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Regreening Africa

World Agroforestry

TREE NURSERY MANAGEMENT GUIDE FOR LAND RESTORATION PLANNERS

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TREE NURSERY MANAGEMENT GUIDE
FOR LAND RESTORATION PLANNERS

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Front cover images: Left: Re-greening Africa nursery in Niger with ready planting materials. © Sammy Carsan/World Agroforestry (ICRAF). Right: A farmer cooperative nursery with avocado seedling ready for grafting in Rwanda.

Back cover images: Clockwise: Sargini women group nursery, Oullam Niger; *Ziziphus sp.* germinant; Twigire Buhinzi Cooperative nursery, Rwanda, *Cordyla pinnata* tap root & *Faidherbia albida* nursery in Oallam, Niger & Cashew stock.

ABOUT THIS GUIDE

This guide has been prepared for the Re-greening Africa project to support grass-root actors such as Non-Governmental Organizations (NGOs), Community-Based Organizations (CBOs), Forest Service Departments, Agriculture departments, local institutions and farmers and their cooperatives to operate successful tree nurseries. The information provided here has been sourced from literature reviews, direct consultations with tree nursery practitioners and authors' experiences.

Information on tree nursery establishment, species propagation techniques and tips on successful plant nursery management are discussed. The guide does not offer specific advice on appropriate species for each region nor does it suggest production targets for individual nurseries. This type of information is best obtained from experienced technical personnel with knowledge of appropriate tree species and their performance in each project area.

Users will find useful information on (i) nursery siting and establishment (ii) planning and scheduling tree nursery operations (iii) seed handling and pretreatment (iv) potting media and containers and (v) key nursery records. Technical notes are presented in simple language using illustrations to enable nursery staff implement nursery procedures effectively. In addition, the guide offers insights on practices to improve tree seedling quality standards in anticipation of plant businesses that will emerge.

CONTENTS

1. INTRODUCTION

Re-greening Africa is an ambitious five-year project (2017 to 2022) that seeks to reverse land degradation among 500,000 households across one million hectares in eight countries in Sub-Saharan Africa; and catalyze a much larger scaling effort to restore tens of millions of hectares of degraded land across the continent. It is implemented by the World Agroforestry (ICRAF) in partnership with World Vision, Oxfam, CARE, Catholic Relief Services, and Sahel Eco. In East Africa, the project is focused in Ethiopia, Kenya, Rwanda and Somalia (Somaliland and Puntland); and in West Africa, Ghana, Mali, Niger and Senegal. Tree establishment in croplands, communal lands and pastoral areas are targeted to help reclaim some Africa's degraded landscapes.

Tree-based restoration as a major component of the programme demands quality planting materials. This requires efficient tree nurseries producing correct vigorous tree seedlings for planting at the right locations. In other words, selected tree species must meet community interests and grow well to help restore degraded sites and agro-ecologies.

This guide provides research knowledge and - good nursery practices to help accelerate implementation of tree planting programmes. Straight-forward protocols on how to start a tree nursery and basic steps involved in growing quality tree seedlings are provided. The resource is intended to promote sound management practices for quality nursery stock production with good field establishment and survival.

The aim is to update available standard guidelines on nursery establishment, propagation and management procedures. A general framework that can be used in any nursery has been illustrated. Further, the guide offers generic information to support propagation of diverse native tree species that have no major pest or invasive problems to a given land restoration circumstances.

2. WHY A TREE NURSERY?

A nursery is a managed site or area designed to produce or raise seedlings or young plants under favorable conditions until they are ready for out-planting on farms, community areas, forests (enrichment planting or plantations) or public areas. Tree nurseries aim to produce sufficient quantities of high quality seedlings to satisfy users needs.

A growing human populations and expansion of agricultural activities have depleted natural tree source. Tree and tree products demand for livelihood and environmental restoration is on the increase. Many farmers want to plant trees but cannot obtain enough, diverse and high-quality tree seedlings. Establishing tree nurseries can help meet this demand and provide extra income.

A simple illustration on components involved in successful tree nursery management is shown in Figure 1. Paying close attention to these factors by nursery managers can help produce quality tree stock fit for purpose.

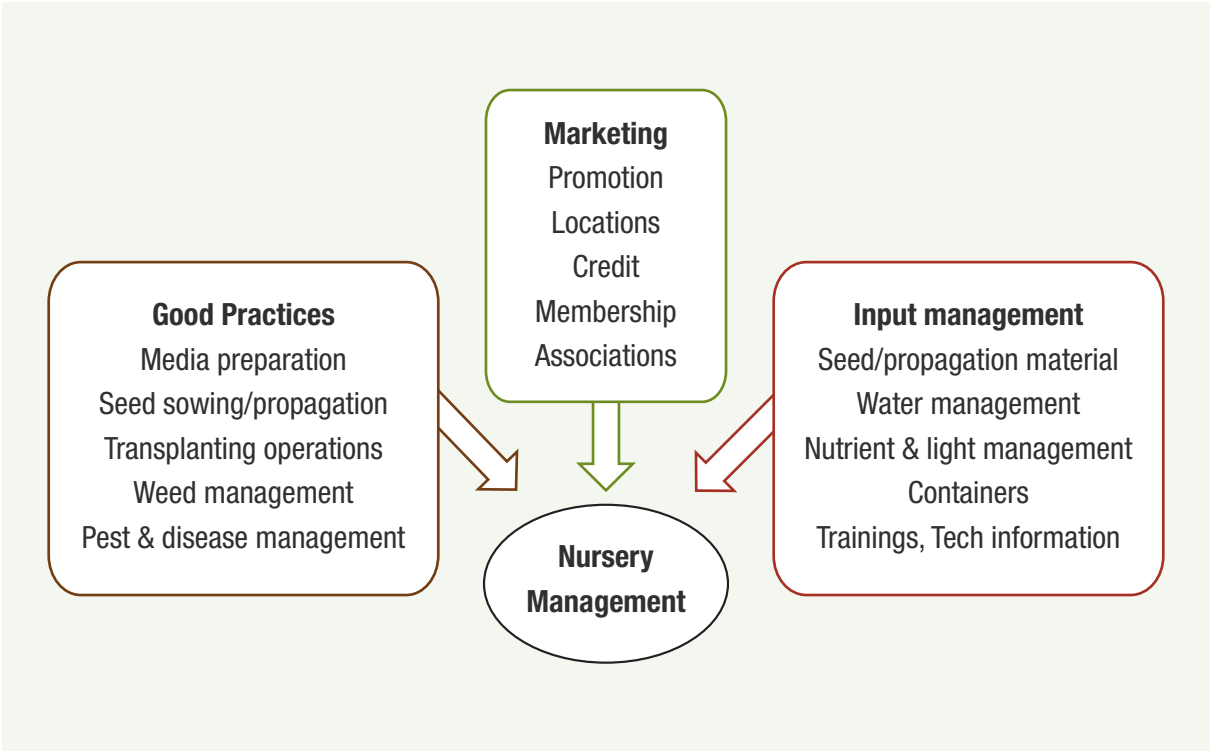


Figure 1: *Components for successful tree nursery management*

2.1 Types of nurseries

There are two types of tree nurseries: (i) temporary /short-term and (ii) permanent. They are distinguished based on their duration of operation and types of planting materials produced.

A **temporary** tree nursery operates for a season to meet specific planting programmes demands. These nurseries may be set up or contracted to satisfy personal, project or government planting programmes such as in reforestation campaigns. Few tree species are often produced to coincide with rainfall season. They tend to dwell on few exotic species.

A **permanent** tree nursery is set up to serve long-term seedling production needs. They raise high quantity seedlings from year to year and may have more investment in nursery infrastructure such as soil media storage, permanent shade and water supply systems. Most of these nurseries run as private, group or government enterprises may serve commercial seed supply purposes. They produce more diverse species involving indigenous species and grafted fruits that require longer nursery care.

3. DESIGNING A GOOD NURSERY

A good tree nursery design should be considered carefully in order to serves its purpose effectively and ensure operations run efficiently. As a rule of thumb, nurseries should be:

i. located near a reliable water supply
ii. easily accessible site for ease monitoring production activities and transportation of seedlings,
iii. close to cheap and skilled labor
iv. near source of good soil media, free from pathogens.

3.1 Site selection

Tree nurseries should be sited in a central location preferably close to areas targeted for land restoration activities. Assess if your nursery site meets some of the following conditions:

i. Gently sloping site with good water drainage. Avoid exposed hilltops, clay soils and swampy valley bottoms to prevent water-logging which may lead to seedling stress and nutrient imbalance.

ii. Not heavily shaded with trees for proper light management and encourage air circulation

iii. Availability of good potting soils (fertile and well-drained type)

iv. Reliable water supply (quality and quantity) for irrigation purpose

v. Accessible throughout the year to facilitate efficient nursery operations

vi. Design should provide paths for ease nursery workers movements to potting and seedling production areas; also plan for kind of irrigation to be used for large nuseries

vii. The site should be well protected from strong winds, livestock and unauthorized people.

Pictorial illustration of good nurseries by Re-greening Africa Project in the Sahel and E. Africa is shown in Figure 2.

Figure 2: *An example of a good nursery site: (A) Sahel, (B) E. Africa*

3.2 Nursery construction

Tree nursery construction requires thorough planning to ensure optimum seedling growth and ease of site maintenance to promote hygienic conditions. Use of locally available

construction materials such as poles, grass and banana fibers is recommended where feasible to reduce cost. Four main activities are involved in nursery construction work:

i. nursery design
ii. clearing
iii. fencing and
iv. bed construction.

Nursery Design: There no standard blueprint for designing a plant nursery. Your nursery can assume a unique design based on seedlings needs, available resources, and future requirements. A nursery is usually arranged in a series of beds for seed sowing and germination with pathway between them. Layout should be in a way that enables operations to flow logically so as to save labor and time. Walk paths within the nursery should be carefully planned. The nursery facilities should be kept clean. A simple layout plan for a central project nursery is shown in Figure 3. Some key facilities to include in the design:

i. Water tank/supply
ii. Tools and equipment store/shed
iii. Germination beds area
iv. Potting/container filling area,
v. Seedling raising area/ shaded area
vi. Office room,
vii. Propagation structures
viii. Composting area.

An open area is needed at one end where work such as sieving of soil and filling of containers can be done. Every effort should be made to control weeds in and around the nursery as they may host insects and pathogens. Consider available labour to set up construction works.

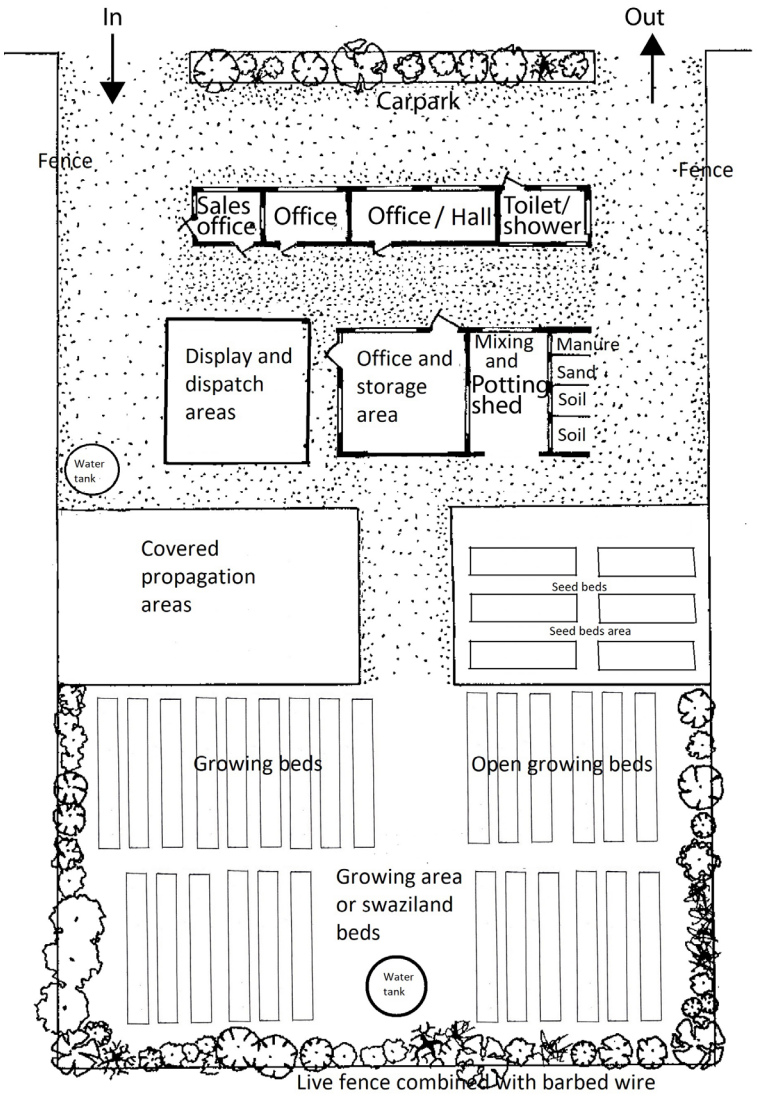


Figure 3: *A general layout and design for central project nursery*

Installing nursery structures

Clearing: After setting nursery boundaries, clear all vegetation and remove tree stumps, leaving some shade trees at least 2 months before the arrival of the seeds. If the area is not flat, make terraces at this stage.

Fencing: You may erect a fence around the nursery area for example a four-strand, barbed wire with wires spaced at 0.3, 0.6, 0.9 and 1.2 m from ground should be adequate (Figure 4a). If a natural windbreak does not exist, plant some trees t shade.o also provide shade. Consider use of chain links where free grazing livestock is a challenge (Figure 4B).

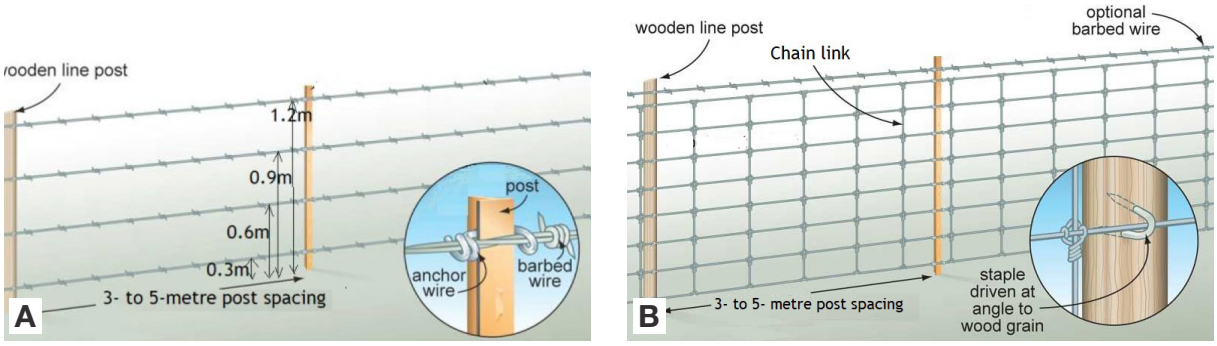


Figure 4: *Illustration of barbed wire and chain link fencing in a nursery*

Once clearing and fencing work is completed, the following activities should be undertaken to complete the nursery establishment:

Nursery beds construction:

i. Level the site of the swaziland beds and firm the soil
ii. Mark out the shape and sizes of the beds
iii. Erect the beds using durable poles or sawn timber
iv. Install the irrigation system if required
v. For shade, one can use any local material available.

Seed-beds preparation: Seed-beds should be 1-1.2 m wide but length is determined by the size of the nursery. It depends on the amount of seed you intend to sow and the space available. The bed should enable the nursery worker to reach plants at the centre of the plot. Washed river sand is generally ideal for seedbeds. Fill the beds with sand and level with plank. Sand offers plants good root penetration and drainage characteristics.

If dealing with containerized seedlings e.g. polythene pots/tubes, arrange 10 x 10 pots widthwise to facilitate counting (Figure 5). Leave 0.45-0.5 m width between one seedbed and the next to act as paths to facilitate movement. Beds should be orientated to run from East-West to avoid direct sunlight in the early stages of seedling growth. Lining (polybag arrangement) can be carried out to space the polybags evenly in the nursery at this stage to give each seedling the optimum growth space.

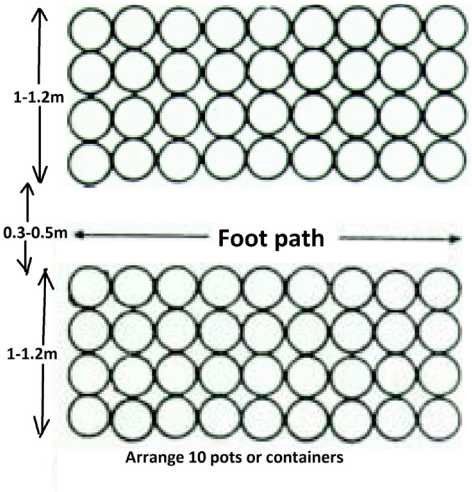
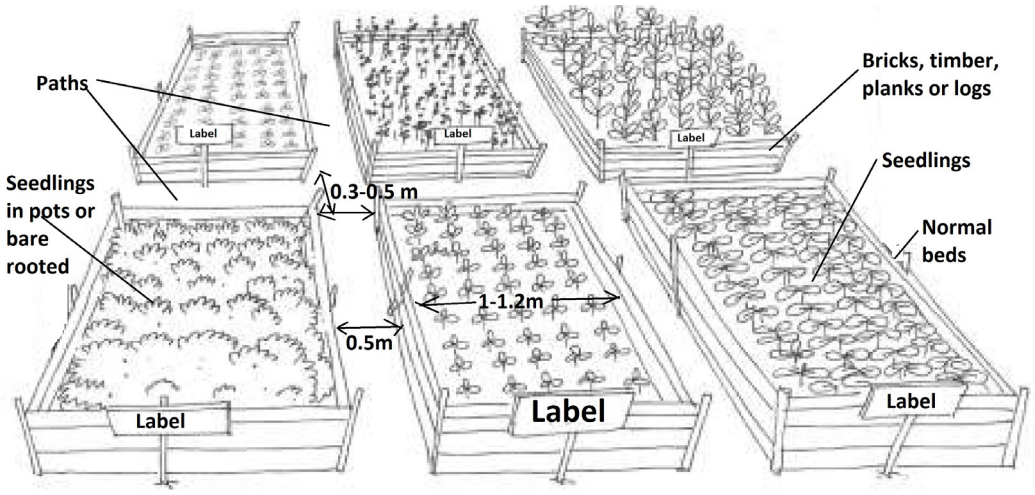
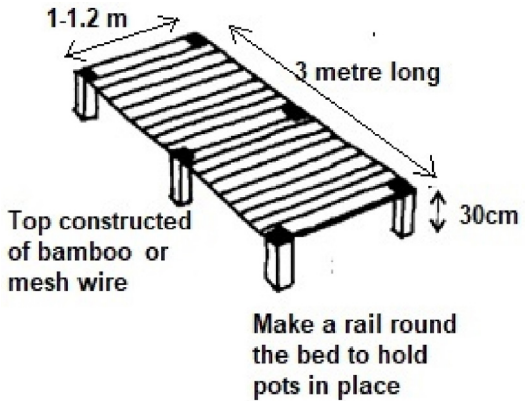


Figure 5: *Polypot arrangement*

Raised Beds: In a flat area, make three rectangular foundations (3 metres long x 1.5 metres wide or of convenient size) side by side using bricks or wooden beams or posts. Allow 1 metre between the rectangles as a path for working. On top of this foundation, construct a flat bed with bamboo, wood, metal poles or chicken wire (Figure 6A). If grass or thatch fronds are used, be sure to leave enough cracks and holes for air circulation. Choose materials that will not rot too quickly. If discarded wooden pallets are available they can be used for this purpose or laid directly on the ground avoiding the need for the block or brick foundation.



A - Normal Beds



B - Raised Beds

Figure 6: *Conventional nursery beds (A) and Raised beds (B)*

3.3 Tools, equipment and materials

Several basic implements are required to run a successful nursery enterprise:

i. **Equipment:** Wheelbarrow, sprinklers, hoses or watering can, sprayer, protective clothing: gloves, gumboots, protective eye googles

ii. **Materials:** Sand, soil, agrochemicals, seeds, fertilizers, perforated plastic trays, pots, potting bags, seed bags, nails, and notebook

iii. **Tools:** Shovels, spade, fork, hoe, hammers, machete, rake, saw, tags, seed dibbler, media filter, media mixture, vegetative propagation tools e.g. secateurs, and grafting knives and assorted garden tools.

3.4 Soils: potting media and mixtures preparation

Successful seedling production practices is anchored on suitable potting media. Seedling growing media should be light in weight, well decomposed and well drained and free from insects as well as weed seeds. Potting soils should be fertile, well draining preferably collected from the forest or under trees along the fence in the farm. Steps to collecting good potting soils:

i. Identify suitable soil collection spots

ii. Clear the surface to remove off all plants and litter before digging the topsoil

iii. Dig the top soil rich in organic matter using a hoe preferably 15-25 cm deep

iv. Transport the collected media to the nursery site

v. Sieve the soils to remove undesirable materials, e.g. stones and sticks before storage in the nursery (Figure 6).

Several materials and combination of different materials are available as media for germinating seeds, raising seedlings in pots and rooting cuttings. A good propagation medium should be firm and dense to hold seedlings, cuttings or seeds in place during potting, rooting or germination. They should retain sufficient moisture but be sufficiently porous to permit excess water to drain away and promote proper root zone aeration. It must be free from weed seeds, nematodes and pathogens. Including compost in the posting media not only increases nutrient content but also enhances the air spaces and water holding capacity of the mixture. Nursery manager should determine appropriate potting mixture based vailab;e soils type. Usually quality forest soils with good organic matter content would not require soild amendments. However bulk soil types with clay may require amendments to promote aeration of water holding capacities. Common potting growing media ratios of any measure may include: two buckets of forest soil, one bucket of compost or manure, one bucket of sand (ratio of 2:1:1, respectively) mixed together thoroughly (Figure 7B).

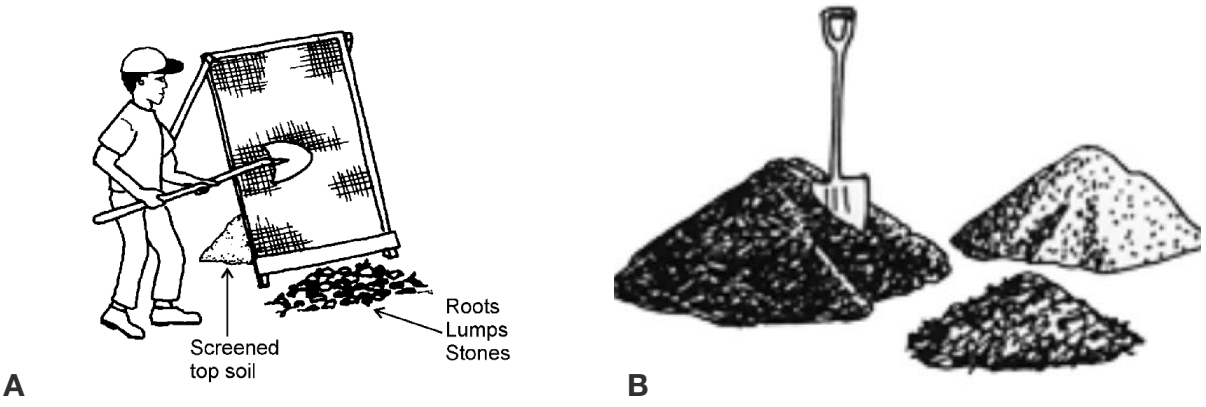


Figure 7: *Sieving soil (A) and potting ratio (B)*

This mixture is used to fill the seedlings containers, such as polytubes, pot trays or polybags, to provide a good source of nutrients for new tree seedlings. The forest soil give sufficient moisture holding capacity to promote good germination whereas the sand provides porous texture for good root penetration of the germinating seeds and easy to lift when pricking out. Compost/manure supply organic matter and nutrients to of the

potting mixture and enhances the air spaces and water holding capacity of the mixture. It can easily be prepared by decomposing organic materials (green leaves).

3.5 Soil solarization

This is a technique involves sterilizing of the growing media using the heat of the sun. This technique will kill most pathogens in the soil and appears to favour the build-up of micro-organisms that are beneficial to plants. Some tough weed seeds may not be killed. Steps to conduct soil solarization:

i. Moisten the medium to normal potting texture.

ii. Spread it evenly on a concrete slab, or a thick sheet of plastic, to a thickness of 10 cm in direct open sunlight (Figure 8). Cover the soil medium with clear polythene sheeting.

iii. Seal down the edges with soil, stones or logs to prevent loss of heat and moisture. The required time of treatment varies with the daily temperature variation ranging from 1-6 weeks.

Figure 8: *Solarisation of growing medium*

Potting containers: Locally available container materials e.g. milk packets, clay pots or bamboo stems can be used. Polythene bags with holes punched in the bottom for drainage and filled with a potting or rooting medium are used for propagation in the

nursery beds or mist chamber. Seedlings are transplanted in these polythene bags in the nursery to kept them till they attain required growth for transplanting to the main field.

When to fill the tubes: Ideally, the tubes should be filled one month before seed sowing.

How to tube fill: Take the soil mixture and moisten it by sprinkling some water on it, ensure it is neither too dry nor too wet. Open the polybag and place one open end on the ground. Fill soil to half depth and firm down strongly with your fingers to form the bottom of the tube. Then gently fill the rest of the tube to the top with the compost mix. Take the tubes and arrange in their final position. The above mixtures should be keep moist and left to mature for 2-4 weeks before use.

With the current ban of polythene tubes and polythene sheets in some of the countries like Kenya and Rwanda have passed policies restricting use of polythene bags. Alternative containers for propagation and growing young plants are being used even though still not widely adopted due to availability and cost implications. Some of the alternative commercial containers are:

Earthen pots: They are made of burnt porous clay in various sizes to provide requisite amount of soil and root space to different kinds and sizes of plants (Figure 9). They have straight sides and are made wider at the top than at the bottom to hold the greatest bulk of compost where the feeding roots are and also to facilitate easy removal of soil, intact with roots (ball of earth) at the time of planting or repotting.

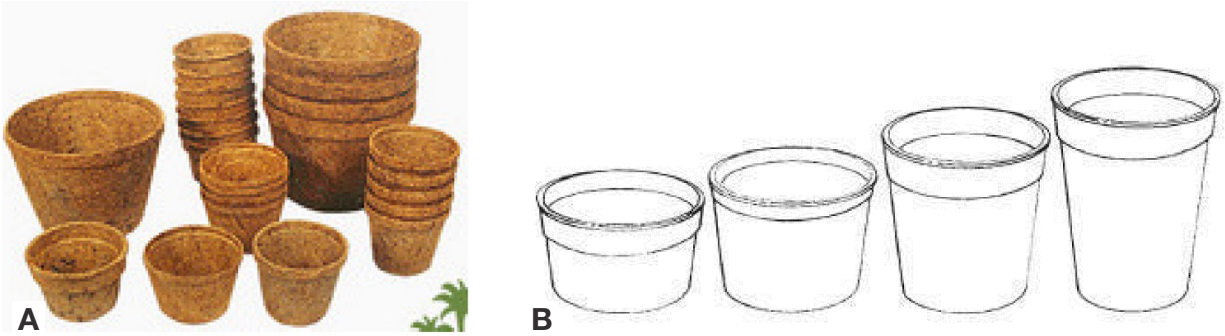


Figure 9: *Earthen ware pots*

Seed pan and seed boxes: Seeds pans are shallow earthen pots about 10 cm high and 35 cm in diameter at the top. They have one large hole for drainage in the centre or 3 holes at equidistant from each other. Seed boxes are made of wood 10 cm deep, with holes drilled in the bottom.

Plastic pots: Plastic pots, round and square are used to keep mostly indoor plants (Figure 10). They are reusable, light weight, non-porous and they require only little storage space

Figure 10: *Plastic container pots available in market*

4. MASTERING KEY NURSERY OPERATIONS

4.1 Seed Propagation

Seed propagation is the most common means of producing seedlings for agroforestry and other tree planting activities. It has many advantages:

i. **Cost:** plants grown produced from seed are inexpensive.

ii. **Ease of propagation:** propagation by seed is simpler and easier than vegetative propagation.

iii. **Seedling vigor:** Plants grown from seeds often grow faster than those produced from cuttings.

iv. **Phytosanitary restrictions:** It is easier to import and export seeds than vegetative material or whole plants.

4.1.1 Seed collection and sourcing

Source of Seeds: Seeds or any other planting materials should only be purchased from reputable and tested suppliers like seed centres or directly from producers. Consignments should be accompanied by at least a minimum information such as type of seed, source, date collected and expected germination percentage. Seeds are normally ordered well in advance of requirement at least 6 month to one year. Seeds can also be collected locally from healthy selected trees (Figure 11). Seeds are best collected from fully mature or ripe fruits before the fruits have begun to decay with postharvest diseases. Seeds from the

larger fruits generally produce the most vigorous seedlings. If seeds are collected from the ground, look carefully for insect attack or disease. It is always preferable to collect from the tree to ensure better quality and cleaner seed. A simple record of seed sources collection can be maintained as shown in Table 1 to help track performance.

Figure 11: *Faidherbia albida fruits being dried and stored (A) Calliandra calothyrsus seeds from a farmer (B)*

Table 1: Example of a seed collection form for farmers

SEED SOURCES RECORD			
Species Name:	**Date collected:**	**Seedlot No.**	**Collected by**
Location……GPS Coordinates……..			
Flowering time……Seeding time…….			
Seed trees:			
Number……..Height…….. Diameter…….			
Associatedspecies……			
Weight collected……....Seed germination %.....Seeds/kg……			
Other information or comments e.g. presence of pest and diseases			
Seed Use:			
Date	Consignee	Amount sent	Amount remaining

Quantity of seed to be ordered: To determine the quantity to be ordered the various losses (in the nursery and field) and culling rates should be to be considered in addition to the potential total seedlings required in the field. The number of seedlings or plants required to be produced from a nursery can be calculated as below:

i. Number of plants required for that season = W
ii. Mortality in nursery = X
iii. Transportation/culling loss = Y
iv. Seedlings requirement after buffer loss = Z
v. Total seedlings required to be produced from the nursery = W + X + Y + Z

4.1.2 Seed pre-sowing treatments

Pre-sowing treatment is done for seed that do not germinate easily to improves the uptake of water and lessens germination time. This ensure rapid, uniform and timely seed germination that facilitates seedling production. Appropriate pre-sowing treatment methods depend on the dormancy characteristics of the seed being treated. Some of the common pre-sowing treatment methods are discussed below:

i. **Soaking in cool water**: Soaking in cool water is applied to overcome the physical, mechanical or chemical seed dormancy for some species (Figure 12). Most often seeds are soaked in water for one day, while seeds of a few species may require soaking for two days. This method is for example applied on seeds of *Sesbania sesban*, *Tamarindus indica*, *Gliricidia sepium, Faidherbia albida* and *Dalbergia sissoo*.

Figure 12: *Seeds pretreatment: cold water method*

ii. **Soaking in hot water:** Seeds with hard, thick and waxy seed coats are treated with hot water to overcome the physical dormancy. Boiling water is added to seeds in a container and left to cool overnight (Figure 13). This method is applied to hard coat seed such as *Acacia* species, *Calliandra calothyrsus* and *Leucaena spp.*

Figure 13: *Seeds soaked in hot water*

iii. **Mechanical (scarification) methods:** This technique is used to overcome physical and mechanical dormancy for seeds with hard and thick seed coats. A small hole is scrapped or cut on the seed coat with a nail clipper, knife, metal file or abrasive material to allow water absorption (Figure 14). After scarification, seeds are usually soaked in cool water for some hours or overnight. This method can be used as an alternative to the hot water pre-treatment. Some fruits with hard woody shells such as *Melia volkensii* and *Sclerocarya birrea* may require a nut cracker equipment or hammers to crack the shells.

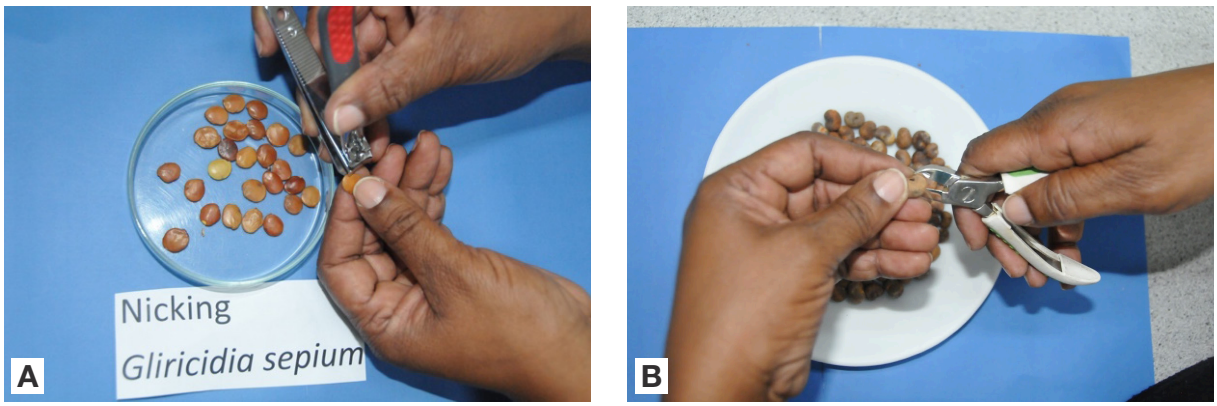


Figure 14: *Seed nicking with clipper*

4.1.3 Seed sowing

It is important that seeds are sown in time to attain plantable sizes (20 cm – 30 cm) by the onset of rainy season. Do not sow the seed too deep in the soil as it can affect seed germination. As a rule the thickness of soil cover layer should be equal or proportional to seed size; a thin layer of soil should be used for small seeds. There are several methods used for seed sowing:

i. **Broadcasting:** Seed is spread on top of the nursery seedbed, either by hand or a mechanical broadcaster. This mainly applies to small seeds sizes that are fine and light such as Eucalyptus, Casuarina. They are usually mixed with sand and uniformly broadcasted on the seedbed to avoid overcrowding.

ii. **Drill-sowing:** Make ruts or drills in the seedbed media and drop seeds in and lightly covered with the seedbed soil mixture. This mostly applies to small-sized seeds such as those of cypress, eucalypts, casuarina and others within that range.

iii. **Direct sowing:** Large sized seeds can be planted directly into containers or to the field. Some trees/shrubs can be established by sowing the seeds directly into an area or field where they are to grow until harvest time. This method can be done in areas, which receive reliable rainfall. Direct sowing can be a good method for species and technologies, which require very many trees/shrubs, e.g. live fences, dense woodlots and improved fallows.

    In the nursery, 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. This method also allows undisturbed seedling growth and therefore reduces stress for the seedlings (Figure 15).

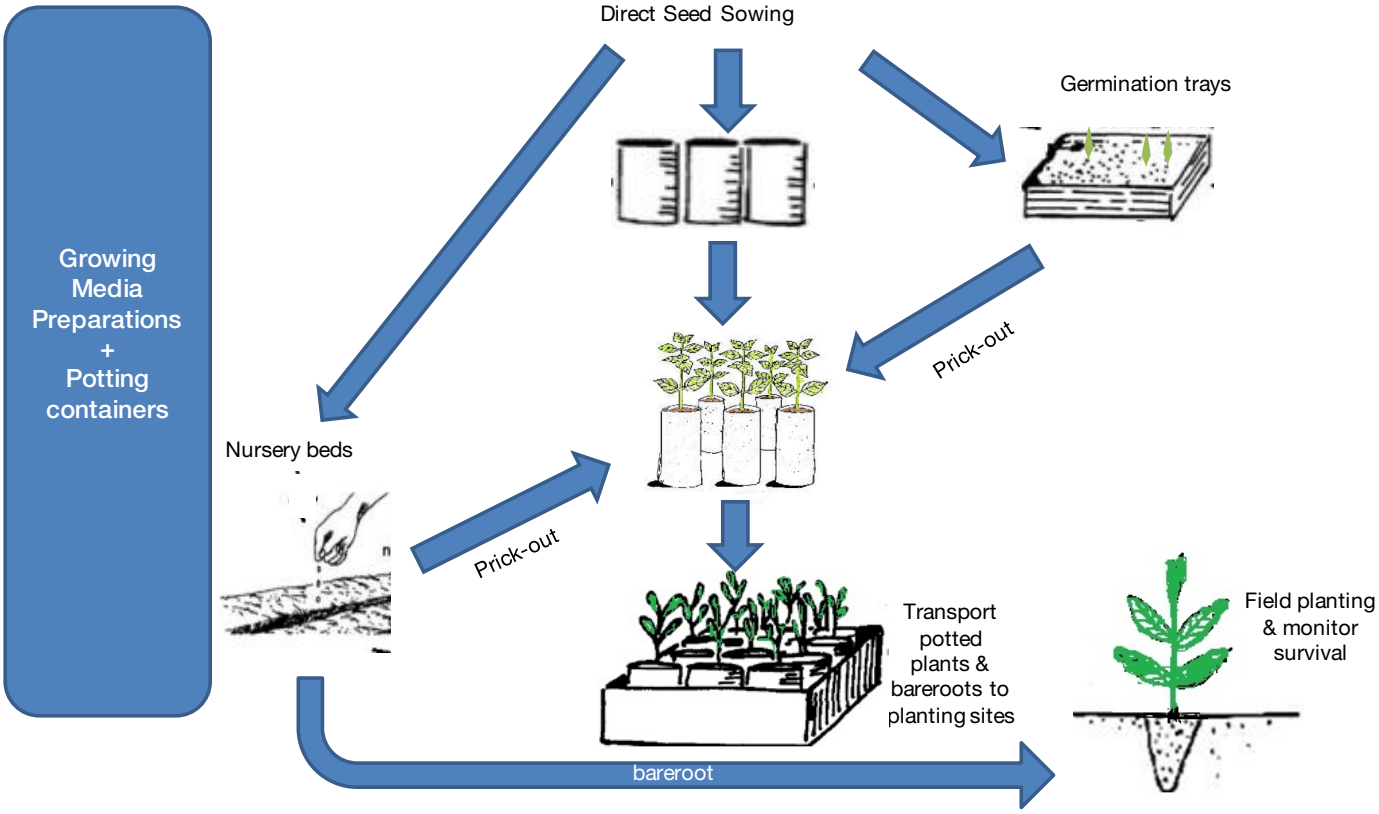


Figure 15: *Nursery process for seedling production*

Filling seedling containers:

When to fill the tubes: Ideally, the tubes should be filled one month before seed sowing to stabilize the media (to allow the weed seeds in media to germinate and avoid competition with targeted species).

How to fill seedling containers: Take the soil mixture and moisten it by sprinkling some water on it, ensure it is neither too dry nor too wet. Open the polybag and place one open end on the ground. Fill soil to half depth and firm down strongly with your fingers to form the bottom of the tube. Then gently fill the rest of the tube to the top with the compost mix. Take the tubes and arrange in their final position. The above mixtures should be keep moist and left to mature for 2-4 weeks before use

4.1.4 Transplanting or pricking out

Transplanting or pricking-out should be done once the seedlings have 1-2 pairs of leaves. When transplanting, it is important to minimise shock by not letting the radicle grow too long to transplant without being damaged or distorted:

i. Water the seedbed and potted containers properly before commencing the operation

ii. Hold the young seedlings by the leaves and insert a stick or dibber underneath the root system to loosen the soil

iii. Pull out the seedlings gently and immediately put in the container with water (Figure 16)

iv. In each container, make a hole in the soil mixture with dibber large and deep enough to take the seedling root without distorting it.

v. Remove one seedling at a time from the tray, holding it by the leaf and not the stem. If the root is too long shorten it by cutting to a manageable length. Place the seedling in the prepared hole, ensuring that the root is not distorted, and bury the seedling slightly deeper than it was in the tray.

vi. Firm the soil around the seedling roots using your fingers to cover the hole you made. This ensures that all the air pockets around the roots are closed

vii. Gently water the containers properly once more.

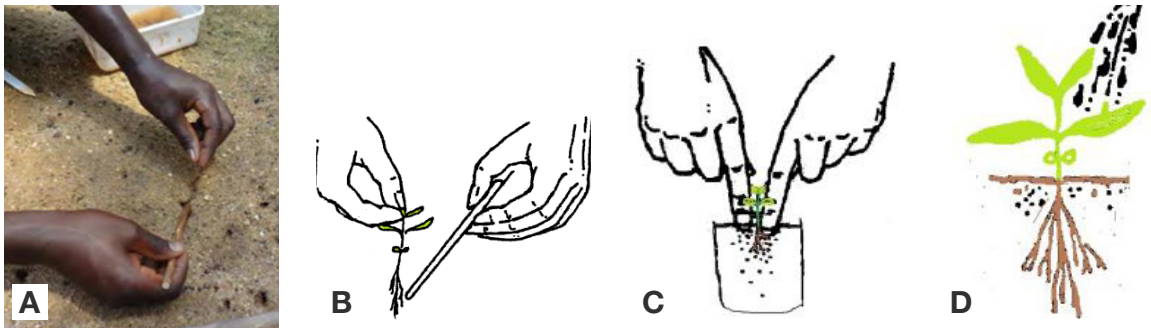


Figure 16: *Pricking-out seedlings from the germination beds with a dibbler, planting out in pot and watering*

4.2 Shading

Nursery plants need to be protected from extreme environmental conditions until they are strong enough to withstand them. It is necessary to shade the plants from direct sunlight for two to three weeks after pricking-out, to also provide an additional safeguard against watering irregularities. During germination, most plants require 40–50% shade, though some species may require more or less. A good nursery practice is to regulate the amount of shade and water together. When plants are in heavy shade, they require less water. When plants are in full sun, they require more water. Shade should be removed as the

plants grow. A good nursery practice is to accustom the plants gradually to full sun. During the course of 10 days, remove the shade partially for first two days then completely. Start by removing the shade during the early morning or late afternoon.

This process is part of hardening-off to help plants become accustomed to field conditions and minimise transplanting shock. A poor, but unfortunately common nursery practice is to remove the shade at once on a hot, sunny day, burning the plants.

Shade benefits

i. reduces water loss in the soil (evaporation) and leaves (transpiration).

ii. reduces the temperature of the plants and of the substrate.

Plants grown under too much shade often have the following characteristics:

i. they are stunted and grow slowly, or they are tall and skinny with a soft stem which

ii. does not become woody

iii. their leaves are either dark green or, in very dark conditions, yellow

iv. they are susceptible to disease or insect attack

v. they are easily sun burnt when taken to the field.

Shade construction

Different types of materials such as palm leaves, bamboo, shade cloth, and grass woven into mats can be used to provide shade. Shade cloth or netting of between 30% and 60% shade can also be used. Ensure shade nets are UV-stabilized so that they don't deteriorate quick. Enforced metal rivets, a more expensive option may be used for fastening shade net to a support. Mats must allow rainwater and light to flow through evenly. A good nursery practice is to repair, adjust, and replace shade material in time to prevent damage to plants.

The height of the shade above the plants influences the shade's effectiveness. When placed 2 m above the plants, it is easier for the workers to water or weed, but it might allow too much sunlight in from the sides. A good nursery practice, is therefore to adjust the height of the shade to the sun's movement throughout the day. If the bed length runs from east to west (which we recommend), then the shade can be fairly high. If the beds run north–south, the shade should be fairly low and should cover the sides of the beds so that plants on the sides of the bed are protected from full sunlight throughout the day.

Good nursery practices

i. cut back the branches of natural shade trees
ii. repair and replace shade material in time to prevent damage to seedlings
iii. regulate the amounts of shade and water together
iv. align beds or rows of plants with the sun's path
v. add shade to the sides of the bed, or let shade cloth overhang, if sun is directly on plants most of the day
vi. gradually remove the shade as the plants grow
vii. observe how the plants react to shade removal and adjust your treatment as necessary

Poor but common nursery practices

i. maintaining the seedlings in shade during the entire nursery production
ii. applying too much shade- plants will grow more slowly and are more susceptible to diseases
iii. aligning plants opposite the sun's path
iv. removing the shade too quickly and burning the plants

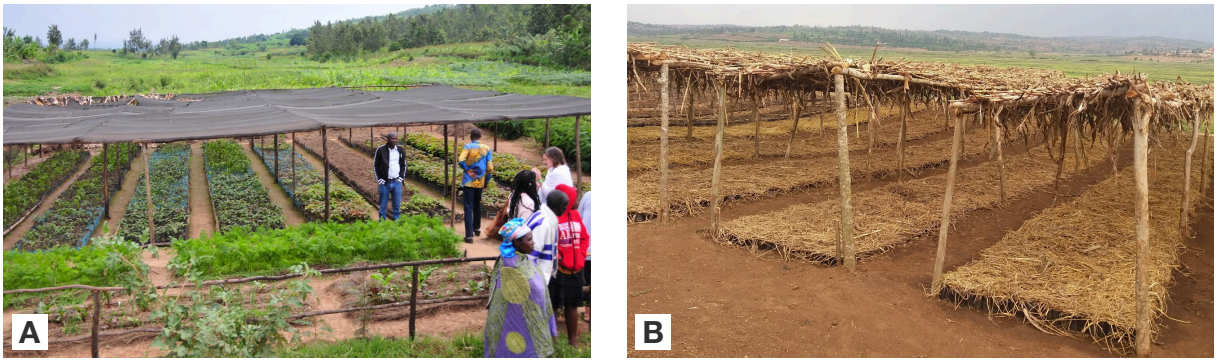


Figure 17: *Shaded nursery area using different materials: Shade netting (A) & Grass and banana sheaths (B)*

4.3 Watering

Regular supply of clean water is essential for plant growth (Figure 18). The amount of water seedlings require depends on; seedling age, local temperatures, soil type and turbulence (presence of wind). Poor watering regimes and practices will lead to poor quality seedlings. Water early in the morning and / or late afternoon. Keep the growing

media moist but not wet. Avoid using salty water or dirty water as it contains many plant diseases. Regularly check the water status of the leaves and feel the media wetness to determine when to water. If the soil is covered with green moss or algae that mean you are watering too often. Watering plants regularly during the dry season is far more important than fertilizing them.

Figure 18: *Watering seedlings*

4.4 Weeding

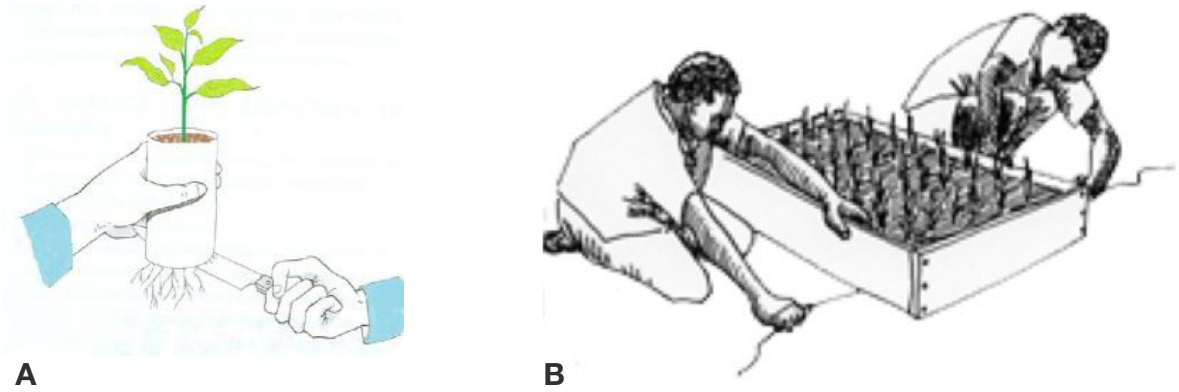
Weed control is important for a rapid and vigorous plant growth. Weekly weeding operations should therefore be scheduled to ensure potted plants are completely free of weeds as they compete for nutrients, moisture and sunlight. This practice also helps promote hygiene conditions in the nursery. Removing weeds is easiest when they are small to avoid seedling root damage when they are removed. Grass next or around the nursery should always be kept short to prevent weeds from seeding with subsequent dispersal of seeds into nursery pots.

4.5 Root pruning

Root pruning is the cutting of roots to control root system development beyond the container: Water the seedling properly before root pruning. Using a sharp knife cut the

long roots underneath the container or a wire under nursery beds. 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.

You can simply, move the bags from one bed to another each month as a way of air pruning the roots. With boxes as nursery beds, cut the soil into squares. Use strong wire (e.g. a fine guitar string!) to prune the roots under the Swaziland beds or cut the soil into squares (Figure 19). Keep seedlings shaded and water regularly.



A B

Figure 19: *Root pruning individual seedling (A) and (B) using a wire to prune a whole bed*

4.6 Pests and diseases in the nursery

Pests and diseases can be a source of plant losses in nurseries if left unchecked. Regular checking allow fast corrective action in case of pest and disease break-outs. Most pest and disease problem can be avoided by correct management practices, early detection and prompt control measures.

Nursery managers need to apply good management practices that reduce pests and diseases problems. Most micro-organisms, insects and pests that cause diseases live in weeds, trash and puddles. Therefore, keeping nursery working areas neat and in clean condition helps to reduce chances of seedlings attack by common pests. All trash, waste, polythene bags and diseased plants should be immediately removed and burnt far from the nursery.

Pests may eat tender shoots of newly germinated seedlings, in some causing severe damage. More direct control methods can involve laying of poison baits.

Common pests include ants, crickets, grasshoppers, nematodes, snails, caterpillars and red spider mites. Common diseases agents include viruses, fungi and bacteria. In vegetatively propagated plants, virus-infected plants may lead to impairment of plant vigour, hardiness and graft incompatibility, among other problems. Fungi infections such as *Pythium spp* can cause dumping-off disease for germinating seeds. This problem is worsened in temperatures below 25 ^{O}C and high moisture conditions which may be due to over watering nursery beds or pots.

Pest presence could be detected by observing hosts living in seedlings pots or under the leaves or in stems. Signs of fungus problems could also appear on soil surface, on stem or leaves. For animal pests feaces is often a lead sign. Various pest and disease causal agents such as bacteria, fungi, viruses and insects can be prevalent based on particular season of the year as shown in Table 3.

Table 2: Pest and disease causal agent and season when common

Causal agent	Season
Bacteria	Hot season
Viruses	Cool weather (when leaves are first expanding)
Insects	Year long
Fungi including leaf spots	Hot season

By spending time observing happenings in your environment one should get clues on what to do to keep weeds, pests and diseases under control. Diseases can also be a product of the surrounding environment and/or nutrients, minerals and trace elements deficiencies. So replenishing plant needs with a conditioner or fertilizer and simply cutting back damaged part to help rejuvenate new growth.

There are a number of measures that can assist in reducing incidence and severity of pest and diseases in the nursery. Whenever possible, budget for raised beds to place seedlings so as to minimize chances of disease spreading from the ground soil into the pots/containers, and to keep seedling production areas clean. Make sure there is good airflow around the seedlings. Pathogens can multiply quickly in still, humid conditions, with tightly packed plants.

It is always best to avoid the use of chemicals and only use as a last resort after alternative methods are exhausted. When insecticides, fungicides, and additives are used, several safety considerations must be adhered to:

i. Use of pesticides should be regulated to promote safety and good health of both workers and plant materials;

ii. Always read the label instructions carefully before mixing and follow safety directions on proper doses;

iii. Gloves and appropriate clothing must always be worn when mixing and applying;

iv. Protective gear such as clothing, mask, gloves and goggle and respirators will be necessary when spraying chemicals;

v. Application is carried out safely avoiding windy days; Equipment should be cleaned after each use. Never mix insecticides and fungicides together in the same sprayer. Never eat, drink or smoke while spraying. Never use pesticides containers to store other things;

vi. Extra chemicals should be stored safely.

Common pesticides available in the market are: Diazinon. Melathion, Sevin

Common fungicides: Bavisteen. Benlate, Captan, Dithane M-45

Natural insecticides: Neem seeds- Make powder of 500g dried neem seeds and soak overnight in 15 litres tap water. Sieve it twice and spray. Besides this, chilli powder and tobacco leaves powder can also be used. They generally take a little longer to repel or kill insects, therefore, apply them immediately when insect problem is noticed. The main advantage is that they are natural, hence safe and biodegradable.

It is certainly worthwhile to train nursery workers to recognize the symptom of more common pests and diseases in the nursery. This training provides an “early warning” system on any outbreak before widespread disease problems occur.

4.7 Grading or culling plants

It is good practice to have even-sized plants of a given species grouped together in the nurseryto allow for even competition between plants for light and water in order to produce a more uniform stock. It also makes the nursery look neater and more orderly (Figure 20). Seedlings produced at closer spacings grow taller and have smaller stem diameter; while seedlings produced at lower densities have physical and physiological properties that lead to improved out planting performance.

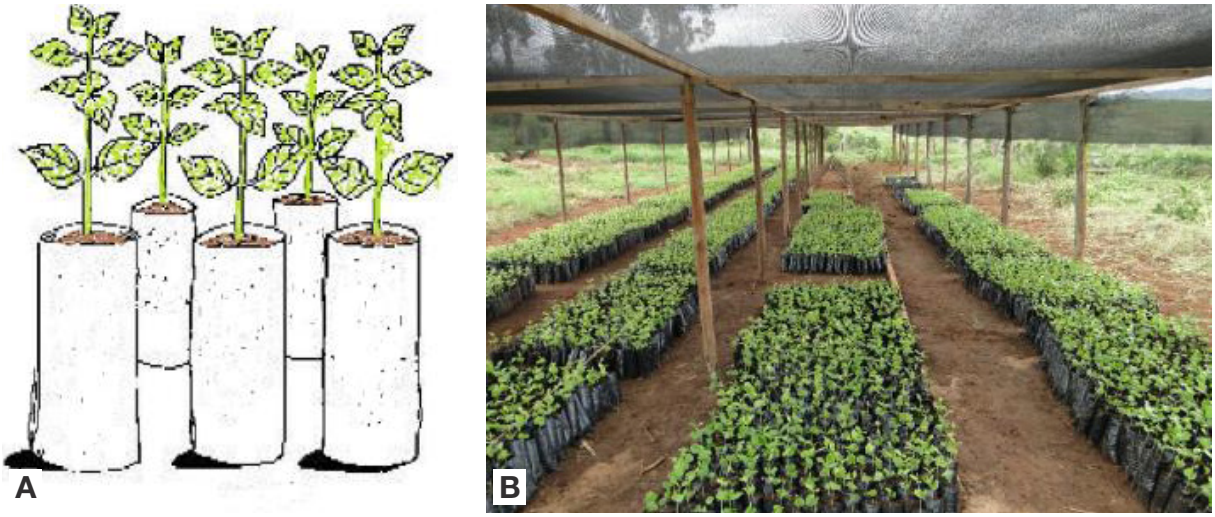


Figure 20: *Grading seedlings according to their sizes and health*

Figure 20 C: *Poor nursery pots arrangement in the nursery leading to uneven nursery stock*

Every month you should go through the seedlings of each species and:

i. Discard any diseased, malformed or stunted seedlings. These seedlings will only take up space and time in caring for them, and will probably never achieve the

quality required to ensure out-planting success. The earlier sub-standard seedlings are discarded, the more efficient a nursery becomes.

ii. Put different sized seedlings of each species into separate groups. Seedlings will naturally grow at different rates but eventually the faster growing ones may suppress the weaker ones by competing for light and deflecting irrigation water away from them. Medium and small-sized seedlings, that have been separated out, may need to be held for several weeks longer before planting out (this does not apply to cull seedlings which must be discarded without hesitation).

Poor management practices such as inadequate watering, can cause an increase in defective seedlings and therefore unnecessary losses.

Seedlings or materials being distributed should be labelled. The period between collecting from nursery and transferring to restoration sites or farms should be as short as possible to to improve seedlings survival rates in the field.

4.8 Hardening off

This is the gradual preparation of seedlings for field conditions. It involves cutting overgrown roots, reduction of watering intensity and frequency, and opening shade to expose seedlings to more sunshine (Figure 21). Good preparation for out planting results in good field survival. Hardening off should be done 2 – 3 weeks before out planting time.

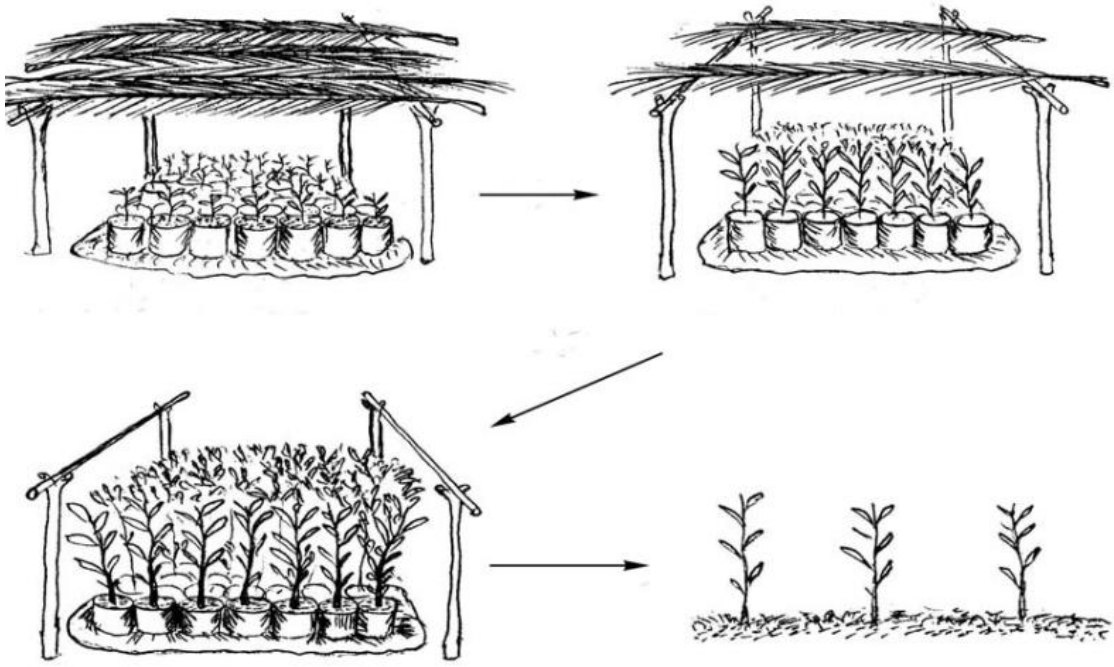


Figure 21: *Hardening off the seedlings for planting out*

5. RECORD MANAGEMENT

Nursery records are essential to allow effective control of plant stock maintained at nursery. The nursery manager should always be aware of the status and movements of plants through the nursery.

Seedling numbers in the nursery should be monitored regularly so that the nursery manager always knows how many seedlings he has in stock and of what species. To have accurate stock control production, deliveries, discards and transfers records should be kept.

Up-to-date records of all purchases e.g seed, chemicals, media; observation data e.g sowing, germination dates and growth; labor engagement and attendance; sales, pest and disease outbreaks; permanent and temporary stocks (including species, seedling stocks) and movement register should be to be maintained.

Expenditure and income records are recorded in different book such as purchase book, sales book, ledger, cash book and dispatch register.

It is advisable to maintain books of accounts for the following reasons:

i. They provide up-to-date nursery business information and guideline for planning
ii. They help to analyze the performance of nursery activities

5.1 Tree nursery calendar

A nursery calendar is simply a schedule of activities to be conducted at the nursery throughout the year (Table1). The schedule may vary from place to place and helps the nursery manager to know specific activity to be conducted on a monthly basis. The calendar helps in scheduling:

i. Fresh seed procurement
ii. Soil collection in good time to cure (1-3 months)
iii. Manure collection in time to mature (1-3 months)
iv. Mixing of all parts of soil potting media to cure before use (1 month)
v. Timing of seedlings production to grow to required size
vi. Seedling hardening period
vii. Planting stock inventories
viii. Tools and equipment maintenance

Table 3: An example of a tree 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						■	■					

The time to start tree nursery work depends on the anticipated time of planting out. Seed sowing schedule helps determine how long seedlings will take to attain optimum size before field planting. Enough time should be allocated for the seedlings to grow to field planting sizes (20 cm – 30 cm) in order to ensure high survival. Seedling production generally starts 2-4 months before planting in the field (when trees are being cultivated in bags) however this time varies by species. Plants grown from clones or indigenous species may require up to 6 months or more before planting out in the field. In areas where there is a long, harsh dry season, you should time your tree nursery production to plant your trees in the field as soon as the rains commence.

5.2 Online Nursery Information and Sales Systems

Nursery Management Information System (NMIS) can be developed through mobile platforms to support nursery records. The Regreening Africa application downloadable on google play store, is one such application for use. Overall, Apps can be used to track seed collection, storage, sowing of seed, seedling inventory, seedling lifting, grading and culling, packing of seedlings for storage, shipment and distribution of seedlings. Interactive mode with clients, customers and farmers can be linked with the system on real time showing the species and stock availability. This can also improve the marketing strategies of nursery system.

5.3 Seedlings pricing and sales

Examine the level of demand for your tree nursery's services in your business plan. List farmers and landscaping or environmental organization needs in your area to show the

number of prospective customers. Devote space in your business plan to reconcile your start-up budget with the costs of wholesale trees, wages and other costs over the first year.

Establish your tree and accessory prices before opening a tree nursery. Create pricing for individual trees and bulk purchases to encourage businesses and developers to acquire dozens of trees with each trip. Calculate the hourly wages of your teams and add a slight mark-up when pricing your delivery and transplant services.

6. FURTHER READING

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