



STANDARD OPERATING PROCEDURES FOR NURSERY TECHNIQUES



Indian Council of Forestry Research & Education

(An autonomous body under Ministry of Environment, Forest and Climate Change)

P.O. New Forest, Dehradun - 248006 (Uttarakhand)



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2023

Submitted To:
Forest, Environment and Climate Change Department,
Govt. of Odisha

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Publication No.: *IFP/BOOK/05/2023*

Funding Agency



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Message

The Manual of Nursery Techniques for Forestry Species is a thorough document that will provide the users knowledge and abilities to grow healthy forests and contribute to sustainable land management. This manual will go-to resource for forestry experts, conservationist, or any person just interested in caring for forest and growing trees. The manuals elaborate the fundamental procedures of nursery techniques that are especially suited for forestry species and goes above and beyond, to provide the user a complete grasp of effective forestry nursery procedures.

This section of the book will walk you through the process of selecting and preparing a nursery site, including discussions on shading structures, soil analysis, irrigation frequency, etc. Producing healthy and robust seedlings depends on understanding the unique needs of individual tree species and designing the nursery environment accordingly.

The crucial methods for producing seedlings, including seed collection, processing, sowing, germination and transplanting have been detailed species-wise. Insights into bare-root seedlings production, containerized nursery systems and the role of nursery substrates in encouraging ideal root growth are provided in this guidebook. One may produce seedlings that are robust and ready for successful out planting, through effective implementation of these approaches.

I compliment the team of scientists and contributors of ICFRE who have dedicated their time and expertise to develop this comprehensive manual on Standard Operating Procedures for Nursery Techniques. This manual will be helpful to the officers and frontline staffs of the State Forest department of Odisha to embark on an enlightening journey through the world of nursery techniques for forestry species. Together, let us sow the seeds of sustainable and thriving forests.

Dated: 10 July, 2023


(Arun Singh Rawat)

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Foreword

Intricate ecosystems that sustain numerous species, offer crucial ecosystem services and play a critical role in reducing climate change, forests are more than just a collection of trees. We must arm ourselves with the knowledge and skills to grow healthy and resilient forests as our world faces tremendous challenges including habitat loss, climate change and deforestation.

The Manual of Nursery Techniques for Forestry Species fills a significant vacuum in the literature by providing experts, researchers and amateurs working on reforestation and forest restoration initiatives with a thorough and useful reference. This manual represents a larger perspective of sustainability and ecological resilience, it is more than just a collection of practices. It emphasizes the need of careful nursery site selection and suitable nursery management techniques to guarantee the growth of strong and healthy seedlings.

I would want to offer my appreciation to ICFRE whose efforts had made this manual possible. We have the means to forge a greener and more resilient future thanks to their combined efforts.

Dated: 10 July, 2023

(Debidutta Biswal)



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Preface

The Manual of Nursery Techniques for Forestry Species is a thorough manual that examines the complex art and science of growing trees for regeneration and sustainable forest management. We are excited to share it with you. This guidebook embodies our persistent dedication to safeguarding and regenerating our priceless forest ecosystems.

In addition to being a source of natural beauty, forests are crucial for the health of our world. However, the difficulties they confront, such as habitat deterioration, climate change and deforestation, demand our immediate attention and action. This guidebook serves as a useful tool to provide experts, researchers and enthusiasts with the information and methods necessary to grow strong and resilient forests.

You may find a wealth of knowledge on all facets of nursery operations within these pages. Our booklet covers nursery site selection, soil preparation and effective seedling production methods, providing helpful guidance to guarantee the growth of strong and healthy seedlings.

By following the guidelines outlined in this document, nursery personnel can consistently produce healthy seedlings, optimize efficiency and contribute to the preservation and sustainable management of forests. Ultimately, the implementation of SOPs is instrumental in maintaining and enhancing the invaluable environmental and societal benefits provided by forestry species..

I want to express my sincere gratitude the Scientists and contributors of Forest Research Institute, Dehradun who gave their time, knowledge and unshakable devotion to creating this comprehensive resource. Their combined efforts have resulted in a guidebook that will definitely lead the way for a future when our woods are more sustainable and wealthy advantages for communities.

Dated: 10, July, 2023

(Sanjeev Kumar)

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CHAPTER

1

Introduction

- What is a Nursery?
- Types of Nursery
- Essential Requirement for a Nursery



1.1 What is Nursery?

A nursery is an area where seedlings are produced or seeds are sown and seedlings are raised for the purpose of planting out for afforestation and reforestation purposes.

1.2 Types of Nursery

Based on the need and the management requirement, nurseries are classified into the following types-

i) Based on longevity/duration of operation

a) Temporary nurseries:

- A nursery is said to be a temporary nursery when it is set up for a specific period and to fulfill the seedling requirements of a smaller area.
- The seedlings produced are used for gap-filling or causality replacement and supplementing planting stock.

b) Permanent nurseries:

It is a nursery that is maintained for supplying nursery stock for a long time permanently.



Fig.1. Permanent nursery

ii) Based on water availability

a) Dry nursery:

It is a type of nursery in which a permanent facility for irrigation or artificial watering does not exist.

b) Wet nursery:

It is an irrigated nursery with a permanent source of water during the drier periods.

Once the nursery area is identified and selected, proper planning is essential to establish the nursery. A nursery should have all infrastructures to support quality seedling production.



1.3 Essential Requirements of a Nursery

1. **Protection fence:** The nursery area should be protected from the entry of cattle and intruders and also from heavy wind. For this, a chain link fence and a row of trees all around the nursery should be established.
2. **Office:** An office should be established for administrative purposes besides maintaining the records and stock registers.
3. **Store:** A store room for storing nursery tools, chemicals, fertilizers, polythene bags, etc. is very essential.



Fig. 2: Green House

4. **Storage Yard:** Nursery potting mixtures like compost, topsoil, sand, etc. need a 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 and water tanks (both underground and overhead) are required.
6. **Mist chamber:** For mass multiplication and efficient rooting of clones, an organized mist chamber is essential.



Fig. 3: Mist Chamber



7. **Hardening chamber:** The propagated plants from the 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 required for preparing cuttings and grafting before they are placed inside the mist chamber.
9. **Waste pit and compost yard:** To dump unwanted materials and prepare compost for use in the nursery.
10. **Green house:** Provides controlled temperature, irrigation, humidity and light conditions for better plant growth. It protects seedlings from an adverse environment.
11. **Shade/Net house:** The main purpose is to grow plants under protection from birds, insects, animals and human beings.
12. **Labour Shed/Maali Hut**

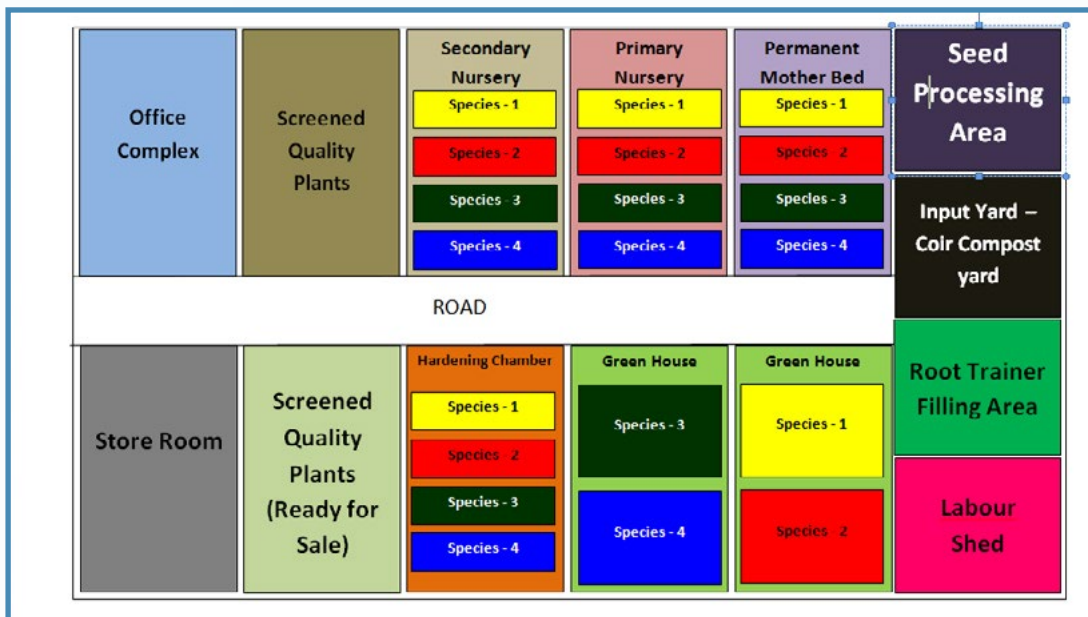


Fig. 4: Layout of a Nursery

13. **Inspection path.**
14. **Motorable road:** For transporting nursery materials like soil, sand, FYM, etc. for raising the nursery and for easy lifting of seedlings from the nursery to the planting site.
15. **Entry gate:** The entrance should be provided with a strong lockable iron gate.

CHAPTER

2

Site Selection and Preparation

- Criteria for Site Selection
- Site Preparation
- Size of Nursery Beds
- Types of Nursery Beds



2.1 Criteria for Site Selection

1

Area selected for nursery should be well drained and free from water logging.

2

There should be proper sunlight.

3

It should be near permanent source of water.

4

Area should be well protected from animals.

5

Sandy loam soils are most suitable.

6

Species raised in the nursery should be in their zone of natural occurrence.

7

Nursery should be free from permanent shade.

8

Nursery should have gentle slope.

9

Size of nursery should be according to the seedling demand and needs.

10

Adequate labour should be available.

11

The soil pH between 6.5 and 7.5 is preferred.

12

Nursery site should be free from floods, frost and heavy winds.



2.2 Site Preparation

- The site should be cleared properly by removing all the stumps, boulders, roots, grasses and large pebbles.
- The soil should be ploughed to a depth of about 30cm.
- Removal of topsoil should be avoided.
- The drainage channel should be dug as early as possible to avoid erosion.
- In plains, drainage should be adequately sloped to check the water flow.
- Mixing of soil with well-decomposed farmyard manure is necessary for getting the correct texture.
- Paths between the nursery beds can be 0.5m wide for human movement.
- Beds should be separated from the main path for vehicles.

2.3 Size of Nursery Beds

The size of the nursery bed varies from species to species and locality to locality. After the soil preparation, the seed beds are prepared for the sowing of the seed.

- The seed bed should be rectangular.
- The standard size of the bed is 12m × 1.2m (in plains)
- The width of the bed should not be more than 1.2m
- The bed should be in an east-west direction in the plains.
- The beds should be filled with soil: sand: FYM in the ratio of 1:1:1.
- The medium composed of soil: sand: compost in equal proportions produced the tallest and thickest seedlings (Bana *et al.*,1996)
- The various methods that can increase the physical, chemical and biological properties of the soil are:
 - ✓ Mixing well with decomposed FYM
 - ✓ Addition of humus/surface soil of the forest
 - ✓ Addition of compost
 - ✓ Use of fertilizers
 - ✓ Green manuring.

2.4 Types of Nursery Beds

1) Raised bed:

- Prepared in high rainfall areas.
- Beds are raised 15cm above the ground to increase drainage.
- Beds are given side support using bamboo, twigs, bricks, etc.



- Good for the seeds which do not require much moisture.
- Eg: *Phyllanthus emblica*, *Buchnanania cochinchinensis*, etc.



Fig. 5: Raised Beds

2) Sunken bed:

- Prepared in drier/arid areas to conserve moisture.
- Nursery beds are 10-15cm deeper than the normal ground level.
- Prevents outflow of rain water and reduces the rate of evaporation.
- Seeds with hard seed coat are sown in such beds.
- Eg: *Terminalia alata*, *T. bellirica*, *T. chebula*, etc.

Based on the plants growing on the beds, nursery beds are classified into:

- Germination bed:** Beds in which seeds are sown to raise seedlings.
- Transplant bed:** Seedlings from the germination beds are transplanted after germination takes place for further growth and development.
- Storage beds:** These beds are used for storing poly pots after seedlings have been pricked out into them from germination beds or trays.

Tall polybag nursery:

Tall seedlings are to be raised depending on the scheme, objectives and type of plantations. To have 5ft to 8ft high tall seedlings, two-year-old seedlings may preferably be used for plantations. In a few fast-growing species, even one and half-year-old seedlings may acquire 5ft to 8ft height. The main benefits of planting tall seedlings are:

- Quick establishment and crown development that is insurance against problems like grazing/ browsing and weed infestation.
- Relatively more resistant to diseases and pests as well as more likely to withstand adverse climatic conditions.



- Reduction in plantation cost in terms of barbed wire fencing, watch and ward and yearly maintenance cost, etc.
- Overall benefit and success rate will be higher.
- Less number of seedlings are required to be planted and thus saving cost.
- A full-grown plantation can be developed in a short time.

The following are preferable target places for planting tall seedlings:

- ✓ Strip plantations along the roadside, Canalside and Railway side.
- ✓ Avenue plantations
- ✓ Forest plantations, Enrichment plantations Block plantations, etc. where there are requirements for tall seedlings beyond the grazable or browsable limit.



Fig. 6: Sunken Beds

CHAPTER

3

Nursery Containers and Pots

- Growing Media
- Nursery Containers



3.1 Growing Media

There are different growing media that are being used for plant/ seedling propagation. Growing media is a combination of different materials. Better growing media produces good-quality seedlings that have a good survival rate. Components of growing media include:



Fig. 7: Bagasse



Fig. 8: Saw Dust

- ✓ Sand
- ✓ Soil
- ✓ FYM/ Compost
- ✓ Mycorrhizae



- ✓ Vermiculite
- ✓ Bagasse
- ✓ Peat
- ✓ Bark and sawdust
- ✓ Perlite.

The different potting mixtures used in forest nurseries are:

- Loamy soil: Sand: FYM: Vermicompost
- Loamy soil: Sand: Bio-fertilizers
- Loamy Soil: Sand: FYM: Vermicompost: Bio-fertilizers
- Loamy Soil: Sand: FYM: Vermicompost: Oil cakes: Bio-fertilizers
- Loamy Soil: Sand: FYM: Compost: Biofertilizers
- Loamy Soil: Sand: FYM: Oil cakes
- Loamy Soil: Sand: FYM: Oil cakes: Biofertilizers
- Loamy Soil: Sand: FYM: Leaf Mould: Oil cakes
- Burnt Rice Husk: Sand: Cowdung (1:1:1)

Nursery stocks can be planted out by two methods-

- 1) Entire Planting- It includes naked root planting, planting with ball of earth and container planting.
- 2) Stump Planting- For stump planting, seedling have to be maintained in the nursery for one year. Seedlings are uprooted, all the leaves and secondary roots are removed and stumps are prepared. This method is used for *Tectona grandis* and *Dalbergia sissoo*.

3.2 Nursery Containers

Containers are made up of different kinds of materials and in different sizes and shapes. The main objective of the shape and size of containers is to have improved root growth and morphology. The various types of containers are as follows:

1. Polythene bags:

- ✓ The size of polybags may vary according to the size of the seedlings to be raised.
- ✓ It may be black or transparent.
- ✓ Size: 23cm × 15cm, 30cm × 20cm (for larger seedlings)
- ✓ Polythene bags should have 7-10 holes at the lower half.
- ✓ These should be shifted in the nursery during the active growing season to prevent roots from penetrating the ground



Fig. 9: Polybags



Fig. 10: Polybags with Transplanted Seedlings

2. Root trainers:

- ✓ Used in both temperate and tropical forest regions.
- ✓ Have self-root pruning ability.
- ✓ Develops more secondary roots.
- ✓ It consists of cells in groups of about 16-30 (in a single frame).
- ✓ The lower end of the root trainers is open (called a drainage hole).
- ✓ Root trainers should be suspended on a wire frame above ground level.



Fig. 11: Root Trainers



Fig. 12: Root Trainers with Bamboo Seedlings

3. Dona containers:

- ✓ Leaf cups
- ✓ Made from leaves of Ficus, Mango, Bauhinia, etc.
- ✓ It should be filled with soil and FYM in equal proportion.

4. Baskets:

- ✓ Made of bamboo strips/ Tamarix which is used as plant containers.
- ✓ During transplanting, they are buried in the pits, along with the seedlings.



5. Earthen pots:

- ✓ Made locally, with or without bottoms
- ✓ It is costly and increases transporting cost.



Fig. 13: Earthen Pots



Fig. 14: Bamboo Pots

Eco-friendly Alternatives to Polythene bags in Nursery:

- Wooden boxes
- Peat fibre boxes
- Bamboo pots
- Jute bags
- Bamboo leaf sheath pots
- Coconut shells
- Paper bags and cloth bags

CHAPTER

4

Seed Sowing and Maintenance of Nursery Beds

- Quantity of Seeds Required
- Time of Sowing
- Methods of Sowing
- Maintenance of Nursery Beds



4.1 Quantity of Seeds Required

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.

The seed weight, size of beds, spacing and plant percent are the factors for calculating the number of seeds to be sown in nursery beds.

Where, The formula is: $W = \frac{A \times D \times 100}{P \times N}$

W = Weight of seeds required in grams

A = Area of nursery bed in square meters

D = Number of plants needed per m²

P = Plant percent of the species

N = Number of seeds per gram.

4.2 Time of Sowing

The time of Sowing depends on:

- Time of seed ripening
- The growth rate of species
- Size of plants for transplanting
- The climatic condition of the locality

Viability	Sowing time
Short viable seeds	Should be sown immediately
Long viable seeds	When the temperature is moderate i.e. between September to October or between February to March

Requirement	Sowing time
For small seedlings	Sowing time: Spring Transplanting: Rainy Season
For tall seedlings/ stumps	Sowing time: Rainy Season

4.3 Methods of Sowing

A. Broadcasting:

- Seeds are spread uniformly over the mother bed and covered to the thickness of the smallest diameter of the seed.
- Usually used for small seeds (*Eucalyptus*), light seeds (*Casuarina*) and seeds with poor germination percentage.



Fig. 15: Broadcasting

B. Line Sowing:

- To prevent overcrowding of seedlings.
- To produce healthy seedlings.
- Mainly used in case of those seedlings which are directly taken out from the mother bed to the main field.
- Lines are drawn on the mother bed and seeds are sown in these lines and covered with soil.
- For seedlings that are to be transplanted, the line distance is close when compared to those which is taken directly for out planting from the mother bed.
- Recommended for the species having high germination percentage.



Fig.16: Line Sowing



C. Dibbling

- Adopted for bigger-sized seeds with high germination percentage.
- In the case of seeds with low germination, seeds are dibbled with an increased number per drill.
- Seeds are sown into the containers by making a hole to a depth of one centimeter.
- Seeds dibbled at greater depth will have delayed germination / be killed due to lack of water or air.



Fig.17: Dibbling

TIPS FOR SOWING:

- ✓ Sowing time - early in the morning or late evening.
- ✓ Beds and containers should be watered and soaked thoroughly before sowing.
- ✓ Seeds should be sown at shallow depth.
- ✓ In general the depth of seed sowing should not be more than double the size of seed.
- ✓ Treat the seeds with some fungicides to prevent fungal disease and ant removal.
- ✓ Scarified seeds should be given a coating of microbial cultures like *Rhizobium* to produce healthy seedlings.
- ✓ When pre-sprouted seeds are sown, care should be taken to see that the sprouts are not damaged.



4.4 Maintenance of Nursery Beds

i. Weeding:

- ✓ Weeds compete with the seedlings for nutrients and water.
- ✓ Weeds should be removed on time to reduce competition.
- ✓ Weeds should be removed by uprooting.
- ✓ Seedling damage should be avoided.
- ✓ It helps in loosening the soil which provides aeration and reduces runoff.

ii. Shading:

- ✓ To protect the top surface of the soil from drying up.
- ✓ To protect the young seedling from scorching sunlight.
- ✓ To protect the frost-tender species in the initial stages, temporary shade houses are erected over the mother beds.
- ✓ Shade houses can be erected permanently to cater to the protection needs of germinating seedlings.

iii. Hardening off:

- ✓ To reduce the mortality rate.
- ✓ It is done by reducing the watering, shade, etc.
- ✓ To withstand the harsh climatic conditions in the field after transplanting.

iv. Watering/ Irrigation:

- ✓ Necessary for proper growth of seedlings.
- ✓ Over-watering and under-watering are harmful.
- ✓ For most species: one irrigation per day is adequate.



Fig. 18: Sprinkler Irrigation irrigation



- ✓ During winter: one irrigation in 2-3 days.
- ✓ Best time: early morning or late in the evening.
- ✓ Polythene bags containing seedlings should be adequately watered.
- ✓ Different methods of watering nurseries are:
 - Can irrigation
 - Atomizer irrigation
 - Sprinkler irrigation
 - Flood irrigation: The seed bed is flooded with water. This method of irrigation is adopted in dry/arid regions where sunken beds are formed for conserving moisture.
 - Percolation: Water is allowed to stand around raised narrow beds so that moisture percolates throughout the beds from the sides.



Fig. 19: Can Irrigation

CHAPTER

5

Pricking Out

- General Guidelines
- Advantages of Pricking Out
- Pricking Out Seedlings in Polybags
- Shifting of Plants and Root Pruning



5.1 General Guidelines

- Seedlings can be transplanted to containers or transplant bed.
- It should be carried out when seedlings have 2-3 pairs of leaves.
- Late transplanting can cause the death of seedlings due to root damage.
- Transplanting should be done in the shade.
- Transplants should be kept in the shade for one week for their establishment.

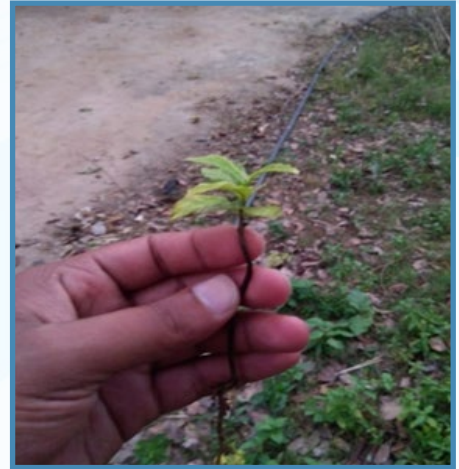


Fig. 20: Seedling used for Pricking Out

5.2 Advantages of Pricking Out

- ✓ Produces efficient root system.
- ✓ Based on the species, spacing can be adjusted/ varied.
- ✓ Wider and regular spacing between plants helps in the development of healthy seedlings.
- ✓ Makes seedlings more hardy.
- ✓ The desired size of plants can be obtained in a shorter time.



Fig. 21 & 22: Transplanted Seedlings

5.3 Pricking Out Seedlings in Polybags

Shifting of seedlings grown in germination beds to polybags requires care and observance of the following:

- ✓ Pricking into polybags should be done in cool, cloudy weather or during evenings.
- ✓ Thoroughly water the filled polybags to settle the soil before pricking seedlings into these.
- ✓ Lift the seedlings from the germination bed using a stick to prevent the breaking of the roots.
- ✓ Make a deep hole to accommodate the roots of seedlings in the polybags using a stick.



- ✓ Insert a stick in the hole and then lift the seedling slightly to open out the roots.
- ✓ When planting the seedling in polybags, make sure that the taproot is not bent.
- ✓ Irrigate the polybags well after planting seedlings.

Pricking of seedlings from germination beds to polybags provides the first opportunity for grading and ensuring quality planting material. Thus,

- Select seedlings with a straight tap root. Discard seedlings with bent taproot (J root), or the ones with a few root hairs.
- The seedlings should have straight and stout stems and well-formed apical buds.
- Do not use diseased/ deformed seedlings. Such seedlings should be taken out from the nursery program and destroyed/ culled.

5.4 Shifting of Plants and Root Pruning

Polybags with seedlings are usually kept in nursery beds in rows. Keeping plants in one place for a long is likely to result in their roots striking through the drainage holes of the polybags into the bed soil. Such outgrown roots, at the time of lifting of polybags for planting out, tend to break resulting in the plants suffering from shock, adversely affecting their survival in the field. The polybags, therefore, need to be periodically shifted and outgrown roots pruned to prevent roots from striking the bed soil.

At the time of shifting, always remember to-

- Trim any roots that might have emerged from the polybag. This trimming should be done with sharp knives/ secateurs to avoid any injury to the plants.
- Start lifting the polybags from one end of the bed. If roots have already struck the bed soil, don't pull the roots out. Rather tilt the polybag to one side and carefully cut the roots below the polybag by using a trowel or sharp knife.
- Hold the plant for pruning of roots in a way so as not to cause any disturbance to the root system in the polybag.

Root pruning also triggers the growth of smaller roots in the poly bags and helps plants gain better collar diameters and become sturdy. Such root pruning and shifting polybags 1 or 2 months before planting out are highly recommended to prepare the plants for field conditions.

The best time for shifting and root pruning is just before the onset of monsoons and/or in winter before the new flush of leaves starts emerging.

Grading of Plants:

An associated activity with the shifting of polybags is the size-wise grading of plants. The plants kept in close rows tend to have fierce competition for sunlight making some plants grow taller than others. Size-wise grading at the time of shifting helps the plants to have better exposure to sunlight for optimum growth of plants.



Table.1: Time of Sowing and Germination Period in Nursery for Some Forest Species of Odisha

Species	Time of sowing (Month)	Normal germination period in the nursery (days)
<i>Acacia catechu</i>	March-April	40
<i>Adina cordifolia</i>	May	30
<i>Aegle marmelos</i>	May-June	21
<i>Anogeissus latifolia</i>	April-May	15
<i>Artocarpus heterophyllus</i>	June-July	21
<i>Buchanania cochinchinensis</i>	May-June	15-23
<i>Dalbergia sissoo</i>	March	10-15
<i>Madhuca indica</i>	July-August	15
<i>Michaelia champaca</i>	September-October	60
<i>Pongamia pinnata</i>	July-August	30
<i>Pterocarpus marsupium</i>	June	55
<i>Pterocarpus santalinus</i>	May-June	35
<i>Terminalia alata</i>	April-May	25
<i>Terminalia arjuna</i>	April-May	12-13
<i>Terminalia bellirica</i>	March-April	30-60
<i>Terminalia chebula</i>	June-July	90

CHAPTER

6

Protection Against Diseases and Insect-Pests

- How to Prevent Diseases and Pests in a Nursery?
- Cultural Methods of Nursery Disease Management
- Seed Dressing
- Chemical Methods of Nursery Disease Management
- Biological Methods of Nursery Disease Management
- Common Nursery Diseases and Their Management
- Common Insect Pests of Forest Nurseries and Their Management



6.1 How to Prevent Diseases and Pests in a Nursery?

- Clean seeds should be used.
- Avoid collecting fallen seeds from the ground, as it may carry soil-borne pathogens.
- To prevent seed or seedling diseases, treat the seed with hydrogen peroxide solution (3%) before sowing.
- Remove the plant debris before sowing.
- Use only clean containers such as root trainers, pots, etc.
- Overwatering should be avoided.
- Irrigation should be done in the morning.
- Reduce the humidity within the leaf canopy to prevent the development of foliar diseases.
- Use separate propagation structures for plants with very different environmental requirements.

6.2 Cultural Methods of Nursery Disease Management

- Avoid using the same bed for the propagation of the same species.
- Avoid the continuous shade.
- Maintain proper spacing between plants.
- Fertilizer application based on prior soil testing and soil health status.
- Use healthy seeds for germination.
- Use organic manure.
- Regular weeding should be done.
- Use well-drained seed beds, Practice adequate watering.
- Eradication and burning of infected plants.

6.3 Seed Dressing

- The seed is dressed with either a dry formulation of fungicide (non-systemic, Thiram at 0.3% or systemic, Bavistin, Benlate, etc. at 0.02% by seed weight) or wet-treated with a slurry or liquid formulation.
- For orthodox species, dry the seeds to a moisture content of 5-6% after treatment and store the seeds in a refrigerator.
- For recalcitrant species, sow the seeds immediately after treating them with fungicides.



Advantages of seed treatment:

- ✓ Protect seedlings from both seeds as well as soil-borne pathogens.
- ✓ **Precision targeting:** Seed treatments are not subject to spray drift and little is wasted on non-target sites, such as bare soil.
- ✓ **Optimum timing:** Applying treatments to seeds allows pesticides to be present when needed most.
- ✓ **Low dose:** Relatively small amounts of pesticides are used in seed treatments compared to broadcast sprays.
- ✓ **Easy to apply:** Seed treatments are relatively easy and cheap to apply.

6.4 Chemical Methods of Nursery Disease Management

Different types of fungicides and insecticides are used in forest nurseries to control diseases and insect-pest attacks. Fungicide is a chemical or physical agent that kills or inhibits the growth of fungi. Two types of fungicides are used to control nursery disease:

Systemic fungicide: A fungicide that is absorbed into plant tissue and may offer some after-infection activity, i.e., Bavistin, Movement in the plant varies by fungicide, from moving to old and new tissues (true systematic), new growth and moving from the top to the bottom of the leaf surface.

Contact fungicide: A fungicide that remains on the surface where it is applied but does not go deeper. They provide a protective barrier that prevents the fungus from entering and damaging plant tissues; these fungicides have no after-infection activity, i.e., Thiram.

Control of diseases:

- ❖ Periodical spray of insecticides and fungicides is essential.
- ❖ Commonly used fungicides and insecticides are :
 - Capton
 - Zineb
 - Bilttox
 - Cumin
 - Dithane
 - M-45
 - Thimet
 - Chloropyrphos

Protection against white ants:

Chloropyriphos 20 EC should be sprayed after mixing 3-4 litres of insecticides in 1000 litres of water.

Control against rats:

Zinc phosphide or Aluminium phosphide.



6.5 Biological Methods of Nursery Disease Management

The reduction of pest populations by natural enemies typically involves an active human role.

Biological control agents (BCAs): In simple words, it is one living organism that manages another. In the case of plant diseases, they are most often referred to as antagonists. Actinomycetes, bacteria (*Pseudomonas*, *Bacillus*, etc), fungi (*Trichoderma*, *Beauveria*, etc), nematode (entomopathogenic) and viruses (Baculoviruses) are popular BCAs. Natural enemies of insect pests include predators, parasitoids and pathogens.

Integrated pest management (IPM): It is a broad-based approach that integrates management practices for economic control of pest.

With the introduction of synthetic pesticides in the 1950s, it was easy to control pests. There were problems associated with the use of pesticides such as resistant pests, non-target effects on beneficial organisms, environmental pollution, health issues, etc. Biological control is nothing but the ecological management of a community of organisms. It involves harnessing disease-suppressive microorganisms to improve plant health. Disease suppression by the use of biological agents is the sustained manifestation of interactions among the plant (host), the pathogen, the biocontrol agent (BCA, antagonist), the microbial community on and around the plant and the physical environment.

Application of BCAs can result in levels of disease suppression between 79-98% depending on the BCA. Example: *Trichoderma harzianum*, *T. koningii*, *T. viridae* (isolates) based formulations are currently being used for seed diseases, foliar spray, soil treatment and cuttings treatment. One of the problems with biocontrol is the lack of consistency in disease suppression. Using the mixtures of BCAs can increase the consistency of biocontrol across sites with different conditions.

Advantages:

- Biological control is less costly and cheaper than any other methods.
- Biocontrol agents give protection to the crop throughout the crop period.
- They are highly effective against specific plant diseases.
- They do not cause toxicity to the plants.
- The application of biocontrol agents is safer for the environment and for the person who applies them.
- They multiply easily in the soil and leave no residual problem.
- Biocontrol agents can eliminate pathogens from the site of infection.
- Biocontrol agents not only control the disease but also enhance the root and plant growth by way of encouraging the beneficial soil microflora.
- Biocontrol agents are very easy to handle and apply to the target.
- Biocontrol agents can be combined with biofertilizers.



6.6 Common Nursery Diseases and their Management

1) Damping off:

- **Causal organisms:** *Pythium*, *Phytophthora*, *Fusarium*
- **Symptoms/Damage:** The infection takes place at the base of the young stems or the soil level. Tissues become water soaked and rapidly collapse thus topping the seedlings. These pathogens cause pre and post-emergence damping off and cause the mortality of seedlings.
- **Management:** Drench the seedling beds with Dithane M-45 (0.01%; 1g/10 liters of water). Repeat the treatment two times at 20 days intervals.

2) Wilt:

- **Causal organism:** *Fusarium*
- **Symptoms/ Damage:** Start with the yellowing of leaves. Affected seedlings will die within 48 hours.
- **Management:** Burn diseased plants. Avoid excess watering of the beds. Use 0.01-0.02% solution of Bavistin/ Dithane Z-78 at monthly intervals.

3) Root-Rot:

- **Causal organism:** *Fusarium*, *Phytophthora* and *Rhizoctonia*
- **Symptoms/Damage:** The plant starts wilting initially, dark spot on the stem, leaves start yellowing and roots completely rot.
- **Management:** It can be controlled by Dithane M-45 or Bavistin at monthly intervals.

4) Collar-Rot:

- **Causal organism:** *Botryodiplodia theobromae*
- **Symptoms/Damage:** It starts with a collar with small spots over the collar. Black pycnidia can be observed in an upward direction. The disease is most prevalent in dry conditions.
- **Management:** It can be controlled by soil drenching with Dithane Z-78 (0.2%).

5) Powdery Mildew:

- **Causal organism:** *Uncinula spp.*
- **Symptoms/Damage:** White chalky appearance can be observed on the upper surface of the leaves which spread through spores very rapidly.
- **Management:** It can be controlled by sulphur-based fungicides. Karathane at 0.05% spray on leaves at the interval of 20-30 days.

6) Leaf spot/ Leaf blight:

- **Causal organism:** *Alternaria*, *Colletotrichum*, *Cercospora*



- **Symptoms/Damage:** Small circular dark spots, as the disease progresses, spots grow larger.
- **Management:** Captan, Mancozeb and Thiram at 0.02% concentration.

6.7 Common Insect Pest of Forest Nursery and their Management

The major insect pest of forest nurseries and their management is shown in Table 2.

Table 2. Insect Pests of Forest Nursery

Common name	Nature of damage	Management
Cutworms	<p>Larvae cut off young seedlings soon after germination usually in March-April.</p> <p>Feed on young seedlings during night, cutting them off, at the ground level.</p> <p>Life cycle: Nocturnal in habit and remain hidden during the day. They come out from hiding in the evening, dusk and lay eggs in small batches on ground litter, humus. Eggs hatch in 2 days in summer and in about 7-8 days in winter. The larval period varies from 20-35 days.</p>	<ul style="list-style-type: none"> • Collection and destruction of larvae hidden under soil, debris, leaves, stems, etc. • Digging in early winter exposes the hibernating larvae to frost and causes a decline in their population. • Flooding the nurseries so that larvae come out of tunnels. Collect them and dispose off. • Proper weeding of nursery beds prevents egg laying by the moths. • Drenching of nursery beds with Chlorpyrifos (0.04%).
Termites	<p>Termites attack mainly the upper 20 cm of the soil layer. Termites feed on the tap roots and result in tapering and complete severance of the root system. The seedlings become yellow and wilt and die. One-year-old seedlings are severely damaged.</p> <p>Life cycle: Winged forms emerge out from their nest during early monsoon.</p>	<ul style="list-style-type: none"> • The site for forest nurseries should be free from wood debris, termite nests, etc. • Strong silvicultural practices should be followed which promote vigorous growth of plants, as such plants can withstand termite attack to a great extent. • Drenching of beds and termite mounds with Chlorpyrifos (0.04%).



Common name	Nature of damage	Management
White grubs	<p>They feed on the roots and rootlets of seedlings in forest nurseries. They disrupt the soil around the growing plants and disturb the root system and cause loss of moisture necessary for root growth. With their movement they loosen the soil surface, resulting in loose and porous soil. Roots become dry and cause the death of the seedling.</p> <p>Life cycle: They emerge with the onset of monsoon. The incubation period varies from 10- 15 days. The eggs and larvae can be seen simultaneously in the soil 4-6 weeks after the first rain shower in summer.</p>	<ul style="list-style-type: none">• Deep ploughing of nursery beds in winter so as to expose the grub population to predators and sunlight.• Sowing should be done when the beetles are not on the wings.• Use of light traps during adult emergence from 7.30 pm onwards for about 20 days.• By shaking the branches of host plants and collecting the beetles and killing them in keratinized water.• Drenching of nursery beds with chlorpyrifos (0.04%).
Defoliators	<p>Leaf-feeding beetles damage the foliage of nursery stock. Adult beetles are polyphagous feeders of foliage, flowers and fruits.</p> <p>Leaf rollers are an important group of defoliators. An adult female rolls a leaf by cutting it across near its base from the opposite edges. The larvae feed on the inner surface of the soil. The infected leaf falls or remains suspended. Some larvae feed on leaf tissues except the larger veins.</p>	<ul style="list-style-type: none">• A spray of monocrotophos (0.036%) gives a good result in controlling the defoliators.• A foliar spray of Endosulfan, Fenitrothion, or Malathion (0.1-0.2%) water emulsion can also be used for effective control of defoliators.



Acacia catechu (L.f.) Willd.

Family: Fabaceae **Local name:** Khair

General description:

Acacia catechu is a small to moderate-sized deciduous tree. The tree occurs in tropical and subtropical climates in plains and low hills up to 1200 m altitude in north and central India in areas of 500 to 2160 mm rainfall. The most important product obtained from khair is Katha, which is used in pan preparations and in medicine.



Fig. 23: *Acacia catechu* flowering

Pre-treatments:

- Soaking seeds in cold water for 24-48 hrs.
- Soaking seeds in cooling boiled water for 6 hrs.
- Soaking in sulphuric acid (5-7%).
- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Techniques:

- Generally propagated by seeds in nursery beds or polybags
- Seed sowing months: February- March.



- Seed beds must have well-drained sandy loam soils.
- In nursery beds, line sowing is preferred.
- Spacing between lines should be 20 cm and 2 cm between the seeds in line.
- The depth of sowing is 0.5 cm.
- Healthy seedlings should be pricked out from the nursery bed and transplanted into the polybags (10cm × 15cm).
- **Polybag sowing:** Seeds should be sown at a depth of 1.5 cm in February-March. 2 seeds should be sown in one polybag and each polybag should be filled with sieved soil and compost in the ratio of 2:1.
- Regular weeding and watering should be done.
- Germination commences in 5-7 days.
- When the plant had grown to a height of about 15 cm, nitrogenous fertilizer like calcium ammonium nitrate of 2 g is added to every plant about 4 times during May-June.



Adina cordifolia (Roxb.) Benth

Family: Rubiaceae **Local Name:** Karam (Hindi), Holondo (Oriya)

General description:

Adina cordifolia is a large deciduous tree. It usually grows on sandy loam and clayey loam soils. A light-demanding tree, growing best on freely drained soil. It grows in a wide range of soils and will tolerate soils with high pH values of up to 8.3. It is susceptible to frost damage and fires.



Fig. 24: *Adina cordifolia*

Pre-treatments:

- Pretreatment is not required.
- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Techniques:

- Time of sowing: March-May
- Broadcasting of seeds should be done in raised beds as the seeds are very minute.
- Soil Mixture: Soil: Sand: FYM in 1:1:1 ratio, covered with a fine layer (2cm) of sand.
- Seeds mixed with ash sown during March-May.
- Germination takes place in 3 to 6 weeks.
- Regular light watering is done and care should be taken to avoid washing away tiny seeds.



- Organic pesticides like Neem leaf extract can be used for protection against insects and pests.
- Partial shade is provided in hot climates.
- Two-month-old seedlings should be pricked out and transplanted into polythene bags for hardening and afterward for eventual planting out.
- Soil Mixture in Polybags: Sand: Soil: FYM in 1:2:1 ratio.
- Regular watering twice a day.
- Root cutting, grading and re-setting of poly pot seedlings are done at regular intervals of about 30 days.
- The poly pots should be kept in nursery beds, on polythene sheets to prevent root penetration into the soil.
- Shade is provided using agro-green shade net in hot climates.



Aegle marmelos (L.) Correa

Family: Rutaceae **Local name:** Bel (Hindi), Bilwa (Oriya)

General description:

It is a small to moderate-sized deciduous tree with branches armed with spines. It is found typically on stiff, dry clayey, alluvial soils, after growing gregariously. It is found wild almost throughout India, except in the arid zone of Rajasthan and the high rainfall zone of the Western Ghats.



Fig. 25: *Aegle marmelos*

Pre-treatment:

Pre-soaking of seeds in the water for 4 hrs.

- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Techniques:

- The seeds should be sown in nursery beds and covered lightly with earth during May - June.
- The seed beds should be watered daily.
- Seedlings from germination beds are pricked out at a stage of 2-3 pairs of leaves and transplanted in the containers.
- Pricking out healthy seedlings from the mother bed and transferring them to polythene bags after two months.
- Seedlings are most commonly raised in containers, i.e. polybags and root trainers.



- Only one seedling is allowed to grow per container.
- **Vegetative planting:** Root suckers can be used for vegetative propagation. Root suckers can be planted in polythene bags containing sand, soil and FYM in a ratio of 1:1:2.
- Daily watering is required.



Anogeissus acuminata (Roxb. Ex DC.) Guilum. & Perr.

(Syn. *Terminalia phillyreifolia*)

Family- Combretaceae Local name- Phasi

General description:

It is a deciduous tree with a narrow crown and can grow up to 40m. Its long, straight bole is unbuttressed and can be 100cm in diameter. A deciduous tree with rough dark grey bark and drooping branches. The tree is harvested from the wild for timber. Its habitat is tropical lowland open forests or semi-deciduous forests at elevations below 700m. It is found particularly in deep humus-rich, loamy soils, along streams of river banks.



Fig. 26: *Anogeissus acuminata*

Pre-treatment:

- Pre-soaking of seeds in water for 24 hrs.
- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Techniques:

- Sowing pre-germinated seed in the sandbox or sand bed is necessary.
- Pre-germination seed beds are raised above the general land level to improve soil aeration and drainage.
- River sand is used in the beds, which are 0.9 meters wide, 3.0 meters in length and 20 cm. high.

Fruit/ seed collection time	July-October or until March
Germination days	7 - 10

- Sowing method: Line sowing.
- Line sowing depth: 1 cm depth.



- Spacing: 5 cm apart.
- The seeds are spread thinly in the lines.
- The seeds are then covered with loose sand.
- Watering is done with a fine spray.
- Seed germination commences: after 7-10 days.
- The germinated seeds are transferred to the pot after it produced two pairs of leaves.
- Partial shade is constructed with posts and bamboo at a height of 2 meters from the ground with 18% available light.
- Normally three to four weeding are necessary.
- It is advisable to fumigate the soil mixture with a re-emergence weedicide before potting.
- Even though the seedlings may appear healthy and free of pests or blight, it is necessary to protect them by spraying fungicide fortnightly.



Anogeissus latifolia (Roxb. Ex DC.) Guilum. & Perr.

Family : Combretaceae **Local name:** Bakli (Hindi), Dhavada (Oriya)

General description:

It occurs widely throughout Odisha as a principal species of dry deciduous forest. Identified by greenish or greyish spotted white bark exfoliating in irregularly rounded scales and copper red foliage in cold weather. The species is recommended for plantation in sandy loams, poor arid kankar soils and alluvial soils. It avoids badly drained ground and soil with low pH and very little calcium. It is a light demander, fire resistant and produces copious root suckers.



Fig. 27: *Anogeissus latifolia*

Pre-treatment:

- Pre-soaking in normal water for 48 hrs.
- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Techniques:

- Seed sown in April- May.
- Pre-treated seeds are broadcasted in prepared nursery beds.
- Seeds can be coated in ash before sowing.
- Potting mixture is used as soil, sand and FYM in a 1:2:1 ratio.
- Germination starts in 15-20 days.
- Healthy seedlings should be pricked out from the mother bed and transferred to polythene bags after 40- 45 days.
- Seedlings can be transplanted directly to the field after 12- 14 months.



Fruit/ seed collection time	January-February and July- August (Twice a year)
Nursery sowing	March-May
Planting season	July
Germination days	15-20

- **Stump planting:** The stump should be prepared from a one-year-old seedling. The shoot and root size of the stump should be 40cm and 60 cm respectively.
- **Vegetative propagation:** Suitable shoot size for vegetative propagation is 10-20 cm. Shoots are dipped in 50 ppm IBA for 24 hours. Shoots are planted into polythene bags containing Sand: Soil: FYM (1:1:1) mixture. Initiation of rooting after 5-6 weeks.



Artocarpus heterophyllus Lam.

Family name: Moraceae **Local name:** Katahal (Hindi), Panas (Oriya)

General description:

It is grown by tribals and farmers for its fruits. It grows on a variety of soils. Identified by thickly coriaceous, dark green, shining leaves and fruits developing on the stem.



Fig. 28: *Artocarpus heterophyllus*

Pre-treatment:

- Pre-treatment is not required.
- As the seeds are recalcitrant, sow the seeds immediately after treating them with fungicide.

Nursery Techniques:

- 2 to 3 healthy seeds are dibbled in the center of poly pots filled with soil mixture during July.
- Mulching is provided to facilitate germination.
- Regular watering twice a day is to be followed.
- Root cutting, grading and re-setting of poly pot seedlings are done in the nursery at regular intervals for about 30 days.
- The poly pots are kept in the nursery beds on polythene sheets to prevent root penetration into the soil.



- Shade is provided preferably using agro-green shade net in areas with hot climates.

Fruit/ seed collection time	May - July (Rainy season)
Nursery sowing	June-July
Germination days	21

- **Vegetative propagation:** Soft wood grafting for large-scale propagation of jack fruit tree can be done by cleft grafting during July-August on 4-month-old seedling rootstock.



Bridelia retusa (L.) A. Juss.

Family: Euphorbiaceae **Local name:** Kasi

General description:

Found in the forests throughout the state. Identified by rigid coriaceous leaves with straight parallel lateral veins and strong spines on the bark of young stems. It is a drought-hardy species, produces root suckers and a good coppice.



Fig. 29: *Bridelia retusa*

Pre-treatment:

Soak the seeds in cold water for 24 hours or overnight soaking in hot water.

Nursery technique:

- Sowing method: line sowing.
- Sowing depth: 0.6 to 10 cm in lines.
- Spacing between lines: 6 to 8 cm.
- Spacing between seeds: 5 cm.
- Germination starts after 25 days of sowing and continues up to 60 days.
- Seedlings are pricked out from the mother bed at three leaves stage and transplanted in polybags.
- It should be transplanted under shade.
- Irrigation: Once a day.

Fruit/ Seed collection time	December- January
• Weeding and spraying of insecticides are carried out as per requirement.	
• The seedling's growth at the initial stages is very slow (5 to 8 cm in the first season).	



Buchanania cochinchinensis (Lour.) M.R.

Family: Anacardiaceae **Local Name:** Chironji (Hindi), Charu (Oriya)

General description:

Common in our forests mostly in eroded ravine lands and occurs with species like *Soyamida febrifuga*. It avoids waterlogged areas but occurs locally in clay soils. Identified by dark grey crocodile bark with red blaze. A good species to plant on bare hill slopes. It has poor coppicing capacity and produces root suckers sparingly.



Fig. 30: *Buchanania cochinchinensis*

Pre-treatment:

Seeds are dipped in diluted sulphuric acid (5-7%) for 10 minutes.

Nursery Techniques:

- Generally propagated by seed.
- Seeds are sown in raised beds/containers during June-July.
- Seeds are dibbled about 0.5cm to 1cm deep.
- Freshly collected seeds are to be sown in well-drained nursery beds.
- Germination commences in 10-15 days and completes in about 30 days.
- Regular weeding of sown beds is essential.
- Seedlings from the mother beds are pricked out at the stage of 2-3 pairs of leaves and transplanted into containers.



Fruit/ seed collection time	April-May
Nursery sowing	June- July
Germination days	15-30

- Seedling is sensitive to frost; cannot withstand excessive dampness; fairly resistant to drought and moderate light demand.

Time for planting out: Seedlings will be ready for planting out after one year.



Careya arborea Roxb.

Family: Lecythidaceae **Local name:** Kumbhi (Hindi), Kumbh (Oriya)

General description:

Found throughout the State in the moister part and the ravines and valleys. It is abundant in the Mayurbhanj district, Sambalpur district. It is identified by leaves turning red in the cold season, dark grey thick bark and large showy flowers. It occurs both on alluvial soils and loams. It also occurs on lateritic soils. It is a fire-resistant species. It is a good coppicer.



Fig. 31: *Careya arborea*

Pre-treatment:

- Pre-soaking in normal water for 12 hrs.
- As the seeds are recalcitrant, sow the seeds immediately after treating them with fungicides.

Nursery Techniques:

- Seeds are sown in July.
- Sown in patches or pits.
- Depth is 1.5cm and spacing is 2m apart.
- Weeding is essential.
- Germination starts after 30- 40 days.
- Root cutting, grading and re-setting of poly pot seedlings are done in the nursery.
- The poly pots are kept, in the nursery beds, on polythene sheets to prevent root penetration into the soil.



- The suitable polythene bag size is 10cm × 6cm.
- Shade is provided using agro-green shade net in areas with hot climates.

Seed collection	June- July
Seed Sowing	July
Germination days	30-40

- **Time for planting out:** Seedlings are planted during July of the following year after attaining a height of 50 to 60 cm. Seedlings should be kept in a nursery for more than one year for better survival in plantation areas.



Dalbergia sissoo Roxb. ex DC.

Family: Fabaceae **Local name:** Shisham (Hindi)

General description:

It is a medium to large-sized deciduous tree and attains a height of 30 m. It is one of the important timber species in India. It is a strong light demander from the seedling stage. It is a tree of tropical and subtropical climate and grows throughout India except in temperate climates. It grows well in a wide range of soil types, from pure sand and gravel to rich alluvial soil of riverbanks.



Fig. 32: *Dalbergia sissoo*

Pre-treatment:

- Pre-treatment of seeds is not required, but soaking in water for 12-24 hrs accelerates germination.
- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Techniques:

- Seedlings can be artificially propagated by direct sowing, entire planting, stump planting and other vegetative methods.
- Stump planting is the best method known.
- Line sowing of seeds is done during February-March on raised beds.
- Seeds are sown 5 cm apart in each line.
- Seeds should be lightly pressed into the soil and covered with 2 to 4 mm of sand/grass straw.
- Nursery beds are prepared to measure 12 m X 1.5 m and have 10 cm spacing.



Fruit/seed collection time	November-March
Nursery sowing	February-March
Planting season	July- August
Germination days	10-15

- Regular watering is required.
- The mixture of soil, sand and FYM in a proportion of 1:1:1 covered with a fine layer (2 cm to 4 cm) of sand.
- **Entire planting:** Done only in special cases such as arid areas, areas infested with tall grasses, wet sides, or along the roadsides. Planting is done in summer rains.
- **Stump planting:** For the production of stumps, 12-16 months of seedlings are required in the nursery. The stump planting period is extendable from July to September. The best time for planting is the rainy season. Stumps are spaced 1.8 m apart in lines on trenches which are 3 m apart from row to row.
- **Time for planting out:** Seedlings should be planted out during June-July.



Gmelina arborea Roxb.

Family: Lamiaceae **Local name:** Gambhari

General description:

G. arborea is a fast-growing tree, that grows well on deep, loamy, clay loams calcareous and moist soils with optimum rainfall from 1800 to 2300mm per annum and temperature ranges from 12 to 45°C. It is found throughout the state mainly in deciduous forests but never occurs gregariously. Identified by light grey bark, broad-ovate acuminate leaves with cordate base and the presence of 2 to 4 shining prominent glands on the undersurface of the leaves between the primary nerves.

It shows a preference for fertile, deep, well-drained, sandy loam soils in moist valleys.



Fig. 33: *Gmelina arborea*

Pre-treatment:

- The seeds have no dormancy and no pretreatment is required. However, soaking the seed in cold water for 24-48 hours.
- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Techniques:

- Seeds are sown directly in the root trainer or raised beds.
- Germination beds with a mixture of sand and loam and covered with a thin layer of sand or compost.
- Raised beds can be 0.6 m in height and 1m within convenient length.
- The bed should be filled with sand up to a height of 0.5 m.
- The seeds are closely placed in the bed in rows with a gap of 5 cm.
- Germination occurs in 7-21 days after sowing.



- When the first pair of leaves appear, seedlings are ready for pricking out from the mother bed and transplanting to poly bags.
- Poly bag of 10×15 cm is widely used.

Fruit/ Seed collection time	April- June
Nursery sowing	May
Planting season	June- July
Germination days	21 days

- Root pruning and hardening off of the seedlings are beneficial for maximum field survival.
- After germination, the seedlings are pricked out and transplanted into containers for hardening of seedlings and for easy transportation to the plantation site.
- **Time for planting out:** Seedlings should be planted out during June-July.



Grewia tiliifolia Vahl.

Family- Tiliaceae **Local name -** Dhaman

General Description:

Dhaman is a moderate-sized to large tree, attaining a bole length of about 30 ft and a girth of 7 ft. or more. Bark grey or dark brown. The leaves of dhaman are oblique heart-shaped.



Fig. 34: *Grewia tiliifolia*

Pre-treatment:

- Pre-soaking of seeds in water for 24 hrs.
- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Techniques:

It can be propagated by seeds.

- The time of seed sowing is March -April.
- Sowing should be done in sunken beds as moisture is needed for germination.
- Sowing method: Dibbling.
- The seeds are spaced about 10 cm apart in lines.
- Sowing depth: about 2 cm deep in lines 15 cm apart.
- Transplanting of nursery-raised seedlings can be done by cutting or planting stumps.
- Germination starts in about 10 days and takes a month to complete.
- Watering twice a day enhances germination percentage. Watering is done regularly till germination is over.



- The growth of the seedlings is fairly fast and they attain a plantable height of 30 cm or more by July.

Fruit/ seed collection time	March-May
Seed sowing	April- June
Germination days	10-30

- For stump planting: 15-month-aged seedlings are used.
- **Vegetative Propagation:** It can be successfully propagated by cuttings, under intermittent mist. The technique used for mass multiplication of cuttings for plantation and seed orchard establishment. It can also be propagated by air layering.
- **Time for planting out:** Planting is done at the onset of the monsoon. Seedlings uprooted from the nursery with balls of the earth are wrapped in moist gunny bags and transported safely.



Lagerstroemia parviflora Roxb.

Family: Lythraceae **Local name:** Sidha

General description:

It is a very common tree both in the moist and dry deciduous forest of Odisha. It is a light demander, drought resistant, good coppicer, non-browsable and fire-resistant species. It comes up in a variety of soils including black cotton. It thrives best on deep porous loam but does not stand water logging.



Fig. 35: *Lagerstromia parviflora*

Pre-treatment:

- Soaking in cold water for 24 hours.
- As the seeds are orthodox, they can be stored after treating with fungicide.

Nursery Technique:

- The species can be raised in polybags from April to May.
- Sowing method: dibbling in polythene bags.
- Time of sowing: March.
- Germination starts within 15 days and is completed in three months.
- Seedlings reach a plantable size from July to August.
- Soil, sand and FYM should be in the ratio of 1:1:1.



Fruit/Seed collection time	February
Nursery sowing	March
Planting time	July
Germination time	3 months

- Vermicompost / neem oil cake can be used as manure.
- Soil mixture can be treated with insecticide chloropyrophos to prevent white ant/termite attack.
- Mulching is to be provided to facilitate germination.
- Seeds are normally dibbled at the center of the poly pots so deep that the depth of the soil above it is not more than the diameter of the seed.
- Regular watering twice a day is to be followed.
- Shade may be provided depending on the intensity of sunlight.
- Root cutting, grading and resetting of poly pot seedlings are done at regular intervals of 30 days.
- The polypots are kept in the nursery beds on polythene sheets to prevent root penetration in the soil.
- Polythene bags of size 10× 6 inch size are suitable as the seedlings are kept for more than one year in the nursery.
- **Time for planting out:** One-year-old seedlings attaining 60 cm height can be planted next year in July.



Madhuca indica (Roxb.) A. Chev.

Family: Sapotaceae **Local name:** Mahua (Hindi), Mahula (Oriya)

General description:

It is found throughout Odisha, being a characteristic tree of moist dry mixed deciduous forest. It prefers sandy soil but also grows on shallow, bouldery soils. Identified by exudation of milky latex and clustering of leaves at the ends of the branches. It is a drought-hardy species.



Fig. 36: *Madhuca indica*

Pre-treatment:

- Soaking seeds in water for 24 hours.
- For recalcitrant seeds, sow the seeds immediately after treating them with fungicides.

Nursery Techniques:

- Seed sowing is done in the month of June-July.
- Freshly collected seeds will be sown in polythene bags or nursery beds.
- Freshly extracted seeds are sown in polythene bags at a depth of 1.5 to 2.5cm.
- Germination initiates in 15- 20 days.
- One-year-old seedlings are transplanted with a spacing of 30cm X 15cm (transplant bed spacing).
- Soil mixture: Soil and FYM (1:1).



Fruit/ seed collection time	June-July
Seed sowing	June-July
Germination days	15-20

- **Vegetative propagation:** Air layering- one year-old shoots are ringed on Mahua shoots and the upper end is treated with IBA (5000 ppm). Rooted shoots are removed 60 days later. Shoots are planted in polythene bags having sizes 15cm X 30cm.
- **Time for planting out:** One-year-old seedlings are used for planting in the main field. Planting is one in 30 cm³ pit at a spacing of 4m × 4m.



Mesua ferrea L.

Family: Calophyllaceae **Local name:** Nagesar (Hindi), Nagakeshara (Oriya)

General description:

A medium-sized to large, handsome, evergreen tree, often buttressed at the base, usually attaining a height of up to 24 m and a girth of up to 2.4 m. Bark grey and smooth, warty in young trees, dark-brown in mature trees, exfoliating in large white flakes exposing the warty, reddish-brown inner surface. It is a common constituent of the tropical rain forests in the Western Ghats from South Konkan downwards. In Bihar, Odisha and West Bengal it is found locally in a few places.



Fig. 37: *Mesua ferrea*

Pre-treatment:

- Seeds should be soaked in warm water for 24 hrs.
- For recalcitrant seeds, sow the seeds immediately after treating them with fungicides.

Nursery Techniques:

- Seeds are sown in raised beds during May- June.
- Seeds are sown 5 cm apart in each line with a spacing of 5 cm.
- Soil mixture for seed beds: Soil: Red sand: FYM (1:2:1) inside poly houses.
- Watering should be done regularly.

Fruit/Seed collection time	July- September
Nursery sowing	August
Planting season	May- June (next season)
Germination days	60



- Partial shade is provided in hot climates.
- Pricking out: Seedlings get ready in 30-40 days after germination. Soon after germination, healthy seedlings are pricked out from the mother bed and transplanted to transplant beds or poly bags.
- Transfer seedlings into polythene bags after 2 months; keep in the shade till the next rainy season.
- Seedlings are planted in poly pots with a soil mixture Sand: Soil: FYM (1:2:1).
- The poly pots are kept in poly houses.
- Time for planting out: The cuttings or the seedlings can be transplanted into the fields after 12 months.



Michelia champaca L

Family: Magnoliaceae **Local name:** Champa (Hindi), Chompa (Oriya)

General description:

A beautiful tree frequently cultivated around temples and gardens. It occurs on deep moist, well drained good quality soil. Identified by grey bark, straight bole, convolute bud and dark shining lanceolate leaves.

Pre-treatment:

No pre-treatment is required.

Nursery Techniques:

- Seeds are sown immediately after collection in a shaded nursery in the month of August-September.
- Seeds are coated with red-oxide before sowing to prevent attack by red ants and rats.
- Seeds should be sown either by broadcasting or by drills.
- Drills are made 8-10 cm apart.
- Mulching is required to hasten germination.
- Germination is completed after 45 days.
- **Pricking out:** Seedlings of 4 to 5 cm in height are pricked out from the mother bed and transplanted into polythene bags.
- Regular watering twice a day is followed.
- Root cutting, grading and re-setting of poly pot seedlings are done in the nursery at regular intervals of about 30 days.



Fig. 38: *Michelia champaca*

Fruit/seed collection time	August-September
Nursery sowing	September
Germination days	45

- **Stump planting:** 2-year-old seedlings are suitable for preparing stumps. Stumps should contain 10- 15 cm of shoot and 20- 30 cm of roots.
- **Vegetative propagation:** Cuttings, grafting and layering can be used for propagation.
- Grafts are taken from shoot tops. Layers are etiolated with IBA (Indole butyric acid), 5000 ppm.
- **Time for planting out:** One-year-old seedlings, with the ball of earth, are fit for planting out in the following rains.



Mitragyna parviflora (Roxb.) Korth.

Family: Rubiaceae **Local name:** Ghorkaram

General description:

It is widely occurring throughout Odisha. It is identified by grey bark with shallow depressions. It has smaller leaves compared to *Adina cordifolia*. It attains its best development on well-drained ground with deep soils. It often grows more or less gregariously on low-lying ground with clayey soil, around the edges of tanks and swamps. It is also recommended for plantations in black cotton soils and on the alluvial ground near rivers.



Fig. 39: *Mitragyna parviflora*

Pre-treatment:

- Pre-treatment is not required.

Nursery Techniques:

- Seeds mixed with ash broadcasted on nursery beds during March - April.
- Generally raised beds are used for the sowing of seeds.
- Raised bed with a bottom layer (8 cm to 10 cm) of a mixture of soil, sand and FYM in a proportion of 1:1:1 covered with a fine layer (2 cm) of sand.
- Seeds can be treated with fungicides like Bavistin and soil can be treated with insecticides like chloropyrophos to prevent white ant/termite attack.
- Regulated watering is done; careful watering should be done as the seeds are very minute.

Fruit/ seed collection time	December- January
Seed sowing	March - April
Planting season	July

- **Pricking out:** Two-month-old healthy seedlings which attained a height of 3-4cm are to be pricked out and transplanted into polythene bags. Regular watering, twice a day, is followed.
- Shade is provided using agro green shade net in areas with hot climate.
- **Time for planting out:** Seedlings are fit for planting during July next year.



Morinda tinctoria Roxb.

Family: Rubiaceae **Local name:** Aal

General description:

It is a small evergreen shrub or tree growing to 5-10 m tall throughout tropics. Tree grows in shady forests as well as open rocky or sandy shores. The leaves are long, oblong to lanceolate.

Pre-treatment:

- Soak the seeds in boiled water and allow to cool for 24 hrs.
- As the seeds are orthodox, it can be stored after treating with fungicide.



Fig. 40: *Morinda tinctoria*

Nursery Techniques:

- Seeds should be pre-treated before sowing it to nursery bed.
- Pretreated seeds are covered with pulverised soil.
- Germination starts within 7 days.
- After germination, the seedlings are transplanted to the polythene bags.
- The seedlings of one year may be planted out with root system intact.



Phyllanthus emblica L.

Family: Phyllanthaceae **Local name:** Amla (Hindi), Aula (Oriya)

General description:

It is a common species of dry deciduous forests. It is identified by greenish-grey bark exfoliating in small irregular patches and light green feathery foliage. Recommended for afforestation on dry rocky areas and refractory sites. It is a light demander and sensitive to drought. It coppices well and produces root suckers.



Fig. 41: *Phyllanthus emblica*

Pre-treatment:

- 24 hours soaking in warm water.
- Treated with diluted sulphuric acid for 3 minutes.
- Soaked in 500 ppm Gibberellic acid solution for 24 hours.
- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery techniques

- Line sowing of pre-treated seeds is done during December-January on raised beds.
- Seeds are sown on nursery beds.
- Soil layer: 8 cm to 10 cm.
- A mixture of soil: sand :FYM: Soil (1:1:1).
- Line spacing of 5 cm.
- Mulching is done using straw.
- Regulated watering is done twice a day.
- Six months to one-year-old seedlings are used as rootstock.

Fruit/seed collection time	January- February
Nursery sowing	March
Germination days	30 days

- **Vegetative propagation:** Propagated by budding or softwood grafting. Each graft is planted 4-5 meters apart. Suitable time: July- August or February.
- **Pricking out:** 30-40 day old seedlings, which are 10-15 cm tall, are transplanted from the mother bed to the transplant bed at a spacing of 15x15 cm.
- **Time for planting out:** Seedlings will be ready for planting next July when the average height will be about 45 cm.



Pongamia pinnata (L.) Pierre

Family: Fabaceae **Local name:** Karanj (Hindi), Bruttaphala (Oriya)

General description:

Pongamia pinnata is a legume tree that grows to about 15-25 m in height with a large canopy that spreads equally wide. It may be deciduous for short periods. It has a straight bole of 50-80 cm (20-30 inch) diameter with grey-brown bark, which is smooth or vertically fissured.



Fig. 42: *Pongamia pinnata*

Pre-treatment:

Soaking seeds in water for 48hrs.

Nursery Techniques:

- Seeds are sown in July -August.
- Fresh seeds are directly sown in polybags of 20 cm ×15 cm.
- Polybags filled with soil, sand and FYM in the ratio 2:1:1.
- Seed germinates in 10-15 days.
- If seeds are sown in mother beds, then they can be pricked out from the mother bed and transplanted to poly bags after germination at 30-40 days.
- In nursery beds, seeds are dibbled at a spacing of 7.5 cm×15 cm.
- Mulching of sown beds is helpful.
- Daily watering is preferred.

Fruit/seed collection time	April - June
Nursery sowing	July- August
Planting season	June - July
Germination days	30

- **Stump Planting:** 13-14 month-old seedlings are suitable for making stumps. The stumps should contain 20- 30cm of roots and 10- 15cm of shoot.
- **Time for planting out:** The stumps/seedlings can be planted into the field directly during the rainy season.



Pterocarpus marsupium Roxb.

Family: Fabaceae **Local name:** Bijasal (Hindi), Bijja (Oriya)

General description:

It is a common tree in the moist and dry deciduous forests of Odisha. Identified by imparipinnate (5-7 leaflets), coriaceous, dark green, shining leaves and exudation of red juice from the bark on incisions. It grows better on well-drained alluvial and sandy loam to loamy soils.

Pre-treatment:

Pre-soaking of seeds in cow dung slurry for 48hrs.



Fig. 43: *Pterocarpus marsupium*

- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Techniques:

- Seed sowing is done in February- March.
- Seeds are sown in lines 20cm apart in nursery beds.
- Germination starts in about a fortnight and completes in 8 weeks.
- Seedlings can be raised in containers like polybags/ bamboo baskets with sieved soil with compost.

Fruit/ seed collection time	February- May
Nursery sowing	March
Planting season	June- July
Germination days	14-56

- Stump Planting:** 1 year old seedlings are preferred for making stumps. Stumps have a shoot of 2.5 cm and roots of 25-30 cm with a collar diameter of 1-2 cm.
- Time for planting out:** Stumps and seedlings should be planted out during the rainy season. One year old seedlings are transplanted in the following rainy season with the ball of earth. The usual size of the planting pit is 30 cm³ and the spacing is 3×3 m.



Pterocarpus santalinus L.f.

Family: Fabaceae **Local name:** Rakta Chandan, Rakhtha Chandan (Oriya)

General description:

It is endemic to Koraput district of Odisha. Recommended for plantation on lateritic loam, quartzite shale and limestone. It requires perfect drainage and is found mainly on stony or gravelly soils.



Fig. 44: *Pterocarpus santalinus*

Pre-Treatments:

- Pre-soaking in normal water for 72 hours.
- Soaked in Gibberellic acid solution (500mg/L) for 24 hours
- Soaked in cow dung slurry for 48 hours.
- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Techniques:

- Seed sown in May- June.
- Pre-treated seeds are dibbled in nursery beds/poly pots with line spacing 20 cm apart.
- Germination starts in about a fortnight.
- Mulching is provided to facilitate germination.
- Regular watering, twice a day.
- Root cutting, grading and re-setting of poly pot seedlings at regular intervals for 30 days.
- The poly pots are kept in the nursery beds, on polythene sheets to prevent root penetration into the soil.
- Shade is provided using agro-green shade net in areas with hot climates.



Fruit/seed collection time	March-May
Nursery sowing	May- June
Planting season	July
Germination days	35

- **Stump planting:** One-year-old seedlings are preferred for making stumps. The stumps should contain 25-30 cm of roots and 10-15 cm of shoot. These stumps can be transplanted into the fields during the rainy season.
- **Poly pot planting:** The pods are allowed to germinate in a heap. The germinated seeds are planted in seed poly pots. The poly pots are kept in a hot, humid and shady place or a polyhouse.
- The seedlings require a considerable amount of humidity for their survival.
- **Artificial regeneration:** Germination in trays. Pre-soaked seeds in Gibberellic acid are sown.
- Vegetative propagation under controlled conditions via shoot tip or root tip explants can be done.
- **Time for Planting out:** Rainy season.



Syzygium cumini (L.) Skeels

Family- Myrtaceae Local name- Jamun

General description:

It is a large evergreen tree widely distributed in Odisha. Found along streams and in damp and even in marshy localities, where it is often gregarious. Identified by the fibrous red blaze, intra-marginal venation and channeled petiole. Recommended for plantation on alluvial soil of varying texture, clayey soils and loamy sands.

Pre-treatment:

- No pre-treatment is required.
- For recalcitrant seeds, sow the seeds immediately after treating them with fungicides.



Fig. 45: *Syzygium cumini*

Nursery Techniques:

- Propagation: Through seed and vegetative methods.
- Fresh seeds can be sown by broadcasting or by dibbling.
- Seeds are dibbled 10 × 10 cm in unshaded beds.
- Germination takes place in about 10 to 15 days.
- Regular watering and weeding are required.
- **Pricking out:** Spring (February to March) or Monsoon (August to September).
- **Air layering:** Practiced in spring.
- **Budding:** Practiced on one-year-old seedling stocks, having 10 to 14 mm thickness. The best time for budding: July to August in low-rainfall areas and early in May-June in heavy-rainfall areas. Shield patch and forkert methods of budding have proved very successful. The possibility of better success has been reported in forkert method compared to shield or 'T' budding.

Fruit/ seed collection time	June
Nursery sowing	June- July
Planting season	July (next season)
Germination days	30

- **Time of planting out:** Both in spring i.e. February - March and the monsoon season i.e. July-August. An annual dose of about 19-20 kg farmyard manure during the pre-bearing period and 75 kg per tree, bearing trees is considered.



Terminalia alata Heyne ex Roth

Family: Combretaceae **Local name:** Ain, Asna (Hindi)

General description:

It is the most common and most widely distributed. Identified by crocodile skin bark, red blaze and stick-like glands at the base on the backside of the leaf. Development of the tree is best on deep rich alluvial soils but it avoids sandy soil. Silviculturally, it is regarded as suitable for afforestation on clayey soils



Fig. 46: *Terminalia alata*

Pre-treatment:

- Pre-sowing treatment is not necessary; however, seeds can be soaked in water for 48hrs for quick and good germination.
- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Techniques:

- Direct sowing and stump planting are the best methods for raising this species.
- Seeds should be dibbled in shaded beds with a spacing of 7.5 cm × 7.5 cm.
- Seeds should be sown to the bed immediately after the collection in March- April.
- Germination commences in 2-5 weeks.
- Regular weeding and watering are necessary.

Fruiting/ seed collection time	February- March
Nursery sowing	March- April
Planting season	June- July
Germination days	25

- **Stump planting:** 12-15 months old seedlings are suitable.
- **Time for Planting out:** If the seedling is regularly watered and weeded, then seedlings are ready for planting out can be done in the rainy season of the same year. Planting is done in pits of 30 cm³, spaced 2×2 m to 3×3 m.



Terminalia arjuna (Roxb. ex Dc.) Wight & Arn.

Family- Combretaceae Common name - Arjun

General description:

Distributed throughout Odisha, frequenting the banks of the water courses. Identified by thick grey smooth bark, exfoliating in large thin irregular sheets and buttressed trunk. It thrives best on loose moist, fertile alluvial loams and light deep sandy soils, often overlying more or less impervious rock. The soil should have ample water supplies but should normally well-drained. The soil under this tree becomes rich in calcium as the leaves are rich in this element.



Fig. 47: *Terminalia arjuna* flowering

Pre-treatment:

- Soaking in cool water for 48 hours.
- Soaking in cooling boiling water for 72 to 90 hrs.
- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Technique:

- Seeds are sown from April to May.
- Seeds are sown in lines 30 cm apart, with a spacing of about 5 cm between the fruits.
- Germination commences within 8-12 days of sowing.
- Healthy seedlings are transplanted into polybags with clay, manure and sand in equal ratios.
- Pre-treated seeds can be directly sown in poly bags, with half of the fruit above the soil.
- Alternatively, pretreated fruits are directly put in polythene bags in April, with half of the fruit above the soil.



Fruit/ seed collection time	March-May
Nursery sowing	April- May
Planting season	June- July
Germination days	12-13

- **Stump Planting:** Seedlings about 15 months old are suitable. Their optimum size is 1.3 to 2.5 cm collar diameter and the planting time is mid-July.
- **Time for Planting out:** About 10-month-old saplings are transplanted in the field in pits during July–August. Irrigation of 15-day intervals summer season (for young plantation). Irrigation is not done during the winter season in the peninsular region.



Terminalia bellirica (Gaertn.) Roxb.

Family: Combretaceae **Local name:** Bahera (Hindi), Bahada

General description:

It is found in all dry deciduous forests of Odisha. Identified by bluish-grey or ash-coloured bark and leaves clustered towards the end of the branches. It is found on different types of soils.

Pre-treatment:

- Seeds should be soaked in warm water for 24 hrs.
- As the seeds are orthodox, they can be stored after treatment with fungicide.

Nursery Techniques:

- Seeds are sown in raised beds during June-July with the commencement of monsoon rains.
- Sowing is done in lines about 20cm apart and seeds about 5 cm apart in lines.
- Germination commences in about a fortnight and completes in about a month.
- Seeds are covered lightly with sand after sowing.
- Watering and weeding should be done regularly.



Fig. 48: *Terminalia bellirica*

Fruit/ seed collection time	February-April
Nursery sowing	June-July
Planting season	June-July (Next Year)
Germination days	14-30

- **Stump Planting:** The stumps are made from 12-15 month-old seedlings and planted in July-August. The stumps should contain 10 cm of the shoot and 20 cm of the root. The non-pruned seedlings are better for making stumps. The stumps can be planted directly into the fields.
- **Time for planting out:** The seedlings can be transplanted into the fields during July - August when plants are 12 months old with balls of earth, in pits 30 cm³ generally spaced 3 × 3 m. For avenue or roadside planting, 15-16 months old seedlings are used, which are planted in pits 60 cm³, spaced 6-8 m apart.



Terminalia chebula Retz.

Family- Combretaceae Local name- Harida

General description:

The tree is found mostly in mixed dry deciduous forests. It is capable of growing on different types of soils but attains its best development on loose well-drained soils, such as sandy loam as well as clayey loam. Identified by dark brown bark exfoliating in irregular woody scales and the presence of pair of large glands at the top of the petiole.

Pre-treatment:

- Pre-soaking in water for 24 hours.
- As the seeds are orthodox, they can be stored after treatment with fungicide .



Fig. 49: *Terminalia chebula* seeds

Nursery Techniques:

- The saplings are raised from seeds in a nursery in June-July with the onset of monsoon season.
- Seeds may be sown in prepared beds or polybags.
- Germination is slow.
- The soil and organic manure ratio should be at least in the proportion of 2:1.
- Pre-germinated seeds are used for sowing to get a better survival rate.
- Generally, large-sized polybags (35cm × 22cm), are used, since the root growth is comparatively faster.
- The seedlings are required to be kept in the nursery for at least one year.
- The nursery should be partially shaded against the sun.

Fruit/ Seed collection time	January – March
Nursery sowing	June- July
Planting season	July (Next Year)
Germination days	90

- **Time for planting out:** Transplantation of one-year-old saplings is done in the next monsoon.



Xylia xylocarpa (Roxb.) Taub.

Family: Fabaceae **Local name:** Jambu (Hindi), Kangara (Oriya)

General description:

It is one of the chief associates of teak and is found to the east of Tel River (Odisha) and in the Sabari basin (Odisha, Chhattisgarh andhra Pradesh). It is identified by reddish-grey bark exfoliating in large irregular flakes, leaves with one pair of pinnate at the end of the common petiole with a gland at the apex. Recommended for plantations on shallow, rocky, laterite soils. It does not grow well on black cotton soil.

Pre- Treatments:

- Pre-soaking in normal water for 12 hours.
- Soaking in warm water (70-80°C) for old seeds.

Nursery Techniques:

- Direct seed sowing in June- July.
- Seeds are sown in well-loosened patches, 3 m apart.
- Treated seeds are sown in raised nursery beds (12 m x1.2 m) at a distance of 4-6 cm.
- Germination starts after 10-12 days.
- Regular watering for the first 3 months.
- Regular weeding should be done.



Fig. 50: *Xylia xylocarpa*

Fruit/ seed collection time	March - April
Seed sowing	June-July
Germination days	10-12

- **Stump Planting:** For stump planting, 3 months old seedlings are suitable. Stump size should be 20 cm shoot and 25-30 cm root. Stumps can be planted directly in the field.

LITERATURE CITED

The background features a dark olive green top section with the text 'LITERATURE CITED' in white. Below this is a white section with a wavy, undulating border. At the bottom, there are light blue wavy lines and a solid light blue area on the left side.



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