

# Nursery Establishment and Management

## A TerraFund for AFR100 Guide to Restoration Champions



Peer-to-Peer Learning Exchange Program

March 2026

## Contents

<b>1. Introduction</b> .....	3
<b>2. Nursery establishment</b> .....	4
2.1 Nursery site selection .....	4
2.2 Preparation of the site .....	4
<b>3 Nursery management</b> .....	5
3.1 Design and Layout .....	5
3.2 Soil collection .....	6
3.3 Potting.....	7
3.4 Seed and seedling handling.....	7
3.5 Pricking out of seedlings.....	10
3.6 Factors Affecting Seedlings-How to raise quality seedlings .....	12
3.7 Nursery Diseases and Pests .....	14
3.8 Hardening off .....	15
3.9 Grading/Sorting .....	15
3.10 Vegetative Propagation.....	16
3.11 Common Errors in Nursery .....	17
3.12 Nursery Records.....	17
3.13 Useful tools and Equipment .....	17

## 1. Introduction

This document provides practical guidance for Restoration Champions to establish and manage nurseries that produce healthy, field-ready seedlings, the foundation of successful land restoration. It outlines key steps across the nursery cycle, including seed sourcing, potting, sowing, watering, hardening off, grading, and basic record-keeping. Strong nursery practices improve seedling survival, reduce planting losses, and ensure reliable supply for restoration activities. Developed for use during the Peer-to-Peer Learning Exchange, the guide encourages champions to share experiences, reflect on their current practices, and apply improvements suited to their local context while maintaining high standards of seedling quality and nursery management leading to vigorous seedlings that will turn into mature trees in the field.

### Types of Nurseries

Nurseries are generally classified into two types according to the intended duration of their establishment. Proper identification of the nursery type is critical, as it guides decisions related to site selection, structural design, operational planning, and cost estimation.

- **Temporary- (Small scale) nurseries** are types of nurseries established to raise a small number of seedlings for a small-scale tree planting project planned for a short period of time.
  - Benefits include improvement of survival rates due to proximity to planting sites, reducing transit time and less damage to seedlings through avoided overheating, windburn, soil loss and breaks by long journeys, less transportation cost, better species range to farmers, easy isolation of diseases.
- **Permanent - (Large scale) nursery is** a fixed, long-term facility established to continuously produce large quantities of high-quality planting materials (tree seedlings and other perennial plants) using permanent infrastructure (e.g., seedbeds, shading, irrigation, and storage). It is designed to operate year-round, serve multiple planting seasons and projects, and supply planting materials at scale for forestry, agroforestry, and restoration programs.
  - Benefits of this type of nursery are high production levels and high seedling survival rates providing efficiency, reliable operation and consequently lower unit cost per plant; stability of infrastructure leads to higher quality of seedlings and diversity; reduced loss due to regular on-site supervision.

## 2. Nursery establishment

### 2.1 Nursery site selection

Look out for these features

- **Water availability:** A reliable and continuous supply of water should be available throughout the year. Regardless of water source, always keep water storage facilities at sites that can serve for at least 3 days. Sandy soil requires more water than other types of soil.
- **Location:** near to the planting site or demand as much as possible to avoid the transportation of seedlings over long distances. Be close to communities as much as possible to avoid costs related to security, dwellings and long distances to find living facilities for nursery workers. Accessibility is key to allowing easy transportation; networks have also become important for nursery site selection to ease communication. The area should be free from frost.
- **Topography:** on a gentle slope sufficient to allow excess water to run off without causing water logging. Proper drainage is necessary.
- **Size of the nursery:** consider the number of seedlings/ plants required to produce.
- **Soil:** consider balanced soil particles, pH, moisture content, soil porosity, and organic matter.
- Sheltered from the wind.
- Accessible by vehicles.
- Ideal to have a live fence on the leeward side of the nursery to act as a windbreak thereby reducing water loss and potential mechanical damage to seedlings.

*Places where a Nursery Should not be Located*

- a. Hill-top – a point which is at a hilltop will make it difficult for vehicles to reach the nursery for seedling collection or delivery of nursery material.
- b. Down the Valley – a point down the valley may be water-logged and flooded during the rainy season.
- c. Along the slope – siting a nursery along the slope may bring problems of run-off during the rainy season. However, a slope can be terraced to get level beds.

### 2.2 Preparation of the site

After selecting the site, preparing it towards a more level area is the next step. The following are some of the important work done:

- **Removal of unwanted vegetation:** trees and other unwanted vegetation, such as shrubs and small plants, should be removed. Be careful of what you remove, sparing

those that might be useful in future (ex: shade construction, shade for workers, windbreaks, etc.). Unwanted trees/shades might lead to diseases such as fungi.

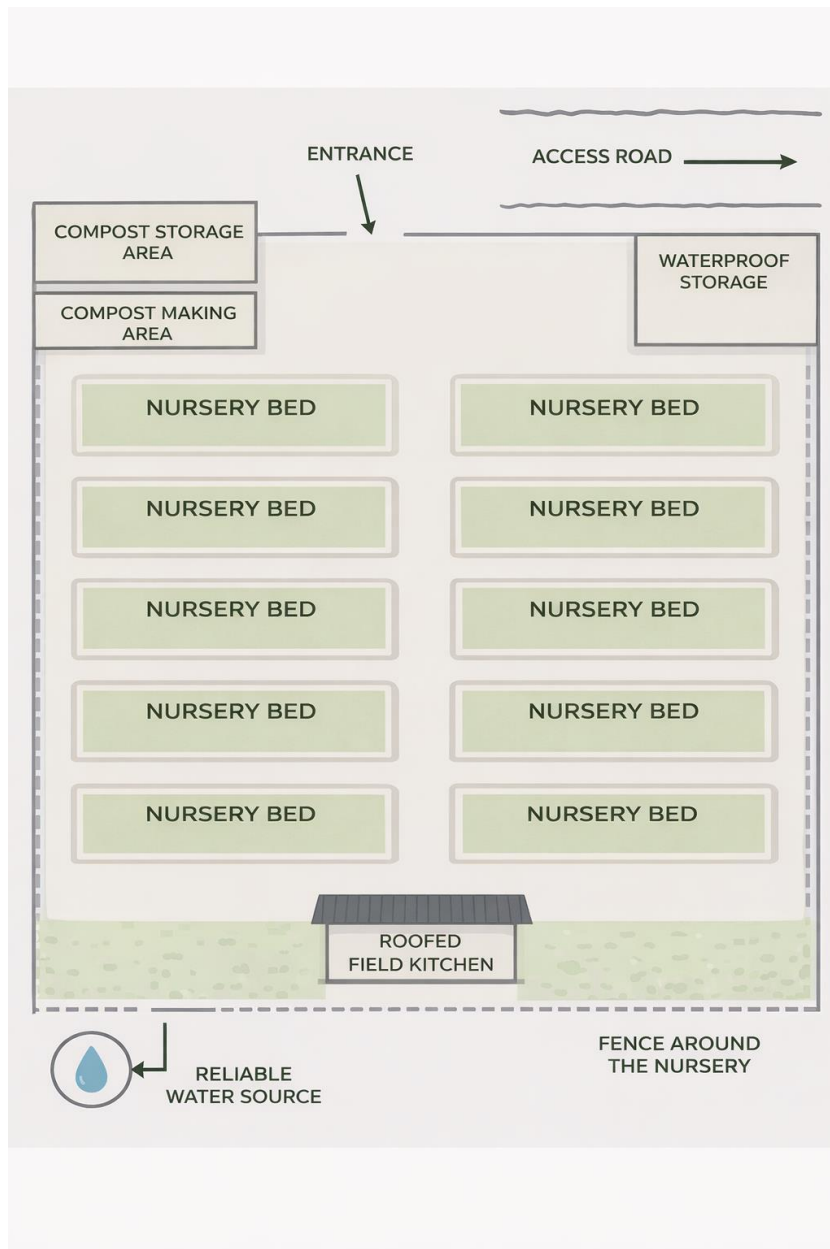
- Removing topsoil: to level the site, remove the topsoil and store it for growing media preparation. Take care to prevent erosion or pollution of nearby streams. Where needed, form terraced beds with a 4–5% slope.
- Mark out the shape and size of the beds. If possible, the beds should be oriented to run East-West to maximize the effect of shade. The width of the nursery beds should be 1m for easy watering of seedlings in the middle, while the length should be determined by other factors such as nursery size, terraces dug, and quantity of seedlings to be produced. Leave at least 0.5 m width between seedbeds for easy movement. Types of seedbeds are sunken, basin-like excavated about 12cm deep, and raised bed used mostly in high rainfall areas
- Construct the beds using strong poles
- Fencing: after levelling up the nursery site, fencing with strong materials is done to keep animals out and provide security.

### **3 Nursery management**

#### **3.1 Design and Layout**

- Administrative Area: especially for permanent nurseries to provide working space for nursery management. These include stores, sheds, and latrines. The facilities should always be located close to the entrance to minimize movement within or past nursery spaces. It should allow easy supervision of nursery work. If latrines are installed, place them at least 50-200 m away from water bodies to avoid contamination. If applicable, reserve eating, fuel storage spaces.
- Operations area: seed handling places, soil mixing and storage area, composting and potting areas.
- Production areas: germination beds, seedling beds, transplanting zones/hardening off, cutting preparation areas, grafting and budding spaces; water wells-tankers and pipes are essential.

Note: At least, a standard nursery should have a shed, seed sowing bed, soil storage area, soil mixing area, and seedlings bed.



A standard nursery layout-revised by AI (Ken Coetzee & Wallie Stroebel, 2025).

### 3.2 Soil collection

Nursery soil should be collected from fertile and well-drained soil. Forest soil is highly recommended. During forest soil collection, it is important to clear the surface to remove all plants and litter before digging topsoil. Dig the topsoil then sieve to remove undesirable materials like sticks. Standard seed bed mixture consists of sieved black forest or topsoil, and sieved sand at a ratio of 1:1 which varies depending on whether clay or sand component is higher in the local soil mixture and ecological zone. The sand improves soil texture for easy movement of air and water while the forest soil improves holding capacity and inoculation

of mycorrhizae. Where there are no fertile top/ forest soils, a mixture of the available local soil, sand, and composite manure can be mixed in a ratio of 1:1:1 or as per local recommendations.

### **3.3 Potting**

Moisten collected soil mixture by sprinkling water on it to ensure it is neither dry nor too wet. Put the soil into the potting containers, press the lower  $\frac{3}{4}$  of the container while the upper  $\frac{1}{4}$  should be loose to allow root penetration, arrange as per bed size and direction.

### **3.4 Seed and seedling handling**

#### **3.4.1 Seed procurement and storage**

Tree species are selected in collaboration with communities to ensure their preferences while keeping restoration/plantation objectives. Seeds are sourced according to national regulations from certified institutions, or as indicated by responsible institutions or locally collected from selected healthy mother trees.

#### **3.4.2 Seed storage**

If short-term storage is needed, seeds should be kept in rodent- and insect-proof, preferably airtight containers, protected from extreme or fluctuating temperature and humidity. Maintaining the temperature above 5 °C is recommended (not freezing), using a cloth bag inside a plastic or glass container to manage condensation. To reduce temperature fluctuations, divide seed into small batches and remove only what is needed for sowing. Seeds with short viability, including recalcitrant and intermediate types such as *Maesopsis eminii*, *Azadirachta indica* (neem), *Cordia africana*, *Persea americana*, *Mangifera indica*, and *Syzygium guineense*, should be sown promptly to avoid loss of viability. Apply fungicide and insecticide on arrival if not already treated and is required. Seeds with short viability, such as *Maesopsis eminii*, *Azadirachta indica* (neem), *Cordia africana*, *Persea America*, *Mangifera indica*, *Syzygium guineense* should be sown immediately upon arrival. It is advised to sort and to drie seeds to avoid infestation.

#### **3.4.3 Seed dormancy and pre-treatment**

Seed dormancy is a condition where viable seeds fail to germinate under normally favorable conditions (moisture, temperature, light). Dormancy can be beneficial by preventing premature germination during storage but may cause poor germination if complex dormancy requires specific pre-treatments. Some pre-treatments are used not to break dormancy but to accelerate germination. Maximizing germination often requires appropriate pre-germination treatments.

- Sorting empty seeds: usually with small seeds, soak seeds in cold water overnight and remove those that float. This usually indicates emptiness. Soaking may even be used to trigger quick germination.
- Pre-treatment to weaken seed coat or break dormancy: many seeds show dormancy due to factors like hard seed coats, chemical inhibitors, or underdeveloped embryos. Overcoming dormancy requires species-specific techniques to enable germination:
  - **Stratification:** Many woody temperate species require a cool and moist treatment called stratification to germinate. This typically involves 6–12 weeks in a moist, aerated environment, followed by a warm, moist period. Seeds must remain cool and moist throughout, as warmth or dryness during stratification inhibits germination. Burying seeds in wet, sifted sand is a common stratification method. (Keats C.Hall, 2003). *Example: Prunus africana, Juniperus procera, Acacia senegal, etc.*
  - **Scarification:** Promotes germination by weakening or breaking the hard seed coat to allow water and air entry. This can be done by nicking, piercing, chipping, filing, or lightly scratching the seed coat using tools such as a knife or needle, or by hot water treatment. Examples include *Acacia spp., Albizia spp., Erythrina spp., and Sesbania sesban.*
  - **Soaking in Hot Water:** hot water treatment breaks dormancy in hard-coated Leguminosae seeds by creating tension that cracks or weakens the seed coat. It is most effective when seeds are submerged into hot water rather than heated with them, and a quick dip prevents damage to the embryo. For most hard-coated *Acacia species*, boiling water is removed from the flame before adding the seeds, which can then be planted once cooled or stored briefly.
  - **Soaking in Sulfuric Acid:** soaking hard-coated seeds in sulfuric acid for 5–60 minutes can improve germination by weakening the seed coat, but careful timing is needed to avoid damaging the embryo. Acid strength may decline with reuse. After treatment, seeds should be thoroughly rinsed under running water for at least 10 minutes. e.g., *Acacia nilotica, Acacia senegal, etc.*
  - **Fungicide application:** treating seeds with fungicides or insect repellents is helpful when there is a risk of fungal damping-off or insect damage. This is done by coating the seeds with suitable fungicide or insecticide before sowing.

#### 3.4.4 Timing of sowing

Sowing time is an important consideration, and it should usually match the rainy season. For example, In Rwanda's Lake Kivu and most parts of Rusizi River (LKR) landscape, sowing typically occurs during the short rainy season (March–May). Slow-growing native species are sown in March or early April, while fast-growing species like *Grevillea robusta* and legumes are sown in May or June, ensuring seedlings are ready for planting during the long rainy season (September–November).

In Kenya, sowing typically occurs at least a year prior targeted planting season for indigenous tree species that take long to grow to a planting size (25-35 cm). , while seedling for agroforestry needs at least 6 months. In Ghana, the timing of sowing is also closely aligned with the country's rainfall patterns, which vary slightly across ecological zones but generally include a major rainy season (April–July) and a minor rainy season (September–November). Aligning sowing with these seasonal rainfall patterns helps ensure seedlings are planted when soil moisture conditions are adequate, improving survival and early growth rates in restoration sites.

- Methods of sowing:
  - Broadcast: mostly done with small seeds, mix the seed intimately with an equal part of fine, dry sand of a similar size and spread the mixture evenly with the fingers.
  - Direct sowing: mostly done with larger seeds, a seed is directly placed in pre-prepared container. Although only one seed is necessary if the germination rate is high, the aim is to sow an average of two to three seeds per container. This method allows cutting costs and the avoidance of damage to seedlings through careless transplanting.

Notes:

- The yield of planting seedlings from a given seed lot is usually much greater with broadcast sowing
- With broadcast, development of transplants is sometimes slow compared with undisturbed direct sown seedlings
- There is a risk of root distortion during transplanting with broadcast sowing
- Depth of sowing: A general rule is to cover the seed to a depth equal to twice the seed diameter and not deeper than 1 cm in the case of *A. mangium* and similar small seed sizes. The recommended practice is to apply the lightest cover which can withstand routine watering. (Hannah J, 1999).
- Care of seedbed and direct sown container:
  - After sowing, lightly cover seeds with fine sand, sifted soil, or potting mix and water gently.

- Do not press seeds into the soil. Immediately shade the seedbed using dry grass or a cloth or a net or any available cover to protect seeds and maintain moisture.
- As seedlings begin to emerge, lift the cover about 30 cm and remove it completely soon after to prevent weak, pale seedlings.
- Water gently with a fine spray; in larger nurseries with piped water, use mist nozzles with a filter to prevent clogging.

### 3.5 Pricking out of seedlings

This is the process of transferring seedlings from seedbeds into containers. Seedlings are usually ready for pricking out 3–5 weeks after germination, once 2–3 pairs of leaves have formed. For *Pinus caribaea*, transplant at the “matchstick” stage while the seed coat is still attached; for *Acacia* spp., transplant when the first pair of leaves appear. Some selection may be needed as seeds germinate at different times.

*Important to:*

- Water seedlings well the day before to keep them fresh and firm; soil should be moist, not wet.
- Ensure pricking out is done under shade to allow seedlings to keep moisture. In warm or dry conditions, seedlings may die.
- Lift seedlings carefully without damaging roots or stems-preferably as a whole soil block, not individually.
- Handle seedlings by leaves or needles (for pines) to avoid bruising stems or roots.
- Roots should be exposed to air or sunlight for only a few seconds; place immediately in shallow water if needed.
- Plant at the same depth as the seedbed (or slightly lower), using a flat stick or fingers to prepare space. Avoid narrow holes that distort roots.
- Trim excessively long roots to about 5 cm with a clean cut.
- Firm soil gently around roots to remove air pockets without compacting.
- Plant seedlings upright in the center of the container, keeping roots straight.
- Water gently after transplanting (if seedlings are directly brought for planting in field) and providing shade on hot days, unless seedlings are hardened in full sunlight. (*Hannah J., Tree Nursery Practices ,1999 p.g. 14*).

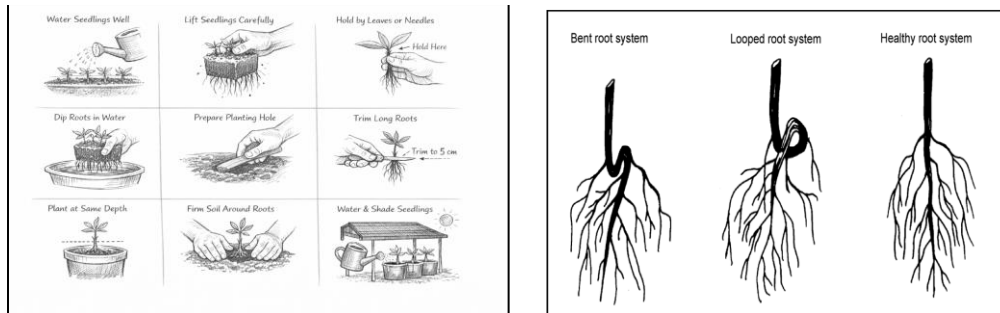


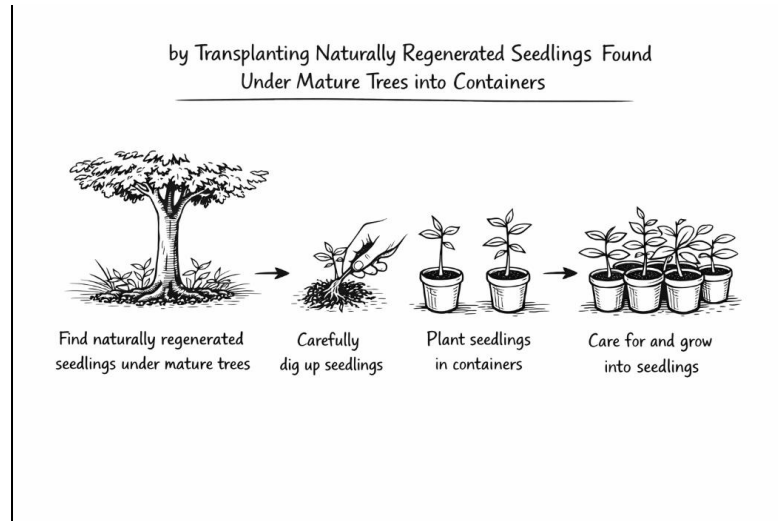
Figure 3: Prick out process, AI generated diagram. Figure 4: examples of improperly done prick out (Source: Manual on Nursery Practices, Keats C. Hall, 2003)

- **Wildlings as sources of seedlings:**

Natural regeneration seedlings, sometimes called wildlings, can also be used as sources of seedlings. These refer to seedlings that have germinated below parent trees either individually or under forest cover. In recent years, there has been an increased demand for and use of seedlings from this source due to shortage of planting stock, inadequate seed supply, and seed germination failure, higher demand at short notice in the absence of proper care and attention to detail, the survival of newly transplanted wildlings in the nursery and in the field is often sporadic.

Good results can be obtained if the following practices are followed:

- Select younger seedlings before tap roots have developed and penetrated deep into the soil,
- arrive on the site with the necessary tools and equipment consisting of fork or pickaxe to loosen the earth, burlap or plastic for packaging, coir dust or compost material to reduce moisture loss from roots and stems, sharp knife or secateur for root pruning- container with supply of water to keep package damp and reduce shock
- Do not wrench seedlings which are firmly rooted in the soil.
- Place lifted seedlings in water; root prune, if necessary,
- Package seedlings in bundles of 20 or less packing damp coir dust or compost around the roots.

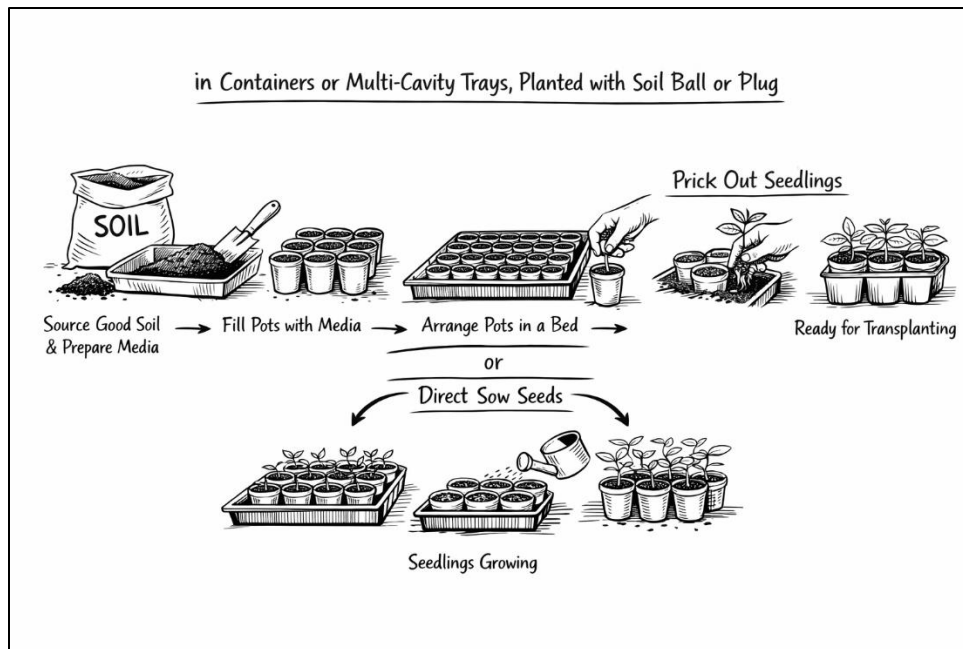


AI generated illustration for transplanting naturally regenerated seedlings (J. Ndera, WRI)

### 3.6 Factors Affecting Seedlings-How to raise quality seedlings

#### 3.6.1 Light and shade

Light is essential for the growth of tree seedlings because it drives photosynthesis, allowing the plant to produce carbohydrates, amino acids, fats, and oxygen needed for respiration and energy. Seedlings grow best under high (day) light, ideally in open conditions. Shade may be provided in a balanced way to protect seedbeds and transplant bags during extreme heat or heavy rain. However, transplanted seedlings only require shade for up to three days if transplanting is done properly. Prolonged shading can hinder growth and is unnecessary under proper transplanting conditions.



AI generated illustration for in-container seedling raising (J. Ndera, WRI)

### 3.6.2 Watering

Seedlings, like other living things, require water for their survival. Nutrients that seedlings depend on are dissolved in water and absorbed by the plants through their hair roots.

- Watering is done twice a day, in the morning and evening, for seedlings exposed to sunshine. Seedlings in the shade can be watered once a day. During the rainy season, water is not necessary.
- The temperature of the water used is an important factor to consider. Water obtained directly from a stream or a river is usually colder than stored water. Therefore, seedlings should be watered using stored water whenever possible.
- In the afternoon, water trapped in pipes can become very hot and may not cool quickly. During evening watering, this hot water should be poured out until cooler water from the tank comes out. Using excessively hot water may result in high seedling mortality.

### 3.6.3 Weeding and Cultivation

Weeding involves removing any other growing vegetation except for the desired seedlings. It is necessary to eliminate competition for soil nutrients and water. Weeding can be done whenever necessary.

Cultivation of the topsoil in a bed loosens the soil, enhancing water movement and air circulation. Without cultivation, the top layer of soil forms a hard crust, which can turn green

and hinder water movement to the roots and air circulation. This results in poor seedling growth.

### **3.6.4 Root Pruning**

Root pruning involves cutting roots that grow beyond the bottom of the tubes or beds. It should be done six weeks after pricking out every four weeks thereafter.

- For seedlings in containers, the containers are lifted, and the protruding roots are cut off with a knife or panga. In some cases, lifting the containers is enough as it breaks exceeding roots.
- Moving seedlings in containers often prevents root development in the ground and saves pruning time. Placing seedlings on a hard surface or polyethylene material also prevents root penetration into the ground.

In seedling beds, root pruning involves three main steps:

- Run a sharp knife deep into the soil between rows of seedlings parallel to the seedling bed.
- After two weeks, repeat the process across the seedling bed.
- Cut the roots deep into the soil using a wire. Two people are required to place the wire below the log or plank of wood at one end of the bed. Through a see-sawing motion, the wire is pulled from one end of the bed to the other, cutting the roots deeper than the width of the log.
- It is important to prune seedlings at least one or two weeks before field planting. Frequent pruning facilitates the development of a more fibrous root system, which hardens the seedlings for the harsh conditions in the field where care is less than in the nursery.
- The use of large pebbles and stones at the bottom of the bed can interfere with both horizontal and lateral root pruning. It is necessary to place a layer of soil at the bottom before adding the pebbles to facilitate horizontal pruning using the wire.

### **3.7 Nursery Diseases and Pests**

Nursery seedlings can be affected by diseases and pests that reduce growth and survival. Common diseases, such as damping off, are usually caused by fungi and can lead to seedling death, especially under excessive moisture and poor ventilation. Pests like insects and termites may damage leaves, stems, or roots, weakening the seedlings.

To prevent and manage these problems:

Keep the nursery clean and well-managed

Use healthy seeds and clean soil

Avoid overwatering and ensure good drainage

Provide adequate spacing and airflow

Regularly inspect seedlings and remove affected plants

Use simple control methods such as manual removal or locally available treatments when necessary

Proper nursery management is the most effective way to minimize diseases and pests and ensure healthy seedling production.

### **3.8 Hardening off**

This refers to the progressive withdrawal of the favourable conditions in which the seedling has developed in the nursery with the objective of conditioning the plant for survival in the harsher environment in the field.

Hardening off can simply be achieved as follows:

- Reduce the frequency of watering
- Reduce the quantity of water
- Cut off fertilizer applications early
- Expose plants to full sunlight as soon as possible
- Cut back roots
- Cut back shoots if oversized
- Ensure that each plant has adequate space

It is very important to remind restoration champions that hardening off is a very important step to make if you intend to plant seedlings that are ready to resist/adapt to harsher environmental conditions. In past, it has been observed that this step is often ignored, leading to poor survival rates or preventable seedling loss after planting.

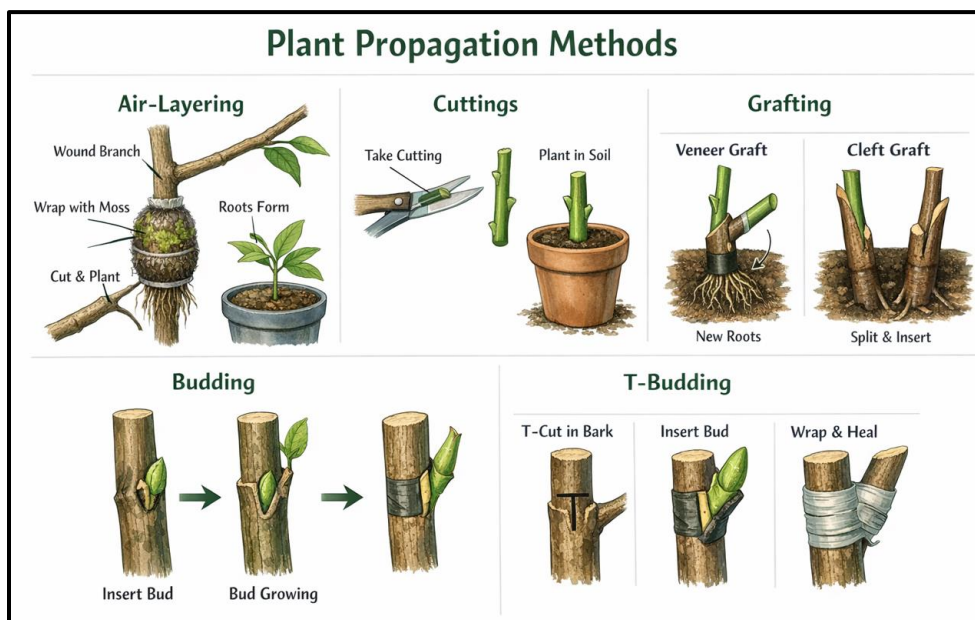
### **3.9 Grading/Sorting**

This should be done per tree species, date of germination, and seed collection source. Planting poor quality seedlings leads to lower field survival rates. Ensure plants are healthy, free from diseases and insect attacks. Healthy seedlings should also be green, not discolored. Seedlings should also have no injuries, have strong and straight stem and adequate size. Usually 25-35cm is the best height; longer stems tend to bend as they have difficulty finding balance.

### 3.10 Vegetative Propagation

Vegetative Propagation of plants: Vegetative reproduction is the method of producing plants without the use of seed. Also called asexual reproduction, the methods most often used to produce trees are cuttings, air layering, grafting, and micropropagation.

1. **Air-layering:** a vegetative propagation technique where a branch is wounded and wrapped with moist soil or moss while still attached to the parent plant, allowing roots to form before the branch is cut and planted.
2. **Cuttings:** a method where a piece of plant material (stem, leaf, or root) is cut from a parent plant and planted in soil or another medium to develop roots and grow into a new plant.
3. **Grafting (Veneer and Cleft):** grafting is joining a scion (desired plant shoot) to a rootstock, so they grow as one plant.
  - **Veneer grafting:** a thin slice is made on the rootstock and scion, which are then fitted together and tied.
  - **Cleft grafting:** the rootstock is split, and a wedge-shaped scion is inserted into the split.
4. **Budding:** a propagation technique where a single bud from a desired plant is inserted into the stem of a rootstock to grow into a new plant.
5. **Shield or Inverted T-budding:** a specific budding method where a T-shaped cut (or inverted T) is made in the rootstock bark and a shield-shaped bud from the scion is inserted under the bark and tied until it grows.



Illustrated Plant Propagation diagram

### **3.11 Common Errors in Nursery**

- Container errors: not filled properly- compacting all potting soil in the potting containing as opposed to compacting only  $\frac{3}{4}$  and  $\frac{1}{4}$  left loose, not well arranged in beds leading to seedlings growing with different shapes, stem curvature,
- Soil and sand (media mix) in the germination bed not changed for several seasons leading to diseases and dumping off,
- Errors during seed sowing- too deep or too shallow,
- Poor seedling management and transplantation leading to losses
- Poor record keeping

### **3.12 Nursery Records**

Many records can be kept at the nursery among them are the following:

- Nursery calendar: showing planned activities and when (dates) they will be implemented
- Seed and plant identification (labeling): records from seed procurement to dispatch- seed sources, Species, seed/seedling ID, date of sowing, prick out date, transplant, etc.
- Nursery production records
- Name of trees species,
- Seed pretreatment subjected to seed

### **2.1 Useful tools and Equipment**

- Watering cans for watering seedlings,
- Hoes or folks for digging soil, panga for cutting and cleaning nursery area,
- Rake for leveling the soil, wheelbarrow for internal transport,
- Pruning and grafting knives, sieve,
- Hose pipes for delivery of water within the nursery,
- Weighing balances for measurements,
- Measuring tape, dibber for making planting holes in beds,
- Buckets for water or seed collection,
- Other useful tools