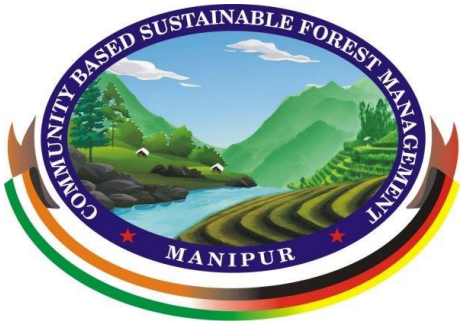

Community-Based Sustainable Forest Management for Water Resource Conservation in Manipur (COSFOM-KfW)

Community Nursery Manual

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1. Introduction

Community-based Sustainable Forest Management for Water Resources Conservation in Manipur is a development project of the Government of India supported by the Federal Government of Germany through KfW within the context of the Indo-German Program on Climate Change Adaptation in the Himalaya. The project is implemented by the Manipur Forest Department (MFD, the Project Executing Agency) and managed by the Community Forestry and Water Conservation Society-Manipur (CF&WCS-M) as Project Management Unit (PMU). The project outcome is formulated as: 'Climate resilience of upper watershed ecosystems is improved or sustainably restored and the adaptive capacity of forest dependent communities is increased (through sustainable forest management and water resource conservation)'. The project will work in three catchment areas—the Ukhrul Block of the Thoubal catchment in Ukhrul District, and the Imphal and Singda catchments in Kangpokpi District.

The project area is located in the eastern Himalayas at the altitude between 786 m (Imphal) and 3,114 m (Ukhrul). Average precipitation of Manipur ranges from 956.5 mm to 2,270 mm. whereas, average monthly total rainfall maximum is 407.3 mm (July), minimum is 12.2 mm (January). More than six months of the year is almost dry (September to April). Average temperature of the State ranges between 14.6ºC to 27.3ºC. Average relative humidity is 74.22%[1].

Nursery is the basic requirement of plantation activities of various purposes, whether for horticulture, vegetable, ornamental plants or forestry species. Plant propagation techniques and practices are the main functions of nursery. The planting materials for various plantations are raised from seeds and vegetative parts. Moreover, in nurseries seedlings/ saplings of plants, which are in limited numbers in natural environment due to some harsh environmental conditions or some other reasons and have difficulties in germination or regeneration, can be multiplied under artificial conditions *ex-situ* with special care. The role of mother plant/ the seed source is very important for propagating high quality seedlings.

Community nurseries in present context are proposed for raising the seedlings of various species, which need to be planted in the watershed areas of the project site of Manipur state. Species will be preferred which have water conserving qualities, native of the area, easy and fast growing, have economic value and are declined due to over use and destructive harvesting in the past.

The project target is to sustainably manage 21,800 ha of forest, 2,000 ha *jhum* cultivation buffer and 1,500 ha riparian forests. High quality seedling production for various project interventions such as afforestation, gap filling and others is one of the major project activities. Most of the seedlings will be produced through Community Nurseries operated by WRCC.

It supports the establishment of community-managed nurseries as per requirements, fulfilling all technical aspects to establish and operate the nursery to produce quality seedlings. The manual includes general nursery practices and seedling raising of specific species as required for COSFOM project, targeting community forestry, enrichment plantation, riparian plantation, watershed management, farm plantation, agroforestry and others.

The primary objective of the Community Nursery is to provide healthy saplings of required species on time in a sustainable manner and enhance the capacity of the local community in nursery operation and management.

This Manual targets the community member in COSFOM project villages, in particular members assigned to the WRCG, and project staff at the level of the Field Supporting Units. It shall be used by nursery forepersons and nursery managers, including rangers, foresters and forest guards.

[1] Detailed Project Report: Community Based Sustainable Forest Management for Water Resources Conservation

2 Nursery Site Selection

The location of nursery should be decided upon the land availability and terrain. A nursery must provide ideal conditions for the growth of seedlings and must protect them from stresses. It must also be a comfortable and safe place for nursery workers.

2.1 Location

A nursery site should be protected from extremes of climate. It also should be:

- Established on adequate land area, free from problematic ecological concerns (free from water stagnant, noxious weeds, industrial emissions etc.) and political concerns (historic land, land right issues etc.);
- On a levelled ground instead of slopes (to avoid costly land cutting and filling activities) and well drained;
- Sheltered and partially shaded (a site protected by existing trees is ideal), yet with sufficient sunlight, preferably southern aspect depending upon the site;
- Close to a permanent supply of clean water (but free from the risk of flooding);
- Close to suitable soil (free from pathogens, insects);
- Accessible enough to allow the convenient transportation of young trees and supplies;
- Inexpensive and reliable energy/ electrification etc., if available;
- Large enough to produce the number of trees required and to allow for future expansion.

2.2 Nursery Size

Size of the nursery depends on the quantities of plants by specific species required for plantations and distribution. It should also consider specific end-user requirements for species, size and age of stock preferred. It is important to assess the season during which people prefer to plant. People of distant localities may also prefer to obtain the saplings.

Shape of the nursery will depend upon the topography and slope. A square or rectangular shape of the nursery is preferred for effective layout, which is ideal on a levelled ground. Moreover, area requirement depends upon size of nursery (its capacity in terms of plant production per season) and also upon whether large-scale growing field (mother beds) will be used for producing tall plants. At the moment, the seedling production capacity of a Community Nursery will range from 50,000 to 100,000 saplings production per year depending upon the demand. Given to this net demand, a nursery should produce 10% extra seedlings for counting the culling.

2.3 Soil Type

Soil plays a vital role for raising plants in a nursery, the quality of the soil is to be assessed based on texture of soil, depth, drainage and acidity (measured by pH level that ranges from 1 to 14). Seven is neutral, while below seven the soil is acidic, above seven is alkaline.

Preferred soil would be loam or sandy loam, avoid the area of clay soil. Soil pH is to be normal between pH 5 – 7, neither very acidic nor alkaline.

Forest top soil with humus should be available near the nursery so that the transportation is easy. As necessary, sand should also be available nearby.

Good and rich soil promotes healthy development of seedlings. Before a nursery is established, the soil should be tested for its suitability with the trees to be used. Factors to be tested for include pH, nutrients (nitrogen, phosphorus, potassium, others), and overall composition. Adjust the soil according to the needs of the plants, if possible. Adequate fertilization is especially important to open-rooted stock.

2.4 Water Supply

Securing source of water for irrigation is a must for establishing a nursery. Special consideration are to be made for assessing the water availability and timing, as watering is required during growing phase of the plants and dry season.

Water quality and quantity is also an important factor and it should be observed that there is not any contamination with harmful chemicals/ minerals, seeds of weeds, pathogen etc. High concentration of these can lead to unwanted vegetation in seedbeds and cover-crops – a major issue.

2.5 Drainage

Proper drainage system in the nursery is important to protect soil erosion from heavy rain and other excess water supply. Drains should be constructed at higher elevation to prevent inward drain from outside the nursery if the terrain slopes towards to nursery. Drainage should be constructed along the periphery of the nursery and along the bed, if necessary. If the drainage is in slopes, some stones and boulders should be kept at drops and along the drain to reduce the water current. Drainage channels should not be more than one percent gradient.

3 Design of Nursery

3.1 Layout

After site selection, planning, designing and layout of the nursery are followed up which assure the management and optimal use of the area. A nursery should be as compact as can be, either square or regular in shape - to minimize the length of the boundary for reducing the cost of fencing and time of moving from one part of the nursery to another.

Access paths are to be developed for accessing to the nursery beds as well as capable of taking vehicles (tractor/ semi truck etc.) up to delivery site, traffic in all the seasons including parking areas with particular attention to labour movement and vehicle traffic flows.

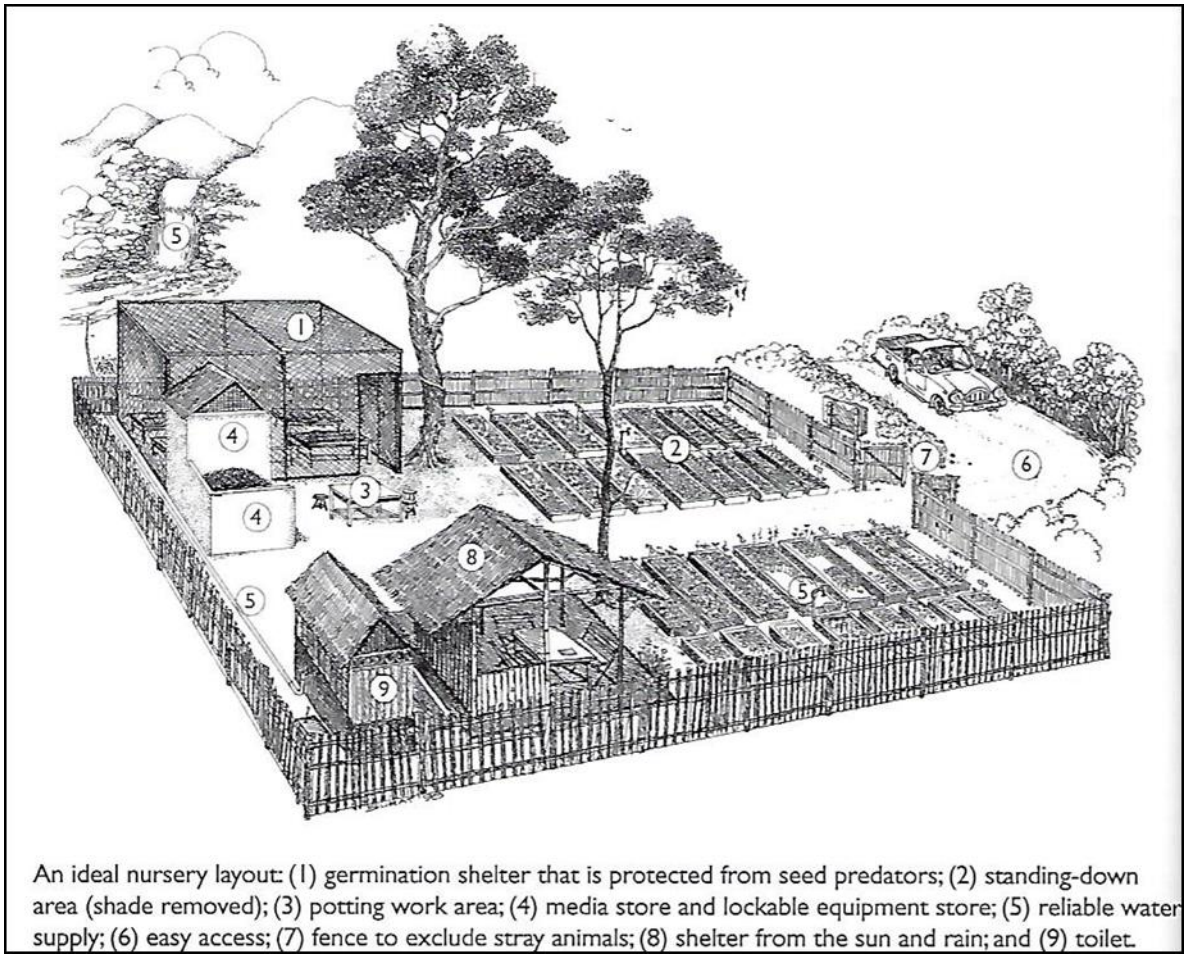

Figure 1: Simple Nursery Layout

However, the walkways (distance between beds) should be a minimum of 50 cm wide to permit enough space for foot and wheelbarrow traffic. The beds should be no wider than 1.2 m in order to make weeding easy. The length of beds should not be too long. The maximum length, as recommended in most cases, should not exceed 20 m. If possible, arrange the beds so that their longer dimensions are placed in an east-west direction. This will give the seedlings a more even distribution for sunlight (Figure 1).

Care must be taken to avoid conflicts with people, vehicles, buildings and landscaping at the time of laying out the nursery design. Access road to the nursery should be consulted with the neighbouring community as they may be disturbed by traffic, noise, dust and others. The community should cooperate for the establishment of the nursery so that there will not be any problem and conflicts on the nursery operation.

3.2 Site Preparation

After layout, an area for nursery site preparation is required in which places of various units are to be fixed. Before fixing various units it is a must to make the site ready by removing existing vegetation/ thorny bushes etc. and prepare the soil to enable the seedlings to utilize the existing soil moisture as effectively as possible. Site preparation includes the removal of bushes and shrubs, terrace making if necessary and levelling of the site. To improve water infiltration and root development aeration, tilling/ploughing should be undertaken in contour line to avoid soil erosion, if necessary.

Enough space should be available for nursery soil work, storage and others. Similarly, space should be available for vehicle parking and delivery near the main entrance gate. Along this side there should be:

1. Soil storage space
2. Thatched hut of proper size for labour work of soil mixing and potting
3. Compost mixing
4. Tools and equipment storage
5. Other, such as rubbish disposal area etc.

Thatched/corrugated roof hut with three-sided cover is ideal for the soil storage and labour work and will also protect from rain. Mycorrhizal soil should be stored in the shade.

Removal of all shrubs and bushes may not be necessary since some plants are shade loving so if any mature tree of native species is found on the designated nursery site, such valuable trees can be incorporated into the nursery site.

3.3 Fencing

Fencing is important to protect the nursery from animals and other unwanted intruders. Type of fencing to be applied will be finalised on the basis of field conditions. Effective low cost fencing is recommended (Figure 2). It should be noted that the fence should also be underground to some depth, depending upon the animal burrow such as porcupine, rodents, rabbits and others.

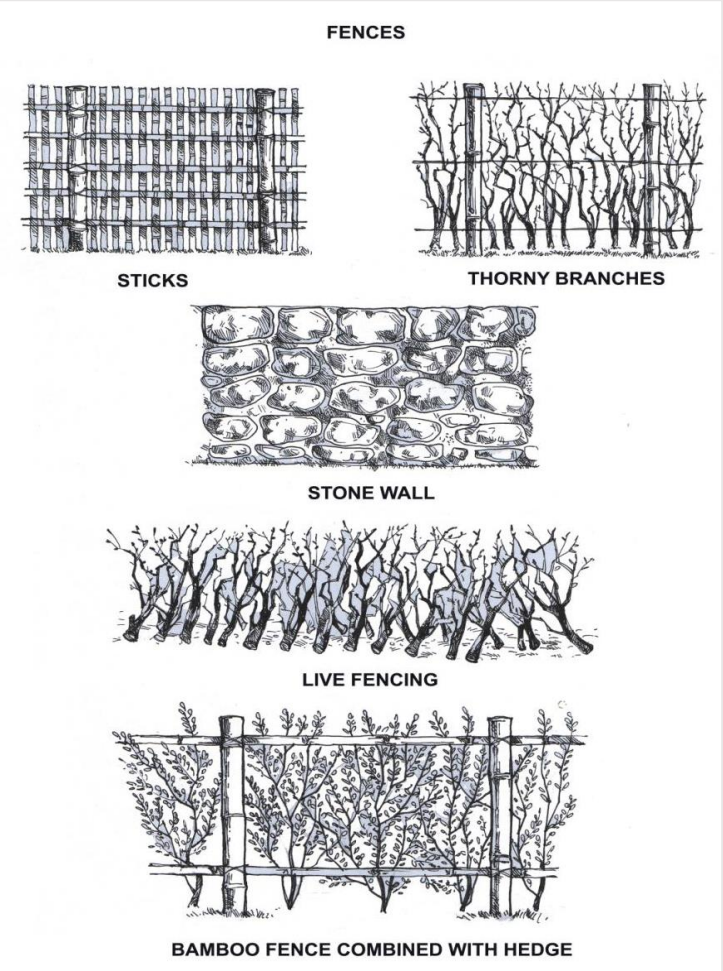

Figure 2: Fences Made by Different Materials

3.4 Operational Area

This is the area where various operations of nursery are to be done, i.e. preparation of planting media, seed germination unit, filling of potting mixture, stock of vegetative propagating materials etc. (compare figure 1: units (1), (3) and (8)). This unit (1) may have small green net shed chamber in which humidity and temperature are maintained, which help in seed germination and sprouting of new shoots from vegetative cuttings etc. Green net shed chamber are followed by hardening chambers where plants are kept for sustaining the environmental conditions, so that sapling when shifted / planted in field can tolerate the atmospheric conditions and grow properly.

3.4.1 Production Area / Standing Down Area

This area (compare figure 1: unit (2)) is the main nursery area covering seedling production including the beds with poly pots, containers and other beds. In due time, the seedlings that are ready to be planted in the field are stocked recording the bed numbers and number of plants that can be dispatched.

3.4.2 Water Supply Unit

Water supply unit will be designed based on the supply type, e.g. source is ground water (tube well) or surface supply (canal/ pond or supply tank).

In both the cases, if an overhead tank (OHT) is constructed, it should be designed for a pressure head and a capacity that will serve its purpose well. It should be kept in higher elevation for gravity irrigation. Irrigation sprinklers are valuable not only because they save on labour but also because they economise water use. These should be designed keeping in view the daily requirement of water and its pressure and the salinity level in water. Perforated pipes will be suitable only if water salinity is low and the pores do not get clogged too frequently. They are the best choice because of their linear geometry and efficient irrigation of the beds on both the sides. Rotary type sprinklers connected to hydrants are more suited for irrigating mother beds and other large blocks of plants growing in the nursery. Excess water should drain safely or be used for other purposes such as agriculture and village community use.

3.4.3 Composting Unit

This is the unit where compost requirement of nursery can be developed. The site can be open or covered depending upon the compost making technique. Introduction to compost making is provided in Section 4.8.

3.4.4 Working shade/ shelter

This is the area (8) required for nursery staff/ labourers doing various activities i.e. preparation of soil mixture, soil sieving, seed sorting and treatments, filling containers with planting media etc. It provides a shaded area to protect from sun but also to protect from rain.

3.4.5 Nursery Equipment

There will be nursery equipment storage where the equipment is kept properly. There are various types of equipment, i.e. for weeding, hoeing, loosening the soil, watering the plants manually, pitting, filling the containers etc. Names and pictures of few commonly used nursery tools are shown in Figure 3.

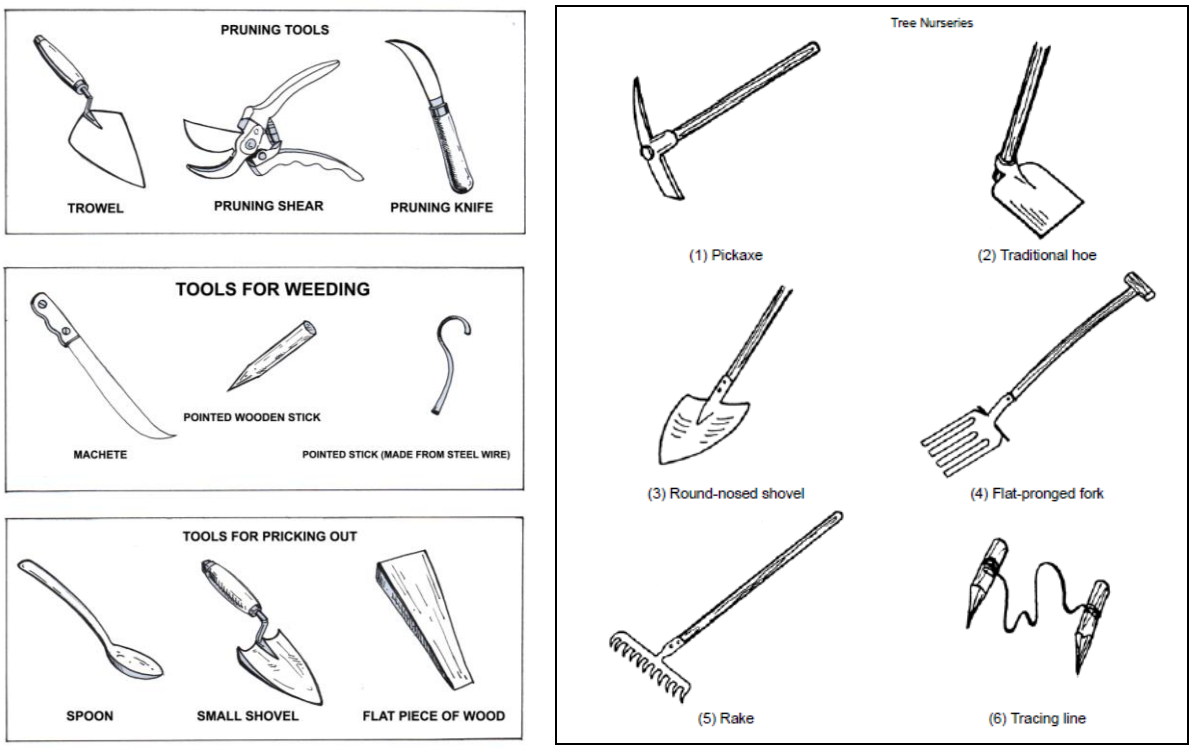

Figure 3: Nursery Tools

4. Bed Preparation and Containers

Preparation of bed for raising seedlings can either be flat or by raising beds depending upon the species to be raised. Some of the species grow well in flat beds, however. Some are more conveniently grown in raised beds, and some of the species can grow well in both the conditions (Figure 4).

Raised beds are mostly used for establishing bare-rooted seedlings; as the sides of the bed can be broken down to reveal the roots of plants, ready for transplanting. Staking slats of wood into the ground in a square or rectangle with sides of about 1 m and then filling this structure with soil (soil, sand, compost) makes a raised bed. Alternatively, the sides can be made from mud or soil collected from deepening of that area selected for bed or from bricks. It is easy to germinate small seeds like Sesbania, Eucalyptus spp. etc. in this type of beds, and allow them to germinate before transferring small seedlings to pots or planting them directly in field.

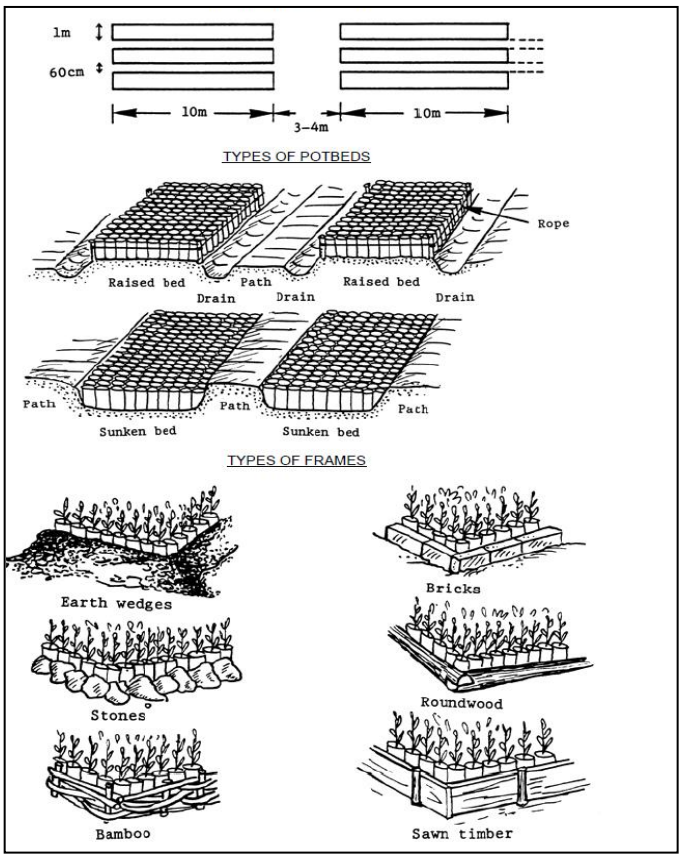

Figure 4: Types of Beds and Bed Frames

4.1 Polybags

Use of polybags is the most common nursery practice to raise the seedlings. The polybag sizes increase as required for the seedling production. Black polybags are used being slower in degradation from sunlight and prevents algae growth. A number of holes are punched at the lower portion of the bag to drain water, however, there must be hole at the bottom of the bag to completely drain.

Nutrient rich soil with humus is filled into the polybags to help the seedling growth (detailed in Section 5). Polybags with seedlings are taken to plantation sites that help to establish the saplings at the plantation area due to nursery soil supporting the root system. Seedling damage will be low while transported to plantation sites. It has to be carefully observed that too much watering in the nursery will damage the root system, resulting in water collection in the polybags. Growth of the root system cannot be assessed in the polybags if roots including the tape roots are curled and not suitable for the plantation. Such can be the case with overgrown seedlings and hence, the seedlings should be used at the right time.

4.2 Bamboo Node

There is another practice using the bamboo nodes having some holes at the bottom for drainage. It is reusable but heavy to transport to plantation sites. It is better to use in the nurseries near the bamboo plantation area.

4.3 Plastic Container Box (Root Trainer)

Plants grown in plastic container box are safe and result in minimum damage to the seedlings during transport. It is also lighter in weight, resulting in cheaper transportation (Figure 5).

Coco peat is also commonly used to grow seedlings. It is light and free from weed seeds and contains much air-filled pores. Due to visible root system development, it is easy to seedling grading ensuring the quality before

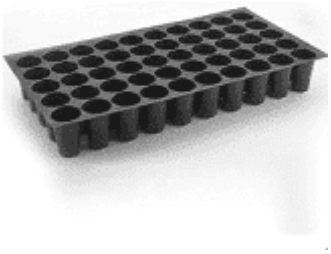

Figure 5: Plastic Container Box and respective seedling taken out of a container (Acacia Spp.)

4.4 Bare-root Plants

Due to easy transportation and assessment of root system development, bare-root plants are also commonly raised. It has to be carefully supervised in the bare-rooted plants plantation especially to plant with the root system straight downward. Skilled labour should use for high percentage of survival. Species like *Schima wallichii and Alnus nepalensis* can be raised by bare-rooted seedlings.

However, bare rooted plants are easy to transport but disadvantage is that they require more space and bit of time in the nursery than the potted seedlings. The roots are sensitive to air exposure during lifting, transporting and planting and more complicated to store at the planting site. However, potted plants also have disadvantages, i.e. they are more complicated to raise and if they are seeded in germination bed first and then shifted to pots, they require regular root pruning in the nursery and are heavy to transport.

4.5 Soil Mixture

Nutrient-rich soil should be developed for nursery use by the mixing of soil, sand and compost. The mixing should be correctly carried out. Whereas highly clayey soil drain badly and root systems cannot develop well, developing more root curling, too much sandy soil will easily drain water which will lead to leaching of nutrients. Generally, standard mixture is 1/3 sand or loose soil, 1/3 clay, and 1/3 compost. Sand should be washed well to drain out unwanted materials. These ingredients should be sieved (1 cm^2) well and carefully checked for mixture use. It has to be mixed thoroughly with a spade or shovel. If using seed trays, don't use compost to omit any damping off fungus. Following table will provide specific mixing proportionate.

Table 1: Soil Mixture Proportions

Topsoil/ Forest Soil	Sand	Compost	Remarks
3	1	1	Slightly infertile soils with too much clay
3	2	1	
1	2	1	
2	2	1	
3	0	1	Too sandy soils
4	0	1	
3	1	0	Slightly too much sandy soils
4	1	0	

Source: Jackson, J. K., 1994 (Napier and Robbins, 1989)

4.6 Compost Making

There are mainly two types of compost making i.e. organic compost and Vermi-compost. Organic compost is made from dead and decayed organic wastes under anaerobic conditions. The process of composting involves soaking the agro-waste in water containing cattle dung, urea, and superphosphate. In Vermi-compost technique, worms/ earthworms are introduced in the heap of organic waste/ dry leaves/ farm wastes and such organic materials. Layered with decayed cow-dung, this heap is kept moist for survival of earthworms. Vermi-composting is more beneficial as the cocoons / shelled fertilized eggs of earthworm transferred to the field and grow in soil and improve the porosity of soil near the roots of growing plants.

This can substantiate the expenditure of FYM (Farm Yard Manure) in future and can also provide additional income to the community in due course of time.

5. Propagation Methods

There are several methods to raise the seedling of which seeds and vegetative propagation from cuttings/ grafting are common. Generally, cuttings are used for the species, which have less seeds or seed germination is difficult.

5.1 Seeds

Raising plants from seeds is very common. Main important point to be taken care is to select the seeds from healthy plant, if its fruit bearing tree then quality of fruits/ flowers to be superior have higher fruiting potential. Seeds should be free from any infection, and superior in quality.

5.2 Seed Treatment

Seed treatment is the process required to set the seed for germination there is common practice of seed treatment to remove it from any infections and others. However, some other treatments are required to break the seed dormancy period and enhance the viability of it.

Common treatments are hot water, cold water treatment for a definite period or sometimes if seed coats are thicker then specific treatments like embedding in cow dung, rupturing seed notch etc. are provided as per specific to species.

5.3 Filling the Containers

Containers such as polybags are filled with soil mixture using the scoop, leaving about 1 cm from the top. The bags should be well packed but not tight so that the root system can develop easily.

5.4 Seed Sowing directly to Container

The polybags should be well watered in the evening prior to sowing. Make a hole of 0.50 cm depth and put in the seed, then cover with washed sand. After germination, there should be only one seedling per container and retain only the best one (Figure 6).

Germination testing of each lot of seeds provided to nursery should be carried out in a seed tray with properly recording the germination percentage with the number of seeds applied.

5.5 Seedbed Germination

The raised germination bed is prepared and properly levelled. Apply water before seed sowing. Lines of 0.50 cm depth and 5 cm apart are drawn across the width of the bed using a small bamboo stick. Large size seeds (such as *Quercus* spp.) are sown in this line and covered with soil mixture ensuring homogeneous soil cover.

Small seeds are broadcasted in the germination bed covered with soil mixture as above. Regular watering will be followed by rose can in lower height so that seeds will not be exposed to water.

The width should be 1 to 1.5 m width depending upon the hand reach from both side to middle of the bed and with a length of about 12 m. Put a layer of 5 cm coarse gravel at the bottom of the bed to allow for surplus water to drain, add 3 cm sieved forest top soil, and compact again. Tie 5 cm thick bamboo or bed side materials strapped on 15 cm high bamboo pegs around the bed.

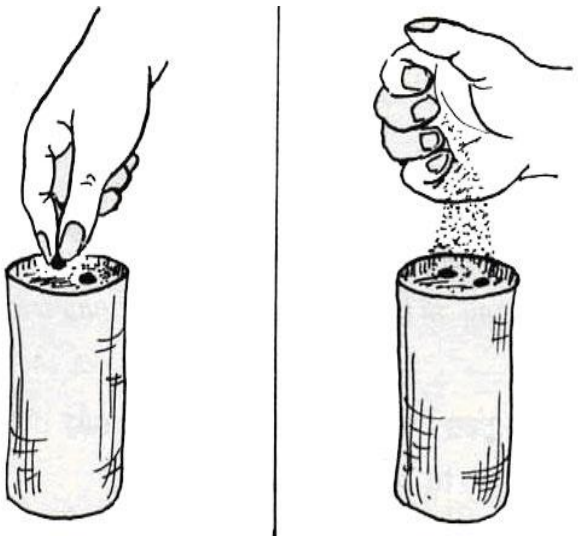

Figure 6: Seed Sowing in Polybags

5.6 Pricking Out

After germination at 2-4 true leaf stage, watering and pricking out preferably late afternoon to avoid drying. Gently hold by the leaves and use a wooden tweezer to prick out the seedlings (Figure 7). **Never lift seedlings holding the stalk**. Prepare container with mixture as mentioned above, water it, use a stick to make a hole about the length of the roots, carefully place the seedlings without disturbing the roots, and fill the hole half sieved soil and half sieved river washed sand. Cover using net strapped with bamboo for shading. Keep watering twice a day, morning and late evening, and if soil is wet, water alternate days. Fill gaps and as new leaves start emerging acclimatize it. **Never put pricked seedlings under direct sunlight**.

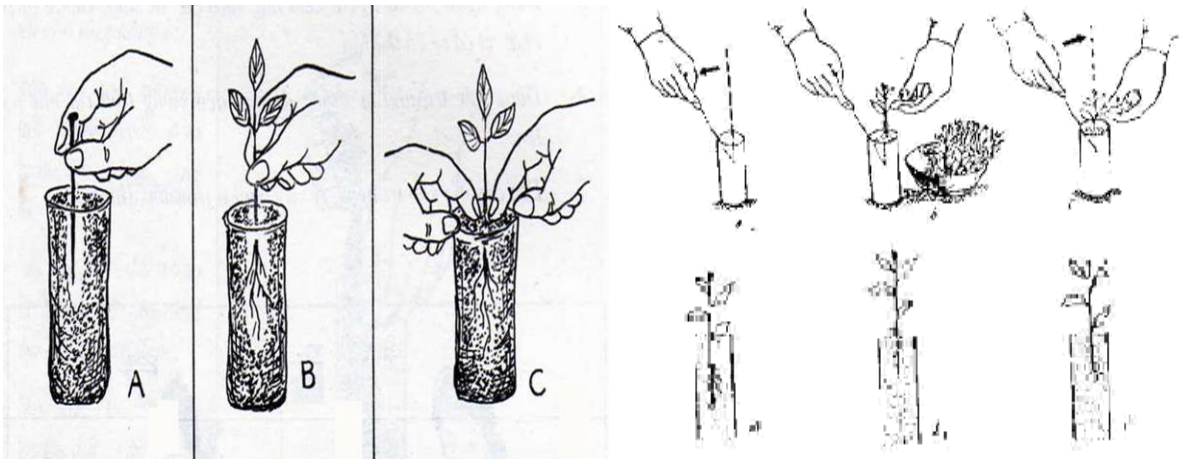

Figure 7: Transplanting (pricking out) technique

5.7 Caring of Seedlings

5.7.1 Shading

Provide shading at 50 cm height for smaller ones and 1 m height for taller seedlings. Keep provision to remove and place shades (Figure 8).

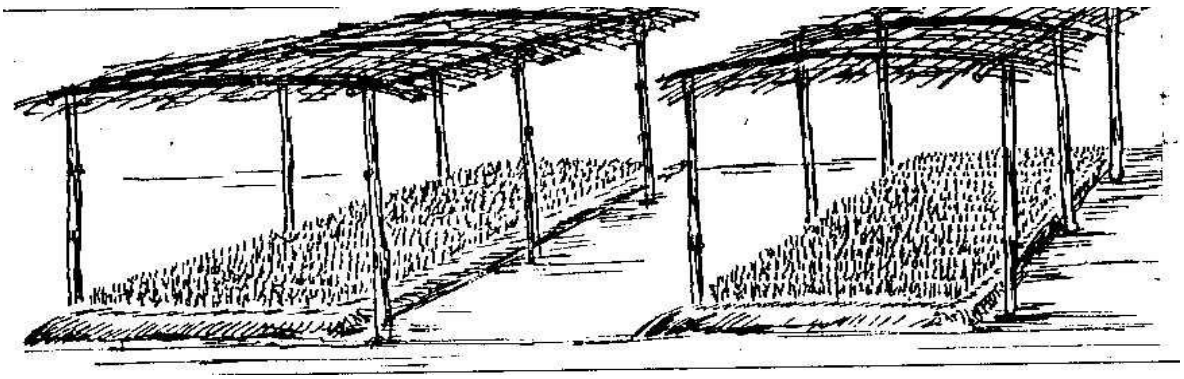

Figure 8: Nursery Bed Shading

5.7.2 Spacing of Seedlings in Bed

As seedlings grow taller, one seedling overlaps the other, and seedlings will be congested. Use bamboo slices and move containers to keep spacing. Leaves of one seedling should not overlap with the leaves of the other seedling.

5.7.3 Root Pruning

Lift containers and check if roots coming out. If yes, prune the roots. Prune the roots of the seedlings about 45 days before field transplantation.

5.8 Vegetative Propagation

This method is used for propagating the perennial species and trees. Most of the fruit trees in horticulture are propagated through vegetative propagation techniques.

Material used for vegetative propagation is twig, branch of plant, root suckers, runners, plant buds etc. Common fruit trees, which are being propagated from vegetative methods are *Aonla* (Goose berry), mango, blackberry, apple, strawberry etc.

5.8.1 Cuttings

With this method of propagation, new plants get ready from shoots/ branches/ twigs of mother plant. This method is used when the plant produces custard of rooted stems. In the late growing season and at the beginning of the dormant stage, we can divide the plant for several new specimens according to the number of rooted stems. During this process, the old part of the plant should be removed. This technique basically rejuvenates the plant.

It is a simple method where twigs or branches of the mother plant are cut in a way that it contains at least two leaf buds, the lower part of the twig is dipped in the solution of root hormone for a while and then dipped in soil bed (composition of soil and sand would be equal). After few days or a week, leaf sprouts and new plant establishes which can be planted after some time.

5.9 Hardening off

Hardening off is a process to harden (woodening) the seedlings for plantation where the saplings have to cope with the natural condition without nurturing as in the nursery. Stems should be durable for handling, planting and field persistent.

One of the reasons of seedling casualty in the plantation occurs if hardening is not sufficiently done while in the nursery. Casualties are mainly due to wilting, insufficient stem hardening and excessive evapotranspiration. The seedlings in the nursery should be fully exposed to sun for a time period before planting to acclimatise to the stress and be kept in wider spacing.

6. Nursery Protection

Protection measures to be adopted as per the field conditions, but regular monitoring for that is one of the important parameter. Symptoms to any of the impact to be highlighted and accordingly suitable measure are to be identified for that.

6.1 Fire Control

To manage the fire incidences, proper fire lines have to be established and community user groups have to be trained appropriately for handling the fire incidences. Firefighting equipment, soil etc. are to be kept for such cases and in case of major incidences, firefighters have to be notified/ called immediately.

6.2 Pest control

Regular monitoring of the nursery and planting stock with proper supervision have to be done. In case of any symptoms like leaf rotting, twisting or any spot noticed on the seedlings it has to be managed immediately and such plants have to be separated from others. Some of the common pests are

1. White grubes
2. Larvae of beetles of subfamily *Melolonthinae* including cockchafers and their allies
3. Caterpillars
4. Crickets and grasshoppers

6.3 Birds and Animals

Birds may be menace especially at the time of seed sowing as the birds will come to feed. The beds should be properly covered, even not blown from wind, and long light fabrics should be tied to a pole or similar to scare the birds. Animals such as porcupine, rabbits, rodents and others are also problematic and seedlings have to be protected from their burrows. Other animals like chicken, cattle, goats, pigs etc. should be kept away and fencing should be secured.

6.4 Disease Control

Damping off: There are pre-emergence damping off and post-emergence damping off. Pre germination damping off attacks the seed causing radical to rot before the emergence of the shoot. Post emergence damping off spreads rapidly with patches of dead seedlings. This fungus also causes root rot in older seedlings. Leaves become yellowish, top of stem downwards, following wilting, discoloration and ultimately death of the seedling. High value pH soil will tend to damping off. Damping off fungi thrive in warm, humid and shady conditions and in the presence of organic material.

Prevention: control of water use, do not water if wet, no over watering, seed sowing in dry season, removal of shade, use well-drained sandy germination medium. Direct sowing in polybags reduces damping off. Bed should be open, to free circulation of air, seeds should not be sown too closely. Dead and diseased seedlings should be removed and burnt.

Plants and beds should be watered with a fungicide such as Blitox or Dithane 45 – apply 5 gm/litre of water twice a week until the disease is controlled.

Overall, the nursery should be kept hygienic with some actions as follows.

1. Immediate removal and burning of all seedlings with diseases.
2. Pots should not be used again and be discarded.
3. Nursery should be weed free
4. Too much watering and shade should be avoided.

Some of the pest and diseases of important species are provided in Annex 2.

7 Nursery Management

7.1 Decision making and record keeping

An efficient and effective nursery should be managed to produce quality seedlings as demanded by the community members and plantation purpose. Selection of species to be raised in the nursery should be determined in advance consultations with the stakeholders, particularly the community members who require the seedlings and for project initiated afforestation programs. Once the decisions on the species are made, propagation methods should be decided so that the seed collection will be done on time. In some cases it has to be done a year in advance. Seed collection with proper storage should be completed on time. Species selection and production quantity should be discussed during the village meeting so that all the project beneficiaries will participate in the decision making process.

Nursery beds should be numbered and register the bed numbers for various purpose used such as germination bed, poly bags and others. The beds should level with species in the bed.

Depending upon the annual target of seedling production, nursery materials should be assessed and estimate for funding and delivery source should be determined. Project technical staff will assist to prepare detailed cost estimates of the nursery operations and seedling production. The budget should be approved by the WRCC.

Though the nursery supplies will be made available after the funding provision, however, the nursery operation by season should not be obstructed and continued so that the season by species can be followed appropriately. It is the responsibility of the nursery foreperson, supervised and supported by the project technical person. Each of the Community Nursery will be provided with a project technical person.

All the nursery records should be kept and maintained by the nursery foreperson as provided in this manual. It is not limited, new records as required can also be developed and should be maintained. Depending upon the nature of the record, it can use either a registry book or loose sheets, although a proper nursery registry book is easier to maintain as single papers get lost easily. Proper filing system should be kept for the nursery management.

Management aspect of the nursery covers day-to-day operation, production system by season, seedling supply during the planting season, cleaning after seasonal operation and maintenance. Nursery protection from fire, animals, vandalism and other unwanted activities that will adversely affect to nursery operation is equally important. Timely reporting by nursery foreperson to WRCC and project technical person (depending upon the nature of the report) is important for the timely action and decisions.

Workload is high during the seedling production and seedling dispatch period. Proper supervision is important during seedling handling to storage for the transport to plantation sites. Nursery code will be provided to each COSFOM Community Nursery so that seedling at the plantation sites can be identified by seedling source for the quality and survival percentage of the plantation.

7.2 Nursery Activities

Nursery work is categorised as follows for the planning purpose so that the tasks can be followed appropriately.

1. Site measurements and layout
2. Site preparation, levelling and others
3. Fencing material and installation
4. Water supply and drainage work
5. Nursery work area construction
6. Shade houses for soil/sand, soil mixing, potting, compost making, storage and garbage disposal area, water supply
7. Germination beds, polybag beds, reserve beds and others
8. Seed sowing, pricking out
9. Watering

10. Caring of seedlings (growth monitoring etc.)
11. Prevention from pest and diseases
12. Health and Safety

Materials required: Seeds, polybags by size, soil, sand, compost, bamboo and others, water tank and pipes, fence materials and others

Detailed cost estimates with labour estimates based on cost norms should be prepared with the help of project technical person. Project technical person will process for the approval once agreed by WRCC.

7.3 Nursery Schedule

Nursery operation is seasonal for the seedling production. The schedule of the nursery activities is presented in Table 2.

Table 2: Activity schedule of Nursery

No	Activities	Schedule (Months)												Remarks
		1	2	3	4	5	6	7	8	9	10	11	12	
1	Nursery layout/measurements													Establishment only
2	Fencing, water supply, working sheds, storage construction and others													Establishment only and maintenance
3	Germination beds, production beds preparation													Regular
4	Soil mixture and potting													Regular
5	Seed sowing													Regular
6	Transplanting													Regular
7	Watering													Regular
8	Shading													Regular
9	Weeding													Regular
10	Root Pruning													Regular
11	Hardening Off													Regular

8 Health and Safety

Health and safety at the nursery operation is important to follow for all labour and visitors, also in line the COSFOM´s environmental and social safeguards (E&S). Some of health and safety regulations to be introduced in the nursery are the following:

1. There should be a designated area to properly store nursery equipment and tools. All equipment and tools should be collected and stored instead of scattering all over the different work sites. Nursery foreperson is responsible to check that this is being properly followed.
2. Nursery construction materials such as bamboo, stones, bricks, timbers and alike should be safely stacked or stored so that it will not obstruct anybody, creating any potential for accidents.
3. For soil, sand and other small particle materials in the nursery it has to be ensured that these materials are not washed away during rain or blown away by strong wind. Proper measures should be taken such as to cover by plastic sheets. Dust is hazardous to health and proper precautions should be taken by labourers.
4. A signboard will be kept at the entrance of the nursery gate, informing the health and safety measures in the nursery so that labourer and visitors will be aware of the hazardous condition of the area. Children's entry to nursery will be only with the permission of the nursery foreperson and under supervision of adults.
5. All the agrochemicals, insecticides and other such **materials will be packed with proper labelling and locked in a cabinet.** Such materials have to be handled properly with the permission of the nursery foreperson and/or technical person after suitable instructions only. All the baskets and other such materials should be completely cleaned after use. Ensure that it is not left without cleaning or dispose anywhere. **Do not discharge leftovers in rivers or streams!**
6. For insecticide spraying, **sprayer must use protective clothing such as mask during the spraying**. There should not be anybody nearby during the spraying – mind the wind direction!
7. **A First Aid kit** with essential medicines especially to treat wounds from cutting or similar will be kept on site or carried by the foreperson and should be readily available in an emergency case.

References

- Elliott, S.D., D. Blakesley and K. Hardwick, 2013. Restoring Tropical Forests: A practical guide, Royal Botanical Gardens, Kew;
- Plantation Manual, Bulletin No. 56, 2011: SFRI, Jabalpur, Madhya Pradesh, India
- New Zealand Institute of Forestry, 2005: NZIF Forestry Handbook, New Zealand
- Manipur Forest Department, Manipur, 2009: A preliminary report on the compilation of a handbook on Nursery and Plantation Technique of Forest Trees Volume 1
- Natural Resources Training Institute, Lobesa, MoA, Field Guide 2000/1
- Gyem Tshering, D. B. Chhetri, August 2000: Important Forest Insect Pests and Diseases of Bhutan with Control Measures, Renewable Natural Resources Research Centre, Yusipang
- Jackson, J.K., 1994: Manual of Afforestation in Nepal Volume 1, Forest Research and Survey Centre, Nepal
- Sharma, Jyoti and Mathew, George (1990): Diseases and insects in forest nurseries in India and their management.

Annexes

Annex 1: Suggested Propagation Techniques

No	Local Name	Name of Species	Seeding Time	Propagation Method	Quality Standard
1	Kadam	*Anthocephalus cadamba*	Jan-Feb	Seeds	Up to 1 m height or > 10 months of age
2	Siris	*Albizzia chinensis*	Jan-March	Seeds	Up to 1 m height or > 6 months of age
3	Agor	*Aquilariam alaccensis*	June-July	Seed/ Vegetative	
4	Alder/Utis	*Alnus nepalensis*	November-Dec	Seed/ Vegetative	Height > 2 feet and > 6 months of age
5	Neem	*Azadiracta indica*	June-Aug	Seed/ Vegetative	Up to 1 m height or > 6 months of age
6	Urium	*Bischofia javanica*	December-January	Seed/ Vegetative	Up to 1 m height or > 6 months of age
7		*Cassia fistula*	July-Aug	Seeds	Up to 1 m height or > 6 months of age
8	Kapoor	*Cinnamomum zeylanica*	October-Nov.	Seeds	Up to 1 m height or > 6 months of age
9	Wang	*Gmelina arborea*	May-June	Seed/ Vegetative	Up to 1 m height or > 6 months of age
10	Chinjali	*Litsea glutinosa*	February-March	Seed germination is poor/ Vegetative propagation/ Micro-propagation are suggested	1 year old seedlings to be planted in field
11	Champ	*Michelia champaca*	June-August	Seed / Vegetative cutting is more successful	1 year old plant
12	Yongchak	*Perkia roxburghii*	March-May	Seed	I year old seedlings
13	Uningthou	*Phoeb hainesiana*	October	Seed	Up to 1 m height or > 10 months of age
14	Khashru	*Quercus incana*	December-Feb	Seed	Up to 1 m height or > 6 months of age
15		*Salix tetrasperma*	March-April	Seed	Up to 1 m height or > 6 months of age
16	Arjuna	*Terminalia arjuna*	Feb-May	Seed/ Vegetative	Up to 1 m height or > 10 months of age
17	Tolhao	*Terminalia myriocarpa*	Dec-Jan	Seed/ Vegetative	Up to 1 m height or > 10 months of age
18		*Terminalia chebula*	March-May	Seed/ Vegetative	Up to 1 m height or > 10 months of age
19	Tooni	*Toona ciliata*	March-Aug		Up to 1 m height or >10 months of age
20	Chilauane (Nepali)	*Schima wallichaii*	Feb- March	Seed	Up to 1 m height or >10 months of age

Annex 2: Common Diseases in Nursery

No	Name of Trees	Disease & Pest	Nature of Damage	Season of Attack	Treatments
1	Alder/Utis		Defoliators (shoot of plant)		Natural predators (Birds, Ants, Spiders etc.)
		Aphids	Attack on leaves and young shoots	September-February	Natural predators like Lady Beetle are suggested or Organically certified insecticides such as azadirachtin (Neemix), neem oil (Trilogy), and pyrethrin (PyGanic) to be used.
2	Kadam, Khasru, Arjuna	Serious defoliation	*Plant became leafless*		0.2 % Fenitrothion 0.1% Carbaryl (Sevin), 0.05% Quinalphos (Ekalux), 0.05% *Deltamethrin*
	Terminalia arjuna		Rust like round shaped whitish and one celled spots on lower surface of leaves. Fruiting body	Throughout the year	
	Terminalia spp, T. myriocarpa. T. arjuna. T.cattappa, T. chebula	Leaf Blight	Leaf blight, damaging leaf and seedling growth		Use of and Dithane M 45, fungicides
3	*(Neem*	Caused by parasites on this plant and causes powdery mildew on upper leaf surface.	Upper surface of leaf has whitish capsule shaped spores.	October- February	
			Wilt, Root rot, collar rot		Soil drenching with 0.1% Carbendazim
			Leaf Blight		0.2 % Carbendazim
			Powdery mildew		Spraying 0.2 % Dithane Z-78 or Bordeaux mixture 0.1 %
4	Wang		Feeds along the vein of the leaf at the age of four months. Shoot die back and seedling mortality.		0.1 % Quinalphos

No	Name of Trees	Disease & Pest	Nature of Damage	Season of Attack	Treatments
5	Yongchak		Wilt rot of roots in nursery plants		Soil drenching with Soil drenching with 0.2 % Bavistin 50 %
6		Common for various tree species in nursery Mealy bugs, white flies, cow bugs, aphids and psyllids are the major sap sucking insects	Shoot die back and mortality of seedlings	October-February	Use of tobacco/ soap emulsion reported to be effective in managing sap sucking insects. Application of dimethoate (Rogor) or monocrotophos (Nuvacron, Monophos) (0.01-0.05%); phosphamidon (Dimecron) (0.04%) or fenitrothion (Sumithion) (0.02%) or Tiamethoxam (Actra 0.25gm/1 lit) or Fusarium 16 suspension has also been suggested.
7		Root boring insects Shoot borers both adult and larvae	Bore holes into the shoots and causing seedling mortality		Removal of affected shoots and maintaining low density suggested
8		Gall forming insects Leaf and stem galls are formed	Infected leaves and shoots		Removal of affected shoots and application of insecticide i.e. Dimethoate (Rogor) or Monocrotophos; Nuvacron, Monophos) (0.01-0.02%); phosphamidon (Dimecron) (0.04%) or fenitrothion (Sumithion) (0.02%) or Tiamethoxam (Actra 0.25gm/1 lit) may be used to control the gall insects.
9		Root bores Termites, root feeding beetles	Mortality of Seedlings		Soil drenching use of insecticide: Phorate 2 G effective for white grubs

Annex 3: Seedling Production Planning

Seedling Production			
Targeted seedling use Year: 202….	Community forest Area: Ha. No of Seedlings:	Riparian plantation Area: Ha. No of Seedlings:	Private plantation Area: Ha. No of Seedlings:
Species	Spp.	Spp	Spp
Stocking from last year			
Raising in current year 202…			
Seedlings for next year			
Seed requirement (estimated from 1 kg)			
Total seeds required			
Targeted seed source			
Estimated seed delivery			

Annex 4: Seed Delivery and Storage

Tasks	Spp.	Spp.	Spp.
Seed source	(collection site/ Collection date)	(collection site/ Collection date)	(collection site/ Collection date)
Date of seeds delivered to Nursery			
Quantity of seeds			
Seed packing while delivery			
Storage container in the nursery	Sacks Tin box Open ground	Sacks Tin box Open ground	Sacks Tin box Open ground
Seed viability, after tested			
Seed quantity sufficient/deficit (+/-)			

Annex 5: Seed Sowing Registry and Pricking Out

Tasks	Species	Species	Remarks
Pre-treatment			
Sowing date and bed no.			
Quantity/number of seeds sown			
Date of germination			
Germination %			
No. of plants pricked out to bags			
Date pricked out and bed number			
Other records: watering, shading, insecticides			
Pest and diseases/dates			
Number of seedlings ready and date			

Annex 6: Seedling Dispatch Registry

Seedling Counting	Species	Species	Species
Seedlings required this year 202…..			
Seedling stock from last year			
Seedling ready this year 202…….			
Total seedling ready			
Seedling dispatch:			
Community forest at ……..			
Forest closer at …….			
Riparian plantation at …….			
Private plantation at ……			
Total			
Balance left in Nursery			