages and the calendar dates it covers. The three stages include:-
- germination stage which require more frequent watering and care against diseases.
- Juvenile growth which begins when the seed is exhausted. The seedling grows continuously. Watering is less frequent than during germination . This helps control damping off.
- Exponential stage- grow occurs after the seedling has fully taken hold and resembles a nature tree.

After recording each of these periods for each species one is then able to plan a programme from seed preparation to distribution of all the species.

7.9 (1) **Seedling distribution record**

This record is quite useful, especially for follow-up of the seedlings distributed to either groups, institutions or individuals. This record will help the nursery manager to determine which species are most desirable than others for future planning. Seedlings distribution sheet will include:-

- Name of the person issued with seedlings
- Number of seedling issued and species
- Date issued.

SEEDLINGS DISTRIBUTION FORM

Name of the Nursery : _____

Date	Section/Organiz./ Individual	Species	Quantity	Remarks

8.0 Plant protection

Introduction.

Every nursery manager must know that tree crops have to be protected against pests and diseases from sowing stage until the time of the seedling are ready for out planting.

8.1 **Disease** - Disease can be caused by carious agents acting singly or in combination. The agents themselves fall into 7 categories:-

- Bacteria
- Fungi
- Viruses
- Nematodes
- Some insects
- Some plants
- Mineral deficiencies/foxicuties

Mostly this chapter will concentrate on diseases of bacteria, fungi, viruses and mineral deficiencies

8.1.1 Damping -off and seedlings blights.

The diseases of germination seeds and of seedlings, are collectively known as damping- off. The main feature include poor emergencies even with seeds of high germinate capacity. Seedlings that have emerged often show water soaking, browning, or shrivelling of the stem tissues at soil level and they fall over as a result. In addition, an apparently well established young plant may stop growing, followed by yellowing and wilting of the foliage. When the plant are pulled out they are found to have extensive browning and rotting of the smaller roots, or stem lesions at soil level. This conditions can occur when soil conditions are unfavourable for plant growth, but favourable to fungal growth e.g. water logged condition.

≥

Control

1. Good seedbed management. These fungi can survive for long periods in soil. Once the problem has been noticed immediately discard that germination media and replace with fresh media. If the damping off becomes a problem, step can be taken through partial sterilization of the soil or other media
2. Treatment of the seeds with a chemical is another method
3. A form of biological control can be used by increasing the micro organisms which are antagonistic to disease causing pathogens.

51	Faurea saligna	Mukwa, Muto	-
52	Ficus benjamina	Mukuyu	-
53	Ficus natalensis	Kiumo	-
54	Ficus thorningii	-	-
55	Glicidia sepium	King'the	-
56	Gmelina arborea	-	Meliana
57	Grevillea robusta	Mukima	Mfaridi
58	Jacaranda mimosifolia	Mukengele	-
59	Kingelia africana	Kiatine	Muvungunya
60	Leucaena africana	Lukena	Lusins
61	Melia azadirach	Mukau	-
62	Melia volkensii	Mukau	Mpenda mbure
63	Parkinsonia aculeata	Musokasoka	-
64	Piliostigima dharngii	Mulema, Mukolokolo	-
65	Poscarpus milanjianus	-	-
66	Prosopis juliflora	Mutalakwe	-
67	Salvadora persica	Mukanyau	Mswaki
68	Schinus molle	Muthangu	-
69	Senna siamea	Ikengengeka, Mukengele	-
70	Senna spectabilis	Ikengengeka, Mukengele	Mrihi, Mhomba
71	Sesbania sesban	Mwathia, Munyonyoo	-
72	Sesbania grandflora	-	-
73	Sparthodea nilotica	Ilaitune	Kibobakazi
74	Zyzydium cuminii	Musambalau	Mzambarau
75	Termarindus indica	Kithumula	Mkwanju
76	Terminalia brownii	Muuku	Mbarao
77	Terminalia catappa	Muwanga	Mkungu
78	Terminalia kilimandschario	Muuko, Muhuku	-
79	Terminalia mentaly	Mwavuli	-
80	Terminalia pruniodes	Mutoo	Mwangati
81	Terminalia spinosa	Mutula	Mwangati
82	Thevetia peruviana	-	-
83	Warburgia ungandensis	Muthika	-
84	Vitex doniana	Kimuu	-
85	Zyzygium guineense	Mukunasi	Mkunazi, Mjafari
86	Lasiosiphon latifolia	Muthila, Mubila	Kinyungwa
87	Merua angolensis	Mukolekya	Mlalambuzi
88	Zyzygium guineense	Nzambalau	-
89	Mangifera indica	Kiembe	Muembe
90	Euphorbia candelabrum	Muthuri	Mutungutungu
91	Euphorbia garkeana	Kitoo	-
92	Lowsonia inermis	-	Henna
93	Moringa stenopetala	-	Mrongo

SEEDLING RECORD FORM

Necessary Pot	ⓑ

SPECIES _____

	ⓐ	ⓑ/ⓐ=ⓒ	ⓓ	ⓒ*ⓓ

No.	Place of collection	Germination % of germ. test	Necessary No. of seed for sowing	Weight per one seed	Necessary quantity for sowing(g No.)	Used seed	Date sown	Sowing type	Date germinated	No. of Pot germinated or pricked out	Remark
1							/		/		
2							/		/		
3							/		/		
4							/		/		
5							/		/		
6							/		/		
7							/		/		

No.	Date /		/		/		/		/		/	
	No. of seedling	Size of seddling	No. of seedling	Size of seddling	No. of seedling	Size of seddling	No. of seedling	Size of seddling	No. of seedling	Size of seddling	No. of seedling	Size of seddling
1												
2												
3												
4												
5												
6												
7												

APPENDIX 1

Time of flowering, fruit, seed dispersal in Kitui

○ : Flower
● : Fruit
☆ : Seed dispersal

No.	SPECIES	1	2	3	4	5	6	7	8	9	10	11	12
	Acacia abyssinica		○		●		☆						
	albida								☆				
	gerrardii			○			●			☆			
4	holocicilica		○		●			☆					
5	hypochylla												
	mellifera			○			●			☆			
	nilotica		○			●		☆					
	polyacantha	○			●			☆					
9	pendula												
10	salicina												
	senegal					○		●	☆				
	tortilis						○		●	☆			
	xanthophloea												
14	Acrocarpus fraxinifolius			○		●			☆				
15	Albizia amara		○		●		☆						
	anthelmintica								○	●	☆		
17	Azadirachta indica				○		●		☆				
	Bahaunea thnorngii							○		●		☆	
	Balanites aegyptiaca	●	☆								○		
20	Bombax rhodognaphalon					○				●		☆	
	Caesalpinia decapetala	○	●		☆								
22	Callitiriss robsta	☆					○		●				
23	Cassia siamea	○			●				☆				
24	spectabilis	○		●				☆					
25	Casuarina equisetifolia									○	●		☆
	Croton megalocarpus		●	☆						○			
	Dalbergia melanoxylon	●		☆								○	
28	Delonix regia	○				●		☆					
29	Dovyalis caffra	●	☆					○					
30	Eucalyptus camaldulensis								☆	○		●	
31	maculata								☆	○		●	
32	paniculata								☆	○		●	
33	tereticornis								☆	○		●	
34	Ficus capenses												
35	Gmelina arborea	●	☆								○		
36	Grevillea robusta	○	●	☆									
37	Jacaranda simosifolia				●			☆		○			
	Kigelia africana		○				●			☆			
39	Machaerium tipu												
	Maesopsis eminii												
	Lawsonia inermis	○				●		☆					
42	Leucaena leucocephala	○			●		☆						
43	Melia azedarach	○		●	☆								
	volkensii		●					☆		○			
	Newtonia hildebrandtii					○		●			☆		
46	Parkinsonia aculeata	☆								○		●	
47	Phoenix reclinata												
48	Prosopis juliflora		●	☆					○				

■ : indigenous tree

APPENDIX 2

SCHEDULE OF ACTIVITIES - PILOT NURSERY 1997

ACTIVITY	MONTH											
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
Construction/maintenance	◁	▷										
Soil/Manure sieving	◁					▷						
Pot cutting/filling	◁			▷								
Sow slow growing spp.	◁			▷								
Seed collection/extraction		◁									▷	
Root pruning				◁							▷	
Sow other spp					◁			▷				
Hardening										◁	▷	
Watering												