STANDARD OPERATING PROCEDURES FOR POST 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 Post Plantation Techniques

Submitted To:

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

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Message

In our pursuit of sustainable forestry methods, I hope this manual finds the users motivated and prepared to start a new chapter. I am pleased to announce the publication of our ground-breaking Standard Operating Procedures of Post Plantation Techniques for the selected forestry species. This comprehensive manual will transform the way we care for and maintain our priceless forestry species.

The result of countless hours of teamwork and the scientific knowledge of our ICFRE team members is this guidebook. It acts as a key resource for enhancing the development, well-being and long-term viability of our forestry plantations, ensuring that we get the most out of our initiatives to establish strong and resilient forests.

This manual will aid the forestry practitioners in enhancing ecological resilience and productivity of our forests by using the methods described in this handbook, which will also promote sustainable development, economic prosperity and social well-being. Our forestry plantation have immense potential to offer timber for building, fuelwood, NTFPs and a wide range of ecosystem services, which would be advantageous to the populations who rely on them and the environment as well.

I urge foresters to explore this manual, to incorporate its methods into our forestry operations. Let's together seize the chance to lead the way in sustainable forestry management, creating new standards for excellence and motivating others to take lead.

Let's work together to discover the benefits of sustainable forestry so that we may create a future where healthy trees stand as a symbol of our unshakable dedication to environmental care.

Dated: 10 July, 2023

(Arun Singh Rawat)

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Foreword

In our combined efforts to manage forests sustainably, the Standard Operating Procedures on Post Plantation Techniques will be a key turning point. These manual provide a plethora of information that has been particularly adapted for the exceptional ecological environment of Odisha.

We must tackle post-plantation processes with precision and ingenuity due to Odisha's varied geographies, abundant biodiversity and the critical role that forests play in maintaining livelihoods. For foresters, environmentalists and all other parties concerned in the preservation and management of our priceless forest ecosystems, these guides are an essential resource.

The Post Plantation Techniques of Forestry Species of Odisha Manuals provide in-depth analyses of the distinctive traits of our forestry species, their growing needs and the most effective methods for their successful establishment and upkeep.

I would like to express my sincere gratitude to the hardworking team of ICFRE who have contributed their knowledge and enthusiasm to the creation of this manual.

Dated: 10 July, 2023

(Debidutta Biswal)

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Preface

Our globe depends on forests, which offer a wide range of advantages including carbon sequestration, clean air and water, biodiversity preservation and sustainable livelihoods. But the difficulties we have in managing and recovering forests need for fresh ideas and efficient post-planting methods.

This manual is a useful tool that provides a variety of information and useful ideas for caring for and managing forestry species following the planting stage. Numerous issues are covered, such as the plantation management, soil health, insect control and sustainable harvesting procedures.

The methods described in this manual are based on academic study, practical experience and the knowledge of forestry experts who have committed their careers to the conservation of our natural resources. It demonstrates our dedication to ethical environmental management, the preservation of biodiversity and sustainable land management.

I express my sincere gratitude to the dedicated team of scientist and officers of Institute of Forest Productivity, Ranchi who contributed their expertise and passion to the development of this manual. Their collective efforts have resulted in a comprehensive resource that will guide us toward more sustainable and responsible forestry practices.

Dated: 10, July, 2023

(Sanjeev Kumar)

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CHAPTER 1

CASUALTY REPLACEMENT & IRRIGATION

- Casualty Replacement
- Irrigation

After planting, various types of post plantation method is required for promotion of growth at different stages of development of crop with minimizing the mortality rate of plants. Of these, watering, weeding, soil working, mulching, fire trenching, gap filling, cleaning and spacing, fertilizing, pruning, thinning and improvement filling are considered important.

1.1 Casualties Replacement

As soon as the main plantation operation is over the entire area shall be gone over in the same order as plantation was carried out and casualties if any shall be replaced. It is often convenient to combine this operation with the first weeding. One year and two year old plantations shall be visited early in June-July. Pits or places where casualties have occurred shall be marked with new stakes. The area around the new stakes shall be cleared. Pits shall be re-dug and prepared for planting. Replacement of these casualties shall be carried out simultaneously with main plantation operation of the year.

Healthy and good sized stumps, pre-sprouted stumps or seedlings shall be used for replacements. The usual tendency to utilized rejected seedlings for replacement shall be drastically checked. Where stump planting has been carried out pre-sprouted stumps or vigorous potted seedlings shall be used for replacement in the current year's plantations. Stumps may be used in the older plantations provided planting is carried out at the time suitable for stumps.

1.2 Irrigation

Adequate supply of water in all the seasons should be available. Small dams also ensure water in an otherwise seasonal stream for supply to the plantation areas.

Sources

Open water sources require less investments and water can be diverted to some extent by channel and check dams to the site of application. Increasing the depth of the well as the water table drops or constructing, at the outset, a deep well equipped with powered pumps can overcome difficulty in dry areas. When water is pumped from a nearby stream or reservoir, equipment for filtering out small particles of sand and debris should be installed. The number of screens required in a filtration system is influenced by the character and amount of material to be removed from the water. Artesian wells are also used in the terai of Uttar Pradesh.Centrifugal pumps operated by electric supply or diesel oil for lifting water from deep well or through bores done in the ground water are in common use in the countryside.

1.2.1 Types of irrigation

1. **Flow Irrigation**

- The method is not suitable for water scarcity areas, as also not suited to irrigate seed beds where sowing has been done with minute seeds.
- Flow irrigation results in formation of hard crust on the ground surface after it gets dried, which retards the growth of seedlings.
- The method particularly suits to light soils with good drainage.

2. Overhead irrigation

(a) Atomizer

- Watering by atomizer is the best known method for seed beds.
- Fine seeds and tiny seedlings for which there is a danger of washing away or suffer damping off and lodging due to excessive irrigation should be watered by this method.
- A pump fitted with pipe to the water source driven by hand produces fine water vapours in the form of mist.
- The automizer should be applied gently so that the water vapours settle down on bed smoothly without any force, which consequently would damage the tiny seedlings.

(b) Rose-can

- It is suited to most of the species including the minute seeded species like *Adina cordifolia* and *Eucalyptus spp*.
- As the seedlings are tender, watering has to be done from a close distance to avoid physical injury.

(c) Sprinkling

- When water is pumped through, it comes out with pressure in fine jets. Both permanent and portable type of sprinkling system is available in the market.
- Such a system includes water mains, pipelines, risers, oscillators, flush valves and pipe.
- Ordinarily it is not necessary to sprinkle the entire plantation area at one time, so it is not necessary to install pumping facilities of sufficient capacity to operate all the overhead lines simultaneously.

(d) Drill system

- In the recent years efforts have been made to develop irrigation techniques and practices fostering maximum economy and water use.
- Completely underground irrigation system with the aid of minute sized perforations in polythene pipes, buried in the ground which feed water directly to the plant roots have been tried.
- It reduces or eliminate two forms of water losses incurred namely losses in transit in the open drains and evaporation from the soil surface.

1.2.2 Quantity of Water

- With all species, overwatering must be avoided, the pots and their contents must be kept moist, but not waterlogged.
- Watering needs soaking the soil rooting medium to its field capacity.

- Apart from the initial stages of watering when heavy and continuous watering is to be carried out to ensure complete saturation of the soil contents, watering during the germination stages must be just but frequently throughout the day.
- Ideally, once seedlings are well established in the pots, water should be applied only when they show signs of wilting.
- Towards the end of the season after rainfall, watering must be reduced to the minimum. Although there is no evidence that irrigation nursery methods produce drought hardy plants, it is sensible to attempt "hardening off" before planting out.
- Continuous under watering, however, creates a superficial root system for the plant which cannot withstand drought when planted.
- Some species can withstand drought periods better than others. Experiments have shown that well established *Azadirachta indica* pot plants can recover from wilting after ten days without water, but longer than this period losses are very high.
- Increasing availability of moisture is essential for the growth of sal seedlings. In case of light soils irrigation should be given after 25% to 50% depletion of available moisture for good growth of sal seedlings.
- In heavier soils irrigation should be given after 50 to 75% depletion of soil moisture. Irrigation at 50% available soil moisture is also found to be beneficial for the uptake of applied N.P.K. fertilizers for example by sal seedlings.

1.2.3 Quality of water

The quality of water being used for irrigating should be tested particularly in arid and semi-arid areas. The total concentration of dissolved salt and sodium absorption ratio are two important characteristics to be studied. If water of acceptable quality is not available, it can be improved. For example 25 gm of aluminium sulphate per 100 litre of water can reduce pH of 8 to 5. Calcium nitrate can be used for increasing the pH.

CHAPTER 2

CULTURAL OPERATIONS

- Hoeing or Pullling
- Basin Prepararion
- Weeding

For better and healthy growth of seedlings planted, following cultural operation needs to be carried out in the plantations:

1. Hoeing
2. Basin Preparation
3. Weeding

2.1 Hoeing or Pulling

Hoeing is best done when the weeds are very small seedlings or newly emerged shoots of perennial weeds. This allows shallow hoeing to kill the weeds without bringing new seeds to the soil surface.

1. Shallow hoeing also reduces root damage to the crop. Stirrup hoes (shuffle hoes) are ideal for shallow weeding. A garden rake moved in an oval motion covers large areas quickly.
2. Traditional chopping type hoes are sometimes useful for hacking back weeds in untilled corners of the garden, but in loose soil they tend to dig too deep, damage crop roots and bring up more weed seeds.
3. If the weeds are so large that a traditional hoe is needed, hand pulling or digging them out may be more efficient in the long run.
4. One objective of hoeing should be the creation of a dust mulch. This is a layer of very loose soil crumbs, typically 0.5 to 1.5 inches thick. It can be achieved with most tools that work the soil shallowly including a rake, garden claw or stirrup hoe.
5. Weeds seeds need good contact with the soil for germination just like crop seeds. Since most individuals of most annual weed species emerge from the top inch of soil, maintenance of a dust mulch greatly decreases weed density.
6. Obviously, a dust mulch is impossible to maintain during wet weather, but when it is feasible, a dust mulch is a highly effective weed management technique.
7. Crops that you expect to hoe should be planted with hoeing in mind. For example, sweet corn plants should be spaced sufficiently to allow your hoe to slide between the plants after the prop roots form.
8. Having hoes of several widths and types helps you match the hoe's action to the crop and situation.

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Hoeing is best done when the soil is slightly dry and the weather is warm and sunny. First, such conditions are ideal for drying out uprooted weeds and producing a dust mulch. Second, the hoeing will do less damage to soil structure under such conditions than when the soil is wet. Third, hoeing in rainy, or foggy conditions is likely to spread disease, both on your clothing and by bringing soil into contact with crop foliage.

2.2 Basin Preparation

Immediately after transplanting, a basin is prepared around the tree to prevent run-off and to ensure a sufficient supply of water to the plant. When using a micro irrigation system, it is recommended to have a basin of approximately 1 m in diameter and 20 to 30 cm deep. The basin should have a slight downward slope towards the plant to allow the water to reach the root system of the young plant.

2.3 Weeding

Weeding is done in seeding stage. It is done in the nursery is the cultural operation that involves the removal or cutting or suppressing undesirable vegetation which if not eliminated can impair the growth of plantations. As the weeds compete with the forest crop for light, water and nutrient, this operation helps to provide these critical elements to the planted crop. Weeds are also to be eliminated due to the danger of fire hazard build-up steadily and also because of the fact that weeds can shelter harmful insects.

Weeds can eventually kill trees by their cumulative weight, shading and by exerting pressure by twinning and twisting of some climbers. The density, height growth and nature of root system of the weeds affect the establishment and growth of tree crop.

2.3.1 Patterns and Types of Weeding

Two operations are involved in weeding i.e. suppression and elimination.

Weed suppression can be carried out by trampling or crushing down the weeds by cutting above the ground level. Weed elimination requires however, complete removal by killing of weeds.

Following are the types of weeding:

1. Complete weeding: It requires all vegetation competition to be eliminated around the plants and the areas may be hoed or harrowed. It is a costly operation and is not possible on a large scale.
2. Line weeding: This pattern is adopted in the areas thickly infested with weeds. In the hills this should be carried on contours. A strip of one metre wide is hoed along the planting line.
3. Strips and inter-row cultivation: In this pattern cultivation is done is the interrows to avoid weed competition and the same time to grow food crops as in taungya plantations.
4. Spot ringed: This is the method usually adopted for manual weeding in India. All plant growth around the centre of the plant in a circular ring of 1 to 2 m diameter is hoed around the plants. When the weed growth is heavy and the tree growth is slow, the cost of weeding operations may be very high. In such cases, a decision has to be taken as to the type of weeding to be employed.

Factors like the weed intensity, age of the crop, the terrain, labour availability etc. would determine the type and method to be employed.

2.3.2 Methods of Weeding

Three common methods are manual, mechanical and chemical control, besides biological control.

1. Manual Weeding

It is by far the commonest method. Simple tools such as sickles, brush hooks, kassies, showel and similar implements are used to cut away the competing vegetation. Manual weeding needs little skill and supervision and can be carried out on all sites in almost all the weather conditions with all species. Manual weeding as noted above is restricted to line or spot weeding patterns.

2. Mechanical Weeding

In mechanical weeding, a machine operates between the rows of trees, cultivates the ground by harrowing, or shallow ploughing and outs/turns down the weed growth. The machine is pulled by a tractor, so it is workable only when the spacing of rows is atleast 3 m. Weeds in the rows get missed which can be eliminated by supplementing hand weeding close to the plants.Mechanical cultivation for weed control has been extensively used in large projects. It must, however, be remembered that deep harrowing may damage the roots.

The rear mounted disc harrows and rotavators on agricultural tractors have proven satisfactory in practice. When inter row weeding is in one direction only it is supplemented by line weeding. When it is in M directions i.e. cross weeding, it is supplemented by spot weeding. Tillage by these means is quite effective on most annual weeds as the weeds are cut, rooted out and buried under soil. This method is quite effective in hot, dry weather with dry soils as in moist soils, or when it rains soon after the operation, the roots may quickly re-establish. Such cultivation may also increase the rainfall percolation and reduce evaporation from the soil, which is of considerable significance in certain areas with a marked dry season.

3. Chemical Weed Control

Herbicides have been extensively used in conifer plantations since chemicals which kill grasses and herbs are unlikely to damage coniferous trees, but the essential feature is that experiments are necessary to find out correct dosage and its application, suited to a particular site and species. Herbicidal use in broad leaved plantations is much more difficult as chemical which kills as angiospermic weed is equally likely to kill an angiospermic tree. Precautions should be taken that the recommendation that come with the chemical is rigorously followed. Only pesticides which are bio-degradable and can be broken down easily in the environment (Organophosphates and carbamates) should be used. Inappropriate dosages and techniques should be avoided.

The development of ultra-low volume sprayers has generally widened the possibility of herbicide use. Aerial spraying is feasible for some large scale plantations of one species. Foliar sprays of brush killer (2, 4, 5-T and 2,4-D) has been observed to be effective in controlling Lantana weed in Pine plantations.

Advantages of chemical weed control

(1) The one application provides long lasting control.

(2) Dead weeds are left in situ acting as a mulch and reducing the risk of soil erosion.

(3) High productivity is achieved than in manual weeding. Herbicides should not persist for a long time in soil in toxic form otherwise it may adversely affect the seedlings. The chemicals used for control of perennial weeds in young plantations should be highly toxic but selective for plantation species.

The major disadvantage is being its possible adverse ecological effects. Repeated application of herbicides and pesticides exert a continuous selection pressure on species, favouring development of some genetic resistance.

4. Biological Control

Biological control is still another method in which diseased organism or insect is used which is harmless to the desired plants but kills weed. Use of parasitic plants, selective browsing by livestock and rodents and highly growing competitive replacement plants are other forms of biological control. An excellent example of biological weed control is the prickly pear or opuntia spp. in Australia. Originally planted as an ornamental, its threat had spread to cultivated fields. A moth borer (*Cactoblastis cactorum*) from Argentina was found which attacked only cactus and no other plants. In India, biological control of exotic weeds of Lantana, *Mikania micrantha* and *Eupatorium spp*. have been attempted by introducing exotic insects.

2.3.3 Weeding Regime

In the coniferous forests of Himalayas, usually weeding should begin on 1st June and should be repeated in August. In places where under growth is not aggressive, one weeding early in the rains is sufficient, chir seedlings are not harmed by grass, especially in the lower limits and are best left unweeded except in cases of exceptional herbaceous weed growth in burnt areas.

- Tall weeds like strobilanthes and balsam in deodar, kail, spruce and silver fir areas must be cut back in the rains from the upper sides of the plants to a distance equal to about their height so that they may not be flattened over the plants by snow.
- Weedings are generally required for 3 to 4 years in these plantations. In the plains where heavy rainfall occur, two weedings are necessary, one in September and another before the onset of winter rains. Poplars need weedings for two to three years after planting.

CHAPTER 3

FERTILIZER APPLICATION

- Why Fertilizers
- Types of Fertilizer
- Timing Of Fertilizer Application
- Method of Application
- Rate Of Fertilizer Application
- Frequency of Application
- Time of Application
- Deficiency of Nutrients and its Symptoms in Plants

One of the most desirable functions of forester is to maintain and ameliorate the site conditions for sustainable productivity. The natural forest soils generally contain the essential nutrients for adequate growth of trees but when degraded and mismanaged soils are afforested, plant nutrient supplemented in the shape of fertilizers and manures improve the crop as well as the site.

3.1 Why Fertilizers 

- To correct nutrient deficiency.
- To enhance the rate of growth of trees after planting so as to increase the chances of survival and to shorten the establishment phase.
- To afforest the inhospitable sites or impoverished soils due to general lack fertility.
- Application of fertilizers to selected forest stands or elite trees or seed orchards for increasing production of better quality seeds of desirable phenotype is another possible use especially in anticipated poor seed years.
- Other benefits accruing from the application of fertilizers are lower susceptibility to diseases and overcoming the adverse factors of drought, frost etc., as by addition of fertilizers plant put some some extra growth in the initial period and they become sturdy to overcome such phases.
- The major nutrients e.g. nitrogen, phosphorus, potassium and calcium etc, are required in large quantities by trees while some micronutrients or trace elements are required in small fractions. These nutrients can be added by a balanced composition of some chemicals, called fertilizers.
- The fertilizers which contain only one essential plant nutrient are called straight fertilizers and those containing all the tree elements N, P and K in suitable proportions are called compound fertilizers.

3.2 Types of Fertilizer

Nitrogenous fertilizers: The nitrogenous fertilizers are either nitrate type or ammonium type, some of which are acidic, some alkaline and others neutral. Calcium ammonium nitrate (CAN) is a neutral fertilizer, sodium and potassium nitrates are alkaline in reaction while ammonium sulphate, diammonium phosphate are examples of acidic fertilizers. Alkaline fertilizers may be desirable in many conifer plantations to lower the acidity and for controlling soil mycorrhiza. Ammonium nitrate is very hygroscopic and contains about 35 percent nitrogen and act very fast. Urea is the vastly used fertilizer as it cannot be absorbed directly and has to be first converted into ammonium nitrate by soil organisms and is less toxic to seedling roots.

Phosphatic fertilizers: The most common phosphate fertilizer is the super phosphate which contains 16-20 percent P_2O_5 and small quantities of other nutrients. Double and Triple super phosphate contains 40-50 percent P_2O_5 while metaphosphate contains 63 percent. The metaphosphate is not beneficial for alkaline or calcareous soils, as in these soils much of the applied phosphorus may become fixed and liming may have to be done to increase its availability.

Potassic fertilizer: Potassium chloride is the common potassic fertilizer containing about 50 percent K_2O readily available to plants. Where larger applications are expected to be applied, it is preferable to use potassium sulphate with the same percentage of K_2O, as excessive chlorine ions are toxic to roots.

3.3 Timing of Fertilizer Application

Timing of fertilizer application is important as some species respond soon after planting while for others fertilizers may have to be added years after planting. Moreover, the water regime of the different soils and their structure make it difficult to decide where, should different species be fertilized.The fertilizers, however, generally are applied at three or four stages of life cycle. The total requirement of fertilizer should not be applied at a single time but should be distributed over 3-4 times.

- The first application to trees should be applied within 3-4 months of planting, after the roots have started expansion and extraction of nutrients at the planting site.
- The second application may be carried out when signs of deficiency begin to show.
- The third application may conform to early thinnings to boost thinning response.
- The fourth application may be done well before felling so that extra increment is added before rotation.
- The last two applications are not practiced as no definite advantages have been noticed.

The first application is the widely known practice all over the world. In dry areas, application of fertilizer may cause greater mortality, in newly planted areas if adequate rainfall does not follow, in such areas it is advisable to defer fertilizer application. As fertilizing is a part of the cultural operations, competition of grasses and weeds can negate the positive results of fertilizer applications, only weeded plants show better results.

3.4 Methods of Application

There are several methods of applying fertilizers to trees and shrubs. The method selected depends upon soil characteristics, site factors, cost and type of nutrients to be applied.

Liquid soil injection: This is the method most often used by professional arborists because it is quick, easy and also leads to rapid uptake of nutrients. It utilizes high pressure injection of liquid fertilizer into the soil. Injection points should be 2-3 feet apart depending upon pressure and about 8-12 inches deep. Slow-release forms of liquid injection fertilizers are also available.

Drill hole: This technique requires drilling holes into the soil and distributing granular fertilizer evenly among the holes. Holes are drilled to depths of 8-12 inches and are spaced 2-3 feet apart in concentric circles around the tree, beginning at a point about 1/3 the distance from the trunk to the drip line and extending 1-3 feet beyond the drip line. While rarely used today on a commercial scale, this method is effective in opening heavy compacted soils, allowing fertilizer, water and air to reach the root zone. The holes may be left open or filled with compost, peat or other organic material. The drill hole method should be used where high fertilizer rates or fertilizers with a high salt index create a potential for injury to fine turf.

Surface application: Granular forms of fertilizer may be spread by hand or mechanical spreader over the surface of soil around trees and shrubs. This method is quick, easy and inexpensive and recent studies have shown this method to be as effective in supplying nutrients to plant roots as other techniques. It is particularly appropriate for applying fertilizers to mulched areas and shrub borders. A tree growing in a lawn area will utilize nutrients from surface applications of fertilizer made to the

lawn and may not need additional fertilizer.

Fertilizer spikes/stakes: With this method, solid rods of a pre-measured amount of fertilizer are placed in holes in the soil around woody plants. Wide spacing of holes and slow lateral distribution of nutrients limit the effectiveness of this technique. It is not recommended.

Foliar fertilization: This technique entails spraying liquid fertilizers onto the foliage of plants. It is used primarily as a "quick fix" for minor nutrient element deficiencies. Foliar feeding is not effective in supplying essential nutrients in quantities necessary for satisfactory growth. The most effective time to spray foliage with micronutrient solutions is just before or during the growth period.

Tree trunk injections: Injections of nutrients directly into a tree is used almost exclusively to correct minor element deficiencies, e.g. iron, manganese and zinc. This technique may also be used in urban settings where root or surface applications of fertilizers are not practical.

3.5 Rate of Fertilizer Application

Rates of fertilizer application are typically based upon the amount of nitrogen in the fertilizer since nitrogen is the mineral element most responsible for vegetative growth. For annual maintenance, it is recommended that a tree receive 1 to 3 pounds of actual N per 1000 sq. ft. of surface area. The actual amount of a fertilizer to apply for maintenance of woody plants may be determined by the area method.

Reduce the amount of fertilizer applied at any one time to trees on shallow, sandy, or poor sites, so as not to burn the plant's roots. Using fertilizers with slow-release forms of nitrogen will also help reduce the possibilities of root injury in such situations. Rates of nitrogen application should be adjusted on sites where there is a high potential for ground water contamination from nitrate leaching. On such sites, nitrogen application rates of 1 lb N/1000 sq. ft. or less would be advisable. Several applications at these reduced rates may be made during the growing season if needed for improving plant health. Again, use of slow-release forms of nitrogen can reduce the potential for leaching.

Rates of nitrogen application should also be adjusted according to levels of soil organic matter. Applying high rates of nitrogen to soils low in organic matter will accelerate depletion of the organic matter and in the long run reduce the fertility and structural integrity of the soil. Analysis of organic matter levels may be requested when submitting soil samples for testing. Soil organic matter levels of 4% or greater are desirable. In coastal areas where organic matter content of sandy soils is often in the range of 1-2%, use fertilizers with at least 50% of the nitrogen in water-insoluble or slow-release form. In general, at a pH between 6 and 7, it can be assumed that 1/4-1/2 pound of nitrogen per 1000 square feet is being made available per year for each one percent of organic matter in the soil. Therefore, a soil with 4% organic matter can contribute from 1-2 pounds of nitrogen per 1000 square feet per year. That is typically enough nitrogen to support healthy growth of woody plants.

3.6 Frequency of Fertilizer Application

Frequency of application depends on the general vigor and growth of the plant, with the exception of newly planted trees and shrubs. Woody plants growing in rich soils with continual replenishment of nutrients from decomposition of organic matter may not need regular fertilizing. However, plants that are in a nursery production cycle, as well as landscape plants that show either abnormal leaf size or color, little or no annual growth, or significant amounts of dead wood within the plant, should be fertilized annually.

3.7 Time of Fertilizer Application

Fertilizers are best applied in late August through September. Root absorption of nutrients is very efficient in late summer and remains so until soil temperatures approach freezing. Nitrogen that is absorbed in fall will be stored and converted to forms used to support the spring flush of growth. The next best time to fertilize woody plants is early spring prior to initiation of new growth.

Trees and shrubs should not be fertilized during times of drought stress or when they are showing signs of water stress unless irrigation is available. Plants do not absorb nutrients without adequate water. Some fertilizers may also damage roots if water is lacking.

Table 1. N, P & K content in common biofertilizers

S. No	Manure	% Nutrients			
		Nitrogen (NO_3)	Phosphoric acid (P_2O_5)	Potash (K_2O)	Calcium (CaO)
1.	Farm Yard Manure	0.50	0.30	0.50	0.30
2.	Compost	0.75	0.50	1.5	2.2
3.	Town refuse	0.5	0.3	1.0	0.4
4.	Night soil	1.5	1.0	0.5	0.3

List of commonly used chemical fertilizers and bio-fertilizers

S. No.	Name of Fertilizers
1.	**Straight Nitrogenous Fertilizers** I. Ammonium Sulphate II. Urea (46% N) (While free flowing) III. Urea (coated) (45% N) (While free flowing) IV. Ammonium Chloride V. Calcium Ammonium Nitrate (25% N) VI. Calcium Ammonium Nitrate (26% N) VII. Anhydrous Ammonia VIII. Urea Super Granulated IX. Urea (Granular) X. Urea Ammonium Nitrate (32%) (Liquid) XI. Neem Coated Urea
2.	**Straight Phosphatic Fertilizers** I. Single Superphosphate (16% P2O 5 Powdered) II. Triple Superphosphate III. Bone meal, Raw IV. Bone meal, Steamed V. Rockphosphate VI. Single Superphosphate (16% P2O 5) (Granulated) VII. Superphosphoric Acid (70% P2O 5) (Liquid)

S. No.	Name of Fertilizers
3.	**Straight Potassic Fertilizers** I. Potassium Chloride (Muriate of Potash) II. Potassium Sulphate III. Potassium Schoenite IV. Potassium Chloride (Muriate of Potash) (Granular) V. Potash derived from Molasses
4.	**Straight Sulphur Fertilizers** I. Sulphur 90% Powder II. Sulphur Granular
5.	**N. P. COMPLEX FERTILIZERS** I. Diammonium Phosphate (18-46-0) II. Diammonium Phosphate (16-44-0) III. Ammonium Phosphate Sulphate (16-20-0) IV. Ammonium Phosphate Sulphate Nitrate (20-20-0)
6.	**N.P.K. Complex Fertilizers** I. Nitrophosphate with Potash (15-15-15) II. N.P.K (10-26-26) III. N.P.K.(12-32-16) IV. N.P.K. (22-22-11) V. N.P.K. (14-35-14) VI. N.P.K. (17-17-17) VII. N.P.K. (14-28-14) VIII. N.P.K. (19-19-19)
7.	**Micronutrients** I. Zinc Sulphate Heptahydrate (ZnSO4.7H2O) II. Manganese Sulphate III. Borax (Sodium Tetraborate) for soil application IV. Copper Sulphate V. Ferrous Sulphate VI. Ammonium Molybdate VII. Chelated Zinc as Zn-EDTA VIII. Chelated Iron as Fe-EDTA IX. Zinc Sulphate Mono-hydrate (ZnSO4.H2O) X. Magnesium Sulphate

S. No.	Name of Fertilizers
8.	**Fortified Fertilizers**
	I. Boronated Single Superphosphate(16% P2O5Powedered)
	II. Zincated Urea
	III. Zincated Phosphate (Suspension)
	IV. Zincated NPK (12:32:16:0.5)
	V. Zincated NPK (10:26:26:0.5)
	VI. Boronated DAP (18:46:0:0.3)
	VII. Boronated NPK (12:32:16:0.3)
	VIII. Boronated NPK (10:26:26:0.3)
	IX. Calcium Nitrate with Boron
	X. 15:15:15:0.2:B
	XI. DAP:0.5 Zn
	XII. SSP:0.5Zn
9.	**100% Water Soluble Complex Fertilizers**
	I. Potassium Nitrate (13-0-45)
	II. Mono Potassium Phosphate (0-52-34)
	III. Calcium Nitrate
	IV. NPK (13-40-13)
	V. NPK (18-18-18)
	VI. NPK (13-5-26)
	VII. NPK (6-12-36)
	VIII. NPK (20-20-20)
	IX. NPK (19-19-19)
	X. Potassium Magnesium Sulphate
	XI. Mono Ammonium Phosphate (12-61-0)
	XII. Urea Phosphate (17:44:0)
Bio-Fertilizers	
1.	Rhizobium (Symbiotic)
2.	Azetobactor (Non-Symbiotic)
3.	Phosphate solubilizing Bacteria (P.S.B.)
4.	Zinc Solublizing Bacteria (ZSB)

3.8 Deficiency of Nutrients and its Symptoms in Plants

Element/status	Visual symptoms
Nitrogen (N)	
Deficiency	Light green leaf and plant color with the older leaves turning yellow, leaves that will eventually turn brown and die. Plant growth is slow, plants will be stunted and will mature early.
Excess	Plants will be dark green in color and new growth will be succulent; susceptible if subjected to disease and insect infestation; and subjected to drought stress, plants will easily lodge. Blossom abortion and lack of fruit set will occur.
Ammonium toxicity	Plants fertilized with ammonium-nitrogen (NH4- N) may exhibit ammonium-toxicity symptoms, with carbohydrate depletion and reduced plant growth. Lesions may occur on plant stems, there may be a downward cupping of the leaves and a decay of the conductive tissue at the base of the stem with wilting of the plants under moisture stress. Blossom-end rot of fruit will occur and Mg deficiency symptoms may also occur.
Phosphorus (P)	
Deficiency	Plant growth will be slow and stunted and the older leaves will have a purple coloration, particularly on the underside.
Excess	Phosphorus excess will not have a direct effect on the plant but may show visual deficiencies of Zn, Fe and Mn. High P may also interfere with the normal Ca nutrition, with typical Ca deficiency symptoms occurring.
Potassium (K)	
Deficiency	On the older leaves, the edges will look burned, a symptom known as scorch. Plants will easily lodge and be sensitive to disease infestation. Fruit and seed production will be impaired and of poor quality.
Excess	Plants will exhibit typical Mg and possibly Ca deficiency symptoms due to a cation imbalance
Calcium (Ca)	
Deficiency	The growing tips of roots and leaves will turn brown and die. The edges of the leaves will look ragged as the edges of emerging leaves stick together. Fruit quality will be affected with the occurrence of blossom-end rot on fruits.
Excess	Plants may exhibit typical Mg deficiency symptoms and when in high excess, K deficiency may also occur.
Magnesium (Mg)	
Deficiency	Older leaves will be yellow in color with interveinal chlorosis (yellowing between the veins) symptoms. Plant growth will be slow and some plants may be easily infested by disease.
Excess	Results in a cation imbalance showing signs of either a Ca or K deficiency.
Sulfur (S)	
Deficiency	A general overall light green color of the entire plant with the older leaves being light green to yellow in color as the deficiency intensifies.
Excess	A premature senescence of leaves may occur.
Boron (B)	
Deficiency	Abnormal development of the growing points (meristematic tissue) with the apical growing points eventually becoming stunted and dying. Rowers and fruits will abort. For some grain and fruit crops, yield and quality is significantly reduced.

Element/status	Visual symptoms
Excess	Leaf tips and margins will turn brown and die.
Chlorine (Cl)	
Deficiency	Younger leaves will be chlorotic and plants will easily wilt. For wheat, a plant disease will infest the plant when Cl is deficient.
Excess	Premature yellowing of the lower leaves with burning of the leaf margins and tips. Leaf abscission will occur and plants will easily wilt.
Copper (Cu)	
Deficiency	Plant growth will be slow and plants stunted with distortion of the young leaves and death of the growing point.
Excess	An Fe deficiency may be induced with very slow growth. Roots may be stunted.
Iron (Fe)	
Deficiency	Interveinal chlorosis will occur on the emerging and young leaves with eventual bleaching of the new growth. When severe, the entire plant may be light green in color.
Excess	A bronzing of leaves with tiny brown spots on the leaves, a typical symptom frequently occurring with rice.
Manganese (Mn)	
Deficiency	Interveinal chlorosis of young leaves while the leaves and plants remain generally green in color. When severe, the plants will be stunted.
Excess	Older leaves will show brown spots surrounded by a chlorotic zone and circle.
Molybdenum (Mo)	
Deficiency	Symptoms will frequently appear similar to N deficiency. Older and middle leaves become chlorotic first and In some instances, leaf margins are rolled and growth and flower formation are restricted.
Excess	Not of common occurrence.
Zinc (Zn)	
Deficiency	Upper leaves will show interveinal chlorosis with an eventual whiting of the affected leaves. Leaves may be small and distorted with a rosette form.
Excess	An Fe deficiency will develop.

CHAPTER 4

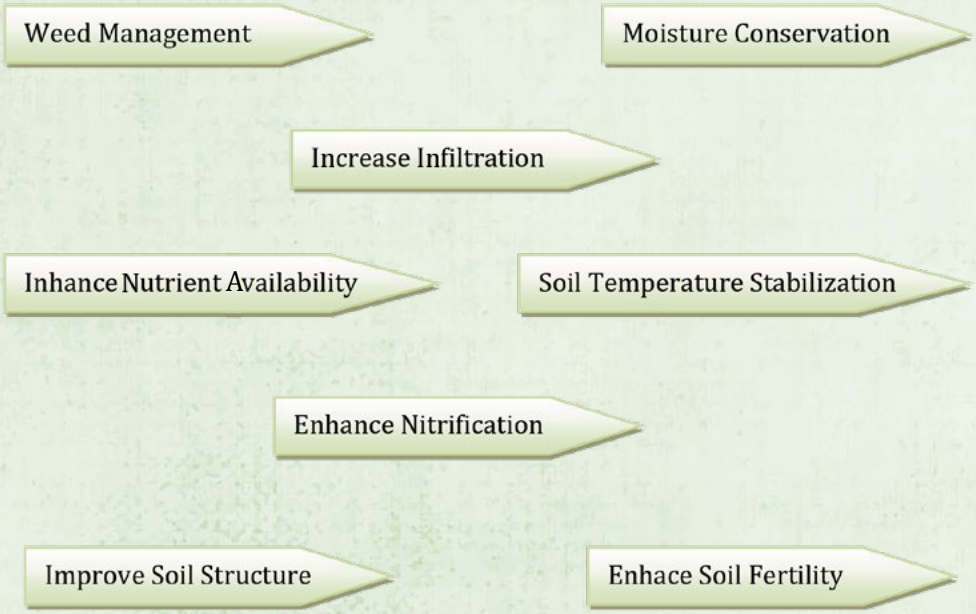
MULCHING

- Advantages of Mulching
- Types of Mulches
- Mulching Application Methods

Application of any plant residues and other materials used as a covering for the soil to conserve moisture, reduce runoff and erosion, check weed growth, protect from winter climate or improve the soil is called mulching.

Mulching is one of the several means of modifying the micro environment to meet the needs of the seed and the seedling. Spreading stone or straw on the ground to conserve moisture and also to reduce wind erosion is an age old tradition of cultivation in the arid zones. Mulching materials are usually foliage or straw, but may include compost, wood chips, saw dust, paper, sand stones, glass wool, metal foil, cello phane etc.

4.1 Advantages of Mulching



4.2 Types of Mulches

4.2.1 Organic Mulches

Organic mulches comprise of materials like animal compost, grass clippings, straw of various crops, dried leaves, tree bark clippings and saw dust. It has easily degradable capacity because nature of appealing slugs, insects and worms that eats them and help them in rapid degradation, which results in addition of some quantity of nutrient and organic material in the soil. Organic mulch has a large number of helpful features. Some of them are: soil moisture conservation by reducing the rate of evaporation, moderates soil temperature, lessens soil erosion, hinders growth of weed, cheers the growth of beneficial soil bio-organisms and diminishes the blowout of soil-borne pathogens. Organic mulches after decomposition over time improve soil structure and increase nutrient content of the soil. The illustration of different organic mulches and their usages are given below:

(1) Bark clippings: Bark clippings are long lasting materials and permit appropriate aeration to the soil. It can be used properly in dry as well as wet regions and it has more water holding capacity. In wet region, if rain is too much the wood bark will reduce waterlogging condition after absorbing the

excess water and if rain is too little, the wood bark will release the holding water, providing water to the plants in dry times also.

Bark (hardwood): Hardwood bark clipping is the derivative of paper and timber industries and differs in sizes ranging from chips to bigger nuggets. It is mostly used nearby the shrubs and trees. Both coloured and natural varieties of bark is obtainable. Colored varieties are generally a mixture of recycled wood waste comprising non-natural peroxides.

Bark (softwood): It is similarly a derivative of wood and paper industries. The common example is pine bark and it is commonly used under large shrubs and trees. It is somewhat acidic in behavior, takes more time to decay. These barks are obtainable in several sizes and generally applied to 2 to 4 inches of depth.

(2) Tree waste: Generally, this mulch outcomes from larger lumps of timbers. At the time of decomposition, the fresh tree chunks will utilize larger sums of nitrogen inside the soil. This type of mulch is specifically useful for making pathways.

(3) Leaf mulch: Leaves are decent for mulching which is easily and profusely available. However, leaves are good for shielding inactive plants during winter season by keeping them warm and it helps in starting germination throughout winter season but they may be blown away even by little speed of wind due to its light weight. Bark, stone or any other material which are useful in reducing wind speed, should be used to lessen these problems. It can be made at home by composting shredded leaves. Leaf mulch can be used in all types of gardens. Leaves infected with disease should be disposed instead of composting. Proper thickness of the leaf mulching is about 3 to 4 inches

(4) Grass clippings: Grass clippings are effortlessly and profusely available mulch materials in agriculture. It provides some quantity of nitrogen and organic material into the soil if freshly incorporated in the soil. If green grass clippings added in the soil, it can develop its root system it can create damage to growth and development of crops. So, use of dry grass is more favorable as mulch material. Grass clippings should be spread in thin layers for better result across perennial and vegetable beds and concave at the end of the growing season. Before adding extra layers let every layer to dry. Grass clippings will mat if thick layer of clipping is applied instead of thin layers. Grass clippings taken from lawns which is treated with insecticides or herbicides never be used. It should apply at a depth of 2 to 3 inches

Sawdust: Sawdust is obtained from wood and furniture making industry and very deprived in nutritive value. It is slowly decomposable. It is acidic in nature so it should not be used in acidic soils.

4.2.2 Synthetic Mulches

Synthetic mulches: Synthetic mulches are made of artificial non-living substances. Various types of synthetic mulch materials are available in market for use in crop fields such as plastic films, plain and oiled paper, spun materials etc. Plastic mulches are mainly used

Types of Plastic Mulches: -

Colored Mulches

With the appropriate assortment of plastic mulch composition, thickness and color, soil environment can be accomplished exactly. Many color mulch films are available including red, white, black, silver, clear or transparent etc. But the selection of the color hinge on definite targets. Different types of

colored mulches are described below:

I. Single colored mulch films:

1. White: Cools the soil better than all available colors.
2. Red: Increases vegetative production of many crops.
3. Black: It is very helpful in soil moisture conservation, reducing weed growth due to lack of photosynthesis beneath the film, economical in use and does not permit the entry of sunlight through it.

II. Double colored mulch films:

1. Yellow/ Black: Work as ambush for various insects and pests.
2. White/ Black: Cool off the soil.
3. Silver/ Black: Cool off the soil but not more than white/black film and prevent attack of some aphids and thrips.
4. Red/ Black: Partially translucent in nature allowing some solar rays to lead through it to warm up the soil and reflect some radiation back to plant canopy, which results in vegetative growth, better development of flowers and change in metabolism to increase the production and reduce the time of fruiting in some vegetable and fruit crops.
5. Blue/ Black: Restricts reflections of radiation.

III. Clear or transparent mulches:

It is used to solarize and increase the temperature of soil.

IV. Degradable mulches:

A. Photo-degradable plastic mulch: It gets easily disintegrated by sun during mulching period.

B. Bio-degradable plastic mulch: It is primarily made from polyester fibers, plant sugars, starches or firewood resources which can come from maize and wheat plants. It gets easily decomposed under natural environmental conditions and gets mixed in soil after mulching period. The biodegradable mulches were prominently thinner than the photodegradable mulches.

4.3 Mulching Application Methods

a. Surface mulching:

When mulches are spread on the soil surface in order to lessens the evaporation rate and increase the moisture holding capacity of soil, then it is called as surface mulching. In rain-fed farming, surface mulching is broadly used as water conserving practice.

b. Vertical mulching:

It is the soil treatment which is conducted near the root system of tree's in order to improve the root function and health of tree by ventilating the compressed soil, increasing water retaining

power of soil, advancing infiltration capacity of soil and adding nutrients to the soil. Vertical mulching commonly known as composting. It is conducted by digging of 30 cm deep and 15 cm wide trenches across the slope at interval of 2 to 4 m and adding some organic materials like grasses, straws, stubbles etc.

c. Growing Vegetative Barriers:

Subabul and Glyricidia plants are planted on the contour lines as vegetable barriers in order to serve as mulch, which can improve the moisture holding capacity of soil.

CHAPTER 5

THINNING

- Purpose of Thinning
- Kinds of Thinning

Thinning is the treatment of forest crops whereby the number of trees growing in a stand are reduced. It consists of a series of successive operations for a number of times and starts just a few years after the canopy closure. Thinning as defined by B.C.F.T. is a felling made in an immature stand for the purpose of improving the growth and form of the trees that remain without permanently breaking the canopy. According to the Terminology of Forest Science, Technology, Practice and Products (Winters, 1977) thinning is "A felling made in a stand at any time between establishment and the initiation of a regeneration cutting or clearfelling in which the trees removed are of the same species as the trees favoured". The science of thinning is based on the biological law of struggle for life and survival of the fittest. At the start, a stand has many trees per hectare, but as it grows many trees become retunded or left out of the race, so that at maturity only a few trees remain per ha. But as it is not certain that the trees remaining will be of definite use, the forester makes use of this feature and tends to alter the crop of the desired composition, form and quality. By manipulation of space it is possible to produce trees of practically any shape or vigor with some desirable qualities.

5.1 Purpose of Thinning

The thinning may be carried out for the following reasons:

1) To favor the most vigorous trees with good form which are likely to constitute the final crop.

2) To remove dead, dry, diseased and any other trees which may become a source of infection or cause damage to the remaining healthy ones.

3) To reduce the number of trees in stand so that the remaining ones get more space for crown and root development which, in turn, accelerates the rate of growth of stands.

4) The fourth objective is to remove trees of poor form such as crooked, forked, roughly branched or moribund form so that all future increment is concentrated only on the best trees.

5) To obtain a desirable composition of crop, the unwanted and less valuable species are eliminated in a manner to ensure uniform and proper distribution of trees all over the area.

6) Sometimes, it is not possible to control the undesirable species during regeneration operations, which may be eliminated during thinning operations.

7) Thinnings may help in obtaining suitable seed bearers for regeneration in a mixed stand.

8) Thinning is also carried out to provide on intermediate financial return from sale of thinning.

9) Thinnings are also carried out for local reasons such as to provide grazing, to obtain poles and posts and to increase the amenity value of stands and to meet the specific requirements of industry.

Before the subject is dealt with further, the definitions of important terms are given under:

a. Thinning Cycle: It is the planned interval which elapses between successive thinning in the same area.

b. Thinning Intensity: A term generally used to indicate in numerical terms the extent to which a crop is thinned in other words, it is a measure of the yield removed over a specified period of time it

may be expressed in volume per hectare per annum.

c. Thinning Grade: It refers to the relative extent to which a crop is opened up in thinning standard thinning grades are distinguished in ordinary and crown thinnings with reference to the extent to which stems are removed.

Regime and grade must not be confused with each other. The former relates to the whole set of thinnings from pole stage to maturity and the latter to the type of removals at each thinning operation in fact "grade is the means and the regime the end".

It is an operation of removal of live or dead branches from standing trees for the improvement of the tree or its timber, Pruning is the instrumental technique in the hand of a forester to get knot free timber and improve wood quality. Generally the operation is distinguishable into two operations, low pruning and high pruning.

5.2 Kinds of Thinning

Following are the various kinds of thinning used in regular crops:

1. Mechanical thinning
2. Ordinary thinning
3. Crown thinning
4. Free thinning
5. Maximum thinning
6. Advance thinning

1. Mechanical Thinning /Stick Thinning

Mechanical thinning is defined as thinning in which the trees to be cut are selected by some rule-of-thumb, e.g., trees, in alternate diagonals or rows, alternate trees in alternate rows or every second, third, fourth, etc., line or a minimum spacing gauged by a standard stick (stick, thinning). It is applied to regular crops'. Syn. line thinning.

- This thinning is carried out in early stages of the crops when the canopy differentiation has not taken place.
- This thinning is to be carried out in plantation or natural regeneration which is uniformly spaced and have nearly uniform growth.
- The thinning is to be carried out either by some rule –of-thumb or with the help of stick.
- When mechanical thinning is practiced with the help of stick it is called as stick thinning.

2. Ordinary Thinning / German Thinning

When the crop passes the early stages and develops canopy differentiation, mechanical thinning loses its value. As indications are available as to which individuals have lost in the struggle for existence and which have succeeded and which are likely to give most value in future crop, a

silvicultural thinning is called for and one of the ways in which it can be done is by removing those which have been left behind in the social competition. Since in this case, the felling starts from the lower most canopy or crown classes and progresses gradually to higher canopy or crown classes, it is called 'low thinning' or 'German thinning' or 'thinning from below'; however, now the more commonly used term for such thinning is 'Ordinary thinning'. It is defined as 'the method of thinning in common use that consists in removal of inferior individuals of a crop, starting from the suppressed class, then taking the dominated class and lastly some of the dominants. It is applied to regular crops.

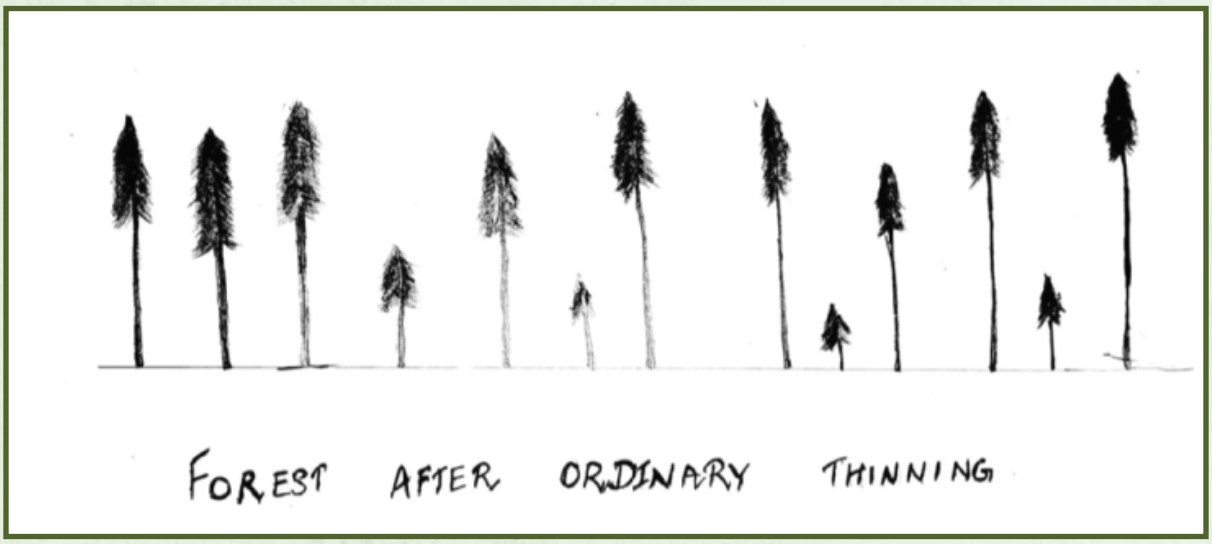


Figure 1. Overview of a forest after crown thinning

Application Of Ordinary Thinning-

Ordinary thinning is applied in the following cases:

(i) Light demanders such as, chir, teak, sissu, Gmelina and because in the case of light demanders the trees which are left behind in the struggle for existence and therefore occupy the lower canopy layers, cease to grow and gradually die.

(ii) Where there is market for small-sized timber.

(iii) Areas which are infested with climbers and where there is a danger of crown fire.

(iv) Area where there is no danger of soil deterioration as a result of removal of suppressed and dominated trees.

Merits of Ordinary Thinning

(i) Ordinary thinning is very simple and easy to execute as it consists in the removal of trees left behind in the social competition.

(ii) It is useful in areas where small-sized timber obtained from the suppressed and dominated trees, is saleable.

Demerits of Ordinary Thinning

(i) This thinning is carried out when the trees have been in competition for a sufficiently long time to develop canopy differentiation and, therefore, the dominants have already suffered from the adverse effect of competition.

(ii) Studies made on teak thinnings do not support the view that the removal of the trees left behind in the struggle has any appreciable effect on the growth of dominants. The smaller trees removed in this thinning are often not sold and therefore, such thinned material increases fire hazard.

(iii) The removal of the suppressed and dominated trees exposes the soil and often results in the deterioration of the site. This may also result in the infestation of the area with grasses and shrubs, thereby increasing fire hazard.

3. Crown Thinning

As the beneficial effect of removal of the suppressed and dominated trees on the growth of the dominant trees is doubtful and as some of them have to be kept for the protection of the soil, another method of thinning was evolved to meet the requirements of the dominant trees by removing inferior trees from amongst the dominant class, ignoring the dominated and the suppressed class. As most of the trees removed in this thinning, are from the upper crown classes, it is called crown thinning which may be defined as a method in which thinning is primarily directed to the dominant trees in a regular crop, the less promising ones being removed in the interest of the best available individuals; the dominated and suppressed stems are retained unless they are dead, dying or diseased'. It is also called 'French thinning' because of its origin in France, 'thinning from above' and 'high thinning' to differentiate it from the corresponding names of ordinary thinning, viz, 'German thinning", "thinning from below and low thinning.'

The basic principle underlying crown thinning is that the trees which show signs of success in the struggle for existence forming the dominant canopy and which promise good value as future crop should be helped immediately by felling inferior trees in the dominant class so that their growth may not be adversely affected. Therefore, the heaviest felling is in the dominant class and only those suppressed and dominated trees are felled, which are dead, dying or diseased are, in some way, actively interfering with the growth of any good dominant.

4. Free Thinning

Free thinning has been devised by Heck. It is defined as a method of thinning in which attention is concentrated on evenly spaced selected stems (called elites or alpha-stems) which are retained until maturity or till the last thinning or two, thinning being directed to the removal of other stems hindering their optimum development. It is applied to regular crops. This method of thinning has been applied in India with slight modifications under various names, such as, 'Elite thinning' of Kerala, Tamil Nadu and U.P.

5. Maximum Thinning

Maximum thinning has been developed by Gehrhardt as a modification of Heck's free thinning. It is defined as a method of thinning which aims at putting as high a proportion as possible of the total potential increment of the area on the retained stems; from an early stage the number of such stems is limited to the minimum that can fully utilized the growing space. It is applied to regular crops.

It is, thus, the heaviest form of free thinning, so much so that there are practically no trees other than the elites. As the thinning is extremely heavy, it may result in deterioration of the site due to exposure to infestation of the area with heavy grass and shrub growth and in production of knotty timber, poor in strength properties.

6. Advance Thinning

Advance thinning is defined as a thinning done in a regular crop in anticipation of suppression. This method of thinning was developed by Craib and O'Connor for wattle and pine plantations in South Africa and therefore it is also called "craib's thinning".

In all the methods of thinning described so far, thinning is done after the trees have been adversely affected by the competition of their neighbours. In order that competition may not have any adverse effect on the crop, it is argued that thinning should be done before competition actually sets in before it is actually required Craib, who developed this thinning, also devised a research technique for determining numerical thinning schedules which could be used in general practice.

CHAPTER 6

PRUNING

- Objective of Pruning
- Types of Pruning
- Timimg of Pruning

It is an operation of removal of live or dead branches from standing trees for the improvement of the tree or its timber. Pruning is the instrumental technique in the hand of a forester to get knot free timber and improve wood quality. Generally the operation is distinguishable into two operations, low pruning and high pruning.

6.1 Objectives of Pruning

a. Reducing Risk and Inconvenience to the Public

(i) Keeping the roads clear and safe by removing the branches which obscure sightline of motorists or physically obstruct the vehicular accesses, leaving insufficient headroom for large vehicles or double-decker buses.

(ii) Preventing interlacement with overhead cables by regular pruning of trees to maintain acceptable clearance from overhead cables.

(iii) Protecting pedestrians and properties from damage by the dead, hanging and detached twigs/ branches falling from the tree. Twigs/branches with potential to fall should be removed once detected.

(iv) Maintaining road lighting condition by removing the branches of trees blocking street lamps.

b. Maintaining or Improving Health and Structure of Trees

To maintain trees in healthy growing conditions by:

(i) Controlling the invasion of pests and diseases by removing dead or insect-carrying twigs and branches in order to eliminate the harbourage for pests and diseases.

(ii) Avoiding wastage of food reserve by removing weak branches and undesirable shoots originating from the tree base to save food reserve for healthy parts of the tree.

(iii) Allowing more light and air in or through the crown by removing overcrowded leaves, twigs and branches.

(iv) Minimizing the chance of damage under strong wind by reducing the weight of the tree by pruning out overcrowded twigs and branches. This is essential particularly when the root anchorage of the tree is not firm when the root system is disturbed by transplantation or adjacent construction work.

c. Improving the Appearance of Trees

To maintain trees in their most desirable form and structure.

6.2 Types of Pruning

A. NATURAL PRUNING

In some trees natural death and fall of branches of standing trees from causes of deficiency of light, decay and snow occurs which is called natural pruning .

- Pruning occurs naturally when the density of the crop is high, the lower branches are shed when the crowns of the adjacent trees are close together.

- Shedding of branches from the main stem is followed by the occulusion of the short stubs produced by the dead branches.
- The rate of killing of lower branches, shedding and healing of the branch stub depends on species and the density of crop.
- The rate of natural pruning can be accelerated by simply manipulating the dense stock, but it costs the diameter increment.
- As the initial costs of establishment of plantation at close spacing are very high, artificial pruning becomes necessary for obtaining clean boled timber.

Moreover, there are a very few species in which natural pruning is of significance. *Anthocephalus chinensis, Eucalyptus* spp*., Bombax ceiba* are known as good natural pruners.

B. ARTIFICIAL PRUNING

From the above it is apparent that artificial pruning is necessary in the stands where wide spacing and heavy thinnings are practiced. Another technical consideration to apply pruning is to know its object of management. If a plantation is grown for an end use requiring high-grade, clean construction timber where uniform strength and good machining, finishing and seasoning qualities are important in the market, some pruning must be carried out on all species where branches persist for more than a short time after suppression and death. In some species such as teak, pruning does not give the desired results as the adventitious branches are developed next to the pruning scar.

B.1 Methods of Artificial Pruning

1. Formative Pruning

Selective pruning of the lateral branches of a tree so as to develop a strong and straight trunk, a well-balanced crown with properly spaced scaffolding branches and a clear central leader.

2. Crown Lifting

Selective pruning to remove lower branches to increase vertical clearance from ground level.

3. Crown Reduction

Selective pruning to reduce the overall height and spread of the crown, leaving the tree in a well-balanced and natural form and shape.

4. Crown Thinning

Selective pruning to remove weak, thin, crossing and live branches to reduce the density of foliage. Crown thinning should not affect the overall height and spread of the tree.

5. Cleaning

Selective pruning to remove dead, withered, damaged or diseased branches.

6.3 Timing of Pruning

The best timing for pruning each species may vary and expert advice should be sought when necessary. In general, the following criteria apply:

Evergreen Tree

Pruning of evergreen trees just before spring is preferred due to faster healing in the coming growing season.

Deciduous Tree

Pruning of deciduous trees after shedding leaves in winter when trees are dormant is preferred. This can minimize the risk of pest problem associated with wounding and allowing trees to take advantage of the full growing season to close and compartmentalize wounds.

Young Tree

Suitable structural pruning of young trees would facilitate the development of a straight trunk.

CHAPTER 7

Major Plantation Diseases & their Management

- Tree Leaves Diseases
- Tree Bark Disease
- Tree Root Disease
- Steam Disease
- Other Protection Measures

7.1 Tree Leaf Diseases

As the name suggests, these affect foliage. The main culprits of foliar infections are fungi. However, signs and symptoms can be similar to chemical injury of insect infestations, which complicates tree leaf disease identification and the choice of corresponding management. The problem eradication strongly depends on the reasonability of treatment costs and is not always possible due to favorable weather conditions for fungi development. In this regard, the most typical method of foliar tree disease treatment is removing and destroying the leaves in the fall. It prevents pathogen overwintering and relapse in spring.

Tree leaf diseases affect both conifers and hardwoods and differ by the degree of severity. While some cause little harm, the rest are rather dangerous and can cause mortality.

1. **Anthracnose**

   The anthracnose infection reveals leaf necrosis of irregular shapes and burnt foliage that may also affect stems. This is a fungal pathology that may cause severe damage, yet it is difficult to tackle, especially in wet spring weather favorable for fungi development. Anthracnose is typical for walnut, oak, maple, birch, hickory, among others.

2. **Leaf Rusts**

   Leaf rusts are among common tree diseases and are typically non-dangerous unless they cause early leaf sheds and, thus, negatively impact growth. Rusts are yellowish spots with powdery spores on the upper leaf part. Typically, rusts cover hosts in the second part of August and affect maple, birch, poplar, ash, plum, willow and cottonwood.

3. **Leaf Spots**

   These tree diseases are infections in the form of spots, most of the brownish color. They are caused by some fungi species (like *Actinopelte, Septoria, Mycoshaerella, Phyllosticta*) and parasitic algae. Cool wet springs are particularly favorable for the infection spread. Poplar hybrids are especially prone to leaf spot infestations.

4. **Powdery Mildew**

   The signs of this tree leaf disease look exactly like white talcum powder. It should be distinguished from dust or bird droppings. It spreads in spots or patches and is mainly induced by the Microsphaera fungi. Unlike other fungi infections, it particularly persists in hot dry weather and colonizes succulent plants. The most common treatment is chemical control. The fungi are sensitive to sulfur dioxide and are not common in SO2-polluted regions. The pathogens can be transferred by wind, animals, or rain.

5. **Leaf Blister**

   In this case, leaves are infected by the Taphrina genus that causes additional growth of the contaminated area (blisters, curling, expansion, puckering). The pathology starts with light green spots that acquire a white coating and eventually become brown. This tree disease is frequently found in the oak family, peaches, female catkins and alder. It develops under cool wet weather conditions at the stage of leaf expansion. Leaf blisters do not result in defoliation and do not produce a serious impact on the suffering plant.

7.2 Tree Bark Disease

Stem pathologies are typically induced by fungi like leaf ones. However, these are more serious, depending on what part is affected. Tree branch diseases have less severe consequences for the plant since the infected branch can be removed. Little can be done with tree trunk diseases though when fungi reach the vascular system, the host dies.

1. **Rusts**

   Rust is among the most common evergreen tree diseases, in Arkansas pines in particular. It is especially dangerous and can be lethal for young samples due to trunk galls. Mature plants can live with that as long as only branches are infected and the disease does not destroy the central stem.

2. **Black Knots**

   The black knot is a fungal pathology typical for the genus of Prunus, fruit and ornamental cherries and plums in particular. This tree bark skin disease is caused by Apiosporina morbosa that may dwell on the host plant for several years. Black knots start as greenish-brown and brown formations (swellings) during the first year that grow into black hard galls during the second one. After two or three years, mature galls usually die and turn whitish or pinkish due to fungi colonization. Such galls can be numerous on a tree and this is a danger.

   The fungi spores spread to new branches in wet mild weather. The treatment includes chemical or mechanical control (fungicide spraying or pruning, correspondingly). The removed branches must be instantly destroyed because the spores continue to release up to four months. This tree branch disease becomes lethal when it reaches vital stem parts.

3. **Cankers**

   Canker is a tree bark disease with necrotic areas. It occurs due to pathogenic fungi (e.g., Botryosphaeria, Hypoxylon, Phytophthora, Botryosphaeria, Cytospora) that penetrate through bark cracks or mechanical and natural injures (e.g., man-made wounds, frost cracks, fire burns, sunscalds). Healthy plants cope with the infestation, yet weakened ones cannot resist it.

4. **Decays**

   This tree disease diagnosis is pretty simple – typically, it is identified through mushrooms (aka conks) covering the tree and discolored bark. The conks develop for many years before they can be noticed. They penetrate the plant through wounds and are located deep inside. For this reason, simple conk removal won't solve the problem. Instead, the host can combat the conks itself thanks to compartmentalization. It is a natural process to release chemical compounds to get rid of the fungi as well as to plug the vascular tissue and generate callus. The success depends on the fungi' ability to adjust to the change and the host's health. Decays are not lethal, but they do weaken the plant and spoil the timber salability. In severe cases, such trees are omitted during timber harvesting operations, as they lose their economic value.

5. Wilts

Wilt is a lethal tree trunk disease that is diagnosed through burnt leaves with no defoliation. The plant dies due to fungi inside its vessels that hinder crown water saturation. Susceptible species include mimosa, oak, Dutch elm and more.

7.3 Tree Root Disease

Tree root diseases affect the root and lower stem of both evergreen and hardwood species. Compared to leaf and bark infections, they have the highest tree mortality rates since they prevent water and nutrient absorption by the plant. Also, as it develops in the unseen tree part, it remains undetected until the damage becomes visible. Thus, it is more difficult to diagnose tree root diseases.

The roots are below the ground level and therefore the diseases caused in the roots are noticed only when symptoms on the above ground parts are manifested. The root diseases may be due to parasitic causes such as fungi, bacteria, nematodes, insects etc. or it may be due to physiogenic causes.

- To control root diseases fumigation with methyl bromide and steam are practiced in glass house before sowing operations.
- It is also controlled by changing planting time and taking mixed plantations of susceptible and resistant species.
- Similarly a sound knowledge of silviculture is necessary to select suitable site.
- The controlled burning also checks development of root diseases .
- Similarly while preparing site the stumps should be uprooted to control various root fungi.
- Isolation trenches are also made to control spread of the diseases.
- The cheap chemicals which are non-poisonous to livestock and wild life can also be used. The chemicals such as creosote, ammonium fluoride, sodium nitrite, borax, urea and ammonium sulphamate have been used with success.
- To control heart rot strict fire control measures are adopted as they are the chief cause of wounds.
- The decay fungi gets established through frost or fire injury.
- Silvicultural measures such as adjustment of canopy, thinnings and improvement fellings to remove diseased, forked, malformed and injured trees etc. are carried out to improve the stand.

General methods of silvicultural control may include:

- Decay reduction through rotation.
- Fire prevention and care when logging.
- Reduction of disease through timber stand improvement operations and the use of partial cutting methods.
- Use of prescribed burning.
- Maintenance of high stand densities where applicable.
- Salvage to reduce losses.

7.4 Stem Diseases

STEM CANKER

Stem canker is one of the important diseases of the tree and possess threat to the quality timber production. Many insects and fungi are reported to cause stem canker in different tress. A wide range of trees and shrubs suffer from canker diseases. A canker is in fact a symptom of an injury often associated with an open wound that has become invaded by the pathogenic microorganisms. Canker diseases kill the branches or structurally weaken a plant until the infected area breaks free. In the arid region of India, insect pests and diseases studies revealed that the tree deformity pertaining to hollowness might initiate the formation of cankers in the main trunks of the trees. It was further stated that the infection occurs in the form of splitting of bark on the bole, which spreads in upward and downward direction.

Causal organism**:** *Fusarium solani*, *F. oxyporum* and *F. decemcellulare* and *Aremonium strictum* and *F. roseum*.

Symptoms:

- Cankers are generally oval to elongate, but can vary considerably in size and shape.
- Typically, they appear as localized, sunken or raised, slightly discolored, brown-to- reddish lesions on the bark of trunks and branches, or as injured areas on smaller twigs.
- The bark between the diseased and the healthy tissue often splits and sometimes ooze a watery sap.
- Sometimes, the inner bark turns black and gives off a foul odor.

Figure 2. Different forest tree diseases.

7.5 Other Protection Measures

It is our duty to protect the forests and plantations by closure of the area. The plants if not protected may be damaged by browsing, trampling, scratching, uprooting, bending of stems etc. The following types of fencing may be used to protect the plantations.

1. Fencing

a) Live-Hedge Fencing

- The species selected to act as live fence must be thorny.
- It should be able to come up by cuttings.
- It should also have good coppicing power.

  The species suitable for live-hedge fencing are *Euphorbia spp. Agave sisluna, Agave americana, Jatropha curcas, Acacia nilotica, Acacia tortilis, Acacia catechu, Prosopis juliflora, Ipomara* etc

  Similarly brushwood cuttings may also be used for fencing for short periods.
- For smaller plantations fences can be built with branches cut from thorny trees or other suitable material to protect the plants for the first couple of years. Other types of live fences are bamboo fence combined with thorny branches, bamboo fence combined with hedges.

b) Wire fencing

c) Electrical fencing

2. Protection from wind

- Planting of shelterbelts at suitable positions.
- Planting of wind firm and deep rooted species.
- The area should be properly drained. Wet – waterlogged soil provides ideal conditions for wind blow.
- The thinning should be adequate and regular. Under thinning should not be done as it creates conditions for wind damage.
- The young plants in a plantation can be protected from winds by tree tubes or toly tubes. They are simply plastic tubes known as tree shelters.

3. Fire Trenching

It is necessary to prevent damage from natural fire. It is done to individual plant or to whole plantation. For individual plant belt of 2m diameter around the plant is cleared, absolutely by removing the grass, weed so that fire will not enter in that area. In case of block planting a strip of 4 m width kept clean around the block plantation so that fire will not enter the plantation. It is also called as Fire tracing.

CHAPTER 8

Post Plantation of Referred Species

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
  - **Weeding:** In the first two or three years, weeding is required on a regular basis. Two good weedings are usually sufficient, but with the first rain, a third weeding may be required. The amount of weeding needed will depend on the site.
  - **Cleaning and thinning**: Plants should be spaced about 80 to 120 cm apart in the early cleanings. Early thinning is very important for the proper development of the crop. Normally, the first thinning should not be delayed beyond the 5th year.
  - **Pruning:** Within 3-5 years, it becomes required in coppice crops to restrict the number of coppice shoots emerging from a single stump to one or two.

Management of diseases/insect-pests/parasites

- **Insects:**

  Beetles, larvae of borers, defoliators and sap suckers cause damage to the young living plants.

- **Diseases:**

  Root Rot: *Ganodermalucidum* (Leyss.) Karst caused enormous mortality in reforested stands due to root rot. The damaged plants develop light foliage, which then dries. Young plants die quickly after infection; however mature trees die when the majority of their roots are infected. Dark brown and lightly zoned on the stem and upper surface. Extraction of old stumps and clearing of detritus from the site, digging of isolation trenches in young plantations, planting of resistant species like *Bombax ceiba* and *Ailanthus excelsa* and mixed cropping (50:50) with resistant species are all efficient ways to control the disease.

  Heart Rot: *Fomes badius* Berk. causes heart rot in Khair and is found in both natural and planted Khair forests. Heart rot worsens with age and old trees are no longer suitable for the extraction of cutch and katha due to complete collapse. To some extent, the disease can be controlled by avoiding tree injuries by taking the sporophoces from the trees and burying them in the soil on a regular basis.

Anthracnose

Causal organism- *Colletotricum*

Symptoms: It is appeared as brown sunken circular to irregular lesions, progressing to larger necrotic areas. The fungus produce erumpent, mucilaginous, orange spore masses under high humidity condition.

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*
  - **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).
  - **Mulching:** A layer of straw, dry leaves, twigs and brushwood is spread over the beds and burnt to kill the seeds of weeds and to add ash to seedbeds.Special care should be taken to protect the plant from dry, wind and frost.
  - **Weeding:** Weeding is avoided for some weeks after germination as the seedlings are very minute.3 weeding in first year during July, August and September.

Management of diseases/insect-pests/parasites

- **Insects:**

  By folding the leaves and feeding from within, the insect *Parotis vertumnalis* causes more than half of the damage to foliage. Defoliation of young trees is caused by Epiplema quadricaudata caterpillars, which can be suppressed by applying a 0.1 percent solution of Ekalux 25EC (Quinalphos).

- **Diseases:**

  Regarding the diseases, *Phytophthora* spp. causes crown rot when the trees are planted too deep in the soil. Powdery mildew is caused by *Podosphaera leucotricha* and fire blight also occurs in several areas, which is controlled by the application of antibiotic sprays (Streptomycin or Terramycin) during the bloom period.

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

Habitat information

- **Natural forests:** Tropical dry deciduous forest and Southern thorn forest.
- **Distribution in India**: It found almost in all the states of India. Uttarakhand, Jharkhand, Madhya Pradesh, Uttar Pradesh, Bihar, Orrisa and the Deccan Plateau and along the east coast. It is extensively planted all over the country for its fruits.
- **Global distribution:** India, Sri Lanka, Thailand, Pakistan, Bangladesh, Myanmar, Vietnam, the Philippines, Cambodia, Malaysia, Java, Egypt, Surinam, Trinidad and Florida.

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: 570-2000 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 - 30cm × 30cm × 30 cm.
- **Spacing:** 4m x 4m or 3m x 3m.
- **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 (N), 25 (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.
- **Thinning and weeding:** It requires attention during first year when they are well manured and weeded after the rains. Framework of branches is allowed to develop above 06-1.0 m from the ground level.
- Bael trees may be trained in modified central leader. Pruning is done twice in a year, once in May and other in August. Pruning is limited to the removal of dead and diseased twigs/branches in May while in August healthy leaves are pruned for sale.

Management of diseases/insect-pests/parasites

- **Insects:**

  Termite attacks on young plantations are a major problem. Application of chlorpyriphos at 2-3/ml/ plant has been found effective. Chafaer beetles, or leaf-eating caterpillars, cause damage to the plants and can be controlled by 2-3 sprays of dimethoate at 15-day intervals.

- **Diseases:**

  Bacterial shoot-hole and fruit canker caused by *Xanthomonasbilvae* having symptoms: Round and water soaked spots (0.5 mm) surrounded by clear halo.The spot increase in size(3 to 5 mm) and form brown lesion with saucer-like depression in the centre surround by oily raised margin. The primary localized lesions all the leaf are always followed by falling-out of the necrosed tissue leaving circular or slightly irregular perforation of shot holes. It can be control by 2-3 spray of 500 ppm streptomycin at 15 days' interval.

- **Fruit drop:**

  In Bael, fruit drop is a severe issue. Because of a shortage of food supply, if the orchard is not irrigated, or because of fungus assault (Fusarium). Plantations should be irrigated at a fortnightly

interval in the summer and a monthly interval in the winter, save during the rainy season, for effective control. When the fruits are little, two or three sprays of carbendazim (0.1 percent) every two weeks or streptomycin (500 ppm) every 15 days are indicated. Better management practises and the administration of growth hormones like NAA (15-20 ppm/litre) can significantly reduce the level of fruit drop in bael.

- **Fruit rot:**

  In Bael, fruit rot is a common problem. Aspergillus nidulans is to responsible. Harvesting completely grown fruits, minimising damage to the fruit and wrapping the fruit with newspapers or phenol paper can all help to avoid this.

- **Physiological disorder:**

  Fruit cracking: Fruit cracking occurs twice a year, once in the winter when the developing fruit is immature and again in the summer when the fruit is maturing. Maintaining an optimal soil moisture regime and installing wind protection against the hot, desiccating wind side of the orchid can help to reduce cracking. In semi-arid locations, organic mulch can also be utilised to conserve soil moisture.

4. *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

➢ **Irrigation**

In early stages, the jamun tree requires frequent irrigations but af1cr the trees get established, the interval between irrigations can be greatly decreased. Young trees require 8 to 10 irrigations in a year. The mature trees require only about half the number, which should be applied during May and June when the fruit is ripening. During autumn and winter months, just an occasional irrigation may be applied when the soil is dry. This will also save the trees from the ill effects of frost in winter.

➢ **Tending operation:** In plantation, weeding is required in the first year. Removing of climbers and pruning of side branches are beneficial.

Management of diseases/insect-pests/parasites

- **Insects:**

Two species of longicorn borer, namely *Olenecamptus anogeisii* and *O. indianus* which attack the dead and dying trees and bore tunnel traps through sap wood and sometimes hardwood also.

Leaf miner, leaf blotcher, Myllocerus leaf weevil, leaf weber, bark eating caterpillar and termites are the known to cause damage to the tree. *Badamia exclamationis* Fab. (*Lepidoptera: Hesperiidae*) was a polyphagous pest causing heavy reduction in the foliage of trees. Application of cypermethrin (0.05%) and fenpropathrin are effective to control it.

- **Diseases:**

Nigrospora species cause leaf spot and *Pestalatiops*is species cause folia blight. Root pathogens were identifies to be *Ganoderma lucidum* and *Macrophomina phaseolina*.

- **Parasites:**

Old trees are liable to be attacked by *Loranthus*.

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
  - In young plantations, **weeding** is essential.
  - Coppice thinning is required. During the wet season, coppicing and pollarding should be avoided.
  - Pests, animals and fire need to be kept out of the planting area.
  - Irrigation should be provided following planting if there isn't going to be any rain for a few days after planting.

Management of diseases/insect-pests/parasites

- **Insects:**

  Both dead and dying trees are attacked by the borers i.e. *Olenecamptus anogeissi* and *Olenecamptus indianus.Orgyia postica*is a general feeder. It occasionally defoliates forests of this tree.
- **Diseases:**

  Sarcinella apocynacearum, *S. combratcearum, Tripospermum caseariae* and *T. lougurensis* are ectoparasitic fungi associated with living leaves. The fungus *Uncinula* spp is reported in *A. latifolia.* Other fungi reportedly causing leaf spots are *Pestalotiopis versicolor, Marssonina poonensis* and *Monochaetia jabalpurensis*. Contact fungicidal treatment is effective in controlling these fungi.

  Heart rot: It cause by *Fomes caryophylli, F. fastuosus, F. robiniae, Trametes corrugate, T. cubensis* and *T. straminea*. The trees during extreme drought are under stress and lose vitality, thus becoming infected with leaf spot and stump –rot fungi and prone to insect attack.
- **Injuries:**

  Plants are killed by fire. It is readily grazed by cattle.

6. *Artocarpus heterophyllus* Lam.

General information on the species

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

Post Plantation Management

- **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.
- **Pruning:** If not pruned regularly, it will grow very large; height can be kept at 8–14 ft (2.4–4.3 m) by selective pruning on a regular basis.
- **Thinning:** Fruit thinning, the number of fruits per tree or major limb should be limited to one on young trees, as heavy fruit loads have been observed to result in limb decline or death and tree stunting. On mature trees, limiting the number of fruits per major limb may enhance the quality and size of the remaining fruit. The thinning may lead to die-back.
- **Weeding:** Both inter-row and circle weeding are employed to keep down weeds. Mulching may also be used to suppress weeds and conserve soil moisture.

Management of diseases/insect-pests/parasites

- **Insects:**

Shoot and fruit borer (*Diaphania caesalis*): The shoot borer is primarily found in nursery stock and causes harm to developing fruit, buds and young shoots. It will be controlled either by cutting infected shoots and branches and bagging the fruit, or by applying chemical techniques, such as spraying malathion (0.05 percent and methomyl) on the afflicted shoots and branches (0.5 %).

Stem borer (*Batocera rufomaculata*): It harms the tree by causing holes in it. It's controlled by removing infested branches and killing the grubs, eliminating beetles when they're detected and spiking out the grubs when bore holes are discovered. Control can also be achieved by putting pesticide emulsions or fumigants into larval tunnels and then plugging the holes with mud or clay.

Fruit fly (*Bactrocera dorsalis, Chactodacus ferruginens, Dacus umbrosus*): Maggots eat rotten and ripe fruits. It is controlled by harvesting mature fruits before they ripen and keeping methyl eugenol traps for adults. Because it infests ripe fruit, chemical spraying is not recommended.

Mealy bug (*Planococcus lilacimus*): Bug damage to plant by feeds on sap and cause leaf defoliation. It is controlled by cut and destroys severely affected plant parts. Also controlled by using Dimethoate (0.05%).

- **Diseases:**

Leaf spot: *Altermaria spp., Cercospora species, Colletotrichum gloeosporioides, Gleosporium sp., Laseodiplodia theobromae, Phomopsis spp., Phyllosticta artocarpina and Septoria spp*. are some of the pathogens that cause leaf spot. It causes premature defoliation and dark brown to brick red blotches on both surfaces of the leaf, which eventually change into a greyish-white in the centre and a dark brown margin. Carbendazim (0.1%), methyl thiophanate (0.1%), or chlorothalonil (0.2%) are used to control it.

Die-back: It is caused by the *Laseodiplodiaspecies*. It affects growing shoots. It spreads downwards from top to bottom and eventually kills the tree. It is controlled by pruning the infected twigs or using a chemical spray, i.e., carbendazim (0.1%), Topsin M (0.1%), or chlorothalonil (0.2%); also trunk injection with antibiotics.

Fruit rot: *Rhizopus artocarpi*, Phyllosticta sp., Phytophthora sp., Rhizoctonia solani and *Physalospora rhodina* are among the pathogens that cause it. They wreak havoc on the flowering stems and stalks of fragile fruits, causing soft rot. It's kept under control by gathering and destroying afflicted fruits. Control using a 0.05 percent propiconazole treatment or a bordeaux combination.

Canker: *Corticium salmonicolor* is the canker-causing pathogen. It has an impact on the twigs and stem. Use Bordeaux paste or 0.2 percent copper oxychloride, or prune afflicted branches as soon as feasible.

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

  - **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.

8. *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

  - **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.

  - **Mulching:** During the winter and summer seasons, proper mulching around the plants, with or without thatching, is essential.

  - **Pruning**: Except for the removal of dead, diseased and crossing branches, chironji plants do not require pruning.

  - **To control weed growth** in new and old plantation, hand weeding, hoeing and ploughing the area 2-3 times a year is done.

Management of diseases/insect-pests/parasites

- **Parasitic plant:**

  Loranthus longiflorusis reported on the trees. Weeding must be done on a regular basis to remove it.

- **Insects:**

  Hoppers (Sucking pest): During blossoming, this is the most destructive insect. The crop is harmed by both adults and nymphys. They feed on the sap of young shoots and panicles. Panicles wither and fruit set suffers as a result. Honeydew is excreted by them, which causes a sooty mould to form on the leaves and panicles. Spraying with dimethoate (0.03 percent) or phosphomidon (0.05 percent) at the time of panicle emergence and again at fruit set stage will help suppress it.

  Mealy Bugs: The waxy coating on these insects' bodies distinguishes them. Mealy buds can be found in large numbers on the ventral surfaces of leaflets, the base of leaf petioles, tender shoots and even fruits, sucking cell sap from a range of places. Leaflets turn chlorotic and fall off and fruit may fall off prematurely in severe infestations. Sprays containing dimethoate (0.03 percent) or phosphomidon (0.05 percent) are effective for controlling pests.

- **Disease:**

  Phytophthora gummosis: Fungus damages bark and only penetrates wood in a restricted way. Use a little extra healthy tissue to scrape the problematic area without damaging the wood. Disease control and plant recovery may be aided by applying Bordeaux paste to the scraped and healthy region around the diseased zone.

  Powdery Mildew: During the flowering season, the appearance of greyish-whitish powder on flower buds, fruitlets and the rachis of the panicle indicates fungus attack. In severe situations, the panicle seems to be burnt from top to bottom.Spraying 2-3 times with wetable sulphur at a 15-day interval is the most cost-effective method.

9. *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

➢ **Irrigation**: Plantations in arid regions need periodic watering during the first growing season to obtain a satisfactory survival rate.

➢ **Weeding**: Weeds must be managed on a regular basis using the proper weedicide and manual method.

➢ **Hoeing** and **earthing** should be done every three months for two years.

➢ **Pruning:** Pruning is an important practice in the cultivation of Gmelina arborea in farm land, pruning decides the growth, clear bole and intercropping ability. Pruning of side branches is usually carried out in every six months. The pruned branches can be used as fire wood.

➢ **Thinning:** The thinning begins at 4-5 years of age for the woods, that are used for pulp productions. The alternative trees in the row are to be thinned, to avoid competition between the trees and maximize the growth.

➢ **Protection**: Wild pigs are very fond of bark, so proper fencing around the plantation should be done to avoid animal attack.

Management of diseases/insects-pests/parasites

- **Insects:**

Helopeltis antonii and *Helopeltis theivora* are the most common tea mosquito bugs that infest the plant. *Lambda cyhalothrin* (0.6 ml/lit), profenophos (1.5 ml/lit), acetamiprid (0.5 gm/lit), triazophos (1.5 ml/lit), imidacloprid (0.6 ml/lit) and carbaryl (1gm/lit) are some of the chemicals that can be sprayed in rotation to control infestation.

The tree is defoliated by the larvae of a large number of *Lepidopterous* insects. Sap is consumed by *Kerna lacca, Cerothrips tibialis, Heliothrips spp.* and *Rhipiphorothrips cruentatus. Chaetodaucus ferrugineusincisus* larvae bore into fruit.

- **Disease:**

Polyporus weberianus causes yellow conk rot.

10. *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

  - **Irrigation:** Two irrigations in the first year and hoeing is done for proper growth.

Management of diseases/insect-pests/parasites

- No major insect-pests and diseases were reported on this species. In general, this species is tolerant to diseases and pest.

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

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

➢ **Weeding:** It is needed during the early life of a sissoo. First weeding is indicated as soon as the seed germinates or the stump has sprouted. Weeding should be done two to four times.

➢ **Thinning:** In mixed plantation, three thinning are done in the 6th, 10th and 14th years. In pure Plantation, two thinning are done in 6th and 11th Years.In the new plantations of sissoo the first thinning is more or less a mechanical operation for giving adequate spacing to the plants. For the second thinning C-grade intensity is recommended based on previous study.

Management of diseases/insect-pests/parasites

- **Leaf Spot:**

  Causal Organism- *Curvularia affinis*

  The symptoms of the disease appear as irregular spots which starts from the leaf margin to inwards. The colour of leaf spots is light reddish with dark margins and a light yellow halo surrounding the lesion. Light reddish spots appear on leaves which increase in size with time.

  The disease can be effectively managed through proper sanitation, weeding and foliar application of bayleton-0.1% at fortnightly interval.

- **Leaf Blight**

  Causal Organism- *Rhizoctonia solani*

  The disease first appears on leaves close to the ground. The leaflets eventually turn brown and the infected adjoining leaflets often join together by the fungal hyphae. There is a cluster of hyphae at the base of the petiole or petiole.

  The disease can be effectively managed through proper sanitation, weeding and foliar application of Bayleton -0.1% at fortnightly intervals.

- **Leaf and petiole rust**

  Causal organism- *Maravalia achroa*

  Deformity and premature defoliation of younger leaves and juvenile twigs in early spring (February – March), leading to growth retardation of the plants. The initial symptoms appear as yellowish-orange pustules appearing on the lower surface of the leaves and on petioles and juvenile twigs.

  Bavistin 0.01 % found to be effective in control of disease.

- **Insects:**

  Plecoptera reflexa (a defoliator), *Dichomeris eridans* (a leaf binder), *Brachytrypes portentosus* (a nursery pest) and termites have all been reported. Termite infestations are frequent in dry areas. *Plecoptra reflexa* and *Dichomeris eridantis* are two defoliating moths that can severely lower biomass in sissoo.

- **Diseases:**

  Fusarium, Ganoderma lucidum and *Phellinusgilvus* are fungi that affect the root and vascular systems of plants.

  Powdery Mildew: On the lower surface of sissoo leaves, the fungus forms yellowish, persistent, dense mycelium. Sulphur-based fungicides were shown to be the most effective in controlling powdery mildew disease, followed by Baycor, Mortesan and Calixin.

  Injuries: Readily browsed by cattle and other animals.

12. *Gmelina arborea* Roxb.

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

  - **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.
  - **Weeding:** In the first two years during rains and loosening of soil around plants in October/November.
  - **Pruning:** Pruning is an essential aspect of Gmelina arborea cultivation in farms. Growth, clear bole and intercropping capabilities are all determined by pruning. Side branch pruning is normally done once every six months. The branches that have been trimmed can be utilised as firewood.
  - **Thinning:** Thinning is another important practice to enhance the production of sawlogs. The thinning begins at 4-5 years of age for the woods that are used for pulp production. The alternative trees in the row are to be thinned to avoid competition between the trees and maximize growth.

Management of diseases/insect-pests/parasites

- **Insects:**

  Calopepla leayana larvae consume a large amount of the tree's leaves. In the month of May, it lays eggs. Melathion 50CC 0.1 or 0.2 percent sprayed in water has been demonstrated to be beneficial. The larvae of *Dihammus cervinus*, which burrow longitudinal galleries in the saplings' cambial layer, are serious plantation pests. Defoliation is caused by Ozola minor, which destroys out-planted seedlings and a leaf-cutting ant (Atta spp.).

- **Foot rot:**

  Causal organism - *Fusarium oxysporum*

  Infected portion exhibits water-soaked depression which late turns dark brown causing wilt and subsequent death of plants.

  Control Measures: Soil drenching with 0.2% Bavistin or Dithane M-45 at monthly intervals effectively controls the disease.

- **Root rot and Collar rot:**

  Causal organism - *Sclerotium rolfsii*

  Foliage turns pale yellow and leaves sheds and there is subsequent death of the seedlings.

Control Measures: Soil drenching with 0.2% Bavistin or Dithane M-45 at monthly intervals effectively controls the disease.

- **Leaf spot**

  Causal organism - *Pseudocercospora ranjita*

  Paling of foliage and shedding of leaves are the common symptoms.

  Control Measures: Application of bavistin (0.1%) and dithane M-45 (0.1%) are found effective against the diseases in nursery.

- **Leaf and shoot blight**

  Infected plants exhibit blighting of shoots and leaves. Subsequent colonization by Fusarium solani hastens blighting.

  Control Measures: The disease has been effectively controlled by two applications of Bavistin at weekly interval.

- **Phoma stem rot**

  Causal organism- Phoma nebulosa

  The infected seedlings wilt and eventually die. Numerous pycnidia develop on dead stem and spore masses ooze out from them on maturity.

  Control Measures: It can be effectively controlled by removing the affected seedlings from the seed beds, regulating the water to bare minimum and applying 2-3 foliar sprays of Dithane M-45 (0.05% a.i.) at weekly intervals.

- **Leaf deformities**

  Microstroma pongamiae causes white to cream-coloured spots giving a yellowish appearance to the leaves.

  Control Measures: Foliar spray of Bavistin fungicidal solution (0.1%) is found to be effective in minimizing the disease.

- **Leaf Rust**

  The rust fungus, Ravenelia hobsoni infects the leaves and produces numerous chest-nut brown teliospore heads on the lower surface of the leaves.Another rust fungus, R. stictica is also known to attack the leaves.

  Control Measures: Dusting or foliar spray of sulphur based fungicide (0.05%) is found to be effective in minimizing the disease.

- **Powdery mildew**

  Causal organism - Oidium spp.

  The pathogen form irregular white patches, con sisting of mycelium and asexual conidia on the surface of the leaves.

  Control Measures: Foliar spray of Bavistin fungicidal solution (0.01%) is found to be effective in minimizing the disease.

- **Injuries:**

  In first two years browsing and girdling by deer should be prevented by fencing. Cattle may eat the foliage and rabbits and deer consume bark, seeds and foliage avidly.

13. *Grewia tiliifolia* Vahl.

General information on the species

- **Synonyms**: *Grewia tiliifolia* A.Rich.

  Grewia subinaequalis DC.

- **Odiya name**: Dhamuro, Bhangia, Dhamono

- **Other vernacular names**: Dhaman, Dhamani

Management of diseases/insect-pests/parasites

- **Insects:**

  Larval host plant for *Coladenia indrani*. Several insects are known to cause damage either by boring into logs or dry wood or by defoliating the trees. This can be controlled by using commonly insecticides.

- **Diseases**:

  Several fungi cause mottled sap root, motted spongy rot, white spongy rot and brownish heart root.

14. *Lagerstroemia parviflora* Roxb.

General information on the species

- **Synonyms**: *Fatioa napaulensis* DC.

  Lagerstroemia fatioa Bl.

- **Odiya name:** Chhena, Salora, Sidha

- **Other vernacular names**: Lendia, Bakli, Sidi, Seina

  - **Irrigation:** Regular irrigation in the first year of plantation is recommended.

  - **Weeding and cleaning:** Normal weeding and cleaning are required in the early stages.

  - **Thinning**: Adequate thinning from the pole stage onwards promotes growth.

Management of diseases/insect-pests/parasites

- **Insects:**

  Sphaerotrypesglobulus bores into the bark, while *Agrotera basinotata* and *Lamida carbonifera, Meyrick* larvae defoliate the tree.

- **Diseases:**

  Powdery Mildew is caused by *Phyllactinia terminaliae*, a fungus. Depending on the severity of the infection, 2-3 sprays of 0.05 percent Dinacop WP (Karathane) or 0.2 percent Wettable Sulphur (Sulfex) spaced 15 days apart are effective in controlling the disease up to 95%. Furthermore, field sanitation is essential.

  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.

15. *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

  - **Irrigation:** Irrigation during initial years of establishment is very essential.
  - **Weeding:** Sown lines should be kept weeded regularly for first two years.
  - **Earthing and hoeing:** Loosening of soil helps in proper growth of the plant. So earthing and hoeing at regular intervals should be carried out.
  - Young plantations have to be protected against fire and browsing by cattle and goats.

Management of diseases/insect-pests/parasites

- **Insects:**

  Among the defoliators of the tree are caterpillars of *Achaea janata*, *Anuga multiplicans*, *Bombotelia nugatrix, Metanastria hyrtaca.Unaspis acuminata* is a sap sucker and *Indarbella quadrinotata* feeds on the bark.

- **Diseases:**

  The fungi, *Polystictus steinheilianus* causes decay in felled timber, *Fomes caryophylli* causes heartrot; *Cercospora haticola* causes leaf spot and *Scopella echimulata* is a leaf rust. *Loranthus* is a serious pest of trees in some localities. Leaf blight is caused by *Pestalotiopsis dichaeta*.

- **Injuries:**

  The plant is damaged by fire and readily browsed by cattle and monkeys are fond of its flower and fruit. Loranthus is a serious parasite and its systematic eradication is advocated.

16. *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
    - **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.
    - Opening up of the top canopy is necessary for increased seeding.
    - **Regular thinning** at the interval of 4-5 years are proved beneficial.
    - **Regular weeding** is necessary until the plantation is established.
    - **Tending:** Regular thinning at intervals of 4-5 years is highly beneficial. Regular weeding and cleaning are also necessary under the artificial regeneration till the plants are established.

Management of diseases/insect-pests/parasites

- **Insects:**

  Phenacaspis dilatata and *Toxoptera aurantii* larvae feed on the sap of plants but do not cause major harm. Living trees are attacked by the buprestid borer and the cerambycid borer, which can cause considerable harm.

- **Diseases:**

  A number of fungi cause various form of damage, such as tar spot, gauj brown cuboidal rot, white rot, spongy root and butt rot, white rot, brownish pocket rot and white spongy rot.

- **Injuries:**

  Eupatorium and *Lantana* are a menace to natural regeneration. Saplings and poles are damaged by elephants and bisons.

17. *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 Chempaca

  - **Irrigation:** Water adequately when the plant is young, water moderately when the plant is mature.

  - **Thinning**: The first thinning in well-stocked plantations will normally be required in the 5 year if the spacing is about 1.8m x 1.8. The first thinning may be fairly heavy and subsequent thinning heavier.

  - Excessive pruning should be avoided as it reduces flowering.

  - **Fire:** The species of Michelia are very sensitive to fire and even large tree will die on being exposed to a low ground fire.

Management of diseases/insect-pests/parasites

- **Insects:**

  Urostylis punctigera is a serious pest of *Michelia champaca*. Spraying with a suitable mixture of nicotine sulphate 1 part and soap 1.8 kg in 450 liters, is helpful. Smoke produce under affected trees using damp thatch grass or straw or cow dung cakes which makes the adult insects and nymphs fall to the ground. Biological control by *Pachyneuron pentatomivora*, a parasite, *Calvia tricolor*, a predator or red ant can be introduced. *Rynchothrips champaceae*, another insect, attacks the leaves resulting in dying off.

- **Diseases:**

  Rhizoctonia solani, a soil borne fungus, causes leaf spotting and blight of seedlings in the nursery can be controlled by proper sanitation and cultural practices or raising of seedlings in polypots instead of beds.

- **Injuries:**

  Hailstorms, which occur in March-April, destroy the flowers and the young fruits. It is very sensitive to fire and even large trees will die on being exposed to a low ground fire.

18. *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, Kadam

  - **Irrigation**: During the first three months after planting, the field must be irrigated on a regular basis.

  - **Mulching**: Mulching is required for soil moisture conservation and it is reported to have facilitated the growth of plants.

  - Young plants must be protected from extreme heat and cold**.**

  - Hoeing and weeding twice a year facilitates good growth of the plant.

Management of diseases/insects/pests/parasites

- **Insects:**

  Spodoptera litura is the species' defoliator. Spodoptera NPV(Nuclear Polyhydrosis Virus*)* is effective against this insect. Light traps and pheromone-baited traps can be used to attract them.

19. *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

  - **Manure and Fertilizers**: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.
  - Weeding is done at least twice after transplanting and begins about a month afterwards. After the first year, no major maintenance is required.

Management of diseases/insect-pests/parasites

- **Insects:**

  Noni plants are attacked by a variety of sap-sucking insects that cause direct feeding damage and injury. Furthermore, these pests trigger the growth of sooty mould (a parasitic fungus that is black in colour) on noni leaves. Control measures includesCrop Spray: pyrethrin insecticide, Trilogy: neem oil (insecticide, fungicide), Carbaryl 4L: insecticide (non-bearing fruit trees only), Azatin XL: biological insecticide.

- **Diseases:**

  Noni is susceptible to plant diseases produced by fungi or fungus-like organisms in wet, high-rainfall, or flooded areas, such as leaf spots (*Colletotrichum* sp.) and stem, leaf and fruit blights (*Phytophthora* sp. and *Sclerotium rolfsii*). Although fungal leaf spot illnesses are small, they can be a nuisance in some areas. They can be reduced by sanitation (cleaning up or removing badly diseased leaves) or by using certified fungicides on a regular basis (copper-based fungicides).

  Leaf spot diseases: Anthracnose (*Colletotrichum* spp.): It is associated with fungi. The disease is more common in locations with more rainfall. It causes leaf blight, defoliation and huge, expanding leaf spots with dark brown to tan centres and diffuse, fast expanding, uneven edges. Warm, muggy, rainy weather and high relative humidity are conducive to disease. It is controlled by sanitation; good drainage; weed control to reduce relative humidity in the plant canopy; adequate plant spacing to improve air flow in the plant canopy; branch pruning to increase air flow and remove severely diseased tissues; avoid the use of over-head irrigation; and pruning

of branches to increase air flow and remove severely diseased tissues. Periodic protective spray treatments of fungicide effective fungicides.

Stem blight: *Sclerotium rolfsii* is the causal organism. Foliar chlorosis (yellowing) and wilting; stem girdling at or near the soil line; internal stem necrosis; stem rot; defoliation; root rot; and plant mortality are all symptoms of stem blight. Flooded or damp soil conditions favors disease. Planting in low-lying regions with poor drainage, avoiding plant-parasitic nematodes, avoiding harming stems with weedwhackers, not putting pebbles or uncomposted mulch around the base of noni plants and avoiding undue plant stress are all ways to keep it under control.

Root knot: Root-knot nematodes are the casual organism. Avoid putting noni seedlings in untreated soil; use composts; chicken manure; foliar nutrients; do not introduce nematode-infected plants to a new field; use disease-free planting material; moderate irrigation; do not plant in nematode-infested field soils.

20. *Phyllanthus emblica* L.

General information on the species

- **Synonyms**: *Emblica officinalis* Gaertn.
  Cicca emblica (L.) Kurz

  Emblica arborea Raf.

- **Odiya name**: Aula

- **Other vernacular names:** Amla, Gooseberry

  - **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.

  - **Pruning:** Judicious pruning to develop a strong framework is advocated to avoid branch breakage from heavy loads of fruit.

  - **Weeding:** Usually plantations need much weeding because the thin crowns do not form a closed canopy.

  - **Mulching:** During the summer, the crop should be mulched at the base of the tree, up to 15-20 cm from the trunk, using paddy straw or wheat straw**.**

  - The tree coppices well and pollards fairly well.

Management of diseases/insect-pests/parasites

- **Insects:**

  The bark-eating caterpillar, Indarbela sp., is the main pest of this tree in India. White cotton, resembling insect bunches, is seen on the branches, resulting in the drying of the branches and other portions of the plant. Termites are also a major problem on this plantation. Rogar at 1% on leaves and branches twice a week can help control the problem. Bavistin and Endosulphon, at 1% in the soil twice a week, are also necessary.

  Leaf eating caterpillar and stem weevils: Spray the plants with 0.2% Nuvacron to control the insect pests.

- **Diseases:**

  There are a few major diseases, but ring rust, leaf rust and fruit rot are caused by the fungi Bestonea stylophora, Phakospora phyllanthi and Ravenelia emblicae. In September and October, bi-monthly borax sprays can be used to combat it.

  Rust: Rust appears on leaves and fruits as a round reddish solitary or gregarious spot. From July to September, spray 0.2 percent Mancozeb every 7 to 28 days.

  Powdery mildew: Sulphur-containing fungicides, such as sulphex @ 0.25 percent, can successfully suppress powdery mildew.

  Injuries: Pruning can help to control stem swelling or bulging. Monocrotophos 2.0 ml/lit can be sprayed twice at fortnightly intervals as a prophylactic spray.

21. *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
  - **Mulching:** It is helpful for soil moisture conservation around the plantation.
  - **Weeding:** 2-3 weeding is required per year for first 2-3 years.
  - **Pruning:** Side branches should be pruned to get proper bole.

Management of diseases/insect-pests/parasites

- **Diseases:**

Leaf spot and blight: It is caused by *Fusicladium pongamiae*. It is controlled by using a foliar spray of bavistin fungicidal solution (0.1%), which has been found to be effective in minimising the disease.

Leaf rust: *Ravenelia hobsoni*, which infects the leaves and generates a large number of chestnut brown teliospore heads on the bottom surface, causes it. A sulphur-based fungicide (0.05 %) dusting or foliar spray has been proven to be beneficial in reducing the disease.

Powdery mildew: It's caused by Oidium spp. and it's been reported on Pongamia seedlings as well. On the surface of the leaves, the pathogen developed uneven white patches of mycelium and asexual conidia. These patches merged and covered the entire leaf lamina, making it seem greyish white. The leaves and leaflets of severely diseased leaves and leaflets defoliate early. Bavistin fungicidal solution (0.01 percent) foliar spray has been proven to be beneficial in reducing disease.

22. *Pterocarpus marsupium* Roxb.

General information on the species

- **Synonyms**: *Pterocarpus marsupium*
- **Odiya name:** Bija, Piasal
- **Other vernacular names**: Malabar kino, Indian kino, Vijayasar and Bijasar
  - **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.
  - FYM @ 25 kg per plant, nitrogen @ 200 g/plant and phosphorus @ 150 g/plant are required every year for the first three years.
  - The fertilizer is applied in two split doses, the first in September and the second in January.
  - **Pruning, weeding** and **thinning** must be done at regular intervals.

Management of diseases/insect-pests/parasites

- **Insects:**

  In mature stems and roots, no major insect pests or diseases have been found. Leaf-eating insects and white grub attacks are common in the nursery and early growth stages and can be managed with four sprays of Endosulphan @ 0.003 % at fortnightly intervals and application of Phorate 10 G in the root zone, respectively.

- **Diseases:**

  Seed treatment with Thiram @ 3 g/kg of seed is vital to keep the plants disease-free in the nursery and early phases of development in the field.

- **Injuries:**

  Frost and fire are the causes of the dieback phenomenon. Wild animals, particularly deer, cause significant harm to plants.

23. *Pterocarpus santalinus* L.f

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

  - **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 fertiliser applications should always be followed by irrigation.

  - **Irrigation:** After planting, the plants are to be promptly irrigated. Irrigation can be done every 10–15 days after the seedlings have established themselves, depending on the weather conditions and soil moisture.

  - Weeding, cleaning, pruning and irrigation should be done for the first 3 years of the plantation.

Management of diseases/insect-pests/parasites

- **Insects:**

  During the months of April and May, **leaf-eating caterpillars** have been reported to harm the crop. Spraying 0.2 percent monocrotophos twice a week will keep them under control.

- **Injuries:**

  It is readily browsed by cattle and repeated fires can kill the plant. Sambhar and spotted deer, particularly the former, greedily browse seedlings in natural forest and plantations. Raising *Cassia siamea* as a border barrier to protect red sanders seedlings from browsing animals.

  Young plantationsare often badly affected by climbers, specially *Cassytha filiformis* which completely entwins the young seedlings and kills them in matter of months. These have to be controlled by physical removal or by allowing browsing selectively.

  Fire: Normally fire creep along the ground burning grass and fallen leaves, but sometimes they cause permanent injury to sapling and poles while completely destroying young regeneration to ground. It controls by adopt fire preventive measures.

24. *Syzygium cumini* (L.) Skeels

General information on the species

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

➢ **Irrigation**: Drip irrigation is advised for orchards. Watering can be done every 10 to 15 days in winter and at weekly intervals during summer.

➢ Fertilizer Application: An annual dose of about 19 kg farmyard manure during the pre-beating period and 75 kg per tree bearing trees is considered.

➢ **Tending operation:** Weeding and cleaning are necessary during the initial year of plantation. Previous study by Srivastaves (1945) reported that in the canal plantation, where jamun is a component species, thinning of C/D – grade is prescribed when the crop is 3, 6 and 10-year-old.

Management of diseases/insect-pests/parasites

- **Insects:**

Leaf eating caterpillar (*Corea subtilis*): The leaves of the tree are attacked by caterpillars and the tree becomes defoliated. Dimethoate 30 E.C. (0.06 %) or malathion. (0.05%) spraying is use to control the pest during the active vegetative development period.

White fly (*Dialeurijdes eugenia*): The fruits decay as a result of this. Affected fruits have a wormy look on the surface. Maintaining plantation cleanliness, which includes picking up damaged fruits and burying them deep in the soil, could be an effective way to deal with it. To kill the maggots in the injured fruits as well as the pupa hibernating in the earth, the region beneath the tree canopy should be dug out.

Bark eating caterpillar (*Indarbela tetraonis* and *Inderbela quadrinotata*): The larvae feed on living bark tissues and stay overnight under a layer of silken webbing, tunnelling into the branch and stem and staying there during the day. As a result, the damaged tree's vitality deteriorates and its yield decreases. It can be dealt with adequately by keeping the plantation clean and injecting 2.0 ml of fuel into the holes before filling them. Spraying with dimethoate 30 EC (0.06 percent) or acephate (1.5 g/l) at tri-weekly intervals will effectively suppress the insect.

Jamun leaf miner (*Acrocercops syngramma* and *Acrocercops phaeospora*): During the reproductive phase, from April to September, the pest causes harm. The newly born caterpillar mines a tiny silvery thread-like gallery down the midrib of the leaf upward. Infected leaves can be dipped and burned, then sprayed with dimethoate 30 EC (0.06 percent) to control the pest.

Jamun leaf roller (*Polychorosis cellifera*): The larvae web the leaves by feeding on the inside and folding the tips downwards parallel to the mid-rib on both margins. A quarter of the lamina is devoured during a severe attack. Between March and April and September and October in north India, the pest goes through 3–4 generations. The second generation is the most dangerous. Clipping and burning sick leaves on a regular basis can help keep the population under control. In the event of a serious illness, spraying with dimethoate 30 EC (0.06 percent) is recommended.

Fruit fly: Following an attack by fruit flies, the affected fruits become unmarketable. Infected fruits should be collected and buried deep in the soil and the soil around the tree stem should be dug up to kill the maggots in the fruits and the pupae hibernating in the soil. Birds wreak havoc on jamun fruits as well. Various bird-frightening strategies can assist in keeping them at bay.

- **Diseases:**

Leaf spot and fruit rot (*Glomerella cingulata***)** have been reported in Jamun. Small, scattered spots of light brown or reddish brown colour appear on diseased leaves. Spraying dithane Z-78 on the diseases can help to control them (0.2 percent).

25. *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

➢ **Irrigation:** For new plantations, irrigation should be done at 15-day intervals during the summer season.

➢ **Weeding:** During the first few years of establishing a plantation, weeding is essential.

➢ **Thinning and pruning:** Trees should be pruned every year for optimal growth. Dense line sowings require thinning in 3rd and 4th year.

Management of diseases/insect-pests/parasites

- **Insects:**
  Aphids (*Aphis sp*.) attack tender leaves and cause galls to grow on them. This pest is controlled by spraying biopesticides like Azadirachtin.

- **Diseases:**

  Dacdalea flavida, Fomes melanoporus, Ganoderma lucidum, Metanestria hyrtaca, Denia litura and other fungi induce wood rot, which results in premature leaf fall. Spraying chlorpyriphos 20EC or phosalone 2 ml/l on the trunk and branches (about 4 feet surrounding the tree) or releasing a chalcidid wasp, *Brachymeria* sp. in the field. Fungal diseases can be managed using a 0.05 percent carbendazim spray.

26. *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
  - **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.
  - Young seedlings require **protection fromdirect sunlight and hot wind.** For young seedlings, fungicide and pesticide spraying is required 2 to 3 times every 15 days.
  - **Weeding and Thinning:** *Terminalia arjuna* has not been grown in regular block or mixed plantations and no specific tending regime has been developed. As a result, it is expected that weeding in young plantations would be done on a regular basis. Thinning of the plantation will be necessary at a later time.

Management of diseases/insect-pests/parasites

- **Insects**:

  Arjuna is largely devoid of major insect infestations. The most harmful pests of *T. arjuna* are termites. Termite damage can be prevented by spraying insecticides like imidacloprid 17.8 SL @ 0.6 ml and chlorpyrifos 20 EC @ 2 ml.

- I**njurie**s:

  Frost damage can result in the stem forking and the development of a bushy habit. Heavy shade is also harmful to seedlings, causing die-back over time and resulting in a bushy tree.

- **Diseases**:

  No major diseases are reported. Polystrictus affinis causing white fibrous rot and incidence of powdery mildew caused by *Phyllactinia terminala* reported occasionally.

27. *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
  - **Mulching**: During the winter and summer seasons, proper mulching around the plants, with or without thatching, is essential. In colder climates, mulching is required.
  - **Weeding**: Regular weeding and cleaning should be done for 2-3 years to keep the field weed free and moist.
  - In mixed crops, thinning and improving fellings are important.

Management of diseases/insect-pests/parasites

- **Insects:**

  The larvae of *Trabala vishnou* are known to feed on this plant. The beetle and larvae of *Thamnurgidesindicus* and *T. opacifrons* are said to bore in the bark. Significant damages are not reported.

- **Disease:**

  Prone to fungal infection,Fungicides like bavastin (1% conc.) should be used at proper intervals.

- **Injury:**

  Fruits are greedily eaten by rodents, monkeys and wild animals.

28. *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

  - **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.

Management of diseases/insect-pests/parasites

- **Insects:**

  It is tolerant to seasonal insect and pest infestations. Anti-termite treatment with chlorpyriphos 20 percent EC should be provided in termite-prone areas.

- **Disease:**

  On clonal plants of Terminaliachebula, Uredo terminaliae develops leaf rust disease. At biweekly intervals, a sulphur-based fungicide (Sulfax @ 0.05 % a.i.) is applied as a foliar spray and soil drenching. It has been shown to be useful in the treatment of disease.

29. *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
  - **Manure** FYM, from second or third year onwards, 50-70g N, 50-60 g P_2O5 and 50-70g K_2O 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 Bison browse the seedlings, causing significant harm by trampling them. Weevils are seed eaters.

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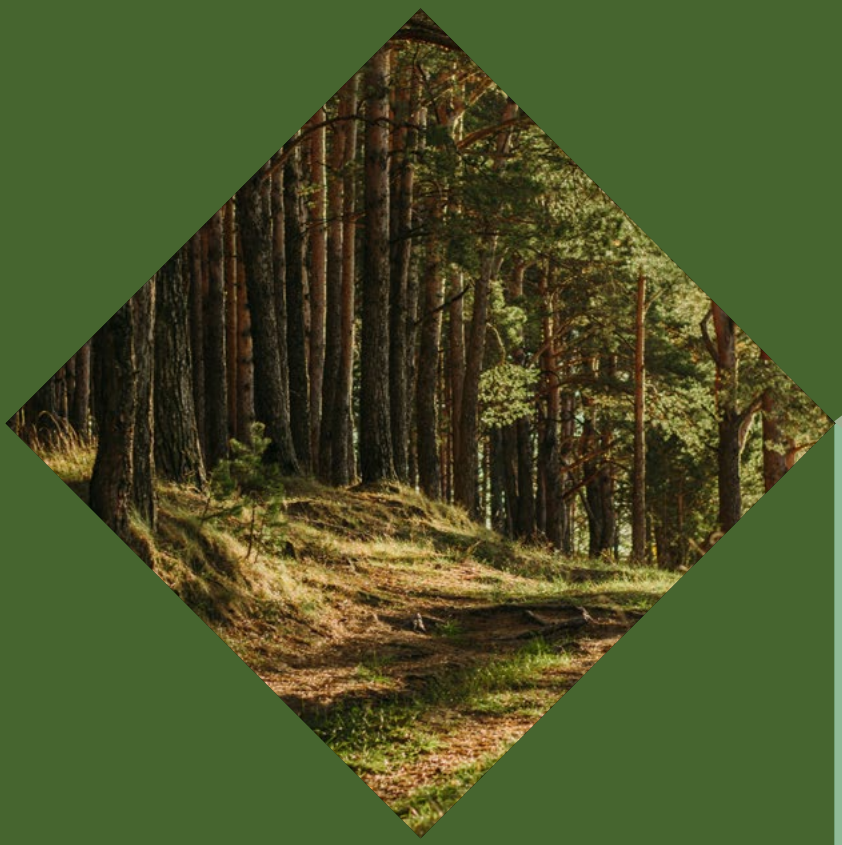

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