Nursery Manual

SCATFORM Manual and Guideline Series No.1

2020.1

Nursery Manual

ABSTRACT

Successful nursery operation depends upon many factors such as good site selection, adequate planning, use of good technical methods, (cultivation, disease/pest control, efficient supervision and administration), etc. A nursery needs to be managed, designed to produce seedlings grown under favourable conditions until they are ready for planting. All nurseries primarily aim to produce sufficient quantities of high-quality seedlings to satisfy the needs of users. This manual describes various aspects of nursery operations in order to disseminate better plant production under SCATFORM in Tripura (**Nursery Manual, Page-1**).

In SCATFORM Project there are three types of nurseries namely; High Tech Nurseries (HTNs), Central Nurseries (CNs) and Decentralized Peoples Nurseries (DCPNs) are going to be established or improved existing facilities of these nurseries. The total number of nurseries planned to be supported under SCATFORM as HTN, CN and DCPN are 160 (HTN: 3 nos, CN: 7 nos and DCPN: 150 nos) (**Nursery Manual, Page-1**).

HTN will be used for developing advanced technologies including research on propagation methods of economically important plants and rare/endangered/threatened plant species. Production area of HTN is about 1.5 ha with production capacity 500,000 planting material. HTN is operated directly by TFD and research will be conducted with Forest Research Division. In order to produce a large number of quality seedlings, CNs are established. The size and capacity of CN is equivalent to HTN and operated directly by TFD. On the other hand, DCPNs are established in order to produce seedlings in remote JFMC areas where transportation of seedlings is costly and difficult. DCPN will be managed by JFMC members and thus, it will provide economic income to JFMC members. Approximate area of one DPN will be about 0.25 ha with a capacity of 20,000 seedlings production. Main features and typical infrastructures of these nurseries are provided below: (**Nursery Manual, Page-1 to 3**).

No	Facility	High Tech Nursery	Central Nursery	Decentralized People's Nursery
1	Nursery bed	Permanent	Permanent	Temporary
2	Superstructure (iron frame)	✓	✓	-
3	Manure mixing space	✓	✓	✓
4	Hardening chamber	✓	✓	-
5	Overhead water tank	✓	✓	-
6	RCC/brick road	✓	✓	-
7	Labor shed	✓	✓	-
8	Storage room	✓	✓	-
9	Drying shed	✓	✓	✓
10	Vermi compost	✓	-	-
11	Seed germination unit (mother beds)	✓	✓	✓
12	Office room	✓	✓	-
13	Visitors shed	✓	✓	-
14	Fencing	✓	✓	✓
15	Mist chamber/poly house	✓	✓	-
16	Deep tube well with pipeline, submersible pump & sprinkler	✓	✓	-
17	Seed testing laboratory	✓	-	-

Selection of an appropriate nursery site is an important decision for efficient production of quality plants. It must start from well-defined objectives of the nursery, which includes number of plants to be produced each year, species to be selected, type and size of plants, location of the plantations where plants are to be supplied. HTN and CN nurseries should be located as much as

possible in a flat land, near perennial water sources. However, the ideal nursery location should fulfil the following requirements such as land availability, good permanent water supply or piped water system, good drainage with gentle slope, easy accessibility with road communication, good supply of suitable soil materials, no chance of flooding and not prone to soil erosion, etc. (**Nursery Manual, Page-3 to 4**).

A nursery design varies according to the objective such as type of plants to be raised, topography of the land, etc. The basic facilities of nursery includes entry gate, internal paths, fence or wall, office room, storage room, labour shed, vehicle shed, drinking water facility and toilet. The typical infrastructures required to produce seedlings in a nursery includes mother beds, seed beds, poly house, hardening shed, drying shed, water tanks, water distribution system, drainage system, soil storage shelter, compost-making area, seed treatment pit and research area (**Nursery Manual, Page-5 to 6**).

Prior to production of quality planting material in nurseries some of the time bound routine activities need to be carried out by the nursery managers and these are quantity of seeds required, collection of seeds from candidate plus trees of forestry species, proper storage of seeds, testing of viability and germination percentage of seeds by adopting appropriate methods discussed in the nursery manual. Prior to planting of viable seeds in to the germination bed treatment of seeds with appropriate mechanical, chemical or biological means is needed to break the dormancy of seed germination (**Nursery Manual, Page-7 to 17**).

Preparation of soils in the seed beds, mother beds and germination beds is of utmost important for a nursery. During the dry season, dry fine textured consistent soil may be prepared. Collect topsoil, break clods, remove foreign materials, and mix soil with sand and farm yard manure (FYM) if required in the ratio of 1(soil): 1(sand): 1(manure). Moisture and temperature of the soil in the nursery beds are very important factors for germination of the seeds. To get good size seedling (thumb size), the seed may be sown by spreading in the mother bed and when they have few leaves, some may be pricked out so that the remaining may be spaced at about 3-4 cm apart. The pricked out seedling may be planted in poly bag nursery. Remove the weeds by hand regularly and use natural neem pesticides with fortnightly intervals for insect pests. Regular checking and monitoring of seedlings for pest and disease attack is highly recommended for raising healthy seedlings (**Nursery Manual, Page-17 to 21**).

In order to increase the survival percentage of seedlings in the field, seedlings are exposed to rough treatment called "Hardening". The main treatment for hardening is the reduction of water with full exposure to sunlight to make seedlings more tolerant under such conditions. The hardening treatment should begin well in advance of the timing of transporting out seedlings from nursery to plantation sites (**Nursery Manual, Page-21 to 22**).

The nursery manual also provided a comprehensive nursery journal for record keeping and seed calendar for forestry species going to be raised under SCATFORM Project which specifically mentioned the seed collection months for individual species as well as their viability periods at the end of the manual.

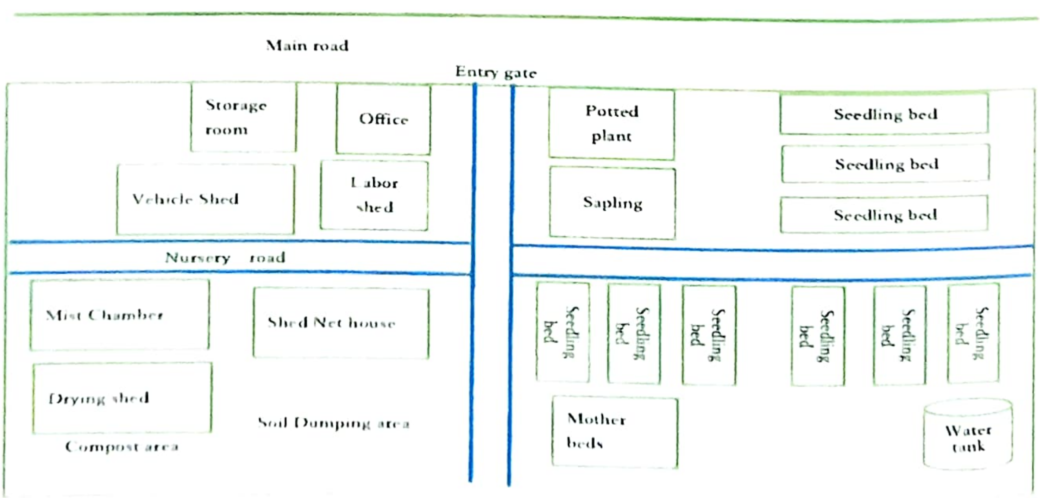

Image: Schematic diagram of Nursery layout at Padmabil Central Nursery.

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Nursery Manual

1. Introduction

The production of Quality Planting Material (QPM) is a vital operation of forest management. Successful nursery operation depends upon many factors; good site selection, adequate planning, use of good technical method(cultivation, disease/pest control, efficient supervision and administration), etc. Nursery work is complex.A nursery needs to be managed, designed to produce seedlings grown under favourable conditions until they are ready for planting. All nurseries primarily aim to producesufficient quantities of high-quality seedlings to satisfy the needs of users. This manual describes various aspects of nursery operations in order to disseminate better plant production under SCATFORM in Tripura.

2. Type of Nursery

There are three types of nurseries established or improved underSCATFORM.

i. High Tech Nurseries (HTN)
ii. Central Nurseries
iii. Decentralized People's Nurseries (DCPN)

2.1 High-Tech Nursery

In order to produce high-quality seedlings which require intensive care with a help of advanced technology (e.g. bamboo and cane species), High Tech Nursery (HTN) are established. HTN will be used for developing advanced technologies including research on propagation methods of economically important plants and standardization of propagation methodology of rare/endangered/threatened plant species. HTN is considered to be advanced version of Central Nursery. Production area of HTN is at least 1.5 ha withminimum production capacity 500,000 planting material. HTN is operated directly by TFD and research will be conducted with Forest Research Division.

2.2 Central Nursery

In order to produce a large numberof seedlings with reliable quality, central nurseries (CN) are established. Difference between HTN and CN is only advanced facilities (seed testing laboratory or mist chamber will be absent in CN). The size and capacity of CN is equivalent to HTN. The total number of nurseries planned to be supported under SCATFORM as HTN and CN are 10 (HTN: 3 nos and CN: 7 nos).

2.3 Decentralized People's Nursery

In order to produce seedlings in remote areas where transportation of seedlingsis costly and difficult, Decentralized People's Nurseries (DPNs) are established. DPN will be established in JFMC and managed by JFMC members or SHG;thus, it provides economic income to JFMC members. The staff working for DPN will be trained for nursery management.

The number of DPNplanned to be supported by SCATFORM is 150; roughly among every 3 JFMCs one DPN will be established. DPNs are to be established during the 1stor 2ndyear of the implementation stage after JFMCs will be formulated at the preparatory stage. Approximate area of one DPN will be about 0.25 ha with a capacity of 20,000 seedlings production. DPN will be established as temporary setting with minimum facilities.

Table: Main features of each type of nursery

Nursery type	Objective	Main features
High Tech Nursery	• Production of high-quality seedlingswhich require intensive care with a help of advanced technology (e.g. bamboo and cane species) • Research on propagation methods of economically important plants • Standardization of propagation methodology of rare/endangered/threatened plant species	• Permanent nursery for large scale production equipped with modern facilities such as seed laboratory to produce seedlings of specific species which require intensive care. • Managed directly by TFD. • Size: minimum: 1.5 ha • Production capacity: larger than 500,000 seedlings
Central Nursery	• To produce a large number of seedlings with reliable quality	• Permanent nursery for large scale production equipped adequate facilities to produce many seedlings. • Managed directly by TFD. • Size: minimum: 1.5 ha • Production capacity: larger than 500,000 seedlings
Decentralized People's Nursery	• To produce seedlings to establish plantations in remote areas where transportation of seedlingsis costly and difficult • To contribute to livelihood of villagers • To train local people to manage nursery	• Established near plantation sites with small scale as a temporary setting. • Managed byJFMC (or SHG under the JFMC) under supervision of TFD (Beat Officer). • Size: approx. 0.25 ha • Production capacity: approximately 20,000 seedlings

Table: Typical nursery infrastructureby type

No	Facility	High Tech Nursery	Central Nursery	Decentralized People's Nursery
1	Nursery bed	Permanent	Permanent	Temporary
2	Superstructure (iron frame)	✓	✓	-
3	Manure mixing space	✓	✓	✓
4	Hardening chamber	✓	✓	-
5	Overhead water tank	✓	✓	-
6	RCC/brick road	✓	✓	-
7	Labor shed	✓	✓	-
8	Storage room	✓	✓	-

9	Drying shed	✓	✓	✓
10	Vermi compost	✓	-	-
11	Seed germination unit (mother beds)	✓	✓	✓
12	Office room	✓	✓	-
13	Visitors shed	✓	✓	-
14	Fencing	✓	✓	✓
15	Mist chamber/poly house	✓	✓	-
16	Deep tube well with pipeline, submersible pump & sprinkler	✓	✓	-
17	Seed testing laboratory	✓	-	-

3. Nursery site selection

The selection of an appropriate nursery site is an important decision for efficient production of good quality plants. It must start from well-defined objectives of the nursery, which include the followings:

- Number of plants to be produced each year
- Species to be selected
- Type and size of plants
- Location of the plantations and villages where plants are supplied
- Expected life of the nursery

In order to have a central nursery with better management, the nursery should be located as much as possible in a flat land, near water perennial sources.

The ideal nursery location should fulfil the following requirements:

- Land availability
- Good permanent water supply or piped water system.
- Good drainage with gentle slope
- Easy accessibility with road communication
- Good supply of suitable soil materials
- No chance of flooding
- Not prone to erosion

<u>Availability of Land</u>

It is important that the site selected for the nursery has enough land to raise the number of seedlings needed, and if possible, scope for expansion. A small nursery raising 20,000 plants in 4 by 6 size pots, and keeping the plants in a nursery for a year could require about 500m^2 of land; this includes potting beds, 20 per cent extra for losses and damage, paths between the beds, soil storage, thatched shelter, and the compost-making area. But for sloping sites the land requirement may be double the size, that is,

$1000m^2$. The size of the nursery depends on the number of plants to be produced, the time they will remain in the nursery, as well as the quantity and slope aspect of the site. The size of the area must be large enough to accommodate any possible expansion of the nursery.

The land should be owned by TFD. If it is institutional or privately owned land it is important to formalize the use ofthe land by obtaining a letter from the owner agreeing to its use as a tree nursery for a defined period of time.

Water supply

A reliable and adequate water supply is always a requisite in nursery establishment. The nursery site should be located near the source of water either from a running stream or main pipe water supply to sustain rapid and healthy growth of the seedlings. The ideal situation is where there is a perennial stream at a higher level than the nursery, and fairly close to it, so that water can be diverted from the stream to the nursery throughHDPE pipes(which should be buried 15cm deep). Alternatively, a water storage tank should be installed for sustainable water supply with micro-irrigation facilities.

Topography and aspects of slope

The area for tree nursery establishment is preferably flat with a gentle slope to allow for drainage. Contour terracing should be done if the slope is in excess of 2 per cent. Try to locate the Nursery on the Northern, Western aspects of a Hill slope; try to avoid Southern Aspects on hill slope because of too much sunshine and heat. The nursery beds must not be allowed to become dry after the seeds are sown. The nursery beds should be well drained, and there should be no stagnancy of water.

Location close to plantation site/available access roads

The nursery site should be located near the planting site to minimize injury in handling and during transportation. It must be easily accessible to facilitate nursery field operations and supervision. Access roads should be usable during all seasons of the year.

Labour availability

A lot of labour is required for the construction of a nursery and subsequent nursery activities. Hence, nurseries should be located where labour is available. Establishing a nursery on a main trail near a village will also increase awareness and enhance patronage.

Soil Availability

Deep, good-structured, easily pulverized soil is desirable. Avoid shallow soils with a hard sandstone band near the surface. A very sandy-structured soil should also be avoided because of poor moisture retention characteristics and faster leaching of plant nutrients. Soil containing too much clay has poor drainage characteristics and should not be considered in site selection.

Sandy soil is required for Bamboo rhizome preservation technique so that fine roots of the rhizomes not get damaged.

4. Nursery design and construction

4.1 Nursery design and infrastructure

A nursery design varies according to the objective such as type of plants to be raised, topography of the land, etc. Before the construction begins, draw a sketch plan. Measurements should preferably be made with a tape. In order to have comfortable environment for labour, labour shed, drinking water facilities and toilets should be constructed. The typical infrastructure of nursery includes followings.

Basic facilities:

- Entry gate
- Internal paths
- Fence or wall
- Office room
- Storage room
- Labour shed
- Vehicle shed
- Drinking water facility
- Toilet

Infrastructures to produce seedlings:

- Mother beds
- Seedbeds
- Poly house
- Hardening shed
- Drying shed
- Water tanks
- Water distribution system
- Drainage system
- Soil storage shelter
- Compost-making area
- Seed treatment pit
- Research area(Room)

Nursery Layout example

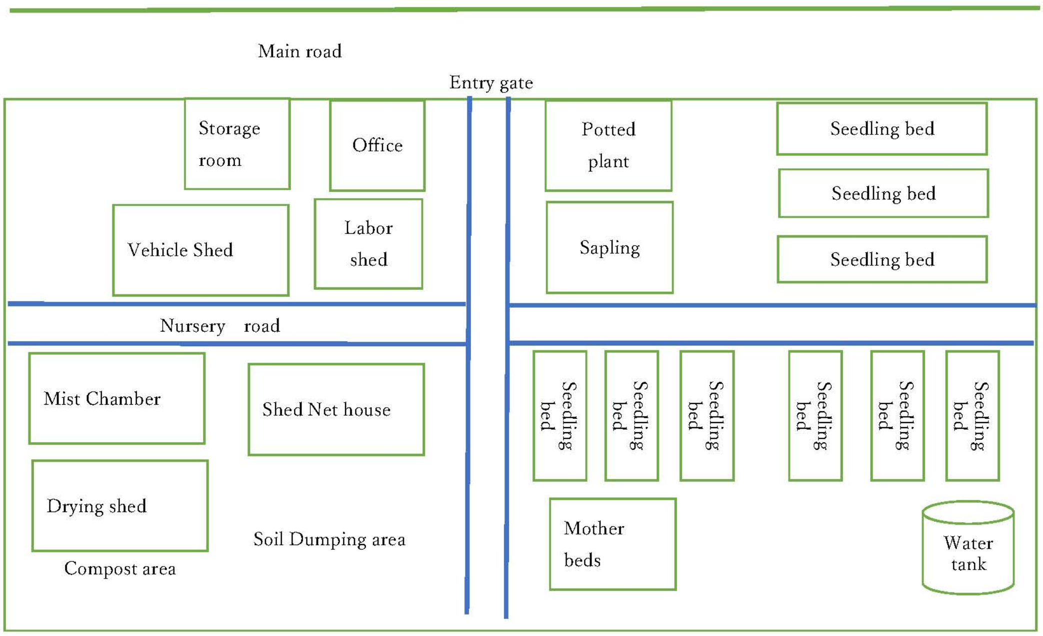


Figure: Example of Nursery layout at Padmabil Central Nursery

Tipsfor designing nurserylayout

- Soil dumping area should be accessible by vehicle and close to mixing shed and seedling bed if topography allows.
- Water tank should be on the highest elevation area and close to centre of nursery if topography allows.
- Water distribution system should be close to water tank.
- Poly house is closed to office to pay attention easily.
- Mixing shed should be accessible by vehicle and better to be centre of nursery because of transporting soils.

4.2 Construction

A. Land preparation

The new nursery site must first be cleared of all rocks, stumps, trees and shrubs. It should be clearedfrom all vegetation's. The jungle clearance may be done during winter to early spring season preferably before weeds ripen their fruits so that weeds may be eliminated from the Nursery beds. It is desirable to plough or hoe the soil in the winter and allow it to weather for some time. The Nursery beds may be raised if the area is plain to ensure good drainage, in hill sides it may be a little sunken to conserve moisture during heavy rain.There is possibility of it getting flooded if drainage is not made.

B. Fence or wall

It is necessary that all animals are totally excluded from the nursery, so a fence or wall must be built. A brick wall 1.8m high is ideal. It should be about 60cm below ground and 120cm above, when measured from the outside, and with a layer of thorny shrubs on top of it. A brick wall is effective and long lasting.

C. Nursery beds and other structures

Ideal size of the nursery bed is 1m to 1.2m wide. It should not be wider than 1.2m because of the difficulty of reaching the centre when weeding, watering or manuring. Seedbeds which are narrower than 1m are a waste of land. The typical length of the bed is 5m to 10m due to drainage purposes. If possible, the beds should be oriented from east to west to provide better shade against the midday sun. Paths should be 50cm to 60cm wide to provide adequate working space. When the area for the beds has been leveled, protect the corners and the edges.

Nursery beds can be temporal or permanent. Permanent beds are made on the concrete floor. Advantage of having a concrete floor is to avoid root growing to the ground. However, when the concrete floor is heated and the temperature of nursery is raised, the growth of root is negatively affected.

The ploughed soil can be organized into beds of 1 metre wide, 15 cm high, 6- 10 metres long, or as long as the topography would allow. The soil in the nursery should be worked into a compact, smooth, and fine textured consistency.

A waterproof soil storage shelter is needed to store the potting mixture and to provide working space. A large working shed as well as an office space is also required.

5. Production of planting materials

5.1 Preparation of seeds

A. Seed collection

Seed collection aims to obtain a large amount of seeds with good quality with low cost. A nursery manager needs to decide amount of seed necessary based on the size of planned plantation area, and make seed procurement plan. As for native species, TFD should collect seeds as many as possible from the good forest stock. Good forest stands, seed sources of major forest species should be surveyed and recorded for selection of candidate plus trees for seed collections.If collected seeds are not sufficient, the seeds can be purchased from certified seed centers.

B. Seed collection and storage

Timing of flowering and fruiting of major forest species should be surveyed and recorded in order to plan seed collection.

C. Seed collection method

There are two ways to collect seeds depending upon species; ground collection of natural seed fall and direct collection from standing trees. The former ones (trees to collect seeds from ground) has a fruit with more water contents which drops right after it gets matured. All the collected seeds should be recorded.For direct collection seeds from standing trees, identification of mother tree (candidate plus trees) is needed.

D. Seed testing

Seed testing isused for control of quality parameters during seed handling. Standard parameters such as seed weight, purity, and germination or viability enters as factors in the calculation of seed demand for nursery sowing. Seed is sold on a weight basis; these seed quality parameters are essential and economical for nursery management.Quality tests need to be carried out at intervals from harvest until the seeds leave storage to be sown in the nursery (Yue-Luan, 1993). Most tests are simple non-standardized tests serving as practical guidelines during daily seed handling and nursery practice. Such 'simple tests' range from simple cutting tests which are little more than observations and moisture content tests using calibrated field moisture meters.

Sampling of seeds:

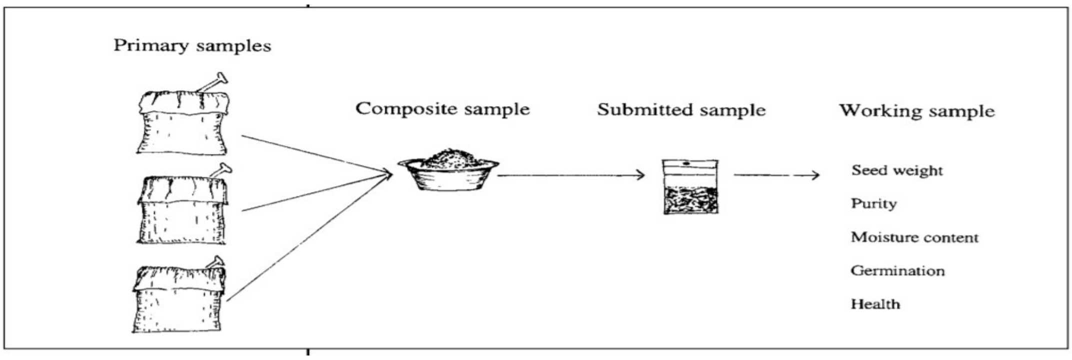
Sampling is very important for both simple and advanced testing. In the case of standard testing, drawing of samples from seed lots and forwarding them for testing by authorized HTN seed testing laboratories (Bhodthipuks*et al.* 1996) are necessary. Whether a sample is to be submitted for standard testing or is used for more simple tests, it must comply with the basic rule of being representative of the whole seed lot in any aspect to be tested. A sample should thus have the same average seed size, moisture content, viability etc. as the whole seed lot. The higher the degree to which a sample is representative of the seed lot from which it was taken, the better is the test results can be valid for the whole lot.

Drawing of samples:

In principle, there are two ways of drawing test samples: (1) by subsequent divisions after mixing, and, (2) by triers taking out samples from different parts of the seed lot and then mixing them into a larger sample.

Reduction of sample size for testing:

Several terms apply to the different types of samples during the sampling process: a primary sample is a small quantity of seed taken out from a single position in the seed lot, e.g. by the help of a trier. When a number of primary samples taken from different parts of the lot are bulked, and then make up a composite sample. Usually this sample is several times larger than the sample actually needed for testing. The quantity of seeds submitted for standard test is called the submitted sample. This sample is further reduced in the HTN laboratory to a working sample according to the quantity required for the individual test (ISTA, 1998).



(*Source: 'Guide to Handling of Tropical and Subtropical Forest Seed' by Lars Schmidt, Danida Forest Seed Centre. 2000*)

Figure: Procedure of sampling. Primary samples are drawn from the seed lot and mixed into a composite sample. The composite sample is reduced to a submitted sample to be forwarded to the seed laboratory for testing. In the seed laboratory working samples are drawn for the individual test. The same working sample may be used for more than one test if the test is not destructive e.g. purity test → germination or moisture content

Seed testing is an analysis of some physical parameters and the physiological quality of a seed lot, based on a small representative sample. The 'quality' (here strictly referring to physiological quality, in contrast to the genetic quality) is the measure of potential performance of a seed lot under optimal conditions. Seed testing includes a number of parameters such as seed weight, purity, viability, germination and moisture content, each with its own test procedure as will be defined and outlined below.

Table: Seed testing during the period of seed handling.

	Harvest	Processing	Before storage	During storage
Simple Test	Maturity, health (cutting test) Moisture content (moisture meter)	Health (cutting test) Moisture content (moisture meter) Purity (screening)		
Standard Test			Seed weight, Purity Moisture content (oven method) Viability/germination (TTZ, X-ray, germination etc.)	Viability/germination ability/ Moisture content

Simple seed testing:

Whenseeds are to be sown locally and immediately after collection or processing, expensive testing rarely make sense (Yue-Luan, 1993). Yet, information on seed quality is still very useful for nursery operation. Further, regular simple tests often serve as a valid guideline during seed handling. Simple tests do not follow the strict conditions prescribed for standard testing. Simple tests often suffice when information is only required for an individual seed lot, e.g. to determine the need for further cleaning or drying, or to state the physiological quality. Simple testing encompasses the same parameters as those used in standard tests such as:

Seed weight:

Number of seeds and their weight must be known to calculate number of seeds per kg. An electric digitalscale (Sensitivity: 1 to 50 gm) is preferred. If scale balance is not available use digital balance for weighing seeds. There are two methods:

i. Put a known number of seeds on one side of the balance and weights on the other until it balances.

ii. Put a known weight on one side and add seeds on the other until it balance.

Count the seeds and calculate seed weight:

Purity:

Nursery managers are interested in knowing the fraction of pure seed, not the composition of other matter. Therefore, weigh a sample of seeds with impurities, then separate the two fractions and weigh one of them.

i. Pour the sample into one bowl of the balance against a known weight e.g. 250 g. Remove all the entire pure seeds manually with tweezers. Throw the impurities out and weigh the seed fraction.

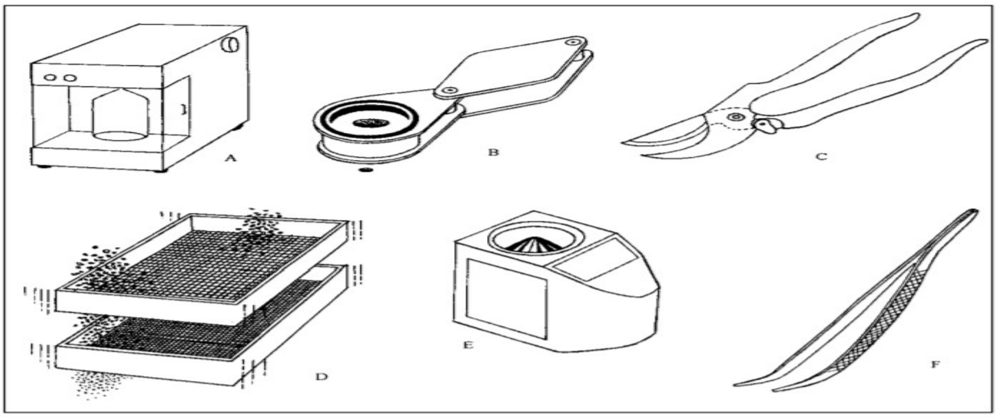
ii. As above but sorting is done by spreading the sample on a table cloth or the like. Impurities may also be removed by blowing, sifting or letting the seeds roll down a slanting cloth frame. However, care should be taken during sorting not to lose 'pure seeds' because the sample is small.

Moisture content:

Quick measurement of moisture content may be carried out with the aid of a digital moisture meter or by Microwave drying. Microwave drying is a quick method of moisture measurement for large seeds for which moisture meters are less applicable. The seeds are cut into small pieces before drying in the micro-oven for 5-6 minutes (Bonner *et al.* 1994). The sample is weighed before and after drying and moisture content calculated as after the oven drying method.

Germination and viability:

The simplest viability test is the cutting test. Seeds are cut longitudinally through the embryo. For some seeds soaking in water facilitates cutting. Seeds with firm, white or light green, healthy looking embryo are deemed viable (Bonner *et al.* 1994). It can be carried out at ambient temperature and does not require sophisticated laboratory equipment. Germination trials in nursery plots give valuable information on germination under field conditions and are often the only method for recalcitrant seed. Seedbeds or pots are prepared as during normal nursery operation. Where dormancy is known or suspected, appropriate pretreatment should be carried out prior to sowing. It is advisable to sow the seeds in a design that permits easy counting of germinants.



(*Source: 'Guide to Handling of Tropical and Subtropical Forest Seed' by Lars Schmidt, Danida Forest Seed Centre. 2000*)

Figure: Equipments needed for simple seed testing: A. Balance, B. Magnifying lense, C. Secateurs, D. Screen, E. Moisture meter and F. Teezers.

Standard seed testing parameter:

Generally, standard seed testing is carried out whenever seeds are to be stored for a prolonged period, or whenever seeds are to be traded by authorized seed suppliers.

Weight:

Seed orders are given by weight, seedlings planted by numbers. Seed weight is therefore, together with purity and germination percentage, important when calculating seed demand for a given planting programme. Further, seed size may be correlated with vigour and hence be an indirect measure of potential performance. There are two ways of indicating seed weight: either in number of seeds per kg (or for small seeds occasionally per 100 grams), or in weight in grams for 1,000 seeds. The figure can easily be transformed to number of pure seeds per kg.

Examples: a. 1,000-seed weight of *Eucalyptus camaldulensis* is 1.5g. Number of seeds per kg is: 1000seeds/1.5g x 1000 g = 666,000 seeds. b. *Pinuscaribaea* contains 3500 pure seeds per kg. 1,000-seed weight is: 1000g/3.5 = 285 g. Seed weight is usually calculated on replications of samples of 100 seeds. For very large seeds, calculation is conveniently based on a smaller number. In official seed analysis, variance analyses are carried out based on several replicates of 100 seeds. The figure expresses the variation in seed weight within the sample.

Purity:

Purity of a seed lot indicates in percentage how large a fraction is made up of pure seeds of the species in question, and how much is made up of inert matter and other seeds. Impurities may be any non-seed material (leaf, flower, fruit fractions, soil, etc.), small fractions of seeds of the actual species, as well as seeds of other species (ISTA, 1996).

During purity analysis each 'pure seed' fraction (1-3) is separated from the working sample. Purity is expressed as the weight percentage of pure seed fraction over the total weight of the working sample:

Purity = [Weight of pure seed (g) x 100 ⁄ Total weight of working sample (g)]%.

Table: Example of fractions indicated in a purity test of seed.

	Weight	Percentage
Working sample	60 g	100 %
Pure seed	54 g	90 %
Other seed	1 g	1.7 %
Inert matter	5 g	8.3 %

Moisture Content:

Moisture content (M.C.) is crucial in connection with storage and longevity. Since moisture content of seeds tends to vary with atmospheric humidity, it is important that exposure to varying humidity is minimized before testing. Therefore, seeds should be packed in waterproof material as quickly as possible after sampling.Seed moisture is measured by the ovendrying method, which is the direct method, prescribed by ISTA (1996) and described below:

i. Container (heat resistant) including cover is weighed (M1).

ii. Seeds are ground or cut into smaller fractions before drying to assure that moisture can escape from the interior.

iii. The seeds are placed in the container and weighed together with the container (M2).

iv. Seeds are placed in an oven at 103 +/- 3°C for 17 +/- 1 hour.

v. After drying, the seeds are placed in a desiccation chamber while cooling (to avoid reabsorption of moisture from the atmosphere).

vi. After cooling, the seeds plus container are weighed again (M3).

The moisture content (fresh weight basis) = [(M2-M3) x 100 ⁄ (M2-M1)]%

Viability and germination test:

A high germination percentage is obviously desirable for the nursery management; anything other than pure germinable seed is waste. Germination potential is most directly determined in a germination test: under the appropriate conditions everything that can germinate should germinate. Germination tests are widely used in both standard seed testing and more informal simple nursery tests. However, the tests have several limitations, some of which may either over-estimate or under-estimate the actual germination potential of a seed lot. Three situations where germination tests are less applicable are the following:

i. Where seeds have a very short viability. Duration of a germination test is typically 3-5 weeks. For short-lived recalcitrant seed significant loss of viability may take place during the test period. Hence, the germination percentage obtained by the test may not be valid for the seed lot from which it was taken because the viability of the seed lot has declined during the test period.

ii. Where germination is delayed or suppressed by deep dormancy. If pretreatment has been insufficient to overcome dormancy, germination may be low even if seeds are viable.

iii. Where fast test results are required. Especially for slow germinating species (some species take several months to germinate) the duration of a germination test may be inconvenient. Where a seed lot is to be dispatched soon after collection, there is often not enough time for a germination test.

Several types of viability tests are available. The most common ones are cutting test, tetrazolium, X-ray, excised embryo, and hydrogen peroxide test, which are described below. Of these methods only tetrazolium, hydrogen peroxide and excised embryo tests actually prove a life manifestation, in the first case as the activity of a metabolic enzyme complex, in the latter as a directly observable embryo development. It should be emphasized that all types of viability test are subject to some subjectivity in the interpretation of results.

Cutting test:

Cutting tests are never used as the sole viability test in standard testing, but rather to examine the conditions of non-germinated seeds in a germination test. The method is, however, widely used in simple seed testing, both during collection and processing. In a cutting test, viable and dead seeds are distinguished visually, which in practice means that seeds that are empty, insect-damaged, under-developed or showing other distinct signs of damage are deemed non-viable, and the remaining portion viable.

Tetrazolium test:

The Tetrazolium (TZ) test is the most widely adopted biochemical method to examine seed viability. The method is also called Topographical Tetrazolium test (TTZ) to emphasize that specific areas of the seed are examined rather than just general evidence of viability (Enescu, 1991). TZ test is especially useful as an alternative to germination test for species that require long periods of pretreatment to overcome dormancy (e.g. several temperate species), but the test is also widely used as a quick test for species with less complex dormancy. Although the method is in principle applicable to all seed types, interpretation of results becomes extremely difficult for very small seeds.

The principle of TZ test is as follows: dehydrogenases are a group of metabolic enzymes in living cells. During the reduction processes in the metabolically active cells dehydrogenases release hydrogen. The hydrogen is able to reduce an applied pale yellow solution of 2,3,5-triphenyl tetrazolium chloride or bromide (TZ) to a stable, bright red triphenylformazan. Hence, the formation of red formazan is an indication of dehydrogenase activity, which is in turn an indication of viability. Because staining of tissue is local, it is possible to distinguish living (red-coloured) and dead (colourless) parts of the seed. Where dead (necrotic) tissue occurs only superficially in cotyledons, while the radicle stains normally, the seeds may still be viable. On the other hand, even small patches of necrotic tissue in the vital part of the embryo normally mean that the seed wouldnot be able to germinate. The exact evaluation of these partly stained seeds requires a fair amount of experience.

Seed embryos are likely to stain whether they are dormant or not, and damaged but not necrotic tissue may stain normally. Therefore, the result of the TZ test is likely to include the three classes in the germination test: normal seedlings, abnormal seedlings, and live but not germinated seeds (including hard seeds) (ISTA, 1998).

X-radiography:

X-radiography is a quick test to differentiate empty, under-developed, insect or physically damaged seeds from morphologically intact and healthy seeds by the aid of X-rays (ISTA, 1996). X-rays are electromagnetic waves with wavelengths of 0.05-100Å (visible light approx. 4000 - 8000 Å). The seeds are placed between the X-ray source and a photosensitive film or paper. When the seeds are exposed to X-rays of low energy (longer wavelength, approx. 1 nanometer), an image (radiograph) is created on the film/paper. Photographic processing converts the radiograph into a visible picture. Since X-rays are nondestructive, seeds examined by the X-radiographic method may also be used in direct germination tests.

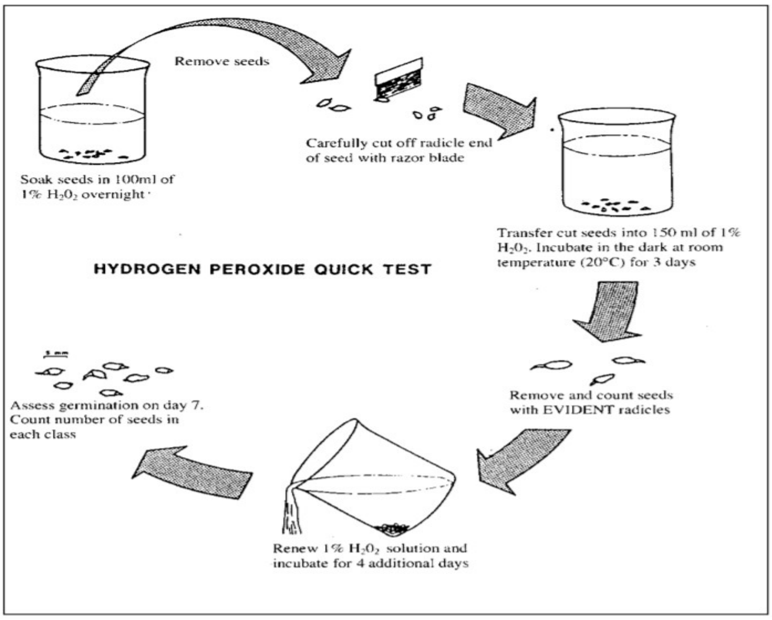
X-radiography is especially useful for estimating viability of recalcitrant seeds because they are short-lived and their germination potential has to be determined quickly (Saelim*et al.* 1996). Application of specific contrast chemicals e.g. BaCl2, AgNO3, NaI, or KBr to the seed before X-ray enhances the possibility of evaluating viability of tissue. Because these chemicals stain differently in live and dead tissue, the X-ray contrast (XC) method gives a different image of live and dead seed (or seed tissue) similar to the TZ test (Saelim*et al.* 1996).

Excised embryo test:

This method is used where seeds germinate very slowly or where the seeds are deeply dormant and require long pretreatment. It may also be used where the nature of dormancy and hence pretreatment is not known. The principle of the test is that the embryo is manually excised from the seed-coat and possible endosperm under aseptic conditions, placed on filter or blotting paper and incubated in germination cabinets at 20-25°C. The result of the excised embryo test is germination percentage under incubation. It should be noticed that in order to be statistically valid, also seeds with damaged, deformed, discoloured or lacking embryos must be included in the final calculation (ISTA, 1996). Because the embryo is surgically excised from the seed during the operation, it requires a certain minimum size of seed and embryo before it is practically possible. The method is thus not applicable to very small seeds. The excised embryo test is a transition form to a true germination test, since the embryos are evaluated on radicle development that is essentially an early germination event. However, the germination process is concluded before the seeds develop into seedlings that could be evaluated for normal growth, as is done during normal germination tests.

Hydrogen peroxide test:

This test is another viability test, which forms a transition to a germination test (Bhodthipuks*et al.* 1996). During the test, initial germination is evaluated after application of the chemical hydrogen peroxide (H_2O_2). The purpose of applying $H_2O_2$is to increase the supply of oxygen to speed up initiation of germination. Seeds to be tested are initially soaked in a 1% solution of the chemical for 8-12 hours. They then have a small piece of their seed-coat removed at the radicle end and are incubated for a period of about 7 days. The solution is changed after about 3 days. Incubation is conducted under dark conditions as the chemical is very light sensitive. Seeds are considered viable when radicles emerge from the cut end.



(*Source: Laedem, 1984*).

Figure: Procedure for hydrogen peroxide viability test.

Germination test:

During germination tests, seed quality is measured directly as the ability of the seed to germinate under optimal germination conditions of temperature, moisture and light. It is anticipated that germination is not impeded or delayed by possible dormancy. Therefore seeds should be pretreated before a germination test (ISTA, 1996). Germination is normally carried out in germination cabinets under controlled environment. The conditions prescribed by ISTA include the following variables:

i. temperature (level and regime, e.g. constant day and night or fluctuating)

ii. light (+/- light or period of day/night cycles)

iii. substrate (sand (S), top of sand (TS), top of paper (TP), between paper (BT) and pleated paper (PP).

Germinated seeds are counted regularly during the prescribed germination period from the indicated 'first count' to 'final count'. Counting once per week is usually sufficient, but species with rapid germination may be counted and removed every two days. Removal of germinants is done in order to facilitate subsequent countings and to avoid possible fungal spread. Both 'normal' and 'abnormal' germinants are counted, registered and removed during the period. At the end of the period all ungerminated seeds are examined. The final test result is grouped into the following classes:

i. Normal germinants: The cumulative number of seeds which have developed into seedlings of normal and healthy appearance with all essential structures of a seedling. This also includes seedlings where possible damage is caused by secondary infection.

ii. Abnormal germinants: The cumulative number of seeds which have germinated during the test period but in which the seedlings show abnormal or unhealthy appearance e.g. lacking essential structures such as cotyledons, or being discoloured or infected by seed-borne pathogens (primary infection).

iii. Ungerminated seeds: Seeds which have not germinated by the end of the test period. These are grouped into the following sub-classes:

a. Hard seeds, which are seeds that remain hard because they have not imbibed (normally because of insufficient pretreatment).

b. Fresh seeds, which are seeds that have not germinated although they appear firm and healthy.

c. Dead seeds, which are seeds that are soft, or showing other signs of decomposition.

d. Other seeds, e.g. empty seeds.

Category a. and b. may be germinable but dormant. Their correct status may be further determined by viability test. If the number of viable but not germinated seeds is high, a new germination test following new pretreatment may be appropriate.

E.Seed treatment:

Seed collected should be inspected and treated before sowing in order to have a better germination. A common way to treat seeds is to soak the seeds for 24 hours and reject the floating ones which are considered to be empty with poor germination vigour. There are various pre-sowing seed treatment methods. The effectiveness depends upon species to species. Other seed treatment method includes followings.

- Bio-fungicide treatment: mixing with 6 - 10 g of *Trichoderma viride* powder per kg of **seed** before sowing. In case of *Pseudomonas fluorescens*, mixing with 10g/kg of **seed** and soak in 1lit of water for overnight before sowing.
- *Albizziafalcataria*: seeds need to be boiled in hot water at 90ºC for two minutes or soaked in normal water for 24-48 hours before sowing.
- Teak: Alternate wetting and drying of seeds for 6 to 7 days is needed to break the dormancy before sowing.

F.Seed storage:

Seed storage aims to preserve seeds to maintain the germination capacity, protect seeds from damage by insect, birds, rodents, and preserve quantity of seed for the year when limited seeds are available. There is a great variation among species regarding retaining viability under natural conditions.Some seeds can be stored long time under dry condition (orthodox seeds), but some seeds can last only a short time and die when they become dry (recalcitrant seeds). Temperature of seed storage (recalcitrant seeds which are tolerant under dry conditions) should be kept about freezing point (zero degree). Many tropical rainforest species lose viability under dry (moisture <35%) or low temperature conditions (lower than 10 degree).

Tips for species selection for plantation and nursery

- Some important species do not seed every year. Plantations of these species can be raised annually only by collecting all available seed in years of moderate and good seed years and sowing it in nursery to raise seedlings to be planted out in various years.
- Some species grow very slowly and if the seed sown directly in plantation that can be damaged and killed due to the competition of weeds. So, the slow growing species are generally raised in nursery and planted out only when the seedlings are not liable to be damaged by weeds.
- Success of roadside avenue plantations depends largely on planting tall and sturdy plants which can only be obtained from a nursery.
- Seedling production at nursery is very essential to introduce exotic species (e.g. Tropical Pines, Poplars, Eucalyptus) since planting is the only way.
- For barren site and poor regenerating area planting of nursery grown plants is the only method of artificial regeneration.
- There is a wide scope for fruit orchards, ornamental, vegetable, and landscape gardens at public places, highways and co-operative housing societies.
- Nursery provides employment opportunities for technical, skilled, semi-skilled, unskilled Labour.

5.2 Preparation of soil

During the dry season, dry fine textured consistentsoil may be prepared. Collect topsoil, break clods, remove foreign materials, and mixsoil with sand and farm yard manure (FYM) if required. Generally,soil can be mixed with 1(soil):1(sand):1(manure).

5.3 Preparation of mother beds

Prepare mother beds including breaking clods, removing foreign materials, mixing sand with decomposed cow dung/ compost, and sow seeds and make watering.

5.4 Seed sowing

For small sized seeds, seeds may be sown evenly spread over the beds, and a thin layer of fine soil is spread evenly over the seeds. For bigger sized seeds, a small straight furrow across the length of the bed may be made in the beds with a light dibble or a wooden stick and the seeds sown in the furrows and covered up with soil.

Tips for soil preparation and seed sowing

- **Soil solarisation:** Solarisation is an effective and eco-friendly method of soil sterilization and it involves trapping of solar heat and energy through polythene covering. This raises the temperature to levels at which many soil-borne plant pathogens will be killed or greatly weakened.
- Seeds may be sown directly into the bags during the sowing season i.e. February-June. *Azotobacter/Rhizobium*(Nitrogen fixing bacteria) 4-5gm/poly bag and neem cake (organic manure) 5 gm/poly bag will yield good results.
- **How deep must the seeds be sown**? The Thumb Rule is to bury the seeds at the depth of the seeds' diameter.
- **Maintaining Moisture/Temperature of the Beds**: Moisture and temperature of the soil in the Nursery beds are very important factors for germination of the seeds. To achieve this, the beds may be covered with transparent polythene sheets with its end weighed down by small stones or clods of soil. This will prevent moisture loss through evaporation and increase the temperature of the nursery beds. It is more practical to expose the beds to the Sun to water the beds to maintain the correct moisture level in the nursery beds.
- **Timing of Sowing**: Seed sowing should be done according to season of the species in concern.
- **Pricking out seedlings in a Mother Bed**: To get quality sized seedling (thumb size), the seed may be sown broadcasting in the mother bed and when they have few leaves, some may be pricked out so that the remaining may be spaced at about 3-4 cm apart. The pricked out seedling may be planted in polybag nursery.
- **Fertility of the nursery**: For proper growth of the seedling, a fertile soil is desirable. However, when soil in the nursery is more fertile than the plantation site, the plants do not grow very well initially in the first year of the plantation. The first year growth of the seedlings determines the success or failure of the plantation. Therefore, raising of seedlings from normally fertile soil (not too fertile) would be best suited in the field condition.

5.5 Polybag filling and watering

Obtaining polybags:

The first thing to be done is to collect polythene bags from the markets which are available in various sizes. The size of poly bag depends upon the size of seedlings. To prepare bigger size seedlings, bigger polythene bags are needed. Normally three sizes of polybags are used in Tripura:

Polybag size

i. 15 cm × 23cm size
ii. 20 cm × 30 cm size
iii. 23 cm × 55 cm size

Filling Polybag with soil

The polybags should be filled up fully to be able to fully receive water when watering. IT means poly bags are attending with open mouth fully. Soil must be compacted by holding the fully filled bag and dropping it to the ground from 30 cm above the ground without letting the soil spill out. If the soil settles at a level less than the mouth of the bag, more soil may be added to make the soil almost filling the bag fully (Photo 1). The sown poly bags should be preferably kept in shade and the soil not allowed to becoming dry.

Watering the plants

The seeds can be sown broadcast in a prepared nursery bed and watered regularly. Water should be sprayed in the beds preferably till root systems of the seedlings are well developed. Beds should be moist rather than wet. If beds are kept constantly moist, it may not require sheds. The seeds are allowed to be germinated and grow up to about 3-5 cm and then pricked out and planted in the poly bags and grown till it is fit for plantation in the field.
In order to prevent the rooting of seedlings to grow through the poly bags into the soil, either making permanent beds with concrete (or compacted soil) floor or spreading a poly sheet below the poly bags should be done. This will also reduce the weed growth.

Nursery practice work steps:

1) Setting up nursery beds

- Plough the area when there is enough moisture.
- Cultivate the land thoroughly to produce fine soil tilt and to kill existing and germinating weed seeds.
- Establish straight lines indicating planting points at a distance of plants.
- Make small holes using a dibble stick enough to accommodate the germinated seeds.

2) Filling up polybags for nursery

- Clean the area and remove all plant debris, weeds and other unwanted plants.
- Prepare polybags from the polybag sheet roll or buy the preferred size.
- Fill the perforated bags with loamy soil (compost, fine sand, top soil in a ratio of 1:1:1) or forest soil, collected from the top layer below the litter layer.
- Arrange the polybags in single rows.
- Fence the perimeters properly to ensure safety of the plants against stray animals or intruders.

3) Planting of germinated seeds

- Carefully plant the germinated seeds in each hole for ground nursery or each bag for the polybag nursery with the radicles pointing downward.
- Cover the entire root system including the cotyledon with fine soil. Press the soil lightly to compact it around the plant.

• Water the plant as often as necessary during the dry season.

4) Weeding

• Remove the weeds by hand, with monthly intervals. Reduce the frequency of weeding as the plants grow older.

• Spray herbicides made of 2,4-Dichlorophenoxy acetic acid or Gyphosate (This chemical herbicides in India permitted only for Tea and non-crop areas in India)(Herbicide use in Indian agriculture, ICAR, Information Bulletin No. 22)between rows taking care not to spray other green parts of the plants.

5) Disease control

• Monitor and check the occurrence of the diseases.

• Identify the symptoms and control measures.

• Make the solution as prescribed.

• Spray the solutions using Knapsack sprayer early in the morning or in the evening.

6) Hardening off

• Reduce the frequency and quantity of watering.

• Expose plants to full sunlight as soon as possible.

• Cut off fertilizer applications, if applied before.

• Start hardening off much before shipping out the plant.

5.6Weed control

Weed control in the nursery aims to minimize competition from weeds for light, water and nutrients. Nursery can be weeded only when the root system of the seedlings has established properly. Leaves of the mature seedlings may be plucked off to distribute sunlight to other smaller seedlings, so that all seedlings attain equal size.

At the time of preparing nursery sites, the plant debris should be burnt thoroughlyto increase the nutrient level in the soil.

5.7 Pest and Disease control

Making nursery hygiene

Many diseases attack plants in nursery. Diseased seedlings grow slowly. Plants may die under severe infections. Most of the micro-organisms, insects and pests that cause diseases in the nursery live in weeds, trash and puddles. Therefore, keeping a nursery neat and clean reduces the chances of attack of common diseases. All trash, waste, polythene bags and diseased plants should be immediately removed and burnt keeping away from the nursery.

Symptoms of disease are varied. Common symptoms include: root-wilting, withering of plant without any apparent damage of shoots or leaves, shoot-cut either near ground or up, cutting of leaves smoothly or irregularly and other symptoms including pox like marks, many punctures, rasped and distorted leaves, blotching of leaves, etc.Common solutions to apply are varied depending upon the symptom.

Symptoms	Control measures
Decay of seedling with blackening of collar portion.	Mancozeb (0.25%) or Chlorothalonil (0.2%). Malathion 0.1% (Permitted in India as per Insecticides Act, 1968)
Black spots and yellow patches on leaves. White growth around, black/brown spots on the underside of leaves.	Bordeaux mixture 1%@560lts/ha of nursery soil. Preparation of Bordeaux mixture 1%: Copper Sulphate:2kg+Quicklime:2kg+ Sugar:60 gm and all these are added to 225 ltr of water.
Insect pest	Crude oil emulsion: add 1 lt diesel and 350gm of crude vegetable soap (sliced) added in 3liters of hot water and stir violently to make an emulsion with no free oil on the surface. Then add 12 liters of more water to it along with 25gm glue to make it adhesive.
Insect pest	Nicotine solution: Dry Tobacco leaves: 1.25 kg Crude soap: 400gm Water: 100 ltr Boil tobacco with soap in 10 ltr of water, and then add balance 90 ltr of water.

5.8 Natural insecticides using neem seeds

Make powder of 500gm dried neem seeds and soak overnight in 15 ltr of tap water. Sieve the solution twice and spray. Beside this, chilli powder and tobacco leaves powder can also be used. They generally take a little longer to repel or kill the insects; therefore, apply them as soon as the insect problem is discovered. The main advantage is that they are natural, hence safe and biodegradable.

Tips for applying natural insecticidessubstances:

- Proper doses should be prepared by carefully reading the label or guidelines.
- Always provide protective clothing, masks, gloves and goggles to the person spraying the pesticide.
- Never mix insecticides and fungicides together in the same sprayer.
- Never eat, drink or smoke while spraying.
- Never use pesticide containers to store other things.
- Extra pesticides should be disposed of by burying them in a hole far from rivers and wells.

5.9Hardening seedlings

In order to survive for seedlings in a harsh environment in the field, seedlings are exposed to the rough treatment called “Hardening”. The main treatment for hardening is the reduction of water with full exposure to sunlight withdrawing from the favourable conditions in order to make seedlings to be more tolerant under such conditions. The hardening treatment should begin well in advance of the timing of transporting out. It should be not later than a halfway through the life of the seedling in the nursery. The process to reduce the amount and frequency of watering depends upon the species and local climatic conditions; commonly reducing watering gradually to two or three applications per week.

Hardened seedlings have the several important characteristics of 1) firm, lignified stems, often brown in colour, 2) sturdy, well developed crowns with leaves extending over three quarters, 3) the length of the stem, and 4) vigorous, healthy, leathery leaves, compact rather than oversized and weak.

The practice of hardening off is often neglected leaving to the last week or two when the first rains have already started. As a result, the plants are never really hardened and often suffer a setback being intolerant against a dry condition. In order to avoid it, it is advisable to extend the growing time by sowing seeds two or three weeksearlier to maintain hardening period during that time plants grow slowerdue to the reduced watering.During the hardening period, the reaction of the plants must be carefully observed since the changes in the plant should take place gradually.

Shipping out the seedlings

A good amount of final watering should be given to the plants immediately before the shipping out from the nursery. The seedlings should not be lifted by the stem at this or any stage.

5.10Quality Controlfor shipping seedlings

In order to ensure good survival rates of the plants, only healthy, right sized and plants with balanced root and shoot ratio should be sent to plantation sites. At the time of lifting or packing for transport, all the plants which are not satisfactory to the condition should be rejected. Thin, dead and unhealthy seedlings have to be culled out. Only healthy seedlings have to be transplanted.Rejected plants should be burned. It is very important to realize that it is wasteful and expensive to improve them by repotting.

6. Planning and record keeping

6.1 Time of seed collection and sowing

One of the main constraints on nursery plans is the availability of seed. Each and every type of seed has different collecting seasons. The plan of seed collection is very essential. For every activity conducted, for instance, fruit or seed collection, sowing, seedlings transplanting; keep a record file, a signboard or tag placed in front of each bed or bag/ container with seeds, with the following information:

- Name of variety/type
- Place of seeds collection
- Date when seeds or nuts are harvested, if available or sowing
- Number of seeds are sown
- Seedbed number

6.2 Planning seed supplies

The quantity of seed required must be calculated, the sources identified, arrangements made for collection and the cost estimated.

- Prepare a table listing the number of healthy plants of acceptable size required at the planting site.
- In the absence of germination test results, assume that for every four seeds sown, only one healthy seedling will be produced; this means that the above number must be multiplied by 100/80 or 5/4.
- Find the number of seeds per gram.
- Calculate the weight of seeds to be sown in grams.

6.3 Nursery operation tools

Nursery calendars: A nursery calendar to help plan necessary actions and purchases of seed, supplies and equipment.

Plant development registers: A plant development register for collecting species-specific information about seed treatment, germination requirements and duration, plant development, special requirements for potting substrate, watering, shading or disease control.

Nursery inventory: A nursery inventory to keep track of the species and numbers of seedlings in different stages of development.

Records of nursery experiments: A record of on-going nursery experiments.

All four can be maintained in a Nursery Journal format (Annexure-I) designed for ease of data capture on to computer programs. Computerized systems have increased the flexibility of data collection and analysis, making it easy for a nursery manager to correlate the collected information to necessary actions rapidly.

These are needed for production management as well as for research. The significance of staff training, particularly in the use of pesticides, plant protection and general safety issues regarding nursery management is required.

7. Nursery calendar and estimated labour required

Nursery calendar shows all activities, their timing and required labour amount and materials needed. It forms the basis of the budget for planning. It can indicate when extra labour is needed and materials that cannot be obtained locally and must be ordered.

Polybag nurseries of Misc. species(1st year Creation and Maintenance)

Sl.no.	Work item	Timing of work	DL/1000
1.	Collection cost of seed	Seasonal	As per actual requirement
2.	Cleaning of site, preparation of primary nursery beds (Mother beds) of size 5m × 1.12m(5'× 4') including hoeing up to 30 cm depth, re-hoeing, breaking of clods, removal of roots and foreign materials, mixing sand and decomposed cow dung/compost including cost of cow dung/compost and preparation of beds and sowing of seeds and watering etc complete.	Seasonal	6
3.	Collection of top soil, breaking of clods, removal of foreign materials, mixing of soil, sand and farm yard manure proper filling up to mixed soil, 1(soil): 1(sand):1(manure) in poly bags including stacking of soil filled bags in row in secondary bed made with bamboo edging and cost of materials like bamboo, manure excluding the cost of poly bags. Filling of soil should be made properly so that there is no scope of stagnation of water in the top iv. 15cm × 23cm size v. 20cm × 30cm size vi. 23cm × 55cm size Providing polythene sheet over the bed to control weeding.	As and when required	30 70 168
4.	Pricking out a healthy seedling from the mother bed and transplanting in the poly bag and watering, etc. to be completed including vacancy filling.	As and when required	6
5.	Providing fixing temporary overhead shed with thatch and with bamboo posts complete during dry season. (Special type of overhead shed with agro-shed net, etc. of permanent or semi-permanent nature will be done separately and rate will be decided by SDFO with the approval of DFO).	October	3 per 10 bed
6.	Application of insecticides and fungicide including the cost of chemicals, etc.	As and when required	15
7.	4 times weeding including cleaning of nursery area with gap filling and restocking of vacant poly bags and 2 times shifting of poly bags.	As and when required	8
8.	Watering throughout the dry period as per necessity.	November - March	6

2nd year maintenance

Sl. no.	Work item	Timing of work	DL/1000
1.	4 times weeding including cleaning of nursery area with gap filling and restocking of vacant poly bags and 2 times shifting of poly bag	As and when required	3.5
2.	Vacancy filling including cost of seed		0.5
3.	Watering as and when required for 4 months in dry season		2
4.	Maintenance of overhead shed and fencing		1

Bamboo nursery

As bamboo flowers after long time intervals, the availability of seeds and seedlings as planting materials is uncertain. Therefore, the knowledge of different aspects of seed propagation and physiology is very limited. However we need to take the advantage of good seeding year of a bamboo species and raise seedling nurseries for establishing plantation.

A. By branch cutting(Mother bed)

Species: Bari, Barak, Mritinga, Pecha, Bom, Paura, Makal, Rupai, etc.

Specification of the mother bed: mother bed to be made with brick platform provided with vertical edging with 3-rows of bricks without cement mortar, the beds filled with clear river sand, each bed will be 15ft × 4ft in size.

No. of branch cutting per bed:1000 nos.

Sl. no.	Item details	Time of work	No. of man days
1.	Cleaning of site, dressing of the ground, spreading of 2-3 layers of sand(1-2 inch), on the dressed surface, laying of bricks for platform, (17'× 6'), vertical edging with 3 rows of bricks without cement and mortar filling with white river sand cleaned properly.	Feb.-Mar.	2.5
2.	Collection of river sand including carrying to the nurserysite, 58 cft/per bed.	Feb.-Mar.	-
3.	Cost of 1st class brick for brick platform of size 17'× 6' (306 nos.) and for vertical edging with 3 rows of brick(152 nos.) total 458 bricks per bed.	Feb.-Mar.	-
4.	Cost of 1000 branch cutting per bed including cost of bamboo.	Apr.-May	-
5.	Planting of 1000 branch cutting per bed.	Apr.-May	-
6.	Providing overhead shed by 50% agro-shed net-9.5 sqm.	Apr.-May	-
7.	Application of insecticides, fungicides including the cost of these chemicals and root hormones.	As and when required	-
8.	Watering as and when required per bed.	As and when	1

		required	
9.	Weeding per bed.	As and when required	0.5
10.	Providing bamboo fencing including maintenance per bed.	As and when required	1

Important note:

1. Bamboo nursery (mother bed) to be raised preferably where the facility for watering is available.

B. Culm cutting (Mother Bed)

Species: Paura, Bom,Dolu, Mritinga, Makal, Pecha, Rupai, Barak, Bari, etc.
Specification of mother bed: mother bed to be made with brick platform provided with vertical edging with 3-rows of bricks without cement mortar, the beds filled with clear river sand, each bed will be 15ft × 4ft in size.
Number of culms cutting per bed: 30 nos.

C. Seed Sowing(Mother Bed)

Only muli bamboo produces big fleshy onion like green colour seed of 7-50 gm weight. Life of bamboo seeds are short, 30-45days.

- Germination media should be either sandy loam or mixture of sand, soil and cow dung/ FYM 2:2:1, the germinating media should be moist and well drained in the bed.
- Most of the grain like seeds may dibble or broad cast in seed bed.
- The seed should be shown in lines, germinate in 3-4 days. As the muli seeds are big in size they should be sown 1 cm below the soil surface.
- Root and shoot desiccation is high if swollen portion of muli seed above the soil surface.
- When the narrow beak portion of muli seed is up the plumule(shoot) need to bend and move upright and may die before reaching above the soil surface.
- Therefore, muli seed should be placed under the soil surface either horizontally or vertically keeping the swollen portion up. This is the correct way for sowing the seeding of muli bamboo.

For success in bamboo seed germination there should be a proper seed bed. Temperature should maintain 25-35 degree Celsius and there should a partial overhead shed (shed net).

- It required regular watering and weeding from the seed bed.
- The seed bed and germinating seedlings required protection from grazing.
- Well ventilation is required.

Seedlings are to be transferred to the poly bags containing the FYM/ soil. Then poly bags are to be placed under partial shed till the outdoor planting.

NURSERY JOURNAL

Name of CN/HTN: ....

Location: ....

DMU:.. SDMU: ....

RMU: .... Beat: ....

Year of raising: .... Scheme/ Project: SCATFORM

Batch code (Each batch will have unique batch code. E.g. all polybag sown in January, 2020 in Kanchanpur under SCATFORM will have Batch code [ID]: SDNKCP20001):
MIS updation done: Yes/ No
Photograph Annex.: Yes/ No

Target: Species-wise (noted below). Layout plan: Annexed

Misc. (polybags)			Bamboo/Cane (polybags)		
Sl.No.	Species	Quantity	Sl. No.	Species	Quantity
	Total			**Total**	

Availability of infra-structures:

Permanent beds:............ Nos(New). Germination beds:..........Nos(New).

.... Nos (Old). ....Nos(Old).

Water facility: Overhead tank/ Sprinklers etc. Fencing:........ Yes/No

Permanent structure for shading: ……. Yes/No Sign boards: ……. Yes/No

Seed storage facility: ....Yes/No Road connectivity: …….Yes/No

A) Activities relating to Advance Actions:

i) Seed collections: **Expenditure incurred:**

Name of species	Date/ period of seed collection	Seed source/ Plus trees nos with location	Mode of seed collection Dept./Agency	Techniques applied for seed extraction from fruit		Quantity of clean seeds
				Traditional method	Special method	

ii) Germination beds: ....Nos Year/Period: ....

Expenditure incurred:

Name of species	Seed treatment (if any)	Date of seed sowing	Average time for germination	Germination percentage	Remarks

B) Filling of polybags: ....Nos Year: ....

Expenditure incurred:

Date /period of filling soil in polybags	Size of polybags	Soil compositions (Top forest soil/mixing cow dung/sand etc) with ratio	Type of beds Where polybags kept (permanent beds/field beds)	Observations Of inspecting Officers with date

C) Transplanting to polybag nursery (as noted below) Year:....................

Expenditure incurred:

Name of species	Date of transplanting to polybags & date of vacancy filling	Size of polybag	Survival percentage & average growth				Observation on Growth of seedlings by Inspecting officers (with date)
			After 1 month	After 3 month	After 6 month	Final Survival rate (after 9 month)	

D) Use of Insecticides/Pesticides/Fungicides etc.& reasons for mortality (if any).

Date of application	Periodical observations of RO/Fr.& reasons of mortality (if any)			

E) 1 year maintenance of nursery

Expenditure incurred:

Item of works	Period of work	Mode of execution of work (M.R/ Contract)	Observations/ remarks
1st weeding			
Vacancy filling			
2nd weeding			
3rd weeding			
4th weeding			
Watering			
Providing shade			
Application of insecticides, etc.			
Others works Fixing of signboard /Labels			

F). Achievement during the year

Misc. (polybags)			Bamboo (polybags)		
Sl.No.	Species	Quantity	Sl. No.	Species	Quantity
	Total			**Total**	

G) 2nd year maintenance of nursery:

Expenditure incurred:

Item of works	Period of work	Mode of execution of work (M.R/ Contract)	Observations/ remarks
1st weeding			
2nd weeding			
Watering			
Application of insecticides, etc.			
Others works Fixing of signboard /Labels			

H)Damages (if any) & Reasons thereof & action taken in case of damages.

Date	Extent of damages (if any)	Reasons	Action taken

I) Utilization Status:

Date	Challan No.	Species	No. of Polybags	Dispatch to whom	Enter in stock reg. page no.	Authority no.	Balance stock

Forest Seed Calendar- Tripura SCATFORM Project

SN	Species (Botanical name)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Acacia (*Acacia auriculiformis*)	90	90			90	90						
2	Agar (*Aquilariamalaccensis*)					7	7	7	7				
3	Aam (*Mangiferaindica*)					30	30						
4	Amalaki (*Phyllanthusemblica*)	90	90							90	90	90	90
5	Amra(*Spondiasmangifera*)					30	30						
6	Arjun (*Terminaliaarjuna*)	90	90	90	90	90	90			90	90	90	90
7	Awal (*Vitex*penduncularis)	30	30										
8	Bahera (*Terminaliabellirica*)	30	30							30	30	30	30
9	Bakul (*Mimusopselengi*)					60	60						
10	Bel (*Aeglemarmelos*)	30	30	30	30	30	30						
11	Black pepper (*Piper nigrum*)							180	180	180	180	180	180
12	Boroi (*Ziziphusmauritiana*)	90	90										
13	Bot (*Ficus* sp.)	60	60	60	60	60	60						
14	Bottle brush (*Callistemon* sp.)							365	365				
15	Chalta (*Dilleniaindica*)									30	30	30	30
16	Chamal (*Artocarpuschaplasha*)					15	15						
17	Champa (*Micheliachampaca*)					60	60						
18	Chatim (*Alstoniascholaris*)					60	60						
19	Darchini (*Cinnamomum* sp.)					30	30	30	30				
20	Dhup (*Canariumstricum*)					7	7	7	7				
21	Eucalyptus (*Eucalyptus globulus*)					30	30	30	30				
22	Gab (*Lagerstroemia pariviflora*)							30	30	30	30		
23	Gamar (*Gmelinaarborea*)					15	15						
24	Jarul (*Lagerstromiaspeciosa*)							60	60				
25	Garjan (*Dipterocarpusturbinatus*)					7	7						
26	Ghora neem (*Melia azedarach*)					30	30	30	30				
27	Golap jam (*Syzygiumnervosum*)							30	30				
28	Harboroi (*Polyalthialongifolia*)					30	30	30	30				
29	Hartaki (*Terminaliachebula*)							90	90	90	90		
30	Jalpai (*Elaocarpusprunifolia*)	60	60	60	60								
31	Jam (*Syzygiumcumini*)					30	30	30	30				
32	Jambura (*Citrus maxima*)							30	30	30	30		
33	Kadam (*Neolamarckiacadamba*)					30	30	30	30				
34	Kamranga (*Averrhoacarambola*)					30	30	30	30				
35	Kanaidinga (*Oroxylumindicum*)	60	60	60	60							60	60
36	Kanchan (*Bauhinia* sp.)							90	90	90	90		
37	Kathal (*Artocarpusheterophyllus*)					15	15	15	15				
38	Kau (Garciniagummi-gutta)					30	30	30	30				
39	Koroi (*Albiziaprocera*)	30	30	30	30								
40	Krishnachura (*Delonixregia*)			180	180	180	180						
41	Latkan (*Baccaurearamiflora*)					15	15	15	15				
42	Mahogany (*Swieteniamahagoni*)							15	15				
43	Menda (*Litseaglutinosa*)					30	30	30	30				
44	Monkata (*Randiadumetorum*)					90	90	90	90				
45	Nageshwar (*Mesuaferrea*)							30	30	30	30		
46	Neem (*Azadirachtaindica*)					30	30	30	30				
47	Neur (*Protiumserratum*)					60	60	60	60				
48	Palash (*Buteamonosperma*)					30	30						
49	Pichla (*Microcospaniculata*)							30	30				
50	Pongamia (*Millettiapinnata*)							30	30				
51	Rain tree (*Samaneasaman*)			90	90								
52	Raktakanchan (*Bauhinia purpurea*)			90	90	90	90						
53	Ramdala (*Duabangagrandiflora*)			30	30	30	30						
54	Rudraksha (*Elaeocarpusganitrus*)							90	90				
55	Sajna (*Moringaoleifera*)			30	30	30	30						
56	Sal (*Shorearobusta*)					5	5						
57	Simul (*Bombaxceiba*)	90	90	90	90								
58	Sitaashok (*Saracaasoca*)							15	15	15	15		
59	Sonal (*Cassia fistula*)			180	180								
60	Subabul (*Leucaenaleucocephala*)							60	60				
61	Suna (*Cassia senna*)					60	60						
62	Teak (*Tectonagrandi*)	90	90							90	90	90	90
63	Tekroi (*Flacourtiajangomas*)					60	60						
64	Tetul (*Tamarindusindica*)	30	30	30	30								
65	Udal (*Sterculiavillosa*)					30	30						
Key:	Viability (in days)->	180	>90 days		60	60 days		30	30 days		5	15 days or less	