Japan International Cooperation Agency

NURSERY TECHNIQUES FOR THE ARID AND SEMI-ARID AREAS OF KENYA

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PREFACE

Kenya/Japan Social Forestry Training Project (SFTP) started its preparatory phase for 2 years on 26th November 1985 followed by a main phase of 5 years terminating on 25th November 1992. The Pilot Forest Scheme was established in November 1986. In that year seedling production was not among the activities carried out in the Pilot Forest Scheme. The required seedlings were supplied by Kenya Forestry Research Institute (KEFRI) and Forest Department (FD). Seedling production at Tiva Nursery started in 1987 and this activity has continued for the last 5 years. This "Provisional Nursery Manual" for Tiva Nursery has been written following the 5 years activities at the nursery.

It is however important to note that the technical aspects require further refinement. As this manual has been written through 5 years' experience in Tiva nursery. I'm convinced that it could have a wide application in especially Kitui districts.

I must note that the making of this manual has a lot of meaning especially as it comes at the end of the main phase of SFTP.

This manual written by Messrs.' R. O Nyambati and S. Hirao is a product of this good co-operation between Kenyan and Japanese experts attached to Tiva nursery.

Finally the project wished to thank Prof. S. Asakawa who has on annual basis since 1987 visited the Pilot Forest Scheme for his technical advices and guidance in the making of this manual.

SUMMARY

This manual has been prepared on request by the Kenya/Japan Social Forestry Training Project (SFTP). Since the start of the Project (1986) none has been written. As we all know, not much has been done on Forestry Development in Arid and Semi-arid lands (ASALs) of Kenya. We have therefore very little understanding of the technical aspects that will lead to successful seedling raising and subsequent tree growth in ASALs. This manual deals specifically with all the activities aimed at the production of viable and healthy seedlings at Tiva tree nursery. Most of the technical aspects mentioned here though unique to Tiva nursery may also be applied to other nurseries in the ASALs of Kenya.

1.0 INTRODUCTION

Arid and semi-arid climates are characterized by low and unreliable rainfall, high temperatures, low humidity, poor and saline soils. Nursery practices are an important and essential part of forestry development anywhere. However, dryland nurseries are unique in that the areas where they are located and where the seedlings will be planted are Arid and semi-arid climates are characterized by low and unreliable rainfall, high temperatures, low humidity, poor and saline soils. This poses a problem to those bestowed with the responsibility of raising seedlings in dry areas.

It is at the nursery level that seedlings are prepared to meet the future conditions in the field. This therefore calls for a special attention. In addition the dry land nurseries deals with a wider variety of tree species than those in high potential areas. The main technical practices that require special attention are; the potting medium, sowing schedule, watering intensities, root pruning and hardening up, pest and disease management. It is however important to note that information on the key aspects required to produce healthy and quality seedlings foe ASAL afforestation is lacking. .

2.0 SEED COLLECTION, HANDLING AND STORAGE

2.1 Seed procurement and handling

Seed procurement is a basic step in re-afforestation. The seeds should be collected from trees of superior quality growing in areas with similar environmental conditions to the area in which the seedlings are to be planted. Due to seed off years and other vagaries of climate, there is no constant supply of seeds annually. To circumvent this problem, appropriate seed storage methods must be looked into. However, for seeds of trees that may lose viability if stored for a long time, ways and means of getting a continuous supply of seed must be looked into.

2.2 Seed provenance

The seed collection site is called a seed provenance and finding a good provenance is just as important as the choice of species. It is advisable to collect seed from trees that are

growing on similar sites to those where the seed will be sown, because those trees will be fully adapted to the particular physical conditions of that environment (rainfall, soils, etc.). A good seed provenance will consist of a stand of several healthy, vigorous trees of same species (mother trees).

2.3 Seed collection

Seed should only be collected from fruits, pods or cones that are ripe or mature. Since different trees flower at different times, it will be important therefore to note flowering periods of different tree species so as to monitor seed maturity closely. This will go a long way in aiding seed collection at an appropriate time. As a general rule, mature seed pods will be almost dry and brown in colour (e.g Leucaena l*eucocephala* pod or *Grevillea robusta* capsule) and just about to open. A simple way of checking ripeness is to extract some seeds from a sample of pods and cut them in half; the inside should be white, firm and should fill the seed coat. If possible, seed should be gathered from the entire crown of the tree.

The more accessible fruits on lower branches tent to contain fewer good seeds than those higher up, so these are the ones that are worth climbing for. Fruits or pods that have been damaged by insects or disease should be avoided. The same also applies to the fruits of species such as *Markhamia lutea,* which tend to remain attached to the tree for a long time and may have deteriorated.

When collecting seeds, it may be useful for the seed collection team to keep records of seed provenance specifying location, altitude soil type and details of climate for future reference.

2.4 Mother tree

Usually trees which produce good quality seeds are used continuously as the seed source until they lose the fruiting vigor. These trees are called “Mother trees”. Selection of mother trees is the first step of seed collection. Mother trees must be healthy, vigorous, well-formed and sustain good quality and quantity of seeds.

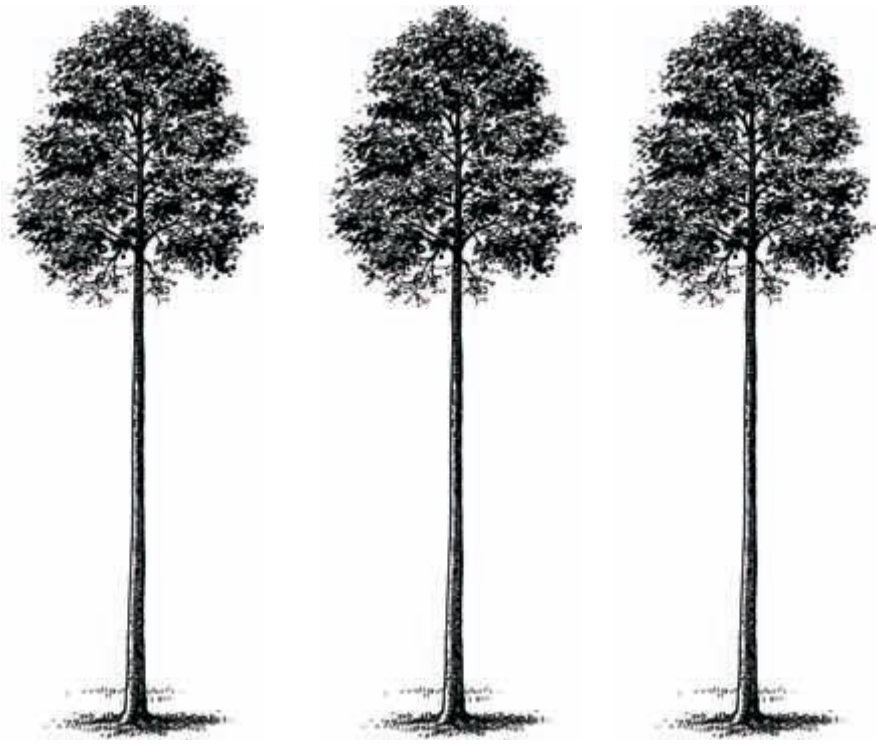

Figure Seed trees with ideal physical characteristics

2.5 Selection

Once a provenance has been identified, Mother trees that are healthy, vigorous, well formed to sustain good quality and quantity of seed should be chosen.

It is advisable to avoid trees that appear diseased or generally unhealthy as well as those that are young and isolated. Although an isolated tree may appear healthy it may nevertheless be a genetic fluke. The seed of such a tree may not be viable because it is likely that the tree has self-pollinated, its offsprings could turn out to be weak or stunted.

A good seed source should consist of a stand of several healthy, vigorous trees of the same species. In order to guarantee sufficient genetic variation, a seed lot is generally best if it contains seeds from more than ten tees. Note however that it may not be possible to maintain such criteria for some indigenous tree species that tend naturally to grow in isolation. Characteristics of the trees to be planted depend on the purposes of tree planting. Mother trees must therefore be superior in all the points.

2.6 Seed collection methods

There are many seed collection methods, and these depend on tree height, thorniness and behaviour of pods once mature.

2.6.1 Thornless trees whose pods do not burst

Seed collection in this case is done by either climbing up the tree, from natural seed fall or after shaking the tree. Tree species in this category include: *Acrocarpus fraxinifolia, Cassia spectabilis, Croton megalocarpus, Delonix regia, Ficus natalensis, Grevillea robusta, Jacaranda mimosifolia, Terminalia brownii, Terminalia mentalis, Terminalia pruinoides, Tamrindus indica* and *Sesbania grandiflora.*

2.6.2 Thorn less trees whose pods burst

For the trees in this category, seeds must be collected before pods burst and release seeds. In this case, seed collection is done by either climbing the tree or by shaking the tree and collecting fallen seeds. Tree species in this category include: *Albizia anthelmintica, Cassia siamea, Leucena leucocephala and Newtonia hilderbrandtii.*

2.6.3 Thorny trees whose pods do not burst

This is done in several ways, seed from natural fall or those that fall after shaking the tree can be collected. Seed can also be collected with the help of pole implements or by use of a ladder. The trees in this category include: *Acacia albida, Acacia gerrardii, Acacia nilotica, Acacia polyacantha, Acacia tortilis, Balanites aegyptiaca, Parkinsonia aculeata* and *Prosopis juliflora.*

2.6.4 Thorny trees whose pods burst

The seed in this case must be collected before the pods burst. This means the trees must be climbed and shaken for the seed to fall or a ladder and or pole implemented used. The species in this category include: *Acacia mellifera, Acacia senegal* and *Caesalpinia decapetala.*

2.7 Seed extraction

Most seeds collected are contained in cones, fruits or pods. The seeds must therefore be extracted out from their cones or fruits. Grevillea robusta seeds are extracted from the

capsules. The capsules open when dried in the sun for 7-10 days. The seeds are extracted from open capsules by rubbing them against each other by hand. The extracted seeds are then dried for 3 - 4 days in the sun.

The seeds of *Acacia albida, Acacia gerrardii, Acacia plyacantha, Acacia senegal, Acacia tortilis, Acrocarpus flaxinifolia, Albizia anthelmintica, Caesalpinia decapitala, Cassia siamea, Sesbania grandiflora* and *Sesbania sesban* are thrown out when the pods split open. The 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 dried for 3-4 days in the sun after which they are put in sacks bounded and tossed around to extract the seeds. Failure to put the seeds in sacks will lead to heavy loss seeds because pods split open by explosive mechanisms and throw out the seeds.

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. The seeds of *Balanites aegyptiaca* and *Tamarindus 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.

For *Cassia spectabilis, Delonix regia* and *Jacaranda mimosifolia* whose pods are very hard, extraction is done by opening the pods with a knife. Before opening, the pods should be dried for 5 - 7 days. 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 pods of *Prosopis juliflora* are heaped on metal sheet. The heap should be about 10 cm high. They are then covered by a layer of grass and then soil. The whole heap is then watered. Prosopsis pods will be attacked by termites. The termites will consume the pulp and the grass leaving the seeds.

The soil will then be removed after 2 weeks and the seeds washed and then dried for 2 - 3 days. The seeds of *Melia azedarach, Terminalia brownii, Terminalia mentalis, Terminalia pruinioides,* after being collected are directly stored.

2.8 Cleaning and sorting

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

2.9 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 drying process 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.

2.10 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.

2.10.1 Seed purity analysis

This is mainly carried out on seeds that have been cleaned and sorted. This is necessary for good germination and protection against diseases. Generally tree seed samples contain impurities such as detached seed structure, leaf particles and other objects. The above analysis is conducted to determine the composition by weight of the sample being tested.

2.10.2 Direct inspection

The exterior parts of the seeds are observed closely and carefully. The interior part is observed after the seed coat is cut with a sharp knife. A sample of seeds should be obtained from a well-mixed stock of seed.

2.10.3 Seed germination

This is the resumption for active growth in an embryo which results in its emergence from the seed and development of those structures essential in plant growth, in fact the potential germination of seeds is the most important factor of measuring seed quality.

The germination test is used as an estimate of the number of seeds, which can germinate at a given time.

2.11 Seed storage

Freshly gathered seeds will germinate best, and preferably should be sown as soon as possible. However some seeds may have to be stored for some time, perhaps waiting an appropriate sowing time or for use during a lean year. The seed storage process involves maintaining the viability of a seedlot from collection time till testing or sowing time. The storage longevity of seeds is affected by their storage conditions. The two most important factors in seed storage are keeping them dry and cool. Wet/moist seeds spoil and rot in storage so they must be dried in air first. They are then stored in dry containers such as jars, boxes and bags. The seed storage containers should be kept on wooden shelves.

The collection of seeds showing a high incidence of fungal or insects attack should be avoided. All operations for collection, transport, processing etc. have to be carried out as quickly as possible to ensure seed is not damaged before it goes to storage. The seeds are normally stored at room temperature of 20^{o} C.

Some species are sown fresh due to rapid loss of viability. e.g. *Azadirachta indica* (neem) while other species e.g. acacias may be stored for 3-15 years. We must always remember that the most important factors to be considered for seed storage are moisture content and temperature. There are seeds that are killed by excessive drying e.g. *Grevillea robusta, Dovyalis caffra, Azadirachta indica, Ficus benjamina* and *F. Natalensis.*

When using sealed containers, the following must be remembered:-

a) Moist (wet) seeds must not be sealed.
b) Air-tight containers should be used for storage.
c) The container should be clean and dry.
d) The container should not be opened except when necessary.
e) It is advisable to keep the container full of seed.
f) A label on which the name of the species, collection date and place or mother trees are written should be attached to the container.

2.12 Seed pretreatment

Seed pretreatment is recommended for several types of dormant seed to help ensure rapid germination of a maximum number of seeds sown in the nursery. Some seeds will germinate naturally only after a prolonged period; of perhaps two to four weeks in the nursery after they have been exposed to specific moisture, temperature, or light conditions necessary for that species or when the seed coat has rotted. Such seeds are said to be dormant and a number of pretreatment measures can be taken to break their dormancy so as hasten germination. Seeds also become dormant during a period of storage and some pretreatment is necessary to activate the germination process before they are ready for sowing.

2.12.1 Nipping

Nipping is the treatment-involving cutting the seed coat to enable moisture to enter the inner parts of the seed. This treatment can be done with nail clippers, fine pliers, knives or a needle. A small scar at the end of the seed indicates the point to nip. One should be careful not to damage the radicle. Sometimes a hot wire is also used in nipping for some species. Nipping may be used to pretreat the following species;

Acacia albida, Acacia brevispica, Acacia millifera, Acacia nilotica, Acacia polyacantha, Acacia senegal, Acacia tortilis, Acacia xanthophloea, Acrocarpus fraxinifolia, Albizia anthelmintica, Albiziagummifera, Cassia siamea, Cassia spectabilis, Leucaena leucocephala and *Melia volkensii.*

2.12.2 Soaking in "boiled" water

This is a frequently used technique whereby the seeds are immersed in boiled water 4-10 times their volume, then the heat source is immediately removed and the soaked seeds are left in water to cool gradually for 12-24 hrs. The method is widely used but it can give erratic results. The optimum soaking time varies between species. This method appears to give good results for Acacia spp. The hot water softens the seed coat making it more permeable to water. The following species may be pretreated using this method. *Acacia senegal, Acacia polyacantha, Leucena leucocephala, Acacia mearnsii, Delonix regia.*

2.12.3 Soaking in hot water

The soaking of seeds in water within a range of 60^{o}C-90^{o}C is often as effective as soaking at 100^{o}C (boiling water) but there is less chance of damage at the lower temperatures. This method is normally applied for the seeds with hard coats or testa e.g. *Acacia gerrardii, A. mearnsii, A. mellifera, A. xanthophloea, Cassia siamea, Cassia spectabilis, Delonix regia, Leucaena leucocephala, Prosopis juliflora and Tamarindus indica.*

2.12.4 Soaking in cold/warm water

a) Soaking of seeds in water below or about 40^{o}C is effective in promoting germination only in those seeds, which already have a permeable seed coat. In some instances most seeds tend to develop impermeability as they mature or in subsequent storage e.g. Acacia senegal. The following species may be pretreated using cold water: *Tipuana tipu, and ziziphus Mauritania.*

2.12.5 Fresh seeds only

As it was mentioned earlier some species will not germinate after be4ing stored for some time. These species should be sown very soon after collection e.g *Azadirachta indica, kigelia africana, salvadora persica and warbugia ugandensis.*

2.13 Species that require no treatment

Casuarina equisetifolia, Croton megalocarpus, Dalbergia melanoxylon, Eucalyptus spp, Grevillea robusta, jacaranda mimosifolia and Melia azedarach.

Table 1. Pre-sowing treatments applicable to various tree species

	SPECIES	**PRETREATMENT**	**GERMINATION (%)**
1.	*Acacia abyssinica*	80°C for 15 minutes	78
2.	*Acacia albida*	80°C for 3 minute	39
3.	*Acacia gerrardii*	Cold water 12 hrs.	75
4.	*Acacia holoicilia*	80°C for 7 minutes	86
5.	*Acacia mearnsii*	80°C for 7 minutes	69
6.	*Acacia nilotica*	Nipping	50
7.	*Acacia polyacantha*	80°C until water cools	77
8.	*Acacia tortilis*	Nipping	73
9.	*Acrocarpus flaxinifolia*	Nipping	60

10.	*Azadirachta indica*	None	95
11.	*Bombax rhodoghaphalon*	80°C for 2 minutes	57
12.	*Caesalphinia decapetala*	60°C for 3 minutes	75
13.	*Cassia siamea*	60°C for 20 minutes	92
14.	*Cassia spectabilis*	80°C for 10 minutes	68
15.	*Casuarina equisetifolia*	None	90
16.	*Croton megalocarpus*	None	99
17.	*Eucalyptus spp.*	None	90
18.	*Jacaranda mimosefolia*	None	69
19.	*Leucaena leucocephala*	60°C for 15 minutes	96
20.	*Melia volkensii*	Nipping	27
21.	*Parkinsonia aculeate*	80°C for 3 minutes	86
22.	*Phoenix reclinata*	60°C for15 minutes	18
23.	*Prosopis juliflora*	80°C for 15 minutes	84
24.	*Sesbania grandiflora*	Cold water 12 hrs.	74
25.	*Sesbania sesban*	None	86
26.	*Tamarindus indica*	60°C for 3 minutes	95
27.	*Terminalia brownii*	Nipping	39
28.	*Terminalia catappa*	60°C for 3 minutes	90
29.	*Terminalia mentalis*	80°C for 15 minutes	49
30.	*Terminalia prunioides*	Nipping	5
31.	*Terminalia spinosa*	80°C for 3 minutes	13

3.0 NURSERY TECHNIQUES

The success of seedling production in the nursery not only depends on efficient management or resources but also availability of the resources in the right quality and quantity.

3.1 Factors that influence siting of a nursery

(1) Accessibility

(2) Good drainage

(3) Source of good fertile soil

(4) Reliable source of water

(5) Security

3.2 Nursery facilities and layout

1) Storage for keeping the nursery tools safely and in good condition
2) Fencing around the nursery to keep livestock and intruders away
3) Water tank or drums for water storage

4) Offices
5) Green house
6) Potting shed
7) Carpentry workshop
8) Seed store

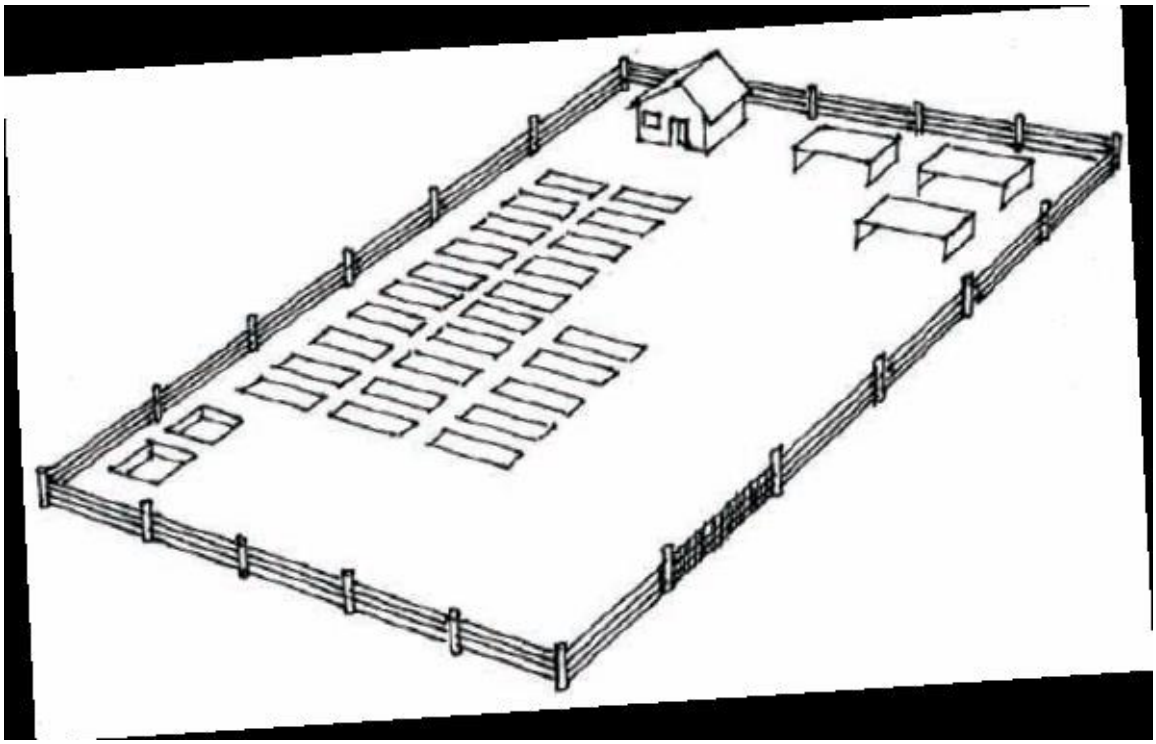

Figure 1: Nursery layout

3.3 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 during the season and therefore be acquired in time. Tools include: rakes, jembes, watering cans, wheelbarrows, pruning knives, sharpening files, soil sieves, shovels, pangas, jerrycans, etc.

3.4 Time to start Nursery work

The time to start work at the nursery is dependent on the time to plant seedlings. There must be enough time for the seedlings to grow to plantable size, secondly, availability of

labour should be considered since initial labour input for bed construction, soil collection, procurement of tools and materials etc. It is a lot much higher than daily operation activities. It is important that work is started in January-March for some of the slow growing species to reach plantable sizes by the onset of rains in October. (Appendix 2)

3.5 Soil mixing and preparation for sowing

In the preparation of the soil mixture it should take into consideration the fact that this is a semi-arid area and that the soil in the field is usually poor in nutrients. As much as possible, the seedling growing in the nursery should meet the soil will experience in the field. The soil would be collected from a forest areas. The soil must have good physical structure and humus content. The surface layer consisting of grass, sticks, roots is removed to a depth of 10cm; the depth at which soil is collected. It is important that the soil is collected 2-3 months prior to potting so that the organic matter can decay and the seeds of weeds germinate can be removed easily, and soil must be sieved before mixing to remove stones, branches, roots and other unnecessary matters. However, roots and other unnecessary matters. However if it is late, sieving should be recommended immediately after collection of soil. The soil is mixed with cow manure in the ratio of soil to one part manure.

Figure 1: Soil mix ratio

3.6 Potting media quantity calculations

A nursery manager should be in a position to know the quantity of soil and manure that he may require to raise a given number of seedlings. The quantity of two mainly depends on the pot size, mixing ratio, number of seedlings required and survival ration is 70% and pot size is 4" x 7". Soil mixture can be computed as follow;-

$$\text{Total soil quantity } (m^3) = \frac{A \times B \times C}{D}$$

Where A = Capacity of pot
B = Mixing ratio

C = No. of seedlings required
D = Survival ratio

3.7 Potting

Potting is done in polythene tubes (normally (4 x 7) clear or black in colour. It is important that they are open at the bottom to facilitate root development and movement of water. The pots should be filled in such a way that ¾ of the lower bottom of the pot is compacted to ensure that the pot does not bend and spill the contents when it is being carried. The top is not compacted so much because compaction will not only make seed sowing difficult but also lead to localized resistance to root penetration (fig.3-2). The pots are filled to the brim because the level of the soil goes down after watering. The soil mixture should be moist but not wet when preparing. A little water may be added to make it moist for easy potting. Potting under shade ensure that the soil does not loose moisture fast. The working efficiency is also higher under shade considering the high temperature in these areas.

Figure 2: Compaction of the soil in the pot

3.8 Seed sowing schedules

The time for sowing a specific type of seed depends mainly on the time it takes to attain plantable size. In this case, the plantable size stock is 30 to 50 centimeters. From KEFRI/JICA research partnership, schedules for various dry land species have been developed as shown in the table below:

Table 2: Sowing schedule of different tree species in the ASALs of Eastern Kenya

No.	Species	Month						
		2	3	4	5	6	7	8
1.	*Acacia abyssinica*							
2.	*Acacia gerradii*							
3.	*Acacia nilotica*							
4.	*Acacia polyacantha*							
5.	*Albizia amara*							
6.	*Albizia anthelmintica*							
7.	*Azadarachta indica*							
8.	*Senna siamea*							
9.	*Senna spectabilis*							
10.	*Croton Megalocarpus*							
11.	*Dalbergia melanoxylon*							
12	*Eucalyptus camaldulensis*							
13	*Gmelina arborea*							
14.	*Grevillea robusta*							
15.	*Melia volkensii*							
16.	*Parkinisonia aculeata*							
17.	*Prosopis juliflora*							
18.	*Tamarindus indica*							
19.	*Terminalia brownii*							
20.	*Terminalia mentalis*							
21.	*Osyris lanceolata*							
22.	*Terminalia prunoiodes*							
23.	*Moringa oleifera*							
24.	*Delonix regia*							

3.9 Timing

This is particularly important for seedlings to attain a plantable size of between 30-50cm at planting. The main reason for this is for the seedlings to develop a proportionate root system. Very small seedlings have been found to wither and die because of poorly developed root systems. This is particularly so if the rains fade of immediately after planting. Overgrown seedlings at the nursery level tend to die because the root systems are not able to support the large shoots in terms of nutrients and moisture requirements. It is therefore important that a seed sowing programme that takes into account the growth rate of specific species is developed and properly followed.

The following table shows the seed sowing schedule for some ASAL species in Kitui Kenya

Table 3: Sowing schedule (Tiva nursery)

No. of months before planting date	Species
18 months	Acacia plectocarpa (No. 16182)
16 months	Albizia anthelmintica Cupressus pyramidalis Newtonia hildebrandtii
12 months	Terminalia pruniodes
11 months before	Acacia pendula (No. 11225) Albizia amara Azadirachta indica Bauhinia thorngii Terminalia brownii
10 months before	Acacia holoicilica Acacia tortilis Cassia spectabilis Balanites aegyptiaca Gmelina arborea
9 months before	Acacia gerrardii Acacia juliflora Acacia pendula (N0. 11223) Acrocarpus fraxinifolia Dalbergia melanoxylon Delonix regia Grevillea robusta Melia azedarach Tamarindus indica Terminalia mentalis

8 months before	Acacia harpophylla (no. 15100) Acacia pendula (No, 10426) Acacia salicina (No. 16293) Caesalpinia decapetala Croton megalocarpus Cassia siamea Eucalyptus brevifolia Parkinsonia aculeate Terminalia catappa Terminalia spinosa
7 months before	Acacia albida Acacia nilotica Acacia polyacantha Acacia salicina (No. 15465) Acacia xanthophloea Casuarina equisetifolia Mellia volkensii Prosopis juliflora Sesbania grandiflora
6 months before	Acacia senegal Dovyalis caffra Eucalyptus paniculata
5 months before	Eucalyptus camaldulensis Eucalyptus tereticornis Schinus molle
4 months before	Acacia abyssinica Sesbania sesban Leucaena leucocephala

3.10 Sowing

Use of potted seedlings for re-afforestation is a very expensive venture as compared to the use of bare–root seedlings. This is due to the cost of pots, pot filling, transportation of pots and arrangement. However, in order to attain a high survival percentage in the field, there is not much choice but to produce seedlings in pots.

3.10.1 Direct sowing

This is done for medium to large sized seeds. The following table shows some of the species that can be sown directly.

Table 4. Species that are directly sown

1.	Acacia abyssinica
2.	Acacia hypophylla No. 15100
3.	Acacia juliflora No. 14890
4.	Acacia nilotica
5.	Acacia pendula 11225
6.	Acacia plectocarpa No. 16182
7.	Acacia polyacantha
8.	Acacia pruinoicarpa No. 7889
9.	Acacia salicina No. 15465
10.	Acacia salicina No. 16293
11.	Acacia stenophylla
12.	Acacia tortilis
13.	Acacia torulosa No. 47490
14.	Acacia tunida No. 17181
15.	Acrocarpus fraxinifolia
16.	Albizia amara
17.	Albizia anthelmintica
18.	Azadirachta indica
19.	Caesalpinia decapetala
20.	Cassia siamea
21.	Cassia spectabilis
22.	Carica papaya
23.	Croton megalocarpus
24.	Delonix regia
25.	Gmelina arborea
26.	Grevillea robusta
27.	Melia azedarach
28.	Newtonia hildebrandtii
29.	Parkinsonia aculeate
30.	Sessbania grandiflora
31.	Tamarindus indica
32.	Terminalia brownii
33.	Terminalia catappa

3.10.2 Sowing into special transplant beds

For medium sized seeds which are difficult to germinate, sowing is done on seed beds and later pricked out into pots. The following table shows some of the species that can be transplant beds.

Table 5: Species that are sown in seed beds

1.	Acacia gerrardii
2.	Acacia polyacantha
3.	Cassia siamea
4.	Cassia spectabilis
5.	Casuarina equisetifolia
6.	Croton megalocarpus
7.	Cupressus pyramidalis
8.	Dovyalis caffra
9.	Grevillea robusta
10.	Jacaranda mimosifolia
11.	Leaucaena leucocephala
12.	Schinus molle
13.	Sesbania grandiflora
14.	Sesbania sesban
15.	Tamarindus indica
16.	Terminalia mentalis
17.	Terminalia prunioides
18.	Terminalia spinosa

3.10.3 Sowing in seed boxes

This is done for very fine and light seeds. Since these seeds are very small, it is important that these seeds are mixed with fine dry sand. The mixture is then broadcast on the bed. This ensures uniform distribution of the seeds. On germination, the seedlings are pricked out into pots in the nursery. The table below shows some of the species raised in seed boxes.

Table 6: Species that are sown in seed boxes

1.	Acacia abyssinica
2.	Acacia holoicilica
3.	Acacia juliflora No. 14890
4.	Acacia pendula No. 10426
5.	Acacia pendula No. 11223
6.	Allocasuarina sp (caprestri)
7.	Casuarina equisetifolia
8.	Calltris robusta
9.	Dalbergia melanoxylon
10.	Dovyalis caffra
11.	Eucalyptus brevifolia
12.	Eucalyptus tereticornis
13.	Eucalyptus paniculata

14.	Melia vilkensii
15.	Prosopis juliflora
16.	Terminalia spinosa

Note: Sowing depth is a very important aspect to be considered when sowing seeds. This is because when seeds are sown too deep in the soil they take a longer time before emerging from the soil, and they may produce uneven seedlings. Uniform sowing is therefore important for production of uniform sized seedlings.

3.11 Pricking out

Seeds sow in boxes and seed beds once germinated have to be transferred into pots a process known as pricking out. Seedlings should be pricked out at the cotyledon or first leaf stage. When pricking out, the tender seedlings should be held with a lot of care preferably by the leaves not the collar or stem. Before seedlings are pricked out they must be well watered. This also applies to after pricking out is done under shade. Only healthy seedlings which have been uprooted from the seed-bed awaiting pricking into the pots should be kept in a tin or any other maturation container.

Figure 3: Pricking out

Pricking out process

1. Water the seedbed properly before pricking out.
2. Take an empty container and fill with water to ¾ level.
3. Hold the leaves of the seedlings and insert a dibbler underneath the root system to loosen the soil.
4. Pull out the seedlings gently and immediately put them in to the container with water.
5. Water the pots before transplanting the seedlings.
6. Make a hole at the center of the pot using a dibbler.
7. If the roots are too long clip off the tip.
8. Insert the root system gently in the hole while holding the seedlings by the leaves. **Do not hold the stem of the seedling because they are tender and feeble this may injure the seedlings**
9. Hold the dibbler in the tilling position and insert it in the soil about one centimeter away from the seedling to the same depth as the hole.
10. Push the soil towards the seedling to hold it tightly. This ensures that all the air pockets around the roots are closed.
11. Using your fingers cover the hole you made.
12. Water the pots properly.
13. Shade the seedlings.

3.11.1 Good pricking out practices

- Throw away any seedlings that appear sick or deformed
- Transplant when the tap root emerges or seedlings are still small (5cm), before secondary roots are formed
- Water the bags well, one night before you prick them out, so that water penetrates to the bottom of the seedbed
- Ensure that the area where the transplanted seedlings will be kept i.e. well shaded before you begin pricking out.
- Water the seedlings 24 hours before, and one hour before, pricking out
- On days with strong sunshine, prick out in the early morning or late afternoon
- Use stick to gently loosen the soil around the seedlings
- Remove seedlings by holding their cotyledons or lower leaves –do not lift them out by the stem
- Put seedlings in water as soon as you take them from the germination bed
- Prepare planting holes with stick and ensure they are sufficiently wide and deep
- Clip long or very branched roots to ensure they are pointed downwards
- Gently pull the seedlings upwards after placing it in the hole, to straighten out roots.
- Pack the soil against the roots, starting at the bottom of the hole
- Water the plant immediately after transplanting, and again when they wilt

3.11.2 Poor but unfortunately common pricking out practices

- Waiting until plants are large and have long roots
- Pricking out plants into dry soil and then watering them
- Constructing shades after pricking out is done
- Pricking out in direct, hot sunlight
- Transplanting damaged seedlings
- Removing seedlings by holding the stem, as this may permanently damage the flow of water
- Carrying seedlings in your hand or on a plate without water

- ❖ Preparing the holes with a finger – the hole will usually be too small
- ❖ Allowing roots to bend upwards when inserting them into the hole
- ❖ Leaving air pockets around the roots – the plants will die

4.0 SEEDLING CARE AND MAINTENANCE

4.1 Shading

It is necessary to control or minimize evaporation by protecting the nursery bed from direct sun. After pricking out the seedlings should be kept in full shade for 2-3 weeks. The shading material used may be grass net made locally. Some of the species that require shade are *Cassia siamea, Casuarina equisetifolia* while *Acacia polyacantha Tamarindus indica, Prosopis juliflora* and *Croton megalocarpus* may not require shade.

4.2 Watering

The seedlings should be watered twice each day, early in the morning and late in the afternoon when sunshine is not too strong. 30L/1,000 seedlings is used. They should never be watered at mid-day. In the rainy season watering should be done once a day or none at all but the nursery headman should watch whether the stock is not under stress. During watering the intention is to keep the soul highly moist but never sodden or dry. Note, however that both over-watering and under-watering are bad for the seedlings. Over-watering may lead to root rot as a result of water logging and may also encourage proliferation of damping off fungi, while under-watering will result in poor root development since the water will moisten only the surface layer of the soil.

The nursery beds/pots should not be watered using a hosepipe because strong jets of water are likely to wash away the soil and/or damage the seedlings. The water should be evenly distributed over the nursery using a watering can or an old tin with holes drilled at the bottom. Alternatively, a leafy branch can be used. Dip the branch into water and sprinkle the water onto the bed or pour the water down the branch onto the soil.

4.3 Weeding

Weeds are a threat to healthy development of seedlings and must therefore be controlled. This is because they compete with seedlings for water, nutrients and light. Rouging i.e.

the gentle pulling out of the unwanted growth is usually an appropriate method of weed control.

4.4 Root pruning

When seedlings have reached a certain size, their roots become longer than the length of the pots. If the roots are left without pruning, they penetrate into the ground and develop a root system. It is important that strong roots are not allowed to develop because once they are cut the seedlings are likely to be weakened. Hence periodical root pruning is required before the root system is formed in the ground. This is done after every 2-3 weeks it is advisable that the nursery stock is watered before and after root pruning. The watering after pruning helps the plant withstand moisture stress.

4.5 Secondary weeding

This sis a practice aimed not only in controlling the weeds but also in improving the aeration and water percolation. Roots can penetrate easily into the soil which facilitates uptake of nutrients. Experience has shown that repeated watering of the seedlings leads to compaction of the soil in the pot thereby deteriorating the physical properties of the soil. This therefore makes cultivation an indispensable exercise. Convenient tools for the operation are spatulas, dibblers etc

Figure 4: Root pruning

4.5 Cleaning around the beds

Weeds emerge not only in the pots, but also around the beds. These weeds attract crickets, caterpillars and other insects, which feed on seedlings and also give then a place to hide. Remove all the weeds around the beds with jembes and do not leave any rubbish around.

4.6 Hardening up

If seedlings are over-watered and partially shaded up to the time they are out planted to the field, the resulting survival will be low. This is because the act of planting is a shock to the seedlings especially when planting in ASAL conditions. Seedlings in the nursery

are usually weak and succulent. They wilt and die in a short time when exposed to the intense sunlight. Seedlings should therefore be prepared gradually for the field conditions.

One month before the end of the season, watering frequency is reduced to once a day its intensity is reduced from 30 litres to 20 litres/1000 seedlings. Stock is however not allowed to seriously wither but it is the intention to stop soft and succulent growth. The seedlings are separated and rearranged in rows of threes so that they get fully exposed to sunlight.

5.0 STUMP SEEDLINGS

5.1 Introduction

Transportation of potted seedlings may sometimes pose challenge when the planting site is far from the nursery. For species that are able to sprout, stumps will solve this problem. For a number of species, stumps can be stored in a frame prepared in the ground even for several months. This may be favourable in nursery practices from different viewpoints e.g. cost of production, labour requirements and transportation.

Definition

Stumps are seedlings that have grown in the nursery bed and prepared as shown in Figure 4 by trimming both the top and tap root.

Figure 4:

5.2 Production and handling

General appearance and approximate dimensions of the stump is shown in figure 4. The stump usually begin to grow their roots well before they form leaves, which is a big advantage in dry areas. Stumps are usually transported bare and will survive for more than one week if shaded and kept moist with wet hessian, straw or other material. Hundreds of stumps can thus be transported in relatively small boxes or crates. It is

important to note that stumps can survive harsh growing conditions because of their ‘head start’.

Species that can be out planted by stumps

1) Albizia lebbeck
2) Azadirachta indica
3) Senna siamea
4) Chlorophora excels
5) Commiphora Africana
6) Conocarpus lancifolius
7) Dichorostachys cinerea
8) Euphorbia balsamifera
9) Gmelina arborea
10) Khaya senegalensis
11) Moringa oleifera
12) Prosopis juliflora
13) Tamarindus induca
14) Tamarix senegalensis
15) Ziziphus mauritania

6.0 NURSERY PROTECTION

6.1 Introduction

Seedlings are delicate and susceptible to attacks by various pests and diseases as well as some meteorological conditions. Damages by such pests and diseases seriously weaken or

sometimes even kill the seedlings unless they are properly protected before the attacks or treated after the attacks without any delay. It is therefore important for nursery work.

6.2 Damage and disasters in the nursery

There are many factors that affect tree seedlings in the nurseries. They may be categorized into three:-

6.2.1 Physical factors

These are drought, high temperature, strong winds, etc. Most of these can be prevented by physical countermeasures e.g frequent watering, shading and windbreaks.

6.2.2 Human factors

Disasters caused by man are such as trespass in the nursery and robbery of seedlings. These are more social than technical and therefore control measures cannot be specified.

6.2.3 Biotic factors

Some mammals, birds, insects and fungi also damage or attack tree seedlings. Only these factors have been dealt with below.

6.3 Biotic damages by pests and control measures

6.3.1 Insects

Most insects and pests breed and hide under rubbish and weeds. The nursery should at all times be clean by sweeping all rubbish away. All weeds should be regularly uprooted and swept away. This cleaning will reduce the breeding grounds and number of the insect pests. In case of any attacks, protective measures such as chemical application or manual removal should be carried out as soon as possible.

6.3.1.1 Defoliators (leaf eaters)

Various groups of insects such as caterpillars, grubs, crickets, grasshoppers, locusts, etc. are defoliators. They eat a part of or the whole leaves and retard the photosynthetic ability of the seedlings.

Control

Spraying of sumithion or parathion is effective especially for larvae in their early stages.

6.3.1.2 Stem cutters

Cutworms are the caterpillar type larvae of various nocturnal moths. They cut stems of seedlings usually at night. This may lead to immediate death of the seedlings.

Control

It is not easy to deal with cutworms one they have started to attack. However, some measure such as spraying chemicals e.g Aldring and Diazinon could be effective (poisoned bait), or sprinkling of Gammoxane into the soil could also be used when pots are being filled, which will reduce the incidence of loss by these pests.

6.3.1.3 Sap suckers

Small insects such as woody aphids and bugs suck sap from seedlings. These insects sometimes transmit diseases to the leaves of seedlings through their saliva. In t case the attack is serious, the whole seedling is damage and dies. Sometimes unusual structures called galls, are formd on the leaves or stems, which are also caused by insects.

Control

The most effective measure is use of chemicals

6.3.1.4 Termites

More than 2,000 species of termites are distributed mainly in the tropics, common termites seen in semi-arid areas rest in the ground or dead wood an infest seedlings through the tunnels in the soil surface. They eat roots and stems of seedling of many tree species. Eucalyptus spp. are particularly susceptible to termite attack.

Control

Termites can be controlled by several methods:

a) Using ash in the soil mixture
b) Putting a thin layer of ash 2-3 cm thick on the bed where the pots will be placed. However the effectiveness of the ash cannot last long. Periodical application is recommended.

c) Using chemicals such as Deldring and Aldrin
d) Digging out queens of nearby colonies (termite hills). Extermination of all termites in the colonies by chemicals is more effective.
e) If milk packs are used as pots, wash the packs with soapy water or solution of insecticide before use otherwise termites may be attracted.

6.4 Fungal diseases

Although there are various diseases that attack seedlings in the nursery, only damping off and Botrytis wilt are described here since they are the most common fungal diseases in the country.

6.4.1 Damping off diseases and seedling blight

In such diseases, most prevalent of seedlings and cuttings, the roots and the stem base are infected by a necrotrophic pathogenic fungus which usually enter through wounds or through the very thin cuticles which seedling possess when grown under damp, poorly lit

conditions. The pathogens are quite unspecialized; most of them are active producers of pectolytic enzymes and cause local death and collapse of the infected tissues. The plant then topples over and is further invaded by the pathogen.

Conditions favourable for the spreading of damping off are:-

(a) High sowing density.

(b) Over watering.

(c) Using soil with under-composed material.

(d) Using soil affected by damping off.

Control

- Use optimum sowing density in seed bed
- Use appropriate quantity of water
- Do not damage the bark of seedlings
- Do not use alkaline soils

7.0 NURSERY MANAGEMENT AND THE ROLE OF NUERSERY FOREMAN.

7.1 Introduction

In the foregoing chapters, nursery techniques have been introduced.it is however important to note that though it is exceptionally important that technical aspects are adhered to, the management aspects have a big role to play in the success of this activities. Management includes a big role of activities; planning of the operations, procurement of tools and other materials, labor arrangement, supervising the work, rerecording the activities, etc. The person responsible for all this is the foreman.

7.2 Nursery management.

Planning of nursery work: In planning nursery work, the following must be undertaken:

(i) Selection of species. Selection of species to be raised in the nursery should be done in conjunction with technical staff from other sections such us those in extension and plantation establishment as well as farmers. This should be done preferably in December be the start of showing period.

(ii)Scale of operation. Since the scale of operation is highly dependent on availability of funds and labor, the number of seedlings to be raised has to be based on available funds.

(iii)Material. List of the necessary tools should be made early on time (Dec-Jan)

(iv)Annual operation plan. An annual working schedule (nursery calendar) should be prepared by December. Room should however left for any changes that may come up with time depending on the unforeseen circumstances.

Before starting the operation

Before nursery work starts, the following should be done:

(1)Assignment of staff: the nursery manager should assign the nursery foreman, storekeeper, etc.

(2)Condition of work: The should be able to assign the work force.

(3)Technical guidance: All people supposed to work in the nursery should be given the necessary technical guidance by the foreman.

Daily operation

This is supervised by the foreman. This includes:

(1)Assignment of days 'work: The foreman assigns the tasks of the day to workers.

(2)Supervising the jobs: The foreman should supervise the jobs and give the necessary instructions.

(3)Technical consultation: If any technical or other problems are encountered, consultation should be made with the nursery manager or any other technical staff available

(4)Record and record keeping: The foreman should make all necessary records of the nursery activities.

Nursery foreman

The nursery foreman should have the following characteristics:

(1)Writing: Since record keeping is one of the most important jobs in the nursery, he/she should be able to write.

(2)Training: He/she should be trained properly on nursery techniques and management beforehand.

(3)Personality: He/she should be able to keep good relations with other people and be able to lead them.

(4)Honesty: He/she should a very honest and a strict person because there are many valuable things in the nursery.

8.0 NURSERY RECORDS AND RECORD KEEPING

8.1 Introduction

Recording all work and progress in a nursery is essential for nursery management. Well maintained nursery records also improve techniques and rationalize the activities work and can also be used as a basis for the following season's operations. To keep and accumulate the records is also important. Accumulated data may also reveal some knew findings and knowledge.

8.2 Nursery records

8.2.1 Nursery diary.

This is the most important record book. All operations and observations of the day should be recorded in this book in details. The diary should be filled out in the morning after allocations of duties and in the evening before leaving for home.

Date	**Work done**	**Remarks**
10/1/91	200 seedlings of *Terminalia .prunioides* picked out.	Collection of forest soil, 4 people sowing Acacia holoicilica

8.2.2 Nursery register

This is the records on individual's nursery bed basis. All the main operations should be recorded on board.

Species	**Eucalyptus camaldulernsis Bed No.1**
Provenance/source	Tree seed centre
Date sown	8.4.89
Germination date	22/4-6/5/89
Pricking out	15/5/89
Root pruning	3/8,10/9.11/10
Remarks	

8.2.3 Nursery delivery record.

This is a record showing how seedlings were distributed. Names of people who received the seedlings, their locations, the species names and numbers (appendix 5).

8.2.4 Muster roll.

This is where the daily attendance of all workers is recoded. It should be done twice in a day. Early in the morning and late in the afternoon. This is a confidential book and therefore it should be kept safely.

8.2.5 Visitors book

This is not essential record of the nursery operations. However, whenever are some visitors, they should be asked to sign and also make comments about the nursery.

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Appendix 1: List of species, time of flowering, collection and places of collection at Tiva Nursery

No. Species	Time of flowering	Time of collection	Place of collection
1.Acacia holoicilica	February	July	B.L.I Kitui
2.Acacia nilotica	February	September	Kaveta
3.Acacia polyacatha	January	June	Kaveta
4.Albizia amara	February	June	Tiva site
5.Albizia anthelmintica	August	October	Tiva site
6.Caesalphinia decapetala	January	April	Tiva site
7.Calltris robusta	June	January	Kavonge, illoi
8.Cassaia siamea	June	August	Kaveta,kabati,matimyani,kavisuni
9.Cssasia spectabilis	January	July	Kaveta,matinyani
10.Casaurina equisetifolia	July	January	B.L.I
11.Croton megalocarpus	January	March	Kaveta,Tungutu,Matinyani
12.Delonix regia	January	July	Kaveta

13.Dovyalis caffra	July	February	Kaveta,Kitui high sch
14.Eucalyptus camaldulens	June	February	Kaveta
15.Ficus capense	June	February	Kaveta
16.Grevillea robusta	January	March	Kaveta,Matinyani
17.Jacaranda mimosiflia	September	December	B.L.I Kitui
18.Lawsonia inermis	January	May	Kitui high sch
19.Leucaena leucocephala	January	April	Matinyani,Kaveta
20.Melluia azedarach	January	April	Kaveta,Matinyani
21.Mellia volkesii	October	February	Yatta B2 Kwa Vonza Kavisuni
22.Propis juliflora	August	February	Kyuso
23.Sesbania grandiflora	April	August	Matinyani,Syongila
24.Sebania sesban	May	October	Tiva site
25.Tamaridus indica	January	August	Ithookwe Kitui Est,Zombe
26.Tecoma stans	May	November	Isaagwa
27.Termanalia brownii	August	December	Kabati,Isaagwa
28.Termanalia mentalis	December	March	Kaveta,Mulango
29.Termanalia prunioides	January	May	Kitui East,Zombe
30.Thevetia peruviana	January	April	Kaveta

*B.L.I- Better Living Institute (Ministry of Agriculture)

Appendix 2: Annual work plan for Tiva nursery

Time of the year	**Activities to be undertaken**	**Remarks**
December	Collection of forest soil and manure. Maintenance of seed beds. Potting to start. Sowing of *Albizia anthelmintica, Terminalia prunioides*. Collect the seeds of *Jacaranda mimosifolia* and *Terminalia brownii*	
January	Potting to continue, pricking out, and sowing of *Acacia holoicilica,*	

	Balanites aegyptiaca, Bauhinia thorngii and Terminalia brownii. Collect the seeds *Caltris robusta, Casaurina equisetofolia*. Other routine activities to be continued.	
February	Potting to continue, pricking out some of the species sown in January to be carried out. Sowing *Acacia tortilis, Dalbergia melanoxylon, Gmelina arborea* and *Terminali brownii*. Collect the seeds to *Dovyalis caffra, Eucalyptus camaldulensis, Ficus capensis Melia volkensii and Prosopis juliflora*. Other routine activities to continue.	
March	Sowing *Acacia albida, Acacia gerardi, Acrocarpus flaxinifolia, Azaridachta indica, Senna siamea, Senna spectabilis, Delonix regia, Grevellia robusta, Jacaranda mimisofolia, Melia azedarach, Prosopis juliflora, Terminalia mentalis* and *Terminalia spinosa*. Other routine activities to continue.	
April	Sowing *Accia nilotica, A.harpophylla, A. polycantha, A.xanthophloea, Melia volkensii and Temanalia catappa*. Collect the seeds of *Caesalphinia decapetalla, Leucaena leucocephalla, Melia azedarach* and *Thevetia peruviana*. Other routine activities to continue.	
May	Sowing *Acacia senegal, Dovyalis caffra* and *Eucalyptus paniculata. Collect the seeds of lawsonia inermis* and *Terminalia prunioides.* Other routine activities to continue.	
June	Sowing *Eucalyuptus camaldulensis, E.tereticornis and Schinus molle*. Collect the seeds of *Acacia polycantha and Albizia Amara.* Other routine activities to continue.	
July	Sowing of *Acacia abyssinica, leucaena leucocephala and*	

	Sesbania sesban. Collect the seeds of *Senna spectabilis and Delonix regia*. other routine activities to continue	
August	Collect the seeds of *Senna siamea and Sesbania grandiflora*. Other routine activities to continue	
September	Collect the seeds of *Acacia nilotica*. other routine activities to continue	
October	Hardening up to start. Collect the seeds of *Albizia anthelmintica and Sesbania sesban*.	
November	Hardening up to continue and preparation of seedlings for distributions to various sections. Seedlings to be distributed out once the rains start. Collect seeds of *Tecoma stans*. Make an inventory of the tools and materials that may be required in the next season.	