Chapter 2
Mangrove nursery establishment and management

INTRODUCTION

This chapter provides POs, COs, LGUs and NGOs with information on how to select sites, design, operate and manage mangrove nurseries. Historically, mangrove plantations have relied on natural regeneration and propagules as planting materials for their establishment. The development of nursery technologies ensures a reliable source of planting materials and helps POs minimize their reliance on the purchase of these materials from external vendors. Also, by using materials that have been started in a nursery, the PO will likely succeed. Planting mature and established plants decreases mortality at the early stages. Moreover, if a mangrove nursery is large enough it can become a source of income through the sale of mangrove planting materials to other POs and government agencies.

What is a Mangrove Nursery?

A mangrove nursery is a place for raising and tending mangrove seedlings until they are ready for planting or for sale to other mangrove planters.

SELECTION OF THE NURSERY SITE

Site selection is the first step in establishing a nursery. As shown in Table 2.1, poor site selection can result in a myriad of problems.

Table 2.1. Problems resulting from poor nursery selection.

Problem	Likely reason
High mortality due to underwatering.	No nearby water source makes watering difficult.
High mortality due to flooding.	Site placed in a floodplain, tidal range or an area subject to intense runoff from rainfall.
High mortality due to low level of care.	Site is too remote from the barangay.
Loss of plants from theft.	Site is too remote from the barangay.
High mortality due to lack of proper soil for potting.	Site is too remote from a proper source of appropriate potting soil.
High mortality due to overcrowded plants.	Site is too small for the number of plants being grown.
High mortality due to long-distance transport.	Site is not centrally located.

General Criteria for the Selection of Nursery Site

The cost and quality of seedlings produced in a nursery depend on the efficiency of its operation. Critical to this are the nursery's water supply, its location and accessiblity, the drainage and the size of its area. These are described in detail below.

Water supply—Locating a nursery near a brackishwater or freshwater source should be easy since mangroves are located in the coastal zone. Daily watering is a basic requirement for a nursery; thus, secure access to piped water or situate the nursery near a well. While locating the nursery close to a river is a good idea, it is necessary to keep a certain distance to avoid flooding during rainstorms or high tides.

Central location and accessibility—Ideally the nursery should be located close to where PO members live and close to the mangrove area. If this is not possible, find a place close to the *barangay* or one where it can be easily reached by *banca* so that seedlings can be readily transported for planting and potting soil can be brought in for seed beds and pots. The area should be open enough to ensure that the seedlings get enough light. For security reasons, it would also be wise to locate the nursery site near people's homes.

Drainage—Since mangroves are found in or near areas influenced by tides and subject to flooding, it is critical to select a site that drains well and is relatively flat. Proper drainage is essential because plants become waterlogged when standing water is always present and working in the area becomes difficult. Therefore, when evaluating an area as a potential nursery, the surface of the ground should be examined. If it is so moist and soft that puddles of water form, it is probably not a good site for a nursery.

Size of area—The size of an area is the last contributory factor in nursery efficiency. If you are forced to work in different nurseries because there is simply not enough room to have all your seedlings at one site, imagine the extra work you will have to put in visiting each nursery on a daily basis. As a general rule of thumb, about 325 square meters is needed for seed bed. (This assumes 10,000 seedlings per hectare with about 20 percent allowance for mortality.) Add another 100 to 200 square meters for work space—potting, laying seed beds and other activities.

As a general rule, a PO needs 325 square meters of space for every hectare it intends to plant, plus another 100 to 200 square meters for work area.

Types of Nurseries

Permanent nurseries are for mangrove planting over an extended period of time. They tend to have more developed working areas with small sheds to provide shelter from the sun and the rain.

Subsidiary nurseries are designed for areas located at a distance from the permanent nursery, or for areas separated from the permanent nursery by such natural features as large rivers, bays or rough water that make it difficult to move the seedlings (risking damage during transport). Subsidiary nurseries may operate for several years as in permanent nursery.

Temporary nurseries are generally set up where there is a small planting area (typically less than 5 hectares) which could be planted over a one-year period. These nurseries are not nearly as elaborate as permanent or subsidiary nurseries.

DESIGNING AND BUILDING THE NURSERY

After selecting a nursery site, you should think about the design. There are several steps in this process:

- Identify who will work on the nursery project
- Determine the boundary and area of the nursery
- Develop a plan for the nursery
- Build the nursery

Identifying Who Will Work on the Nursery Project

Identifying who will work on the nursery project is crucial to a community-based effort; yet, this step is often overlooked. The PO must decide who will be responsible for all the phases of the project. While it is possible for only one or two people to identify the nursery site, as many as ten or more will be needed to design and build it. The CO should remind the PO officers to meet so the group can discuss who will be responsible for these important tasks.

PO officers should publicly acknowledge the individuals who identified the site and use that as an opportunity to request volunteers for the next step—designing and building the nursery.

Determining the Boundary and Area of the Nursery

Once your PO has determined the general location of the nursery area, you need to determine its boundary and area. Develop a sketch map showing the boundary of the nursery area, including the lengths of its dimensions.

The sketch map need not be a polished map. Rather, it only needs to present basic information about the shape of the area and the approximate lengths of each of its sides. (Chapter 6, *Resource Mapping of Mangroves*, provides information on how to prepare a sketch map.) As much as possible, lay out the nursery as a square or rectangle. After completing the map, determine if the area is large enough to support the nursery management activities. Since the shape of the site will not likely be a perfect square or rectangle, it may be necessary to estimate the distances with simple arithmetic to gauge the area size as illustrated in Table 2.2.

Developing a Plan for the Nursery

Designing the nursery is vital to success. Instead of placing potting soil in one place, seed beds in another, and so on, carefully consider what goes where. The group in charge of nursery activities should do this planning exercise. Developed as part of locating the nursery, the sketch map in Figure 3.1 is a useful planning tool.

Table 2.2. Formulas to determine nursery areas.

Shape of area	Likely reason
Square	Multiply length of two equal sides.
Rectangle	Multiply length of longest side by length of shortest side.

First, determine where the seedlings will be loaded for field planting. Questions that need to be resolved include:

- Will they be taken to the planting area by truck or *banca*?
- Is there a place in the nursery area which people think will be most convenient for loading seedlings?

Is Our Nursery Area Big Enough?

The calculation to answer that question is fairly simple. First, determine how many hectares of plantation your PO expects to put in every year. Next, multiply that number by 325 and add 100 (or 200). The total is the area requirement for the nursery.

Example: If you intend to plant 10 hectares per year, then (325 x 10) + 100 = 3,350 square meters is the minimum area to meet the seedling requirement. A larger area is better than a smaller one. If the site is too small, then:

- ***An area of sufficient size will have to be found;***
- ***An additional area will need to be identified and two nurseries established; or***
- ***Reduce target area for annual planting.***

The location of the loading area determines where to place the hardening beds. Figure 2.1 shows a sample diagram of a nursery which is just one of the many ways to design a site.

Why is the Location of the Hardening Bed so Important?

In order to answer that question, ask another: Which is heavier, the* tongki *or the seedling? Seedlings weigh around 500 grams, considerably heavier than the seeds or* tongki. *Remember, in the beginning planting will involve thousands of seedlings (1,000 seedlings weigh around 500 kilograms). That is ample reason to situate the hardening beds near the seedling loading area.

To begin planning, basic nursery components must be understood. These include:

- Seed germination beds
- Seed box
- Germinating shed
- Potting shed
- Bagging and storage shed
- Potting soil and sawdust stockpiles
- Compost beds
- Seedling hardening beds

Building the Nursery

Building the nursery will probably require more people than there are in the committee. Because everyone will benefit from the nursery, it is suggested that this be a task for the entire PO. Not everyone, however, is required to take part in the actual construction. Other important activities include:

- Buying or obtaining the necessary materials
- Transporting materials or workers to the site
- Buying or lending tools (shovels, hammers, bolos, etc.) needed to build and operate the nursery
- Preparing lunch for those working on the nursery
- Helping those working on the nursery in their full-time job

Site preparation—If possible, the nursery site should be an open area to avoid the cutting of trees. Should cutting be necessary, extra care should be exercised in trimming branches to let in more sunlight.

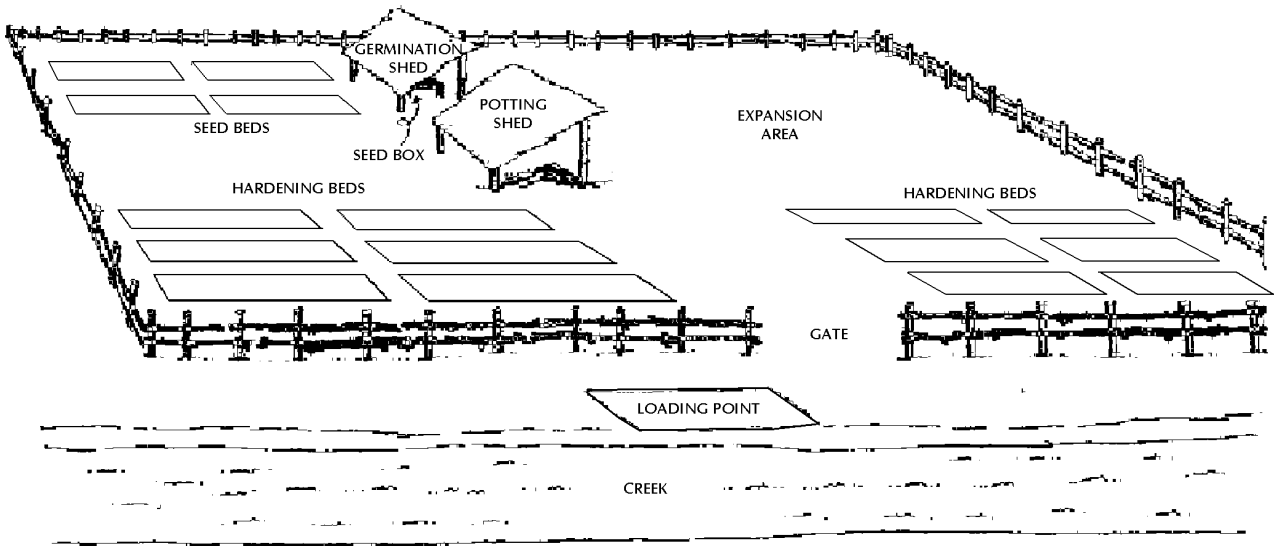

Figure 2.1. A typical nursery layout.

It is not essential to clear all the trees and shrubs; they can be used to shade some areas of the nursery, and leaves and twigs from removed vegetation can be used to start the compost beds. Be sure to remove all stumps and pull up all grasses including the roots to prevent regrowth.

After being cleared, the site should be leveled. This can be accomplished by cutting through the area and breaking up any lumps of dirt. After cutting, the low and high areas should be leveled by digging the high levels and putting the soil in the low spots. Excess soil can be stockpiled at the potting soil area.

Once clearing and leveling have been completed, the nursery should be laid out using the prepared map. With twine and a measuring tape or rope, determine the lengths and widths of the various parts of the nursery, stake out each of the nursery component areas and begin construction.

Seed germination beds—These 1 x 10 meter beds are raised slightly (5 to 10 centimeters) above the level of the surrounding area by adding potting soil to each bed or by digging out the soil from the 40-centimeter wide area immediately next to the beds. Keep the soil from spreading by lining each bed with a wood or bamboo curb. If boards are used, dig a 2- to 3-centimeter groove around the bed and slot the board in. If bamboo is used, a similar (though wider) depression should be dug. A line of concrete blocks (only one block high) makes an excellent curb, but tends to be expensive.

Seed boxes—A number of seed boxes will be needed if you choose to grow trees from the *pagatpat* group. Materials include:

- Boards 1 centimeter thick, 10 centimeters wide and at least 2 meters long
- Plywood (at least 1 centimeter thick) for the box base
- Nails

Assuming that the seed boxes will be 30 x 35 centimeters, the boards and plywood should be cut accordingly and nailed together. Drill a series of small holes between 0.3 and 0.7 centimeters every 5 centimeters in the plywood base to allow water to drain. Fill the boxes with three different layers of sand and stones: fill the bottom 5 centimeters with small stones (less than 1.5 centimeters), the next 3 centimeters with coarse sand and the top 2 centimeters with fine sand mixed with compost and/or potting soil.

Germinating shed—The germinating shed is more like a simple roof with no walls than a shed. Roughly 3 x 5 meters in area, it is constructed by simply putting in four pieces of bamboo with a woven *cogon* grass roof. Under this roof is a simple bamboo table for the seed boxes. Place the legs of the table in cans filled with water to prevent ants and other crawling insects from reaching the seedlings.

Potting sheds—Potting sheds can be made out of *nipa*. Typically not smaller than 3 x 4 meters in area (and maybe twice that), they are built with three walls; and instead of a door, a fourth wall is kept open. Depending on the wishes of the nursery workers, a bamboo table for potting can be built although potting is typically done on the floor.

Bagging and storage sheds—These sheltering and storage sheds, which are also made with *nipa*, are similarly constructed. Since they can be used to store nursery tools, these sheds could be enclosed and locked.

Potting soil and river sand—The potting soil pile should be at least 5 cubic meters in volume and the river sand pile at least 1 cubic meter. To protect the material from rain, stage both piles under a roof similar to that built for the germinating shed. These materials may be brought in by truck and should be staged close to the bagging shed.

Compost piles—Compost piles should also be placed under a roof. Be sure that they are of sufficient size to provide enough mulch for the nursery.

Seedling/hardening beds—Unlike germination beds, hardening beds need not be raised. Figure 2.2 is an example of a hardening bed. Hardening beds require a temporary roof with several layers of covering (coconut leaves or *nipa* shingles) but typically mesh nets gauge 14 to control the amount of light reaching the seedlings. These beds are 20 to 30 meters long and 1 meter wide; bamboo poles can be used to support the roof. The roof

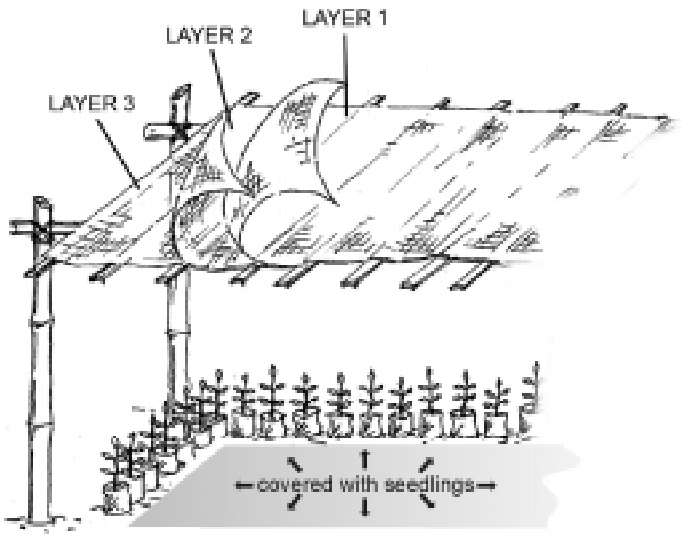

Figure 2.2. Hardening bed.

should be at least 1.5 meters above the ground to allow easy access to the seedlings. Usually the top layer of the roof is *nipa* followed by *cogon* grass on top of a fine mesh net. This enables nursery workers to remove a single layer and allows more light to reach the plants over time.

OPERATING AND

Useful Nursery Tools

Hammer, saw, bolo, hoe, shovel, small shovel, rake, watering cans or boxes, wheel barrow, pick mattock, spading fork

MANAGING THE NURSERY

Once nursery construction is completed, organize shifts to operate and manage the nursery on a daily basis. This requires PO members to assume responsibility for managing the nursery. Typically it takes 4 to 6 months to grow out seedlings to the point where they can be transplanted. This is a rather extended commitment but it need not be a full-time job if there are several people willing to work in the nursery.

The group responsible for finding a site for the nursery and for setting it up may not like the day-to-day management of the nursery. If that is the case, PO officers should call a meeting to determine who is interested in working in the nursery. Again, organizing a committee to run the nursery is the best approach. (This committee should consist of at least five people to make the management less work.)

What Are the Daily Activities at a Nursery?

Seedlings must be watered twice a day at the early stage. Later, watering can be done once daily towards the outplanting season (4 to 6 months old) to acclimatize seedlings. This activity is very important and must be done religiously. Otherwise, the seedlings may dehydrate. For a nursery with 50,000 seedlings, this requires one person watering 2 to 3 hours per day.

At least five hundred 4 x 6 inch bags can be filled with potting soil by a single worker every day (assuming all the potting materials are ready).

The transfer of seedlings from seed boxes/seed beds to plastic bags: Depending on the size of seedlings a laborer can pot 600-1,000 seedlings in an 8-hour day.

During the meeting, explain the daily work schedule, i.e., estimate how long the work will take. The CO should work with the PO officers to decide on a schedule and activities.

Emphasize that all of the PO members are responsible for harvesting seeds and propagules, and for transporting and planting seedlings. Remember that a nursery can become a viable livelihood on its own. Potting soil is also a source of income.

While running a nursery is not commonly thought of as a typical livelihood, it can be a moneymaking proposition for those involved. As described in detail below, the typical activities that make up nursery operations are:

- Collecting and transporting seeds and propagules
- Propagation practices
- Maintenance of the seedlings
- Preparation for planting

Collecting and Transporting Seeds and Propagules

A proper supply of mangrove seeds and propagules is one of the major obstacles to mangrove reforestation in the country, especially for less common species such as *pototan* and *bakauan babae, busain, tangal* and *tabigi*. This may be one of the main reasons why the monoculture plantation of *bakauan bato* is so common in Central Visayas. Another problem is the large numbers of seedlings needed to establish plantations. Upland forest plantations typically have 2,000 seedlings per hectare. Mangrove plantations range from 10,000 to 40,000 seedlings per hectare (assuming a spacing of 1 x 1 meter to 0.5 x 0.5 meter respectively).

Timing of collection—Collecting propagules and seeds at the right time is critical. While collection is possible from some mangrove species almost every month of the year, peak seasons vary by area and date. Knowing when to collect the seed or propagule also makes the operation quicker and more efficient. Table 2.3 shows the approximate time of the fruiting season for the major mangrove species on a province-wide level. The information will not be exactly the same in each area, but this should provide a good idea of the general time to expect to find mature seeds and propagules.

A Nursery as Livelihood

Some people in the PO may challenge the idea that a mangrove nursery can become a livelihood. It certainly can. DENR is actively planting mangroves or assisting LGUs and other organizations in planting mangroves by providing them with planting material*—tongki *or seedlings. If a nursery has sufficient capacity to cover the needs of a plantation, it is possible to sell the excess capacity to DENR or to other POs who do not want to develop a nursery. Make certain you have a market before investing a lot in growing additional seedlings.

Seeds or propagules are not always available. In those cases, wildlings (young saplings less than 30 centimeters tall) may be used as planting material. Wildlings are collected by balling with a spade. For a 10-centimeter wildling, the diameter of the excavation should be approximately 10 centimeters. For a 20-centimeter wildling, 20 centimeters; for a 30-centimeter wildling, 30 centimeters. Insert the blade of the spade into the soil at the appropriate distance from the wildling, lift up the chunk of soil containing the wildling and gently wrap mud around the root ball (this is known as mud paddling). Place the wildlings in folded banana leaf sheets (in groups of 50 or 100 for easy counting) for transportation to the nursery and immediate potting.

The main characteristics of good quality seeds and propagules are:

Hint

When collecting wildlings, always make certain that each one has 2 to 4 leaves (for species that grow from propagules **(tongki)**. ***For other species, the seedling should be from 4 to 6 centimeters in height. This ensures the wildling is strong enough to transplant. Also, be certain that sufficient potting bags are available; wildlings will die if not potted quickly.***

- The material is of average to superior size.
- They are free from defects and insect infestation.
- They are fully mature.
- They are fresh, without developed roots.

Selecting seeds and propagules with all of these characteristics ensures a high rate of germination.

Identifying mature seeds and propagules—In many cases, hundreds or thousands of seeds are wasted because they are collected while still immature. This wastes the time of the collectors and nursery operators and can reduce the overall success rate of the plantation. It is important, therefore, to select seeds and propagules that are ready to grow. Signs and indicators of mature fruits/propagules are as follows:

- All trees from the *bakauan* and *tangal* groups

Table 2.3. Best collection times for selected mangrove species (adapted from Palis et al. 1998).

Species	Climate Type* 1	Climate Type 2	Climate Type 3	Climate Type 4
Bakauan bato	Jan & May	Feb-Jul	Feb, Apr, May	Jan & Feb
Bakauan babae	Oct-Dec	Jan-Aug	Apr-Jun	Jan & Feb
Bakauan lalaki	Aug & Sep	Feb & Mar; Apr-Jun	Mar & Apr	Jan & Mar; May & Jun
Tangal	May	Jan & Feb; May	May; Nov & Dec	**
Busain	Jan; Oct-Dec	Jan & Feb; May-Jul	Feb & May	May-Aug
Pototan lalaki	Jan-May; Oct	May	Apr-Jun	**
Api-api	Jan-Feb; May & Jul	Jan & Feb; Jun-Aug	**	Aug
Bungalon	Apr, Jul; Nov & Dec	Jan; May-Oct	Jan & Mar	Jan-Oct
Pagatpat	Aug-Nov	Jan	Feb-May; Jul	Mar
Tabigi	Aug-Nov	Jan-Aug	Jan-Apr	Mar

*Climate type refers to rainfall pattern. Type 1—Two pronounced seasons; dry from November to April, wet all other times. Type 2—No dry season. Very pronounced rainfall in November. Type 3—No pronounced wet or dry season, but relatively dry from November to April. Type 4—Rainfall distributed more or less evenly throughout the year.
**Species not identified in this climate type.

exhibit a whitish to yellowish ring-like mark on the propagule located 1 to 3 centimeters from the top of the pericarp (where it attached to the mother tree). The ring is absent or very thin in propagules that are not yet ripe. The wider the ring, which can be up to 5 centimeters, the more mature is the propagule.

- Another indicator of maturity is color. The propagules turn from green to brown as they mature.
- The *busain* and *pototan* groups do not exhibit the ring noted above, but immature green propagules turn brownish or bronze as they mature. Mature propagules drop together with the pericarp or fruit, unlike the *bakauan* and *tangal* groups whose propagules drop without the pericarp.
- In the *pagatpat* group, the fruit will turn shiny yellowish to light green and soft when ripe.
- In the *tabigi* group, the light green globular fruit turns light brown with the lines on the fruit becoming prominent.
- *Dungon* seeds turn from green to dark brown.

Methods of sorting and transporting seeds and propagules—Successfully collecting the material is only half the battle. Transporting the collected seeds and propagules can be very difficult when handling big volumes over long distances. Sorting of propagules is the first stage in the transport process. Carefully inspect your material to see if it is:

- Mature
- Healthy
- Free of insect infestation and physical injury

With larger fruits and propagules, inspect each one to determine if it should be included in the shipment. In the case of small seeds, it is harder but less important to do this because the small seeds are generally much larger in number.

The next stage is the packing of the seeds or propagules. Larger materials (e.g., the *tongki* or *bakauan* propagules), can be packed in bundles of 50 or 100. Bundles made out of palm or banana leaves should be kept moist. Small seeds should be transported in bags with a moist cloth placed on top of each bag. Be sure to keep the cloth moist throughout the trip and do not expose the materials to direct sunlight, as this will cause damage. Wildlings, like the propagules, should also be packed in groups of 50 or 100 in a folded banana leaf, palm sheet, or gunny sack to protect plants from the sun while in transit.

Table 2.4. Indicators of maturity for some species of mangrove fruit (adapted from Field 1996).

Mangrove species	Seeds (S) or propagules (P)	Maturity indicator
Saging-saging	P	Fruits become lightly yellowish to reddish brown upon maturity
Api-api, piapi, bungalon and *bungalon puti*	P	Seed coat changes from green to light yellow. Seed coat becomes wrinkly and oftentimes opens
Busain, pototan and *pototan lalaki*	P	Tip of the hypocotyl changes from green to brown
Tangal	P	Ring-like mark immediately below the cap of the propagule and yellow line approximately 1 to 2 centimeters from top of propagule
Nipa	S	Seeds change from light brown to dark brown upon maturity and turns lustrous to dull
Tabigi	S	Fruit changes from light brown to dark brown upon maturity
Bakauan and *tangal* group	P	Presence of ring-like mark (abscission layer) below the pericarp or cap (up to 1 centimeter wide)
Busain group	P	No ring-like mark; green propagule turns brownish/bronze and drops without the pericarp or cap
Pagatpat	S	Dark green or yellowish fruits sometimes with cracks
Pagatpat baye and *pedada*	S	Fruits turn shiny or yellowish and soft
Tabigi group	S	Green fruits turn to brown with compartment becoming prominent

If you are transporting the materials by pump boat it is easy to keep them moist. Pour sea water over them two or three times a day (more if they are in direct sunlight). If the boat is open, protect the shipment with a tarp or some coconut fronds. Do the same if you are transporting the material by truck. Avoid placing the propagules or seeds in direct sunlight.

Upon returning to the nursery, the seeds and propagules must be prepared for planting or storage. Allow small seeds to air-dry somewhat prior to storing. Then place the seeds in polyethylene plastic bags, seal the bags and store them at room temperature. Propagules may be kept under shade for as long as 2 weeks without adversely affecting their viability. Avoid placing them on the ground or any moist surface to inhibit root development.

Protect Your Investment!

Remember that a lot of effort and potential earnings are tied up in these seeds, propagules and seedlings. Protect them from drying out or getting burned by the sun. Without protection, the seeds and propagules will die; this directly affects PO plantation earnings.

Propagation Practices

Propagation practices include the following activities needed to germinate seeds and propagules and produce seedlings:

- Preparation of potting soil
- Germination techniques
- Potting

- Hardening

Preparation of potting soil—The growth of seedlings in the nursery significantly depends on the quality of the potting soil. Fast root development is enhanced when the potting soil is porous. If possible, use sandy-loam soil that is high in organic matter or compost mixed with cured sawdust or rice stalks (*dagami*). Pulverize and then screen these materials and thoroughly mix the soil and organic matter (a 50:50 ratio is best). Potting soil should always be prepared in advance to avoid unnecessary delays in potting which can result in high seedling mortality, especially for wildlings. Thus, it is a good idea to prepare potting soil of several cubic meters and have it on hand at all times. Figure 2.3 shows a person filling bags for potting.

Germination techniques—Mangrove plantations in the Philippines have tended to be monocultures of

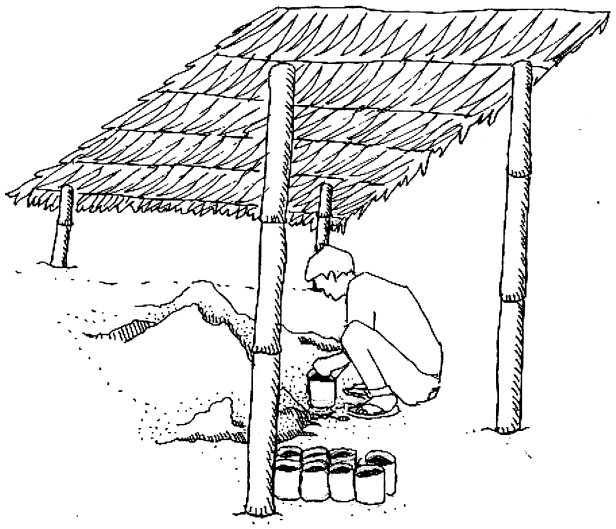

Figure 2.3. Soil bagging under a shed.

bakauan not only because of the absence of germination information for other species but also because many of the areas available for planting are open mudflats (which are much better suited to the *bakauan* species). Below are brief discussions on how to germinate some of the major groups. Figures 2.4 and 2.5 provide some examples of planting depth for selected species.

- *Bakauan, tangal* and *busain* groups—These groups all have viviparous seeds or propagules that are sown or planted directly in the field and have a high survival rate in areas not exposed to strong waves. In cases where there is a need for nursery raised seedling (e.g., an area with unstable substrate), the species may be germinated in a plastic bag. Table 2.5 provides the appropriate size for bagging each species.

- *Pagatpat* group (*pagatpat* and *pedada*)—*Pagatpat* has a big potential for reforestation due to its wide range of habitat from the seaward side and high salinity to the landward portion. The boomerang-shape seeds of the *pagatpat* are planted or sown in a seed box with sandy soil. Seeds are then covered with a thin layer of soil and watered daily with brackish water. For early and uniform germination, soak the fruit in fresh water for 7 days and sow the macerated seeds in depressed seed beds.

- *Api-api* group (*api-api, piapi, bungalon* and *bungalon puti*)—This group is considered semi-viviparous because of its emerging radicle and split seed coat while still attached to the mother tree. It is the easiest to germinate, either in seed beds or directly in bags. Seeds are sown in an upright position half buried with the emerging leaf or the cracked portion of the seed at ground level. For higher germination rates, use seed beds made of sawdust. Once the seedlings develop a pair of leaves they can be handpicked for potting.

- *Tabigi* group—POs often favor *tabigi* because of its valuable wood. Its big angular seeds are germinated in seed beds or potted directly. As in the *api-api* and *saging-saging* groups, the seeds are sown halfway with the embryo eye just at the soil surface.

Potting—Potting is the transfer of germinants/seedlings from seed box/bed to the plastic bag or pot where it is hardened before planting in the field. Table 2.5 shows the different sizes of plastic bags for the different species. Potting is done by pricking the germinants using a flattened stake to minimize root damage. The seedling is then planted in the bag with the

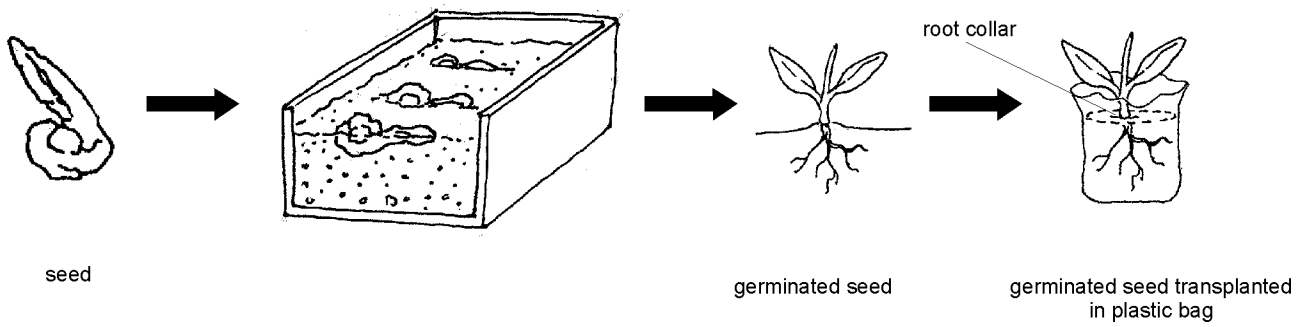

Figure 2.4. Germination of small to medium-size seeds.

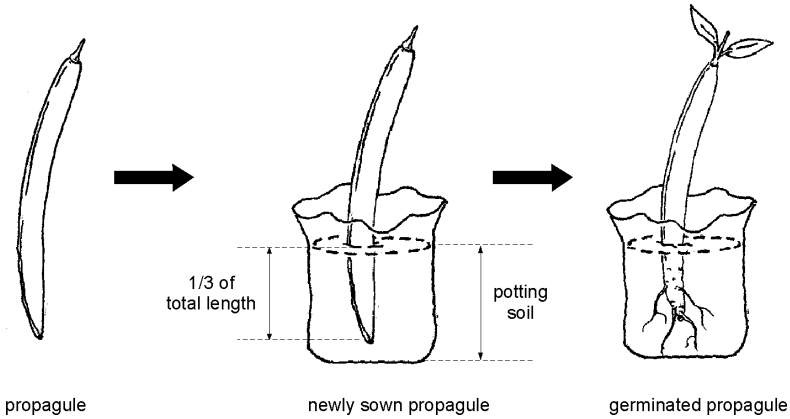

Figure 2.5. Germination of bakauan *species (and other propagules) directly sown in plastic bag.*

root collar level with the surface of the soil in the bag. Propagules are sown about 1/3 of the length of the hypocotyl deep in an appropriately sized bag (see Table 2.5 for suggested bag sizes.)

In the absence of seeds, wildlings may be used and hardened following the same potting and seedling procedure. When potting wildlings, take extra care not to damage the root system.

Maintenance of the Seedlings

Seedling quality in the nursery will depend on care and maintenance. This includes:

- Watering
- Shading
- Weeding
- Protection from pests, diseases and stray animals

Table 2.5. Bag sizes for various species (Sinohin et al. 1996).

Species	Bag size (inches)
Bakauan babae	8 x 12
Bakauan lalaki and *bangkau*	6 x 10
Talisay	6 x 10
Dungon-lati	6 x10
Api-api family	6 x 10
Tangal	6 x 8
Malatangal	4 x 6
Saging-saging	4 x 6
Pototan lalaki	4 x 6
Kulasi	4 x 6
Nilad	4 x 6

Table 2.6. Typical hardening treatment.

Treatment	No. of weeks 1	2	3	4
Sunlight reduction shading	Removed 1st layer (about 25%)	Removed 2nd layer (about 50%)	Removed 3rd layer (about 75%)	No more
Reduction of watering watering frequency	Once a day	Once every 2 days	Once every 3 days	No more

- Records management

Watering—Seeds and seedlings must be watered daily. Prior to placing in hardening beds, use tap water or brackish water. For hardened seedlings, brackish water must be used in order to acclimatize them to the field environment. Wells may be dug if the river is far or when no river is available.

The plants should be watered as early as possible every morning. It is important that this be done every day since failure to water even for one day can adversely affect the growth rate and survival of the plants. (Watering is not required for plants exposed to rain.)

Shading—The newly potted seedling should be shaded from intense sunlight. Shading material usually consists of coconut leaves and wire mesh to gradually expose the seedling in the hardening process.

Weeding—Weeding should be conducted regularly to keep the seedlings free from competition. At least once a week check all seed boxes, seed beds and hardening beds for other plants that might have sprouted. Anything that is not the plant you sowed should be removed from the soil and put in the compost pile. Remember, too, that since weeds are often blown by the wind, regular weeding of the nursery is a must.

Hardening—Hardening is the process of preconditioning seedlings in a nursery to the harsh field environment by gradually exposing the plants to increasing amounts of sunlight. This should be continued until the seedlings are fully exposed to sunlight before planting. Watering is likewise reduced. Select only the larger hardy seedlings for planting. (Smaller seedlings may either be sorted for special care to salvage them or simply discarded.) After sorting, the seedling must be properly packaged in baskets or seedling boxes/trays. Arrange the seedlings so that there is no unnecessary movement during transport. Table 2.6 shows a typical hardening treatment.

Protection from pests, diseases and stray animals—Conduct daily inspections for insect pests. Table 2.7 shows insects (#1-6) and diseases (#7-8) that may harm the seedlings and the corresponding control measures. Like weeds, any insects on the plants should be removed. In areas with stray animals, fence the nursery with local materials such as bamboo poles.

A solution of detergent and hot chili pepper is suggested for pests #3-5 (aphid, scale, slug caterpillar) and or leaf spot and *bakauan* mosaic diseases.

Records management—Nursery activities do not end with the delivery of seedlings. Specific batches prepared by the nursery should be monitored in the field to determine growth performance and survival rate. This is especially important for a new species from a particular mother tree/seed area. Such information is necessary to establish a record of that species for future seed collection. A typical species nursery record is shown in Table 2.8.

Grading, Sorting, Packaging and Transport of Seedlings

After hardening, the seedlings should be graded using certain criteria. Normally, the criterion is height to at least 30 centimeters from the root collar for seedlings

Table 2.7. Damage and control measures for common pests and diseases found in mangrove nurseries (Sinohin et al. 1996).

Pest/Disease	Damage	Control measures
1. Tussock moth (All species)	Larvae or hairy caterpillar feeds on leaves of young seedlings	Manual removal of larvae
2. Seed borer (All species)	Bores propagules and breeds on seedling/hypocotyl	Exclusion of propagules with evidence of insects or holes Air-drying of propagules to reduce moisture content before germinating
3. Aphids (All species)	Sucks nutrients of *bakauan* seedlings	Spraying with chemical at company's specification
4. Scale insect (All species)	Sucks nutrients causing curling of leaves	Spraying with chemical at company's specification
5. Slug caterpillar (All species)	Defoliation	Manual removal of larvae
6. Bagworm (All species)	Defoliation	Manual removal of bagworm
7. Leaf spot (*Nilad, bakauan*)	Brown spot interferes with photosynthesis; defoliation if severe	Removal of infected leaves and burning
8. *Bakauan* mosaic (All *bakauan*)	Defoliation; interferes with photosynthesis	Removal of infected seedlings and burning

Table 2.8. Data that should be collected during nursery operations.

Species	Provenance	Date collected	Date sown	Percentage germination	Date planted	Percent survival	Remarks
Bakauan babae	Banacon, Getafe, Bohol	July 15, 1999	July 25, 1999	98	Oct. 1997	95	As of Jan. 30, 2000
Bakauan lalaki	Bais City, Negros Or.	Aug. 1, 1999	Aug. 7, 1999	100	Nov. 1999	96	As of Feb. 28, 2000
Pagatpat	San Fernando, Cebu	Jan. 15, 2000	Jan. 21, 2000	92	Jun. 15, 2000		Percent survival shall be assessed after 3 months

Note: The sample entries on the above table are hypothetical and do not necessarily reflect actual nursery operations.

from seeds and from the ring-like marks for propagules. Those that pass the grading criterion should be sorted according to height before packaging and transport to the planting area.

When all plantable seedlings are out on the field, the remaining seedlings that do not meet the grading criteria should be reared further in the nursery until the desired size is met. The seedling shall be subjected again to the hardening process before outplanting.

Post Nursery Operations

When all the seedlings are already sent out, the nursery should be prepared for the next batch of seedlings. Some repair of the infrastructure and retooling of equipment may be necessary. Likewise, cleaning and sanitation of the nursery should be done to prevent infestation of the incoming seedlings.