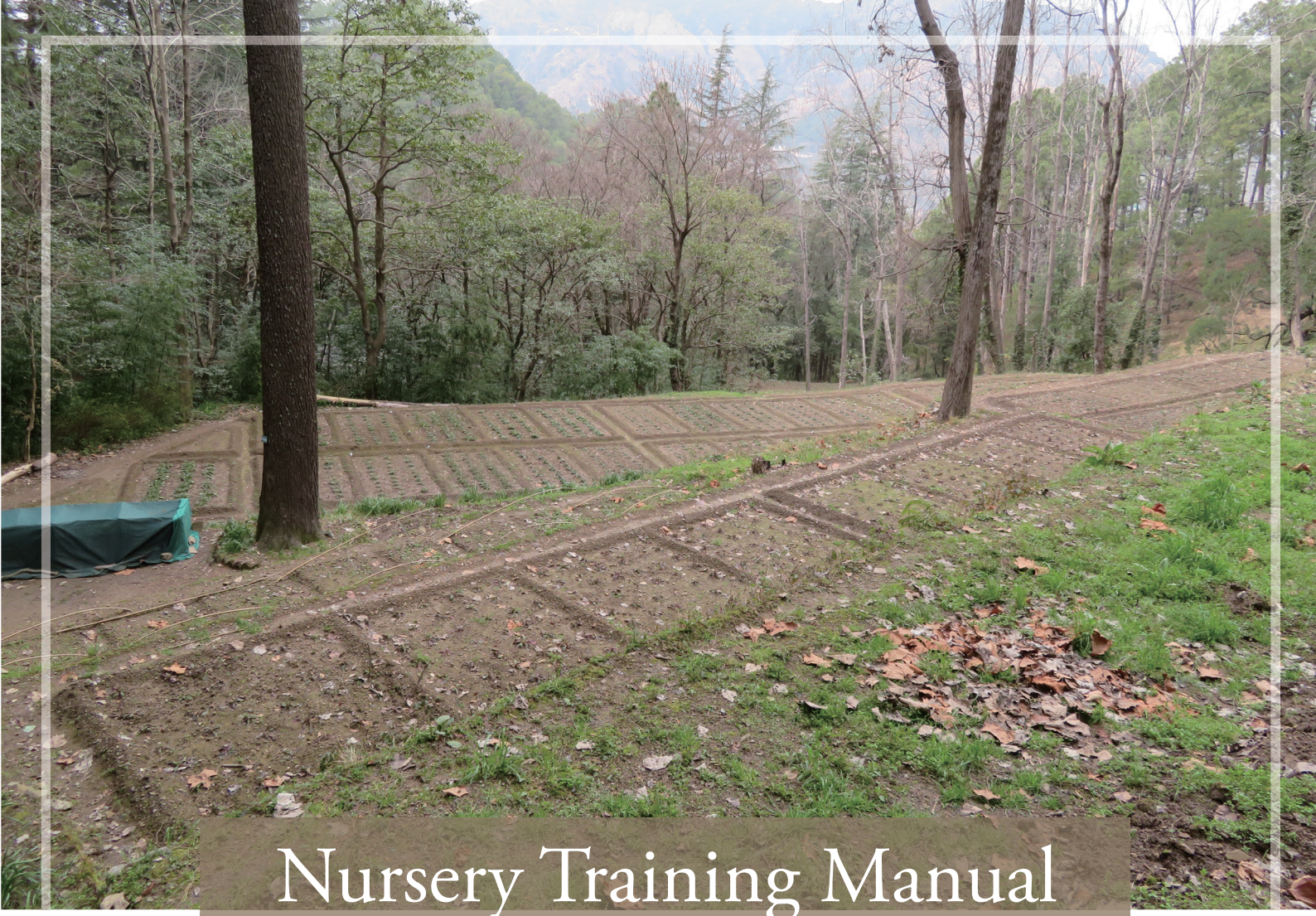

# Nursery Training Manual

2019

Himachal Pradesh Forest Ecosystem Services
(HP-FES) Project

Himachal Pradesh
Forest Department

german
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Address
A-2/18, Safdarjung Enclave,
New Delhi- 110029, India
T +91 11 4949 5353

E biodiv.india@giz.de
W www.indo-germanbiodiversity.com
I www.giz.de

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Indo-German Biodiversity Programme
Conservation and Sustainable Use of Biodiversity in India - Himachal Pradesh Forest Ecosystem Services Project (HP-FES)
The project aims to enable the Forest Department of Himachal Pradesh to introduce the Forest Ecosystem Services (FES) approach in the state's forest management system.
HP-FES

Responsible:
Dr. Joachim Schmerbeck, Team leader
HP-FES Project

Authors:
Jean Pouyet, Two Banyans, Auroville
Ezra Lawanker Rynjah, Freelancer
Anita Stogel, Business Coaching Academy

Photograph Credits:
GIZ/ Harish Kumar

Illustrations:
Madhav Joshi
Aashima Negi, Junior Communication Expert, GIZ



On behalf of
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GIZ is responsible for the content of this publication.

Shimla, 2019

# Nursery Training Manual

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# Preface

Our socio-economic surveys with the local communities in Himachal Pradesh have clearly indicated that the supply of water is the most important ecosystem service. The provision of fuel wood, fodder and timber come next.

Well-established vegetation is well-adapted to intercept and retain the precipitation (rainfall and snow), as well as to enhance the storage capacity of the soil below. For example, trees having extensive root systems[1] like Deodar *Cedrus deodara* for higher elevation and Banyan *Ficus benghalensis* for lower elevation.

It is obvious that protecting the existing vegetation cover and furthering the process of natural regeneration of the species already present on-site is of utmost priority. Anthropogenic disturbances on a landscape such as fire, overgrazing, etc., have to be substantially reduced or stopped for a reforestation programme to be successful. Artificial regeneration (reforestation) can be used to speed up the process of natural regeneration and improve the species composition. The chosen species should be adapted to the particular local conditions of the area where they will be introduced, especially climate and soil. Existing established species already present in the target area are an obvious choice.

In the case of poor natural regeneration of under-stocked areas upstream of water sources, the artificial regeneration of the forest cover by plantations will go a long way in intercepting God-given water and regularizing its flow. It will be invaluable in mitigating floods, reducing stress during dry periods, shortening the time when the streams are dry and eventually lead to perennial flow. The storage of rainwater in the soil of the forests will become a capital/water that increases every year.

This manual covers the important step of nursery establishment dedicated to the production of robust tree saplings to maximize the objective of good forest cover.

1 Terms that have been underlined are defined in the glossary at the end of the manual in alphabetical order. They are underlined the first time they occur in the text.

# Step-by-step Nursery Planning and Management

## Site

The choice of a particular site to establish a nursery (temporary or permanent) will have to be based on the following points. They are listed below in order of priority:

1. A sufficient amount of space should be available for the required number of seedlings to be produced (henceforth referred to as "target"). For every 100 seedlings, at least $3m^2$ is necessary.

2. The amount of water based on the target should be sufficient and based on the need during the driest period of the year. Even though 1 litre of water per seedling per week gives an average over a year, the source of water should be able to provide twice as much during the dry period.

3. To ensure close similarity with the climatic and soil conditions of the planting site and to minimize transport, the nursery should be as close to the planting site as possible. The nursery needs easy access for bringing material and exporting the seedlings to the planting site.

4. The part of the nursery where the seedlings and saplings are kept should be in the sun for as long as possible between sunrise and sunset to enable the maximum conversion of sunlight resulting in faster growth rates. For this reason the orientation of the nursery should be as close to an East-West direction as possible. Areas such as place for stocking and mixing the filling material can be in the shade. The compost pit must be shaded.

5. The whole nursery area should be well-drained. Marshy or water-logged areas should be avoided. Fungal diseases, especially damping-off, will lead to traumatic failure.

## Water

In a hilly region it is often possible to establish a nursery close to a stream. Water can easily be tapped upstream and delivered to the nursery site by gravity through a pipeline of appropriate size that provides adequate pressure and volume. Alternatively, a site can be chosen where water is already available through a well (open or bore) and a pump.

When the water pressure is sufficient, a simple sprinkling system can save the labour of watering manually from a basin or a low-pressure overhead tank.

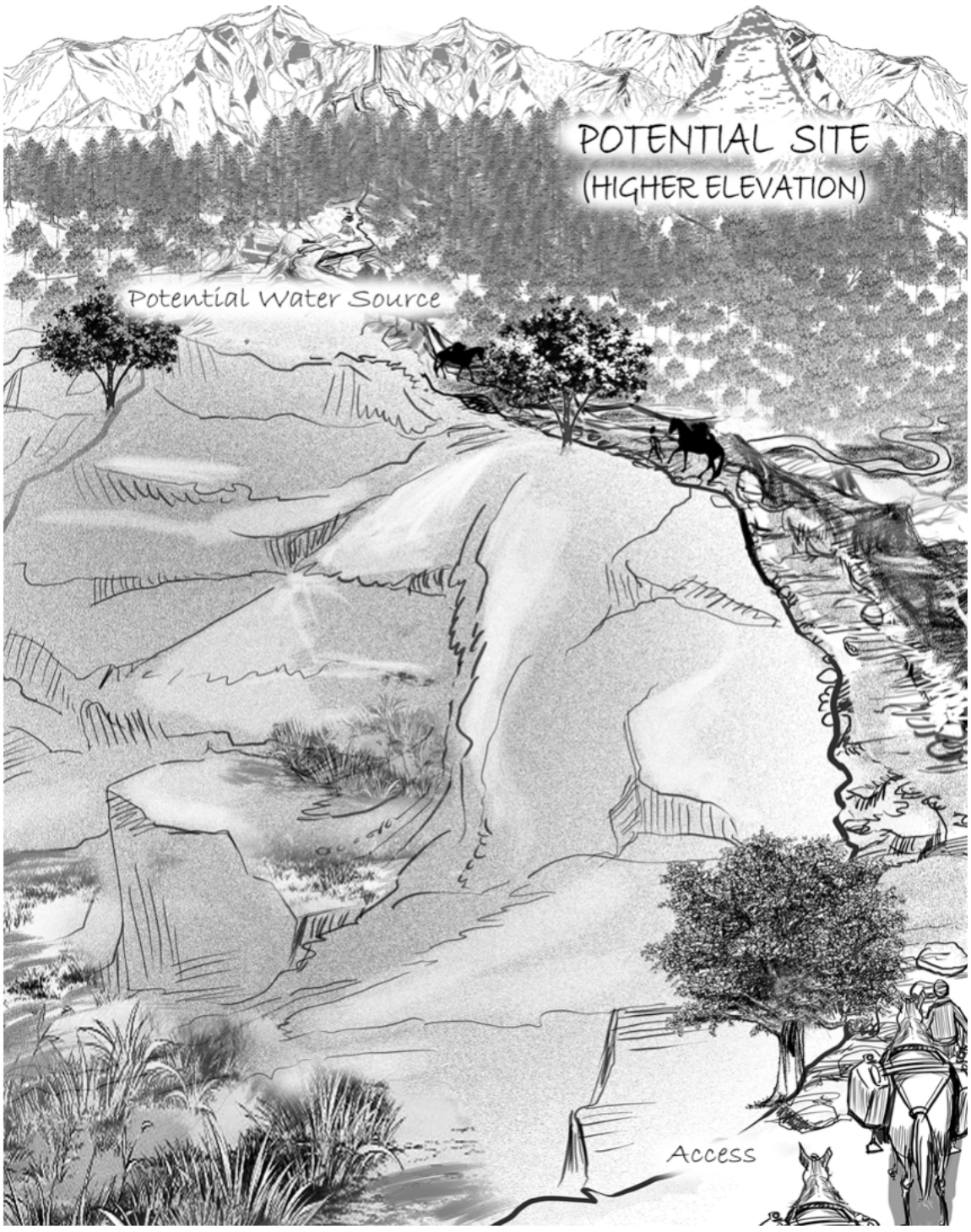



Figure 1: POTENTIAL SITE (FULL LANDSCAPE)

## Layout Planning and Site Preparation

The layout and site preparation should be designed to catch all the rainfall by terracing and levelling to prevent runoff and soil erosion from the site during rains. Provision should be made of emergency drainage from the sides in case of torrential rains. This is to avoid water-logging especially in the lower parts of the nursery.

The total surface of beds should be sufficient for the targeted number of saplings and the area where they are kept should be level to provide for good water conservation and a smooth base for stacking of the saplings. The beds should be approximately 1m wide for easy access from each side for sowing, weeding, watering, shifting, and general maintenance.

If the slope is steep terracing is necessary. Steps should be established to move from terrace to terrace.

A space for loading and unloading should be provided close to the entrance of the nursery for the ease of bringing materials, loading and transporting out the seedlings.

Sufficient pathways providing easy access to the saplings are necessary. An area should be provided for the mixing, screening, and handling of container-filling materials. A space must be provided for a compost pit of adequate size. The compost pit must be shaded.

Once the work of terracing, shaping the ground, laying pathways and setting up enough space for soil mixing, bag-filling, compost pit, etc., a sturdy fence should be established to protect the seedlings and saplings from grazing and other animals. One gate should be provided.

If fire could be a problem, a fire line should be established around the nursery fence.

In certain areas where cold is a factor and seeds are ready for sowing during the winter months it is necessary to establish a greenhouse-type of structure with clear plastic covering to ensure temperatures well above frost during the germination process. This structure should be commensurate with the target number of seedlings to be produced during the cold period.

For larger nurseries, above 50000 seedlings, it may be worthwhile to have provision of a shed to keep seeds, tools, and other equipment as well as shelter for the workforce during inclement weather. It may also be wise to provide a bathroom for the workforce.

Once the plan for the layout is finalized, it is good to execute the work of site preparation, in the following order:

1. Earth moving and shaping, terracing, digging the compost pit.

2. Path-laying and steps between terraces.

3. Establishing open areas preferably close to the entrance for loading and unloading materials for sifting and mixing and container filling.

4. Sturdy fencing, water supply and delivery system, compost preparation.

5. Greenhouse set up, if necessary.

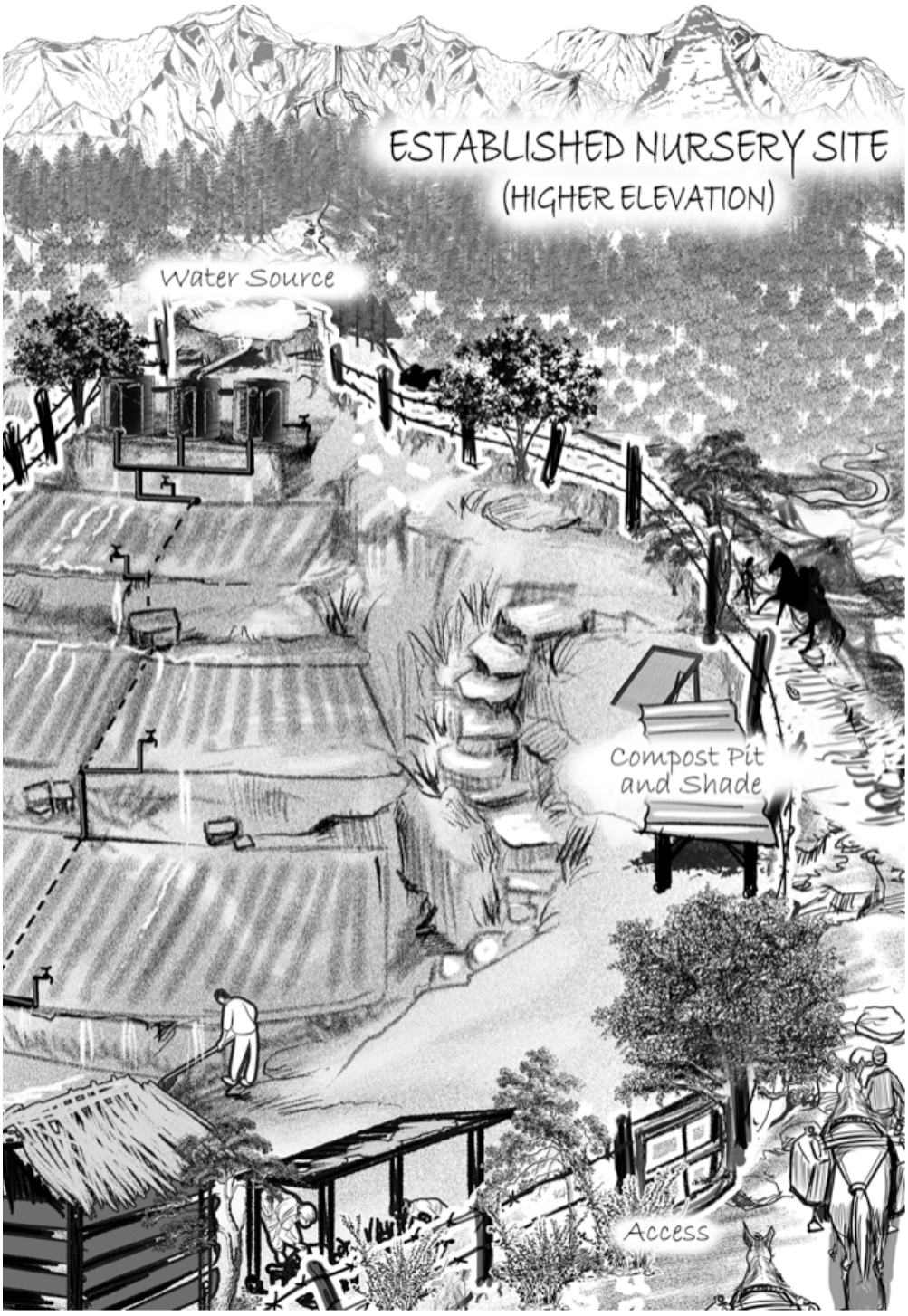
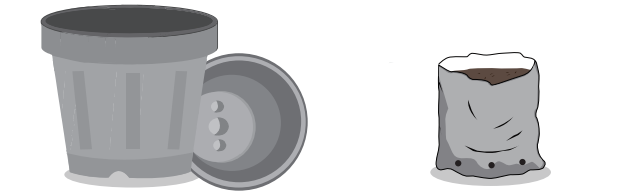


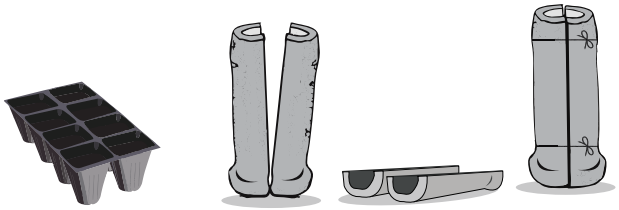

Figure 2: READY NURSERY

## Containers



1. PLASTIC POTS

2. POLY BAG



3. SEEDING TRAY

4. SPLIT BAMBOO STEM

Figure 3: CONTAINERS

Containers are used in nurseries to ensure that a solid nutrient-rich ball of earth remains around the roots of the saplings till the time of planting. This protects the root system from transplanting shock and retains moisture which is important in case of scanty rain during planting.

Many types of containers have been tried over the years in different parts of the world, from clay pots to split bamboo stems and various types of baskets. However, the past 20 years have shown that poly-bags are generally the best option as per cost and ease of handling. In some particular cases, if easy and cheap local alternatives are available, they should be used because plastic has its shortcomings. (Figure 3)

We may have different sizes of saplings at the time of planting, depending on the constraints of climate and planting sites as well as the species characteristics.

If the conditions at the planting site are favourable and the species chosen are suitable, saplings may be planted when they are one or two years old. If the conditions are tough, for example, heavy grazing pressure or long summers, it will be preferable to have larger and taller saplings at the time of planting even though the cost will be higher.

For example, some saplings may be kept in the nursery for 2 years and will require a container of 5”x9”. Saplings remaining for 3-5 years in the nursery would require a larger container of 10”x18”.

The size of containers will also be chosen according to the size and shape of the root system of the respective saplings. Plants with superficial root systems will need broader but shallower containers. Plants with tap roots can be accommodated in narrower containers but they should be deeper (up to 18”). (Figure 4)

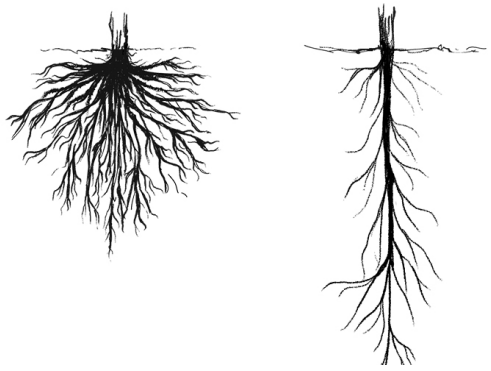
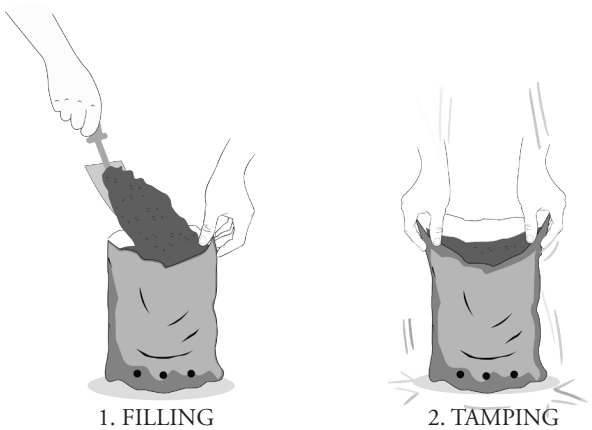


Figure 4: ROOT TYPES

All containers should have drain-holes to avoid water-logging. To that effect, poly-bags should have a few holes punched through the plastic with a sturdy nail prior to filling. Several bags can be punched through in one go. (Figure 5)

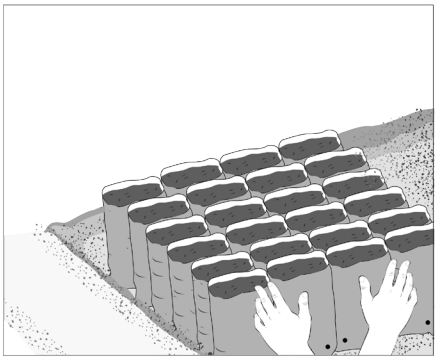
Figure 5: PUNCHING

After filling and tamping, when the containers are finally put in place (tightly stacked), it is also possible to have them one-third their height below the level of the path so that they are held firmly in place. This practice fulfills the need of obtaining soil for the mixture used to fill the containers. The resulting depression achieves a similar result to having bunds around the beds, i.e., prevents water runoff, soil erosion, water-logging on the paths, and minimizes evaporation by allowing the water to remain longer after watering, thereby reducing the frequency of watering. (Figure 6)



1. FILLING

2. TAMPING



3. STACKING

Figure 6: FILLING, TAMPING, STACKING

At least at lower elevations where frost never occurs, species that coppice can usually be propagated by cuttings. (Figure 7) These species can also be directly transplanted bare-rooted (without containers) from nursery beds to the planting site. Care should be taken that they have a well-established root system before planting (at least two years old). This will save labour and transport costs. An example of such a species is *Populus deltoides* (bagnu; bahar; baupipal; chalaun; phalash). Another example of such a species is Bamboo *Dendrocalamus strictus*. This species has a shallow root system that spreads laterally relatively fast and is not suited to narrow containers. However, it can be transplanted bare-root easily with good survival rates when two to three years old.

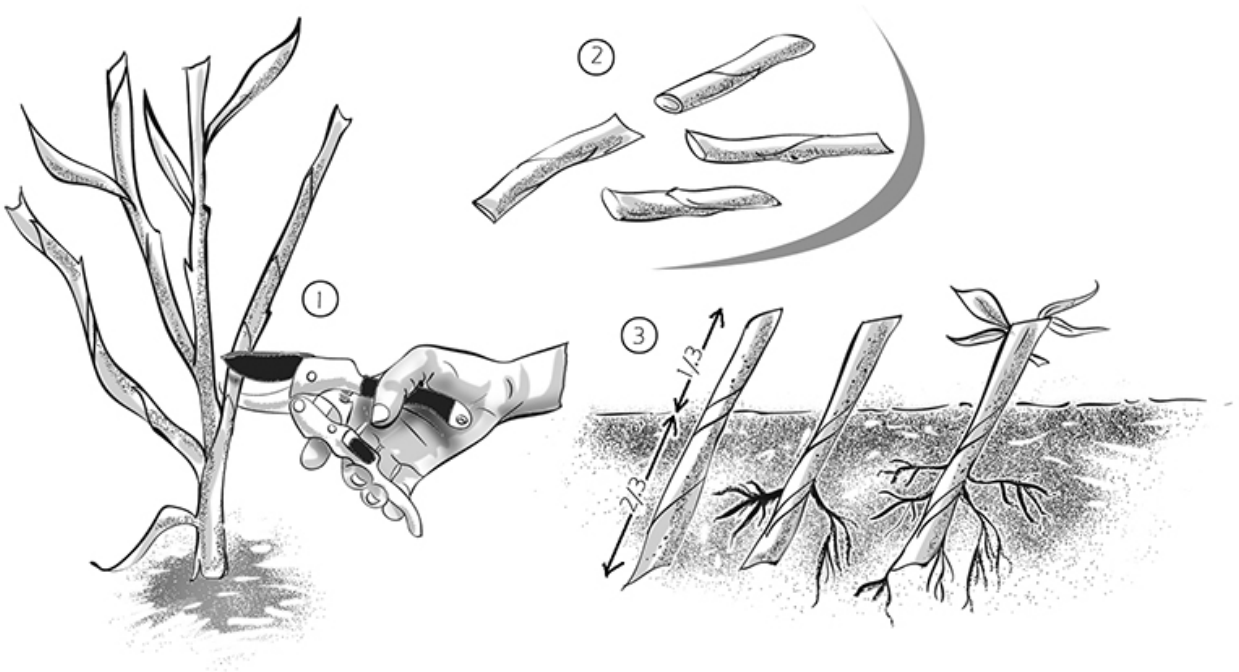



Figure 7: CUTTING

## Soil Preparation

The ideal material used to prepare the germination beds and to fill the containers should be a mixture of one-third clayey soil, one-third sand and one-third compost.

The soil available at the nursery site can be used as a base for the mixture. Soil stratification can be used to determine the components of the nursery soil. (Figure 8)
If clayey, it should be mixed with sand, if sandy, some clay should be added. The clay component is to ensure the solidity of the earth ball in the bag when transporting and it holds water and nutrients that are slowly released to the plant. The sand component is to ensure good *percolation* of water and make it easy for the roots to penetrate the medium. The compost component is to provide nutrients and retention of moisture.


Figure 8: SOIL STRATIFICATION

Those components should be shifted separately to remove stones, twigs, and clods before being thoroughly mixed. This mixture will be used for the preparation of the germination beds and for filling the containers for direct sowing and transplanting. (Figure 9)


Figure 9: SOIL PROPORTION AND MIXING

While filling the containers the mixture should be well-tamped. After a few waterings, when the soil is well settled, it is important to add some of the mixture to the full height of the container. This is to ensure that roots are not exposed and, in the case of poly-bags, that their sides remain straight so that water penetrates evenly, and the water reaches the full ball of earth all the way to the bottom of the bag. This should be checked regularly as soil tends to settle a little after every watering.

Based on the number of seedlings, the size of containers and their volume, a total amount of soil mixture should be arrived at. This will allow for the calculation of the volume necessary for the three components - nursery soil, compost and sand/ clay. The size of the compost pit can be derived from this calculation.

## Making Compost

Fresh manure should never be used for germination beds and container filling as it will hamper the germination of seeds and burn the roots of tender seedlings.

It is important that a sufficient amount of compost is ready well before the time comes to mix the material. It takes at least three months to obtain compost that is well-decomposed and ready for use. The compost pit should always remain moist but never water-logged.

The compost pit is filled to the top by starting with a layer of leaves of mature plants from species to be raised mixed with grass clippings or other readily available organic matter alternating with a layer of manure (10-15 percent ratio by volume). As the decomposition process takes place, subsequent layers can be added due to settling of the total mass. Each layer should be watered once laid before adding subsequent layers. The total mass should not be compacted (air spaces) to allow the presence of oxygen necessary for aerobic decomposition.

When the composting process is achieved, the introduction of earthworms is recommended as a test that the compost is ready for use. They are also beneficial for the quality of the end product and help aerate the compost.

Once the earthworms are thriving, soil which was gathered from under the trees while gathering seeds of the species to be raised should be introduced in the compost pit to inoculate the final mixture used for germination bed preparation and bag filling. This soil has microorganisms that live in symbiosis with the species and are vital for the healthy germination and growth of the trees. (Figure 10)

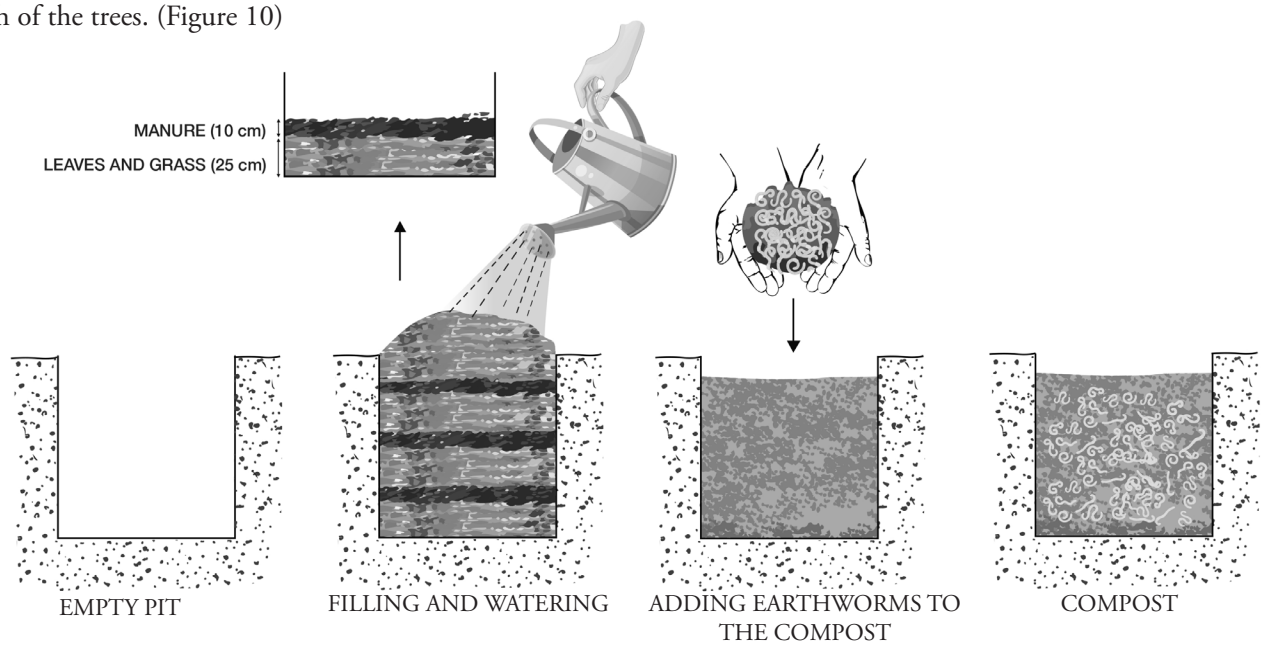



Figure 10: MAKING COMPOST

## Target

The target for planting should be clearly defined. This refers to the age and size of seedlings as well as the total number of seedlings with a species-wise break-up. This target is based on the total surface to be undertaken for planting, the type of planting (reafforestation of areas devoid of tree cover, gap filling between existing trees etc.) and the respective density of each plantation.

It is wise to choose species that are already present in the area to be planted. They are the most adapted to local conditions. When specimens of those species present in the area are of good form and identified as good mother trees, they should be preferred as sources of seeds.

# Seed Gathering, Germination and Sowing

## Seed Gathering

Once the target species have been identified, a calendar should be established (according to local conditions) with the correct time of seeding of the target species to ensure that good seeds (mature and ready-for-sowing) are harvested in a timely manner. Care should be taken to gather seeds that have not been exposed to rain recently.

Mother trees (seed-bearing) should carefully be chosen (healthy, mature and of good form).

To ensure the best results of germination, the storage of seeds should be avoided. Seed beds or containers for direct sowing should be ready before the seeds are brought to the nursery.

At the time of seed gathering (Figure 11), some amount of soil should be collected from under the mother trees (a few kilos) to be incorporated in the compost pit once the earthworms are thriving. This will ensure that the beneficial microorganisms living in symbiosis with the root systems are present and facilitate the germination process. These microorganisms also convert minerals and other nutrients into a form easily absorbed by growing plants.

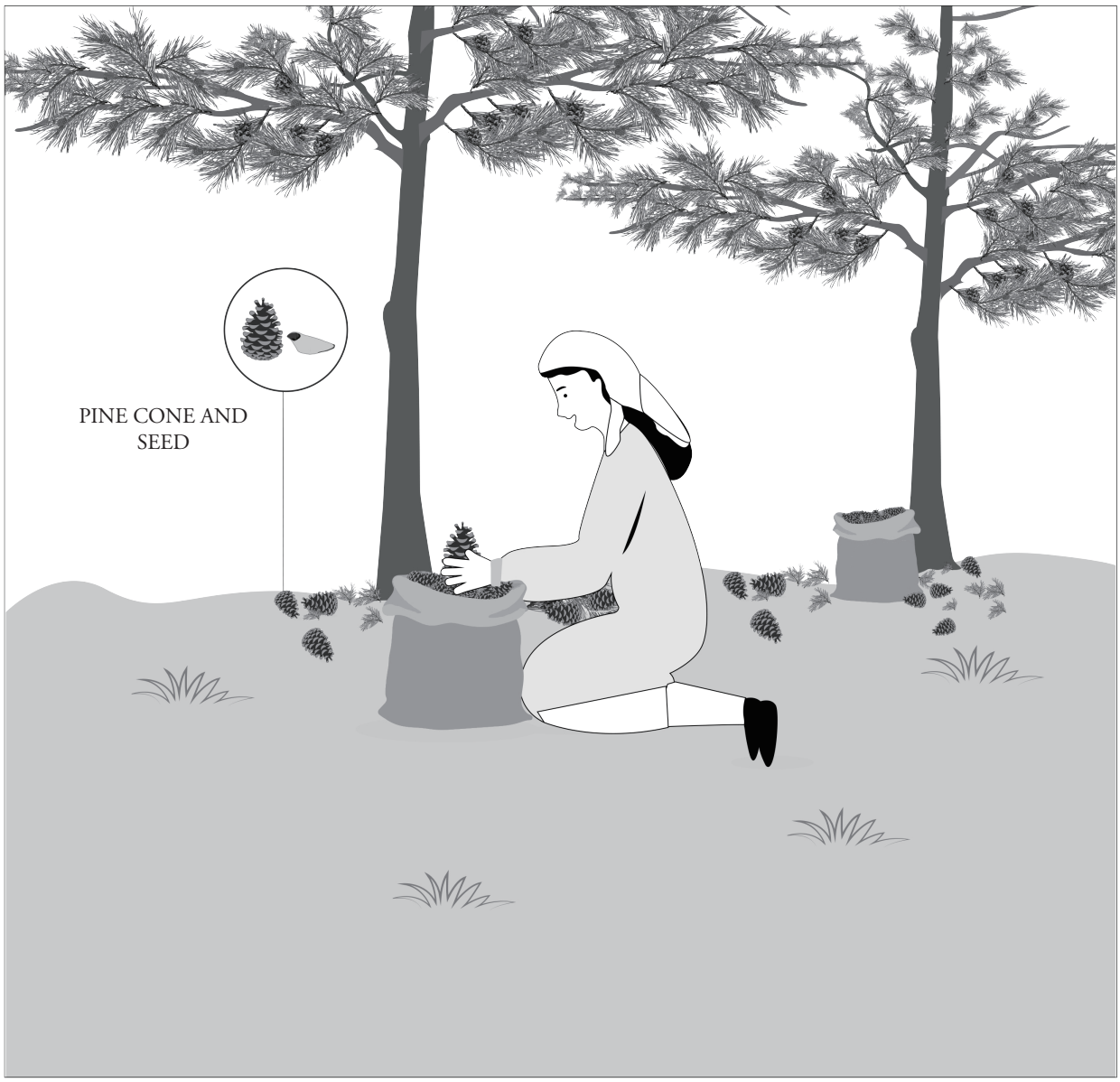



Figure 11: SEED GATHERING

## Germination and sowing

Seeds should be well-formed. After careful winnowing (Figure 12) to remove extraneous materials that could be present such as twigs, stones, etc., it is a good practice to then soak the seeds in water to remove the ones that float and may be empty.


Figure 12: WINNOWING

The seeds used should be the ones that sink to the bottom. (Figure 13)

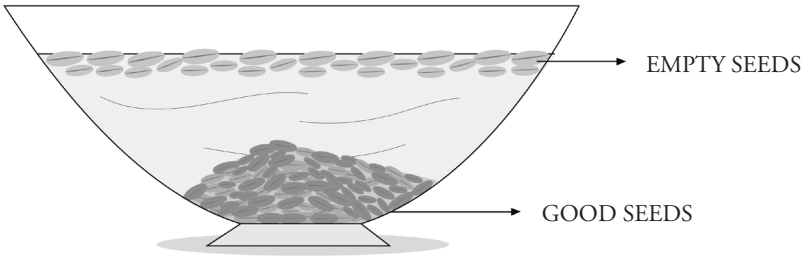



Figure 13: SOAKING TO REMOVE EMPTY SEEDS

The average germination rate of the target species should be ascertained by germination trials before sowing. A hundred well-formed seeds of the species are tried. Most seeds can be germinated by soaking in water, some soft seeds will have to be germinated in germination beds.

The seeds whose germination rate is 100% can be sown singly in containers. If the germination rate is between 50-100%, two to three seeds can be sown in a container and when seedlings have sprouted they should be reduced by thinning to one seedling per container - the most robust seedlings being kept (Figure 14). If the germination rate is less than 50%, or unknown, the seeds should be sown in germination beds.

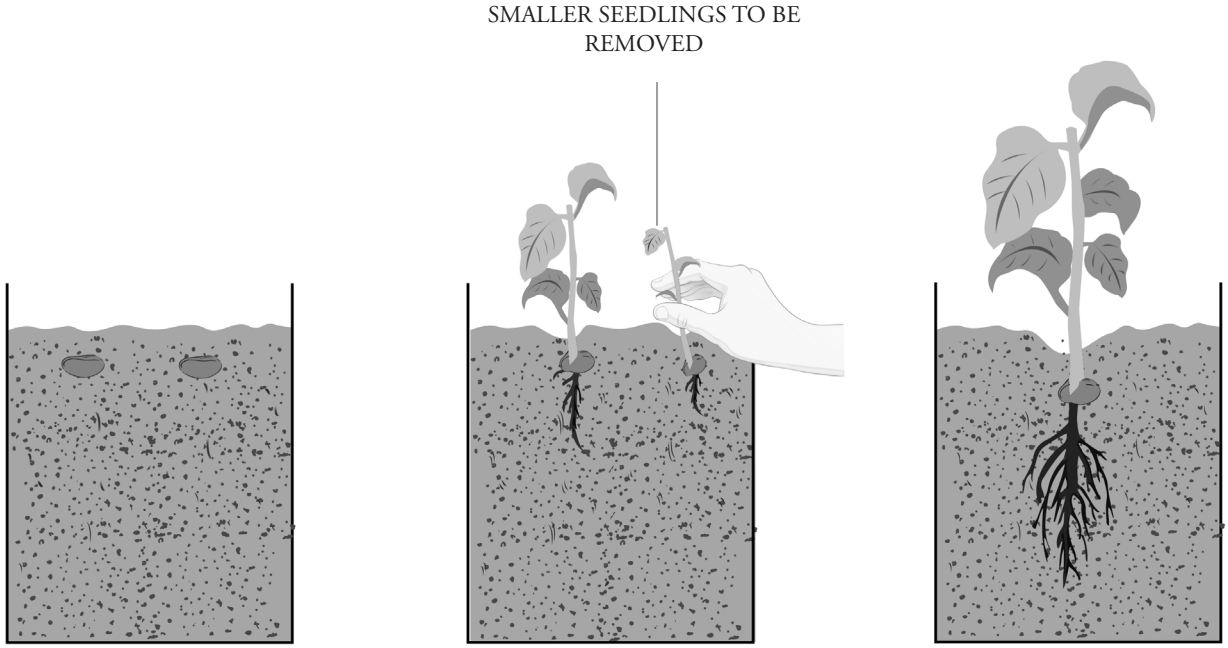



Figure 14: THINNING

To ensure even germination, some seeds may need prior treatment before sowing. Information from knowledgeable local resource persons about the appropriate treatment needed should be sought.

Some species allow the sowing of sprouted seeds by soaking them in water for a few days before sowing them directly in containers. This is advantageous as it gives definite results. If the seeds do not sprout all at the same time, the sprouted ones should be separated and sown on a daily basis. Care should be taken to drain the old water and replace it with fresh water on a daily basis also to avoid putrefaction. The sprouting seeds should be handled delicately. (Figure 15)

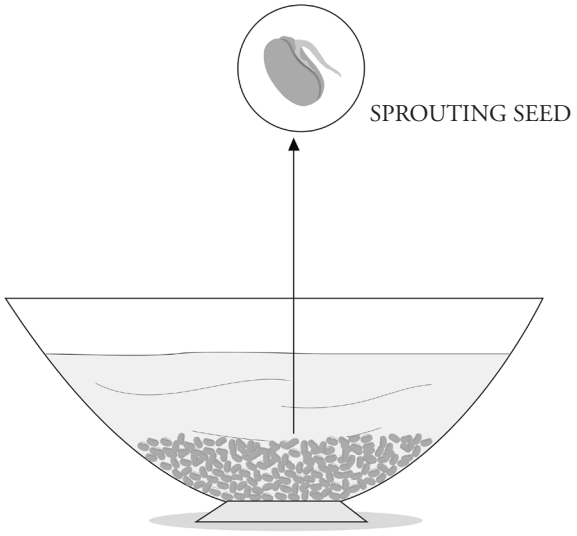
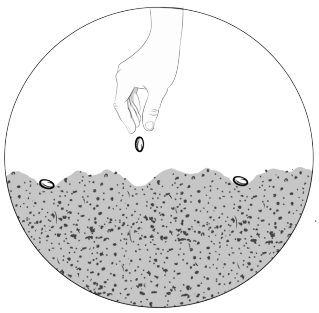



Figure 15: SOAKING TO OBTAIN SPROUTED SEEDS

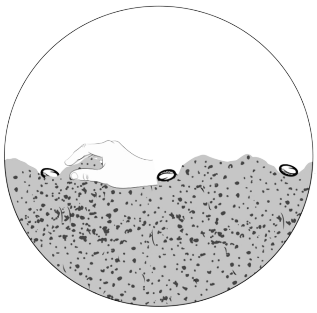
Seeds should be dribbled below the surface of the seed bed or of the containers at a depth of about one to one and a half times the seeds' biggest diameter.

For small and tiny seeds, it is easier to put them on the surface of the soil and cover them to the required depth by sifting compost on top. They should then be watered with a fine rose to settle the compost. Subsequent gentle watering will ensure that the seeds are not displaced/disturbed.

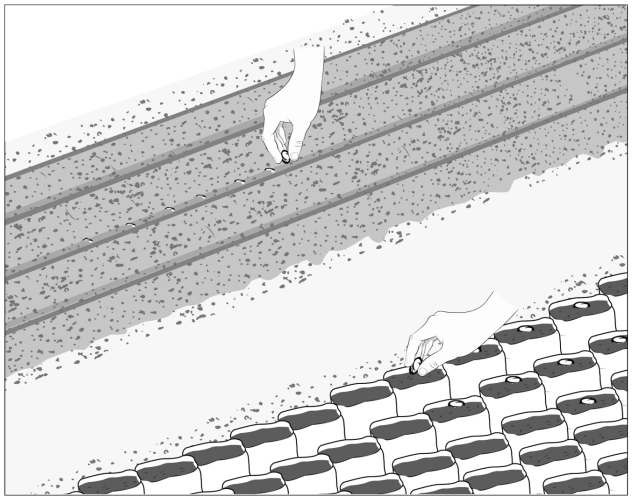
In germination beds, the seeds should be sown in rows evenly spaced apart (15 - 20cm) to make it easier for maintenance: weeding, loosening the soil and transplanting the seedlings to containers. The seeds should not be too close in the row to avoid the possibility of damping-off. (Figure 16)



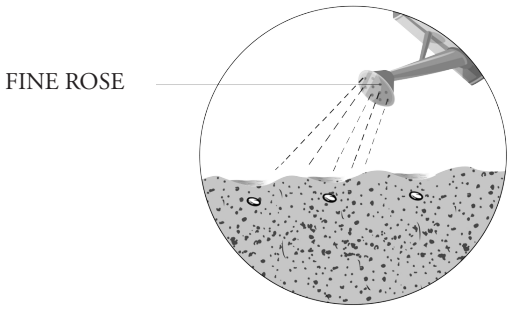
1. DRIBBLING



2. PUSHING SOIL ONTO THE SEED



3. SOWING IN SEED BEDS AND PLASTIC BAGS




4. WATERING

Figure 16: SOWING

## Transplanting of Seedlings from Germination Beds to Containers

Generally, small seeds will provide seedlings that can be shifted to the containers when they have at least six leaves. Larger seeds may be successfully transplanted once they have sprouted. They should be transplanted preferably on a cloudy or rainy day, otherwise, in the late afternoon (never at noon) to allow them to recover. They should be well-watered right after transplanting to ensure that there is an intimate contact between the soil and the root system (no air pockets).

A hole should be made with a pointed stick in the centre of the container. The hole is of a size commensurate with the size of the root system of the transplanted seedling. The root system of the seedling should be accommodated fully into this hole. The soil should be tightened around the root by putting the pointed stick three-quarters of an inch away from the original hole and pressed gently towards the root of the seedling. This could be repeated two or three times in opposite directions to ensure that no air pocket remains around the root system of the seedling. Thorough watering should be done right away to complete the process. (Figure 17)

As in the case of germination beds, transplanted seedlings will need temporary shades which are detailed in the next section.

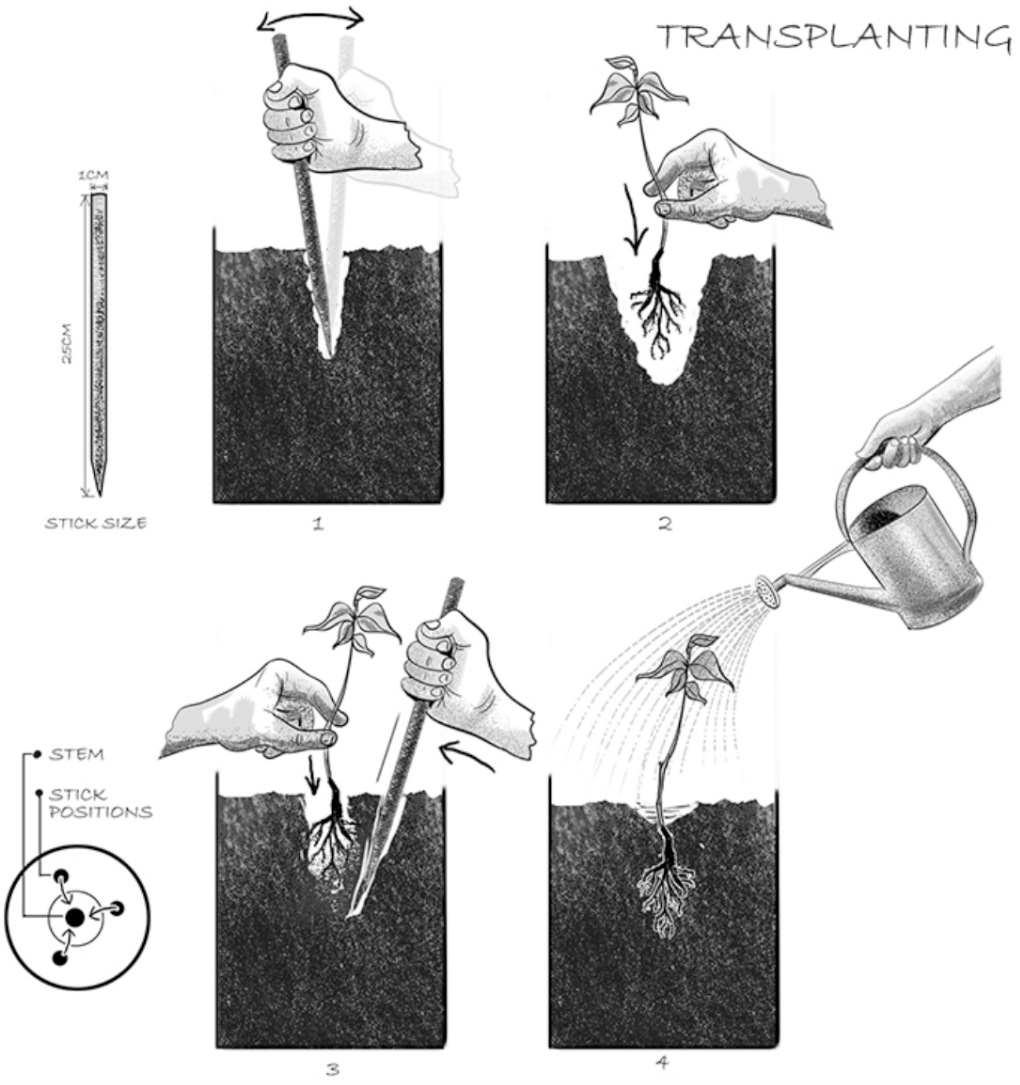
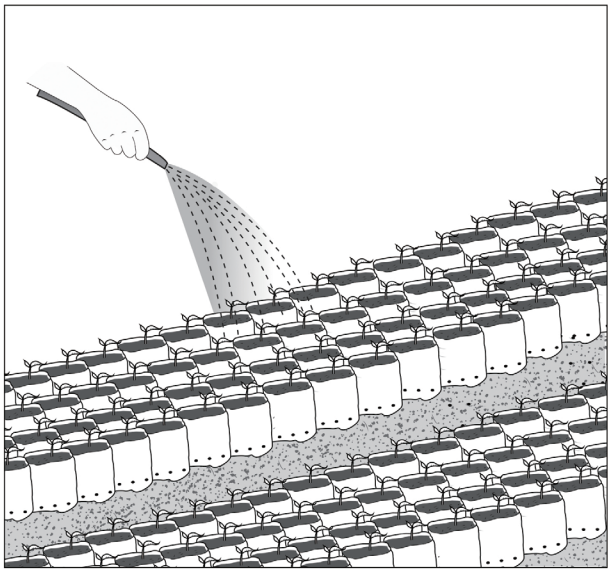



Figure 17: TRANSPLANTING

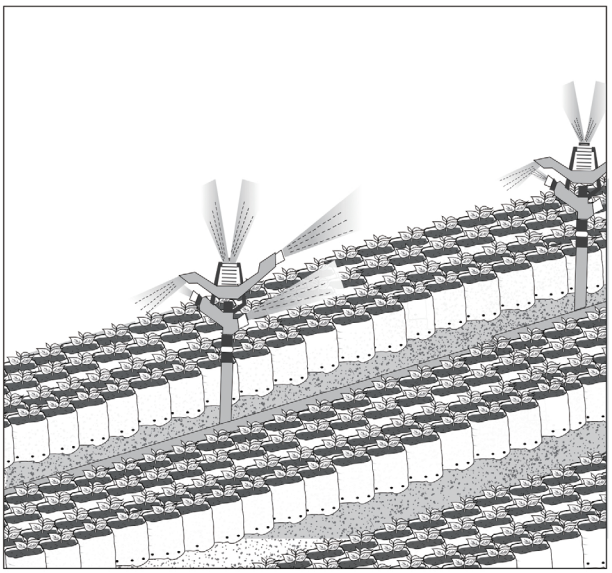
# Maintainance

## Watering (Figure 18)



1. WATERING THROUGH A PIPE

**Germinating Seeds:**
The germinating seeds should be kept moist at all times but never waterlogged. Watering will depend on the season, during sunny days it may be necessary to do three to four watering per day. During cloudy days, this watering may be reduced to only once a day. Once the seedlings are well established the watering will be reduced to twice a day, then once a day may be sufficient, depending on the weather.



2. WATERING THROUGH SPRINKLERS

**Established Seedlings and Saplings**:
Once the seedlings are at the correct size for transplanting into containers or established in the containers when directly sown, they will be called saplings. By then they may need to be watered once or twice a week depending on the weather.

Figure 18: WATERING

## Temporary Shades

If the days are sunny at the time of sowing or transplanting, it is important to establish temporary shades to ensure constant and even moisture by reducing evaporation from direct sun exposure.

These temporary shades (Figure 19) should be made 30-50cm above the germinating seeds and transplanted seedlings for easy access and providing good ventilation. These shades should be made with removable slates, sticks or branches in order to start with 100% shade until the sprouts are out of the ground and/or the transplanted seedlings have fully recovered. The amount of light coming onto the plants can be increased by gradually removing the slates, sticks or branches. Depending on the species and the weather, this process may take from a few days to a couple of weeks.

Nowadays, green plastic materials coming in rolls are available with a capacity to reduce the amount of light going through them graded at 25, 50 or 75 percent. These may be used if local materials are not easily available and/or labour costs are a factor.

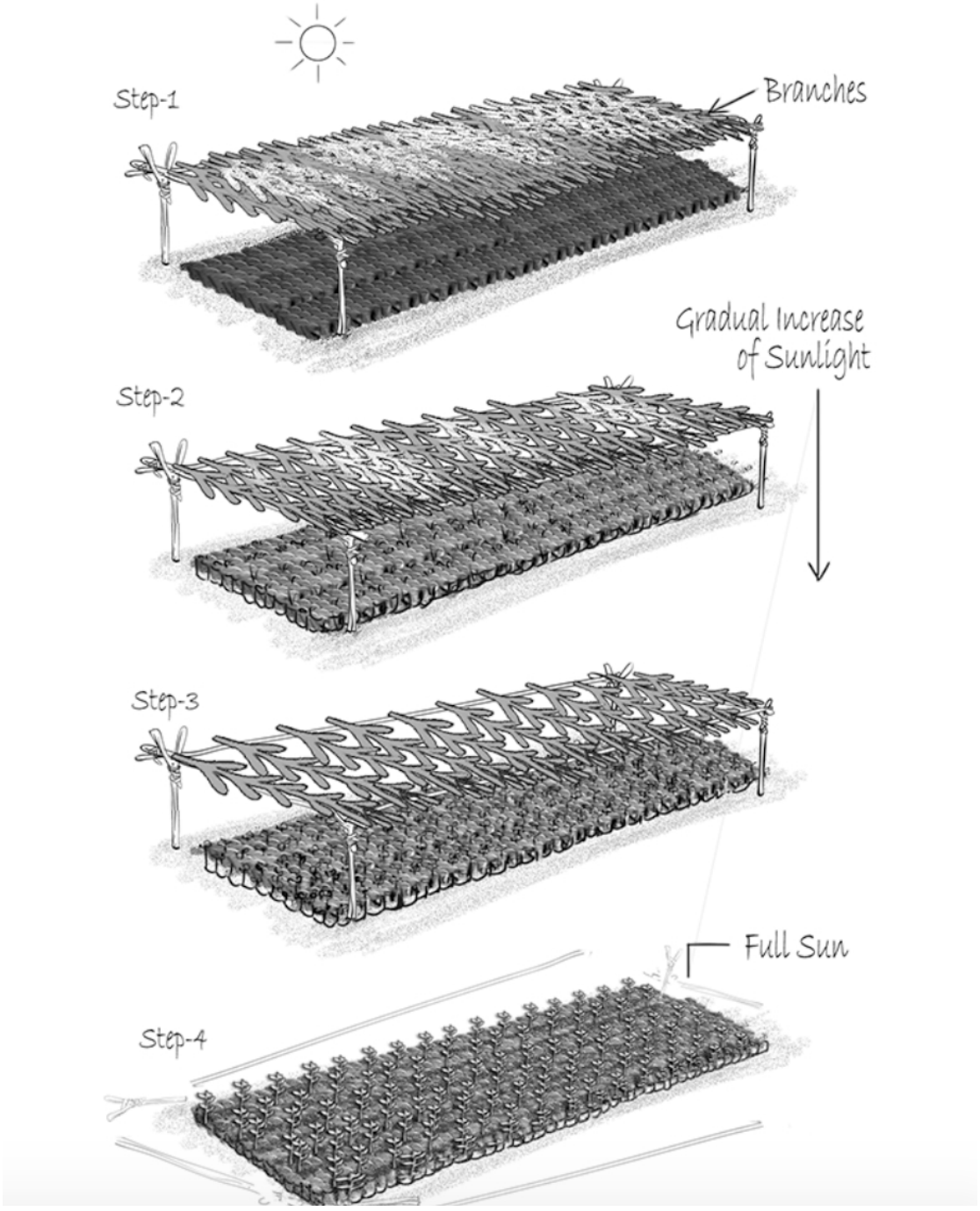
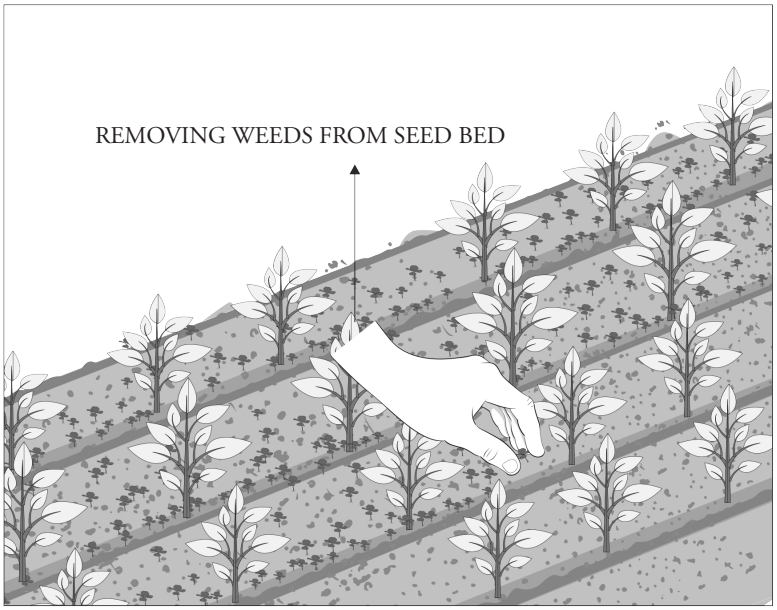



Figure 19: REMOVABLE SHADES



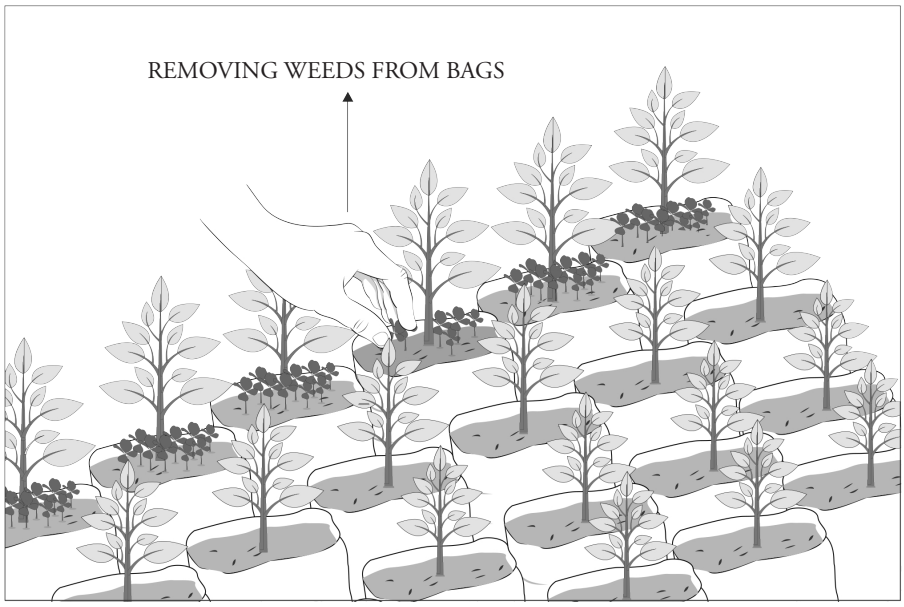




Figure 20: WEEDING

## Weeding

Weeding should be done thoroughly and regularly to remove any other plants that may colonize the seedbeds or containers. This should be done when the weeds are still small to avoid disturbing the roots of the seedlings and saplings while pulling the weeds. (Figure 20)

## Cultivation Tool

After every few watering, the soil will become compacted. It should be loosened regularly by light surface cultivation between the rows of seedlings in germination beds and on the surface of the containers. (Figure 21)

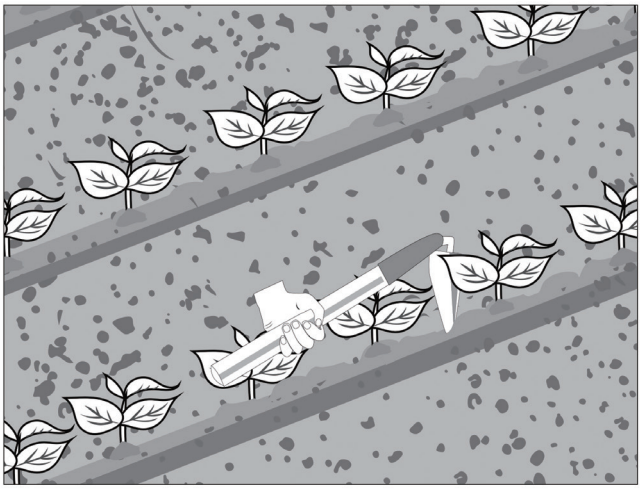


Figure 21: CULTIVATION TOOL

## Shifting and Pruning of Roots

When the saplings are well-established (about a year) it will be necessary, from time to time, to lift a container to check if the root system of the sapling has gone through the drain-hole(s) of the container. When this occurs, the containers should be shifted into another bed to prevent the establishment of the root system in the ground. This will avoid great damage to the root system of the saplings at the time of lifting the containers for planting. In some cases, it may be necessary to trim the root system of the saplings when they are shifted. (Figure 22)

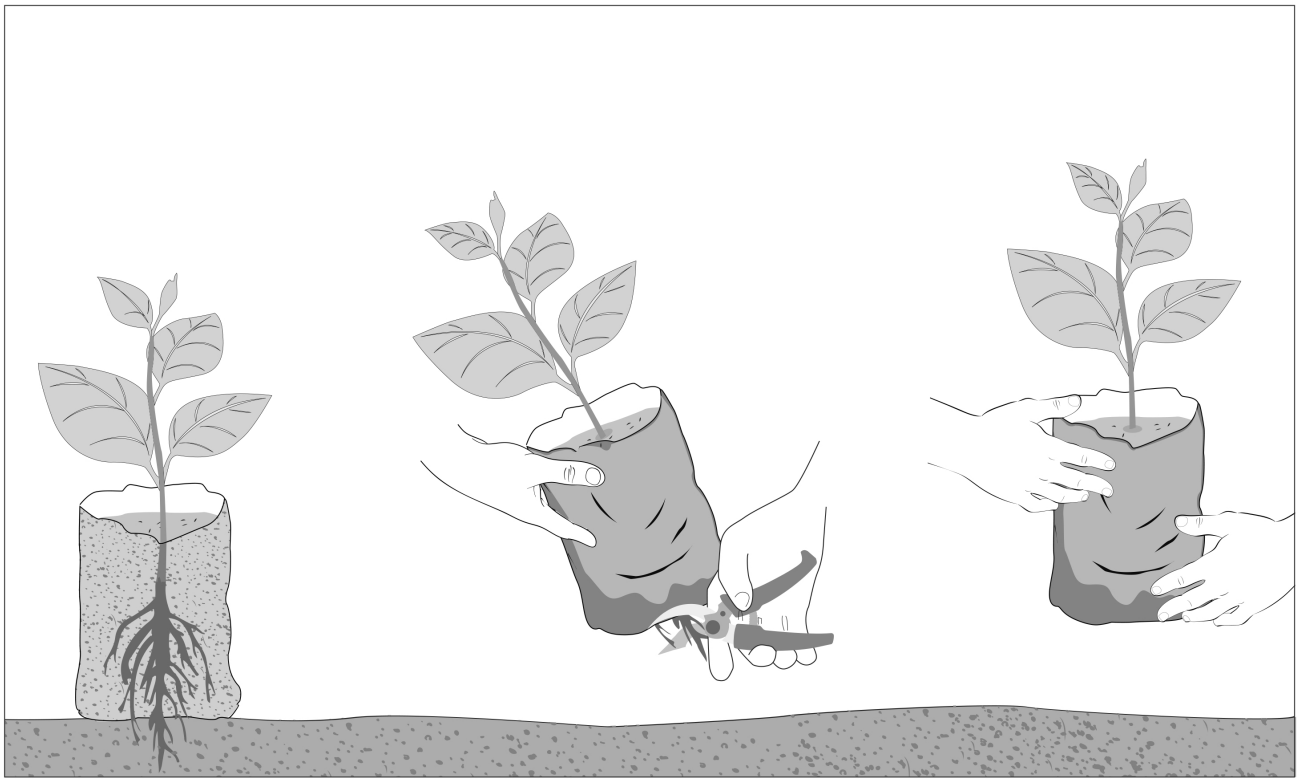


Figure 22: SHIFTING

## Removal of Lower Branches

For good survival rates of saplings to be planted in tough conditions (heavily-grazed or fire-prone areas), it is worth the expense to keep saplings longer in the nursery (up to 5 years). In such a case, after two or three years, when the saplings are strong and healthy, some lower branches may be removed with a sharp instrument to encourage the rapid growth in height of the saplings. (Figure 23)

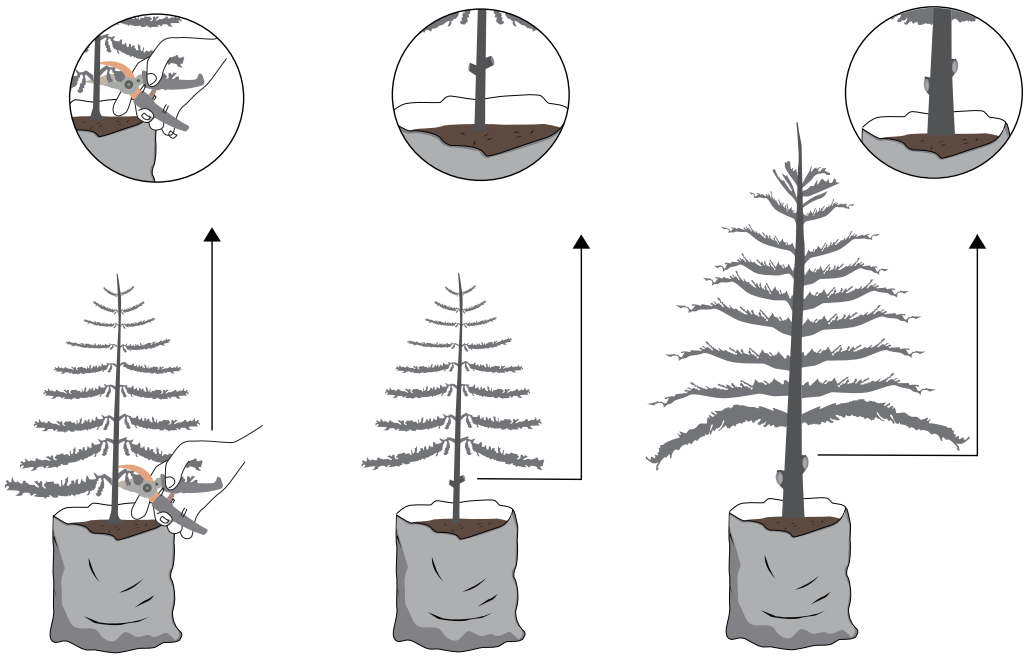


Figure 23: PRUNING

## General Cleanliness and Orderliness

The maintenance of an orderly nursery will ensure an atmosphere conducive to good results. The whole nursery, especially paths and sapling beds, should be kept neat. The infrastructure, such as fences, water supply, etc., should be carefully monitored to avoid painful surprises.

## Size and Age of Saplings

Some favourable sites will allow saplings to be planted when they are only 2 years old and in smaller containers. However, older and taller saplings are generally more robust and better withstand climatic extremes, such as long dry seasons or heavy snow pack. They are also better at withstanding heavy disturbances, like overgrazing or fire. In such cases, saplings should be planted when 3-5 years old, one and a half metres tall, and in larger containers. The aim of ensuring the highest survival rates is important but it should be weighed against the difficulty and cost (especially for transport and pitting) of using larger saplings and containers.

## Personnel

A person dedicated to nature and forests and is aware of their value should preferably be appointed. He or she should be familiar with the local conditions. This person should have or be willing to acquire the technical and social skills necessary for the execution of all the works involved in nursery practice and maintenance. The best case would be that this person has had prior experience in tree nursery work.

He or she will be responsible for the management of all aspects of the production of saplings until ready for planting. An important part of his or her role will be to keep meticulous records of all the activities such as the dates of harvesting seeds, sowing, germination, transplanting as well as the dates at which the saplings should be ready for planting.

This person should be able to hire, guide and supervise the workforce necessary for the achievements of the targets. Apart from this, he or she should be able to foresee potential problems before they occur with the infrastructure especially fences and water supply. He or she will also be responsible for the procuring and safekeeping of the necessary tools and implements.

This person should be able to seek the advice of valuable resource persons that are experts at the setting up and management of nurseries; for example, a Forest Department staff with long-term experience in a nursery nearby.

If this person successfully achieves the target, he or she will be assumed to have gained sufficient experience to be put in charge of the planting and after-care of the plantations.

## Example Calendar/ Timetable

For the good execution and timely achievement of the steps necessary for completing the raising of the saplings to the season chosen for planting, it is wise to have a time-table depicting the order in which the activities will be undertaken.

For any particular species or location, a calendar has to be established defining the appropriate months for harvesting the seeds of the chosen species, the desired age of the saplings at planting time, and the suitable period for planting. All the other operations of the nursery derive from these points.

An enlarged laminated copy of the finalized calendar should be put on display in the nursery for reference.

For the sake of demonstrating such a calendar we use the example of two species: Deodar *Cedrus deodara* and Ban-oak *Quercus leucotrichophora*.

*Calendar for Nursery Activities before and including Plantation*

<table>
<tr><th rowspan="2">Month</th><th colspan="6">Activities</th></tr>
<tr><th>Year 1</th><th>Year 2</th><th>Year 3</th><th>Year 4</th><th>Year 5</th><th>Year 6</th></tr>
<tr><td>January</td><td rowspan="2">Define Project</td><td rowspan="2">Seed B Collection and Sowing</td><td rowspan="11">Maintenance</td><td rowspan="2">Saplings B Ready</td><td rowspan="10">Maintenance</td><td rowspan="6">Maintenance</td></tr>
<tr><td>February</td></tr>
<tr><td>March</td><td rowspan="2">Define Target</td><td rowspan="9">Maintenance</td><td rowspan="4">Maintenance</td></tr>
<tr><td>April</td></tr>
<tr><td>May</td><td>Nursery Site Identification</td></tr>
<tr><td>June</td><td rowspan="3">Site Preparation</td><td rowspan="3">Planting B</td></tr>
<tr><td>July</td><td rowspan="2">Planting A</td></tr>
<tr><td>August</td></tr>
<tr><td>September</td><td>Preparation for Sowing</td><td rowspan="3">Maintenance</td><td rowspan="3">Saplings A Ready</td></tr>
<tr><td>October</td><td rowspan="2">Seed A Collection and Sowing</td></tr>
<tr><td>November</td></tr>
<tr><td>December</td><td>Maintenance</td><td>Maintenance</td><td>Maintenance</td></tr>
</table>

Seed Collection and Sowing | Saplings Ready | Year of Planting | Planting Period

Species A: Deodar *Cedrus deodara* - 4 years old at planting time

Species B: Ban-Oak *Quercus leucotricophora* - 2 years old at planting time

# Planting and After-care

In Himachal Pradesh, there are different climatic and vegetation zones. They depend on the elevation and exposition. Micro-climatic conditions for specific areas may also be present. The planting time will have to be determined according to the local conditions and reliable members of the local community will be the best judges.

For larger containers at least, pitting should be done in advance. The number of pits corresponds to the number of saplings to be planted.

The planting should be done when soil moisture is at least 50 cm deep. Planting is best done during cloudy or rainy weather.

It is important to achieve the planting as early as possible in the rainy season so that the saplings are well-established before the onset of the dry season.

When possible it is good to provide mulch around the stem of the sapling to reduce stress due to evaporation from the soil above the root system of the sapling.

In places where one of the aims of the plantation is the production of timber and where transport is easy, it will be good to increase the number of saplings per surface area. In subsequent years, saplings of poor form can be removed for better quality of the final stand.

# Glossary

| Term | Definition |
|---|---|
| *Aerobic Decomposition* | The decomposition of organic matter in the presence of oxygen. |
| *Bed* | A small area of ground specially prepared for plants (MWD[&], 2019).<br>In this manual, it refers to the regular surfaces established for germinating seeds in the ground and where seedlings are stacked in containers. In India, the prevalent practice is to surround the beds by mounds of earth (bunds) to create a well-defined border and keep the water within. |
| *Compost* | A well-decomposed mass of organic matter with a proportion of carbon and nitrogen as close to forest humus as possible. |
| *Coppice* | The ability of plants to regrow freely from a cut stem and showing a vigorous sprouting of many branchlets. |
| *Cutting* | The section of stem or root that is cut off a plant to be used for propagation. |
| *Damping-off* | A fungal disease developing at the base of the stem of growing or germinating seedlings when they are small and tender which causes a cutting off of the stem and destroys the plant. When a germination bed is affected, usually all the plants die off. Very damp conditions and/or a lack of ventilation are responsible. |
| *Dribbled* | The action of dropping seeds (sowing) in a regular manner and in even rows. |
| *Ecosystem Services* | The benefits people obtain from ecosystems, as defined by GIZ according to the Millennium Ecosystem Assessment of the UN, 2005. |
| *Germination Rate* | The percentage of successful germination of a given number of seeds. |
| *Inoculate* | Introduce an agent into a suitable medium which will thereby be colonized and transformed. An example of inoculation is the introduction of a yogurt culture into milk. |
| *Microorganism* | A microscopic organism, especially a bacterium, virus, or fungus (OED[#], 2018). In this manual, this term refers to organisms associated with and needed by the species used for plantation. |
| *Mulch* | Material (such as decaying leaves, bark, or compost) spread around or over a plant to enrich or insulate the soil. (OED[#], 2018). |
| *Percolation* | The movement of a fluid through a medium. In our case, the penetration of water through the soil. |
| *Root System* | The total mass of roots and rootlets below the stem of a plant. |
| *Symbiosis* | Interaction between two different organisms living in close physical association, typically to the advantage of both (OED[#], 2018) |

**[#]OED - Oxford English Dictionary**
**[&]MWD - Merriam-Webster Dictionary**

**Deutsche Gesellschaft für**
**Internationale Zusammenarbeit (GIZ) GmbH**

Matsubara Building, Village Sargheen
(Near HFRI), Shimla - 171013
Himachal Pradesh (India)