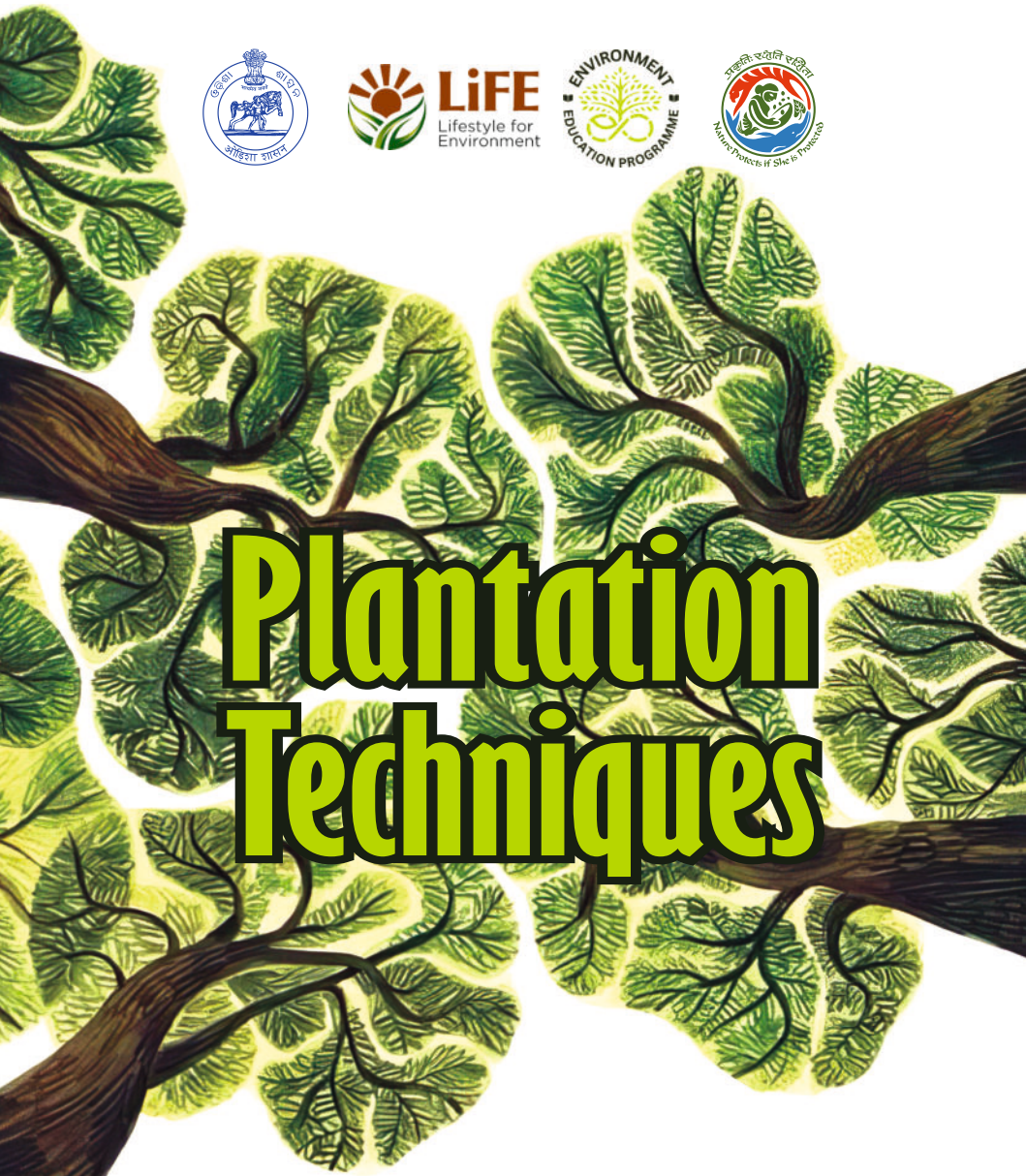

Plantation Techniques

CENTRE FOR ENVIRONMENTAL STUDIES
Forest, Environment & Climate Change Department
Government of Odisha, Bhubaneswar

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PLANTATION TECHNIQUES

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Dr. Sasanka Lenka
Sr. Scientist and Head
Krishi Vigyan Kendra, Nabarangpur

Pravat Mohan Dash
Programme Officer
Centre for Environmental Studies

Swagatika Mishra
Project Officer
Centre for Environmental Studies

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Dr. K. Murugesan, IFS
Director
Centre for Environmental Studies
Forest, Environment & C.C. Department
Government of Odisha

PREFACE

This booklet, Plantation Techniques, is a comprehensive guide designed to empower individuals, communities, and organizations with the knowledge and skills needed to undertake successful tree plantation initiatives.

The contents of delves into advanced techniques such as high-density orcharding, tissue culture, and modern irrigation systems, which are essential for maximizing the success of plantation efforts in various ecological and climatic conditions.

This guide emphasizes the importance of collective responsibility in restoring and preserving our environment. By planting and nurturing trees, we can contribute to a greener, healthier, and more sustainable future for generations to come. We express our gratitude to Dr. Sasanka Lenka for his pivotal contributions to this resource, which have significantly advanced its scientific quality and relevance. We hope that this booklet will serve as a valuable resource and inspire you to take up tree plantation as a meaningful and rewarding endeavor. Together, let us work towards creating a greener and more resilient world, one tree at a time.

I would like to thank Ministry of Environment, Forest & Climate Change (MoEF&CC), Govt. of India for giving opportunity to compile this book under Environment Education Programme (EEP).

(Dr. K. Murugesan)

CONTENT

PLANTATION TECHNIQUES

1.0 Backdrop

Plantation techniques include selecting plants, preparing the soil, and caring for the plants after planting. Plantation techniques used in Odisha include selecting suitable plant varieties based on climate and soil, proper planting timing, digging appropriate pits/holes, spacing plants correctly, mulching, fertilisation, plant protection chemicals, irrigation systems like drip irrigation, and incorporating organic matter into the soil with key considerations like choosing plants suited to local conditions, basic needs, managing pests and diseases, and ensuring proper nursery practices for seedlings or sapling before transplanting.

Tree plantation is done through a series of steps that ensure the successful establishment and growth of the tree. It begins with selecting the appropriate tree species based on factors such as climate, soil conditions, and the intended purpose of the plantation. Once the tree species is chosen, the planting site needs to be prepared by clearing any grass, weeds, or debris that may compete with the tree for nutrients. A hole is then dug, taking into account the size of the tree's root ball. The tree is carefully placed in the hole, ensuring it is upright and centered. The hole is then backfilled with soil, gently firming it around the roots to eliminate air pockets. Adequate watering is crucial after planting to settle the soil and provide moisture to the roots.

Applying a layer of mulch around the base of the tree helps retain moisture and suppresses weed growth. Regular monitoring, watering, and pruning as needed are essential to ensure the tree's health and growth. Ongoing care and maintenance, such as checking for pests and diseases and adjusting watering needs as the tree matures, contribute to the tree's development.

The methods of planting include direct seeding, transplanting, container planting, and aerial seeding. Direct seeding involves planting seeds directly into the soil while transplanting involves moving seedlings or saplings from a nursery to the desired location. Container planting utilizes plants grown in containers, such as pots, which are then transferred to the ground. Aerial seeding is a method where seeds are dispersed from aircraft or helicopters, often used for large-scale reforestation projects. The choice of planting method depends on factors such as the type of plant, project scale, and desired outcomes.

Planting a tree is an act that not only benefits the environment but also brings beauty and serenity to our surroundings. Whether you're a gardening enthusiast or a beginner, knowing the proper steps to plant a tree is crucial for its healthy growth and longevity.

In this comprehensive guide, we will explore how to properly plant a tree, unveiling the nine-step plantation process that will help you to create a thriving ecosystem right in your backyard or in school. Whether you're an experienced gardener or embarking on this journey for the first time, this article will equip you with the knowledge and confidence to plant a tree with care.

2.0 Key Aspects of Plantation Techniques

Cultivation technology incorporates the use of extensive methods of obtaining consistency in soil nutrient content, irrigation, gene modification, temperature control, fertilizer use, and other horticultural/forest techniques to increase plant yield, phytochemical content, or therapeutic potency. Some important aspects are as follows:

2.1 Plant Selection

Choosing plant species that thrive in the local climate and soil type, considering factors like growth habit, size, and intended use.

2.2 Site Preparation

Properly prepare the planting area by digging holes of the right size and incorporating organic matter to improve soil structure.

2.3 Planting Timing

Planting during the suitable season for each species, avoiding extreme weather conditions.

2.4 Spacing and Arrangement

Following recommended spacing guidelines to prevent overcrowding and optimize growth patterns.

2.5 Mulching

Applying mulch around the base of plants to conserve moisture, suppress weeds, and regulate soil temperature.

2.6 Fertilization

Using appropriate fertilizers or organic amendments to provide essential nutrients to the plants.

2.7 Irrigation

Utilizing efficient irrigation systems like drip irrigation to deliver water directly to the root zone, especially in arid regions.

2.8 Nursery Management

Raising healthy seedlings in nurseries with proper care before transplanting them to the field.

General Rules for All Trees

- Choose a site that is appropriate for the particular species you are planting.
- After you have bought your tree plant it within a day or two.
- Dig the hole before removing the tree from its original store wrappings.
- Dig at least twice the width of the root ball or root mass.
- Put the tree in the hole with the 1st main roots (the uppermost roots) of the tree at grade; thus, the root collar (the junction where the uppermost roots join the main stem) of the tree should be level or just above the final ground level after being planted.
- Make sure the tree is straight and plumb (to your satisfaction).
- Backfill the hole with the existing soil on the site; add water every so often while backfilling.
- Gently compact; water after backfilling is completed.

3.0 Nursery Raising Techniques

Over the years, the demand for horticultural crops, ornamental and forest trees has increased day by day due to climatic hazards. With this, the demand for good quality planting materials has gone up and hence the nursery business has developed rapidly in recent years in our state. Nursery product is no longer restricted to orchards or large parks and gardens. It has entered into high-rise buildings, offices, schools, factories, business houses, hospitals, hotels, backyards, roadsides in cities, rooftops, etc. for decoration purposes. Heavy demand is observed during festive seasons and seasons of fairs and melas. The ornamental nursery business has, therefore, come up on a large scale in areas near cities and towns.

3.1 Establishment of Nursery

Nursery is developed gradually. The mother plants are planted for vegetative and seed propagation and seed-propagated plants such as seasonal horticultural crops, forest trees, ornamental trees and flower seedlings are raised for sale simultaneously. Important factors considered for establishing a nursery are agro-climatic conditions, soil types, soil pH, location, area, irrigation facilities, communication, market demand, availability of germplasm or mother plants, skilled persons, etc.

Selection of Site:

The site selected for raising a nursery should preferably be located near marketing centres for the convenience of transportation of the products with minimum or no damage. The site should be convenient enough for transportation of

input materials. It is important to have or develop a perennial source of water inside the nursery. If the need arises, windbreaks of tall plants like eucalyptus, acacia, amla, seedling mango, etc. may be planted to provide necessary shade and protection.

Product Choice:

The product choice will primarily depend on the market demand in nearby areas. For wider market coverage, the choice may be dependent on market studies in the desired areas. Varieties of various ornamental plants like shade-loving foliage plants, flowering plants, creepers, plants suitable for parks, gardens and roadside plantations, offices, business houses, hospitals, residential buildings, etc. may be propagated in the nursery. Planting materials such as seedlings of flowers, bulbs, corms, etc. may also be produced.

Methods of propagation:

Plants may be raised from seeds or by vegetative propagation. Some important aspects of propagation are summarized below along with examples of fruit/forest crops:

1. Raising from seeds:

Germination from seeds may not be 100% even if the seeds are sown in perfect conditions. The factors that control the germination are age, stage of maturity and viability of seeds, water, free supply of oxygen and heat or temperature. Some seeds do not germinate easily for a variety of reasons such as dormancy, rest period and the presence of a hard seed coat. Seeds with hard coats (e.g., Palm, Cannes, Teak etc.) require some kind of external treatment for germination.

Cracking of the coats by mechanical means, abrasion, soaking in water or acid and stratification are some methods commonly applied. Before sowing on a large scale, it is worthwhile to test the viability of the seeds. e.g., Acid lime, amla, mandarin orange, litchi, mangosteen, west Indian cherry, passion fruit, phalsa, teak, etc.

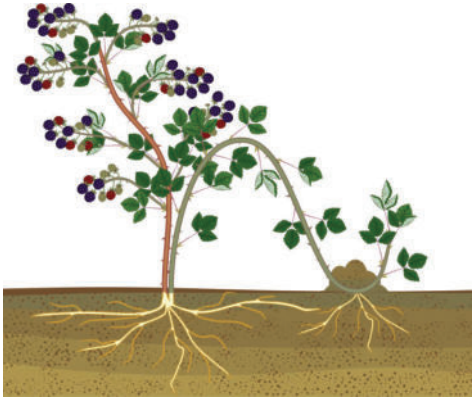
2. Vegetative Propagation:

Safe methods of vegetative propagation such as cutting, layering, division, separation, budding, and grafting are adopted for the multiplication of ornamental plants.

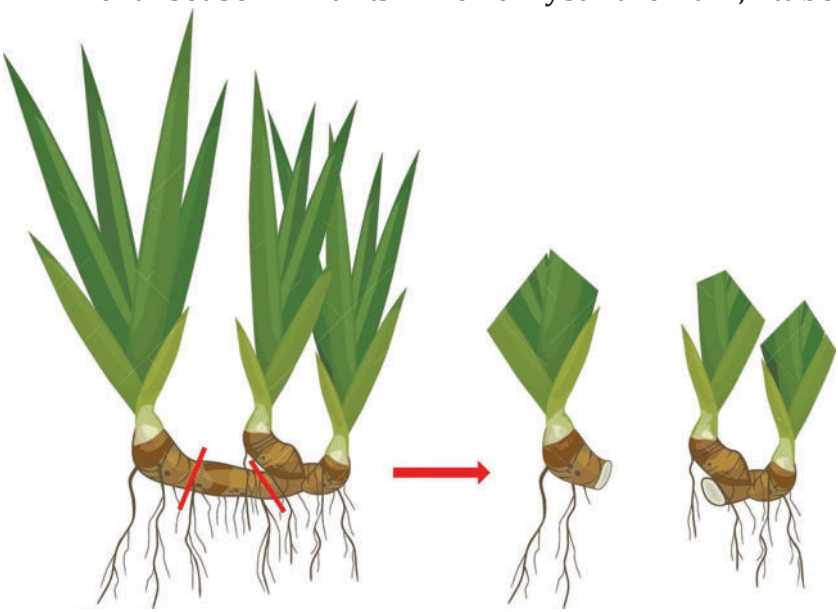
- **Cutting**: Plant parts that are normally used for this purpose are stems, roots, leaves and modified stems such as tubers, corms and rhizomes, runners and bulbs. This method is very popular, particularly because it is the cheapest and most convenient one. However, in the case of annuals, biennials and some perennials, methods such as seed age, layering and grafting are easier and more economical. e.g., Grapes, pomegranate, pear, west Indian cherry, passion fruit, loquat, phalsa, fig, kiwi, breadfruit etc.

- **Layering**: The method of inducing roots in a stem that is still attached to the plant and then detaching it after the root is formed for transplanting is called layering or layering. Mostly creepers and trees are raised by this method. Some herbaceous plants such as carnations,

chrysanthemums, etc. can be raised by layering. E.g., Guava, pomegranate, lemon, West Indian cherry, litchi, Karanda, phalsa, rambutan, breadfruit etc.

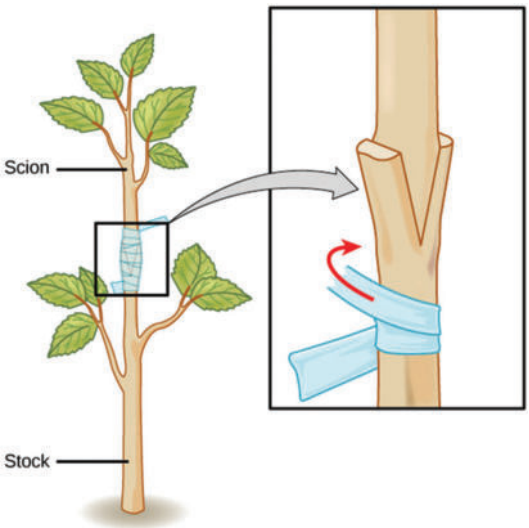


- **Division and Separation:** The plants which produce masses of stems at ground level, each having its root system are lifted from the ground and divided into individuals. This is called division. In separation, the rooted or unrooted parts usually detach themselves on maturity and start or develop as new individuals in the next season. Plants like chrysanthemum, tube

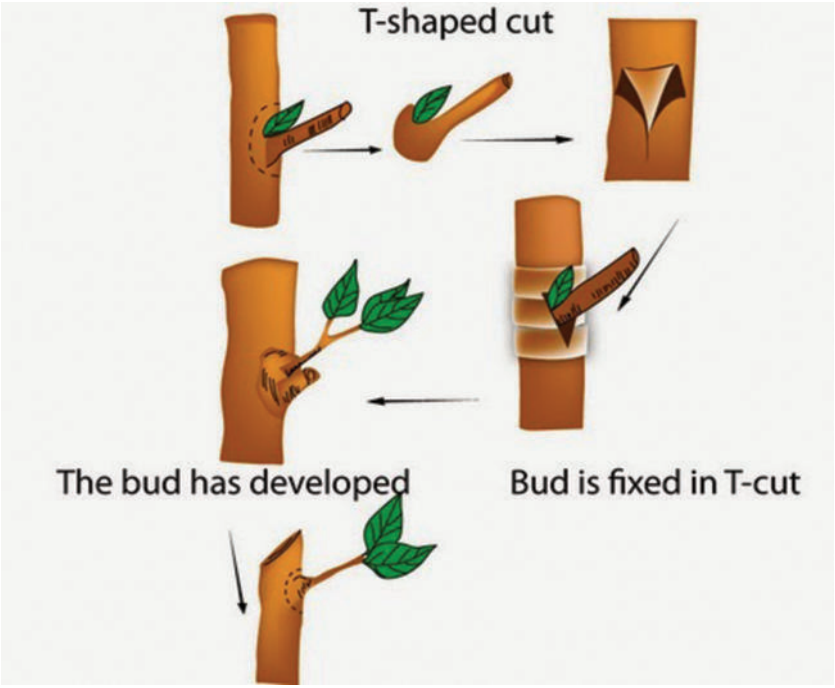


rose, *Russelia juncea* and most of the herbaceous perennials are easily propagated by division. Bulb hyacinth and crocus are examples of plants that can be propagated by separation. Suckers, rhizomes, tubers, runners, stolons, bulbs, corms, bulbils, etc., are some other plant parts that are used for vegetative propagation. e.g., Banana (suckers), pineapple (suckers and slips), strawberry (runners, slips) etc.

- **Grafting:** Grafting, except budding (which is also a form of grafting) is not widely used in ornamental horticulture except in a few cases. The types of grafting that are used in ornamental plants are limited to inarching, side grafting, splice grafting, saddle grafting, flat grafting and cleft grafting. Inarching is followed in the propagation of roses in some parts of the country. The method of side grafting is followed in the case of roses, camellias, etc. e.g., Amla, mango, sapota, jack, durian, apple, pear, avocado, West Indian cherry, annona, rambuton, persimmon, apricot, loquat etc.



- **Budding:** In ornamental horticulture, mostly 'T'-budding or 'Shield' budding is employed for propagation. e.g., Amla, Ber, Mandarin orange, sweet orange, Peach, Plum, Avocado, Litchi, Loquat, Apricot etc.



3. Tissue culture:

The propagation of orchids through meristem culture was the first commercially successful venture in tissue culture. The principles of tissue culture can be successfully employed concerning ornamental plants with soft tissues. Quite a large number of ornamental plants are reported to respond to propagation by tissue culture method. A few such plants are gladiolus, carnation, lily, rose, gerbera, anthurium, magnolia, fern, cacti, etc. Propagation of ornamental plants by this method is gaining popularity. e.g., Banana.

4.0 Standard Operating Procedure for Nursery Raising

4.1 Selection of School Teacher/Students:

Selection of school teachers/students should be based on performance, interest and past experience.

4.2 Organize Training:

Organize a training programme for the point person or for the students on nursery raising. Before starting the activity, they should take an exposure visit to a Govt. or private nursery site. During field visits, they will see the nurseries and be trained on nursery raising techniques, ridge bed method, line sowing, sowing of seeds in a plastic bag, growing forest saplings and maintaining a nursery.

4.3 Weather and Climate:

The dry season with clear bright weather is from January to May. The mean dry temperature is about 35 in summer and 14 in winter.

4.4 Site Selection:

Based on the requirements of water, place and easy transportation, an all-weather road-connected area was selected for the nursery raising site. Critical points that need to be considered while selecting a nursery area are:

- Area selected should be well-drained, and free from waterlogging
- There should be proper sunlight
- The nursery should be near the water supply so that irrigation can be easy.
- The area should be well protected from pets and wild animals

4.5 Field and soil:

The nursery activity was taken up in the upland area having road facilities. The soil of the nursery bed will be dominated by sandy loam. The nursery bed should be watered with good quality water from a water source situated nearby. Nursery bed sites are to be protected by fencing materials.

- Raising forest saplings requires fertile and healthy soil.
- Preferably, the soil for the nursery should be loam to sandy loam, loose and friable, rich in organic matter and well-drained.
- The soil pH should be close to the neutral i.e., about 7.0

4.6 Soil preparation:

- It needs deep cultivation of the nursery land either by soil turning plough or by spade and subsequent 2-3 hoeing with the cultivator.
- After that, all the clots, stones and weeds from the field should be removed and the land should be levelled.
- Mix 2 kg well rotten and fine Farmyard manure/compost or leaf compost or 500 g vermicompost per square meter and mix in the soil. If the soil is heavy mix 2-3 kg sand per square meter so that the seed emergence may not be hampered.

4.7 Soil treatment:

For raising healthy seedlings, the soil must be treated to make it pathogen and pest-free. Different methods adopted for this purpose are given below:

A. Soil Solarization:

Soil solarization is a non-chemical environmentally friendly method for controlling pests using solar power to increase the soil temperature to levels at which many soil-borne plant pathogens will be killed or greatly weakened.

- Suitable Period: January-May as the temperature rises up to 35 to 40°C at this time.
- Wet the soil with water, or saturate it with water
- Spread white polythene of 200 gauges on the whole nursery area for about 5-6 weeks.
- The margin of the polythene should be covered by wet soil (compressed mud) to check the entry of air.
- After 5-6 weeks remove the polythene sheet
- Prepare the beds for seed sowing

B. Formalin Dust Treatment

- This treatment should be done 15-20 days before seed sowing.
- Prepare formalin solution (1.5 to 2%) in one container and drench the soil @ 4-5 litre of water per square meter soil surface to saturate it up to a depth of 15-20 cm.
- Cover the drenched area with a polythene sheet of 200 gauge.

- Put the wet soil on the margin of the covered polythene sheet so that it does not allow the polythene film blown away by the wind and air from the covered area outside.
- Removes the cover (polythene) after 15 days.
- Prepare the beds for seed sowing.

C. Application of Fungicides:

- Generally used fungicides: Captan, and Thiram which kill the soil-borne pathogens.
- Use 5-6 g of any of the fungicides per square meter of nursery area.

D. Insect Control:

- Reason for such application: Presence of certain insect pests and their egg or secondary stage insects present in the soil which can infect the seedlings in the later stage.
- To save the seedlings against them, some insecticides are also used as a soil treatment. A recommended insecticide is Chlorpyriphos @ 2 ml/litre of water.
- depth of 15 to 20 cm in the nursery soil and then prepared the beds for seed sowing.

E. Steam treatment:

- Hot steam can be used to treat the soil against harmful insect pests.
- For this, cover the required area with the help of the polythene sheet and stop the movement of air in the covered area.
- Supply the hot steam for at least 4-6 hours continuously.
- This way all the harmful pathogens and insect pests will be killed.

4.8 Nursery bed preparation

- Nursery beds should be prepared according to the season and crop.
- For a uniform and high percentage of germination, the soil must be fine and moist enough.
- Polythene bags are best for forest sapling. Prepare soil mixture in the ratio of 1:1:1 of soil, sand, well-rotten FYM/ leaf mould, etc. and fill the mixture in these seedlings raising structures. An arrangement should be made to drain excess water from these structures by making a hole in the bottom of all types of bags.

4.9 Direction of the Nursery Beds

- Beds should be prepared east-west direction to protect tiny seedlings from sun and frost and the line should be made from the north to south direction on the beds.

4.10 Raised nursery beds

- The length of the bed may be kept at 3 to 5 meters; however, the width is restricted to 1 meter only which facilitates intercultural operations.

- The beds are raised 15 to 20 cm high from the ground level. A space of 30 - 40 cm is left in between two beds.
- The space between two beds helps in weeding, nursery care against diseases and insect pests and also for draining out the excess rainwater from the nursery beds.

4.11 Sowing of seeds in the nursery

After the seedbed preparation seeds are sown in the nursery bed or poly bags either by line sowing or dibbing depending upon the nature and season of the forest species.

A. Line Sowing

- Line sowing is the best method of seed sowing in the nursery.
- Lines are made 0.5 to 1.0 cm deep parallel to the width at a distance of 5.0 cm from the line and seeds are sown or placed singly at a distance of about 1.0 cm apart.
- Cover the seeds with a fine mixture of sand, soil, well-rotten and sieved FYM or leaf compost, etc. (1:1:1). After the seed covering light irrigation must be given.

B. Dibbling in polybags

The treated seeds can be directly sown in the polybags.

4.12 Mulching Materials

Seed cover

After seed sowing, the seed that is sown either by broadcast method or line sowing method is required to cover for better emergence. Therefore, a mixture of sand: soil: FYM in the ratio of 1:1:1 is prepared, well mixed and treated with any method of soil treatment as discussed above. It will be better to treat this mixture while treating the nursery soil. Apply 3-4 g thiram or captan per kg mixture if, it is not treated. Care should be taken that every seed is well covered by seed covering material.

Use of mulch

To maintain the soil moisture for seed germination, cover the seedbed with a thin layer of mulch of paddy straw or sugar cane trash, or any organic mulch during hot weather and with plastic mulch (plastic sheet) in cool weather or newspaper. It has the following advantages:

- It maintains the soil moisture and temperature for better seed germination.
- It suppresses the weeds.
- Protects from direct sunlight and raindrops.
- Protects against bird damage.

Removal of mulch

Due attention is given to removing the covered mulch from the seedbed. After three days, observe the seedbeds daily. As and when the white thread-like structure is seen above the

ground, remove the mulch carefully to avoid any damage to emerging plumules. Always remove mulch in the evening hours to avoid the harmful effect of bright sun on newly emerging seedlings.

Use of shedding net:

After seed germination during the seedling growth, if there is a very high temperature (> 30° C) then beds should be covered by 50% or 60% shedding nets of green/green + black coloured, about 60 - 90 cm above ground by the use of suitable support.

Poly Tunnel:

A low-cost polytunnel of bamboo or rod poly can be used to protect the nursery sapling at an early stage.

4.13 Watering

- The nursery beds require light irrigation with the help of a rose can till the seeds get germinated.
- Excess rainwater or irrigated water should be drained out from the field as and when it is required otherwise plants may die due to excess water.
- Watering in the beds depends upon the weather conditions. If the temperature is high, open irrigation is applied. Need not to irrigate the beds during rainy days.

4.14 Thinning

- It is an important operation to remove weak, unhealthy, diseased, insect pests damaged and dense plants from the nursery beds keeping a distance of about 0.5 to 1.0 cm from plant to plant.
- The thinning facilitates the balance of light and air in every plant. It also helps in watching the diseased and insect pest-attacked plants while moving around the nursery.

4.15 Weed control

- Timely weeding in the nursery is very important to get a healthy seedling. If there are some weeds in the seedbed, remove them manually either by hand or by hand hoe (thin forked Khurpi).
- Preemergence herbicides can also be sprayed soon after seed sowing to control the weeds. Stomp @ 3 ml/litre of water should be sprayed on the nursery beds after the seed sowing and seed covering with a mixture of FYM, soil and sand.

4.16 Plant protection

Adaptation of plant protection measures in the nursery against the incidence of insect pests and diseases is a very important task to get healthy seedlings. Damping-off seedlings, leaf curl, leaf blight diseases, and leaf miner and borer infect the seedlings in the nursery. The care for controlling them from time to time is essential.

- This is a very serious disease in the nursery
- Pre-emergence death of seeds is seen.
- In the first instance girdling takes place on the stem near the base of the stem and seedlings bent down near the ground and die.
- The causal organisms are pythium, phytopthora, rhizoctonia and *Fusarium* fungi.
- Treat the nursery bed either by soil solarization, formalin solution or formalin dust or fungicides like thiram or captan as discussed earlier.
- Treat the seeds as discussed in seed treatment. If the disease appears after the seed emergence drenches the nursery beds with 0.1% solution of brassicol or 0.7% captan or thiram after germination. It will be better to remove and bury the affected seedlings from the beds otherwise spread will be greater.
- For leaf minor spray 4% neem seed kernel extract on the plants (crush 40 g of neem seed kernal, add some water and allow them overnight. In the morning filter the extract and make up the volume of 1000 ml.)
- Spray Metasystox 1.5 ml/liter of water.

The disease can be controlled to some extent by applying treated sand, soil and FYM mixture up to the level from where the seedlings are falling. It is a very small insect that enters the leaves from the margin side and moves from one place to another by eating chlorophyll. Initially, the infected part of the leaves becomes brown and later on dry.

4.17 Major Components for Community Nursery Unit:

- Hi-Tech greenhouse (fitted with cooling, misting, and heating system along with humidity and temperature control system and raised platforms)
- Naturally ventilated greenhouse (with an inside net system)
- Net house
- Low tunnel polyhouse
- Support system (GI wire) for kiwi, passion fruit, grapes, etc
- Creation of irrigation facilities, water storage tank/water pond
- Overhead drip irrigation system
- Mini-sprinklers to irrigate nursery plants
- Automation fertigation/irrigation unit
- Vermicompost/FYM unit
- Soil solarization/sterilization system
- Shade house for filling of rooting media and for grafting & budding operations
- Tissue culture unit
- Establishment of root Stock and mother plant block

5.0 Care and Management

Structures required: Several structures may be necessary for raising a nursery. To begin with, the following structures need to be constructed:

1. **Workshed**: The work shed of 6 m x 4.5 m with thatch roofs and locally available materials like bamboo, wood, etc. may be constructed. A total amount of Rs.6750/- @ Rs.250 per sq.m. has been considered for this purpose.
2. **Polyhouse**: The polyhouse of 9 m x 4 m dimension with 90 cm, brick wall, 3.6 m tall rhombus netting with expanded metal and polythene roof supported by local materials like bamboo, wood and planks, may be constructed. The cost estimated for such a house is approximately Rs.300.00 per sqm. An additional lumpsum amount of Rs.2000.00 may be considered for the construction of wooden racks inside the poly house.
3. **Store-cum-office**: A store-cum-office of 6.0 m x 4.5 m constructed with locally available materials may serve the purpose. For this, a rate of Rs. 350/- per sq.m. has been considered adequate.
4. **Fencing**: A goat-proof fencing only will be effective for a nursery. For this model of 0.5-acre area, an amount of Rs.16250.00 has been considered as the total cost for erecting goat-proof fencing around the boundary.

6.0 Nine Steps Plantation Process

1. Choose the Right Tree Species

The first step in planting a tree is selecting the appropriate tree species for your location and purpose. Consider factors such as climate, soil type, sunlight requirements, and available space.

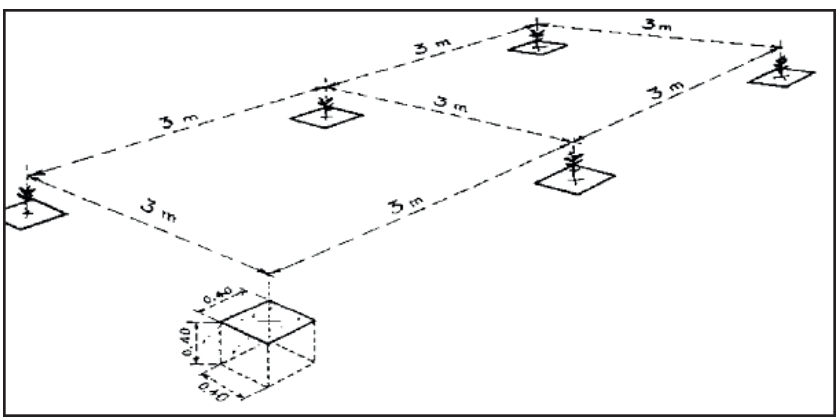
Research different species that are suitable for your region and meet your desired criteria. Native trees are often a good choice as they are well-adapted to the local environment and support local ecosystems.

2. Determine the Planting Location

Once you've chosen the tree species, assess your landscape to find the best planting location. Consider the tree's eventual size and its proximity to buildings, power lines, and other plants. Ensure that the location provides adequate sunlight, proper drainage, and enough space for the tree's roots to grow without obstruction. It's also important to check for any underground utilities before digging.

3. Prepare the Planting Pit/Hole

The third step in the plantation process after identifying the planting location is to prepare the hole. The size and depth of the pit or hole should be appropriate for the tree's root ball. As a general rule, the hole should be two to three times wider than the root ball and just deep enough so that the top



A Planting holes 0.4 m x 0.4 m x 0.4 m at a density of 3 m x 3 m.

of the root ball is level with or slightly above the soil surface. Remove any grass, weeds, or debris from the hole.

4. Handle the Tree with Care

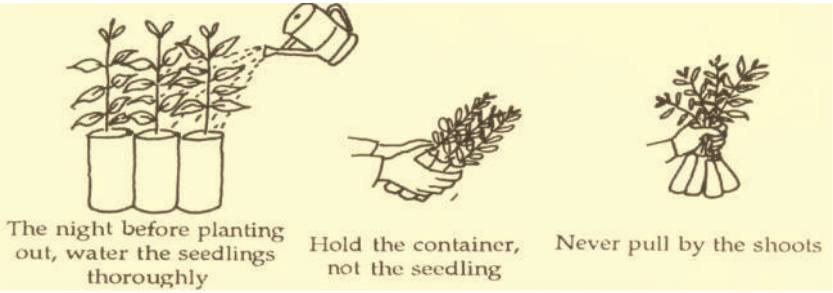
When handling the tree, it's essential to be gentle to avoid damaging the roots and branches. If the tree is in a container, carefully remove it by holding the base of the trunk or the root ball. For bare-root trees, gently untangle and spread out the roots before planting. Avoid lifting the tree by its trunk or pulling on the branches, as this can cause damage.

5. Place the Tree in the Hole

The next step in the plantation process is to lower the tree into the planting hole, ensuring that it sits upright and centered. Take a step back and visually assess the tree's position to make any necessary adjustments. The tree's flare, where the trunk widens at the base, should be slightly above ground level. Backfill the hole with the excavated soil, firming it gently around the roots to eliminate air pockets.

6. Water and Mulch

Proper watering is crucial for the tree's establishment. Immediately after planting, thoroughly water the tree to settle the soil and provide moisture to the roots. Apply a layer of organic mulch, such as wood chips or bark, around the base



of the tree, leaving a gap around the trunk to prevent moisture build-up and the risk of rot. Mulch helps retain moisture, regulate soil temperature, and suppress weeds.

7. Stake and Support

In certain cases, newly planted trees may require staking for additional support. If your tree is top-heavy or exposed to strong winds, carefully insert stakes into the ground outside the planting hole and use flexible ties to secure the tree to the stakes. However, avoid staking unnecessarily, as it may restrict the tree's natural movement and hinder root development.

8. Prune and Maintain

Regular pruning is essential for maintaining a healthy and well-shaped tree in the plantation process. Remove any broken, diseased, or crossing branches to promote airflow and prevent potential hazards. However, refrain from excessive pruning immediately after planting, as the tree needs time to establish itself. Regularly monitor the tree's health, watering needs, and overall growth, providing care as necessary.

9. Monitor and Nurture

After planting, it's important to monitor the tree's progress and provide ongoing care. Keep an eye on watering needs, especially during hot and dry periods. Conduct periodic inspections to check for pests, diseases, or signs of stress. Adjust your care routine as the tree matures, ensuring it has enough space, nutrients, and sunlight to reach its full potential.

7.0 Methods of Planting

Planting in a field has numerous methods varying widely in techniques and tools used. Successful plantation depends

upon the ability of the roots of the planted tree to region contact with the soil so that uptake of water and nutrients can be resumed. Different plants have different planting methods. Some of the planning methods are as follows.

1. Planting with naked roots.
2. Notch planting
3. Planting with a ball of earth
4. Planting with containers
5. Deep planting
6. Stump planting
7. Branch and stem cutting
8. Root cutting
9. Rhizome
10. Brick planting

Planting with naked root:

This method is applied in the case of deciduous spp. In this case, a pit is dug up with spades and the seeding is planted in the center. The pit should be at least as deep as the length of the roots. The excavated soil is then pushed back into the pit and pressed firmly.

Notch Planting:

Notch is a V-shaped figure. Instead of digging a pit, a notch is made in the soil and seedlings are planted. This is the quickest and most rough method than the first method. This method is applied in sandy and areas with light soils. The spade is pushed into the soil obliquely and then pulled in the opposite direction. The seeding is put in the notch and the spade is pulled out. After pulling out the spade, the soil automatically returns and the notches fill back again. If the sol does not return then another

notch is made at some distance and thus the first notch is filled automatically due to side pressure.

Planting with Ball of Earth:

This method is applied to those species that are delicate, comparatively large in size and cannot bear exposure of roots. Handling of such plants must be by a ball of earth and not by the stem. The plant can live for longer periods and would not die even if actual planting is delayed. The plant bonded with roots will supply food to the fronts for a few days.

Planting with Containers:

Containers can be made of any material like concrete, metal, wood or plastics. Some are of big size e.g., tin of ghee and oils, etc. Plants are raised in containers in the nurseries and transported to the site for planting. There is no disturbance to the plant during transportation. In the case of planting with naked roots and planting with a ball of earth, a great disturbance is caused to the plant during transplanting. Before planning hared containers must be removed. Polythene bags should be split. The cost of the container is a disadvantage of this method but the rate of growth and survival percentage of container plant is very great.

Deep Planting:

Deep planting means that the seed collar of seedling should be below the soil surface and some portion of the stem should be buried in the soil. This method is adopted in very dry areas where moisture is very deep in the soil.

Stump Planting:

It is root-shoot cutting. These are pruned root shoot sticks. Their sizes can vary but the common size is 9 inches root portion and 3 inches shoot portion dia ½ inches or 1 inch.

The advantage of stump planting in the case of the carriage, is less risk of damage during transplanting and the chances of success are more. It was suggested that the use of stump has resulted in rotting but not been proven. See pic

Branch and Stem Cutting:

Branch and stem cuttings of poplar, willows, and Tamarind are commonly planted.

Root cuttings:

Poplars are planted by this method also. The plants which produce root suckers freely under natural conditions can certainly be propagated by root cuttings eg Aesculus, Albezzia, Robinia, etc. Shoots are developed either from lateral or adventitious buds.

Rhizome:

It is an underground stem. Bamboo is planted by this method as well as the ground grasses are also planted by this method.

Brick planting:

In this method, the seedling is raised in the nursery in bricks made up of soil. In the center of the brick, there is a cavity (hole). This cavity is filled with fertile soil and the seedling is planted in it. When the seedlings are ready, they are planted out along with the brick. This method is adopted in sandy desert areas where there is a problem of shifting sands.

8.0 Laying out of Orchards

The most effective windbreak is a double row of tall trees alternately placed. There should be at least as much as space between the windbreak and the first row of the fruit trees as between fruit trees. It is preferable to dig a trench of 90 cm deep at a distance of 3m from the windbreak trees and prune

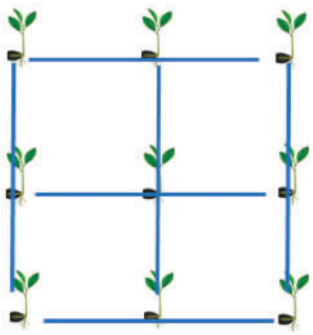
and cut all the roots exposed and again fill up the trenches. This may be repeated for every 3 or 4 years in order to avoid the compe1ition between the wind breaks and fruit trees for moisture and nutrition.

Trees suitable for windbreak should be erect, tall and quick growing, hardy and drought resistant and mechanically strong and dense to offer maximum resistance to wind. The trees which are suitable for growing as wind breaks are *Casuarina equisetifolia, Pterospermum acerifolium, Polyalthia longifolia, Eucalyptus globulus, Grevillea robusta, Azadirachta indica* etc.

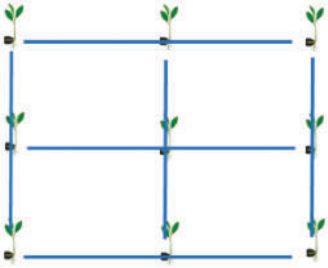
Any method of layout should aim at providing maximum number of trees per hectare, adequate space for proper development of the trees and ensuring convenience in orchard cultural practices. The system of layout can be grouped under two broad categories viz. (a) vertical row planting pattern and (b) alternate row planting pattern. In the former planting pattern

(e.g., square system, rectangular system), the trees set in a row is exactly perpendicular to those. trees set in their adjacent rows. In the latter planting pattern (i.e., Hexagonal, Quincunx and Triangular), the trees in the adjacent rows are not exactly vertical instead the trees in the even rows are midway between those in the odd rows. The various layout systems used are the following:

a) Vertical Row Planting Pattern



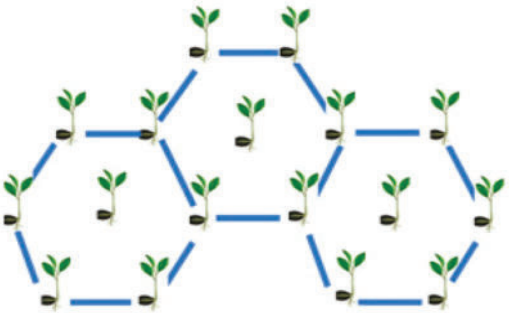
1. Square System: In this system, trees are planted on each comer of a square whatever may be the planting distance. This is the most commonly followed system and is very easy to layout. The central place between four trees may be advantageously used to raise short lived filler trees. This system permits inter cropping and cultivation in two directions.



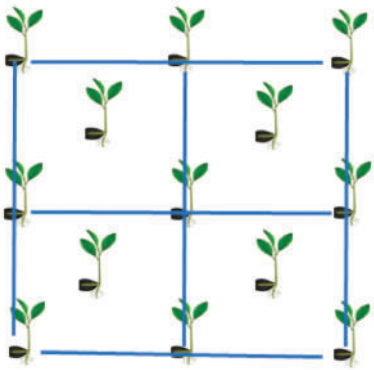
2. Rectangular System: In this system, trees are planted on each corner of a rectangle. As the distance between any two rows is more than the distance between any two trees in a row, there is no equal distribution of space per tree. The wider alley spaces available between rows of trees permit easy intercultural operations and even the use of mechanical operations.

b) Alternate row planting pattern

3. Hexagonal System: In this method, the trees are planted in each comer of an equilateral triangle. This way six trees form a hexagon with the seventh tree in the centre. Therefore, this system is also called as 'septule' as a seventh tree is accommodated in the centre of hexagon. This system provides equal spacing but it is difficult to layout. The perpendicular distance between any two adjacent rows is equal to the product of 0.866 x the distance between any two trees. As the perpendicular distance between any two row is less than unity, this system accommodates 15% more trees than the square system. The limitations of this system are that it is difficult to layout and the cultivation is not so easily done as in the square system.

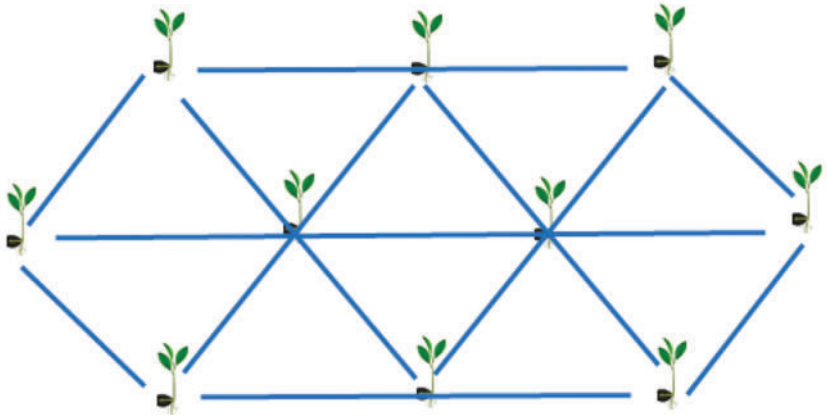


4. Diagonal or Quincunx System: This is the square method but with one more plant in the centre of the square. This will accommodate double the number of plants, but does not provide equal spacing. The central (filler) tree chosen may be a short lived one. This system can be followed when the distance between the permanent trees is more than 10m. As there will be

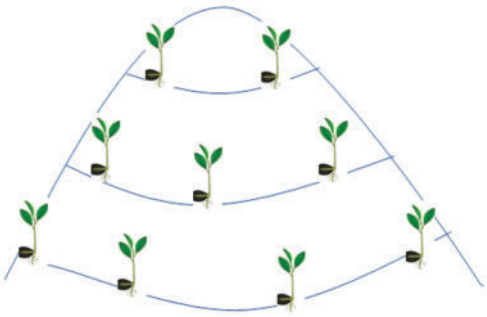


competition between permanent and filler trees, the filler trees should be removed after a few years when main trees come to bearing.

5. Triangular system: The trees are planted as in square system but the difference being that those in the even numbered rows are midway between those in the odd rows instead of opposite to them. Triangular system is based on the principle of isolateral triangle. The distance between any two adjacent trees in a row is equal to the perpendicular distance between any two adjacent rows. However, the vertical distance, between immediate two trees in the adjacent rows, is equal to the product of (1.118 x distance between two trees in a row). When compared to square system, each tree occupies more area and hence it accommodates few trees per hectare than the square system.



6. Contour System: It is generally followed on the hills where the plants are planted along the contour across the slope. It particularly suits to land with undulated topography, where there is greater danger of erosion and irrigation of the orchard is difficult. The main purpose of this system is to minimize land



erosion and to conserve soil moisture so as to make the slope fit for growing fruits and plantation crops. The contour line is so designed and graded in such a way that the flow of water in the irrigation channel becomes slow and thus finds time to penetrate into the, soil without causing erosion. Terrace system on the other hand refers to planting in flat strip of land formed across a sloping side of a hill, lying level along the contours. Terraced fields rise in steps one above the other and help to bring more area into productive use and also to prevent soil erosion. The width of the contour terrace varies according to the nature of the slope. If the slope becomes stiff, the width of terrace is narrower and vice-versa. The planting distance under the contour system may not be uniform. In South India, tea is planted in contours either in single hedge system or in double hedge system. Double hedge contour planting system accommodates nearly 22 % higher population than single hedge system. Number of plant population that can be accommodated in this system is

$$\text{Plant population} = \frac{N \times \text{unit area}}{D(Y+Z)}$$

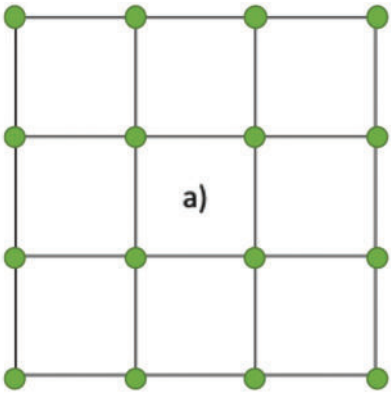
where

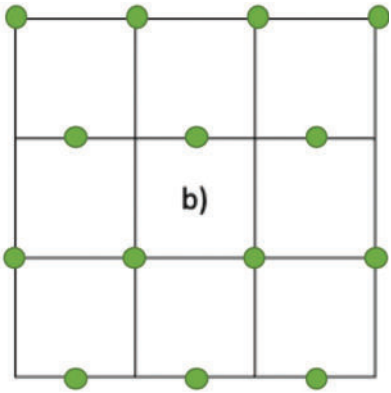
N- number of hedges

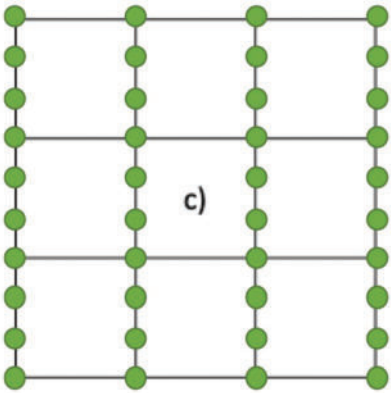
D - distance between plants

y - distance between hedges

z - vertical distance between row







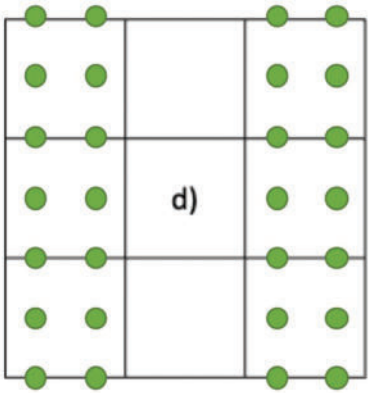


Figure 1: Circular Wampanoag Garden

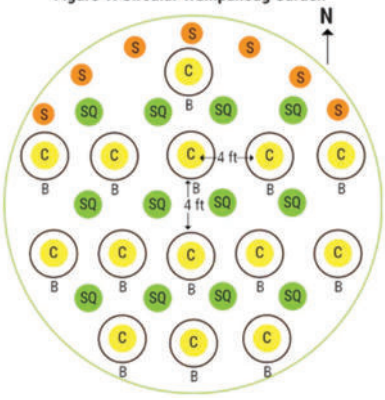
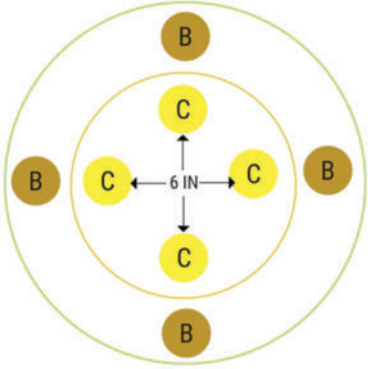


Figure 2: Wampanoag Corn and Bean Mound



7. Distance of Planting: Planting distance varies with the type of fruit plants to be grown. Tall trees like mango, litchi, sapota, are normally, grown at a distance of 10 meters. Medium tall trees like orange, guava, apple, peach, plum is grown at a distance of 5 meters, while other plants like grape, banana, pineapple, papaya are planted at a still lesser distance.

The minimum vertical distance between any two trees or plants is referred as the planting distance and this varies depending upon many factors. The principles in deciding the planting distances are the following.

1. Trees when fully grown, the fringes of trees should touch each other but the branches should not interlock.
2. Tree root will spread over a much larger area than top and there should be proper room for the roots to feed without competition.

Factors which decide the planting distance are the following.

1. Kind of fruit trees - mangoes are planted at a distance of 6m x 6m, guavas at a distance of 5m x 5m while papayas are planted at a distance of 2m x 2m.
2. Rainfall - wider spacing should be given in low rainfall areas than the high rainfall areas for a kind of tree.
3. Soil type and soil fertility - in heavy soils less spacing should be given because the top and root growth are limited.
4. Rootstocks - trees of the same variety grafted on different root stocks will grow to different sizes and as such require different planting distances. eg. Apple.
5. Pruning and training-trees trained on head system requires closer spacing than the other type of training system.

6. Irrigation system-In general, if the spacing is too wide, it is obvious that the yield per unit area would be greatly reduced. Only in very, exceptional cases would this be justifiable. Ordinarily it is more profitable to plant the trees closer together and supply the needed water and food materials. If the trees are too close together, the trees grow tall rendering pruning,

spraying and harvesting difficult. There is root competition and inadequate nutrition and the trees as such give less yield and produce smaller fruits of poor colour. Cultivation also becomes difficult in the closely planted orchards. Close planting results in a greater yield per unit area in the early life of the tree but less in the more important later years. Close planting .is therefore a false economy.

9.0 Best Trees for Plantation in Odisha

Odisha has diverse ecosystems and climatic zones which the home to a wide variety of native trees. These trees contribute to the country's rich biodiversity and play essential roles in ecosystems, culture, and daily life. Here is a selection of native trees of Odisha are as follows:

1. Banyan (*Ficus benghalensis*):

The Banyan tree is famous for its aerial roots that grow down from its branches, forming additional trunks. It's considered sacred in Hinduism and often serves as a gathering place for communities.

2. Neem (*Azadirachta indica*):

Neem is known for its medicinal properties and is often referred to as the "village pharmacy." Its leaves, bark, and oil have numerous uses in traditional medicine.

3. Peepal (*Ficus religiosa*):

Another sacred tree in Hinduism, the Peepal tree is often associated with spiritual and religious practices. It is known for its heart-shaped leaves.

4. Teak (*Tectona grandis*):

Teak is prized for its high-quality timber used in furniture and construction. It's known for its durability and resistance to decay.

5. Jamun (*Syzygium cumini*):

The Jamun tree produces sweet and tangy purple fruits, often used in Indian cuisine and traditional medicine. It's known for its medicinal properties, particularly in managing diabetes.

6. Mahogany (*Swietenia mahagoni*):

Mahogany is valued for its fine timber, which is used in furniture making and boat building. It's native to parts of India, including the Andaman and Nicobar Islands.

7. Sandalwood (*Santalum album*):

Sandalwood is renowned for its fragrant heartwood, which is used in perfumes, incense, and religious rituals. It's native to southern India.

8.Indian Rosewood (*Dalbergia sissoo*):

Indian Rosewood, or Sheesham, is prized for its hardwood, commonly used in furniture and musical instruments.

9. Indian Coral Tree (*Erythrina variegata*):

Known for its striking red flowers, this tree is native to India and has cultural significance. Its wood is used in traditional woodcraft.

10. Indian Gooseberry (*Emblica officinalis*):

The Amla tree produces small, green fruits known for their high vitamin C content. Amla is used in various culinary and medicinal preparations.

11. Indian Beech (*Pongamia pinnata*):

This tree yields oilseeds used in biodiesel production and traditional medicine. It's native to several regions in India.

12. Indian Elm (*Holoptelea integrifolia*):

Also known as the Indian Elm or Chilbil, this tree is valued for its timber and has cultural significance in some regions.

13. Sal (*Shorea robusta*):

Sal is a prominent tree in the Indian subcontinent and is used for its timber and resin. It's often associated with Hindu rituals and beliefs.

14. Indian Mahua (*Madhuca longifolia*):

The Mahua tree produces edible flowers and seeds. Mahua-based products have cultural and economic significance in tribal communities.

Some Popular Ornamental Plant Species

15. Foliage:

Thuja, Crotons, Alocasia, Anthuriums, Coleus, Colocasia, Monstera, Philoderndron, Dracaena, *Ficus pumila, Pleomele reflexe variegata, Ficus radicans variegata, Ficus pumila, Asparagus plumosus, A. springeri, Scindapsus aureus,* Begonia 'Rex', *Caladium* in different colours, *Aglaonema commutatum, Aralia elegantissima, Dieffenbachia exotica, Dieffenbachia picta, Philodendron bipinnatifidum, Polyalthia longifolia,* etc.

16. Flowering:

Roses (Hybrid teas, floribundas, Polyanthus, Miniature roses, etc.) Aster, jasmine, chrysanthemum, tuberose, gerbera, marigold, carnation, crossandra, Baleria, *Begonia glaucophylla, Passiflora caerulea,* African violet, *Begonia manicata,* Calceolaria, geranium, *Azalea indica,* etc.

17. Bulbs:

Cooperanthes, Alpinia, Gladiolus, Dahlia, Caladium, Crocus, Hyacinths, Daffodils, Tulips, Amaryllis, Canna, Bird of Paradise, Datura, *Vinca rosea, Lilium sp,* etc.

18. Ferns:

Adiantums, *Asplenium nidus, Nephrolepsis exaltata,* Platyceriums, *Pteris cretica,* Bird's nest, etc.

19. Palms and Cycads:

Chamaerops humilis, Howea belmoreana, Phoenix roebelenii, Rhapis excelsa, Cycus revoluta (not palm but similar looking), Areca Palm, etc.

20. Climbers:

Bougainvillea, *Hiptage benghalensis, Adenocalymma alliaceum, Aristolochia* sp., *Jasminum* sp., etc.

21. Cacti and Succulents:

Aloe variegatta, Aeonium haworthii, Agave americana marginata, Colyledon undulata, Euphorbia splendens, Sedum sp.,

Epiphyllum sp., Rhipsalis, Zygocactus, *Opuntia microdasys, O. tunicata, etc.*

22. Trees:

Bottle brush, Bauhnia sp., Erythrina indica, Ixora parviflora, Jacaranda, *Michelia champaca, Poinciana regia, Cassia sp., Arancaria cookii, Brassaia actinophylla, Ampherstia nobilis,* etc.

23. Grasses:

Agrostis elegans, A. nebulosa, A. pulchella, Apluda aristata, etc.

24. Annuals:

Antirrhinum, China aster, Ageratum, Arctotis, Carnation, Calendula, Pansy, Petunia, Phlox, Sweet pea, Cosmos, Zinnia, Coreopsis, Gaillardia, Dianthus, Chrysanthemum, Calendula, etc.

10.0 Conclusion

Planting a tree is a rewarding and impactful endeavour. By following the nine-step plantation process you can establish a strong foundation for your tree's growth and contribute to the beauty of your environment. Remember, each tree you plant helps create a greener and healthier world for generations to come. High-density orcharding is one of the recent novel concepts of fruit cultivation, involving the planting of fruit trees densely for better light interception and distribution to increase yield as well as to increase mechanization level.

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