Nursery Manual for Raising Forestry Species

Community Led Landscape Management Project

Meghalaya Basin
Management Agency (MBMA)

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THE NURSERY

INTRODUCTION

Nursery is the prerequisite for raising artificial plantations. The success or failure of plantation can be forecasted by inspecting the site of nursery, composition of planting stock and health of seedlings in the nursery. In the recent years the importance of nursery grown seedlings has grown immensely because of heavy requirements of seedlings both for supply to the public for planting under social forestry programmes and for massive afforestation programmes taken up by the Government. Whereas for a social forestry project it is the choice of species and location of nursery that matters much; for artificial plantation it is the capacity of the nursery that matters most for delivery of seedlings. The cost of raising plantations rises high if the production of seedlings is delayed, seedlings are undersized, malnourished or short of numbers. A well planned nursery with time frame operations, growing genetically improved plants, with abundant supply for field planting is, therefore always essential

Chapter -I
TREE NURSERY

Definition

Nursery is an area where seedlings are produced or seeds are sown and seedlings are raised for the purpose of planting out for afforestation or reforestation purposes. Comprises of nursery beds, paths, irrigation channel etc. ***Nursery bed is defined as 'a prepared area in a nursery where seed is sown or into which transplants or cutting are put***'. On the basis of plants growing in them, nursery beds are classified into seedling beds and transplant beds. Seedling beds are those nursery beds in which seedlings are raised either for transplanting in other beds or for planting out. ***A nursery which has only nursery beds, i.e., in which only seedlings are raised, no transplanting being done is called seedling nursery***. Transplants beds are those nursery beds in which seedlings raised in seedling beds are transplanted before planting out in forest. ***A nursery which has only transplant beds, i.e., in which seedling are transplanted in preparation for forest planting is called transplant nursery***. In India separate seedlings and transplant nurseries are seldom made; in the same nursery, some beds are used as seedling beds and others as transplant beds. ***Generally, whatever is grown in nursery for planting out is called nursery stock. This term is also used for 'plants supplied from a nursery'.***

Important and Object:

1. Nursery occupied an important place in artificial regeneration. The increase in artificial regeneration work in general and the efforts to raise fast growing, short rotation crops involving introduction of exotics in particular, have further increase its important. The following objects for which nursery is generally made, clearly bring out its important:
2. Nursery is important in the development of plantations both for commercial and domestics' utility.
3. Helps to produce seedlings of small, medium and tall plants to cater the needs of industrial / social plantations, urban and recreational programmes.

4. Nursery helps to produce quality and healthy seedlings
5. Nursery grown seedlings ensure higher survival and early reestablishment.
6. Nursery grown seedlings are amenable for both dry and irrigated plantation development programme.[1]
7. Nursery grown seedlings are mostly free from pest and diseases and thus help in establishing a healthy plantation.
8. Success of roadside avenue plantations depends largely on planting tall and sturdy plants which can only be obtained from a nursery.
9. Planting of nursery grown plants is the surest methods of artificially regenerating poor and barren sites.
10. Some species grow very slow and if the seed of these species is sown directly in plantation, the seedlings are most likely to be swamped by weds and killed. Therefore, slow growing species are generally raised in nursery and planted out only when the seedlings are not liable to be damaged by weeds.
11. The best methods of introduction of exotics, viz., tropical pines, Eucalyptus, etc., is only by planting and therefore nursery is very essential for them

Classification of nursery:

Nursery established for tree seedlings production play a vital role in the plantation development programme. Based on the need and management requirement, tree nurseries are classified into the following type-

i. Based on longevity/duration of operation
   a) Temporary nurseries
   b) Permanent nurseries
ii. Based on water availability
   a) Dry nursery
   b) Wet nursery
iii. Based on the purpose and location
   a) Centralized nursery
   b) Decentralized nursery / site specific nurseries

i. Based on longevity / duration of operation

a) Temporary nurseries

A nursery is said to be temporary when it is set up for a specific period and to fulfill the seedling requirements of a small area. Temporary nursery is generally shifted from one place to another place depending upon the demand and supply of nursery

[1]Transplants – a seedling after it has been moved one or more times in a nursery, in contrast to a seedling planted out direct from seed bed.

stock. Seedlings produced in temporary nurseries are mainly used for gap filling or causality replacement and supplementing planting stock.

Since it is put up at the planting site, seedling transport is only for a short distance. Temporary nurseries should not at any cost put up on unfavorable site which lacks water, labour and inspection facilities.

e.g.: all nurseries available with Forest Extension centres are temporary nature based on the project implemented by the concerned state forest department

b) Permanent nurseries

A permanent nursery supplies the seedlings regularly year after year. It caters the needs of larger areas for a longer period. This is provided with enough infrastructure facilities in a central place. It should have permanent staff, transporting facilities, good water sources and availability of labour.

Example: Clonal nursery complex, Central plantation nursery.

ii. Based on water availability

a) Dry nursery

Dry nursery is one which does not have any permanent water source for irrigation. It mainly depends on rainfall for water and hence seedlings are produced only during the monsoon season. Such nurseries are now becoming rare and obsolete. Present day plantations demand seedlings of good and high quality and dry nurseries hardly have the potential to supply quality seedlings.

b) Wet nurseries

Wet nursery is one which have a permanent water source for irrigation such as bore wells, wells etc. the seedling production is possible throughout the year. Many of the government and private nurseries come under this category.

iii. Based on the purpose and location

a) Centralized nursery

It is a nursery established permanently similar to permanent nursery to provide the large volume of seedling requirement for afforestation, reforestation and Agroforestry purposes. As a centralized nursery, all components of Infracture for both seedling and clonal propagation are established. Most of the wood based industries develop such centralized nurseries to cater the seedling requirement for their own Agroforestry and farm forestry plantation development programmes.

Example: Centralized nursery established by TNPL AND SPB in Tamil Nadu and ITC in Andhra Pradesh.

b) Decentralized nursery

These nurseries are also permanent in nature but established in specific localities distributed across the state to cater the needs of seedlings requirement of such localities. Industries like TNPL and Seshasayee papers and Board Limited have established decentralized nurseries in association with farmers and other local nursery groups by providing necessary technological support. These nurseries are also provided with quality seeds for seedling production and clonal mother plants for clone production.

Example: Decentralized nurseries at Coimbatore, erode, Karur, Villupuram, Cuddalore etc.

Chapter-2
NURSERY LOCATION AND PHYSICAL REQUIREMENTS

The location of a nursery is very essential to produce quality planting stock couped with their accessibility to roads and availability of proper communication facilities. The following factors are very essential for locating a nursery.

i. **Location**

The area chosen for nursery should be centrally located for economic transport of materials like potting soil, sands, vermiculite, water etc. and easy lifting of nursery stock. The location should be accessible for transportation with good communication facilities including data transfer.

ii. **Light**

This is an important factor to be considered in selecting an area for raising seedlings. The nursery area should be free from permanent shade. The seedling should not be raised under tree canopy which cause total shading. Seedlings grown under permanent shade will have lanky growth due to etiolatiion and therefore, its establishment in the main field would be a cause of concern.

iii. **Slope**

Nursery should be gentle and flat to ensure good drainage facilities for proper growth and establishment of seedlings. Generally, too sloppy area can be avoided for nursery establishment.

iv. **Size**

The size of the nursery should be decided based on the seedling demand, availability of water and other infrastructural facilities. Choosing a large area for a small demand is unmanageable and uneconomical. A minimum nursery site of 1 ha is preferred but depending on the quality of seedlings to be produced, the size of the nursery can extend upto 4 ha (10 acres).

v. **Soil**

This is the single and most important factor which decides the quality of the nursery produce. The nursery should be selected on the best available soil preferably on deep sandy loam soil. In any case, sand is preferable to heavy clay. The soil pH between 6.5 and 7.5 is preferred for production of quality planting materials.

vi. Water

The site chosen for nursery should have a good source of water for watering the seedlings particularly during the driest months. The pH of water should be around 7.0 and the water should be free from high concentrations of carbonates of calcium, magnesium and potassium. Similarly, the water should be free from high concentrations of chlorides of sodium and potassium, sulphate and phosohates of calcium to avoid drying of plants and to ensure production of quality planting material.

vii. Labour

Nursery activities demand huge volume of labour requirement to caters the needs of input transportation, loading and unloading, mother bed formation, sowing, bag filling, transportation, watering, pest and diseases management etc. All these activities demand continuous availability of labour and hence the nursery should be located near to a villages or an area near where sustainable work force is available for successful establishment and management of the nursery. Nowadays due to mechanization, the labour requirement has been drastically reduced. Nursery should invest on necessary Infrastructure particularly micro irrigation facilities, mechanized filling operations etc. to manage the labour problems during unforeseen conditions.

viii. Flood

The site should not be located in the areas prone to periodic and recurrent flooding. Sites with heavy clay soil are prone to water logging and flooding and hence these sites should be avoided.

ix. Frost

The site should be avoided when the area is subjected to frost and snow.

x. Wind

Area subjected to strong wind should also be avoided. Alternatively, such areas when selected for want of other establishing one or two rows of windbreaks or a site specific shelterbelt depending on the prevailing wind speed.

NURSERY LAYOUT:

Once the nursery site /area is identified and selected, proper planning is essential to establish the nursery. A modern and centralized nursery should have all infrastructures to support seedling production. A typical modern seedling and clonal nursery layout is furnished in Fig.1 and Fig.2.

Essential requirements of a centralized nursery

1. **Protection fence:** The nursery area should be protected from the entry of cattle and intruders and also from the heavy wind. For this, a chain link fence and a row of trees all round the nursery should be established.
2. **Office:** An office should be established for administrative purpose besides maintaining the records and stock registers.
3. **Store:** A store room for storing nursery tools, chemicals, fertilizers, polythene bags etc. is very essential for a centralized nursery.
4. **Storage Yard:** Nursery potting mixture like compost, top soil, sand etc. need storage facility and hence a nursery storage yard is very essential.
5. **Water source:** To cater the water requirement of the nursery, sufficient bore wells, water tank (both underground and overhead) are required.
6. **Clonal hedge garden:** This is essential for maintenance of clones and for collection of cuttings at regular interval.
7. **Hardening Chamber:** The propagated plants from mist chamber need proper hardening and hence a hardening chamber of required size and capacity needs to be established.
8. **Working space:** Sufficient working space is essential for preparing cutting and grafting before they are place in mist chamber.
9. **Mist Chamber:** For mass multiplication and efficient rooting of clones, an organized mist chamber is essential
10. **Waste pit and composite yard:** to dumped unwanted materials and to prepared compost for use in nursery.
11. **Motorable road:** For transporting nursery materials like soil, sand, FYM etc. for raising nursery and for easy lifting of seedlings from the nursery to the planting site.

12. Entry gate: The entrance should be provided with a lockable iron gate.

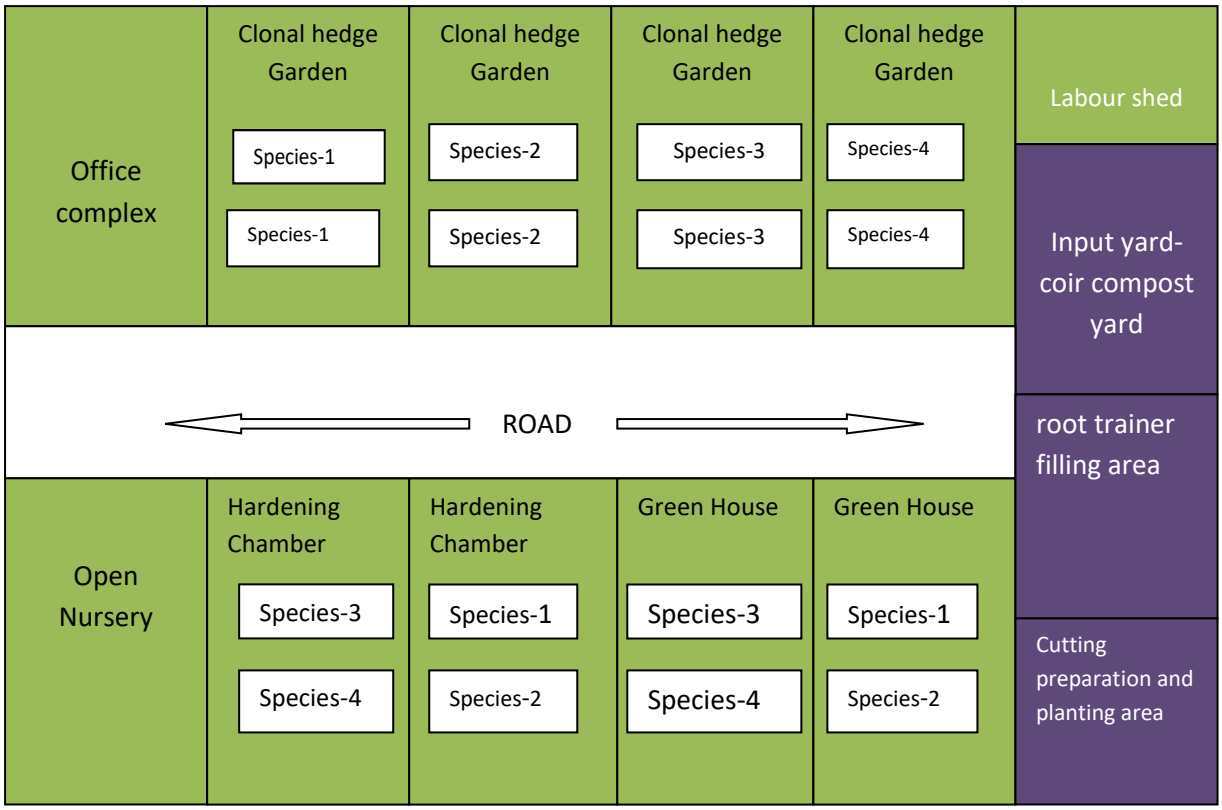
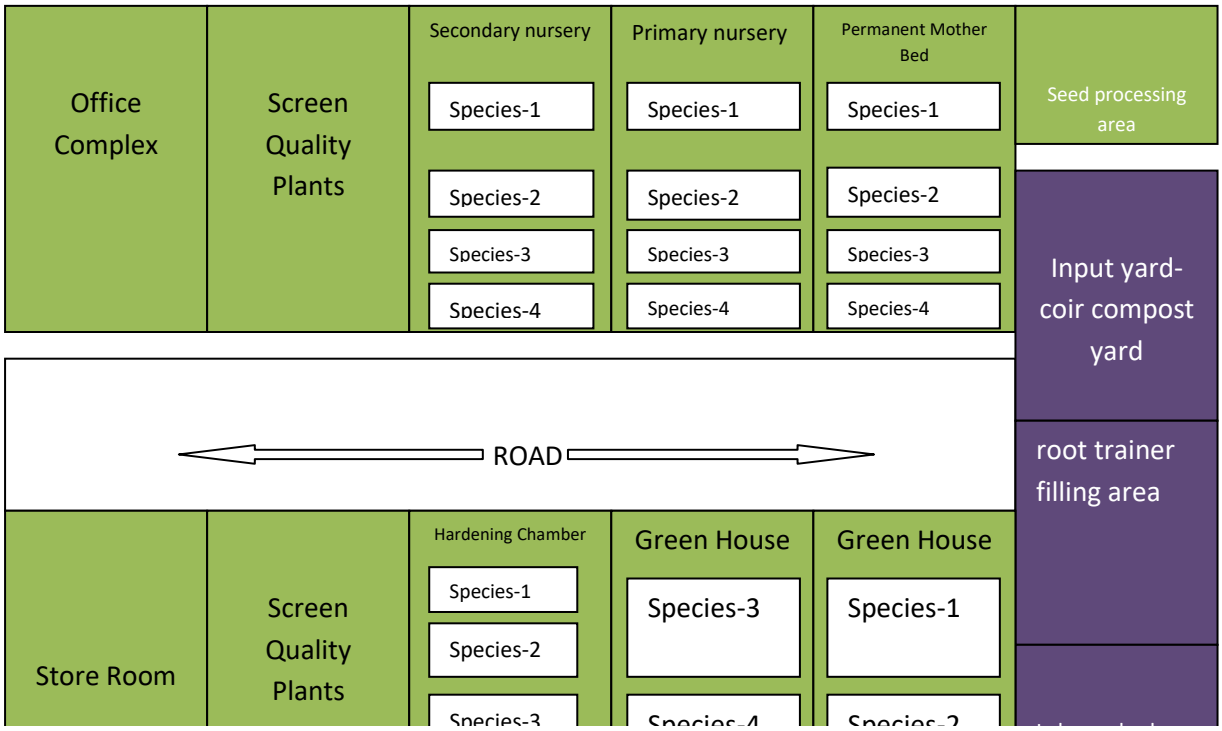


Fig.1. Layout of Clonal Forestry Nursery



Chapter-III
TREE SEEDS

Seed is a vital reproductive material used in all quality planting stock production. Quality seeds should be collected from seed orchards or Seed Production Areas (SPAs) established for the purpose of quality seed production and supply. The quality and quantity of the tree seeds produced by any species will ultimate determine its regeneration capacity. Based on the problems posed by the tree seeds at the time of sowing, they are broadly classified into two main types-

A. **Non-problem seeds**: These are seeds which pose little / no problem in germination and have no dormancy period or do not require any pretreatment before sowing. Example: Eucalyptus, Casuarina.

B. **Problem seeds**: Seeds are said to be problem seeds when they are hindered in the process of germination by various factors. The problems are mainly due to

i. Hard seed coat: Seeds of certain tree species have a hard seed coat which disallows water and air to penetrate the seed coat (testa) and break the physiological dormancy and promote germination. Example: *Acacias, Leucaena, Cassia, Albizia, Delonix etc.*

ii. Fibrous seed coat or hard shell: Some tree seeds have a hard and fibrous seed coat or shell which is very much impermeable to water and air and hence remain dormant till favorable conditions (natural scarification) occur. Example: Terminalia, Teak, Gmelina arborea etc.

iii. Seeds containing fatty oils: Certain tree species possess oil in their seeds and when exposed to room temperature lose their viability quickly. Example: Neem, Pungam, *Bassia*, Kapok etc.

iv. Chemical hindrance: Chemicals produced in the seeds of some tree species reduce their viability quickly after maturity. Example: *Ailanthus spp*.

v. Immature embryo: Seeds of certain trees will not mature even after the fruits are ripened. They require an after ripening period for the seeds to germinate. Example: Pines etc.

SEED TREATMENT:

The germination problems experienced by problem seeds can be overcome by the following seed treatment methods-

Sl.no	Types of seed	Treatments
1	Hard seed coat	a) Soaking in hot water b) Acid scarification using commercial grade conc.H_2SO_4
2	Fibrous or hard shell	a) Alternate soaking and shade drying
3	Seeds with fatty oils	a) Sowing immediately after collection and extraction of seed from fruits
4	Chemical hindrance	a) Collect from the tree before fully mature and soaking in cold water for a day or two and then take up sowing
5	Immature embroyo	a) Cold or hot scarification

1. **Hot water soaking**

Take three times of water when compared with the volume of seeds in a container and boil it. Remove the container from the oven/gas and put the seeds into boiling water. Keep the seeds as such overnight and used them for sowing the next day morning. Care should be taken to see that the seeds are not dropped into the container when the water is boiling and do not exert pressure on the seed coat while sowing which will lead to the expulsion of the cotyledons.

2. **Acid scarification**

For acid scarification commercial grade conc**.** H2SO4 is used. Depending upon the seeds, the quality of acid and duration of scarification will vary.

Some Example:

Species	Concentration	Duration
Prosopis	150 ml / kg 200 ml / kg	3-5 min 3-5 min
Acacias	200 ml / kg	20-25 min
Cassias	200 ml / kg	30-35 min
Delonox	250 ml / kg	40-45 min

Seeds are placed in glass or plastic containers and the measured quantity of acid is added to the seeds and the seeds are stirred for a specific period. The seeds are then washed 8-10 times in cold water to remove the acid and then used for sowing.

3. Alternate soaking and shade drying

In some tree species, fruits are used as sowing instead of seeds (*Example: Teak, Terminallia etc*). To facilitate easy germination, the fruits are initially soaked in cold water for 24 hours and then shade dried for 24 hr and this process is continued for 5-7 days before the fruits are sown. This process will cause swelling and shrinking of fruits which will lead to cracks on the hard shell and will allow water and air to enter the fruit and hence facilitate quick germination.

OTHER METHODS OF PRE-TREATMENT:

i. **For pest and diseases control**
   Seeds are dipped or coated or fumigated with suitable insecticides / fungicide to avoid insect damage after sowing.

ii. **Seed hardening**
   After initial scarification, the seeds are soak in 5% salt solution followed by drying and used for direct seedling which may facilitate for drought hardiness.

iii. **Seed Pellatization**
   Seeds are pelletized with fertilizers and insecticides using a filler and gum and used for aerial seedling.

iv. **Treatment with microbial culture**
   To produce robust and healthy seedlings, seeds are sometimes treated with Rhizobial cultures, shade dried and used for sowing. This will help in fixing atmospheric nitrogen. Phospo-bacterial cultures, Frankia, Ecto and Endomycorrhiza are some of the beneficial microbial organisms which could produce healthy seedlings. Seed treatment with microbial cultures should be provided after acid scarification, if any.

Chapter -IV
GENERAL TECHNIQUES ADOPTED FOR TREE NURSERY

1. **Land leveling and site preparation:**
   The area chosen for nursery should be thoroughly ploughed and hoed to a depth of 45cm and completed removed off its unwanted materials. The clods are then broken and the area is leveled. Depending upon the types of mother bed (earthen beds or filled in polythene containers), the area is laid out. Tree seeds when sown directly into polybag containers and raised which is called as direct sown nurseries or initially raised on mother beds and then transplanted into polybags containers which are called as transplanted nurseries. The beds are laid out in rectangular shape with their length east to west to avoid shade affect.

2. **Enrichment of the site**
   Well ploughed field is nourished with organic fertilizers like compost, manure or well decomposed Farm Yard Manure (FYM) followed by formation of raised bed or sunken beds. Usually a height or depth of about 15cm is given for the raised and sunken beds respectively and for species like teak and Terminallia, the bed height is increase to 45cm. to prevent sliding down of the bed, the side of the bed is consolidated by ramming. In places experiences heavy rainfall, materials like wooden planks, bricks or coconut palm plates may be used. The upper portion of the mother bed (2.5-5 cm) is prepared with a soil composition of Red earth, sand and FYM sieved with a 2 mm sieved and mixed in the ratio of 3:1:1. In case of certain species like bamboo, casuarina etc, the sand fraction should be provided through drainage channels around the nursery to prevent water stagnation. The top portion of the bed is properly leveled and now the bed is ready for sowing. In many case, temporary shade is provided at a height of 3 feet to protect the germinating seedlings from ill effects of scorching sunlight and heavy rain.
3. **Soil mixture**
   The soil selected for potting mixture should be of less clay content so as to encourage easy root development and good drainage. The best potting mixture is red earth or native soil with less clay content, sand and FYM in the ratio of 3:1:1. In places where tank silt is available in plenty, one part should also be added. While filling with the

above mixture, care should be taken to see that they are free from clods and they are thoroughly mixed.

4. **Containers**

   Size of the containers used will depend on the species and the purposes for which they are raised and economy during transportation. Most of the nurseries predominantly use polybags containers for seedling production and root trainers for clonal multiplication.

   - Sizes
     Polybags: 10x20 cm, 15x25 cm, 30 x 45 cm
     Root trainers: 90cc, 150cc, 300cc and 600cc

5. **Transplanting or primary nursery**

   Transplanting nursery is the nursery area wherein the seedlings are pricked out and planted from the mother bed or where seeds are sown directly and seedlings are raised before they are planted out. In this nursery, seedlings from the mother beds are prick out and planted in the poly containers filled with standard nursery mixture to develop complete plantlets for planting out.

6. **Size of the nursery**

   For economic production of tree seedlings, the size of the nursery should be sufficient enough to meet the seedling demands. A mother bed of 1 metre square is sufficient to produce 2000-2500 plan table seedlings and transplanting bed of size 10 m x 1.2 metre can hold 1700-2000 seedlings depending upon the filling of polybags of size 10 x 20 cm. hence, based on the seedling requirement the nursery area should be calculated.

7. **Time of sowing**

   Every nursery man should be carefully plan when he should sow the particular species so that seedlings of optimum age are readily available for planting at the beginning of the monsoon. For most of the species, nurseries are sown during February-March.

   Example: Acacia, Eucalyptus, Casuarina etc. for species like teak it is taken up during September-October. Depending upon the optimum age required at the time of planting, the time of sowing should be adjusted.

8. **Sowing**

   After all treatment, seeds are sown in mother bed or polybag. Sowing should be done in optimum time which varies with different species. Generally seeds are sown in mother beds or poly bag. After sufficient time, the seedlings from these beds are transferred in to a poly bag or directly planted in the field. Normally seedlings of 3-6 month old are ready for transplanting. The following facts are considered while going for sowing:

- Sowing should be taken up early in the morning or late evening
- Beds and containers should be watered before sowing
- The seeds are sown shallow rather than deep
- Treat the seeds suitably with pesticides and biofertilizers
- In case of small seeds, nursery beds are covered suitably to protect the seeds form birds and wind

In some cases, seeds are directly sown in the field for the establishment of plants. The bigger seeds are sown deeply compared to lighter seeds. The method of sowing varies for different kinds of seeds which are explained below:

i. **Broadcasting:** Seeds are scattered uniformly all over the area which is suitable for small size or lighter seeds.
ii. **Line sowing:** lines with suitable spacing are drawn first. Then seeds are sown at a defined spacing within the lines. This is suitable for species showing higher germination. The lines sowing maybe continuous or interrupted one. In some cases the sown portion of the line is opposite to the unsown portion of the concurrent line. This method of sowing is called interrupted and staged line sowing.
iii. **Strip sowing:** Refers to sowing of seeds in narrow strips at definite intervals. Strips vary in their width (40-150cm). In this portion soil is worked well and exposed to sun for certain time. Thereafter sowing is done.
iv. **Patch sowing:** Defined as sowing a number of seeds in specially prepared patches. The shape of the patches maybe square, rectangular or circular. These are space at definite intervals.
v. **Dibbling:** In this method seeds are sown into the containers by making a hole to a depth of 1 cm. this is suitable for bigger size seeds.

9. Seed requirement

The requirement of seeds of a particular species should be worked well in advance and procured or collected at the time of fruiting and kept ready for sowing. Never go in search of seeds after preparing the nursery beds. The quantity of seeds required to plant one hectare is worked out using the following formula-

$$\text{Seed requirement} = \frac{Ha \times N}{S \times PS}$$

Where,

Ha = size of annual planting programme for each species.

N = Intended number of seedlings to be planted per hectare.

S = An Estimate of survival after planting and the need to filled the gap.

PS = Number of plan table plants / kg of seeds.

Example: A farmer want to raise one hector of acacia nilotica at an espacement of 2m x 2m. Calculate the seed required. The number of healthy seedling/kg is 1740 and 1566 for naked rooted and polybag containers planted. The survival percentage is 90.

Number of seedling required per ha= area/ha= 10000 sq. meter.

At an espacement of 2m x 2m = $4m^2$

$=10000 / 4\ m^2$

=2500 plants

Seed requirement in case of naked rooted seedlings = Ha x N / S x PS

= 1 x 2500/ 0.90 x 1740

= 1.59 kg

Seed requirement in case of producing polybag containers plants

= 1 x 2500/0.90 x 1566

= 1.77 kg

= 1.8 kg (approx)

10. Watering

Beds should be kept constantly moist at the time of seed germination. During the early stage, the bed should be given a fine spray of water using rose can. In case of fine seeds which are thinly covered, straw or twigs should be placed over the bed before watering. Watering should be done daily twice till one month after germination and then reduced. Depending upon the species and area for which they are raised, watering should be regulated to harden the seedling in nursery. Watering Is done at intervals of 1-7 days and subsequent watering is usually done by noticing the seedlings at ready to wilt stage. In large scale nurseries, sprinkler irrigation may reduce the cost of watering when put up on a permanent basis. After plants are grown up, watering can be done by rose cane or by plastics hose.

11. Temporary shade house

To protect the top surface of the soil from drying up and the young seedling from scorching sunlight and dispersal by sudden down pour, temporary shade houses are erected over the mother beds. Sometimes this shade house can be erected permanently to cater the protection needs of germinating seedlings.

12. Manuring

The size of the containers and the nutrients in the soils will not be adequate to nourish the seedling for a long period. After three months of growth in the containers, these [2]seedlings maybe given irrigation with cow dung solution. For this, one part of fresh cow dung is mixed with 4 parts of water and kept in a container for 2 days. On the third day, the supernatant solution is taken and to this, adds 10 times of water and used this for irrigation the seedlings once in 15-20 days before shifting. Seed treatment with Rhizobial cultures, VAM, Phosphabacteria and spraying of urea 1% or DAP application @2.5gm/polybag containers is also given to boost up the seedling growth. It is better to prefer organic form of fertilizers which will nourish the seedling slowly and steadily and will help it to survive on waste lands which are characterized by poor nutrition.

13. Shifting and root-pruning

Shifting of containers from its original place is a must to prevent the root from striking into the soil and also to break the top clogged soil caused by continuous irrigation which will prevent the entry of water and air. 15-20 days after germination or planting, check one or two seedlings at random in the bed and see whether they have struck roots ground and if so, do the shifting. After the first shifting operation, shifting of seedling should be done once in 15-20 days interval. Weeding should also be combined with the shifting operation to minimize the cost of seedling production. Protruding roots out of the container should be pruned at the time of shifting to keep the roots compact and prevent them from penetrating into the soil.

14. Thinning and culling

In case of overcrowding of seedling due to sowing of more number of seeds in the polybags or sowing or high germination percentage seeds on mother beds, thinning is advocated to produce healthy seedlings. Thinning should be done once the germination has been completed. While thinning care should be taken to retain those seedlings which have germinated earlier and are healthy and attention should be directed towards removal of late germinated and unhealthy seedlings. See that each polybag hold only one single healthy seedling. To increase production at the time of last shifting,

[2] Damping off – killing of young seedling by certain fungi that cause decay of the stem or roots.

weak, pest and disease attacked seedling are culled out to retain only healthy plants in the nursery for out planting. The culling percentage can go up to 30%.

15. Pest and disease control

To protect the seeds from being eaten away by ants and termites, BHC 50% wet able powder 2 g/lit is applied over the bed. Young seedlings are often attacked by leaf eating caterpillar and leaf Webbers for which any systemic insecticides can be used.

Common diseases observed in the nursery are damping off diseases and root rot. Avoiding overcrowding of seedlings and allowing sunlight to reach the bed can control such diseases. At times when damping off is observed, avoid irrigation and apply Bavistin or Blue copper 2 2gm/lit of water and drench the bed. Pre treating seeds with agrason, thiram, captan will help to control the diseases.

16. Pricking

Seedling from the mother bed is pricked out into the transplanting bed from where they are planted out. The following points should be borne in mind at the time of pricking out of seedlings.

i. Prepared and keep ready the transplanting bed by watering it the previous day of pricking and creating a shade net over it.
ii. Water the mother bed the previous day.
iii. Seedlings shall be pulled out from the mother bed early in the morning or late in the evening and planted in the transplanting bed.
iv. The seeding should be pricked without folding the roots and it should be well compacted.
v. The root portion of the pull out seedling should be kept inside water in the container till they are planted.
vi. Water the seedling daily twice, in the morning and evening.

The age of pricking will vary from species to species and this should be strictly followed or else the seedling may not survive after pricking.

Example:

- Bamboo – 40-60 days after sowing
- Acacia nilotica – 15-20 days after germination

17. Type of planting stock

The following types of planting stocks can be produced in the nursery.

i. **Bare rooted seedlings or naked**

Bare rooted seedlings are used for planting in sandy loam soils where water table is high or areas with high rainfall or with irrigation facilities. Here the seedlings are transplanted from the original mother bed to the transplanting bed at wider spacing from where they are pulled out and planted in the main field. Care should be taken not to injured the roots or keep the plants in the open so that the roots get dried up at the time of planting.

Example: Bamboo, Casuarina, Terminallias etc.

ii. **Containerized seedling**

This is a common method wherein seedling are raised in some containers for the prescribed period and then planted out.

Example: Eucalyptus, Acacia, Albizia, Casuarina etc.

iii. ***Stumps***

In this method, seeds are sown on the mother bed and seedlings are raised. After the prescribed period, these seedlings are pulled out and the shoot portion (2.5cm) root portion (22.5cm) and side roots are pruned off and the left out material called the stump is used for planting.

Example: Teak, Red Sanders etc.

18. Nursery period

The age of seedling at the time of planting will vary from species to species and also with the moisture status. In case of high rainfall areas or irrigated areas, seedlings of the age of 3-4 months old in the nursery could be planted out. In drier tracts, it is better to plant older seedlings of more than 6 months old. The common nursery period for effective planting stock is as follows.

Eg.

- Eucalyptus, Casuarina, Leucaena- 3 months
- Acacias, Ailanthus, Neem etc- 6 months
- Bamboo -9-12 months
- Teak – 10-12 months
- Tamarind - 18 months
- Meria - 3-4 months

Chapter -V
NURSERY MACHINERY, TOOLS AND MATERIALS

For effective functioning of a nursery it should have the following machinery, tools and materials always available and in good condition. The efficiency of the labourers is very well determined with the condition of the nursery tools and the knowledge of the work.

I. **Nursery Machinery**

   i. **Tractors with Trailors, Tanker, Plough:** This is required in all centralized nurseries to transport materials required for the nursery, ploughing and bush clearing operation. In case of failure of pump set in drawing water, the tractor with tanker can be used for transporting water and giving protective irrigation to the seedling.

   ii. **Trowel Trolleys etc:** To carry small quantity of soil and other nursery materials into the nursery.

II. **Nursery tools**

Mummutty, spade, shovel, digging fork, rake, hand fork, watering cans spraying pumps, pen knife, budding knife, secateurs, measuring tape, ranging poles, stakes, budding tapes, dibbler (pointed stick) crowbar, pickaxe etc.

III. **Nursery materials**

Polybags, growth regulators (IAA, IBA), fertile top soil, sand, FYM, seedlings brought out from the mist chamber before they are kept in the open

Chapter - VI
NURSERY RECORDS

For effective management of nurseries proper records have to be maintained for planning, execution and monitoring the cost of production of seedlings. The following register should be maintained in all nurseries.

i. **Planning register**

In this register, the species to be grown for the season, the number, how to be grown, and the inputs requirements etc should be forecasted and got in advance are entered.

ii. **Seed register**

The seed material to be purchased, their sources, date of its collection, date of purchased, method of its storage atc have to be recorded to monitor the quality of the seed. The germination percentage at the time of procurement should also be recorded for each species in this register. The date of issue of the seeds for sowing, germination % should also be recorded.

iii. **Operation register**

This register will have all details from sowing of a species till the seedlings are removed from nursery for out planting.

iv. **Input register**

In this, all details on the cost of seeds, soil, sand, FYM, labour employed, water charges, fertilizer cost etc. is to be recorded.

v. **Forecast register**

Daily work or weekly work in a nursery has to be forecasted and done accordingly it is recorded in this register.

Chapter - VII
COST OF PRODUCTION:

Any nursery could be a failure, if the cost of various inputs applied for seedling production is not calculated and planting stock produced accordingly. The cost of seedling production depends on the following factors.

i. Location of the nursery
ii. Availability of Sand, Soil, FYM, Water, Seeds etc.
iii. Labour availability cost and efficiency
iv. Technical knowledge on the production of seedlings

Depending upon these factors the production cost will vary from place to place which has to be monitored and worked out by the man in charge of the nursery.

OTHER RELATED INFORMATION

PATTERN OF PLANTING

Following pattern of planting are in vogue;

1. **Line Planting** – In line planting, plants are planted at some spacing in lines which are also some distance apart. Thus the planted plants form rectangles.

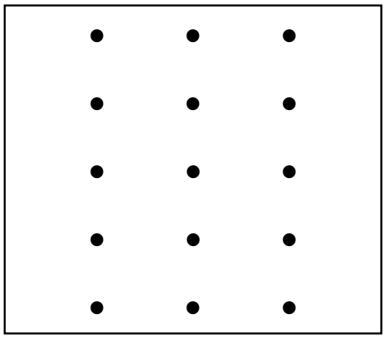


Fig. Line Planting

2. **Square planting** – Defined as planting in square pattern, i.e., with plants occupying the four corners of each successive square. This is achieved by planting plants in lines at the same spacing as that of the lines themselves.

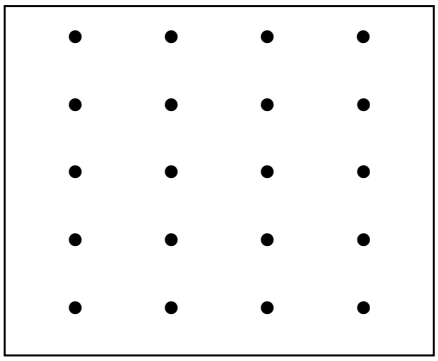


Fig. Square Planting

3. Triangular Planting – Planting in the pattern of equilateral triangles, i.e., with plants occupying the three corners of adjacent equilateral triangles.

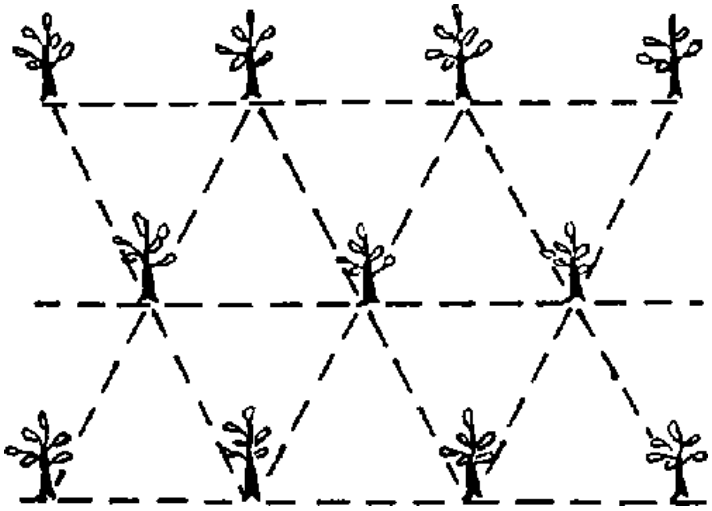


Fig. Triangular Planting

4. **Quincunx planting –** A group of five points, four of which form the corners of a square with the fifth as centre. Thus quincunx planting is that method of planting "in which an extra plant is placed in the centre of each square of four plants".

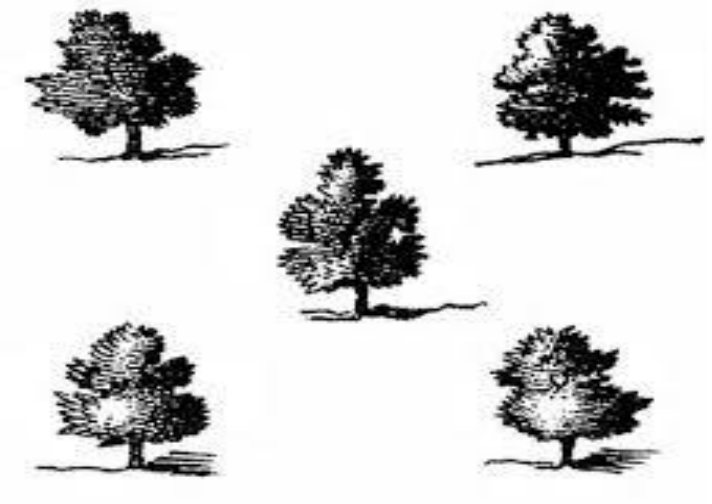


Fig. Quincunx planting

METHODS OF CALCULATING NUMBER OF PLANTS

Number of plants required per hectare in various patterns of planting can be calculated by the formula given below, but in actual practice, 10 to 20 % of plants have to be arranged extra to provide for mortality of plants in extraction from nursery, transport to the planting site or while planting.

1. **LINE PLANTING**

   Number =100 ×100/distance of plants in lines × distance between the lines.

   Example: Calculate the number of plants required for 10 ha of plantation in which plants are 2m apart in rows which are 4m apart.

   Sol^{n}.Number of plants required = 10 x 100 x 100 / 2 x 4
   =12, 500.

2. **SQUARE PLANTING**

   Number of plants = 100 x 100 / square of the planting distance

   Example: Calculate the number of plants required for 10 ha of plantation in which the plants are planted at 2.5 m x 2.5 m.

   Sol^{n} . Number of plants required = 10 x 100 x 100/ 2.5 x 2.5
   =16,000

3. **TRIANGULAR PLANTING**

   Number of plants = 100 x 100 x 1.155/ square of planting distance (i.e., side of the triangle)

   Example: Calculate the number of plants required for 10 ha of plantation in which the plants are planted in a triangular pattern, 2.5 m apart.

   Sol^{n} . Number of plants required = 10 x 100 x 100 x 1.155/ 2.5 x 2.5
   = 16,000 x 1.155
   = 18,480

4. QUINCUNX PLANTING

Number of plants = 2 x 100 x 100/ square of the side of the planting square

Example: Calculate the number of plants required for 10 ha of plantation, planted at espacement of 2.5 m x 2.5 m with a plant in the centre of each square.

Sol^{n}. number of plants required = 10 x 2 x 100 x 100/ 2.5 x 2.5
= 32,000

METHODS OF CALCULATING SPACING FOR GIVEN NUMBER OF PLANTS PER HECTARE

Spacing of a given number plants in various patterns of planting can be calculated by the formulae given below:

1. **SQUARE PLANTING**

Spacing = ($\sqrt{100\times100}$/number of plants per hectare) metre square

Example: Calculate spacing of plants if there are 400 plants in a hectare of plantation raised on square planting pattern.

Spacing = $\sqrt{100\times100/400}$

=√25

=5

2. **RECTANGULAR PLANTING**

Spacing= $100\times100/$number of plants /ha **×** spacing of plants in rows or spacing of rows

i. Example: Calculate spacing of plants in rows made at a spacing of 4m if there are 1250 plants/ ha in a plantation.

Spacing = 100×100/ 1250 ×4

=2m

ii. Example: Calculate spacing of rows in which plants are 2.5 m apart if the plantation has 1000 plants per ha.

Spacing = 100×100/ 1000 ×2.5

= 4m

3. TRIANGULAR PLANTING

Spacing = $\sqrt{100\times100\times1.155/\text{number of plants per hectare}}$

Example: Calculate spacing of plants raised in triangular planting if there are 1848 plants per ha.

Spacing = $\sqrt{100\times100\times1.155/ 1848}$

=√6.25

= 2.5 m

4. QUINCUNX PLANTING

Spacing = $\sqrt{2 \times 100\times100/\text{number of plants per hectare}}$

Example: Calculate spacing of plants raised in quincunx planting if there are 3200 plants per ha in the plantation.

Spacing = $\sqrt{2} \times$100×100 / 3200

=√100/16

= 10/4

= 2.5 m

Table: Following table gives number of plants per hectare for rectangular and square planting for given spacing:

Spacing (m)	Number of plants	Spacing (m)	Number of plants	Spacing (m)	Number of plants	Spacing (m)	Number of plants
1×1	10,000	2.5×2	2000	3.5×3.5	816	6×6	278
1×2	5000	2.5×2.5	1600	3.5×4	714	7×7	204
1×3	3333	2.5×3	1333	3.5×5	571	8×8	156
1×4	2500	2.5×4	1000	4×4	625	9×9	123
1×5	2000	2.5×5	800	4×4.5	555	10×10	100
2×2	2500	3×3	1111	4×5	500	15×15	44

2×3	1666	3×3.5	952	4.5×4.5	494	20×20	25
2×4	1250	3×4	833	4.5×5	444	25×25	16
2×5	1000	3×5	666	5×5	400	30×30	11

1. NURSE CROP

A crop of tree or shrubs grown to foster the growth of another and more important tree crop in its early stages in other words, it is a crop of tree or shrubs, which is introduced in a plantation of less hardy species to help it to grow and, therefore, as soon as the purpose is served, it is removed. The objects of raising nurse crops are:

i. **Protection of shade bearing species** - Shade bearing species of tropical evergreen forest require some degree of shade in early stage. For example, Gmelina is raised as a nurse crop for Dipterocarpus turbinatus.

ii. **Protection against frost** – frost tender species require protection against frost. For example Cajanus and Ricinus communis are introduced in sal taungyas and miscellaneous plantations respectively as frost protection crops. But in such cases nurse crop should not be very dense, otherwise plantation floor remains chilled resulting in damage to plants.

2. COVER CROP

Cover crop is defined as “a subsidiary crop of low plants introduced in a plantation to afford soil cover between or below the main crop”. Thus a cover crop is raised in between the plantation lines to protect exposed soil from deterioration, to check surface erosion, to add humus to the soil, and to reduce the grass and weeds which becomes a sources of great fire danger in hot weather. ***The species which can be used as cover crops are Tephrosia candida, Crotolaria juncea, Indigofera tinctoria, Leucaena glauca,*** etc. The cover crop species should be raised in between the lines of the main species in a strip wide enough to cover the interspace but not the lines of the main species. In order to prevent suppression of the main species, they are generally introduced in the plantation a year or two after the sowing or planting of the main species.

3. UNDER PLANTING

Under planting is defined as sowing or planting under an existing stand. In other words it means sowing or planting of a new species under the canopy of some other species. This is normally done with the following objects;

i. For protection of soil

ii. For increasing the proportion of valuable species in the moist deciduous and semi-evergreen forest.

iii. For the propagation of species which cannot be raised in the open

iv. For multiple use.

Under planting is a difficult operation and unless it is done carefully it is likely to fail. It can only be done when the upper canopy has lifted sufficiently to enable diffused light to entre forest floor. Under planting may sometimes have adverse effect on the growth of the main tree species. For example, growth of teak has been reported to be affected by under planting. Therefore under planting should be done when it is not likely to affect the main crop adversely.

NURSERY TECHNOLOGY OF SOME IMPORTANT TREE SPECIES

1. Michelia champaca

Family	Magnoliaceae
Common Name	Chempak
Uses:	
Other Uses	Beautiful tree, Cultivated for its scented flowers. Woods used for Posts, Boards, carvings, furnitures etc.
Seed Collection time	Fruit ripens in August or later and should look for seeds for then.
No. of Seeds per kg	160 to 300 / Ioz.
Viability	Seeds are oily and quickly loose their germinative power. Seeds should be sown as soon, as possible, after collection
Nursery Technique	It requires moist deep soil. Seeds should be sown in the mother bed and good seedlings should be transplanted. It thrives best in high rainfall area 2000 mm of rainfall.

2. Azadirachta indica

Family	Meliaceae
Common Name	Neem
Uses:	
Fuel (Calorific Value)	More than 4500 Kcal/Kg.
Fodder	Average
Other Uses	Timber, energy, windbreak, shade, soil, improvement, seed oil cake, fertilizer, tannin, seeds and leaves are systemic inspect repellent i.e. goes into the system and repels from within
Seed Collection time	June, July & August
No. of Seeds per kg	1750 fruits or 4000 cleaned seeds.
Viability	2 months. If stored in mud pot the viability can be

	extended to six months.
Germination percentage	50%
Seed Treatment	Not required but depulping the seeds before sowing gives better germination.
Nursery Technique	Fresh seeds sown in pots, 3 feet each. Germination starts within one week and planted out next year. Roots establish first and shoot increases later. They can also be sown in seed beds 15 cm x 3.5 cm apart, sparingly watered and pricked out at 15 x 15 cm when two months old and planted out with ball of earth next year. Planting of seedlings with initial germinating vigour(50% culling) will perform better. For raising taller plants 30 x 45, 35 x 50 HDP bags, proper mixture 1: 1: 1 is absolutely necessary, especially in drip irrigation it gives 8 feet in only 4 months.

3. Gmelina arborea

Family	Verbenaceae
Common Name	Gamari
Fuel (Calorific Value)	4800 Kcal/Kg
Fodder	Average
Other Uses	Good timber used for fumiture; planking. Carriages, printing blocks, carving, musical instruments, shafts, axles, lacquired boxes.
Seed Collection time	May - June
No. of Seeds per kg	2500 - 2600
Viability	Upto six months
Germination percentage	10% to 15% .
Seed Treatment	Soak in cold water for 24 hours
Nursery Technique	Treated seeds sown in mother bed. Starts germination from 7th day onwards. It grow 8 feet tall in 30x 45 cm size bags in 4 to 6 months

4. Dalbergia sissoo

Family	leguminoseae
Common Name	Sissoo
Fodder	Good
Other Uses	Timber is used for making furnitures
Seed Collection time	October - March
No. of Seeds per kg	25000
Viability	1 - 2 years
Germination percentage	70%

Seed Treatment	Not essential
Nursery Technique	Seeds are sown in the mother bed from which seeclings can be pricked out. Germination starts from 8th day onwards. Attains 6 feet height in 6 months in 30 x 45 cm size bags.

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4. Plantation Tree (R.K. Luna)
5. Forestry (Subjective Guide) (K.T. Parthiban, R.J. Sudhagar, S. Umesh Khanna, S. Vennila, I. Sekhar, & K. Barandidharan)

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