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On tree nursery establishment and management

GY Keneni* **and GS Zeleke**

Department of Forestry, College of Agriculture and Veterinary Science, Ambo University, Ambo, Ethiopia

*Corresponding author. E-mail: yadasa2021@gmail.com

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ABSTRACT

Tree-planting is the process of planting tree seedling generally for forestation, reforestation, or ornamental purposes. Trees contribute to their environment over long periods of time by providing oxygen, improving air quality, climate amelioration, conserving water, preserving soil, and supporting wildlife. During the process of photosynthesis, trees take in carbon dioxide and produce the oxygen we breathe.

Tree planting has become one of the international issues, because of it is the only solution to the world threat global warming and climate change. Seedling production is the basic requirement for launching tree planting and forest development. The quality of Seedlings is a major factor that determines the success of tree survival and reforestation programs. The survival of trees, growth, volume and quality of timber are greatly influenced by the quality of seedlings. The quality of seedling is defined by its genetic composition and physical characteristics. The quality of seedlings has a profound effect on the growth performance of planted trees. A low quality seedling is not worth planting because it will always produce a low quality tree, even if it is provided with the appropriate silvicultural treatments and planted in an appropriate site. Further, the plantation maintenance cost of low quality seedlings can be high due to high mortality and more intensive management requirement. By establishing and managing forest tree nursery, it is possible to produce seedlings.

The objective of this manual is to provide information and guidance on how to establish and manage a forest tree nursery and on how to produce seedlings for different purposes. The manual is special interest to nursery workers, nursery supervisors, and foresters, those involved in planning and managing the production and use of forest tree seedlings for any of the above mentioned roles and benefits.

Keywords: Forestation, Reforestation, Climate amelioration, Nursery workers, Silvicultural treatments

INTRODUCTION

Development in plantation forestry begins with the production of good quality seedlings. Forests play many roles and confer a multitude of benefits to society such as food, shelter, shade, timber, natural beauty to the countryside, conservation of our soil and water resources and improved air quality. In fact, next to food, wood is the most basic necessity and important commodity requirement. The forest sector is expected to play a great role in the ongoing effort to attain economic growth in general and assure food security and poverty reduction in particular. Seedling production is the basic requirement for launching tree planting and forest development. By setting-up forest tree nursery, it is possible to produce seedlings. A nursery is a safe area where young plants grown under controlled condition in order to produce strong, healthy and hard seedlings for planting out them in the field. A good nursery will protect young trees and provide them with the best possible conditions for survival and growth. Designed in the right way, even a very basic nursery can provide you with the space and facilities needed to grow your target number, size and quality of trees. a high quality seedling provides minimal plantation cost because of low seedling mortality and the less intensive management needed. Further, the planting of high quality seedlings provides early return on investment because they have more rapid growth, thus rotation age is shortened, a tree nursery is a managed site, designed to produce tree seedlings grown under favorable conditions until they are ready for planting. All nurseries primarily aim to produce sufficient quantities of high quality seedlings to satisfy the needs of seedling users. Users include the nursery operator themselves, individuals, community organizations, farmer groups,

government agencies, non-government organizations, corporate or private customers (Davidson et al., 1988).

Objective

The objective of this manual is to provide information and guidance on how to establish and manage a forest tree nursery and on how to produce seedlings for different purposes.

The manual is special interest to nursery workers, nursery supervisors, and foresters, those involved in planning and managing the production and use of forest tree seedlings for any of the above mentioned roles and benefits.

MATERIALS AND METHODS

Nursery Site Selection and establishment

Factors for site selection: Choosing the best possible site based preliminary survey of potential areas precedes establishment on a new nursery. The use of available maps may facilitate identification of sites. The selection of a site for a nursery should be done with considerable care and thought. Careful analysis before establishing a forestry nursery will pay off. Before deciding to establish new nursery the following basic question can help in determining the objective.

The criteria for choosing the nursery site will be affected by the type of nursery to be established.

Questions you should have to be answer before site selection

- What are the characteristics of the forestation area (remote or easy access)?
- What are the market prospects?
- Will the nursery compete with already existing nurseries?
- Can already existing nurseries provide the needed planting stock?
- Are labors and trained personnel available?
- What equipment is available on the local market?
- What is the legal framework for establishing a nursery (legal requirement for a commercial production employment practices, land ownership)?

Important Factors Nursery Site Selection

- Ecological factors
- Economic factors
- Sociological factors
- Biological factors

Evaluating factors and deciding type of the nursery: Evaluation of sites against the above-mentioned factors can be made by giving different weights for each factor and by rating andscoring the site against these factors. Once we finished the rating, the site that scored the highest can be selected for the nursery site (Table 1).

Table 1: Nursery site selection factor evaluation summary.

Main factors	Sub-factors	Criteria to be select
1. Ecological factors	Altitude	Consider the respective sowing time of species.
	Climate	Areas with extremes of temperature, areas subject to wind, hail or ice storms should be avoided.
	Topography	Relatively level and without large stones and rocks. Ideally with a 2-5% slope is most suitable for a nursery site.
	Soil	Fine particle size 12 mm, good porosity 10%, moisture content 21%-40%.
	Water	Available throughout the year. pH should be between 5.5 and 7.
2. Economic factor	Land	Large enough to allow the yearly production, traditional rights to use the landowner of the land and agreement.
	Labour	Enough number of people who are willing to work.

	Facilities	Transportation facilities, good communication (roads, telephone lines), electric supply, housing for staff and labourers.
3. Sociological factor	Increased population	May depilate seedlings, brings water shortage.
	Wealth	Ablity to buy seedlings or chance to get labours.
	Acceptance of the product	Unaccepted seedlings in community traditionally, environmentally, economically brings bankrupt.
4. Biological factor	Insect	Prensence of insectst that damage seedlings e.g. locust.
	Disease	Presence of disease e.g. rust.
	Weed	Presence of invasive and heavily distribute weed.
	Termites	Presensce of termite, red ants.

Types of Nurseries

If conditions allow us establishing the nursery, we have to set the objectives:

- The required production output per year.
- Permanent or temporary.
- Bare root or potted seedlings.
- Mechanical or manual production.

In this manual, two broad types of nurseries are recognized, namely:

- Temporary nurseries/satellite nursery/small scale Nursery.
- Permanent nurseries/large scale nursery.

And two seedling types, namely:

- Bare root seedlings.
- Potted seedlings.

Categories of nurseries by ownership: Depending on the size and production capacitynurseries can be categorized by ownership (Table 2):

- State nursery.
- Community nursery.
- Private nursery.

Table 2: Categories of nurseries by ownership.

Ownership	Minimum land size	Production capacity
State nursery	0.75 ha	More than 50,000 seedlings
Community	0.5 ha	More than 20,000 seedlings
Private nursery	0.25 ha	Than 5000 seedlings

Nursery Site Preparation

A new nursery can be prepared in the following way:

As soon as the site has been selected, work can start to convert the site into a more or less level area if the topography permits.

- Fell all (site cleaning).
- Plough the area.
- Peg out location of the blocks and roads.
- Level each block, using a levelling.
- Board with rakes.

Nursery fence and hedge: Nurseries are usually surrounded with a fence or a hedge to demarcate the boundaries and to protect the area against animals and to some extent against wind.

A fence may be constructed when protection is needed immediately. It is quick to build and needs very little

maintenance afterwards provided that it is constructed with proper materials. The disadvantage of a fence is that it is expensive. If impregnated (treated with rot preventing chemical) posts and barbed wire are used, it has a shorter life than a hedge and usually gives no protection against winds.

Nursery hedges: A hedge is a one or two rows of seedlings planted in a straight line. Hedges can be planted along the boundaries of the site in area where more protection against wind is needed. Seedbed blocks and other blocks inside the nursery can be surrounded with low hedges too.

A hedge has a disadvantage in that it takes 2-3 years to grow it to full size. It also needs continuous and regular tending. Usually it has to be clipped at least twice a year. The hedge has several advantages including:

- It is cheap to establish.
- It has long life.
- It gives good protection against animals and winds.
- A well maintained hedge is also pleasant to look at.

A good hedge species has the following characteristics

- Fast growing.
- Able to grow in a very restricted space.
- Able to withstand repeated clipping.
- Evergreen looking.
- Long lived.

Design and Layout of a Nursery

Since selected sites are factors for many parameters (land availability, slope, existence of mulchin materials, access to water, availability of labors) there may not be specified standard layout for nursery. An ideal form for a nursery is from square to slightly rectangular which is cost effective. The nursery should, if possible square shaped to minimize the boundary lines which have to be fenced, and to keep the distance between any two places in the nursery at a minimum. If not, rectangular shape is convenient. For smaller nurseries, a rectangular shape with blocks splitted along the longer side of the nursery beds may be economical and convenient (Munjuga et al., 2013).

While in Designing, we have to consider various components of nursery.

These include:

Production areas: These areas designed to carry seed and seedlings, seed beds, transplanting beds, reserved beds.

Non production areas: Buildings, roads, secondary (access roads), path, fences, wind breaks, boarder effect, different operational areas.

- Soil dumping.
- Soil sieving.
- Soil mixing.
- Compost preparation area.
- Pot cutting and preparation area.
- Pot filling area/under shade if possible.
- Pot damping area.
- Short training area.
- Where workers are taking rest/under shade if possible.

Erosion and Wind Protection

High slopes of nursery should be protected by cut off drains construction on upper site of nursery land. If there is a threat of wind damage, a wind-break should be planted around the boundary of the nursery. Hedge also be considered between blocks to reduce wind, control or prevent wind borne weed seeds and damage from dust. The species used as a wind-break and in the hedge should be relatively free of disease and insect attacks. Hedge also planted for protection of seedlings from sudden happens of aggressive insects. E.g. Locust.

Development of Water Collection Chambers

Water collection chambers need to be excavated at some corners of the nursery for workers to take water from the chambers with watering cans and regularly water the seed and transplanting beds. Volume of the water collection chambers depends on the size of the nursery (Figure 1).

Figure 1: Designed nursery main roads, access roads and hedges.

Nursery Tools and Equipment

Nursery should have a sufficient supply of tools for different operations. A good care should be taken of the tools, which would then have a long life. It is not wise to keep workers sitting idle at critical periods of work because of shortage of tools (Table 3).

Table 3: List of standard tools and equipments with their functions.

Tools/equipments	Function/tools description
Spades	Removing trash and soil mixing
Shovels	Soil mixing
Digging forks	For digg in soil and digging up stumps.
Digging hoes	For diggin soil
Funnels (scoops)	For leveling beds
Boxes	For carrying pots and plants
Wheelbarrows	For trasporting soil and compost.
Levelling boards	For leveling beds
Watering cans	For watering seedlings
Hose with spray	For watering seedlings and hedge.
Hedge clippers	For hedge cutting
Pruning knives/wire	For root pruning
Files	For sharpening
Pincers	For binding
Bow saw	For carryin soil
Hammer	For strengething
Nails	For attachment
Machete	For cutting tall grasses and branches of trees.
Measuring tape	For measuring bed width and length.
Buckets	For seed treatment
Carpenters saw	For cutting wood
Rakes	For cleaning the ground and leveling the top soil.
Sharpening stone	For sharpening

RESULTS

Seedling Production

Production of tree seedlings from seed: Foremen should control which tree species to be used or take the responsibility for collecting or purchasing.

Seed collection: After we have identified our parent trees/mother trees (right species, with the desired quality), have trained crew (if necessary reference collection), determined the optimum age, the next step is flower and seed survey.

Planning the seed collection

- **Organising collection teams:** The number of teams depends on the scale (large, small) and purpose (research, developmental) of collection. Each team should however be composed of a climber, ground assistants (1 or 2), and a supervisor. The need for training should also be considered at this stage.
- **Organising equipment and transport:** Ladders, climbing and safety equipment, safety belts and ropes, helmets, climbing spurs, shears, hooks canvas, nets, binoculars, pruning saws etc.

- Organizing permits
- **Organizing record keeping Different types of seed forms but information data to include:** Collector, date of collection, species, location (locality, distance, latitude and longitude), site Characteristics, tree and stand characteristics, collection methods, amount… signature!

Seed collection techniques: Collection techniques to use depends on factors like the way a species disperses, size of the fruit/seed, tree characteristics like diameter, height, bark thickness, crown size, tree frequency, undergrowth and underground vegetation.

Two major techniques:

- Collection of fallen seeds/fruits.
- Collection from the crown.

Seed handling: During the period immediately after collection, seeds are particularly susceptible to damage. So, they should be handled carefully depending up on the nature of the seed.

Aspects to be considered are thickness, hardiness and permeability of the seed coat, moisture content and dormancy. The two main classes of seeds with regard to handling requirement are:

Orthodox: That can be dried to moisture content of approximately 5% and can be stored at a low or freezing temperature for a long time.

Recalcitrant: Which cannot survive being dried below a relatively high moisture content (often 20%-25%) and may not subsequently be stored for long periods without losing viability.

Processing seeds (extraction): Almost invariably it is the fruit not the seed that is harvested though they are loosely referred as seeds. In majority of species, however, fruits are collected but seeds are sown. The aim is to maximize production of clean seeds having maximum viability.

The processes involved are: Maceration and de-pulping, drying, separation (tumbling, threshing and de-winging) and cleaning.

Seed extraction: It is the separation of fruits from seeds. This is necessary to:

- Reduce weight and volume.
- Enable more rapid drying.
- For storage under low risk of fungal attack.
- Eliminate the negative impact of fruit chemistry on germination.

Extraction methods depend on the nature of the fruit: a) De-pulping, b) extraction by drying.

Storing seeds: Storing means that seeds are kept under conditions that maintain viability at reduced physiological activity, and protecting seeds from deterioration by fungi and insect attack.

Storage is meant to bridge the time gap between collection and sowing.

Purchasing Seed

During the purchasing of the seed you should have to know the location where that seed were collected, date of collected and full information about that seed from seed seller.

Seed Dormancy

Many seeds will not germinate even when supplied with optimum conditions: They remain dormant. Dormancy in seeds is a common phenomenon and is often a useful attribute for survival of species. Seed dormancy is a state of viable seeds fails to germinate when provided with favorable conditions to germination.

Three major types of seed dormancy are:

- Exogenous dormancy
- Endogenous dormancy
- Combined/double

Bed Preparation

Construction of bed: Seedbeds should be 1 m wide to reach the center of the bed from either side of the bed. They can be of any length, but usually not longer than 20 m. It is preferable if they are the same lengths for easy of estimation of the area required for all necessary operations. Usually 1 m paths are left in between the beds.

Preparation of Nursery Soil

If only potted seedlings are produced the native soil is not an important site factor. They can be artificially blended. For this dependable source of supply for potting mixtures. It is an advantage if these materials are available within a short distance from the nursery as it could be very expensive to transport them from long distances. Where mainly bare rooted seedlings are produced, however, the soil should have favorable properties (such as soil texture, depth, and friability). In all cases, clay soils with high shrink-swell capacity must be avoided. Bare root seedlings produced best when grown on sandy or sandy loam soil. They do not readily compact as do clay soils, excellent drainage, fewer root rot problems, less damage to the roots during lifting, water more readily available to plant roots and suitability for using heavy mechanical equipment. The optimum soil pH between 5 and 7.2. Soils with pH greater than 7.2 should be avoided because it favors root rot growth and it is difficult and costly to lower their pH. Acid soils can be corrected with lime. A valuable guide in selecting a potential productive site is to look at the past agronomic

history of the site, and native vegetation of the area (Roshetko et al., 2010).

Adequate sources of good quality soil are required in the preparation of the potting mixture and to a lesser extent for seed beds. One of the major components of the recurrent cost in a nursery with container grown plants is the provision of suitable soil. Obviously, the nearer the nursery is to the source of this material, the less will be the cost. A high demand for sand in soil mixtures has developed due to the availability and use of heavy soils. Sand particles however, do not hold moisture and they tend to be inert, conferring few, if any, benefits to the plant. This over-reliance on sand could be avoided with adequate supplies of top soil and a ready supply of compost (Kinney and Simpfendorfer, 2009).

Mixing Soil

Nurseries ratio use a 3:2:1 mixture of local soil/top soil, organic matter/compost/forest soil and sand.

Guidance for mixing

- Proper mixing.
- Mixing is best done on a clean hard surface.
- The mix should be kept under cover if it is to be stored for period (Table 4).

Table 4: Summary of different polytunetube size, different height and their soil volume.

Container lay flat size (cm)	Height of the container (cm)	Circumference of that container (cm)	Diameter of that container (cm)	Radious of that container (cm)	Volume of soil per single pot (m^3)	Number of pot from 1 m^3 volume of soil (No.)
8 cm	12	16 cm	5.095541 cm	2.547771 cm	0.000245 m^3	4081 pots
	15	16 cm	5.095541 cm	2.547771 cm	0.000306 m^3	3271 pots
	20	16 cm	5.095541 cm	2.547771 cm	0.000408 m^3	2453 pots
10 cm	12	20 cm	6.369427 cm	3.184713 cm	0.000382 m^3	2617 pots
	15	20 cm	6.369427 cm	3.184713 cm	0.000472 m^3	2120 pots
	20	20 cm	6.369427 cm	3.184713 cm	0.000637 m^3	1570 pots
12 cm	12	24 cm	7.643312 cm	3.821656 cm	0.00055 m^3	1817 pots
	15	24 cm	7.643312 cm	3.821656 cm	0.000688 m^3	1454 pots
	20	24 cm	7.643312 cm	3.821656 cm	0.000917 m^3	1090 pots
16 cm	12	32 cm	10.19108 cm	5.095541 cm	0.000978 m^3	1022 pots
	15	32 cm	10.19108 cm	5.095541 cm	0.001223 m^3	818 pots
	20	32 cm	10.19108 cm	5.095541 cm	0.001631 m^3	613 pots

Remarks: As it was mentioned in above table it was done without consideration of compaction factor; due to lack of time and lack of budget to do compaction factor; more research work should be carried out to test how compaction factor may reduce number of pots per 1 m^3 of soil.

Soil compaction in pots: Filling the poltytenetube with the soil is an important process. Poorly compaction can affect even the best prepared and mixed soil. Over compaction can have great affect on young seedling can't penetrate easily after germination and reduces the infiltrating of water this may also bring the rotting of seedlings and dumping off. Less compaction is also not good because total porosity is brings the setting out of soil from pot and water easly goes out to ground.

Generally we have to compact ¾ (the lower side) of the pot lightly fill ¼ (the upper side) of the pot, as well filling up to tip of the pot is not recommended (Figure 2).

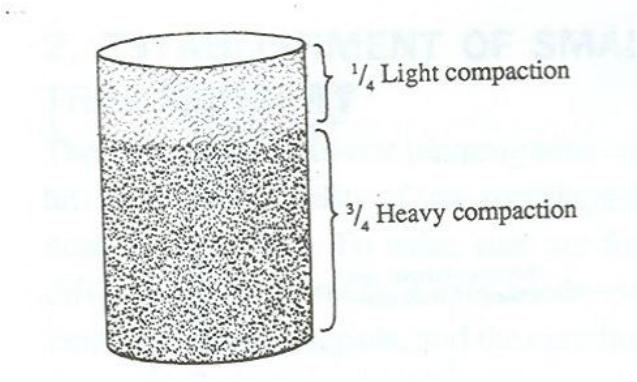

Figure 2: Soil compaction standard during pot filling.

Mycorrhiza: Mycorrhiza is symbiotic (mutually beneficial) intimate association of fungi and roots of forest trees of other higher plants. Mycorrhiza, which is essential in the production of healthy *Pinus* spp. The easiest method is to obtain soil and humus containing the inoculant from under stands of pine in plantation forests.

Compost preparation: Composting is done to produce an organic fertilizer that is balanced in plant nutrients. This organic fertilizer, known as humus, improves soil fertility, moisture retention and soil aeration. Compost is prepared by letting alternate layers of C rich (ex-crop stubble sugarcane waste, sawdust, bones or any other dry organic matter) and N rich (ex-clover alfalfa, fresh leaves, fresh manure) plant or animal waste to decompose through microbial action, in a pile or pit method. Nitrogen is needed for growth and multiplication, and carbon is the source of energy (Cedamon et al., 2005).

If sufficient organic raw material is available, compost with the above characteristics can be produced at the nursery site or at a central location. The following raw materials are also suitable for making compost and should be more easily available on a sustained, self-reliant basis:

Two method of compost preparation depending on loweness or highness of rain fall areas.

- Pile method: For high rain fall areas.
- Pit method: For low rain fall areas.

Type of Seedlings

Bare-rooted seedlings: Bare-rooted seedlings are seedlings directly sown on the nursery beds without the need for the containers such as polythene tubes**.**

Bare root plants are simply grown plants which are lifted, transported, and planted during planting season (Figure 3).

Advantage

- They are easy and cheap.
- They are easy to transport and handle in the field.

Disadvantage

- Can be stored in the field for very short period of time.
- Unreliable.

Figure 3: Bare rooted seedlings.

Potted seedlings: Potted seedlings are seedlings grown in containers such as polythene (plastic) tubes. Potted plants are plants that have been raised in containers (Figure 4).

Advantage

- Potted seedlings can be stored in the field for longer period of time before planting without damage to seedlings.
- Reliable, low mortality after planting.

Disadvantage

- Time-consuming
- Very difficult to handle
- Expensive

Figure 4: Potted seedling of *Grevilia robusta*.

Nursery Seedlings Management

Mulching: Mulching–Artificial modification of soil surface by ordinary cultification and covering of grass. To be effective, a layer of mulching should be 1-2 cm thick.

The primary purpose of mulching is to conserve soil moisture by lowering soil temperature and by physically blocking the loss of water.

Mulching can provide protection from heavy rain and water splash and it reduces evaporation of soil moisture. In dry localities, the presence of mulch on the surface of transplanted seedlings is a great help in reducing the amount of water required and reduces the tendency for the surface to become muddy or compacted. Like a sponge, a mulch can quickly absorb plenty of water which then passes slowly into the soil (Rachmat et al., 2020).

Grass mulching of sowings: In nurseries sown seeds both in seedbeds and in pots are covered with a layer of grass. The reason is to prevent the soil surface and seeds from being washed aside in watering, as local watering cans have very rough sprinklers and the drop size is large. The grass mulch has got some disadvantages. It may bring into pots or beds weed seeds and insects (Figure 5).

Figure 5: Mulching and watering of seed beds.

Shading

Seedlings need protection from drought, cold wind, heavy rain and burning sunshine. shades must be provided especially when the seedlings are young. Germinating seeds and tiny seedlings need protection against both sun and heavy rains. The grass (mulch) must be removed after germination has started. Simple shades for private peasant nurseries can be constructed with any available material. Forked sticks can be used for suport shades, which is 60 cm-100 cm from the ground. Depending on the direction of aspect, the shade facing the strongest sunshine is usually shorter than the one facing relatively less baking sunlight shade is important rather than heavy shade because by photosynthesis, the seedlings are able to produce carbohydrates, amino acids and fats and also generate oxygen which is essential for the respiration of all organisms (Figure 6).

Figure 6: Nursery shade on seed bed of *Casuarinas equoestifolia.*

Watering

It is important that he seedbed is kept constantly moist down to a minimum of 5 cm-6 cm depth. The main objective of watering seedling is to maintain enough moisture to the rooting zone to enable the seedlings grow satisfactorily. The frequency and amount of watering depend on the rate at which water is absorbed by the roots and the water holding capacity of the soil. The rate of absorption depends on species, size of seedling, density of seedling, and on weather conditions. Too much water can be harmful. Light applications of water are better. Watering preferably in the mornings and evening to avoiding excessive evaporation.

To mention some examples of watering quantities: 4 L/m^2 at morning and 4 L/m^2 at evening is more common and watering trials in some nursery indicated that as low quantity as 6 mm/day/seedlings would give satisfactory growth. Excess water is damaging by reducing the air in the soil and cause compaction and also promotes development of fungal diseases like damping off. The visible symptoms of over watering are slight to severe yellowing and stunted growth. Wilting is one of the e signs of under watering. Any signs of wilting should be immediately supplied by the addition of water so as to prevent permanent damage. Watering may be either by hand or by irrigation, Hand watering with cans fitted with spray, Hand watering with a plastic or rubber hose fitted with a spray is also popular. The ideal system for large nurseries is overhead sprinkler irrigation as it is easily controlled and provides the most uniform method for the application of water (Adhikari et al., 2013).

Transplanting

If a seedling is lifted from its bed and planted to another bed or pot in the nursery it is there after called “transplant”.

Seedlings are normally ready for transplanting from 3 to 5 weeks after germination when 2 or 3 pairs of leaves have formed.

Weeding

A weed is a plant growing where it is not wanted. Weeds compete with plants for water, soil nutrients and light. Weeds may also harbor insects or diseases. Therefore, weed competition must be eliminated. If they are not eliminated on time, the competition may hold back the growth of young seedlings.

The most common methods of weed control are:

- Manual
- Chemical

Fungi and insect control

Damping off is a disease of young seedlings caused by a number of soil born fungi. Most likely fungal disease (fusarium, pythium, rhizoctonia).

The symptom is the development of a zone of weakness where the stem and the root meet. The seedling rapidly loses turgidity, bends over and soon dies.

Cause of damping off: Heavy watering, particularly in the afternoon and evening hours, watering should be in the mornings. If possible, to prevent seedlings from damping off, the seedbed should be sprayed once a week with a solution of a copper based fungicide and the fungicide should be applied every three days until they are to be controlled.

Control of birds, rodents and pests: Birds can be kept at a distance by spreading thorny branches onto the seedbeds. A better way of controlling both birds and mice is to construct frames with close mesh wire. Control of pests can be achieved by isolating the plant until spraying is done. Protection against leaf eating insects is also necessary.

Root pruning

The root pruning involves cutting of the taproot, in some cases also of lateral roots, to encourage the development of fibrous root system. Root pruning also controls depth of root penetration and makes lifting of seedlings easier and less harmful. Roots of seedlings required to be straight and dense with healthy root hairs. Pruning stimulates root growth and causes the roots to become compact and fibrous rather than long and thin. As a general rule, the first root pruning is carrying out as soon as the roots appear through the bag and enter the ground. Repeat the pruning every two weeks or as necessary; it is best to practice in a cloudy day when transpiration is low. If there are signs of wilting, then the plants should be watered.

Frequency of root pruning: The frequency of root pruning depends on the growth rate of the seedlings. Weekly pruning are recommended with fast growing like Eucalyptus. With pines and cypress, the interval between pruning's is about 2 weeks. *Pinus patula* has very sensitive root system hence regular and frequent root pruning is absolutely necessary. *Pinus radiata* and *Cypressus lusitanica* are less demanding but would benefit from regular root pruning.

Care of seedlings during root pruning: Pruning should be done on a dull cloudy day, clean cut with a sharp material, should be watered immediately after pruning. Some Eucalyptus or other species show symptoms of wilting after pruning and it may be necessary to put them under shades for a couple of days after pruning.

Cutting oversized: Oversized seedlings may cut back to a convenient height of up to 15 cm and allowed to recover in the nursery before planting in the field. A second pruning of unwanted shoots also done as soon as they appear, to facilitate the growth of the main stem. This method is particularly useful if seedlings reach the desired sizes sooner than the required time for fast growing seedlings (Figure 7).

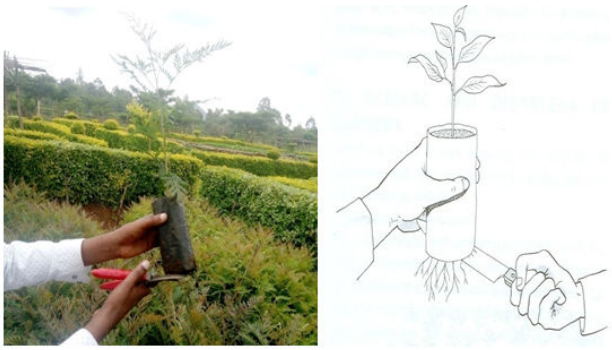

Figure 7: Pruning potted seedlings by root pruning shears and root pruning knife.

Hardening off

In a nursery, seedlings are growing under near ideal conditions with good moisture and nutrient conditions. Gradually impose harsher conditions to the stock starting a few weeks before planting. This is called hardening off. Hardening off is the gradual withdrawal of normal growing conditions to the seedlings in the nursery to facilitate the survival of seedlings in the harsher environment in the planting field. Reduce the amount and frequency of watering gradually to two or three times per week, removing different shades from seedlings, reduce the frequency of watering, reduce the quantity of water, cut off fertilizer applications early, expose plants to full sunlight as soon as possible, prune roots and cut back shoots if oversized (Calkins and Swanson, 1996).

Transporting seedlings

This is the last responsibility of the nursery management. The lorry should be driven without any unnecessary delay to its destination.

If it is necessary to stop on the way, the driver should be instructed to park his vehicle in the shade to protect his load against heat. If immediate planting is not possible the seedlings may be stacked upright on a level ground.

If immediate planting is not possible the seedlings may be stacked upright on a level ground. Watering may be necessary if planting is delayed (Figure 8).

Figure 8: Transporting the seedling.

DISCUSSION

Record Keeping in Nursery

Nursery records: To ensure the complete stand history of certain plantation; it is indispensable to note all operation for raising seedlings.

Nursery record is a valuable document prepared for the purpose of providing particular information for the nursery workers, nursery managers, supervisors or visitors as a whole. For good nursery management recording all work done, the progress made is essential. This includes daily operation, labor management, cost etc. A careful registration will also help to establish the most appropriate production data for each species. The efficiency of a forest nursery may be evaluated by its productivity and costs of production (Denison, 1979).

These can be achieved through proper planning and using the past records of nursery operations (Tables 5 and 6).

- Registration form.
- Nursery diary.
- Nursery calendar.
- Attendance book of daily laborers' is important.

Table 5: Nursery calendar form.

Activities	Months of the year											
	J	F	M	A	M	J	J	A	S	O	N	D
Bed preparation												
Sowing												

Table 6: Attendance book example of daily laborer's.

Name/date	1	2	----------	30
Mr. X	P	S		H
Mr. Y	A	P		

Note: P=Present, A=Absent, S=Sick, H=Holiday

Nursery labels: In each bed it is useful to make labels for each potted or bare root seedlings. In local nurseries, it is commonly practiced by painting detailed information on small rectangularmetal which is fixed with a piece of wood, which contain species of the seedling, no. of bed, no. of block, sowing date, germination date etc. (Calkins and Swanson BT, 1995).

CONCLUSION

"In conclusion, the establishment and management of forest tree nurseries play a crucial role in tree planting initiatives aimed at addressing global environmental challenges such as global warming and climate change. Quality seedling production is fundamental to the success of reforestation and forest development

programs. The selection of appropriate nursery sites, consideration of ecological, economic, sociological, and biological factors, and the categorization of nurseries based on ownership and production capacity are key aspects of effective nursery management.

By following the guidelines outlined in this manual, nursery workers, supervisors, and foresters can contribute significantly to the production of high-quality seedlings for various purposes. These seedlings not only reduce plantation costs and management efforts but also ensure early returns on investment through accelerated growth and enhanced tree quality.

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Ultimately, the efforts invested in establishing and managing forest tree nurseries pave the way for sustainable forestry practices, environmental conservation, and the realization of numerous social, economic, and ecological benefits for current and future generations."

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