FOREST LANDSCAPE RESTORATION PROJECT
ACIAR ASEM/2016/103 Enhancing Livelihoods through Forest & Landscape Restoration

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GUIDE TO

QUALITY SEEDLING PRODUCTION

IN SMALLHOLDER NURSERIES

REVISED OCTOBER 2019

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Guide to Quality Seedling Production in Smallholder Nurseries
(Revised October 2019)

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3. When sowing medium and large seeds, do not place them too close to each other.

4. Sterilize the germination medium and apply fungicide when necessary.

Larvae of insects are the common pests that attack young seedlings while ants and rodents are the usual menace for seeds. Whenever feasible, pick up the larvae, or spray them with insecticides. Also, put a screen barrier around seedbeds and seedboxes to prevent rodents and domestic animals including chickens form damaging the seeds and young seedlings.

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CONTENT

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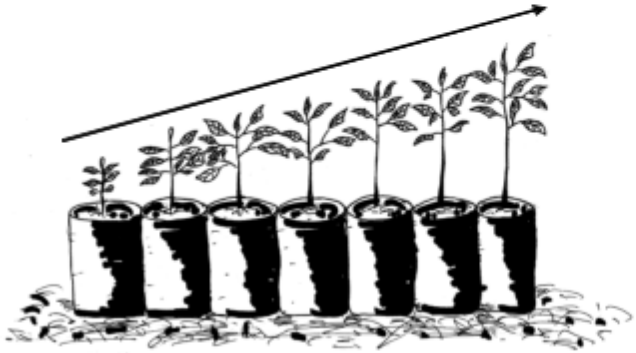
GRADING AND CULLING

A batch of seedlings will not grow at the same rate, some will overgrow others. Arranging seedlings according to height or 'grading' will provide sufficient space for smaller seedlings to receive ample sunlight and water to improve their growth. If seedlings on beds are not graded, the shorter seedlings will be overtopped with taller seedlings and become more deprived with sunlight and water, leaving them unsuitable for planting together with the rest of the seedlings in the cohort.



It is inevitable that in a seedling cohort, a few will exhibit very poor growth even though they are given the necessary treatments. These seedlings must be culled from planting. Page 4 of this manual illustrates the seedlings that must be discarded.

CONTROL OF PESTS AND DISEASES

Damping off is the most common disease of seeds and seedlings in the nursery. Seedlings with damping off have rotten portion at the base of the stem causing the seedlings to topple down and die . Seeds with damping off will rot, thus fail to germinate. Damping off is mostly caused by fungi, hence can be treated by applying fungicide. The following are some practices that will minimize the occurrence of damping off:

1. Make sure that the germination medium has good drainage to facilitate the flow of water and movement of air within the medium.

2. Do not put too much organic matter to the germination medium. Organic matter should be free from fresh animal waste such as chicken dung, goat dung and cattle manure.

INTRODUCTION

The quality of planting stock is a major factor that determines the success of tree farming and forest restoration programs. The field survival of trees, growth performance, length of rotation period and 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. Genetic quality relates to the genetic characteristics of the mother tree, while physical quality refers to the morphological and physiological condition of the seedling as it is cultured in the nursery. There is no quick fix to improving seedling genetic quality. It involves a long-term process of establishing genetically-superior germplasm sources and designing effective germplasm collection protocols. Collecting seeds and wildlings from a superior mother tree in the wild, while straightforward, it is not a guarantee to result in genetically-superior seedlings because the physical quality of mother trees is influenced not only by their genetic characteristics but also affected by a multitude of environmental factors. On the one hand, improving seedling physical quality can be done in a short-term, mainly by applying the appropriate cultural practices when seedlings are tended in the nursery.

This "Guide to Quality Seedling Production in Smallholder Nurseries" demonstrates smallholder-based technologies for producing high quality seedlings. It is envisaged to help enhance the knowledge of smallholders private nursery operators and community groups involved in tree farming and forest restoration projects. The technologies presented incorporate results of research projects in the Philippines funded by the Australian Centre for International Agricultural Research (ACIAR), research activities of the Department of Environment and Natural Resources (DENR), and various publications on nursery seedling production. Being smallholder-based, the technologies presented are simple and less costly for smallholders to practice.

02
Why Quality Tree Seedlings?

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.

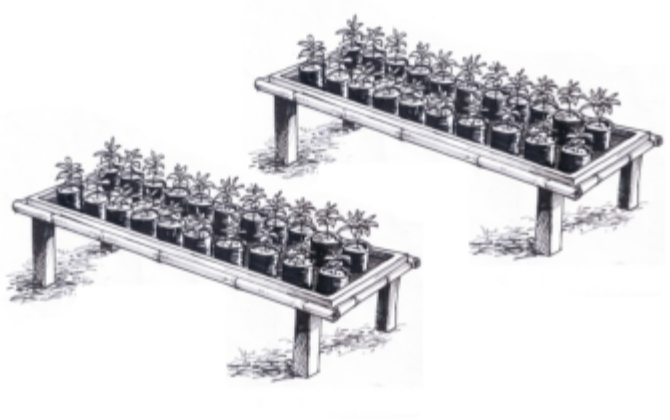
On the other hand, a high quality seedling provides minimal plantation cost because of low seedling mortality and the less intensive management needed. Further, the planting of high quality seedlings provide early return on investment because they have more rapid growth, thus rotation age is shortened. If farmers are particular about choosing the best germplasm of agricultural crops such as corn and rice, the more that they should be selective about the quality of tree seedlings to plant. Most agricultural crops can be harvested in a few months such that any mistake in the selection and use of germplasm can be rectified in the next cropping season. Trees, on the other hand, would require several years before they could be harvested. Thus, the mistake of planting low quality seedlings will also take several years before this can be corrected.

The following are examples of advantages of high quality seedlings compared with low quality seedlings:

HIGH QUALITY SEEDLINGS	LOW QUALITY SEEDLINGS
1. Low Mortality	1. High Mortality
2. Low Plantation Maintenance Cost	2. High Plantation Maintenance Cost
3. Shorter Rotation Period	3. Longer Rotation Period
4. High Timber Recovery	4. Low Timber Recovery
5. High Timber Quality	5. Low Timber Quality

HARDENING-OFF

Trees are mostly planted in adverse sites characterized of having low soil moisture and nutrient supply, and exposed to intense sunlight. To avoid the shock of being exposed to adverse growth conditions, seedlings must undergo the hardening (conditioning) process. Hardening-off can be best facilitated when seedlings are raised off the ground. Elevating seedlings regulates the absorption of moisture and promotes aerial root pruning, preventing the root development into the ground causing severe stress to seedlings when lifted for transplanting.



Hardening-off can be done by controlling:

1. Watering — reduce the frequency of watering and the amount water applied to the seedlings. If possible take the seedling to its wilting point such that shoots will begin to wilt before watering. However, care should be taken not to expose the seedlings to too much wilting that it could not recover anymore and will result to shedding off of leaves. Controlling the watering will accustom the seedlings to limited soil moisture on the field.

2. Shading — shade must be completely removed at least a month before planting the seedlings. This will prepare the seedlings for direct exposure to intense sunlight in the planting site. If seedlings are not accustomed to full sunlight, sun scalding of leaves will occur shortly after planting, which will lead to mortality.

3. Root pruning — necessary to prevent the growth of long taproot and encourage the development of young fibrous roots, but should not be carried out two weeks before planting

4. Fertilizing — tthe frequency of application and amount of fertilizer applied must be reduced, although the application of fertiliser one to two weeks before field planting promotes high seedling survival and growth

The tedious root pruning activity can be avoided if pots are placed on a rack of poles or screen to prevent them from resting on the ground. When roots come out from pots, these will die through air pruning. Elevating the seedlings will also facilitate the hardening process as the availability of water and nutrients to the plants can be controlled.

WEEDING

Weeds compete seedlings with moisture, nutrients and sunlight. Weeding should be done regularly before weeds will outcompete the seedlings. Removing weeds on pots can be done by handpicking or by using hand tools. Weeding should be done carefully not to damage the seedlings as these could be uprooted together with the weeds.

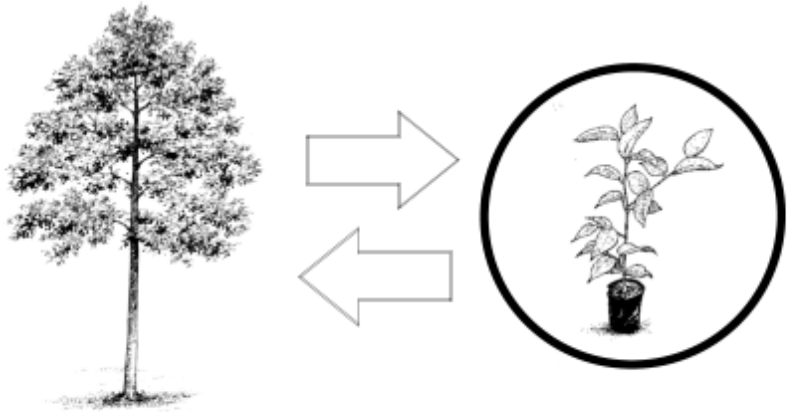
FERTILIZING

The application of inorganic fertilizer may not be necessary if the potting mix contains high amount of nutrients to support the seedling growth. It is easy to scorch the seedlings, thus fertilizer application can damage the seedlings if not done correctly. If it is necessary to apply fertilizer, cheap material can be Urea his is a a . T source of nitrogen which is an essential nutrient for the vegetative growth of seedlings. One teaspoon of Urea dissolved in four gallons of water could be applied during watering.

03

What is Seedling Quality?

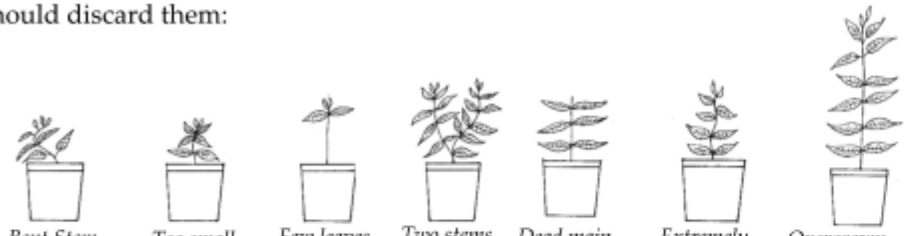
The quality of seedling is based on two aspects, physical and genetic. Physical quality is basically reflective of the nursery seedling cultural practice. It is exhibited by a range of morphological and physiological characteristics although the most commonly used parameters are height, root collar diameter, health and root form. Genetic quality refers to the genetic make up of seedlings, which is a manifestation of the genetic quality of the germplasm source. This can be enhanced through using germplasm from phenotypically superior seed trees, from seed production areas and seed orchards.



A high quality seedling has the following characteristics:

1. Grown from seeds or wildlings collected from genetically and phenotypically superior mother trees or trees from seed production areas or seed orchards.
2. Healthy, free from diseases and with dark green leaves.
3. Sturdy stem and with relatively large root collar diameter.
4. Root system that is free from deformities, dense with many fine fibrous hairs with white root tips.
5. Balanced root and shoot mass.
6. Fully hardened, accustomed to full sunlight and reduced water few weeks prior to outplanting.

If any of the seedlings in your nursery are similar to the following illustrations, you should discard them:



Bent Stem *Too small* *Few leaves* *Two stems* *Dead main shoot* *Extremely small leaves* *Overgrown (Unbalanced Shoot and Root System)*

A high quality seedling must have a healthy root system with many fibrous roots and be free from deformities.

— A good root system free of deformities with straight taproot. Notice the many fine root hairs that are important for the absorption of water and nutrients.

Seedlings with root systems similar to illustrations below should not be planted.

— A deformed root system caused by poor pricking out. Notice that the roots are curled like letter J close to the surface of the container.

— Another deformed root system caused by poor pricking out. Here the main roots was stuffed into a hole too small and the roots were twisted upwards. As the roots began to grow downwards, they formed a complete loop.

— A spiraled root system caused by the smooth surface of the bag. Notice that the roots are coiled at the bottom of the bag.

Normally, about 20-30% of seedlings raised in the nursery will exhibit poor physical quality. Accordingly, there should be an allowance of 20-30% more seedlings than the quantity of seedlings required. Low quality seedlings must be discarded and should not be used for field planting. It is more expensive to maintain a poor quality seedling in the nursery and it is not worth spending resources for planting low quality seedlings in the field. Poor quality seedlings are unlikely to survive in the field.

ROOT PRUNING

Cutting of root that are growing outside the seedling container is essential to prevent the roots from penetrating into the ground. If roots develop in the ground, lifting the seedlings for field planting will damage most part of the root system, which will increase the risk of seedling mortality. Also, taproots penetrating into the ground will defeat the hardening process because roots will continue to absorb moisture and nutrients from the soil.

Root pruning can be done by cutting the roots that come out from the seedling container using a scissor or knife. If the outgrowing roots are still very young, these can be rubbed off by hands.

It is necessary to carry out a regular checking so that root pruning can be carried out while the outgrowing roots are still very young. After cutting the roots, the seedlings should be watered as they may be stressed. Root pruning should be avoided two weeks before planting as seedlings may not be able to recover from the stress before they are planted.

A common practice which is over-watering should be avoided because it will result to etiolated seedlings and promote the spread of diseases caused by fungi and bacteria. The best time to water seedlings is early in the morning and late in the afternoon. If the top of the potting medium is overgrown with moss and weeds, break up the surface using a stick or a hand tool.

SPACING

As seedlings grow approximately 10 cm tall, the shoots will become crowded and prevents most of the leaves to receive sufficient sunlight necessary for growth. Before this happens, seedlings on transplant beds should be spaced appropriately. Spacing will not only allow seedlings to receive sufficient sunlight but also facilitates counting and monitoring for seedlings with pests and diseases. Spacing can be done by leaving approximately 5 inches distance in between two or three rows of seedlings. To prevent the pots from toppling down, a piece of wood or a bamboo stem can be placed on the space in between rows.

Seedlings spaced appropriately

Crowded seedlings should be avoided

05

Establishing a small-scale forest nursery

Why is there a need to establish a forest nursery?

1. Flowering and subsequent seed production of most tree species are irregular.
2. Inapplicability of direct seeding in the field. .
3. Nurseries provide maximum care of the planting stock.
4. Take advantage of the abundance of germplasm during seed year.
5. High quality seedlings are produced in nurseries especially when best practices are applied.

Factors to consider in selecting a nursery site

1. Soil — choose a site that has a light sandy loam or loamy sand foundation and rich in organic matter.

2. Freedom from weeds — establish a nursery in a weed-free area or remove weeds before constructing the nursery. Weeds serve as hosts of pests and diseases that may attack your tree seedlings.

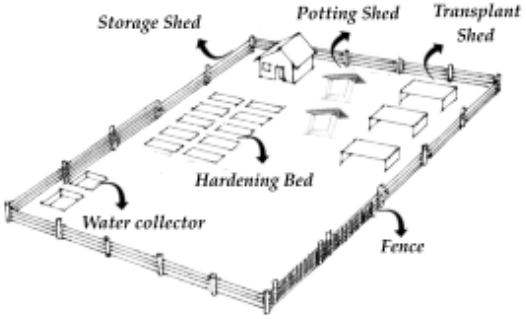
3. Exposure and aspect — nursery should be fully exposed to sunlight; should have a gentle slope (5%); should not be exposed to strong winds; and seed beds and transplant beds should be aligned in the East-West direction to maximize exposure to sunlight.

4. Accessibility — it should be centrally located to avoid long distance for transport of seedlings; accessible by foot or by vehicle.

5. Water supply — the nursery should be near a water source.

6. Size of the area — the nursery should be large enough to accommodate the necessary structures in the nursery.

A nursery should have structures including the potting shed, transplanted, germination shed and hardening beds. A bunkhouse may be needed for storing nursery equipment and a fence could be established to protect the seedlings from stray animals.



Example of a Nursery Layout

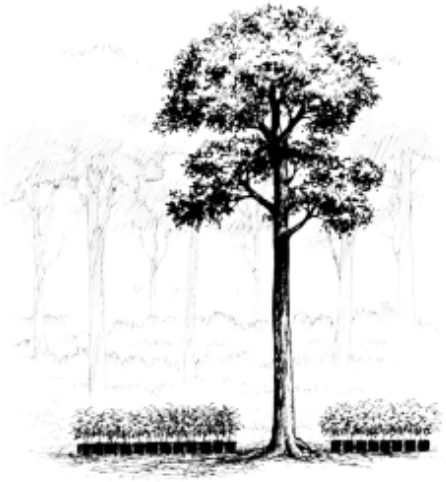
NECESSARY STRUCTURES IN A SMALL-SCALE NURSERY

GERMINATION SEED

Seed boxes with newly sown seeds are placed in the germination shed to protect the seeds from excess sunlight, and damage from raindrops, stray animals and insects. Ideally, a germination shed must have a plastic roofing to allow part of the sunlight to penetrate, but protect the seeds from being dislodged by rain.

POTTING SHED

Seedling containers are filled with potting media in the potting shed. A potting shed should have a roof to prevent the potting medium from getting waterlogged from rain. The floor should be dry, free of weeds and flat for the pots to stand after filling. The area of the shed should be sufficient enough to allow piling of the filled pots and stocking of the potting materials.



Natural shade from standing trees in the nursery can also be used. However, if seedlings are placed under standing trees, regular pruning of tree branches should be done to allow seedlings to receive ample sunlight.

WATERING

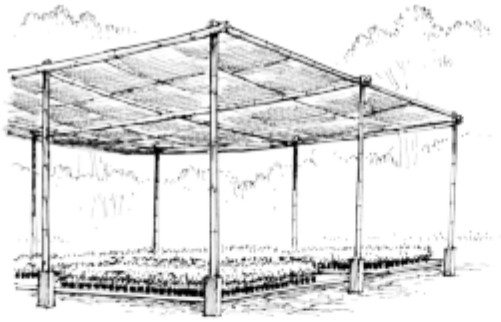
There is no exact regime for watering as this varies according to the species of seedlings, type of potting mix, seedling age, size of pots and the weather. Watering can be done by overhead application using hose, cans and sprinkler. For tender and small seedlings, water can be applied using sprayers or a small hose.

39
Seedling Maintenance Activities

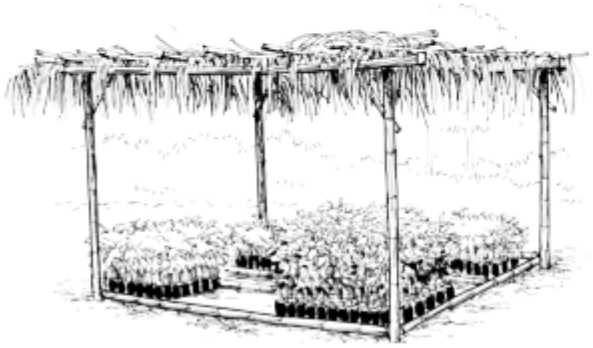
Appropriate care of seedlings in the nursery is crucial for seedling survival and growth after outplanting. Important maintenance activities for seedlings in the nursery include shading, watering, spacing, root pruning, weeding, fertilizing, hardening off, grading, culling and control of pests and diseases.

SHADING

Shading is essential for newly potted seedlings. During the first week from potting, it is essential that seedlings will be under 70% shade. When new leaves develop, shade should be removed gradually. Fish nets, plastic sheets or coconut leaves can be used as artificial shade materials.

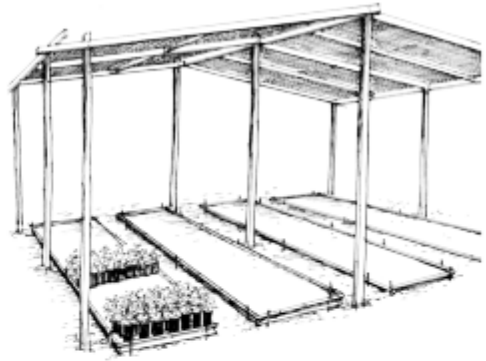


Transplant shed with fish net as shade materia



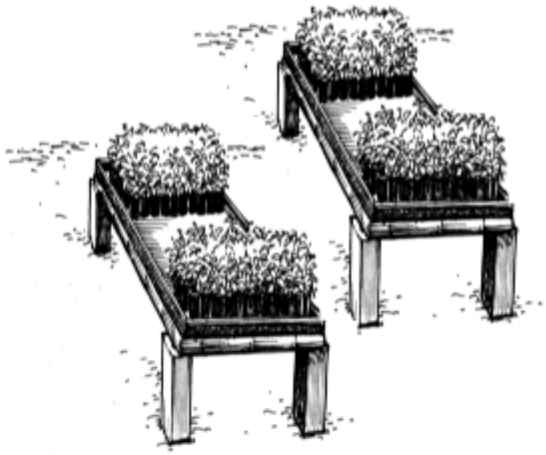
Transplant shed with coconut leaves as shade material

TRANSPLANT SHED



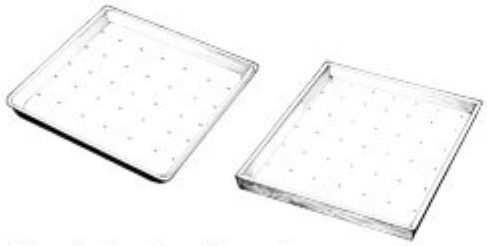
After transplanting seedlings from germination boxes or seedbeds to individual containers, seedlings are placed in the transplant shed. A transplant shed should have a cover to protect the young transplants from intense sunlight, but with sufficient transparency to allow some sunlight to reach the seedlings and nursery floor. The cover must also allow rain to pass through. However, for species with very small seedlings like bagras (Eucalyptus deglupta), transplant shed should have a plastic roof to prevent the seedlings from dislodging by rain.

HARDENING BED



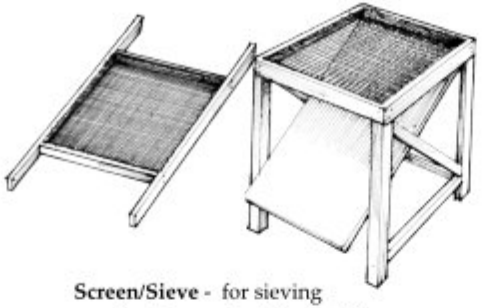
Seedlings must be accustomed to adverse conditions of the planting site prior to planting. This is achieved through the process called 'hardening'. Hardening includes exposing the seedlings to full sunlight, reducing the frequency of watering and fertilizer application, and root pruning. The hardening area should be devoid of shade to expose seedlings to full sunlight. To regulate moisture uptake, it is ideal to elevate the seedlings by placing them on a structure that prevents the pots from resting on the ground. A screen or a bed with bamboo slat floor will serve this purpose. Aside from regulating the moisture available for seedlings, elevating seedlings will promote aerial root pruning. Root pruning will prevent the taproot from penetrating into the ground, which is detrimental when seedlings are lifted for field planting. Preventing the growth of long taproot will also enhance the development of root hairs, which are essential for seedling survival and site capture. A concrete bed can also be used, but should be constructed with good drainage preventing a pool of water forming on the bed floor.

Pruning Shears - for pruning long taproots that grow outside the seedling pot

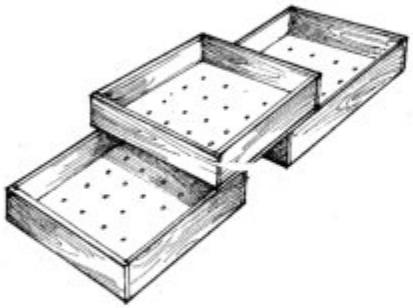


Germination Boxes/Trays - for sowing small to medium-sized seeds

Sterilization Pan - for pasteurizing germination media



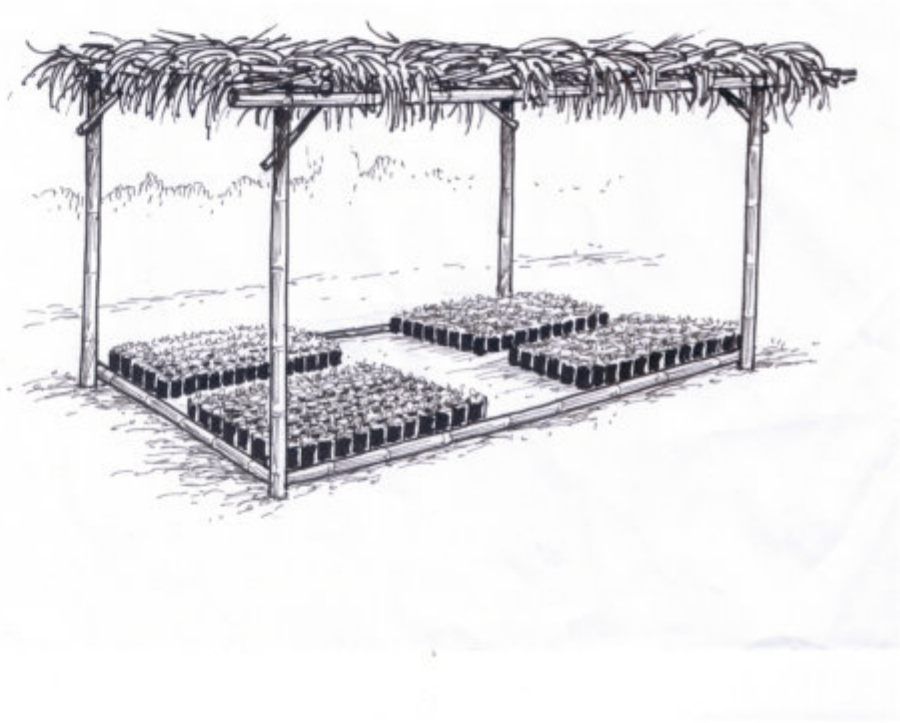
Screen/Sieve - for sieving germination and potting media



Boxes - for carrying seedlings

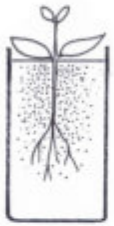
Hose/ Sprinkler - for watering seedlings

8. Water the seedlings immediately after planting and keep the medium moist for the next three days but take care not to overwater to prevent waterlogging and damping-off outbreak.
9. Place the newly potted seedlings on the transplant bed under a shade (about 70%) for few days. When new leaves have developed, the shade must be removed gradually.



The following are common mistakes in potting and must be avoided:

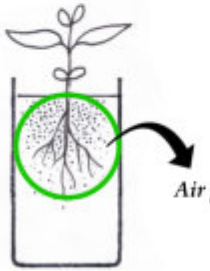
- Hole too deep, resulting in the plant being half buried.



- Hole too shallow, the plant will desiccate rapidly.

- Hole too shallow, resulting in the roots being bent. The growth of the plant will be permanently retarded. Also, plants with this defect will be prone to windthrow when planted out in the field.

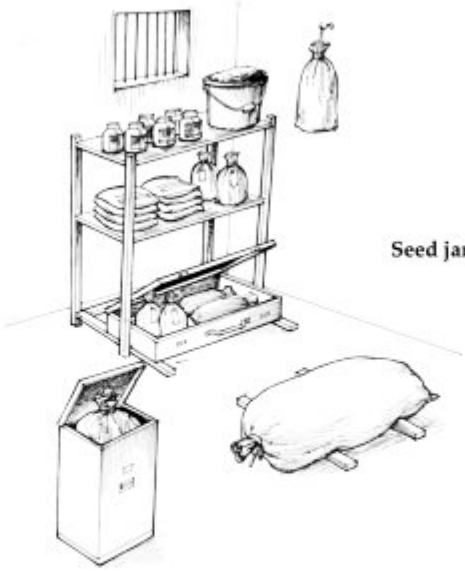
- Air pockets left around the roots; this will cause rapid dessication of the plant.



Sprayer - for spraying chemical controls to insects and pathogens

Shovel- for mixing potting media

Spade- for mixing germination media



Seed jars and seed sacks - for storing seeds

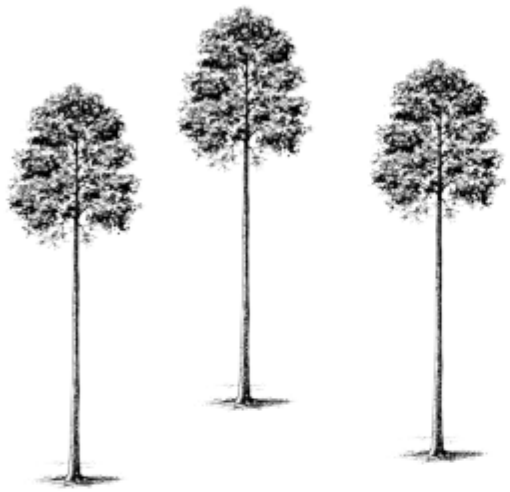
10
Sources of Germplasm

The source of germplasm and collection methods could affect seedling quality. Germplasm used in most nurseries in the Philippines comes from sources including seed trees, seed stands, seed production areas and seed orchards.

SOURCES OF GERMPLASM

SEED TREES

These are individual trees from which seeds and wildlings are collected. This is the main source of germplasm for smallholder seedling production. Seed trees may be in natural forest or plantations and must have superior physical characteristics including straight and single stem, few branches, mature to produce an ample quantity of seeds and belong to the dominant or codominant trees in the site. The following illustrates a good seed tree particularly for seedlings that are planted for timber production.



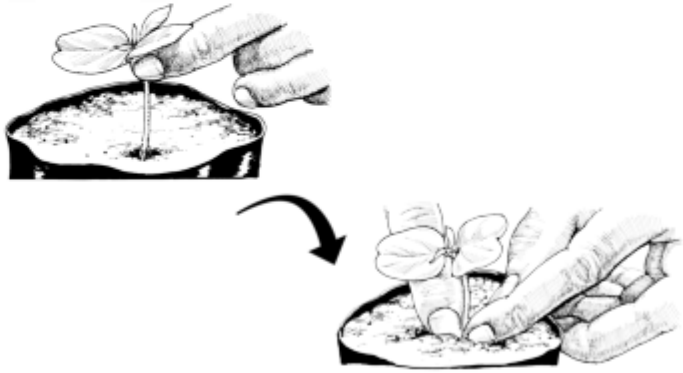
Seed trees with ideal physical characteristics

4. It is ideal that the volume of seedlings to be lifted at one time should be enough to be planted within 15 minutes. Otherwise, seedlings will die due to desiccation.

5. When lifting, seedlings should be held at the terminal leaf, not at the stem.

6. Using a small stick, make a hole in the potting medium enough to accommodate the root system without bending the taproot to avoid root deformation particularly J-rooting. If necessary, the taproot must be cut. Root pruning is particularly necessary when wildlings are used.

7. While holding the seedlings at its terminal leaf, insert the root system into the hole and cover the hole gently with the potting medium and carefully firm the potting mix to prevent air pockets left around the roots.

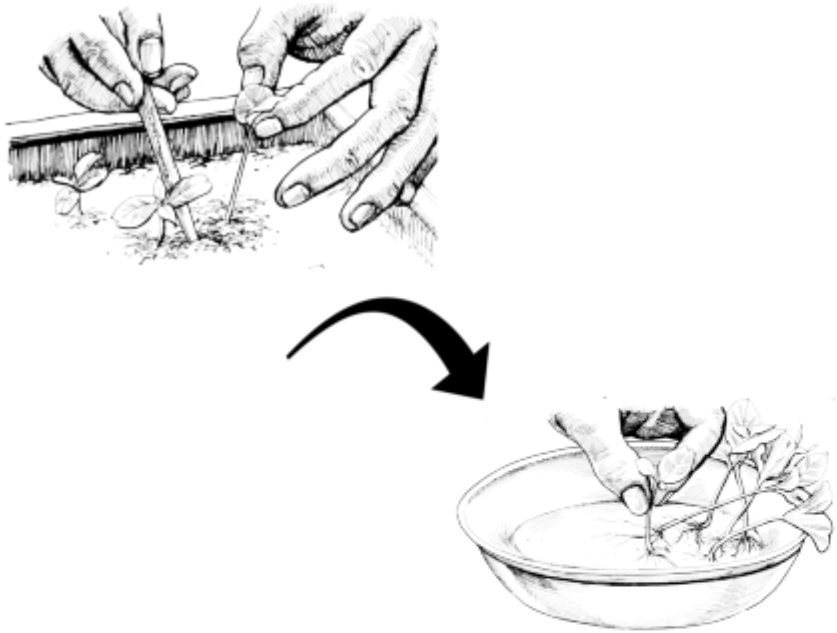


Potting or pricking out is transplanting seedlings from germination boxes and seedbeds to individual pots. This is considered as the most delicate operation of seedling production because very young seedlings are tender and improper potting will damage the root system. The following conditions should be observed during pricking out:

1. Water the pots and germination trays/seedbeds before lifting and planting the seedlings.

2. Prick early in the morning and late afternoon as sunlight is not so intense to damage the young seedlings

3. Lift seedlings from germination media with a flat stick and place them in a shallow bowl of water to prevent wilting.



SEED STAND

These are groups of trees in plantations or natural forest. Trees are identified to have superior physical characteristics similar to individual seed trees. Seed stands are managed for seed production but the management practices are not geared towards improving the quality of germplasm. Removal of inferior trees in the stand is not conducted.

SEED PRODUCTION AREAS (SPA)

These are groups of trees in plantation or natural forest that are improved for seed production. Low quality trees and those attacked by pests and diseases are removed. Thinning is also carried out so that trees are uniformly spaced. The stand is isolated from possible pollination by poor quality trees of the same species from adjacent stands by cutting the adjacent trees within 200 meters radius from the SPA.

SEED ORCHARD

These are stands established for a specific purpose of seed production. Trees are obtained from families of superior genetic quality and planted at regular spacing to provide sufficient space for seed production. Selective thinning is done to maintain the superior quality of trees in the stand. The stand is isolated from adjacent trees of the same species with those at the seed orchard to maintain the superior genetic quality of the germplasm. Isolation is done by cutting trees of similar species in the orchard within 200 meters from the orchard.

UNSELECTED PLANTATIONS AND INDIVIDUAL TREES

This is the common source of germplasm used for private and government seedling production in the Philippines. Germplasm is collected from individual trees and plantations regardless of physical characteristics and unknown genetic quality. Germplasm collected from these sources are generally of low quality and not ideal for seedling production.

Among the various sources of germplasm, seed orchard produces the highest quality seed, followed by seed production area, seed stands and individual seed trees. Unselected trees produced the lowest quality seeds and if possible, should not be considered source of germplasm for seedling production especially if the plantation to establish is for timber production

CHARACTERISTIC OF VARIOUS GERMPLASM SOURCES

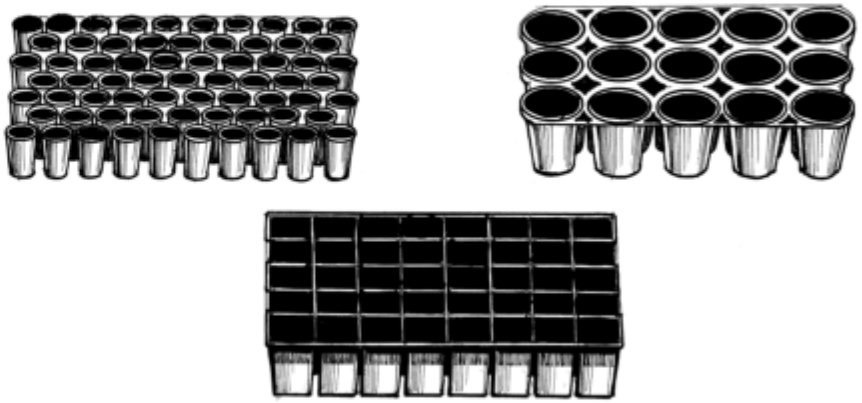
CHARACTERS	SEED SOURCES				
	Seed Orchards	Seed Production Areas	Seed Stands	Seed Trees	Unselected Seed Areas
Planting Purpose	Seed Production	Not for seed production	Not for seed production	Not for seed production	Not for seed production
Seed Origin	Identified	Identified and Unidentified	Unidentified	Unidentified	Unidentified
Quality of Mother Trees	Selected and Tested Trees	Selected Stands, Thinned, Untested	Selected Stands, Unthinned (or thinned), Untested	Selected Trees from Unselected Stands	Unselected Trees from Unselected Stands

Source: Mulawarman et al. (2003

SEEDLING PRODUCTION THROUGH VEGETATIVE PROPAGATION

Some trees do not bear fruits every year. Some dipterocarps, for example, have a seed year interval of 20 yrs. One strategy to produce seedlings of trees with limited seeds or wildlings is through vegetation propagation or clonal propagation. One advantage of clonal propagation is the assurance that clones will have the same genetic characteristics of the mother tree.

Materials that can be used as seedling containers include polybags and waste materials such as juice tetrapacks and cans. Indigenous materials such as bamboo stem sections and abaca sheath can also be used. For best result, containers with root trainers such as hiko tray is recommended. The ridge lines on the inside wall of the hiko tray prevents the roots from curling.



Examples of hiko trays

If a polybag is used, it should have at least six holes on the bottom. During filling, press the two bottom corners of the bag towards the inside to circle and flatten the bottom. This facilitates the bag to stand in an upright position.

The price of pots, size of seeds and wildlings during potting, desired size of seedlings when field planting, type of potting medium, and the length of time the seedlings remain in the nursery are some of the considerations when choosing the size of pots to use in seedling production. The pot should be strong enough to keep the potting medium and root system intact during seedling transport, and large enough to support the desired seedling size when outplanted without resulting in severe root deformation. For most timber species, a 4 inches by 6 inches or 3 inches by 7 inches bag is used.

Once sieved, mix the potting medium thoroughly before bagging.

Bagging

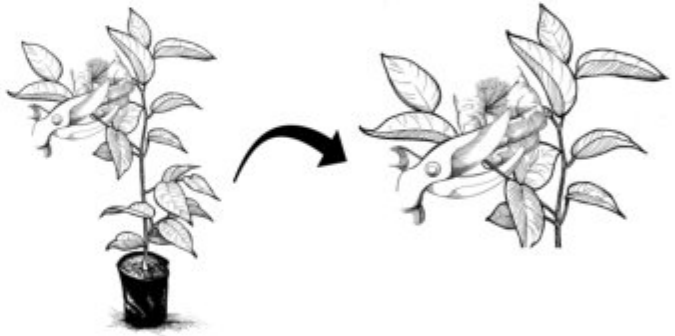
Bagging is filling the pots with potting mix. To facilitate pot filling, a funnel or a scoop could be used. The potting mix must be dry during potting and pots should be shaken during filling to avoid large air pockets .

The pot should be filled right to the top and let to stand upright on the transplant bed.

The following outlines the simplified method of clonal propagation:

COLLECTION OF STEM CUTTINGS

1. From the identified mother trees, harvest young stem cuttings using sharp pruning shears during the morning. Collect only the orthotropic (upright growth) and matured shoots.



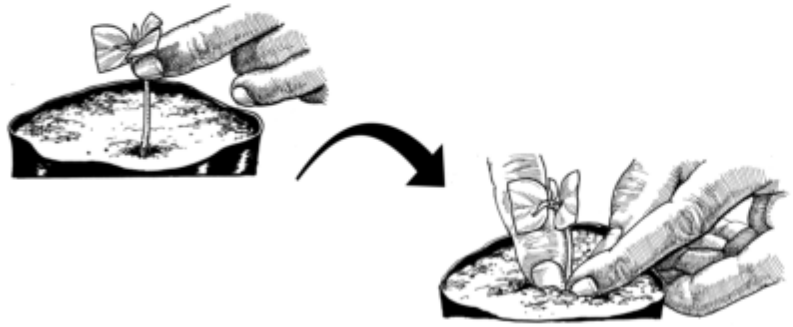
2. Stem cuttings shall be placed in a pail half-filled with clean water to avoid excessive transpiration while they are transported to the nursery or clonal facility.

3. The stem cuttings should be cut into two-node cuttings with a slanting cut at the base, making sure that one of the nodes has leaves. Cut the leaves into half of their original sizes to minimize water loss.

4. When all the cuttings are ready, they should be soaked in fungicide solution for 30 minutes to minimize fungi-caused diseases. Prior to planting, soak the base of stem cuttings on a prepared rooting hormone like to stimulate root growth and development.

5. Plant the prepared cuttings 2-3cm apart in an upright position inside enclosed rooting chamber using river sand as rooting medium. The sand should be sterilized by heating over fire or pouring hot water. Enclosure can be made from transparent plastic sheets for the purpose of preventing water loss from transpiration and evaporation.

6. When the cuttings have produced new leaves and roots, pot the stem cuttings in 4in x6in polyethylene bags using a potting medium of garden soil and river sand at 2:1 ratio or soil + compost + rice hulls at 3:1:1 ratio.



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Potting media, Bagging and Potting

— POTTING MIXTURE —

A good potting mix should be:

1. Free of particles larger than 5mm diameter.
2. Firm enough not to disintegrate around the root ball of the seedlings when it is handled.
3. Friable enough to allow the ready movement of water and air and will not impede the growth of roots.

A good potting mixture is a combination of three parts soil, one part mudpress (or compost) and one part rice hulls.

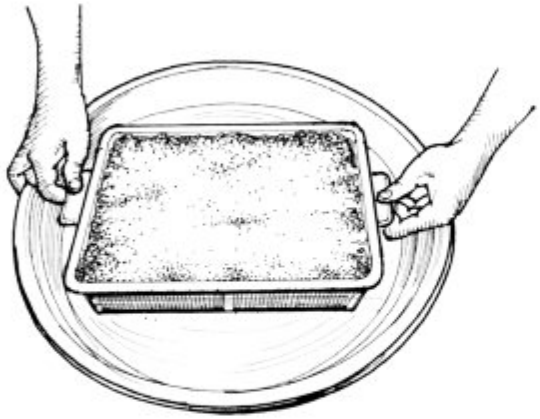
Soil *Rice Hulls* *Mudpress*

The soil supplies nutrients, holds moisture and medium for plant anchorage; the mudpress (or compost) supplies bulk of the nutrients for the seedlings; and the rice hulls promote good drainage. If the supply of mudpress and compost is not available, vermicast and other thoroughly decomposed organic materials can be used. A fresh organic matter such as animal manure should not be used as part of the potting mix.

The potting medium should be sieved through a 5mm mesh screen to remove large clods and irregularities including roots and twigs of trees. Screening will also pulverize the medium thereby promoting good aeration and drainage.

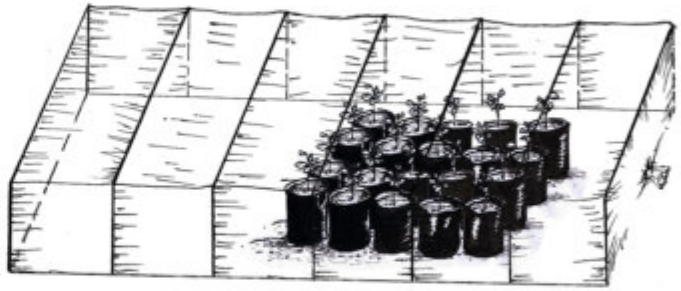
Sieving potting medium using a 5 mm mesh screen

Sub-irrigation method is the most ideal means of watering especially for seeds sown in seedboxes and seedbeds



Seeds sown directly in pots should be watered using hose or sprinkler

7. Water the newly potted cuttings thoroughly and place them inside an enclosed recovery chamber, the same design with the rooting chamber, until new leaves are formed. The recovery chamber must be shaded to protect the set-up from direct sunlight. Without the shade, the temperature inside the chamber will increase significantly, which will result in the mortality of cuttings.



8. When three pairs of leaves are formed, remove the polyethylene sheet but leave the shade to protect the young cuttings from direct sunlight. Remove the shade gradually until exposing the seedlings to full sunlight about one month after removing the polyethylene sheet.

Leave the seedlings exposed to the sun for about three months before field planting. Reduce the frequency of watering to accustom seedlings to limited soil moisture in the field. It is ideal to place the seedlings on elevated or concrete beds to prevent root growth into the ground while in the nursery.

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Germplasm Collection, Processing and Storage

GERMPLASM COLLECTION

Seeds and wildlings are the common types of germplasm used for forest tree seedling production. Planning the germplasm collection is very important. The purpose of collecting germplasm should be defined, the sources should be identified and the timing of collection must be known. Germplasm must be collected from several trees, not from just a single tree to ensure broad genetic variability.

SEED COLLECTION

Harvesting of seeds is done when most of the seeds or fruits are mature. Most fruits change color upon maturity for example, from green to brown, yellow and black. There are two general methods of collecting seeds — from the tree and on the ground.

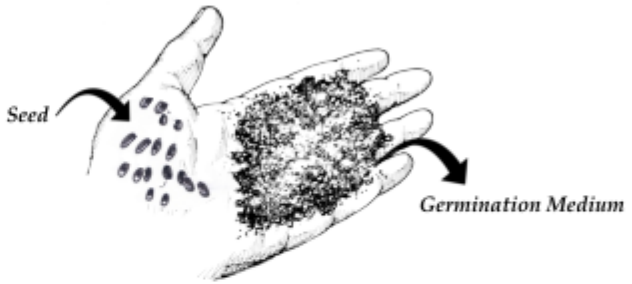
Collecting seeds from the ground

Collecting seeds from the tree

Adapted from: Mulawarman et al. (2003)

Seeds of trees producing fine fruits and those with fruits that open at maturity should be collected when the fruit is still attached to the tree. For some species, nets and mats are used to collect the seeds. For large seeded trees, seeds can be collected on the forest floor. Ideally, it is best to collect seeds before they fall from the tree because seeds on the ground are already contaminated with bacteria and fungi that may damage the seeds. Also, when seeds are on the ground, it is difficult to identify the tree where it comes from especially if there are several trees of the same species in the area.

As a rule of thumb, the size of the germination medium particles should be smaller than the size of the seed.



When sieved, mix the medium following the appropriate proportion. Fill the germination box and level the medium carefully.

Use the germination medium immediately after the preparation. Otherwise, place it in a container or cover the filled germination boxes with plastic sheets or cloth to protect the medium from being contaminated with pathogens.

MAINTENANCE OF SOWN SEEDS

Watering

Watering is the most crucial maintenance activity for sown seeds. It is necessary that seeds will receive adequate moisture all the time. Watering should be done carefully not to dislodge the seeds.

SEED PROCESSING

Processing of seeds immediately after the seed collection is necessary. Seed processing includes extraction from fruit, cleaning and drying.

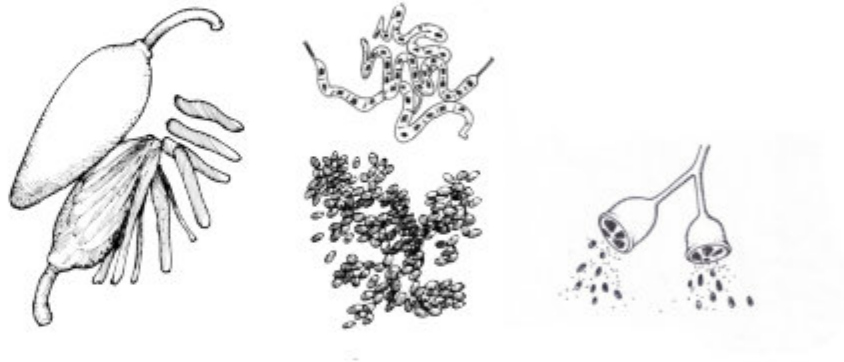
After the collection, separate the seeds from the fruit. If left unextracted, the sap of thick and fleshy pulp of some fruits ferment and damage the seeds. Seed extraction procedure varies according to species

Fruits that are sown as seeds itself (e.g. Dipterocarps)
No seed extraction is necessary.

Seeds of White Lauan

B. Fruits that open when mature
(e.g. mangium, eucalyptus, mahogany, falcata)

Fruits are air dried and spread over a mat, plastic or any material that will collect the seeds once released from the fruit. This is particularly true for fruits with very fine seeds such as eucalyptus. Avoid placing the fruits under direct and intense sunlight and occasionally stir the layer of fruits to facilitate drying.



C. Fruits that do not open at maturity (e.g. gmelina, narra, molave, dao)

Extract the seeds by threshing and by using scissors or knife. Fleshy pulp of seeds of gmelina, molave and dao can be removed by placing them in a sack and threshing or placed on a screen and macerating. Threshing and macerating can be facilitated when fruits are soaked in water for overnight.

Seeds of fruits like narra can only be removed by manually cutting the edge of the fruit using scissors or knife.

Gmelina seeds being trampled

Narra fruit cut on the edge

SEED DRYING

Seed drying is necessary to maintain viability if seeds will be stored, even just for a short period. The drying process will depend on the type of seed, whether recalcitrant or orthodox.

Recalcitrant seeds must retain high moisture during storage and should not be stored for a longer period, only few days or weeks. Recalcitrant seeds must be wrapped in moist cloth or paper and stored in a moist environment. The seed will lose its viability when it dries completely. Examples of recalcitrant species are jackfruit, neem tree, rattan, dipterocarps, and mahogany.

Orthodox seeds must be dried to a low moisture content before they are stored. These seeds will retain its viability for several years when stored in a cold place or even in a room temperature because drying will let them enter to a state of dormancy. Before sowing, these seeds usually require pre-sowing treatments to break the dormancy. Examples of orthodox species are eucalyptus, kakawate, teak, mangium, narra, falcata, molave, and kalumpit.

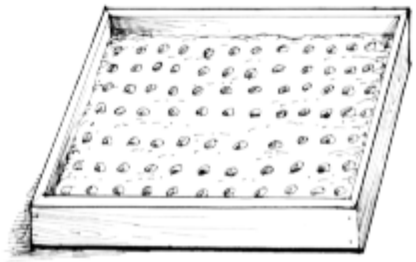
Sowing Seeds in Seedbed

Sowing seeds in seedbeds involves the following steps

1. Moisten the seedbed
2. Make straight furrows across the seed bed.
3. Place the seeds into the furrows.
4. Cover the seeds with a thin layer of soil and water the medium again
5. Cover the seedbed with a shading material
6. Spray the seedbed with insecticide to ward off insects that might consume the seeds

Sowing Seeds in Seed Boxes

The advantage of sowing seeds in boxes over seed bed and direct seeding is that the germination medium in seed boxes can be sterilized. Sowing seeds in seed boxes involves the following steps



1. Place the appropriate germination medium inside the seedbox and level it. The box should have holes at the bottom to prevent waterlogging.
2. Spread the seeds evenly over the medium and cover them with a thin layer of germination medium.
3. Water the seed box through the sub-irrigation method (page 27) so as not to dislodge the seeds and destroy the physical structure of the medium.
4. Place the seed box under a well-ventilated shelter.

PREPARATION OF GERMINATION MEDIA

Water holding capacity, good drainage and free from pathogens are the most important requisites of a germination medium. A mixture of 60% soil and 40% river sand is a good germination medium. The soil holds moisture while the sand promotes aeration and drainage.

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Seed Germination and Germination Media

Seed germination is the production of new plants from seed. Seed germination occurs when the seed embryo is viable and water and oxygen enter the seed.

The method of germinating seeds depends on the size of the seed. For large seeds such as pili, ipil, lauan and akle, these can be sown directly to individual pots . For medium-size seeds such as gmelina, mahogany and dao, seeds can be sown in seedbeds. For seeds of bagras, mangium, auri, kalumpit, molave and other small seeds, these are best sown in seed boxes. If the viability of the seeds is unknown, it is best to sow the seeds in seedbeds and seed boxes instead of sowing them directly to pots.

Sowing Seeds Directly in Pots

1. Water the pots filled with the potting medium thoroughly.

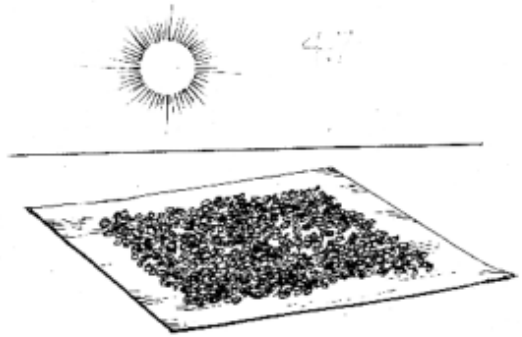
2. With the use of a dibbling stick, loosen the medium and make a small hole at the center. The size and depth of the hole should just be enough to bury the seed with a thin cover of the medium. Burying the seeds too deep will likely result to low germination rate.

3. Place one seed in each pot and cover it with the medium. 4. Water the pots carefully after sowing so as not to dislodge the seeds and keep the medium moist all the time.

5. Protect the newly sown seeds by covering the pots with plastic or any protective material.

6. If possible, spray the pots with insecticide to ward off insects that might consume the seeds.

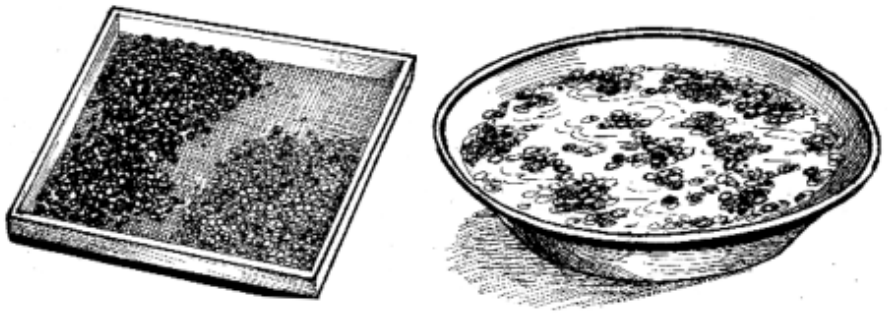
Many orthodox seeds can be sun-dried to reduce the moisture content to the minimum. Seeds are appropriately dry if they are easy to bite, crack or cut and will produce a sharp snapping sound, will make a rustling sound when mixed or shaken and will have a constant weight.



Seeds of Mangium spread on mat and dried under the sun

SEED CLEANING

Before storing, collected seeds must be cleaned to remove irregularities including debris and defective seeds. Seed cleaning can be done either before or after drying. When done after drying, seed cleaning is usually carried out by winnowing and sieving. For some species, defective seeds are removed by immersing seeds in a pail of water. Viable seeds usually sink to the bottom of the container while defective seeds will float and should be discarded.



Seeds being sieved and soaked in water

SEED STORAGE

Seed storage is important in seedling production scheduling. Sometimes, seeds are not available throughout the year so it is best to take advantage by collecting as many seeds as possible and store them for subsequent use. Factors that should be considered in storing seeds include temperature, humidity, moisture content, light, and insects and pathogens. Of these, the two most important are temperature and humidity. Seeds will retain their viability for longer periods when these are stored at low temperature and low relative humidity, placed in an airtight container and kept in a dry and dark storage compartment.

Containers appropriate for storing seeds include sacks, plastic bags, cans, glass jars and empty bottles of soft drinks and bottled water. The containers must be filled to avoid empty space that will lead to increased air humidity. Whenever containers could not be filled with seeds, empty space can be filled with charcoal or any materials that will absorb moisture.

Examples of seeds containers (sacks, cans and jars)

Bottles and jars must be covered air-tight, plastic bags must be sealed and sacks must be tied tightly. Containers must be clearly labelled to indicate the species, date of collection, collector and the source.

Intsia bijuga	Ipil; Moluccan, Ironwood	Cut or scratch through the seed coat opposite the hilum.
Leucaena leucocephala	Ipil-ipil	Soak seed in hot water for 2-5 minutes and then in cool water for 12-24 hours.
Palaquium sp.	Nato	No Treatment.
Paraserianthes falcataria	Falcata; Falcataria	Soak seed in hot water for 2-5minutes and then in cool water for 1 day.
Pinus merkusii	Merkus pine; Mindoro pine; Sumataran pine	No Treatment.
Santalum album	Sandalwood	Soak seed in cool water for 1 day.
Shorea javanica		No Treatment.
Swietenia macrophylla	Mahogany	No Treatment.
Tamarindus indica	Tamarind	Soak seed in cool water for 1 day.
Tectona grandis	Teak	Burning Method. Spread fruits evenly on the soil surface or in a bed of sand and cover with a 2-cm layer of dry straw. Burn the straw. The surface of the fruits should be slightly burnt. Collect seeds and soak in cool water for 1 day. Roasting Method. Place fruits in a pan and heat until the hair on the surface of the fruit is burnt off. Stir the fruit during the heating process. Soak fruits in cool water for 1 day. Soaking Method. Soak fruits in water for 2 days. Then wrap the fruits in a moist cloth and store in a humid place for 5 days.

Source: Mulawarman et al. (2003)

06 Fire Treatment

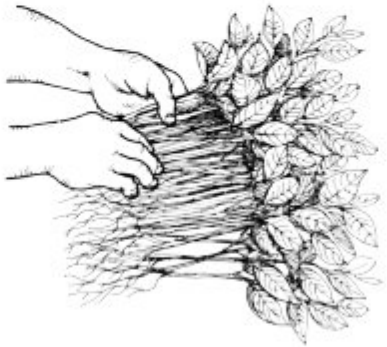
Seeds are placed on the ground and covered with a thin layer (about 3 cm) of dry grass such as cogon and set on fire. As soon as the grass is completely burned, the seeds are placed in cold water. The quick change of temperature will cause the seed coat to crack.

The following are some of the pre-sowing treatments for common tree species.

BOTANICAL NAME	LOCAL NAME	PRE-SOWING TREATMENT
Acacia mangium	Mangium	Soak seed in hot water for 2-5 minutes and then in cool water for 1 day.
Aleurites moluccana	Candlenut (Lumbang)	Burning Method. Spread fruits evenly on the soil surface or in a bed of sand and cover with a 2-cm layer of dry straw. Burn the straw. Pour cool water over the fruits immediately after the straw burns. Soak fruits in cool water for 1 day. Sun-Dry Method. Place wet fruits under direct, hot sunshine. When the fruits become hot, spray them with cool water. Repeat this process until the skin of the fruits crack.
Alstonia scholaris	Pulai, Dita; Milkwood	No Treatment.
Azadirachta indica	Neem Tree	No Treatment.
Calamus sp.	Rattan	No Treatment.
Calliandra calothyrsus	Red Calliandra	Soak seed in hot water for 2-5 minutes and then in cool water for 1 day.
Canarium ovatum	Pilinut	Place wet fruits under direct, hot sunshine. When the fruits become hot, spray them with cool water. Repeat this process until the skin of the fruits crack.
Eucalyptus species	Bagras, Red Gum, White Gum	No Treatment.
Gliricidia sepium	Gliricidia	No Treatment necessary, but soaking seed in cool water for 1 day will hasten and improve germination.
Gmelina arborea	Gmelina; Melina	Soak seed in cool water for 2 days.

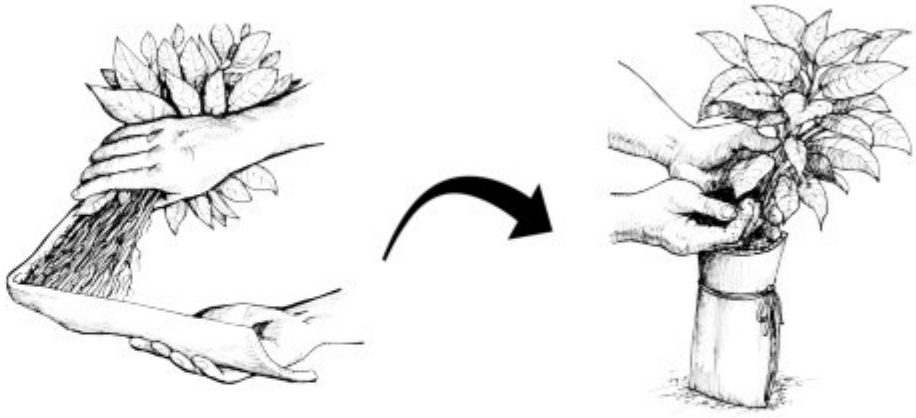
COLLECTION OF WILDLINGS

Wildlings should be collected while they are still very young. Collecting old wildlings will cause severe root damage which will result to high seedling mortality Also, potting old wildlings will usually result to deformed root system . such as J-rooting especially when root pruning is not carried out prior to potting.



Young Wildlings

The best time to collect wildling is early in the morning and late afternoon. If collection is done during a sunny day, wildlings should be covered to protect them from wilting. Mud packing of roots is ideal and fresh banana sheath will serve as a good packing material.



Wildlings packed in banana sheath during the collection proces

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Seed Dormancy and Pre-sowing Treatments

Seed dormancy is a physiological state in which viable seeds will never germinate even if subjected to favorable conditions. This is a seed mechanism to maintain the viability over a long period usually by preventing moisture absorption and some physiological processes. For a germination to proceed, the state of dormancy must be overcome. Methods of breaking seed dormancy varies according to species.

01 Cold Water Treatment

This involves soaking of seeds in tap water until they become bloated. Seeds of pili soaked in tap water for 10 days obtained high germination. Ipil and langil seeds soaked in tap water for 15 hours resulted in 80% and 89% germination, respectively.

02 Chemical Treatment

This is applicable to seeds with very hard seed coat like molave and kalumpit. Seeds are soaked in acid and constantly stirred to abrade the seed coat. The soaking time depends on the thickness of the seed coat. Sulfuric acid is mainly used for chemical treatment. Acids are corrosive and could easily burn skin. Hence, extra care is needed when using acids ad protective gears including gloves are necessary.

03 Hot Water Treatment

Seeds are immersed in boiling water for few seconds or pouring them with hot water in a container. The volume of water should be 5 to 10 times the volume of the seed. When seeds are immersed in boiling water, these should be placed in a cloth before dipping. Hot water treatment is effective for molave and most of the legume species including mangium, auri and falcata.

04 Scarification

This technique is usually used for large seeds to thin down the stony seed coat to facilitate water absorption and exchange of gases. Seeds are rubbed against hard and rough surface to remove a layer of the seed coat. The scarred part of the seed should be farthest from the embryo.

05 Nicking

This involves cutting the seed coat just enough to expose a small portion of the cotyledon. The cut should be made farthest from the embryo so as to ensure that the embryo will not be damaged. This is applicable for seeds of ipil, akle, tindalo and other large seeds with stony coat.