



# STANDARD OPERATING PROCEDURES FOR PLANTATION 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)





# Standard Operating Procedures for Plantation Techniques

2023

**Submitted To:**

**Forest, Environment and Climate Change Department,  
Govt. of Odisha**

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## Message

It gives me a great pleasure to introduce this manual on Standard Operation Procedures (SOPs) for Plantation Techniques, which is the result of in-depth study, practical application and cooperative efforts from the scientists of the Indian Council of Forestry Research & Education. With an emphasis on forestry species, it strives to answer the growing demand for best practices and standardized methods in plantation management.

This was a much needed publication on plantation practices that guarantee both productivity and environmental sustainability, in the wake of the rising need for timber, fiber and other forest products. With chapters on a variety of subjects, including site selection, choice of species and planting methods alongwith amendments, this book provides a thorough framework for effective plantation establishment.

I encourage the foresters to refer this manual to cover and to delve into the abundance of knowledge it contains on plantation techniques of forestry species. One can contribute effectively in the preservation of our forest ecosystems and the sustainable use of forestry resources by putting the standardized procedures and best practices recommended in this manual into practice.

I applaud the scientists and contributors of ICFRE's Institute who devoted their time and skills for developing Standard Operating Procedures for Plantation Techniques of important plantation species of Odisha. I am sure that the officers and frontline staffs of the Odisha Forest Department would find this document practically useful for plantation techniques for forestry species.

Dated: 10 July, 2023

(Arun Singh Rawat)

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## Foreword

This insightful book on plantation techniques for forestry species is something I am delighted to go through. The oxygen we breathe and the commodities we use are all made possible by our woods, which are priceless resources that offer us a wide range of advantages. To protect the future of our forests, it is essential to comprehend and put sustainable methods into practice in light of the rising worldwide demand for resources and environmental issues.

This book covers every aspect, from the preliminary steps of site selection and preparation to the crucial procedures of species selection, seedling production and planting methods.

I want to express my sincere appreciation to the writers, whose knowledge and commitment have made this book possible. These pages reflect their love of forestry and dedication to preserving our natural heritage, motivating us all to adopt sustainable practices.

I cordially encourage you to begin this educational trip as we delve deeply into the field of planting methods for forestry species. Let's work together to preserve the environment, care for our woods and leave a lasting legacy for future generations.

Dated: 10 July, 2023

(Debidutta Biswal)







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## *Preface*

The health of our society as a whole is greatly influenced by forests, which provide more than only ecological balance and sources of subsistence. The vast range of forestry species in India's state of Odisha plays an important role in the state's social, economic and environmental systems. This manual, "Standard Operating Procedures of Plantation Techniques," aims to provide an all-inclusive framework for sustainable practices in recognition of the importance of proper plantation techniques in ensuring successful forest restoration and management.

The plantation and management of well-known forestry species in Odisha serve as important applications of this book for forest managers, practitioners, researchers and stakeholders. It provides a comprehensive collection of standard operating procedures (SOPs) that specify the ideal practices necessary for the successful establishment, maintenance and regeneration of these species. The processes detailed in this book are practical, based on strong science and contextually appropriate to Odisha's distinct environmental circumstances.

I compliment the team of scientists and contributors of Tropical Forest Research Institute, Jabalpur for bringing out this Standard Operating Procedures for Plantation Techniques who have dedicated their time and expertise to develop this comprehensive manual. This manual will be helpful to the officers and frontline staffs of the State Forest Department of Odisha to carry out the future plantation activities

Dated: 10, July, 2023

  
( Sanjeev Kumar )



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# CHAPTER

# 1

## INTRODUCTION

- 
- Brief History of Forestry Plantation in India
  - Need of Standard Operating Procedure (SOP)
  - Calendar of Operations





Plantation forests covers about 131 million ha, which is about 4% of the global forest area and have potential to meet the world's entire wood requirements and, therefore, are now taken up as systematic programmes by many countries and are expected to increase with time. Presently, India is the second most populous country in the world and struggling to meet the population's large demand for wood from its own resources and is a net importer of timber and allied products. India's timber imports in 2025 and 2030 are projected to be 27.01 and 31.5 million m<sup>3</sup> respectively. In India, Forest Development Corporations (FDCs) are entrusted with the mandate to raise plantations of economically important species to fulfil the timber demand of the country. Although, the FDCs have not been able to fulfil this demand, they contribute significantly (~60%) to the total annual production of timber.

After the formulation of National Forest Policy, 1988, there was a sea change in forest management which contained the essence of Joint Forest Management. Many successful planting techniques have been established and followed in the field. Afforestation and Reforestation become one of the core activities of forest department and it is essential to document the successful practices, so that it serves as manual for all the field officers who are engaged in the task of afforestation.

## 1.1 Brief History of Forestry Plantation in India

Plantations are traditionally established to supply fibre and other products, as well as to aid in site rehabilitation. Natural or Planted forests are serving a number of functions and supply a wide range of commodities and services. Wood production, fodder, apiculture, essential oils, tan bark, cork, latex, food, conservation, carbon sequestration, recreation, erosion control and rehabilitation of degraded lands, including landscape and amenity enhancement, etc., are goods and services that are generated forests.

People and the environment in ancient India shared a connection of peace, coexistence, mutual care and concern, with each supporting and complementing the other in their own manner. Emperor Ashoka was the most famous king in ancient India who was dedicated to environmental preservation and wildlife conservation. Ashoka states in one of his minor edicts: "Wherever medical herbs suitable for humans or animals are not available, I have them imported and grown. I have planted mango groves and I have ponds dug up and shelters erected along the roads at every eight kilometres. I have banyan trees planted on the roads to give shade to man and beast." The conservation of particular patches of land or forests as "sacred groves" dedicated to a village deity is one of the best examples of ancient India's tree conservation techniques. These sacred groves are located all over India, particularly around the Western Ghats and are protected and worshipped.

In India in the 19<sup>th</sup> century, tree planting became popular as a forestry activity to replenish the depleted supply of over-exploited natural forests. Because teak was the most sought-after wood, over-exploitation had resulted in its depletion and it was determined that the species needed to be regenerated. Restocking of other timber species in the forest became necessary as and when they were introduced to use. Depending on the species and forest type, both natural and artificial regeneration methods were used. Since 1842, when it was discovered that it was easier to grow teak artificially, teak plantations have been established in a variety of locations throughout British India.

During the second half of the nineteenth century, British India's government forestry policy prioritised the preservation of indigenous forests and the establishment of timber plantations. Teak (*Tectona grandis*) was the first species of tree that British India's government sought to conserve in indigenous forests and grow in timber plantations. Its wood was used for a variety of applications. Teak trees provide robust, durable wood that is resistant to ants and other pests and can be used to construct structures that can withstand long-term exposure to



saltwater and humid, insect-infested tropical conditions. But the success for establishment of teak plantation was after many efforts and experiment conducted by various persons such as Thomas Munro, Hugh Falconer, H. V. Conolly, Collector of Malabar, Chattu Menon, J. Ferguson, Gordon Hadfield. People had to learn what climate teak grew in, what soils suited it best, how to germinate its seeds and how to space and thin teak trees, also understand the disease and pest management. Subsequently, development of silvicultural systems also play a significant in regeneration of forests.

The Eucalyptus tree originally came from Tasmania (Australia) and other Indo-Malaysian islands. According to Shayam Sundar (1984), eucalyptus was first planted in India around 1790 by Tipu Sultan, the ruler of Mysore, in his palace garden on Nandi hills near Bangalore. According to one version he received seed from Australia and introduced about 16 species. The next significant introduction of eucalyptus was in the Nilgiri hills, Tamil Nadu, in 1843.

Commercial teak plantation was established in the Kuls Hills after the commercial teak plantation began in 1872. The major milestones in the history of Indian plantation are given below:

**Table 1. A big milestone in the history of Indian plantations**

1842	Teak plantation in Nilambur (First attempt by Mr. Conolly, Collector of Malabar)
1843	Plantation of <i>Eucalyptus pycnantha</i> , Tamil Nadu (by Champbell)
1866	Fuel wood plantation of Changamanga
1869	Plantation of Teak in Mukum
1872	Teak plantation in Kuls
1874	Charuduar rubber plantation
1890	Taungya plantation (By Sir Dietrich Brandis)
1934	The first plantation scheme was introduced in Sylhet
1948	Commercial plantation was attempted
1950	Van Mahotsav (Shri K. M. Munshi)
1990	Joint Forest Management

Dietrich Brandis, a pioneering German botanist-turned-forester in Myanmar, invented the Taungya method in 1890. The purpose of this method was reduceing the forest establishment costs, enhance the tree survival, providing food crops and financial gain to local people. Sh. K.M. Munshi, the then Union Minister for Agriculture and Food, started Van Mahotsava in 1950 to inspire people to care about forests and plant trees. Van Mahotsava, annual tree-planting festival takes place over the course of a week, from July 1<sup>st</sup> to July 7<sup>th</sup>. During the Van Mahotsav Week, every Indian citizen is encouraged to plant a sapling, as it was the original objective. Awareness campaigns about the advantages and protection of trees, as well as the harm caused by tree cutting, are also held. It's a life feast.

The Joint Forest Management (JFM) Circular of June 1<sup>st</sup> 1990 was based on the National Forest Policy of 1988, which recognised the importance of local people and forest fringe communities in forest protection and management. In this approach local people and state forest department work together on forest management and protection aspect and share the costs and benefits from the forests.

## 1.2 Need of Standard Operating Procedure (SOP)

Plantation is an important part of forestry practice and will continue to be one of the main activities of the State Forest Departments. It is, therefore, necessary to document the field tested standard plantation practices in the form of Standard Operating Procedures. This SOP will be useful to agencies and peoples engaged in forestry plantation. This is a compilation of only the salient points to be kept in mind while embarking on reforestation or afforestation works and to be used as a general ready guide by the field officer.





### 1.3 Calendar of Operations

Calendar of operations may slightly vary as per the environmental conditions. Generalised schedule of operation for preparation of site, pre-planting, planting, post-planting are prescribed herewith.

**Table 2. Generalized Schedule for Pre and Plantation Operations**

	Operations	Period of completion
1	Advance preparation of site	End of October
2	Alignment and digging of pits	End of February
3	Stacking	End of February
4	Planting	1 <sup>st</sup> week of July
5	Causality replacement	End of July
6	Soil working, weeding, manuring	End of August
7	Soil and water conservation measuring	End of September
8	Fire line tracing	During December
9	Watch and ward	July to March



# CHAPTER

# 2

## TYPES OF PLANTATIONS

- Different Terminologies for Describing Tree Cultivation in Non-Forest Areas
- Types of Plantations





## 2.1 Different Terminologies for Describing Tree Cultivation in Non-Forest Areas

### 1. Farm forestry

Farm forestry is the name given to programmes which promote commercial tree growing by farmers on their own land. Farm forestry was defined by NCA (1976) as the practice of forestry in all its aspects in and around the farms or village lands integrated with other farm operations.

### 2. Extension forestry

It is the practice of forestry in areas devoid of tree growth and other vegetation situated in places away from the conventional forest areas with the object of increasing the area under tree growth. It includes the following:

- a) **Mixed forestry:** It is the practice of forestry for raising fodder grass with scattered fodder trees, fruit trees and fuel wood trees on suitable wastelands, panchayat lands and village commons. (Fig. 1)



Fig. 1. Mixed Plantation

- b) **Shelterbelts:** Shelterbelt is defined as a belt of trees and or shrubs maintained for the purpose of shelter from wind, sun, snow drift, etc. (Fig. 2)

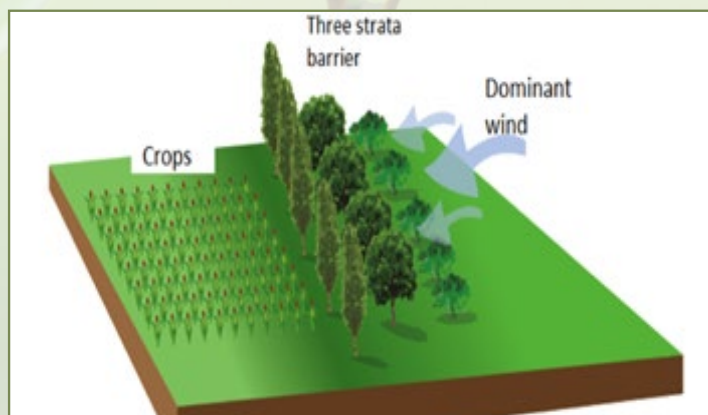


Fig. 2. Model of Shelterbelt Plantations



- c) **Linear Strip plantations:** These are the plantations of fast growing species on linear strips of land.



Fig. 3. Linear Plantation

### 3. Rehabilitation of degraded forests

The term “degradation” is taken to mean a loss of forest structure, productivity and native species diversity. The degraded area under forests needs immediate attention for ecological restoration and for meeting the socio economic needs of the communities living in and around such areas.

Table. 3. Potential key plant species for rehabilitation

Species type	Purpose
Native species	To enhance biodiversity
Species attractive to frugivores	To encourage seed dispersal
Species forming mutualistic relationships with animals	To foster wildlife populations
Poorly dispersed species (e.g. Large fruit)	To facilitate their colonization
Rare or threatened species	To increase their populations
Fast-growing species	To occupy site and exclude weeds
Species tolerant of poor soils	To facilitate rehabilitation
Nitrogen-fixing species	To improve soil fertility
Economically or socially beneficial plants	To provide economic “goods”
Fire tolerant trees	To use in fire-prone landscapes, create new forests or form

Source: Lamb & Gilmour (2003)

### 4. Recreation forestry:

It is the practice of forestry with the object of raising flowering trees and shrubs mainly to serve as recreation forests for the urban and rural population. This type of forestry is also known as Aesthetic forestry which is defined as the practice of forestry with the object of developing or maintaining a forest of high scenic value.



## 2.2 Types of Plantations

Plantations are classified on various basis such as utility/ purpose of plantations, ownership of land, etc. and major ones are briefly discussed as follows:

### 1. Plantations inside forest Areas:

Plantations carried out by the Forest Department inside forest areas are termed as Inside forest plantations. These can be classified into three broad types, viz- (a) Reforestation, (b) Afforestation and (c) Enrichment plantation. A brief description about these are as follows:

- a) **Reforestation:** Reforestation is the process of regenerating or replanting forest areas that have been destroyed or damaged for the benefits of mankind (Fig. 4). This is usually done to reclose an area which has recently lost its forest cover, mainly due to biotic reasons. Occasionally forests have the capability to regenerate due to the trees in the surroundings or due to the dispersion of seeds. However, forest lands that are badly degraded cannot be regenerated unless plants have been planted by using native

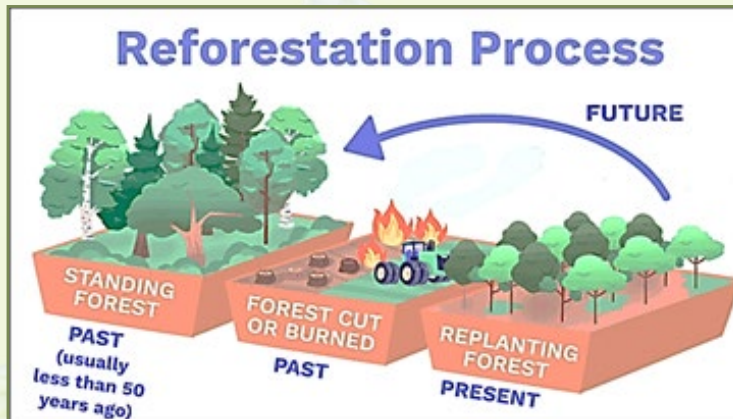


Fig. 4. Reforestation process

methods.

- b) **Afforestation:** Afforestation is the establishment of a forest or stand of trees (forestation) in an area where there was no previous tree covers e.g. Coastal sand dunes. Many government and non-governmental organizations directly engage in afforestation programs to create forests and increase carbon capture. This operation is usually much more difficult than reforestation as it strives to reverse in a few years the ecological degradation which has taken place over ages. Fortunately, species and methods have been designed for certain areas like barren coastal sands so that afforestation work can



Fig. 5. Afforestation Process



be carried out with a better planning to reduce failures.

There are certain precautions while carrying out large scale afforestation in an area. Those are:

(i) The plantation site should be well studied and problems should be examined carefully, (ii) Species which grow comparatively easily in the area should be given preference and (iii) Plantation techniques for the selected species should be followed.

- c) Enrichment Plantations:** The word enrichment plantation means plantation for beautification. Enrichment plantation is the process in which particular species of trees which are commercially profitable are planted after the removal of other species in the area. This causes the destruction of the natural forest. For instance, teak trees have been planted in South India after cutting down the natural forests. Chir Pine plantations have replaced the Himalayan oak and Rhododendron forests in the Himalayan region. These are usually carried out to increase the proportion of valuable species in the existing crop. Such species are introduced either in strips cleared or the purpose or in groups in gaps recently created. The latter operation is also carried out while rehabilitating degraded forests.

## 2. Plantations Outside Forest Areas:

The following kinds of plantations are taken up by the forest department outside the reserved forest areas: -

- i. Planting along the National Highways and Road Sides
- ii. Planting along the railway lines
- iii. Industrial Plantations
- iv. Bamboo Plantations
- v. Tree Cultivation in Private Lands: Agro Forestry, Bamboo Plantations
- vi. Shelter Belt plantations
- vii. Canal bank plantation
- viii. Research plantations

### i. Planting along the National Highways and Roads:

The plantations established along the roads with the primary objective of providing much needed shade to the travellers, particularly during the summer months. Along National Highways, aim of this type of plantation is to promote greening of Highway corridors with participation of the community, farmers, private sector, NGOs and government institutions. The National Forest Policy envisages 33% of the geographical area should be under forest or tree cover, but the notified forest cover is only about 22%. The implementation of Green Highways Policy, 2015 helped in bridging this gap. The main emphases were laid on not only planting trees, but also on how many of them survive and are useful for the local communities.

The objectives of planting along the roads and national highways are to reduce the impacts of air pollution and dust as trees and shrubs are known to be natural sink for air pollutants, to provide much needed shade on glaring hot roads during summer, to reduce the impact of ever increasing noise pollution caused due to increase in number of vehicles, to arrest soil erosion at the embankment slopes, prevention of glare from the headlight of incoming vehicles, moderating the effect of wind and incoming





radiation, reduce erosion on the road slopes and strengthening the slopes.

Ever green semi-evergreen species preferred to deciduous species. In urban /sub-urban stretches of road, flowering trees should be preferred to add to aesthetics of the surround. Design for roadside plantation are balanced line, unbalanced continuous line, unbalanced discontinuous line, sporadic system and parkway system. Of these, the first two are most widely practiced. The balance line system produced with continuous green wall of uniform size trees. Unbalanced continuous line produced as a result of alternating avenues of different species interspersed by ornamental trees. Single row planting is normally done along village roads and district roads while more than one row can be planted in the case of highway roads.

The spacing may vary from high density to low density i.e.  $1\text{m} \times 1\text{m}$  to  $5\text{m} \times 5\text{m}$  depending on the space availability and based on the choice of species. The spacing between the trees in the first row of shade or ornamental trees should be wider than that between the trees in the remaining rows. The crown spread of the species to be planted determines the spacing. For shade trees normally having broad crowns a spacing of 12 to 14 m is suggested. While too wide spacing may defeat the object of providing shade to the travelers, too close spacing may adversely affect the visibility.

## ii. Planting along Railway Lines:

The objectives of planting along railway lines includes stabilization of railway track and protection of railway track against erosion, optimum utilization of the land for tree cultivation to produce products needed by the local people, checking the illicit encroachment on this land, etc. For the planting along railway lines, the first row of trees should not be planted very close to the railway track. The first row of trees is recommended to be planted at a distance of about 7.5 m from the centre of the track. Further, the trees in the first row should be such that it may not attain a height more than their distance from the railway track so that in the events of the wind throw the tree tops may not reach the railway line and create traffic hazard. The inner side of the curves should not be planted to ensure clear visibility of the track. It is also advocated that on either side of an unmanned level crossing a length of about 100 m should be left unplanted. For railway line planting tall seedlings of 3 - 6 ft height are preferred. The pit size should be 60 cm X 60 cm X 45 cm. For railway line planting tall seedlings of 3 - 6 ft height are preferred. The pit size should be 60 cm X 60 cm X 45 cm.

Choice of species depends on climatic and site factors and the products required to be produced from such areas. Care should be taken that trees with brittle stems or branches should not plant especially in the first row. Wind firmness is a desirable character for the species for railway line plantation.

## iii. Industrial Plantations:

Industrial plantations are the “arable” crops of forestry; their principal objective is to grow a product, usually wood fibre, efficiently. The main purposes include fuel production, pulpwood for paper and cardboard, panel products, sawn timber and sometimes veneers. Eg. Plantations of *Eucalyptus*, *Poplar*, *Casurina*, etc.

## iv. Bamboo Plantations:

Bamboo is considered as poor man’s timber. India is the second largest producer in



the world. Bamboos are most integrated part of Asian culture and used as a substitute to woods. Main objective of promoting bamboo plantation is to supplement farmer's income and contribute towards resilience to climate change. Bamboo can grow well on moist soil, but deep porous fertile soil with high moisture content and a PH of 5.5 is preferable. For bamboo plantations spacing should be 5×4 m is preferred. If the objective is to plant bamboo for erosion control along river banks the spacing can be 3×3 m or 2.5×2.5 m. For pit size, as a thumb rule the larger the pit better the growth of rhizomes offsets and rhizomes should be planted in pits measuring 60×60×60 cm to 100×100×100 cm.

### v. Agro Forestry:

Agro forestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agro forestry systems there are both ecological and economical interactions between the different components. There are three main types of agro forestry systems:

- **Agri-silvicultural systems** are a combination of crops and trees, such as alley cropping or home gardens.
- **Silvopastoral systems** combine forestry and grazing of domesticated animals on pastures, rangelands or on-farm.
- The three elements, namely trees, animals and crops, can be integrated in what are called **agro-silvopastoral systems** and are illustrated by home gardens involving animals as well as scattered trees on croplands used for grazing after harvests.

### vi. Shelterbelt Plantations:

Shelterbelt is a wide belt of trees, shrubs and grasses, planted in rows which goes right across the land at right-angle to the direction of the prevailing winds to deflect air current, to reduce wind velocity and to give general protection to cultivated areas against wind erosion and desiccating effect of the hot winds in lee-ward side. A certain amount of penetrability is desirable in shelterbelts as a result of which the zone of influence is very much greater and the velocity curve shows a smooth, slowly declining trend. Coastal Shelterbelt plantation will be raised to avoid soil erosion and to reduce velocity of cyclonic wind.

The height of the shelterbelt, its porosity, orientation are the important factors controlling performance of a shelterbelt. The area ahead of and behind the shelterbelt over which it is effective is a direct function of shelterbelt height. The higher the shelterbelt the larger is the area of shelter. Shelterbelt orientation is another important factor to shelterbelt structure. The maximum shelter effectiveness is generally obtained when the shelterbelt is oriented perpendicular to the problem wind. The porosity of the shelterbelt is also important directly influences the intensity and area of shelter produced by the shelterbelt. Porosity is affected by planting density, canopy distribution, species mix, shelterbelt width and time of year.



### **vii. Canal Bank Plantations:**

Plantations raised along canal banks to augment the aesthetic value and stabilizing the canals are called canal bank plantations. Canal bank plantations are carried out for stabilization of canal banks against erosion, utilization of the available land for tree cultivation and production of tree products, particularly fuel wood and small timber for local people, Checking water logging in strips along canals and in adjoining areas and improvement of aesthetics in the area. The number of rows to be planted and the position of the first row depend upon the width and nature of the land available for planting along the side of the canal. The first row of trees is generally planted about 7.5 m from the beam of the canals in the case of multiple row planting. Subsequent rows are spaced at 5m or 3m or 2m depending upon the species to be planted and the objects of management of such canal bank plantations. For planting along canal bank, the trees with a strong taproot system should be preferred.

### **viii. Research Plantations:**

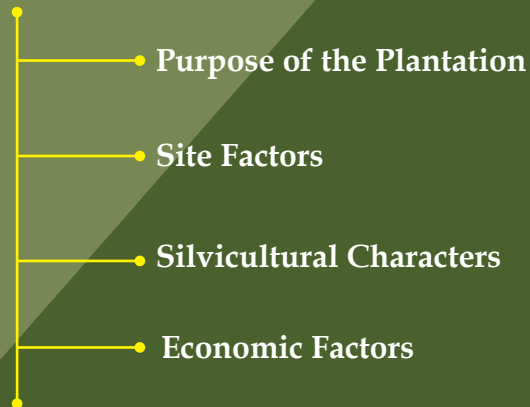
In the establishment of forest plantations for the purpose of making the dry zone green and providing forest products for rural people, it is necessary to establish research plantations to be able to select locally adaptable species, identify better land preparation options and seek new silvicultural techniques so as to ensure better results and performance out of the plantations. Research wings of state forest departments are used to establish such plantations for experimentation. E.g. Progeny trials, seed orchards, provenance trials, etc.



# CHAPTER

# 3

## CHOICE OF SPECIES







Planting a given area is a quite expensive exercise, therefore, the sound knowledge of climatic and edaphic requirements must be known in addition silvicultural requirements of the species selected for planting. Further, the plantation must cater to the socio-economic development of the people in accordance with the National and state policy in forestry. Therefore, choice of species becomes very much important. For growing timber, the species having large rotation are suitable in the forests, whereas for raising fuelwood, fruits and medicinal plants indigenous or exotic trees having medium to short rotation may be desirable. Choice of species is not only determined by the climatic or edaphic factors of a place but also by the use of the planting species by local community. The choice of a tree species depends on whether both productive and ecological advantages can be achieved in the same system and in some cases one function, either productive or environmental, may be desired. Choice of species deserves a thoughtful consideration for a successful establishment of plantations. Since raising of artificial plantation involves heavy long term investments unlike natural regeneration, choice of species becomes further of importance. The selection of species should be carried out only after a careful examination of the nursery techniques, silvicultural requirements and influence of the species on local environment.

Thus, several factors need consideration in selection of species in plantation forestry. These factors can be summed up under these heads:

### 3.1 Purpose of the Plantation

Beside the general criteria for selection of species, it should meet the objective for which the [plantation are raised]. This demands therefore that National and state policy of forestry to be kept in view. For instance: if a plantation is raised to provide raw materials for an industry, the choice should confirm to the specifications of the industry. The purpose of planting should be categorized under following heads:

**Commercial Plantation:** Objectives are the production of wood for specific industrial uses, e. g., ship building, pulp and paper, etc. These are productive or “Commercial Plantations”.

**Protective Plantations:** The objectives of the protective plantations are mainly to maintain a vegetation cover and thus to conserve soil-moisture and to maintain ecological balance of the tract as in the Case of Compensatory plantations.

### 3.2 Site Factors

For a plantation site, the essential features to consider in accordance with the species of selection are: a) Soil, b) Climate c) Physiographic and d) Biotic factors.

Various soil conditions affect the decision on the selection of species. Several physical and chemical characteristic of soil such as texture, stoniness, drainage, pan formation, soil depth aeration and PH are important for selection of species for plantation. The ability of a particular species to establish and grow well on a particular soil largely depends upon its root system and ability to absorb soil nutrients. Therefore prior to selecting species for a site studies of root system of different plants can be helpful. For example, planting a deep-rooted species with a shallow rooted species in the same area will utilize the soil nutrients fully.

In climate, total annual rainfall, number of rainy days, humidity and mean annual maximum and minimum temperature with extreme ranges are important factors. Based on rainfall and temperature, climate of an area can be identified and species suited to that climate can be



selected for plantation. Microclimate is an important factor too. Occurrence of frost or dry desert conditions restricts the selection of species to only, which, those are resistant to such conditions.

Certain biotic factors e.g. grazing, fire etc also need to be considered. In areas susceptible to grazing, species which are not easily grazed e.g. *Cassia siamea*, *Prosopis juliflora* can be selected.

The objective of consideration of site factor in selecting choice of species is to first list out the species which can be planted in the area. Other factors will be required to be considered in order to shorten the list of species to be planted. The ecological conditions of the site and the ecological requirements of the species should be compared, if these are similar, then the species are recommended for plantation in the site.

### 3.3 Silvicultural Characters

Usually afforestation and reforestation are managed under clear felling system. Strong light demander species are advocated. If clear felling is not desirable due to some reasons and retention of a large number of trees is considered essential, it is desirable to select only shade bearing species. Various silvicultural considerations are important in selection of species and important ones are described below:

- **Growth rate:** The need of quickly restoring the degraded forest area has given rise to preferring of planting fast growing species having comparatively shorter rotation. Fast growing species quickly cover the landscape and return investments. Furthermore, fast growing species compensate the gap between the demand and supply of forest produce which is beneficial for the industrialists and private planters.
- **Ease of establishment:** Species which can be easily raised and are hardy with least requirements of cultural practices and of which large quantities of seeds are available are preferred. Species that can be vegetative propagated are preferred over the others.
- **Resistance to insect-pest and diseases:** Species which are susceptible to attacked by diseases and insect pest on epidemic scale should be avoided, but if their selection is necessary due to other factors, protection measures should be carefully planned. Eg. Large scale damage caused by several diseases e.g. root rot by *Ganoderma lucidum* in Khair and sissoo have compelled the foresters to carefully select species for artificial regeneration.
- **Coppicing ability:** In addition to fast rate of growth, good coppicing ability is another desirable property, which help rapid restoration of plant cover after harvesting and recovery of, loses due to fire, insect damages and may considerably reduce the cost of creating crops in subsequent rotations.
- **Tolerance:** Species should also be tolerant to drought or frost or winds especially to sudden and extreme occurrences.





### 3.4 Economic Factors

For any plantation to be carried out the economic prospect cannot be overlooked. The economic aspects that should be considered before selecting a species for plantation are:

The species which can be raised cheaply are preferable because larger area could be afforested with the same investment. Several factors may reduce the cost of establishment of a plantation and some of these factors include: Plantation raised by seed sowing, plantation at wider spacing, low casualty rate and hardy species requiring no elaborated protection measure. In the same manner good returns are ensured by fast rate of growth and short rotation, demand of the produce, easy marketability and high price of products.

Thus, selecting the best tree species for plantation is critical for decision in forest management. For decision making process major weightage should be given to sustainable productivity, crop reliability and silviculture feasibility.

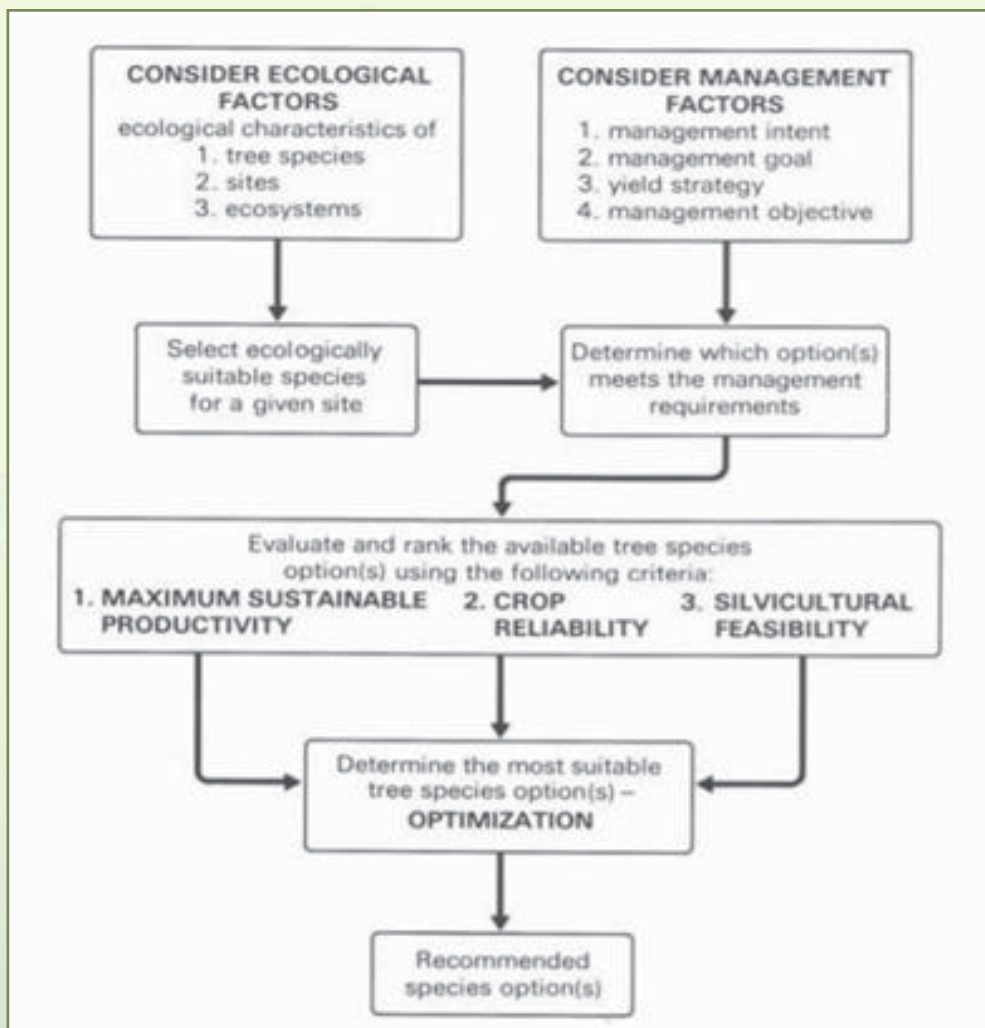


Fig.6. A flowchart illustrating the approach used to develop recommendations on tree species for regenerating forest sites, as described in the text (Klinka and Feller, April 1984 the Forestry Chronicle, 1984, 77-85)



# CHAPTER

# 4

## PREPARATION OF PLANTING SITE

- 
- Demarcation of the Area
  - Clearing of the Site
  - Spacing
  - Digging of Pits
  - Soil Preparation on Slopes
  - Plantation Methods
  - Site Maintenance





The condition of the site can vary from favourable to unfavourable in terms of providing a suitable habitat for the establishment of a new forest or plantation. After considering ecological, physiological, managerial and social considerations, the site preparation needs to be planned.

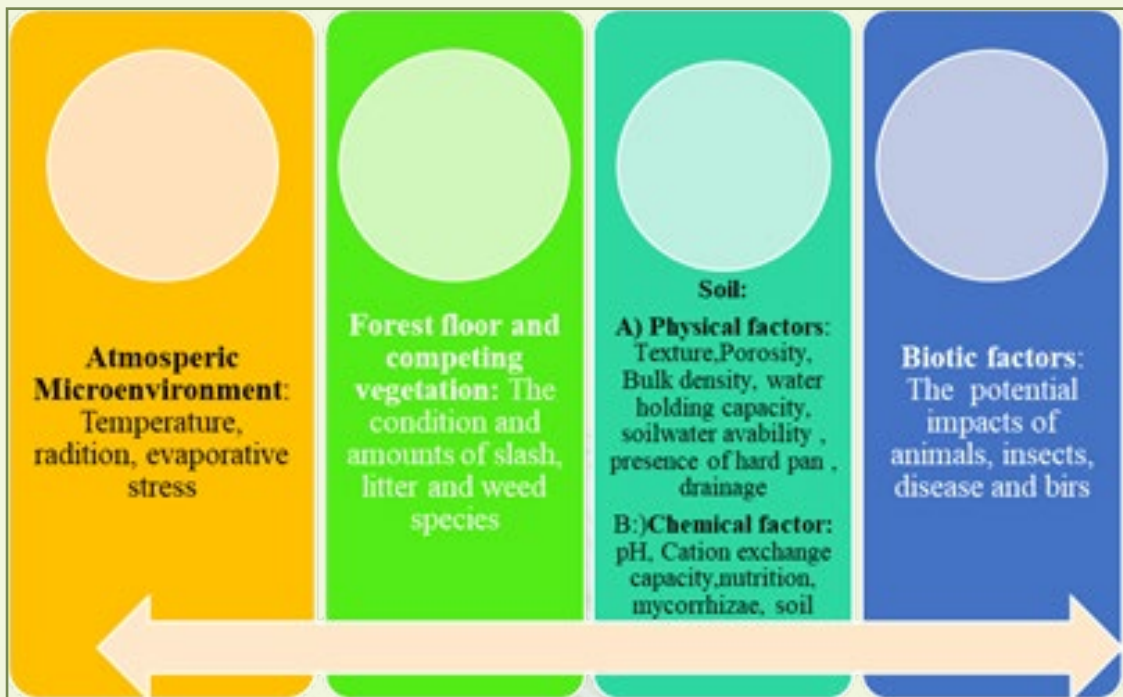


Fig. 7. Site Preparation involves the deliberate manipulation of site factors

## 4.1 Demarcation of the Area

The planting area shall be properly demarcated. A boundary post shall be fixed at each corner, at each place where the boundary line of the site crosses a road or a prominent path and at each other prominent point. If plantation area is inside or adjoining an existing forest it shall be demarcated by a 3 m. wide clear line on all sides where there is forest or shrub growth. The name of the Block or locality, species, year of plantation and area shall be engraved on each boundary post. The area demarcated for plantation shall be accurately survey. A map in the scale 1:15,000 (10 cms = 1.5 kms) shall be prepared showing inspection roads and paths to be constructed. Treatments to be applied to each part of this area and species to be planted shall be shown in this map.

## 4.2 Clearing of the Site

After the unwanted trees are taken out, the remaining standing growth and refuge shall be felled and spread uniformly over the plantation area. Care shall be taken to cover the maximum ground surface with the available waste material piled to about 0.1 m to 0.4 m height. This work shall be completed latest by the end of March. The above material shall then be allowed to dry for a month or two. Burning shall start as soon as the material is dry enough to give a good clean hot fire. The fire shall be started up the wind and shall be worked round the periphery so that the area burns mostly inwards and up the wind with a minimum risk to the surrounding forest and plantations, if any. Burning and re-burning



shall be completed as early as possible as but not later than the end of May. A satisfactory burn is absolutely essential to a good plantation. Lack of a good burn can be compensated by intensive soil working.

### 4.3 Spacing

Spacing is defined as the distance between the plants put out in a plantation or standing crop. This is also referred as espacement. Based on distance between plants, spacing is classified as (A.) Closer spacing and (B.) Wider spacing.

Advantage of closer spacing includes checking of weed growth, The boles of trees are cleaner due to natural pruning, stem straightness and also thinning becomes easier and produces short term return, etc. Whereas, disadvantage includes loss of individual tree growth and higher labour requirement.

Wider spacing also has its own advantage and disadvantages such as danger of soil deterioration as canopy takes longer time to close, weed growth will be higher, trees may become branchy. On other hand cost of plantation is less in wider spacing.

The usual spacing for all plants shall be 2 m x 2 m except where a different spacing has been prescribed in any special scheme or by the working plan. For example, for bamboo plantations, preferred spacing will be 5 m x 5 m or 5 m x 4 m. The number of plants required per hectare at the above and a few other spacing will be as follows:

**Table 4. Number of Plants Required per Hectare at Different spacing**

Spacing	No of plants per hectare
2 m x 2m	2,500
2.5 m x2.5 m	1,600
3 m x3.5m	1,111
5 m x 5 m	400

Immediately after burning, staking shall be done at the prescribed spacing. The plantation area shall be divided into sections. Where possible the last line on all the four sides of the section/block shall be planted with a species other than the main species planted in the block. By doing this not only the demarcation of the block is made more distinct but also required segregation of blocks against insect attack is achieved to a good extent. Where it is not possible to plant a different species to demarcate the planting block it shall be demarcated by posts made of either stone or R.C.C 75 cm long and with a cross section of 15 cm square. Half of this post shall be buried below ground level.

Where the planting area is irregular in shape, two bare lines for staking at right angles to each other shall be laid at the widest part of the area and the staking lines started from there. The planting blocks near the boundary line may be irregular in shape. The planting blocks/ sections shall be shown in the plantation maps. The exact area of each block shall be indicated in the map.

### 4.4 Digging of Pits

Where the area is barren and there is no forest growth which will be cleaned and burnt, digging of pits shall be completed in the winter preceding the planting season. In areas where existing forest growth has been cleared and burnt, digging of pits shall start simultaneously



with staking i.e., immediately after burning is over. It shall be completed preferably two months before or at least a month before planting starts and the interior of the pit as also the dugout soil exposed to the sun.

Pits shall not be dug just at the time of planting except in the sandy coastal areas. While digging pits, the soil of the top half of the pit shall be kept separately. When the pit is filled up this half shall be put in the bottom of the pit and the rest of the soil at the top. All roots, stones, etc., shall be removed from the soil before it is replaced in the pit. The usual size of pits on normal sites and in moist locations shall be 30 cm. cube.

## 4.5 Soil Preparation on Slopes

When the slope is gentle, a half - moon trench-ridge shall be provided on the down-hill side near each pit and When the slope is steep, plantation shall be carried out along contour trenches 45' wide at the base and 45' deep on the down-hill side. The trenches shall be 7 m long each interrupted by un-worked lengths of 3 m. The distance between two trenches along the slope shall be 5m. The soil of the trench shall be replaced in the trench partially; the remaining part being heaped on the down-hill side. The portion of the hillside on which this soil is heaped shall be broken by pick-axe before-hand. The trenches shall be staggered. It is ideal to dig the trenches at the beginning of the year previous to that of planting and allow those to be partially filled by silt during the rains and exposed to weather for about a year.

## 4.6 Plantation Methods

The block planting method is a full planting used where there is no existing forest. Enrichment planting (line conversion planting, gap planting, under-planting) is a method to improve an existing secondary forest.

**Table 5. Different Plantation Methods on the basis of End Product**

Sl. No	End products	Plantation systems	Planting methods
1.	Timber	Large-scale industrial plantation Small-scale community plantation	Block planting, Enrichment planting
2.	Posts / boundary	Agro-forestry system	Trees planted individually or in line
3.	Food	Agro-forestry system	Trees planted individually or in line
4.	Fodder	Agro-forestry system	Trees planted individually or in line
5.	Medicinal products	Agro-forestry system	Trees planted individually or in line
6.	Shade	Planting along Road side / National highways	Trees planted individually or in line
7.	Land reclamation	Large/small-scale non-industrial plantation	Block planting/Nitrogen fixing species
8.	Aesthetics / Biodiversity	Large/small-scale non-industrial plantation	Enrichment planting



## 4.7 Site Maintenance

For healthy growth, plants require adequate amount of nutrients, air and water besides, proper availability of light and temperature conditions. Some soils are unable to satisfy these essential conditions. Many conditions e.g. water logging, aridity, salinity and alkalinity, acidity, poor nutrient status, degraded physical conditions and erosion lead to the conditions in which plant growth is very poor. These form difficult areas for raising forest. Such difficult areas form a significant part of the total geographical area of the country. These areas also exist in our natural forests. In order to improve the growth of existing forest and help proper regeneration; natural or artificial, site maintenance would be necessary.

Maintenance of site, forms an essential component of silviculture. Once a good density forest is established, it is able to maintain the site itself. Only adoption of proper silvicultural system is necessary. Use of manures, fertilizers, soil amendments, soil and moisture conservation measures are usually recommended to improve the nutrient status of the soil, conditions of acidity, salinity, alkalinity and checking of soil erosion.






# CHAPTER

# 5

## SOWING AND PLANTING

- 
- Time of Plantation
  - Types of Planting
  - Soil Moisture Conservation (SMC) Measures





## 5.1 Time of Plantation

A time table shall be drawn up for all operations including planting for each plantation and followed strictly. The followings are the generalised suggestion for regarding plantation time and widely followed by State Forest Departments:

1. Stumps shall be planted just before or with the first pre-monsoon showers.
2. Potted seedlings shall be planted soon after the regular monsoons have set in and the soil has become moist.
3. On the coastal sands plantings shall commence two weeks after the monsoon starts, i.e., after the soil (sand) temperature has come down considerably.

## 5.2 Types of Planting

### 1. Stump Planting

Stump planting shall be the usual method for Teak and Rose-wood. Stumps can also be used for Gamhar, Mahogany and *Albizia* species, but these stumps will do better in moist localities. This method may be employed in any other case where the seedling grows a good thick taproot. The stumps shall be planted ordinarily in crowbar holes in light soils. The hole shall be just long enough to hold the stump up to the collar or a little more. The stumps shall then be jammed down to the bottom of the hole and the soil around it well compacted. Planting in crowbar holes should be avoided in heavy soils.

### 2. Planting Potted seedlings

Taller plant will be necessary in dry areas. The seedlings shall be at least 45 cm. tall when those are planted out. The seedlings shall be watered adequately before being lifted from the nursery. Pots shall be lifted very carefully so that the ball of earth in it is not broken. While preparing these potted seedlings for planting any roots escaping from the pots shall be trimmed. In case of delicate seedlings shall be stripped of the large leaves leaving only a few at the apex. Large side branches if any shall be pruned cleanly.

### 3. Direct sowing

Plantations of some species such as Jack Fruit, Tamarind, etc., can be done by this method. Generally, these seeds retain viability for a very short period. Therefore, fresh seeds shall be collected from the ground as soon as they fall and sown immediately in furrowed lines. Plantation of mangrove species are also raised by direct sowing. Seeds of these species usually germinate while still on the trees or soon after they fall on water. The germinated seeds are collected carefully by nets from the water and sown in the field. Sowing is best done between the new moon and the full moon when the tide is the lowest.

## 5.3 Soil Moisture Conservation (SMC) Measures

Planting on slopes shall be carried out along contours. In addition, small gullies may be plugged by rubble and check dams also of rubble may be erected on small nalas where those run along steep slopes. In very dry areas, where the rain fall is low and plantation is carried out on slightly sloping ground, two channels each about a meter long shall be made in a 'V' shape up-slope near the pit to lead moisture into it in addition to the half-moon trench-ridge.

**Formulae for Calculation of number of plants required in different planting design****❖ Line planting:**

$$\text{Number of Plants} = \frac{\text{Area (ha)} \times (100 \times 100)}{\text{Distance of plant in line (m)} \times \text{distance between the lines(m)}}$$

**❖ Square planting:**

$$\text{Number of Plants} = \frac{\text{Area (ha)} \times (100 \times 100)}{\text{Square of the planting distance}}$$

**❖ Triangular Planting:**

$$\text{Number of Plants} = \frac{\text{Area (ha)} \times (100 \times 100) \times 1.155}{\text{Square of planting distance (i.e.the side of the triangle) (m)}}$$

**❖ Quincunx planting:**

$$\text{Number of Plants} = \frac{\text{Area (ha)} \times 2 \times (100 \times 100)}{\text{Square of the side of the planting square (m)}}$$

1. **Example:** Calculate the number of plants required for 10 ha of plantation in which plant are 4 m apart in row to row and 2m apart in Plant to Plant.

$$\text{Number of Plants} = \frac{10 \text{ (ha)} \times 100 \times 100}{4 \text{ m} \times 2 \text{ m}}$$

$$\text{Number of Plants} = 12500 \text{ plants}$$

2. **Example:** Calculate the number of plants required for 10 ha of plantation in which plant are planted at 3.5 m × 3.5 m spacing.

$$\text{Number of Plants} = \frac{10 \times 100 \times 100}{3.5 \text{ m} \times 3.5 \text{ m}}$$

$$\text{Number of Plants} = 8163 \text{ plants}$$

# CHAPTER

# 6

**Species  
Specific Details**



1

## *Acacia catechu* (L.f.) Willd.

### General information on the species

- **Synonyms:** *Senegalia catechu* (L.f.) P.J.H. Hurter & Mabb.
- **Odiya name:** Khaira
- **Other vernacular names:** Khair, Khayar, Black cutch tree



### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 4.5 -8.7.
  - **Soil type:** It also grows well in sandy and loam soils with varying levels of sand, clay and black cotton soil. It has the ability to grow in poor, shallow murram or kankar soil, but it grows clean and stunted in poor, hard soil dominated by calcareous nodules.
  - **Topography:** Khair is found on flat or gently undulating ground, in ravine areas as well as in hilly regions.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical dry climate.
  - **Elevation:** Upto 1200 meters above mean sea level.
  - **Rainfall:** 500 mm to 2000 mm (natural range of distribution), whereas the tree grows on alluvial tracts with rainfall as high as 3800 mm.
  - **Temperature:** Absolute maximum shade temperature varies from 40°C-50°C; and the absolute minimum from 2.5 °C to 7.5 °C in the natural habitat of Khair.
- **Silvicultural characteristics:**
  - It is strong light demander and drought tolerant.
  - It is fire and frost hardy.
  - Strong winds have no effect on the tree.
  - It cannot withstand shade and waterlogging.

### Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm.
- **Spacing:** 2 m × 2 m or 3 m × 3 m.
- **Growth rate:** Rate of growth is quite fast.
- **Method of planting:** Direct sowing, planting of nursery raised- seedling and stump planting are possible for this species. The success of direct sowing depends upon initial soil preparation, timely and adequate weeding for the first two year, abundance of light from the very beginning and protection from frost, drought in the initial year



**For stumps planting:** Stump should be made from seedling about 15-month old nursery raised plant from seed. Select healthy seedling only and size of root and shoot should be 23 cm to 31 cm and 2.5 cm to 5 cm respectively. On the basis of results of experiment conducted by FRI, Dehradun reported that the best size of stumps at the root collar is 10 mm to 15 mm in diameter. Planting of stump should be done soon after the break of rain; delayed planting is not advisable. Under irrigated condition stump planting can be planted during March-April.





2

## *Adina cordifolia* (Roxb.) Benth. & Hook. f. ex B.D. Jacks.

### General information on the species

- **Synonyms:** *Haldina cordifolia* (Roxb.) Ridsdale
- **Odiya name:** *Holondo*
- **Other vernacular names:** *Haldu, Karma*

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 5.5 - 6.5, tolerating 5 - 8.5.
  - **Soil type:** Sandy, soapy, red alluvial, laterite and black soil. It grows best on a well-drained soil, sandy loam, rich in humus and well aerated.
  - **Topography:** Lower slopes of hills among boulders. Also along rivers or transitional areas between swampy wetlands and dry loamy areas.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical and subtropical climate.
  - **Elevation:** 200 m - 1200 m altitude.
  - **Rainfall:** 1000 mm - 4000 mm.
  - **Temperature:** Annual temperature requirement is within the range of 25°C – 35°C.
- **Silvicultural characteristics:**
  - It is susceptible to frost and fire damage.
  - It is a light demander.
  - Tolerate soils with high pH values, up to 8.3.
  - The young seedlings appear to benefit from shade.
  - It is heavily browsed and lopped.







## Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm.
- **Spacing:** 3 m × 3 m.
- **Growth rate:** Growth is very slow in the first year, following year growth is faster.
- **Irrigation:** Young Jamun plants in early stages requires frequent watering but subsequently, irrigations should be reduced, initial stages of plants requires about 12 irrigations per year (monthly once).





3

## *Aegle marmelos* (L.) Correa

### General information on the species

- **Synonyms:** *Aegle marmelos* var. *mahurensis* Zate
- **Odiya name:** Bela, Baelo
- **Other vernacular names:** Bel, Shirphal, Belpatti

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** Up to 5–8.
  - **Soil type:** Rich, well-drained soil. Also grows well in swampy, laterite, soapy red alluvial, sandy alkaline or stony soils. It is found typically on stiff, dry, alluvial soil, after growing gregariously.
  - **Topography:** It occurs in mixed deciduous forest both on flat and undulating terrain as well on hills.
- **Suitable climatic conditions:**
  - **Climate type:** Subtropical, also grows in tropical environment.
  - **Elevation:** Upto 1200 m.
  - **Rainfall:** Mean annual rainfall: 570 mm -2000 mm.
  - **Temperature:** 5 - 50°C.
- **Silvicultural characteristics:**
  - Species that are drought- as well as frost tolerant. Young plants are susceptible to frost damage, but recovers speedily.
  - It coppices moderately well and produces root suckers in abundance.
  - Fruiting may cease in prolonged droughts.
  - Salt tolerant cultivars also exist.
  - An economically viable fruit tree for otherwise difficult-to-culture environments.





## Plantation techniques and management practices

- **Pit size:** Plants - 30 cm × 30 cm × 30 cm.
- **Spacing:** 4 m × 4 m or 3 m × 3 m.
- **Method of planting:** The tree is usually propagated by planting out nursery-raised seedlings.
- **Manure and Fertilizer:** To one-year-old plants, apply 10 kg FYM and 50 g (N), 25 g (P) and 50 g (K). This should be increased every year in the same proportion up to the age of 10.
- **Irrigation:** Irrigation is necessary for optimal growth throughout the establishment and early phases of growth, particularly during the summer. Plants in the juvenile period require 8-10 irrigations each year, whereas fruit-bearing trees require 4-5 irrigations during the development and ripening of their fruit.





## *Anogeissus acuminata* (Roxb. ex DC.) Guillaum. & Perr.

### General information on the species

- **Synonyms:** *Anogeissus acuminata* var. *phillyreifolia* (Van Heurck & Müll.Arg.) Kurz
- *Anogeissus acuminata* var. *lanceolata* Wall. ex C.B. Clarke
- **Odiya name:** Passi, Phansi
- **Other vernacular names:** Phasi, Dhoy, Dhok

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** Prefers a pH in the range 5 - 6.5, tolerating 4.5 - 7.
  - **Soil type:** It prefers, sandy or alluvial soil on river bank, Deep, humus-rich, loamy soils, along streams or river banks
  - **Topography:** Plain areas and lowland open forest
- **Suitable climatic conditions:**
  - **Climate type:** Tropical and subtropical climate
  - **Elevation:** Below 700 m
  - **Rainfall:** Mean annual rainfall of 1,500 mm- 2,500 mm, but tolerates 900 mm- 3,500 mm
  - **Temperature:** Annual day time temperatures are within the range 22 - 32°C, though it can tolerate 10 - 43°C
- **Silvicultural characteristics:**
  - The species is a light demander, but it can tolerate some shadow in its early growth stages.
  - It cannot tolerate heavy soils.
  - It is a drought-resistant plant.
  - The tree is found only along the banks of rivers and streams and is sometimes gregarious in small patches.





## Plantation techniques and management practices

- **Pit size:** 45 cm × 45 cm × 45 cm
- **Spacing:** 2.7 m × 2.7 m
- **Growth rate:** Very slow growing
- **Method of planting:** The most successful approach to develop a stand is to plant a stump. Two-year-old seedlings with a shoot length of 2 cm - 3 cm and a root length of 23 cm are used to make stumps.
- If the top canopy trees are left at a rate of 25 trees per hectare, the plants grow tall and clean without side branches.
- Plants that grow in flooded areas become stunted and prickly. It's ideal for preventing flood-related bank erosion.





5

## *Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guillem. & Perr.

### General information on the species

- **Synonyms:** *Anogeissus latifolia* var. *glabra* C.B.Clarke  
*Anogeissus latifolia* var. *parvifolia* C.B.Clarke
- **Odiya name:** Dhavada, Dhobu, Dohu
- **Other vernacular names:** Dhaura, Dhawa

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** It grows well on soils with pH 5.5 -7.0.
  - **Soil type:** It is found on a variety of soil types but prefers deep alluvial soils. The wide distribution of species indicates that it is capable of growing on a wide variety of soils, such as sandy loam overlying boulders of sandstone or gravel, or the poor arid kankar soil, to moist deep soil. Better growth requires good drainage.
  - **Topography:** It is found in plains and hilly areas. It thrives amid savanna woodlands and rocky hills. It is most commonly seen in the foothills, on the talus where the hills meet the plains.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical and subtropical climate
  - **Elevation:** Upto 1300 meters
  - **Rainfall:** Mean annual rainfall in the range 800 mm- 1400 mm, but tolerates 600 mm - 2300 mm.
  - **Temperature:** In its natural distribution range, the absolute maximum shade temperature varies from 46 to 49°C while the absolute minimum temperature ranges from 1 to 3°C.
- **Silvicultural characteristics:**
  - Young trees tolerate light shade, but adult trees require a sunny position.
  - It is sensitive to drought. It is also unable to withstand waterlogging.
  - It is fire resistant, but it turns twisted and hollow in highly burned areas.
  - It produces root suckers copiously.
  - It is less susceptible to damage from browsing.
  - Weed competition is extremely difficult for young trees to tolerate.
  - It can tolerate strong winds.
  - It is susceptible to frost.





## Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm
- **Spacing:** 2 m x 2 m or 3 m x 3 m
- **Growth rate:** It is a slow growing species.
- **Method of Planting:** Direct sowing & Nursery raised seedling. Direct sowing, according to earlier research, does not give good results due to poor germination. However, nursery-raised seedling planting produces good results and is the only technique of cultivating the species that has been proved to be successful. The size and age of seedlings are important factors in the success of a plantation's establishment. Because seedlings grow at a slower rate, they had to be cared for in the nursery for 1 or 2 years before being planted out. Drought tolerance was low in the early stages of the seedlings. During the rainy season, planting takes place in pits.





### General information on the species

- **Synonyms:** *Artocarpus brasiliensis* Ortega  
*Artocarpus philippensis* Lam.
- **Odiya name:** Panas
- **Other vernacular names:** Jackfruit, Kathal, Kothal, Katahal

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 5.5 - 7.5, tolerating 4.3 - 8
  - **Soil type:** Plants of *A. heterophyllus* grow in deep, well-drained alluvial soil, sandy loam, or clay loam soils, as well as deep gravelly or laterite soil on rare cases. It grows best in rich, medium-to-open-textured soils, although it can also thrive in poor soils like gravelly or lateritic soils, shallow limestone, shallow light soils and sandy or stony soils.
  - **Topography:** Plains, lowland tropical areas
- **Suitable climatic conditions:**
  - **Climate type:** Hot humid tropics and grows well in the humid subtropical Climate.
  - **Elevation:** 450 m - 1,200 m
  - **Rainfall:** 900 mm - 4000 mm evenly distributed through the year
  - **Temperature:** Mean annual temperature in the range 24 - 28°C, a mean max temperature of 32 - 35°C, a mean minimum temperature of 16 - 20°C
- **Silvicultural characteristics:**
  - It thrives in a wide range of conditions, from full sun to light shade.
  - Moderately drought tolerant.
  - Continuously wet and/or flooded soil conditions are not tolerable.
  - Mild to moderate wind tolerance; hurricane force winds may be survived and recovered from with some limb damage.
  - It can also endure frost and cold temperatures.



### Plantation techniques and management practices

- **Pit size:** 60 cm × 60 cm × 60 cm
- **Spacing:** 8 m × 8 m, 10 × 10 m
- **Growth rate:** Moderately rapid.





- **Method of planting:** Both, direct sowing and planting of nursery raised- seedling can be practiced. Dig pits and fill them with top soil and 10 kg FYM and 1 kg neem cake each pit. During the months of June to December, plants, preferably grafts, should be planted.
- **Manures and fertilizers:** May-June and September-October are the best months to apply manures and fertilisers. As per TNAU, Coimbatore recommendations, amount of fertiliser for one-year-old seedlings is FYM-10 Kg; N, P and K as 0.150 g, 0.080 g and 0.0100 g per plant, respectively. To prevent insect attack, use chloropyriphos in the pit. University of Agricultural Sciences, Dharwad has recommended the doses of nutrients as follows:

Nutrient (g/tree)	Age of tree (years)		
	1 - 3	4 - 7	>7
N	200	400	600
P	120	240	300
K	60	120	240

- **Irrigation:** Once a week till the plant establishes itself. Hand watering is required for young orchards for the first 2-3 years, until the root system has penetrated deeply enough. The frequency of irrigation will be depending on the weather and soil moisture conditions, but jackfruit responds well to irrigation between flowering and fruiting.



## 7 *Bridelia retusa* (L.) A. Juss.

### General information on the species

- **Synonyms:** *Bridelia retusa* var. *glabra* Gehrm.  
*Bridelia retusa* var. *glauca* Hook.f.
- **Odiya name:** Asano
- **Other vernacular names:** Ekdania, Kasai, Kattian

### Habitat information

- **Natural forests:** Dry deciduous to moist deciduous forests, mixed forest and evergreen primary or secondary forests. Also, in Litoral forests.
- **Distribution in India:** Maharashtra, Karnataka, Kerala and Tamil Nadu.
- **Global distribution:** Bangladesh, Nepal, Sri Lanka, southern China, Indochina and Sumatra.



### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 5.5 to 8.5
  - **Soil type:** Sandy-loamy soil, red soils, loamy soils, granite or basalt derived sandy soil and limestone.
  - **Topography:** In forest areas on valley sides and plains, riverbanks, rocky areas, forests and open ground.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical dry climate
  - **Elevation:** Upto 2000 m in South India, 600 m in central and Central-East India, 1600 m on Himalayas and 1000 m in North East India.
  - **Rainfall:** 700 mm to over 5000 mm.
- **Silvicultural characteristics:**
  - It tolerates moderate shade.
  - It is a drought hardy species.
  - It coppices well and produces root suckers.
  - It is reported to be resistant to fire.
  - It is capable of surviving on dry shallow soil.



## Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm
- **Spacing:** 3 m × 3 m
- **Growth rate:** It is a fast growing tree.
- **Transplanting:** 1-year old plants should be preferred for planting in rainy season.
- **Irrigation:** Regular irrigation in young plantations is required.
- **Weeding:** Twice a year by August or September
- Manuring and mulching is important practice.

## Management of diseases/insect-pests/parasites

- No major diseases and insect-pest reported on this species. Birds feed on the fruits.





## *Buchanania cochinchinensis* (Lour.)

M.R. Alameda Spreng.

### General information on the species

- **Synonym:** *Buchanania lanzan* Spreng.  
*Buchanania latifolia* Roxb.
- **Odiya name:** Chanhra, Charu
- **Other vernacular names:** Char, Achar, Chironji

### Climatic and edaphic requirements

- **Suitable soil characters:**

- **pH:** 4.9 to 7.2
- **Soil type:** It grows well in mildly acidic black soil, rocky, gravelly and red soil. According to prior studies by various authors, it is recommended for planting in sandy, loam, black and alluvial soils.

It is unable to survive the flood conditions. Well-drained deep soil and loam soil are ideal for increased productivity.

- **Topography:** Rocks, mountains, semi-arid areas, resource-poor areas and wastelands.

- **Suitable climatic conditions:**

- **Climate type:** Tropical and subtropical climate.
- **Elevation:** Upto 1,200 meters above mean sea level.
- **Rainfall:** Mean annual rainfall is 1,000 mm - 1,500 mm but it can tolerate 750 mm - 2,200 mm.
- **Temperature:** 5 - 48°C

- **Silvicultural characteristics:**

- It is tolerant to drought, high temperature and heavy precipitation.
- It can also sustain cattle grazing.
- It is unable to sustain itself under waterlogged conditions.
- It is also not able to grow in the shade or in the frost.





## Plantation techniques and management practices

- **Pit size:** Plants: 1 m × 1 m × 1 m, Seedlings: 30 cm × 30 cm × 30 cm,
- **Spacing:** 3 m × 3 m
- **Growth rate:** Seedling development is slow, with a mean annual girth increment of 2.24 cm.
- **Manuring and Fertilization:** A dose of 10 kg of farmyard manure, 100 gm of Nitrogen, 50 gm of Phosphorus and 75 gm of Potassium per plant should be given to a one-year-old plant. It should be increased by the same proportion each year until the plant reaches ten years old. Farmyard manure should be applied in the months of July and August. A half dose of N and a full dose of P & K should be applied under rainfed conditions in July, with the remaining half of N applied by the end of August. Manure and a fertiliser mixture should be placed beneath the plant's canopy and integrated into the soil.





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## Careya arborea Roxb.

### General information on the species

- **Synonym:** *Careya arborea* var. *australis* Benth.
- **Odiya name:** Kumbh, Kumbhi
- **Other vernacular names:** Kumbhi, wild guava and Kumari

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **Soil type:** It thrives in alluvial, loam soil, heavy, light soil, well-drained soil. It grows on sandy or rocky and lateritic soils also.
  - **Topography:** Trees occurs on a variety of terrain, from flat or gently undulating plains to steep slopes and ravines.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical climate
  - **Elevation:** Upto 1500 meters above mean sea level.
  - **Rainfall:** The mean annual rainfall ranges from 500 mm to 3250 mm
  - **Temperature:** The absolute maximum shade temperature in its region ranges from 33.9°C to 48.3°C, while the absolute minimum ranges from 0-18.9°C.
- **Silvicultural characteristics:**
  - It is a strong light demander.
  - It is highly fire-resistant.
  - Do not perform well in the shade.
  - It coppices well.
  - It is susceptible to damages by browsing.



### Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm
- **Spacing:** Plants at 3 m × 3 m
- **Method of planting:** The tree is best raised from seed. The rate of growth is rather slow. So, it is raised in the nursery up to a height of 60 cm -90 cm. After that, plant in pits and add FYM.
- **Irrigation:** Plantations in arid regions need periodic watering during the first growing season to obtain a satisfactory survival rate.



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## *Cleistanthus collinus* (Roxb.) Benth. ex Hook. f.

### General information on the species

- **Synonyms:** *Cleistanthus collinus*(Roxb.) Benth.  
*Amanoa collina* (Roxb.) Baill.
- **Odiya name:** Korodo
- **Other vernacular names:** Garari, Suicide tree

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** Grows best in slightly acidic soils (5.5 to 6.5)
  - **Soil type:** Sandy, alluvial, rocky black and red soils
  - **Climate type:** Dry tropical climate
  - **Temperature:** Mean annual maximum daytime temperature 30–40°C
- **Silvicultural characteristics:**
  - Resistant to termite attack, decay and marine borer.
  - Resists fire and grazing.



### Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm
- **Spacing:** 3 m × 3 m
- **Growth rate:** Fast-growing tree
- **Irrigation:** Two irrigations in the first year and hoeing is done for proper growth.



## 11 *Dalbergia sissoo* Roxb. ex DC.

### General information on the species

- **Synonyms:** *Dalbergia sissoo* sensu Miq.
- **Odiya name:** Sissoo, Simsapa, Padimi
- **Other vernacular names:** Shisham, Sisso

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** pH tolerated is in the range of 5-7.7.
  - **Soil type:** It grows well on sandy alluvial, silty soil, well-drained soil.
  - **Topography:** It occurs on streambeds and islands, landslips and plains.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical and subtropical climate.
  - **Elevation:** 900 m in the sub-Himalayan tract and occasionally ascending to 1500 m.
  - **Rainfall:** 500-4500 mm.
  - **Temperature:** 4–45°C.
- **Silvicultural characteristics:**
  - The sissoo is a strong light demander, needing full overhead light from the earliest stages.
  - In its natural habitat, it is drought tolerant. Drought is a problem at seedlings stage.
  - Regeneration is prolific by root suckers, which are produced in abundance. The sissoo coppices vigorously.
  - The species has a low salt tolerance.
  - It is frost hardy; only the leaves of seedlings are affected, not the stem.
  - Although it is a moisture-loving species, it is sensitive to poor soil drainage. The sissoo is not fire resistant and the forests suffer greatly when there is a lot of inflammable grass present.



### Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm
- **Spacing:** 2 m × 2 m or 3 m × 3 m





- **Growth rate:** It grows rapidly under favorable growing conditions.
- **Method of planting:** Direct sowing by line planting, seedlings planting, Stump planting. The seed is usually placed in rows, with distances between lines ranging from 3 m to 9 m depending on the site conditions. One kg of seed is enough to make 120 m to 140 m of running line. The line is meticulously prepared by digging trenches in the winter or early summer and turning the worn, dug-up dirt two to three weeks before the first rain. Preparation should be done with a tractor in mechanised plantations.

Transplanting: In the field, seedlings aged nine to twelve months are planted. In some areas, stump planting is also used for plantation.

- **Irrigation:** Plant requires 2-3 irrigations in a season and 25 day interval in dry period with a depth of 6 cm - 7 cm.





### General information on the species

- **Synonyms:** *Gmelina arborea* var. *canescens* Haines  
*Gmelina arborea* var. *glaucescens* C.B.Clarke
- **Odiya name** Bhodroporni, Gambari, Kumar
- **Other vernacular names:** Gomari, Gammari, Shivan Khamer, White Teak

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** Upto 6 – 8.
  - **Soil type:** Moist sandy alluvial soils, as well as acidic laterites to calcareous loams, perform badly on thin or weak soils with hardpan, dry sands, or severely leached acidic soils and well-drained basic alluviums.
  - **Topography:** Areas close to grasslands and rivers. Hills above 350 - 900m.
- **Suitable climatic conditions:**
  - **Climate type:** Moist and dry deciduous forests, also in the plains.
  - **Elevation:** Upto 2100 m above mean sea level.
  - **Rainfall:** 750 mm – 5000 mm annual rainfall.
  - **Temperature:** Optimum temperature range from 15 - 38°C.
- **Silvicultural characteristics:**
  - It is a light-demander and is intolerant of shade.
  - Does not tolerate severe drought. Moderately frost tolerant.
  - Trees coppice well with vigorous shoot growth.
  - It cannot withstand waterlogging.
  - Susceptible to insect pests.
  - Saplings and young plants are browsed by animals.



### Plantation techniques and management practices

- **Pit size:** 45 cm × 45 cm × 45 cm
- **Spacing:** 3 m × 3 m



- **Growth rate:** It is a fast growing species.
- **Method of Planting:** Direct sowing, stump planting, or entire transplanting.

Transplanting of seedling: About 10-15 cm tall seedlings are transplanted in pits at the beginning of rainy season.

Stump planting: The seeds are sown in the nursery in May or June, soon after collection and when the seedlings are about 5 cm to 7.5 cm high, they are spaced out if in a crowded condition to encourage growth. The seedlings become ready for stump preparation. Stumps are prepared from one to two years old seedlings.

- **Irrigation:** Irrigation should be started in October. Till January once a week, twice a week till April and from May every second day plants should be watered.





### General information on the species

- **Synonyms:** *Grewia tiliifolia* A.Rich.  
*Grewia subinaequalis* DC.
- **Odiya name:** Dhamuro, Bhangia, Dhamono
- **Other vernacular names:** Dhaman, Dhamani

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 6 - 6.5, tolerating 5.5 - 7
  - **Soil type:** Well-drained soils, even on poor and rocky soils. It is best developed on deep loamy.
  - **Topography:** Open woodlands, shrublands, grasslands, more common on the higher and steeper hill slopes.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical dry and moist deciduous forests.
  - **Elevation:** 800 m - 1600 m.
  - **Rainfall:** 1000 mm - 2500 mm, but tolerates 750 mm - 4000 mm.
  - **Temperature:** Range 30 - 42°C, but can tolerate 7 - 47°C.
- **Silvicultural characteristics:**
  - It is a light demander but will bear shade.
  - It is a frost sensitive.
  - It coppices freely and produce root suckers.
  - Performs well in irrigated lands.



### Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm
- **Spacing:** For border planting - 3 m × 3 m, For bulk planting - 6 m × 6 m
- **Growth rate:** Fast growing species
- **Method of planting:** Direct sowing, entre planting, stump planting. Research studies indicated that the best method of raising it is by stump planting.
- **Damages by animals** like elephants, spotted deer and sambhar is reported. So, fencing around the plantation is necessary.



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## *Lagerstroemia parviflora* Roxb.

### General information on the species

- **Synonyms:** *Fatima napaulensis* DC.  
*Lagerstroemia fatima* Bl.
- **Odiya name:** Chhena, Salora, Sidha
- **Other vernacular names:** Lendia, Bakli, Sidi, Seina

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 5.5 - 6.5, but can tolerate 4.5 - 7.5.
  - **Soil type:** Well drained sandy, alluvial and muddy. In Orissa, it is said to be especially common on the shales, where it forms almost pure forest with bamboos. It grown best on deep porous loam and although it is often found on clay, it does not stand water-logging.
  - **Topography:** Plains, open lands, along roadsides and occasional on hills.
- **Suitable climatic conditions:**
  - **Climate type:** Prefers a climate with a distinct dry season. Plant of tropical environment
  - **Elevation:** Upto 900 meters.
  - **Rainfall:** The rainfall ranges from 750 mm to 4500 mm. The species is absent from area with only 500 mm to 750 mm rainfall or below. Optimum growth of the species occurs in intermediate rainfall of 1250 mm to 2500 mm.
  - **Temperature:** 4°C - 48°C.



### Silvicultural characteristics:

- It's a strong light demander. When the plant is in the shade, its growth is hindered.
- It is drought tolerant.
- Coppicing and pollarding produce vigorous regrowth in trees.
- Mature trees are frost-resistant, but immature seedlings are quite susceptible.
- Plants can withstand both grazing and fire.
- It is unable to withstand waterlogging.



## Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm
- **Spacing:** 3 m × 3 m
- **Growth rate:** A fairly slow-growing tree
- **Irrigation:** Regular irrigation in the first year of plantation is recommended.

White stump rot is caused by *Fomes durissimus*, tar spot is caused by *Polyporus lagerstroemiae* and grey heart rot is caused by *Trametes incerta* removing the afflicted parts and burning them in a safe location. It is recommended that Bavistin (0.2 percent) be sprayed every 15 days.

*Fomes fastuosus*, which causes dark brown heart rot, *Fomes pectinatus*, which causes white spongy rot and *Fomes rimosus*, which causes yellow heart rot, all attack the tree.

- **Injuries:** Plants may die back due to prolonged periods of drought.



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## *Madhuca longifolia* var. *latifolia* (Roxb.) A. Chev.

### General information on the species

- **Synonyms:** *Madhuca indica* J.F. Gmel.  
*Madhuca latifolia* (Roxb.) J.F. Macbr.
- **Odiya name:** Mahul
- **Other vernacular names:** Moha, Mahua

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** Moderately acid to slightly alkaline nature, generally with a pH of 5.0 to 7.5.
  - **Soil type:** Prefers a deep loamy or sandy-loam soil with good drainage. It also occurs on shallow bouldery, clayey and calcareous soils, alluvial soil Indo-Gangetic plain.
  - **Topography:** Central and northern plains of India. Can be found scattered in pastures, in crop fields and on rivers banks.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical and subtropical climate.
  - **Elevation:** Upto an altitude of 1200 m -1800 m.
  - **Rainfall:** 500 mm to 1800 mm.
  - **Temperature:** 2 - 46°C.
- **Silvicultural characteristics:**
  - It is a frost resistant species.
  - The tree is a light demander and drought resistant.
  - It tolerates waterlogging.



### Plantation techniques and management practices

- **Pit size:** 60 cm × 60 cm × 60 cm or in crow bar holes
- **Spacing:** 4 m × 4 m or 8 m × 8 m depending upon the size of site.
- **Growth rate:** Medium. mean annual increment of 3-5 cu.m/ha
- **Method of Planting:** Direct Sowing, Entire plant planting and stumps planting.



**Direct Sowing:** In July, direct sowing is done in a line spaced 4 m -5 m apart. The seeds are planted 1.5 cm - 2.5 cm deep. Weeds and bushes are kept out of the lines. Sowing in 30 cm<sup>3</sup> trenches filled with FYM, green manure and soil mixture, spaced at 9 m x 9 m, with 4-5 seeds per pit and intervening spaces, was done and reported as successful. The main issue is protecting plants from hot winds and bamboo shields have been used as sun protection.

Nursery raised seedling planted during monsoon season.

**Stump planting:** Stumps are prepared from one-year old plants which are planted in pits during monsoon season.

- **Irrigation:** Irrigation during initial years of establishment is very essential.







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## *Mesua ferrea* L.

### General information on the species

- **Synonyms:** *Mesua nagassarium* (Burm. f.) Kosterm. *Mesua speciosa* Choisy
- **Odiya name:** Nageswar
- **Other vernacular names:** Nagkesar, Nag Champa

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** Prefers a pH in the range 5 - 5.5, tolerating 4.3 - 6.
  - **Soil type:** Well-drained, moist and deep fertile soil, stiff clay soil.
  - **Topography:** Moist lowland rainforests, associated with riverine sites.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical and subtropical climate.
  - **Elevation:** Upto 1500 m above mean sea level.
  - **Rainfall:** Mean annual rainfall in the range 3000 mm - 4000 mm, but tolerates 2000 mm - 5100 mm.
  - **Temperature:** 4 - 45°C.
- **Silvicultural characteristics:**
  - It is a tolerant to dense shade. The shade-tolerance nature of *Mesua* makes it a valuable component of the understory of evergreen forests.
  - Direct exposure to the sun is harmful.
  - *Mesua* is sensitive to drought and suffers badly when planted outside its habitat in localities subjected to drought.
  - It is sensitive to frost and fire.



### Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm.
- **Spacing:** 5 m × 5 m.
- **Growth rate:** Slow-growing, especially when young.



- **Method of planting:** Direct sowing and planting have both been successful in regenerating the species. May–June is ideal season for sowing. Plant seedlings with naked roots, balls of earth, or in containers have all been successful. During the autumn rains, seedlings of 45 cm – 50 cm in height, about a year old, are planted at a spacing of 5 m x 5 m. During the early stages of establishment, *Cajanuscajan* is planted around the plants to offer partial shade.
- **Manure and Fertilizer:** Initially, once during the rainy season in the first year, NPK fertilisers @ 0.05-0.10 kg/plant are recommended. Depending on the age of the plants, the doses may be increased in subsequent years. After six months, additional Nitrogen is usually added to boost growth. During the first ten years of growth, hoeing and weeding are essential.
- **Irrigation:** Crop requires irrigation at 15 days interval during dry seasons mainly from December to May in early stage.





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## *Michelia champaca* L.

### General information on the species

- **Synonyms:** *Champaca michelia* Noronha  
*Michelia suaveolens* Pers.
- **Odiya name:** Champa, Champaka,
- **Other vernacular names:** Champaca, Champak, Cempaka Merah, Yellow Champaka, Orange Champaca

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 4.5 - 5.5, tolerating 4 - 6.
  - **Soil type:** It occurs on deep, moist, loamy or sandy loam textured, well drained, acidic fertile soil is favored.
  - **Topography:** Low and medium elevation.
- **Suitable climatic conditions:**
  - **Climate type:** Hot and humid climate.
  - **Elevation:** Upto 2400 m.
  - **Rainfall:** 2250 mm - 5000 mm.
  - **Temperature:** Maximum temperature is 35 - 40°C, the absolute minimum temperature 3 - 10°C.
- **Silvicultural characteristics:**
  - It is a light demander. Young plants will be affected by drought.
  - The tree responds well to coppicing and it does not produce root suckers.
  - The tree is susceptible to fire.
  - The tree is frost-hardy.
  - It does not tolerate waterlogged conditions.



### Plantation techniques and management practices

- **Pit size:** 60 cm × 60 cm × 60 cm.
- **Spacing:** 1.8 m × 1.8 m and 2.4 m × 2.4 m.



- **Growth rate:** mean annual increment is 1 m - 1.8 m in height and 1.5 cm - 2 cm in diameter.
- **Planting Method:** The most successful method of plantation is to plant out nearly 1 year old seedlings at the break of the monsoon of the following year. Planting with a ball of earth or with naked roots is possible, but success is largely dependent on favourable planting weather.
- **Irrigation:** Water adequately when the plant is young, water moderately when the plant is mature.





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## *Mitragyna parvifolia* (Roxb.) Korth.

### General information on the species

- **Synonyms:** *Mitragyna parvifolia* var. *microphylla* (Kurz) Ridsdale  
*Mitragyna parvifolia* var. *parvifolia*
- **Odiya name:** Mundi, Gudikaima
- **Other vernacular names:** Kaim, Ghor Karam

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** Upto 4.5-7.5.
  - **Soil type:** Grows well in deep, well-drained soil as well as stiff, poorly drained low-lying clayey soil, black cotton and alluvial soil.
  - **Topography:** From plain areas to ravines.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical and subtropical climate.
  - **Elevation:** 900 m - 1300 m above mean sea level.
  - **Rainfall:** It can withstand annual mean rainfall of 900 mm - 3000 mm but prefers 1500 mm - 2500 mm.
  - **Temperature:** 5 - 47°C.
- **Silvicultural characteristics:**
  - Mature trees of this species are light demanders.
  - It is drought tolerant, though frost can cause damage to the young trees.
  - This plant cannot withstand saline soils.
  - It is tolerant of waterlogging and strong winds.



### Plantation techniques and management practices

- **Pit size:** 30 cm x 30 cm x 30 cm.
- **Spacing:** Mature seedlings can be planted at 2.5 m x 2.5 m or 5 m x 5 m spacings. For agroforestry - 10 m x 2.5 m spacing preferred.
- **Irrigation:** During the first three months after planting, the field must be irrigated on a regular basis.



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## *Morinda citrifolia* L., nom. cons.

### General information on the species

- **Synonyms:** *Morinda tinctoria* L.  
*Morinda angustifolia* Roth, nom. illeg.
- **Odiya name:** Achu, Pindra
- **Other vernacular names:** Indian mulberry, Aal, Surangi, Nagakunda, Nuna

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 5 - 6.5, tolerating 4.3 - 7.
  - **Soil type:** Sandy, medium loamy and heavy clay soils, prefers well-drained soil and can grow in nutritionally poor soil.
  - **Topography:** *M. citrifolia* can be found growing in coastal and littoral forests, disturbed forests, dry to mesic forests, deciduous forests, xerophytic habitats, grasslands, open areas near shoreline, abandoned pastures and coconut plantations.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical and subtropical climate.
  - **Elevation:** Upto 1500 m.
  - **Rainfall:** 1500 mm - 3000 mm, but tolerates 700 mm - 4200 mm.
  - **Temperature:** Annual daytime temperatures are within the range 24 - 30°C, but can tolerate 12 - 36°C.
- **Silvicultural characteristics:**
  - It is persistent and very tolerant.
  - Can tolerate drought.
  - It can grow in semi-shade (light woodland) or no shade.
  - The plant can tolerate strong winds but not maritime exposure.
  - It is frost tender.





## Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm
- **Spacing:** 3 m × 3 m
- **Growth rate:** Has a moderate growth rate (0.75 – 1.5 m/year)
- **Method of Planting:** Choose a site that receives full or partial light and has well-drained, well-aerated soil. Heavy soil, compacted places and flood-prone areas should all be avoided. Make a pit the size of the earth ball and carefully place nursery-raised seedlings in it.
- **Manure and Fertilizers:** Trees that grow in forests usually appear to be in good health, even without the use of chemical fertilizers. This indicates that noni may just require a minimal amount of fertilizer to thrive. More research is needed to determine the optimal fertilizer regimens for noni production in the various parts of the country where noni is cultivated. Application of 20 kg of poultry manure per plant, combined with 4 kg of vermi-compost and 2 kg of PGPR I-enriched neem cake per plant, was found to be the most efficient treatment for producing noni under organic resource management for guaranteeing optimal vegetative growth.
- Drip irrigation and mulching is used to maintain plantation field.



### General information on the species

- **Synonyms:** *Emblica officinalis* Gaertn. *Cicca emblica* (L.) Kurz  
*Emblica arborea* Raf.
- **Odiya name:** Aula
- **Other vernacular names:** Amla, Gooseberry

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 5.5 - 8.5.
  - **Soil type:** It grows on well drained alluvial, murrum laterite, black, red and sandy soil.
  - **Topography:** Plains and lowland regions.
- **Suitable climatic conditions:**
  - **Climate type:** Subtropical and moist tropical climate. Also prefers semi-arid climate.
  - **Elevation:** Upto an altitude of 1800 m.
  - **Rainfall:** Mean annual rainfall in the range 1500 mm - 2500 mm, but tolerates 700 mm - 4200 mm.
  - **Temperature:** Annual daytime temperatures are within the range 20 - 29°C, but can tolerate 14 - 35°C.
- **Silvicultural characteristics:**
  - It is drought tolerant as well as frost tolerant.
  - It cannot withstand waterlogging.
  - It is fire tolerant and is one of the first trees to recover after a fire.



### Plantation techniques and management practices

- **Pit size:** Fertile land: 30 cm x 30 cm x 30 cm, Barren land: 50 cm x 50 cm x 50 cm.
- **Spacing:** 6 m x 6 m or 8 m x 8 m depending upon site.
- **Growth rate:** The tree is rather slow growing.
- **Manures and fertilizers:** Application of 10 kg FYM, 200g N, 500g P, 200g K per plant per year. Manuring should be done immediately after pruning.
- **Irrigation:** Watering is needed in young plantations; thereafter, watering is done only in the dry season.





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## *Pongamia pinnata* (L.) Pierre

### General information on the species

- **Synonyms:** *Millettia pinnata* (L.) Panigrahi  
*Pongamia glabra* Vent.
- **Odiya name:** Koranga, Karanja, bruttaphala
- **Other vernacular names:** Karanja, Karanj, Pongam tree

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** pH tolerated is in the range of 5-7.5.
  - **Soil type:** Sandy and gravelly soils.
  - **Topography:** Riverbanks, roadsides, degraded lands. Plain and hilly area.
- **Suitable climatic conditions:**
  - **Climate type:** Humid and subtropical environments. Also found in the tropics and arid zones.
  - **Elevation:** Upto 1200 m.
  - **Rainfall:** Mean annual rainfall is 500 mm - 2500 mm, with a dry season of 2 - 6 months.
  - **Temperature:** Temperature ranges from a minimum of 1-16°C, up to a maximum of 27 - 38°C.
- **Silvicultural characteristics:**
  - It's a drought-resistant plant. It can withstand saline, alkaline and wet soils.
  - Wind-resistant, with the ability to tolerate slightly salty air.
  - It is not suited to dry sands.
  - It thrives in full sun and generates a large number of root suckers.



### Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm or 45 cm × 45 cm × 45 cm
- **Spacing:** 4 m × 4 m for normal plantation, 6 m × 6 m for avenue plantation and 2 m × 2 m for block plantation. The spacing in case of artificial regeneration would differ with the object of planting.
- **Method of planting:** Direct sowing of ripen seed, planting entire plant and stumps are feasible. Direct Sowing - In June, after the end of the summer monsoons, ripe seed is sown in patches or lines. Stumps - Previous research has found that a collar diameter of 1 to 2 cm gives good results.



### General information on the species

- **Synonyms:** *Pterocarpus marsupium*
- **Odiya name:** Bija, Piasal
- **Other vernacular names:** Malabar kino, Indian kino, Vijayasar and Bijasar

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** Up to 6 -7 but tolerates 5.5 - 7.5.
  - **Soil type:** Sandy, black cotton and alluvial soil.
  - **Topography:** Plains and lowlands. Occasionally on hill slopes if drainage is adequate.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical areas.
  - **Elevation:** From 200 m - 500 m, but exceptionally upto 1200 m.
  - **Rainfall:** Mean annual rainfall in the range 1000 mm - 1500mm but tolerates 750 mm - 2000 mm.
  - **Temperature:** Mean annual temperature falls within the range 22 - 34°C, but can tolerate 4 - 47°C.
- **Silvicultural characteristics:**
  - It is a moderate light demander. Saplings and poles can stand a fair amount of lateral shade but will not tolerate any overhead shade.
  - It's a drought-resistant species.
  - Young seedlings are susceptible to frost.
  - Susceptible to fire damages.
  - Requires a sunny position in a well-drained soil.



### Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm.
- **Spacing:** Monocrop: 3 m × 3 m, Agro forestry system: 8 m × 8 m.



- **Rate of growth:** Rate of growth is slow in the first season, but increases from second season onwards.
- **Method of planting:** Direct sowing, entire planting, or stumps planting are all viable options. Sowing should take place in June, just before the rainy season begins. Planting one-year-old seedlings throughout the plant is beneficial. The planting season is from June to July.
- **Irrigation:** In the first year, irrigation should be done ideally once a month using a check basin system or by filling the pit basin with water.





### General information on the species

- **Synonyms:** *Lingoum santalinum* (L.f.) Kuntze
- **Odiya name:** Raktha Chandan
- **Other vernacular names:** Red Sandalwood, Laal Chandan, Red Sanders Tree

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 5 - 5.5, but tolerates 4.5 - 6.5.
  - **Soil type:** It grows particularly well on lateritic loam. It requires perfect drainage and is found mainly on stony or gravelly soil.
  - **Topography:** The tree grown typically on dry, hilly often rocky terrain. At lower altitude, it found on all aspect but in higher hill confined itself to cooler aspect.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical areas with a distinct dry season.
  - **Elevation:** 500 m -900 m above sea level.
  - **Rainfall:** Mean annual rainfall in the range 800 mm - 1400 mm, but tolerates 600 mm - 2300 mm.
  - **Temperature:** 26 - 32°C, but can tolerate 7 - 46°C.
- **Silvicultural characteristics:**
  - It is a light demander and will not tolerate overhead shade.
  - It requires regular thinning to promote the best growth.
  - It has better fire resistance than its associated species.
  - It regenerates well in a dry, hot climate.
  - Species is resistant to drought. It is not frost-tolerant.
  - It has wide range of pathogen tolerance.



### Plantation techniques and management practices

- **Pit size:** 45 cm × 45 cm × 45 cm
- **Spacing:** 3 m × 3 m, 4 m × 4 m
- **Growth rate:** Fast growing species.



- **Method of planting:** Species plantation can be established by using variety of techniques, including direct sowing, whole planting and stump planting. Pits are dug in the planting area. All roots and other weeds should be removed by the end of May and planting can commence after the monsoons arrive. Saplings that are one-year-old should be placed in pits. The pits are filled with topsoil that has been well mixed with 10–15 kg of FYM (farmyard manure) and 10 g of lindane dust to protect the planting stock against soil-borne fungus.
- **Manure and Fertilizer:** 10–15 kg FYM per plant per year and 150:100:100 g NPK (nitrogen, phosphorus and potassium) per plant per year are necessary for at least the first five years. Fertilizer should be applied in circular trenches 15–20 cm deep dug at a distance of 60 cm around the plant. A full dose of P and K, as well as one-third of N, should be applied by the end of February. The remaining N should be applied to *Pterocarpus santalinus* in two split doses in June–July and October–November. Inorganic fertilizer applications should always be followed by irrigation. The mortality is filled one month after planting. Weeding is done by hand as necessary, especially right before manuring. Hoeing is done on a regular basis to loosen the soil around the basin.





### General information on the species

- **Synonyms:** *Myrtus cumini* L.
- **Odiya name:** Jamo, Jamo, Kudijamu
- **Other vernacular names:** Jambul, Jamun Indian Blackberry, Jambula

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 5.5 - 7, tolerating 4.5 - 8.0.
  - **Soil type:** It grows on alluvial and colluvial soils of various textures, from clayey soils to loamy sands. It can withstand swampy climates and locations that are prone to seasonal flooding. On dry areas, the tree tends to stick to the area around water sources.
  - **Topography:** Along streams, Damp and marshy localities.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical and sub-tropical climates.
  - **Elevation:** It grows well from sea-level to 1800 m and up to 2000 m.
  - **Rainfall:** Mean annual rainfall in the range 500 - 5000 mm, but tolerates 800 - 9900 mm. In drier sites, its occurrence restricted to the nearby of streams and rivers.
  - **Temperature:** 20 - 32°C, but can tolerate 12 - 48°C.
- **Silvicultural characteristics:**
  - It is a shade - bearer, particularly in young stage.
  - It tolerates prolonged flooding.
  - It is drought tolerant.
  - The trees are coppiced remarkably well.
  - Seedlings are readily killed by fire but saplings and trees survive ground fires.
  - It can be grown under adverse soil and climate conditions. It is frost sensitive.
  - It is wind-resistant and sometimes closely planted in rows act as windbreak.



### Plantation techniques and management practices

- **Pit size:** 1 m × 1 m × 1 m.
- **Spacing:** For Budded or grafted plants: 5 m x 5 m, for seedling trees: 10 m x 10 m.
- **Growth rate:** Fast - growing plant.
- **Method of planting:** Direct sowing, by planting out seedlings and by stump planting. Among these three methods, the choice will depend on the site condition.
- **Irrigation:** Drip irrigation is advised for orchards. Watering can be done every 10 to 15 days in winter and at weekly intervals during summer.



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## *Terminalia alata* Heyne ex Roth

### General information on the species

- **Synonym:** *Terminalia elliptica* Willd.
- **Odiya name:** Sahaju, Sajo, Sahaja
- **Other vernacular names:** Asan, Sain, Saj

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 5.5 - 6.5, but it tolerates 4.5 - 7.5.
  - **Soil type:** Alluvial soils are favorable. Planting requires moist conditions with deep, heavy, clayey soils.
  - **Topography:** Low elevation, low slope and high hill shade.
- **Suitable climatic conditions:**
  - **Climate type:** It grows well in all climates, except dry.
  - **Elevation:** Upto 200 - 1400 m.
  - **Rainfall:** The mean annual rainfall requirement is in the range of 1000 mm - 2000 mm.
  - **Temperature:** 22°C - 35°C, can tolerate 5°C - 48°C.
- **Silvicultural characteristics:**
  - It is light demander and is rapidly suppressed under shade.
  - It is seedlings are fairly hardy against drought, the tree is regarded as tender to drought.
  - The species is fairly tolerant to damage by fire.
  - It survives in rainy conditions, but is sensitive to drought.



### Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm.
- **Spacing:** 2 m × 2 m, 5 m × 5 m.
- **Method of Planting:** The best ways for raising the species are direct sowing and stump planting. Direct sowing in worked up soil succeeds well. Stump Planting is preferred for afforestation in areas that are frequently flooded during the rainy season. Stumps with a diameter of 2.0 cm at the collar appear to be suitable. It tolerates heavy soils and does well in clays soils.
- **Irrigation:** For new plantations, irrigation should be done at 15-day intervals during the summer season.



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

### General information on the species

- **Synonym:** *Pentaptera arjuna* Roxb. ex DC.
- **Odiya name:** Koha, Kahu
- **Other vernacular names:** Arjun, Arjuna

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 5 - 7.
  - **Soil type:** It grows best on loose, moist, fertile alluvial loam and light, deep sandy soil.
  - **Topography:** It is found on tropics upland and lowland to streambeds and rivers. Its comparatively shallow root system prevents its establishment in dry localities (Chaturvedi, 1958).
- **Suitable climatic conditions:**
  - **Climate type:** Dry to moist climatic conditions.
  - **Elevation:** 0 - 1200 m above mean sea level.
  - **Rainfall:** It is found in areas with annual mean rainfall ranging from 750 to 1800 mm.
  - **Temperature:** Annual mean temperature of 20°C - 33°C, though it can tolerate 5°C - 47° C.
- **Silvicultural characteristics:**
  - It a moderate shade bearer, but does not tolerate overhead shade. It has a shallow root structure that makes it easy for it to spread along stream banks.
  - For a few weeks, it can survive half submersion.
  - It thrives in open, sunny, low-rainfall environments.
  - It is sensitive to drought, fire and frost.
  - It has high wind tolerance as well as disease and pest tolerance.
  - It has high pollarding and coppice power.
  - Arjun readily produces root suckers, which aid in regeneration.



### Plantation techniques and management practices

- **Pit size:** 45 cm × 45 cm × 45 cm, 60 cm × 60 cm × 60 cm.
- **Spacing:** 6 m × 6 m.





- **Growth rate:** Saplings and poles grow at a fairly fast rate.
- **Method of planting:** Direct sowing, planting out and stump planting are all viable options for raising the species. Direct sowing should be done just before the monsoon rains begin. It should be done in loose soil. For seedling planting, one-year-old nursery-raised saplings should be used.
- **Manure and Fertilization:** 10 kg of farmyard manure (FYM) and 75 gm of Nitrogen, 50 gm of Phosphorus and 30 gm of Potassium per plant will be placed to the pit and properly mixed with the soil as a base dose.
- **Irrigation practices:** During the summer, young plantings should be irrigated at 15-day intervals.





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## *Terminalia bellirica* (Gaertn.) Roxb.

### General information on the species

- **Synonym:** *Terminalia bellirica* var. *laurinoides* (Teijsm. & Binn.) C.B. Clarke
- **Odiya name:** Bahada, Bada, Thara
- **Other vernacular names:** Beda nut tree, Baheda

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** 5.5 - 6.5, but tolerates 5 - 7.5.
  - **Soil type:** Prefers well-drained soil. Grows well on light (sandy), medium (loamy) and heavy (clay) soils.
  - **Topography:** Plain areas.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical and subtropical climates.
  - **Elevation:** Altitude of 600 m -1400 m above mean sea level.
  - **Rainfall:** 1000 mm to over 3000 mm.
  - **Temperature:** Annual daytime temperatures within the range 20°C - 33°C, though it can tolerate 5°C - 45°C.
- **Silvicultural characteristics:**
  - Fairly tolerant of shade, particularly in the early stages of growth. It needs overhead light later.
  - It is a drought-hardy species, but the growth is subdued in dry localities.
  - It thrives in a sunny location.
  - Plants can tolerate short periods of inundation.
  - Frost causes injury to the leaves. Seedlings that are frost sensitive. Trees react well to coppicing.



### Plantation techniques and management practices

- **Pit size:** On dry land - 60 cm x 60 cm x 60 cm, in fertile land - 45 cm x 45 cm x 45 cm.
- **Spacing:** 3 m x 3 m, 5 m x 5 m.
- **Growth rate:** A tree raised from seed grew 11.2 m in height and 71.4 cm in girth in 16 years. The rate of growth of coppice crop is faster.
- **Method of Planting:** The tree can be raised by direct sowing or by planting out of the nursery. For planting out, beginning of the monsoon season is the best time to plant. Stump plants did not produce good outcomes. Direct sowing of seeds in lines or trenches can be done. When direct sowing, it's advisable to keep some seed on hand in case of failure.



## *Terminalia chebula* Retz.

### General information on the species

- **Synonyms:** *Terminalia chebula* var. *chebula*  
*Terminalia chebula* var. *tomentella* (Kurz) C.B. Clarke
- **Odiya name:** Karedha, Harida, Horada
- **Other vernacular names:** Harar, Harra, Harad

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** Prefers a pH in the range 5.5 - 6.5, but tolerates 5 - 7.5.
  - **Soil type:** It best development on loose, well-drained soil such as sandy loam, as well as clayey loam soil.
  - **Topography:** It is found scattered in deciduous forest, Open areas in the forest, rocky hills, on dry slopes.
- **Suitable climatic conditions:**
  - **Climate type:** Tropical and subtropical climates.
  - **Elevation:** Upto an elevation of 600 m.
  - **Rainfall:** Mean annual rainfall of 1200 mm to 3000 mm.
  - **Temperature:** Mean annual temperature range between 36°C and 45°C.
- **Silvicultural characteristics:**
  - Harra is a strong light demander and is unable to tolerate conditions of shade (except during the seedling stage).
  - Drought and frost resistance are moderate.
  - It is a good coppicer and fairly fire tolerant.



### Plantation techniques and management practices:

- **Pit size:** 45 cm × 45 cm × 45 cm, 60 cm × 60 cm × 60 cm.
- **Spacing:** 3 m × 3 m.
- **Rate of growth:** Rate of growth is found slow.



- **Manuring and Fertilization:** Add 15 kg Farmyard manure (FYM) and 75g N, 30 g P and 30g K per plant in pit and thoroughly mixed with soil as basal dose.
- **Method of Planting:** Direct sowing, planting out of nursery-raised seedlings and stump planting have all been viable methods of raising it. However, the published evidence suggests that planting out of one-year-old seedlings is preferable to stump planting and planting out. Transplantation of one-year-old saplings is done in the monsoon season.
- **Irrigation:** In the first three to four years, depending on the soil moisture and season, irrigation in pits is essential. In the summer, the plants should be irrigated at least once a week.
- Tree growth is aided by earthing and hoeing twice a year.





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## *Xylia xylocarpa* (Roxb.) Taub.

### General information on the species

- **Synonyms:** *Acacia xylocarpa* (Roxb.) Willd  
*Xylia xylocarpa* var. *kerrii* (Craib & Hutch.)  
I.C. Nielsen
- **Odiya name:** Kangada, Bolia, Kongora
- **Other vernacular names:** Jambu, Jamba, Yerul

### Climatic and edaphic requirements

- **Suitable soil characters:**
  - **pH:** Up to 5 - 6, tolerating 4.5 - 6.5.
  - **Soil type:** Prefers a deep, well-drained sandy soil, red soil, alluvial and lateritic soil.
  - **Topography:** Lowlands and plains. Occasionally on hill streams.
- **Suitable climatic conditions:**
  - **Climate type:** Moist to wet tropical climates.
  - **Elevation:** Upto 850 meters.
  - **Rainfall:** 1700 mm - 4500 mm, but tolerates 1300 mm - 5000 mm.
  - **Temperature:** 16°C - 35°C, though it can tolerate 8°C - 35°C.
- **Silvicultural characteristics:**
  - The trees coppice and pollard well and produce root-suckers in abundance, particularly in burnt areas and wherever the roots are exposed.
  - It prefers a sunny position, but also succeeds in light shade.
  - It is drought-resistant and shade-tolerant.
  - The species is frost - tender.



### Plantation techniques and management practices

- **Pit size:** 30 cm × 30 cm × 30 cm, 45 cm × 45 cm × 45 cm.
- **Spacing:** 4 m × 4 m.
- **Growth rate:** The growth rate of young trees is reportedly fairly high.
- **Method of planting:** According to previous studies in Tamil Nadu, direct sowing is the best strategy. Nursery seedlings do not stand planting out well owing to injury to their root systems. Direct sowing in well-loosened patches at 2 m intervals in rows 3 m apart is advocated.
- **Manure:** FYM, from second or third year onwards, 50 - 70g N, 50 - 60 g P<sub>2</sub>O<sub>5</sub> and 50 - 70g K<sub>2</sub>O is also added to each plant depending on size.



- **Thinning** of coppice shoots is beneficial in improving their development.
- **Weeding** is necessary in the initial years of establishment.

### Management of diseases/insect-pests/parasites

- **Insects:** Stem borers and defoliators can cause severe damage. The larvae or adults of the families Anthribidae, Bostrychidae, Buprestidae, Cerambycidae, Termitidae and Scolytidae bore into dead wood or into felled or fallen wood.
- **Disease:** *Xylia* trees in fire-damaged areas have been discovered to be infected with fungi such as *Fomes*, *Polystictus* and others. The presence of resin in the wood makes it resistant to fungus and termites. The plant is affected by *Oenospila quadraria*, *Sauris* sp. and *Buzura* sp., however the infestation is not severe.
- **Injuries:** As manure, the leaves are lopped. During the heat season, deer and bioson browse the seedlings, causing significant harm by trampling them. Weevils are seed eaters.





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