
Kenya's Water Towers Protection and Climate Change Mitigation and Adaptation (WaTER) Programme

TRAINING MANUAL FOR TREE NURSERY OPERATORS: KFS, COUNTIES, NGOs, CBOs AND FARMERS



Oballa P., Mengich, E. and Nyambati, R.

Component 4: Science to Inform Design of Community-Level Actions and Policy Decisions

© December 2017



**This programme is funded
By the European Union**



**Kenya Forestry Research Institute
(KEFRI)**

Kenya's Water Towers Protection and Climate Change Mitigation and Adaptation (WaTER) Programme

TRAINING MANUAL FOR TREE NURSERY OPERATORS: KFS, COUNTIES, NGOs, CBOs AND FARMERS

Oballa P., Mengich E. and Nyambati R

Component 4: Science to Inform Design of Community-Level Actions and Policy Decisions

© December 2017

© KEFRI, 2017

This publication may be reproduced in whole or part in any form for educational and non-profit uses without permission of the copyright holder provided acknowledgement is made.

Cover caption:

Main picture: KEFRI staff training farmers in a community tree nursery in Cherangany

Citation:

Oballa P., Mengich E., and Nyambati R.. (2017). Training manual for tree nursery operators: KFS, Counties, NGOs, CBOs and Farmers. KEFRI, Nairobi.

Published by:

Kenya Forestry Research Institute
P.O. Box 20412 - 00200 Nairobi, Kenya
Tel: +254-722-157 414, +254-722-259781/2
Email: director@kefri.org Website: www.kefri.org

Disclaimer

“This document has been produced with financial assistance of the European Union. The contents of this document are the sole responsibility the Kenya Forestry Research Institute (KEFRI), and can under no circumstance be regarded as reflecting the position of the European Union”

FOREWORD

Kenya's water towers are facing unprecedented threats attributable to forest degradation, fragmentation and climate change. The main drivers of degradation include: encroachment, deforestation, charcoal production, unsustainable land use and overgrazing. These factors have severely reduced the capacity of these forests to provide ecological and socio-economic benefits in required quantity and quality in a sustainable manner. There is urgent need to arrest this degradation and enhance resilience and productivity of these ecosystems through suitable rehabilitation and conservation interventions. This will contribute to the desired 10% forest cover as outlined in the MTP II of the vision 2030.

Through support of the European Union (EU), under the Water Towers Programme, KEFRI has developed technologies that can be adopted to conserve these ecosystems with a focus on Mt. Elgon and Cherangany Hills water towers. The activities are implemented through two of the institute's eco-regional research programmes: Lake Victoria Basin Eco-region Research Programme (LVERP - Mt. Elgon) and Rift Valley Eco-region Research Programme (RVERP – Cherangany Hills). Activities already implemented include; demonstration of technologies for rehabilitation of degraded areas in natural forest, establishment of bamboo sources of germplasm and demonstration plots, establishment of on-farm tree demonstration plots, and promotion of alternative energy sources. The demonstration plots serve as farmers' sites for training and learning.

During the first year of project implementation, lack of continued access to adequate high quality and timely germplasm was observed to be one of the main constraints to sustained rehabilitation and conservation efforts. Although a number of on-farm tree nurseries existed in the region, many at times, they were poorly managed and yielded inadequate, low quality seedlings of low species diversity. Farmers across the region requested for training on nursery operations including establishment and management. In response to this, there is need to build the capacity of farmers and nursery operators to produce desired germplasm of high quality in a sustainable manner. This training manual is written for a wide range of nursery operators including Kenya Forest Service (KFS), County Governments, Non-Governmental Organizations (NGOs), Community-Based Organizations (CBOs), and local institutions and farmers who operate tree nurseries. The information provided has been sourced from usual Good Nursery Practices within KEFRI, literature reviews, direct consultations with tree nursery operators, and authors' experiences. We hope it will be of great use to those intended users.

TABLE OF CONTENTS

FOREWORD.....	IV
LIST OF TABLES	V
LIST OF PLATES	VII
TABLE OF CONTENTS	V
1.0 INTRODUCTION.....	1
1.1 WHAT IS A TRAINING MANUAL?.....	1
1.2 WHY A NURSERY TRAINING MANUAL?	1
1.3 IMPORTANCE OF TREE NURSERIES	1
THESE INCLUDE THE FOLLOWING:.....	1
1.4. TYPES OF TREE NURSERIES.....	1
1.5 NURSERY IMPLEMENTS (TOOLS)	3
2.0 TREE NURSERY ESTABLISHMENT.....	3
2.1 NURSERY SITE SELECTION	3
2.2 SITE PREPARATION FOR TREE NURSERY ESTABLISHMENT	3
2.3 PROCEDURE FOR NURSERY ESTABLISHMENT	3
2.4 NURSERY CALENDAR.....	4
2.5 TREE NURSERY DESIGN.....	5
2.6 SOIL COLLECTION AND PREPARATION.....	6
2.7 SOIL MIXTURES.....	6
2.8 SEED BED PREPARATION	7
2.9 POTTING	8
3.0. TREE NURSERY MANAGEMENT	9
3.1 SEED HANDLING	9
3.2 TREE SEED SOURCES	9
3.3 SEED PRE-TREATMENT	9
3.4 SEED SOWING	9
3.4 METHODS OF SOWING.....	10
3.4.1 Broadcasting	10
3.4.2 Drill-sowing	10
3.4.3 Direct sowing	10
3.5 PRICKING OUT	10
3.6 SHADING	11
3.7 WATERING	12
3.8 WEEDING	13
3.9 ROOT PRUNING	13
3.10 HARDENING OFF	14
4.0 SEEDLING PROTECTION.....	14
4.1 EXTREME WEATHER CONDITIONS	14
4.2 HUMAN	14
4.3 LIVESTOCK AND WILD ANIMALS	14
4.4 INSECTS PESTS	14

4.4.1 Blue gum chalcid	15
4.4.2 Aphids	15
4.4.3 Scale insects	16
<i>These are sapsuckers (Fig. 8). They occur in two types: soft and hard bodied. They are some of the most destructive insects on plants</i>	16
4.4.4 Moths	17
4.4.5 Red spider mite	17
Leaf miner	17
5.0 FUNGAL DISEASES	17
5.1 DAMPING OFF	17
5.2 POWDERY MILDEW	18
5.3 LEAF SPOT	19
6.0. VEGETATIVE PROPAGATION.....	20
7.0 TREE NURSERY RECORDS.....	20
7.1 WORKERS REGISTER (MUSTER ROLL).....	20
7.2 EQUIPMENT INVENTORY REGISTER / ASSET FORM.....	20
7.3 WORKERS DIARY/DAILY ASSIGNMENTS AND OBSERVATIONS	21
7.4 WEEKLY REPORTS	21
7.5 SEED INVENTORY BOOK.....	21
7.6 SEEDLING BOOK	21
7.7 NURSERY DELIVERY REGISTER	22
7.8 INVOICE.....	22
7.9 DELIVERY NOTE	22
7.10 CASH SALE RECEIPTS	22
7.11 VISITORS' BOOK	22
8. REFERENCES.....	23
DISCLAIMER.....	23
APPENDIX 1.....	24

LIST OF TABLES

Table 1: Sample Nursery Calendar	5
Table 2: Equipment and material records	21
Table 3: Seed records.....	21
Table 4: Seedling records.....	22

LIST OF PLATES

Plate 1: Rivets of wood around the nursery beds supporting planting tubes	4
Plate 2: Leave 0.5 m width between one seedbed and the next to act as paths to facilitate movement.....	5
Plate 3: Sieving of forest soil at the RVERP Londiani tree nursery	6
Plate 4: Soil mixtures are left to mature for 2-4 weeks before being potted.....	7
Plate 5: Building edges of the seedbed using concrete blocks, planks of wood or poles	7
Plate 6: Arrangement of seedlings in a nursery with one meter width and walk-ways in between.	9
Plate 7: Seedlings being pricked out.....	11
Plate 8: Local materials are recommended for constructing shade in on-farm tree nurseries.....	12
Plate 9: Watering seedlings using a watering can.....	12
Plate 10: Removing weeds from potted seedlings in a tree nursery	13
Plate 11: Root pruning of <i>cuppressus lusitanica</i>	14
Plate 12: Seedling attacked by blue gum chalcid.....	15
Plate 13: A colony of aphids on cypress branch	16
Plate 14: Pine seedlings attacked by damping-off	18
Plate 15: Powdery mildews on leaves of Eucalyptus.....	19
Plate 16: Leaf- spot on Eucalyptus	20

1.0 INTRODUCTION

This booklet starts with the definition of a training manual and proceeds to provide useful information on nursery establishment and management for tree nursery operators. We hope these pieces of information will be of much use to Government institutions, development planners and farmers in Kenya and beyond. In the booklet, we outline all the steps involved in establishment and management of tree nurseries starting from tree seed handling and sowing in the nursery to handling mature nursery products. Good quality seeds and seedlings in the nursery are important for high quality seedlings and mature trees in the field.

1.1 What is a training manual?

A training manual is a book or booklet of instructions, designed to improve the quality of a performed task. A training manual may be particularly useful as:

- an introduction to subject matter prior to training
- an outline to be followed during training
- a reference to subject matter after training
- a general reference document

A training manual may form an important part of a formal training programme. For example, it may help ensure consistency in presentation of content. It may also ensure that all training information on skills, processes, and other information necessary to perform tasks is together in one place and standardized.

1.2 Why a nursery training manual?

A tree nursery is an area where seedlings of various tree species are raised to desirable size for planting in the field. Tree nurseries can be owned and managed by individual farmers, cooperatives, self-help groups, schools, churches and other institutions.

1.3 Importance of tree nurseries

These include the following:

- Flexibility of raising seedlings of desired tree species and in required numbers
- Income generation opportunities
- Flexibility in planting time
- Can be used as demonstration sites
- Possibility of using locally available materials
- A good experience to establish and manage for public good

1.4. Types of tree Nurseries

There are two types of tree nurseries: Temporary tree nurseries and permanent tree nurseries. **Temporary tree nurseries** are those that can be used for a season or two, or a year or two. **Permanent tree nurseries** are those that are meant to serve for a long period of time. Seedlings are raised from year to year.

When deciding on the type of tree nursery to establish, the following factors are considered:

- The number of plants required
- The period the demand is likely to last
- Availability of market/transport

The most important infrastructures in a permanent nursery (Fig. 1) are as follows:

- Shade is required for sheltering tender seedlings and workers from harsh weather conditions.
- Seedbeds are places prepared with good light medium (Soil and sand) for seed sowing and germination. The media can be inert because after germination the plantlet is transferred to growing media with fertility.

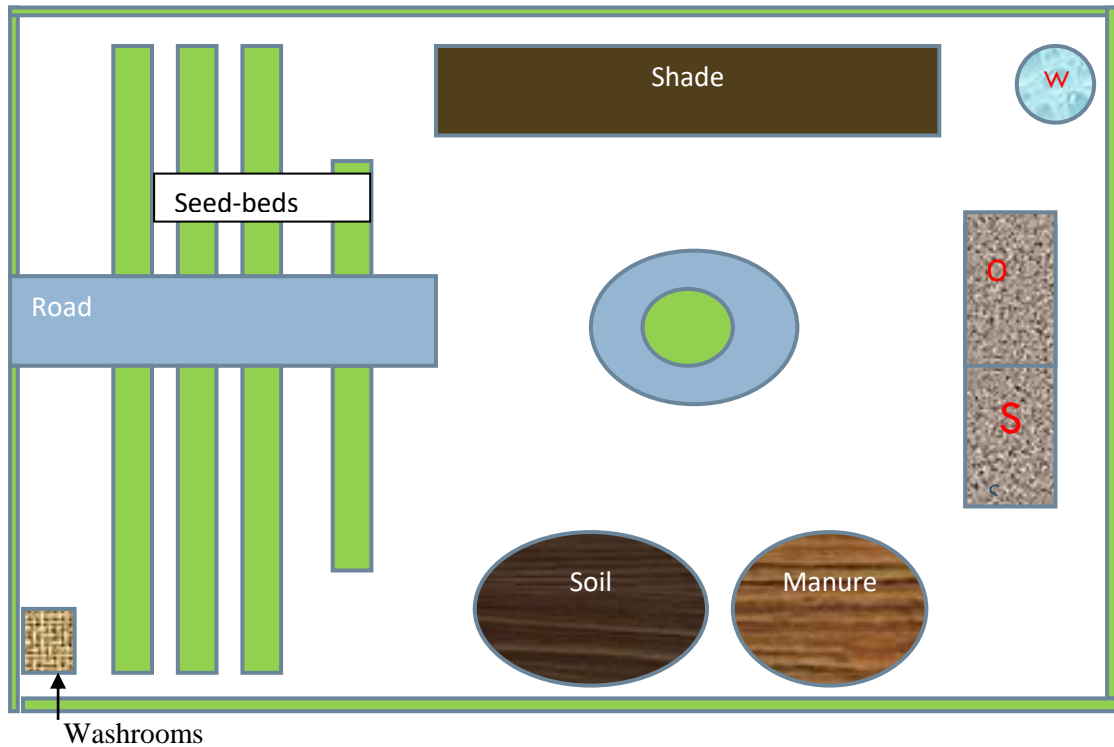


Figure 1: Basic tree nursery infrastructure

- Soil storage is where all the soil for nursery use is heaped and mixed with manure, fertilizer and other inputs until it is required for nursery use. When heaped it is watered to mature and all weeds to germinate before it is put in nursery containers.
- Store (S) is usually required in a nursery situation to keep implements, inputs, containers and seeds
- Water tank (W) must be set to store water within the watering system for ready supply to plantlets. The tank is usually set high for water to be directed by a system of pipes and gravity to where it is required.
- Nursery office (O) to store documents and for staff use
- Good sanitation must be maintained within the nursery, therefore a latrine must be within the compound and pits for throwing rubbish from the compound.

1.5 Nursery implements (tools)

Certain basic implements are required when planning to run a successful nursery business. The tools and their uses are indicated below:

- Panga -For cutting and cleaning nursery area
- Jembe /hoes -Soil digging
- Garden fork -Required for soil mixing
- Rake -Leveling soil and removal of light debris
- Wheelbarrow - Internal transport
- Watering can -Watering seedlings
- Basins/Tins -Seed sowing
- Knife (pruning, grafting) -Cutting and pruning of roots
- Trowel -Filling of pots
- Winnowers -Seed cleaning
- Sieve -Separation of seeds and other particles
- Secateurs - Pruning and smooth cutting at nursery
- Measuring Tape - Taking measurements
- Dibber -Making planting holes in beds and pots
- Hose pipes -Flexible pipes for delivery of water within
- Sprayers -Containers for fine delivery of chemicals
- Buckets -Containers for water or seed collection
- Ropes/strings - For alignment of beds, edges, etc
- Weighing balances (spoons) -For taking solid measurements
- Measuring cylinder (syringe)- For taking measurements of liquids

2.0 TREE NURSERY ESTABLISHMENT

2.1 Nursery site selection

Select a site with the following features for your tree nursery:

- Gently sloping site for good drainage
- Availability of good soils (fertile and well-drained)
- Reliable water supply
- Easily accessible throughout the year
- Protected from strong winds, livestock and unauthorized people.

Avoid clay soils, swampy valley bottoms and exposed hilltops.

2.2 Site preparation for tree nursery establishment

A wide range of materials and implements, some of them listed above are available for tree nursery establishment. However, tree nursery operators are encouraged to use locally available material where feasible e.g. poles, grass and banana fibers as a cost reduction measure.

2.3 Procedure for nursery establishment

To prepare a new tree nursery, the following should be done:

- (a) clear all natural vegetation and remove stumps, leaving some shade trees
- (b) If the area is not flat, make terraces at this stage.
- (c) If a natural windbreak does not exist, plant some trees for future shade.
- (d) You may fence the nursery area.

The following procedure should be followed:

- Level the site of the beds and firm the soil,
- Mark out the shape and sizes of the beds,
- Erect the beds using durable poles,
- For the shade, one can use any local material available,
- Erect rivets (sawn timber or poles) around the beds.



Plate 1: Rivets of wood around the nursery beds supporting planting tubes

2.4 Nursery calendar

The time to start tree nursery work depends on the anticipated time of planting out. There should be enough time for the seedlings to grow to plantable sizes (20 cm – 30 cm). Availability of labour should also be considered, since initial labour input for bed construction, soil aeration, procurement of tools and materials is a lot heavier than daily operations. Therefore a nursery calendar is the plan of activities at the nursery. It varies from place to place but it helps the nursery manager to know specific activity time and seed collection or procurement time. Nursery calendar helps to guide:

- Collection of soil and to give it good time to cure (1-3 months)
- Collection of manure in good time to mature (1-3 m)
- Mixing of all parts of soil required thoroughly and cure before use (1 month)
- The time seeds can be planted fresh
- Seed procurement time
- The timing of seedlings enough to grow to size

Table 1: Sample Nursery Calendar

ACTIVITIES	MONTHS OF THE YEAR											
	J	F	M	A	M	J	J	A	S	O	N	D
Seed procurement												
Soil digging & mixing												
Sowing and pricking out												
Seedling raising												
Weeding												
Inventory and Sales												
Planting out												
Annual Production Tally												

*Note that these major nursery activities may vary from place to place based the onset of rain

2.5 Tree nursery design

The width of the seedbed should be 1 m, while the length will be determined by the size of the nursery. If dealing with polythene pots/tubes, arrange 10 x 10 tubes widthwise to facilitate counting. Leave 0.5 m width between one seedbed and the next to act as paths and facilitate movement. To obtain maximum effect of the shade, beds should be orientated to run East-West to avoid direct sunlight in the early stages of seedling growth.



Plate 2: Leave 0.5 m width between one seedbed and the next to act as paths to facilitate movement

2.6 Soil collection and preparation

Nursery soil should be fertile and well draining. To ensure this, collect soil preferably from some identified part of the farm, especially under trees along the fence. Preferably forest soil is highly recommended.

Procedure:

- Identify soil collection spot preferably among the above stated places
- Clear the surface to remove off all plants and litter before digging topsoil for the nursery
- Dig the soil using a hoe then sieve to remove undesirable materials e.g. stones and sticks.

The sieved forest soil is then mixed with sand and manure in the ratio of 2:1:1, respectively.



Plate 3: Sieving of forest soil at the RVERP Londiani tree nursery

2.7 Soil mixtures

Standard seed-bed soil mixtures consist of sieved black forest or top soil, and sieved sand at a ratio of 1:1. This ratio can vary depending on whether the clay or sand component is higher in the soil build up. The forest soil improves the soil moisture holding capacity for better germination, while the sand improves soil texture for better root penetration and ease of lifting during pricking out.

Standard transplant bed mixtures consist of un-sieved forest soil, sand, small stones (1cm diameter), clay and composite manure at ratios of 6:1:1:1:1, respectively. *Sand and small stones* give good root penetration and drainage characteristics, Clay and top forest soil assist to bind soil near the roots to improve on moisture intake and nutrient retaining qualities, and composite manure supplies organic matter and nutrients to the soil.

The above mixtures can be left to mature for 2-4 weeks or longer before use, keeping it moist.



Plate 4: Soil mixtures are left to mature for 2-4 weeks before being potted

2.8 Seed bed preparation

A seed bed is a place where seeds are sown for germination. To make a seedbed, a trench of one metre width is dug at a depth of 0.5 m. The length will depend on the amount of seed you intend to sow and the space available. The bed is designed to be one metre wide so as to enable the worker to reach the plants at the centre of the plot. A layer of large stones (18 cm – 24 cm) is placed, followed by small stones (kokoto) (15cm) then filled with sand. It is then leveled out using a plank of wood or rake. The edge of the seedbed is build using concrete blocks, planks of wood or logs to prevent soil erosion and control water flow.



Plate 5: Building edges of the seedbed using concrete blocks, planks of wood or poles

There are several types of seed beds that a nursery may have:

a) *Sunken beds*

This is a basin like excavation of about 1 m width by 12 cm depth in which potted seedlings are arranged. Such a structure holds the seedlings together. Sunken beds are commonly used in dry areas. They help conserve moisture.

b) *Raised beds*

This is a raised structure of soil, in which the soil is held in place using materials such as poles, banana stems or timber. The width of a raised bed is 1 m by any convenient length. Such a bed can be used for raising bare root seedlings. It is mostly used in high rainfall areas.

2.9 Potting

This is the process of putting soil in containers or bags for seedling raising. It should be done under a shade closer to the section where mature soil is heaped. The soil should be moist enough to run freely into the tube and easily firmed to form the bottom of the tube. Planting tubes are good where seedlings are raised closer to final planting site while pots are better for long distance transportation.

Procedure:

- Locally available materials e.g. milk packets, used tins, calabashes and clay pots or bamboo stems can be used as containers
- Ensure that containers are open at both ends or have holes at the bottom to allow movement of water and healthy root development
- Take the soil mixture and moisten it by sprinkling some water on it, ensure it is neither too dry nor too wet
- Put the moistened soil into the containers; press the lower part (3/4) of the container while the upper quarter should be loose. Heavy compaction at the top makes seed sowing difficult and inhibits root penetration.



Plate 6: Arrangement of seedlings in a nursery with one meter width and walk-ways in between.

3.0. TREE NURSERY MANAGEMENT

3.1 Seed handling

3.2 Tree seed sources

- Seeds can be collected locally from healthy selected trees
- Seeds can also be acquired from institutions such as KEFRI, ICRAF, Kenya Forest Service, NGOs, CBOs and authorized seed vendors operating in your area.
- Wildlings can be used too.

More information on seed sourcing can be obtained from Kenya Forestry Research Institute.

3.3 Seed Pre-treatment

This is done for seed that do not germinate easily (Appendix 1). It involves soaking in cold or hot water overnight, cutting a hole in the seed coat and burning depending on seed type. The process improves the uptake of water that lessens germination time.

3.4 Seed sowing

This depends on the species and the time it takes to attain plantable size (20 cm – 30 cm). It is important that the seeds are sown in time to attain plantable sizes by the onset of rains, for example, *Eucalyptus* sp. intended for out planting in March/April can be sown during the month of November. There are several methods of sowing.

3.4 Methods of sowing

3.4.1 Broadcasting

Seeds are spread on top of the nursery seed bed either manually by hand or by use of a mechanical broadcaster. Small-sized seeds are mainly sown in this way.

Fine and light seeds such as *Eucalyptus*, *Casuarina* are sown in transplant beds and later pricked out into containers. It is important that fine seed is mixed with sand and uniformly broadcasted on the seedbed to avoid overcrowding that can attract damping off.

Do not sow the seed too deep in the soil. This is likely to affect seed germination. As a rule, the thickness of soil cover layer should be equal or proportional to seed size; thin layer for small seeds.

3.4.2 Drill-sowing

Ruts or drills are made in the seedbed soil mixture. The seeds are dropped in and lightly covered with the seedbed soil mixture. This mostly applies to small-sized seeds, such as those of cypress, eucalypts, casuarinas and many more within that range.

3.4.3 Direct sowing

Sizeable (large sized seeds) such as those of *Grevillea*, *Neem* and *Kei apple* can directly be planted into containers. Direct sowing of seeds into containers/pots saves time, labour and money, because the extra step of preparing a seedbed and transplanting is eliminated. Although it takes a little longer to plant small seeds directly in the containers, it is easier and cheaper than pricking out. Direct sowing allows undisturbed seedling growth and thus reduces stress for the seedlings.

Depending on conditions in the nursery; the tree species (size of the seed), number of plants to be produced, and labour availability, a combination of direct sowing and use of seedbeds may be appropriate. Most nurseries use seedbeds to germinate seeds.

3.5 Pricking out

This is the process of transferring young and tender seedlings from seedbeds into containers.

Procedure:

- Water the seedbed and potted containers properly before commencing the operation
- Ensure adequate shade is available
- Take an empty container and fill with water to $\frac{3}{4}$ level
- Hold the leaves of the seedlings and insert a pencil-thick stick (dibber) underneath the root system to loosen the soil
- Pull out the seedlings gently and immediately put in the container with water
- Make a hole at the center of the pot using a pencil-size dibber
- If the roots are too long, clip off the tip
- Insert the root system gently in the hole while holding the seedling by leaves. Do not hold the stem of the seedlings because they are tender and feeble – this may injure the seedling.

- Hold the stick in the tilting position and insert it in the soil about one centimeter away from the seedling to the same depth as the hole.
- Push the soil towards the seedling to hold tightly. This ensures that all the air pockets around the roots are closed
- Using your fingers cover the hole you made
- Water the containers properly once more.



Plate 7: Seedlings being pricked out

3.6 Shading

- Construct a shade to protect the seedlings from direct sunlight for two to three weeks after pricking-out
- Use locally available materials such as grass, mats, or banana leaves for shade construction
- Raise the shade to at least 1.5 m above the ground



Plate 8: Local materials are recommended for constructing shade in on-farm tree nurseries

3.7 Watering

- Water seedlings twice a day - Early in the morning and late in the afternoon when the sun is not strong
- During rainy seasons, watering may be done once or none at all.
- Avoid under-watering and over-watering. Use adequate amount of water (20 liters for 1000 seedlings)
- Avoid direct use of hosepipes while watering the seedlings as this may wash away the soil. Use of fine watering roses and sprinklers is highly recommended.



Plate 9: Watering seedlings using a watering can

3.8 Weeding

Weeds are a threat to the development of healthy seedlings. They compete with the seedlings for nutrients, water and light hence they must be removed. With hands, gently pull out unwanted growths (rouging). This should be done whenever weeds are observed.



Plate 10: Removing weeds from potted seedlings in a tree nursery

3.9 Root pruning

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

Procedure:

- Water the seedling properly before root pruning
- Using a sharp knife (or wire on beds), cut the long roots underneath the container. You can also lift up the containers (wrenching) to cut the overgrown roots
- Water the seedlings well after root pruning. This helps the plant withstand moisture stress
- Root pruning should be done early in the morning or late in the afternoon when weather is cool
- Root pruning should be done regularly preferably every 2 – 3 weeks.



Plate 11: Root pruning of *Cupressus lusitanica*

3.10 Hardening off

- This is the gradual preparation of seedlings for field conditions. It involves reduction in watering intensity and frequency and exposure to more sunshine. Good preparation for out planting results in good field survival, therefore hardening off should be done 2 – 3 weeks before out planting time.

4.0 Seedling protection

Seedlings are delicate and susceptible to attacks by various pests and diseases as well as weather conditions. Resultant injuries can seriously weaken or kill the seedlings and should be dealt with immediately. Threats may be categorized as below:

4.1 Extreme weather conditions

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

4.2 Human

This is the stealing and/or intentional damaging of seedlings by human beings. Fencing and security are some options to be considered.

4.3 Livestock and wild animals

Livestock and wild animals browse, graze and/or trample on seedlings. Fencing can help offset this.

4.4 Insects pests

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

Termites may be controlled by use of ash, digging out the queen from nearby colonies, use of plant extracts, and use of chemicals such as fipronil, aldrin, dieldrin, carbofuran, or imidacloprid in severe cases.

The other most well known pests in tree nurseries include the following:

4.4.1 Blue gum chalcid

This is a new pest, which has emerged both in nurseries and young plantations of eucalypts. The pest attacks soft tissue of buds and young leaves making swellings that deform leaves and curl them. The plants then develop multiple terminal buds with retarded growth.

Control

At the nursery stage, the chalcid can be controlled using chemical sprays. Spraying of large areas is not cost effective, therefore research is progressing towards the development of biological control measures.



Plate 12: Seedling attacked by blue gum chalcid

4.4.2 Aphids

Aphids cause leaves to curl and blacken, stunting growth. They usually occur in small colonies under the leaves. Leaves become laden with honeydew or blackened with sooty moulds preventing photosynthesis. The coverage may include buds and stem. When the coverage is large, it leads to death of growing tips initially. Some of the well-known aphids include cypress aphid (*Cinara cupressivora* and *C. pinivora*), pinewoolly aphid

Prevention of aphids

- Encourage presence of hover flies, praying mantis and lady birds,
- Restrict the use of insecticides
- Use biological control eg *Paucia juniperorum* for cypress aphid



Plate 13: A colony of aphids on cypress branch

4.4.3 Scale insects

These are sapsuckers (Fig. 8). They occur in two types: soft and hard bodied. They are some of the most destructive insects on plants. The hard covered bodies are best treated with systemic insecticides since contact chemicals will not penetrate the cover. The black ants usually associated with pests such as aphids and scale insects are not friends but enemies helping to transport eggs of the pests to different parts of the plant.



Fig. 15: Scale insects on a branch of an *Acacia* sp.

4.4.4 Moths

The most destructive stage of a moth is the caterpillar. They feed on leaves, defoliate and cover feeding area with silk, rolling the leaves

Prevention

Predators such as birds can be encouraged in the nursery. A regular spray of water will chase away moths. The affected parts can be pruned and burned. The caterpillars can also be picked and killed. Alternatively, they can be sprayed with insecticides recommended by the agrovet nearby.

4.4.5 Red spider mite

Mites are some of the sapsuckers that retard plants growth, causing leaf fall or death of the plant. They are usually found in colonies or scattered on the leaf underside. Initial feeding causes yellowing and leaf drop.

Prevention

Wet the plants, as mites do not thrive in wet conditions. Their population increases in warm and dry conditions. Crop rotation with resistant species will reduce their survival. Chemicals such as horticultural oil and insecticidal soap such as neem can help in controlling the mites.

4.4.6 Leaf miner

White or brown areas on plant leaves are the first symptoms that suggest the presence of leaf miners. The shape of the spots varies with the types of leaf miner. Leaf miners reduce the photosynthetic area of the leaf together with injuries that retard growth.

Prevention

Predator wasps should be allowed in the nursery or plantations. Insecticides can be used to control leaf miners at the nursery stage.

5.0 Fungal diseases

Tree nurseries are usually associated with many diseases that unless they are monitored and controlled or prevented, good seedlings cannot be expected. Some of the diseases that are found almost in all nurseries are discussed below. Monitoring (scouting for) diseases is a daily routine work that must be implemented right from the sowing time to the time seedlings are released for planting out in the field.

5.1 Damping off

It is a disease of germinating seeds caused by various fungi *Pythium* species, *Rhizoctonia salani*, etc, *Pythium* causes disease at temperature of 25 °C and below with high soil moisture.

It occurs before, or at germination and at pricking out time. Attack is at soil level and kills the seedling. It widely attacks pine and eucalypts.

Conditions favourable for the attack

- High sowing density
- Overwatering
- Using soil with undecomposed material
- Using soil with damping – off spores
- Damaging the bark of tender seedlings

Prevention measures

- Use optimum sowing density in the seed bed
- Dig soil one to three months in advance
- Do not overwater
- Replace soil when sowing
- Soil should be less alkaline
- Disinfect soil in seedbed
- Reduce shading
- Use copper based fungicides to control



Plate 14: Pine seedlings attacked by damping-off

5.2 Powdery Mildew

- Is a common disease that appears as a white powdery substance on the leaf surface
- It attacks all kinds of trees
- It is prevalent under moist conditions, especially during the wet season.

Prevention

- Seedlings should not be heavily shaded
- Seedlings should be sown with ample spaces to reduce over crowding
- Thin overcrowded seedlings for effective air movement.

Control

- If necessary, spray with wettable sulfur at the recommended rate specified on the label. Sulfur may injure tender foliage, especially in hot weather
- Use other fungicides as directed by agronomists and guided by the label of the supplier.



Plate 15: Powdery mildews on leaves of Eucalyptus

5.3 Leaf spot

Leaf infections called “leaf spots” are caused by a variety of fungi and some bacteria.

Symptoms

- A leaf spot disease creates spots on foliage
- The spots will vary in size and color depending on the plant, the organism involved and the stage of development
- Spots are most often brownish or black
- Concentric rings or a dark margin around the spot may be present
- Leaves may yellow and drop pre-maturely

Prevention

- Avoid planting too closely
- Thin out seedlings to open up the spaces for the shoot
- Water trees deeply during dry spells

Control

- Use fungicides only when necessary
- The fungicide must be applied prior to build up of disease to effectively control leaf spotting fungi
- If severe leaf spot occurs more often, chemical control is probably necessary, but leaf spot variety must be identified first.
- Samples can be submitted to pathologists for identification



Plate 16: Leaf- spot on Eucalyptus

6.0. VEGETATIVE PROPAGATION

Among regular activities carried out in large nurseries is vegetative propagation. The technology involves use of parts of a selected growing plant for multiplication. The techniques used more often are cuttings, budding, grafting and tissue culture. These techniques always require additional infrastructure to be attached to the nursery e.g. shade nets with various percentage light penetration, green house, mist propagation unit and tissue culture units. Details on these procedures and requirements are covered elsewhere.

7.0 TREE NURSERY RECORDS

In order to have an effective nursery management, up-to-date nursery records should be kept. The major documents include:

7.1 Workers register (Muster roll)

This is a register where attendance and daily occurrences of workers are recorded. It is maintained by the nursery supervisor. It helps in deciding the payment of workers for the days served. This is accountable document that must be handed over when the supervisors are changed.

7.2 Equipment inventory register / asset form

All nursery equipments and assets are entered into the book and their state is recorded. The book is accountable and handed over from one supervisor to another

Table 2: Equipment and material records

Equipment/material	Date of acquisition	Quantity	Cost	Condition	Remarks

7.3 Workers diary/daily assignments and observations

- Indicates daily assignments
- Achievements
- Field/Nursery observations
- Remarks

7.4 Weekly reports

A summary of tasks completed, achievements and remarks. It also summarizes all attendance and occurrences.

7.5 Seed inventory book

This is where all seeds entering the nursery are recorded. It contains all details such as:

- Introduction date
- Species name
- Batch number
- Origin/source
- Amount
- Given code number
- Date of collection
- Given germination rate
-

Table 3: Seed records

Species	Date received	Quantity received	Date collected	Provenance (source)	Remarks

7.6 Seedling book

- Seed code number
- Species name
- Pretreatment
- Sowing date
- Germination date
- Germination percentage
- Seedling periodic inventory (weekly/Monthly)

Table 4: Seedling records

Species name and Code	Date of sowing	Quantity sown	Total No. germinated	Total pricked out	Date of pruning	No. of seedlings		Total sales	Remarks
						Issued out	sold		

7.7 Nursery delivery register

The record shows how seedlings have been distributed.

- Names
- Addresses
- Telephone numbers
- Email
- Number planted locally

7.8 Invoice

This is a documentation that accompanies goods (seeds/seedlings) to a buyer giving details and pricing. It is required for processing of payment for goods. It is accompanied with delivery note.

7.9 Delivery note

This is a documentation that is released with goods delivered to a user showing details of what is delivered. It must be counter signed by the receiving agent showing that goods were in good condition. It opens way for arrangements for payments.

7.10 Cash sale receipts

This is a documentation confirming that money has been received. It is usually exchanged with cash.

7.11 Visitors' book

This is a book where all visitors to the nursery are recorded including buyers. It shows the date of the visit, contact details and remarks that can help in management.

8. REFERENCES

- Buyinza, J. and Opolot, V.I. (2016).** Tree nursery establishment and tree management: Training manual for community tree nursery operators and tree farmers. NAFFORI, ACIAR, ICRAF. 17 p
- CTA. (2007).** Establishing a tree nursery. *CTA Practical Guide Series, No. 10.*
- Dumroese, R.K., Landis, T.D., Luna, T. and Hernández, G.** Afghan Forest Nursery Training Manual. USAID, USDA. 533 pp.
- Kall, K.C. (2003).** Manual on nursery practices. FD, MoA. Kingston, Jamaica. 70 pp.
- Mbora A., Lillesø J-PB., Jamnadass R. (2008).** Good Nursery Practices: A Simple Guide. Nairobi. ICRAF. 36 pp.
- Munjuga MR, Gachuri AN, Ofori DA, Mpanda MM, Muriuki JK, Jamnadass RH, Mowo JG. (2013).** Nursery management, tree propagation and marketing: A training manual for smallholder farmers and nursery operators. Nairobi: World Agroforestry Centre, 49 pp
- Wightman, K.E. (1999).** Good tree nursery practices: Practical guidelines for community nurseries. ICRAF, 95 pp.
- Wilkinson K.M., Landis, T.D. Haase, D.L., Daley, B.F. and Dumroese, R. K. (2014).** Tropical Nursery Manual: A Guide to Starting and Operating a Nursery for Native and Traditional Plants . USDA, USFA. 376 pp.
- World Agroforestry Centre. (undated).** Establishment and management of sustainable on-farm tree nurseries: A farmers manual. 13 pp.

Disclaimer

“This document has been produced with financial assistance of the European Union. The contents of this document are the sole responsibility of the Kenya Forestry Research Institute (KEFRI), and can under no circumstance be regarded as reflecting the position of the European Union

Appendix 1

Germination period and expected percentage of viable seeds in any quantity after cleaning

Species name	Seed pre-treatment	Seed germ period in days	Germination %
<i>Acacia abyssinica</i>	Nick ¹ with a scalpel, a knife, or a nail clipper	7-15	30 -60
<i>Acacia mearnsii</i>	Soak in hot water ² 90° C for 1 min or burn with light fire in the field	3-30	20-50
<i>Acacia melanoxylon</i>	Soak in hot water 90°C for 1 min	10-30	30-60
<i>Acacia melifera</i>	Nick seeds with a scalpel, a knife, or a nail clipper or soak in hot water ³ and cool for 24 hours	2 -14	50-80
<i>Acacia nilotica</i>	Nick seeds with a scalpel, a knife or a nail clipper or soak in near boiling hot water 80°c for 24 hours cooling	4-12	60-80
<i>Acacia polyacantha</i>	Nick seeds with a scalpel, a knife or a nail clipper, or soak in boiling water and cool for 24 hours	10-20	60-90
<i>Acacia senegal</i>	Nick seeds with a scalpel, an knife or a nail clipper or soak in hot water 80°c and cool for 24 h.	3-10	60-95
<i>Acacia seyal</i>	Nick seeds with a scalpel, a knife or a nail clipper and soak in cold water for 24 h.	4-10	60-75
<i>Acacia tortilis</i>	Nick seeds with a sharp tool like a scalpel, a knife or a nail clipper and soak in cold water for 24 h.	5-15	45-85
<i>Acacia xanthophloea</i>	Nick seed with a scalpel, a knife or a nail clipper or soak in cold water for 24 h.	5-15	40-90
<i>Adansonia digitata</i>	Soak in hot water and cool for 24 h.	30-50	
<i>Afzelia quanzensis</i>	not necessary	11-20	90
<i>Albizia gumifera</i>	Nick seed or soak in cold water for 24 h.	7-15	70-80
<i>Aningeria adolfi-friedercii</i>	N/A	18-35	70-80

<i>Azadirachta indica</i>	Soak in cold water	4-20	60-80
<i>Balanites aegyptiaca</i>	N/A	7-30	60
<i>Berchemia discolor</i>	No pre sowing treatment available	50-60	50

<i>Brachyleana huillensis</i>	Seeds should be mixed with moist sand before sowing	7-10	2-10
<i>Brachystegia spiciformis</i>	Nick seed with a sharp tool like a scalpel, a knife or a nail clipper	13-30	70-90
<i>Calliandra calothyrsus</i>	Soak seeds in hot water and cool for 24 hours	3-15	50-80
<i>Casuarina equisetifolia</i>	N/A	11-23	50-70
<i>Celtis africana</i>	Soak in cold water for 24 hours or	40-80	80-90
<i>Cordia africana</i>	N/A	40-60	75
<i>Cordia sinensis</i>	Not necessary for fresh seeds. Pour 40°C water on old seeds, and soak to cool	40-60	70
<i>Croton macrostachyus</i>	Not necessary	6-60	30-40
<i>Croton megalocarpus</i>	Not necessary	6-60	80-95
<i>Cupressus lusitanica</i>	Not necessary	10-20	30-45
<i>Delbergia melanoxylone</i>	Not necessary	8-20	50-60
<i>Delonix elata</i>	Nick the seed	4- 15	40 to 60%
<i>Delonix regia</i>	Nick seed or soak in hot water and cool	8-25	30-50
<i>Diospyros mespiliformis</i>	Not recommended yet	8-25	30-40
<i>Dobera glabra</i>	Not necessary	15-40	70-90
<i>Dombeya torrida</i>	Not necessary	9-30	70-80
<i>Dovyalis caffra</i>	Not necessary	9-30	80-90
<i>Azadirachta indica</i>	Soak in cold water	4-20	60-80
<i>Balanites aegyptiaca</i>	N/A	7-30	60
<i>Berchemia discolor</i>	No pre sowing treatment available	50-60	50
<i>Brachyleana huillensis</i>	Seeds should be mixed with moist sand before sowing	7-10	2-10
<i>Brachystegia spiciformis</i>	Nick seed with a sharp tool like a scalpel, a knife or a nail clipper	13-30	70-90
<i>Calliandra calothyrsus</i>	Soak seeds in hot water and cool for 24 hours	3-15	50-80
<i>Casuarina equisetifolia</i>	N/A	11-23	50-70
<i>Celtis africana</i>	Soak in cold water for 24 hours or	40-80	80-90
<i>Cordia africana</i>	N/A	40-60	75
<i>Cordia sinensis</i>	Not necessary for fresh seeds. Pour 40°C water on old seeds, and soak to cool	40-60	70

<i>Croton macrostachyus</i>	Not necessary	6-60	30-40
<i>Croton megalocarpus</i>	Not necessary	6-60	80-95
<i>Cupressus lusitanica</i>	Not necessary	10-20	30-45
<i>Dalbergia melanoxylone</i>	Not necessary	8-20	50-60
<i>Delonix elata</i>	Nick the seed	4- 15	40 to 60%
<i>Delonix regia</i>	Nick seed or soak in hot water and cool	8-25	30-50
<i>Diospyros mespiliformis</i>	Not recommended yet	8-25	30-40
<i>Dobera glabra</i>	Not necessary	15-40	70-90
<i>Dombeya torrida</i>	Not necessary	9-30	70-80
<i>Dovyalis caffra</i>	Not necessary	9-30	80-90

<i>Eucalyptus camadulensis</i>	Not necessary	3-13	15-40
<i>Eucalyptus ficifolia</i>	Not necessary	7-20	30-90
<i>Eucalyptus globulus</i>	Not necessary	4-15	35-80
<i>Eucalyptus gomphocephala</i>	Not necessary	5-15	25-50
<i>Eucalyptus grandis</i>	Not necessary	9-30	30-90
<i>Eucalyptus maculata</i>	Not necessary	4-15	40-95
<i>Euclyptus melliodora</i>	Not necessary	5-12	50-85
<i>Eucalyptus paniculata</i>	Not necessary	6-12	40-90
<i>Eucalyptus regnans</i>	Not necessary	3-15	20-50
<i>Eucalyptus saligana</i>	Not necessary	3-12	30-70
<i>Eucalyptussideroxylon</i>	Not necessary	7-15	45-90
<i>Eucalyptus tereticornis</i>	Not necessary	14-30	30-70
<i>Eucalyptus urophylla</i>	Not necessary	3-12	30-70
<i>Faidherbia albida</i>	Nick seed and soak in cold water for 24 hours	5-20	60-90
<i>Gmelina arborea</i>	Not necessary	20-50	60
<i>Grevillea robusta</i>	Soak seeds in cold water for 24 hrs	15-20	
<i>Hagenia abyssinica</i>	not necessary	10- 20	
<i>Juniperus procera</i>	The seeds should be stratified in damp sand at 3°C for 60 days or immerse in boiling water at 100°C for 60 sec. and soaking till the water cools, or soaked in acid for 10 min	25-80	60-70

<i>Leucaena diversifolia</i>	Nick seed or soak in cold water	8-10	80
<i>Leucaena leucocephala</i>	Nick seed or soak in cold water	8-10	80
<i>Maesopsis eminii</i>	Nick seed	70	60-70
<i>Markhamia lutea</i>	Not necessary	20-30	30-60
<i>Melia azedarach</i>	Not necessary	35-75	85-100
<i>Melia volkensii</i>	Seed coat should be cracked with a hammer or a table vice and the seed removed completely from the shell. The seeds are then soaked in warm water for 24 hours	15-35	40-90
<i>Milicia excelsa</i>	Not necessary	45-60	45
<i>Moringa oleifera</i>	Not necessary	7-10	
<i>Moringa stenopetala</i>	Not necessary	7-10	70-90
<i>Newtonia buchananii</i>	Not necessary	30-40	70
<i>Ocotea usambarensis</i>	Not necessary	30-45	45
<i>Olea europaea</i>	Crack the seed shell with a hard object or a table vice. Care should be taken not to damage the seeds	20-45	20-60
<i>Olea welwitschii</i>	Crack the seed coat with a table vice or a hammer and remove the seed	35-90	

	coat		
<i>Parkinsonia aculeata</i>	Nick the seed coat at the distal (cotyledon) end of the seed by using a sharp tool like a scalpel, a knife or a nail clipper	2-10	90
<i>Piliostigma thonningi</i>	Nick the seed coat at the distal (cotyledon) end of the seed by using a sharp tool like a scalpel, a knife or a nail clipper	60-75	
<i>Pinus patula</i>	Not necessary	35-60	75-85
<i>Podocarpus falcatus</i>	Crack the seeds with a hammer or table vice to remove the seed out of the shell if the seed were stored for a short period. For storage of 1 and a half years and longer at 3°C in a cold store, pre sowing treatment is not needed.	50-90	30
<i>Podocarpus latifolia</i>	not necessary	30-40	60-80
<i>Polyscias fulva</i>	not necessary	35-45	75
<i>Prosopis chilensis</i>	Nick the seed and soak in cold water	10-30	45-80

<i>Prosopis juliflora</i>	Nick seed or soak in cold water	14-30	60-80
<i>Populus ilicifolia</i>	Not necessary	1-2	20-50
<i>Prunus africana</i>	not necessary	35-50	60-80
<i>Salvadora persica</i>	not necessary	40-50	40
<i>Schinus molle</i>	not necessary	10-30	55
<i>Sclerocarya birrea</i>	Removal of operculum	2-10	50-80
<i>Senna siamea</i>	Soak in Hot water and cool	5-30	60-80
<i>Sesbania sesban</i>	Soak in hot water and leave to cool for 24 hours	2-10	60 to 80
<i>Spathodea campanulata</i>	Not necessary	8-25	30-50
<i>Syzygium guineense</i>	not necessary	40-50	
<i>Tamarindus indica</i>	Soak in hot water and leave to cool for 24 h	4-10	70-80
<i>Tectona grandis</i>	Soak the fruits in tab water for a few hours. This is a preliminary recommendation	sporadic germination	5
<i>Terminalia brownii</i>	The hard woody part of the endocarp should be nipped twice forming a pointed 'V' so that the seed comes out of the fruit.	60-90	30
<i>Terminalia prunoides</i>	The hard woody part of the endocarp should be nipped twice forming a pointed 'V' so that the seed comes out of the fruit.	60-90	20
<i>Trichilia emetica</i>	Remove the aril	18-30	70-80

<i>Vitex keniensis</i>	Not necessary	30-60	60-70
<i>Warburgia ugandensis</i>	Not necessary	15	70
<i>Zanthoxylum gillettii</i>	No successful treatment has been developed.	60-72	60-70

Table adopted with some modifications from Tree Seed Handbook of Kenya 1993 Ed. Albrecht, J and Revised by Omondi, W; Maua, J.O. and Gachathi, F.N..

¹Nicking is only possible with small seedlots

² Seeds are only soaked in hot water for one minute and removed

³ Seeds soaked in hot water (not boiled) and left for 24 hours cooling

NB: Germination period percentage of viable seeds are determined by many factors including age of seed after harvesting, warmth, sowing depth, etc