FOR 111 Introduction to Forestry (1+1)

UNIT I

Forest and Forestry

Introduction-Definition of Forest and Forestry Role of Forest (Production, Protection and Amelioration) Classification of Forest (Regeneration, Age, Composition. ownership, object of management, growing stock) - NationalForestPolicy1988.

UNIT II

Silviculture and Forest plantation

Forest regeneration-Natural regeneration-Seeds and vegetative parts (Coppice, Root suckers) – Artificial regeneration, Objectives Nurseries Types of nurseries, Quality seedling production techniques-Silvicultural practices for Eucalyptus spp, *Casuarina equisetifolia, Tectona grandis, Ailanthus excelsa, Melia dubia, Leucaena leucocephala.* Tending operations-Weeding, Cleaning, Thinning and pruning.

UNIT III

Forest Mensuration

Forest Mensuration - Objectives-Diameter measurements, instruments used in diameter measurement – Height measurement, Instrumental methods of height measurement-Tree form, form factor, Volume estimation of standing and felled trees.

UNIT IV

Social forestry and Agroforestry

Social Forestry and its branches-Extension Forestry, Urban forestry-Agroforestry, definition-Importance- Agroforestry systems-Shifting Cultivation, Taungya, Alley cropping, Windbreak, Shelterbelt, Home garden- Tree and crop combination in Agroforestry-Tree crop interaction in Agroforestry-National Agroforestry Policy2014.

UNIT V

Forest Utilization

Forest Utilization- Definition- Wood products- solid wood and composite wood.-Non Wood Forest Products - fibres, floss, bamboo, tan, dye, resin, oleoresin.

Practical

Identification of important farm grown trees- Identification of tree seeds and seedlings- Sites election for tree nursery and lay out of nursery. Study of nursery techniques for *Casuarina equisetifolia* and *Tectona grandis.* Practicing clonal propagation in trees Practicing land preparation, stacking, pitting, planting techniques and after care operations in plantations- Height measurement in trees, diameter measurement in trees, Volume

Estimation in trees-Identification of wood and non-wood forest products-Visit to Agroforestry plantations

Lecture schedule

1. Introduction about forests, Definition of Forest and Forestry, branches in forestry
2. Role of Forest-Production function, Protection function and ameliorative functions of Forests.
3. Classification of Forest based on mode of regeneration, age, composition. ownership, object of management and growing stock
4. National Forest Policy 1988 – Objective sand salient features
5. Forest regeneration – Types of regeneration-Natural regeneration through seeds and vegetative parts including coppice and root suckers
6. Artificial regeneration, Objectives- Nurseries Types of nurseries, Quality seedling production techniques
7. Silvicultural practices for Eucalyptus spp, *Casuarina equisetifolia, Tectona grandis, Ailanthus excelsa,*
8. Silvicultural practices for *Melia dubia, Leucaena leucocephala.* Tending operations-Weeding, Cleaning, Thinning and pruning.
9. **Mid Semester Examination**
10. Forest Mensuration - Objectives-Diameter measurements, instruments used in diameter measurement
11. Height measurement, instrumental methods of height measurement-Tree form, form factor, Volume estimation of standing and felled trees.
12. Social Forestry and its branches- Extension Forestry and Urban forestry.
13. Agroforestry, definition- Importance- Agroforestry systems-Shifting Cultivation, Taungya, Alley cropping, Wind break, Shelterbelt, Home garden
14. Tree and crop combination in Agroforestry-Tree crop interaction in Agroforestry-
15. National Agroforestry Policy 2014, objectives and salient features
16. Forest Utilization- Definition- Wood products- solid wood and composite wood.
17. Forest Utilization- Non Wood Forest Product fibres, floss, bamboo, tan, dye, resin, oleo resin

Practical schedule

1. Identification of important farm grown trees
2. Identification of tree seeds and seedlings

3. Site selection for tree nursery and layout of nursery
4. Study of nursery techniques for *Casuarina equisetifolia*
5. Study of nursery techniques for *Tectona grandis*
6. Practicing clonal propagation in trees Eucalyptus/Casuarina
7. Practicing land preparation, stacking, pitting,
8. Planting techniques in plantation
9. After care operations in plantations
10. Height measurement in trees
11. Diameter measurement in trees
12. Volume estimation in standing and felled trees
13. Identification and study of wood products
14. Identification and study non-wood forest products
15. Visit to Agroforestry plantations
16. Visit to forest based industry
17. Final Practical Examination

Reference Books

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Lecture 1. Introduction about forests, Definition of Forest and Forestry, branches in forestry

Forest

The word '**Forest' is derived from Latin word 'foris' meaning** outside the village boundary or away from inhabited land.

Forest is an area set aside for the production of timber and other forest produce or maintained under woody vegetation for certain indirect benefits which it provides. But in ecology, it is a plant community predominantly of trees and other woody vegetation, usually with a closed canopy.

Stand is defined as an aggregation of trees occupying a specific area sufficiently uniform in composition (species), age arrangement and condition to be distinguishable from the forest on adjoining areas

Forestry, its Scope and Classification

Forestry is defined as **the theory and practice of all that constitutes the creation, conservation and scientific management of forests and the utilization of their resources.**

It is an applied science which is concerned with not only the raising or cultivation of forest crops but their protection, perpetuation, mensuration, management, valuation and finance as well utilization of the forest products for the service of the nation.

In favourable localities, this science is applied to get maximum return and so it is **called intensive forestry** which is defined as **the practice of forestry with the object of obtaining the maximum in volume and quality of products per unit are through the application of the best techniques of silviculture and management**.

When forestry is practiced to achieve more than one purpose, it is called **multiple-use forestry** which is defined as **the practice of forestry for the simultaneous use of a forest are for two or more purposes, often in some measure conflicting,** e.g., the production of wood with forest grazing and/or wildlife conservation.

Based on the objectives, forestry is classified as under:

a) Protection forestry – Protection forestry is the practice of forestry with the primary object of (1) protecting lands whether those upon which the forest is situated or those at a distance from it, against wind and water erosion, (2) conserving water supplies for human consumption, fish culture, etc., (3) reducing hazards from flood damage to human life and property and (4) amelioration of adverse climatic effects.

b) Commercial forestry – **Commercial forestry is the practice of forestry with the object of producing timber and other forest products as a business enterprise.** A specialized aspect of commercial forestry is to meet the requirement of a particular industry and in that case, it is called **industrial forestry which is defined as the practice of forestry to sustain a given industrial enterprise, such as a saw mill, pulp mill, chemical plant or a combination of these.**

c) Social forestry – Social forestry is **the practice of forestry on lands outside the conventional forest area for the benefit of the rural and urban communities.** Supply of fuel wood to divert cow dung from village hearths to village fields, small timber for rural housing and agricultural implements, fodder for the cattle of the rural population living far away from the forest areas, protection of agriculture by creation of diverse ecosystem and arresting wind and water erosion and creation of recreational forests for the benefit of the rural as well as urban population are the basic economic and cultural needs of the community without which there can be no improvement in the conditions of their living. The application of forestry technology to achieve this social objective is known as social forestry. This is new dimension recently added to the concept of forestry and includes within its scope the following:

1) Farm forestry – Farm forestry is the practice of forestry on farms in the form of raising rows of trees on bunds or boundaries of field and individual trees in private agriculture land as well as creation of wind breaks, which are protective vegetal screens created round a farm or an orchard by raising one at two lines of trees fairly close with shrubs in between.

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

i) Mixed forestry – Mixed forestry is practice of forestry for raising fodder grass with scattered fodder trees, fruit trees and fuel wood trees on suitable wastelands, panchayat land and village commons.

ii) Shelterbelts – Shelterbelt is defined as a belt of trees and/or shrubs maintained for the purpose of shelter from wind, sun, snow drift, etc. They are generally more extensive than the wind breaks covering areas larger than a single farm and sometimes whole regions on a planned pattern.

iii) Linear strip plantations – These are plantations of fast growing species on linear strips of land on the sides of public roads, canals and railway lines.

3) Reforestation of degraded forests

4) Recreational forestry – Recreational forestry is the practice of forestry with the object of raising flowering trees and shrubs mainly to serve as recreation forests for the urban and rural population. The main object is not to produce timber, grass or leaf fodder but to raise ornamental trees and shrubs in some area to meet the recreational needs of the people. This type of forestry is also known as aesthetic forestry which is defined as the practice of forestry with the object of developing or maintaining a forest of high scenic value.

Branches in forestry

Silviculture

According to Toumey and Korstian, **'silviculture is that branch of forestry which deals with the establishment, development, care and reproduction of stands of**

timber'. The art and science of cultivating forest crops (IF&FPT, Dehradun) Theory and practice of raising forest crops (Champion & Seth)

Silviculture may be taken to include both silvics and its practical application

It deals with the procedure of obtaining natural regeneration under the various silvicultural systems, artificial regeneration of various species, and methods of tending young crops, whether natural or artificial to help them to grow into forests of quality timbers and great economic value.

Silvics

The Study of life history and general characteristics of forest trees and crops with particular reference to environmental factors as the basis for the practice of silviculture

Forest Protection

Forest protection is defined as that **branch of forestry which is concerned with the activities directed towards the prevention and control of damage to forests by man, animals, fire, insects, disease or other injurious and destructive agencies**. A knowledge of the injuries caused to forests by the local human and animal population, both domestic and wild, insects, fungi and other adverse climatic factors and the preventive and remedial measures to counteract them, is essential for effective protection of the forests.

Forest Mensuration

Forest mensuration is defined as that **branch of forestry which deals with the determination of dimensions, form, volume, age and increment of logs, single trees, stands or whole woods.** Thus, forest mensuration deals with measurement of diameter and heights of crop so produced, calculation of its volume, age, etc., for sale and research to decide the best treatment to be given to the crop while it is being raised.

Forest Utilization

Forest utilization is defined as the **branch of forestry concerned with the harvesting, conversion, disposal and use of the forest produce.**

Forest Economics

Forest economics is defined as **those aspects of forestry that deal with the forest as a productive asset, subject to economic laws.** Thus, forest economics works out the cost of production including rental of land and compound interest on capital spent in raising the crop, and compares it with the sale proceeds to decide whether raising of the crop is economically profitable or not. It is also the function of the forest economist to compare the cost of production of a particular crop by different methods and then decide the most profitable method of raising that crop.

Forest Management

Forest management has been defined as **the practical application of the scientific, technical and economic principles of forestry.** Thus, forest management manages that crop according to the dictates of the forest policy. Forest management prescribes the time

and place where the silvicultural techniques and operations should be carried out so that the objects of management are achieved.

Lecture 2. Role of Forest - Production function, Protection function and ameliorative functions of forests

Role of Forests

The most of the Indian forests (95.8%) are under the state ownership which have to be managed not only for production of tangible or material products alone e.g. wood (timber and industrial raw material) and host of minor forest produce but also for the intangible services like protective, regulative and social cultural services.

Forests are the most valuable natural renewable resources of the earth

Forests serve two roles viz., **a) Productive role and B) Protective role**

a) Productive role	**b) Protective role**
1. Food	1. Climate amelioration
2. Fuel	2. Soil and water Conservation
3. Shelter	3. Wildlife habitats
4. Clothing	
5. Timber	
6. Industrial wood	
7. NTFP	

a) Productive role

It is estimated that the forest products contribute about 1% of world gross domestic product (GDP). The annual turnover of timber and other wood products from forests is valued at more than US$200 billion. The demand for commercial timber and other products is ever increasing, and expected to rise by 50% by 2010. Apart from that, non-timber products like rubber, cotton, medicinal products, food and so on represent significant economic value.

1. Food

a) Rhizome: *Amarphous campanulatum, Cyprus rotandus*

b) Root and aerial: *Dioscorea, Moringa oleifera Caryota urens, Bauhinia variegate*

tuber

c) Buds: *Dillenia pentagyna*, Phoenix sp

d) Sap, and latex: *Borassus flabellifer, Cissus rapanda*

Bark

e) Stems: *Cycas pectinata, Dendrocalamus strictus*

f) Leaves: *Tamarindus indica, Moringa oleifera*

g) Flowers: *Ficus glomerata, Madhuca indica, Bambax ceiba, Tamarindus indica*

h) Fruits: *Aegle marmelos, Anacardium occidentale, Anona squamosa. Artocarpus heterophyllus,Borassus flabellifer, Capparis decidua, Diospyros melanoxylon, Emblica officinalis, Morus alba, Zizyphus spp*

i) Seeds: *Anacardium occidentale, Juglans regia, Prunus amygdalus, Tamarindus indica, Dendrocalamus strictus*

2. Fuel

Wood is used as fuel for thousands of years, until the advent of coal, oil, gas, electricity, etc. Wood constitutes as chief source of fuel. Even today more than half of the total world consumption of wood is for fuel-wood. Wood remains the major source of domestic fuel in India. Approximately 175 mm^3 of wood is used as fuel in the country. It is estimated that by 2010, most of the 3 billion people who depend on it for their daily living will find it hard to obtain. Already, rural families spend precious hours in collecting firewood instead of other productive work, something that causes losses to the tune of US$ 50 billion to the world economy. Eg, Acacia spp, *Casuarina equisetifolia,* Prosopis, Neem, *Leucaena leucocephala*, etc.

3. Shelter

Wood is used for construction of buildings.

Eg., Palmyra, Teak, Jack, etc.,

4. Clothing

Rayon cloth **Eg.** Eucalyptus species

5. Timber

Timber is a major forest produce and is used extensively for various purposes. In India most of the wood produced is used for construction of houses, agricultural implements, bridges, sleepers etc., In India 12 mm 3 of timber is produced from our forests. More than 1500 species of trees are commercially exploited for timber in different parts of India. It is used in timber-based industries such as plywood; saw milling, paper and pulp, and particle boards.

Many species like teak, sal, deodar, babul, sissoo, chirpine, adina, axlewood, rosewood, dipterocarpus, and etc. yield valuable timber.

6. Industrial wood

1) Forest provide raw material to large number of industries eg: paper and pulp, plywood and other boards, packing cases, matches, toys etc.

Paper and pulp: Bamboos, Eucalyptus, casuarina

Plywood: Teak, Rose wood, Terminalia etc.

Packing cases: Pinus sp, Silver oak, Fir,

Matchwood: Ailanthus, Simaruba, Bombax

Toys: Adina, Redsanders, rose wood

7. NTFP

i) Fibre and flosses

Fibres are obtained from bast tissue of certain woody plants, which are used for making ropes. Flosses are obtained from *Ceiba pentandra* and fibres are obtained from *Agave sisalana, Sterculia urens*

ii) Grasses and bamboos

A large variety of grasses are found in the forests. About 30% of the 416 million livestock population graze in the forests. Among valuable grasses eg: Sabai (*Eulaliopsis binata*) is harvested annually 6.5 million tonnes and 80,000 tonnes of bamboo are harvested from forest every year.

iii) Essential oil

India produced about 1500 tonnes of essential oils during 1980, which was utilized in making soaps, detergents and chemicals eg. Eucalyptus, Bursera, Cymbopogan, *Santalum album* etc

iv) Oil seeds

Many tree species of *Madhuca indica, Pongamia pinnata, Shorea robusta, Azadirachta indica, Schleichera oleosa, Vateria indica* etc., produce oil-bearing seeds, which are commercially important. Presently these seeds are used in the soap industry. There is a potential production of about 1 million tonnes of oil every year from forests tree seeds.

v) Tans and dyes

Important tannins are extracted from myrobolan nuts, bark of wattles (*A.mearnsii, A.decurrens, A.dealbata*) and *Cassia auriculata*, leaves of *Embelica officinalis* and *Anogeissus latifolia*, bark of *Cleistanthus collinus*, fruits of *Zizphus xylophora, Cassia fistula, Terminali alata, T.arjuna* etc., katha and cutch are obtained from *Acacia catechu.*

vi) Gums and resins

Gums and resins are exuded by trees as a result of injury to the bark or wood. Gums *eg: Sterculia urens, Anogeissus latifolia, Lannea coromandalica, Acacia nilotica, Ptercapus marsupium, Butea monosperma* etc.

Resin is obtained from *Pinus roxburghii*

vii) Drugs, Spices and Insecticides

Important spices yielding drugs are *Rauvolfia serpentina, Hemidesmus indicus, Dioscorea spp, Atropa spp, Datura innoxia* etc,

Spices: Seeds of *Carum carvi*, barks of *Cinnomomum zeylanicum*, dried capsules of *Elletaria cardomomum.*

Insecticides: Pyrethrum and neem

viii) Tendu and other leaves

Tendu leaves (bidi leaves) (*Diopyrus melanoxylon*) and leaves of bauhinia spp, Butea spp, plates, dona etc.

ix) Lac and other products

Lac is a resinous secretion of insects which feed on forest trees

Eg; *Butea monosperma.* Silkworm is feed on *Morus alba* or *Terminalia alata.* Honey is produced from forests.

x) Fodder and grazing

About 30% of 416 million livestock population depend up on forest grazing and leaf fodder supply.

Eg; *Luecaena leucocephala, Albizzia lebbeck, Hardwickia binata*

xi) Cane

Canes or rattans are the stems of a climber plant and are used for a large number of household items. It is used to make walking sticks, polo sticks, baskets, picture frames, screens, and mats.

b) Protective Role

1. Forests as Earth's air purifiers

Forests form an effective sink for the carbon dioxide produced as a result of animal respiration, burning of fossil fuels, volcanoes and other natural and human-induced phenomenon. And if that is not all, a by-product of photosynthesis is oxygen. Thus, the Amazon forests are the Earth's air purifiers, given the large amounts of carbon dioxide they absorb from the atmosphere. Forests play a significant role in maintaining the CO^2 balance in the atmosphere without sufficient forest cover all the co 2 released in the atmosphere will not be utilised, resulting in higher per cent of co 2 in the atmosphere. According to scientists, this will result in warming of the world temperature; disturbance in the climate etc., The CO 2 percent in the atmosphere has already reached 0.042 per cent against the normal of 0.03%. If this increases continuously higher temperature and other disturbances o the earth may bring unimaginaste miseries to mankind.

2. Climate amelioration

Forest increase local precipitation by about 5 to 10% due to their arographic and microclimatic effect and create conditions favourable for the condensation of clouds. Forest reduce temperature and increase humidity. It also reduces evaporation losses.

3. Soil and water conservation

Forests maintain the productivity of the soil through adding a large quantity of organic matter and recycling of nutrients. The leaves are used as manure. Tree crowns reduce the violence of rain and check splash erosion. Forests increase the infiltration and water holding capacity of the soil, resulting in much lower surface runoff. This inturn results in checking of soil erosion.

Forest checks floods. Forests intercept 15 to 30% of the caused due to siltation of river channels caused due to erosion. Forests and trees reduce wind velocity considerably. Reduction of wind velocity causes considerable reduction in wind erosion, checks shifting of sand dunes and halts the process of desertification. Forests by reducing erosion check the siltation of irrigation and hydel resources. Rapid siltation of various reservoirs in the country is the result of deforestation in the catchment areas of these reservoirs.

Forest protect us from physical, chemical and noise pollution, dust and other particulates and gaseous pollutants cause serious health problems. Forests protect as from these pollutants.

Forest and trees provide shelter and wind break effect which is beneficial to agricultural crops, particularly in arid and semiarid areas and increase agricultural production.

4. Wildlife habitats

Tees act as a habitat for wildlife.

Lecture-3 Classification of Forest based on mode of regeneration, age, composition. Ownership, object of management and growing stock

FOREST CLASSIFICATION

Forest classification is defined as the grouping and arrangement of forests based on defined criteria such as composition, age, climatic elements, structure, habitat, etc. as like any classification, forest classification is also based many basic elements of forest or characteristics. This includes physiognomy, habitat, species composition, structure of forest, physiography, etc. the objectives and different schemes of forest classification are described here under.

Forests can be classified on the basis of

i) Method of regeneration

ii) Age

iii) Composition

iv) Objective of management

v) Ownership and legal status

vi) Growing stock

Objectives of forest classification

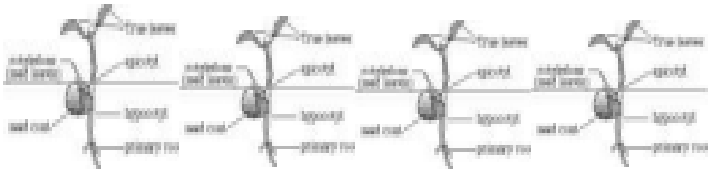
1. To study and characterize the different forest types

2. To develop suitable silvicultural management techniques for different forests

3. To avoid wastage of resource and save money by avoiding

i) Classification based on method of regeneration

High forests are those forests regenerated from seeds.



Coppice forests are those forests regenerated from coppice stools or stumps.

Plantation forests are those forests raised by planting seedlings or vegetative parts raised elsewhere.

ii) Classification based on age

Even aged forest or regular forest is defined as 'a forest composed of even aged woods'. A difference up to 25% is permitted in case where a stand is not harvested for 100 years or more.

Uneven-aged or irregular forest is defined as 'a forest composed of trees of markedly different ages.'

iii) Classification based on composition

Pure forest is defined as a forest composed of almost entirely of one species, usually to the extent of not less than 80%.

Mixed forest defined as a forest composed of trees of two or more species intermingled in the same canopy. At least 20 % of the canopy must consist of species other than the principal one.

iv) Classification based objective of management

Production forest defined as a forest managed primarily for its produce. It is also sometimes referred to as national forest i.e. a forest which is maintained and managed to meet the needs of the defence, communications, industry and other general purpose of public importance.

Protection forest is defined as an area wholly or partly covered with woody growth, managed primarily to regulate stream flow, prevent erosion, carbon sequestration or exert any other beneficial influence.

v) Classification based on ownership and legal status

A. Government Forests:

On the basis of Legal status, Government forests are further classified into:

a. Reserved Forests: A Reserved forest is an area with complete protection, constituted according to chapter II of the Indian Forests Act. 1927.

b. Protected Forests: A Protected forest is an area subject to limited degree of protection constituted under the provisions of chapter IV of the Indian Forest Act., 1927.

c. Village Forests: A Village forest is a state forest assigned to a village community under the provisions of chapter III of Indian Forest Act.

B. Private Forests

C. Forests owned by Corporations, Panchayats, Societies and other Agencies.

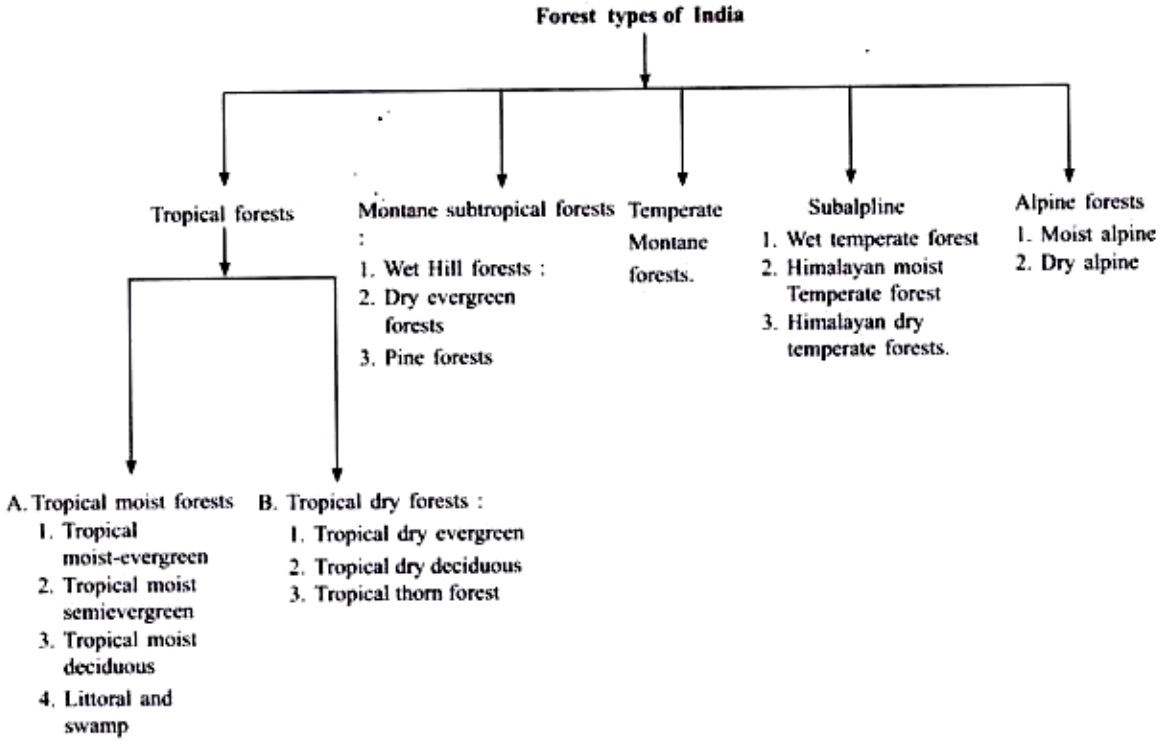
vi) Classification based on growing stock

Normal forest is defined as a forest which is constituted a normal age distribution, normal increment, and normal growing stock and form which the annual or periodic removal of produce equal to the increment can be continued indefinitely without endangering the future yield.

Abnormal forest is a forest in which, as compared to an acceptable standard, the quantity of material in the growing stock is in deficit or in excess or in which the relative proportions of the age or size classes are defective.

Forest types of India (Champion and Seth classification - 1935)

According to this system of classification, forests in India is classified in to five **major groups**. These major groups are further divided in to sixteen **groups** based on climatic data and vegetation.



Lecture-4 National Forest Policy 1988- Objectives and salient features

National Forest Policy-1988

The aim of this forest policy is to ensure environmental stability and maintenance of ecological balance for the sustenance of all life forms, humans, animal and plant this national forest policy is enunciated due to the following need

1. To meet the increasing energy demands of the population
2. To obey the new directive principles and duties given in the Indian constitution
3. Constitutional amendments of 1976 and its stress on environment
4. Marked growth of forest based industries in this era.
5. Need for the guidelines on conservation of wildlife.

Basic objectives

1. To maintain the environmental stability and ecological restoration through preservation
2. To check soil erosion and denudation in the catchment areas and mitigation of floods
3. To check the sand dune extension in desert and coastal lands
4. To increase the forest and tree cover in the denuded and degraded lands**.**
5. To meet the requirements of the tribal peoples
6. To conserve the natural heritage
7. To increase the productivity of the forest to meet the various needs
8. To encourage the substitution of wood and reduction of wood usage
9. To create a massive people movement and minimize the pressure on existing forest

Essential of forest management

1. Existing forest should be protected and its productivity improved
2. Diversion of agricultural lands to forestry should be discouraged
3. Conservation of biodiversity should be strengthened through national parks, sanctuary and biosphere reserves.
4. Afforestation programme encouraged to meet the local requirement of fuel wood 5. MFP production is encouraged to augment tribal employment and income

Management strategy

- ✓ The area under forests should be a minimum $1/3^{rd}$ of total geographical area in which hills and mountains region should have $2/3^{rd}$ cover
- ✓ Afforestation, social forestry and farm forestry and joint forest management programme are encouraged
- ✓ Rights and concessions of the local peoples are suitably addressed.
- ✓ Diversion of forest lands for non-forestry purpose is discouraged.
- ✓ Wildlife conservation is given more importance

- ✓ Shifting cultivation practices are discouraged and cultivation of perennial crops through horticulture and tree farming is encouraged.
- ✓ Fire and grazing management is given special consideration
- ✓ Forest based industries are advised to meet their raw materials requirements from outside the forest
- ✓ Forest Extension Research and personal management are more emphasized. **Broad comparison of forest policies**

Parameter	**1894**	**1952**	**1988**
Objective	Improvement of agriculture and public interest and rights	Balance and complementary use of forest produce	Conservation of natural heritage, biodiversity and genetic resources
Forest classification	1.Forest timber production 2.minor forest 3.Preservation forest 4. pasture lands	1.Protectionforests 2.National forests 3.Village forests 4.Tree lands	No classification
Tribal people and forests	No guidelines	Not much guidelines	Symbiotic relationship between forest department and tribal
Scope for increasing tree cover	No guidelines	Increasing vegetative cover through planting on railways, PWD lands	Massive afforestation programme emphasized through various measures
Control of private forests	No guidelines	Few guidelines given	Detailed guidelines given
Proportion of forest area	No guidelines	1/3rd of forest area,60% in hills and 20% in plains	33%under forest cover and 66%tree cover in hills
Protection to wildlife	No guidelines	Protection of rare and endangered species only	Network of protection measures strengthened

Grazing	No guidelines	Allowed with normal fee	Allowed according to carrying capacity
Shifting cultivation	No guidelines	No coercive measures to stop shifting cultivation	Discourage shifting cultivation

Sustainable yield	No guidelines	Limited scope	Detailed measures are given
Forest administration	No guidelines	Trained foresters are recommended	Personal management for professional foresters
Forestry legislation	No guidelines	Enactment of forest acts	Appropriate legislation is given
Forestry training education and research	No guidelines	Few guidelines given through rangers college and universities	Detailed guidelines on training and scientific forestry research is given for increasing productivity, afforestation, wildlife and wood substitution
Good will of local peoples	No guidelines	Instructs need for peoples cooperation	Focus on peoples participation in forest management

Lecture-5 .Forest regeneration - Types of regeneration - Natural regeneration through seeds and vegetative parts including coppice and root suckers

Methods of Regeneration

i) Natural regeneration

ii) Artificial regeneration and

iii) Natural regeneration supplemented by artificial regeneration

Natural Regeneration

Natural regeneration is defined as **'the renewal of a forest crop by self-sown seed or by coppice or root suckers.** It also refers to the crop so obtained. Thus, the natural regeneration may be obtained from the following two main sources:

i) From seed and

ii) From vegetative parts

When regeneration obtained from seed forms a crop, it is called a **seedling crop** which is defined as 'a crop consisting of seedlings neither planted nor of coppice or root sucker origin but originating *in situ* from natural regeneration'.

When this seedling crop grows into a forest, it is called a **high forest**. When regeneration obtained by coppice forms a crop, it is called coppice crop and when it develops into a forest, it is called coppice forest to differentiate it from the high forest. Root suckers are, however, not used for large scale regeneration operation.

Natural Regeneration from Seed

Natural regeneration from seed depends upon

1) Seed production

2) Seed dispersal

3) Germination and

4) Establishment

1) Seed Production

The most important prerequisite of natural regeneration from seed is the production of adequate quantities of fertile seed by the trees of the area or immediate neighbourhood. The production of seed depends upon species, age of trees, and size of crown, climate and other external factors. All species do not seed annually and abundantly.

The age of trees also affects the production of adequate quantities of **fertile seed.** The seeds produced by immature trees as well as over mature trees are, sometimes, **infertile.** Abundant quantities of fertile seeds are produced by the trees after the height growth has culminated because during the period of height growth, carbohydrate produced is utilized in it. Thus, abundant quantities of fertile seeds are produced from middle-aged trees.

The size of the crown of trees also affects seed production. As a general rule, the bigger the crown, the larger the production of seed. Therefore, while selecting seed bearers for

natural regeneration, **middle-aged mature trees** with **well-developed crowns** should be selected. **Climate also affects the seed production**.

As a general rule, warmer climate favours larger seed production. The other external factors which affect seed production are fire injury, insect attack and girdling. Injury by fire and insect attack stimulate seed production. Similarly, girdling is by heavy seeding.

2) Seed Dispersal

The seed produced by the trees is dispersed by the agency of wind, water, gravity, birds and animals. Some examples of seed dispersal by various agencies are given below:

- ✓ **By wind** – Conifers, *Acer, Betula, Rhododendron, Populus, Alnus, Salix,* most *Dipterocarps, Terminalias, Dalbergia, Acacia catechu, Adina, Bombax, Holoptelia,* most *Apocynacea* and *Asclepiadaceae, Casuarina, Cedrela, Chloroxylon, Pterocarpus marsupium,* etc.
- ✓ **By water** – *Trewia,* most mangrove species, *Dalbergia*, teak, etc.
- ✓ **By gravity** – Oaks, *Juglans regia, Aesculus,* etc.
- ✓ **By birds** – *Prunus, Mulberry, Broussonetia, Trema, Diospyros melanoxylon*, etc
- ✓ **By animals** – *Acacia Arabica, Prosopis juliflora, Ziziphus, Anthocephalus,* etc. As the seeds of all confiers in hills are dispersed by wind, special care has to be taken to see that the seed bearers are retained on ridges and on the upper portion of hill slopes so that they can cover maximum area.

3) Germination

After dispersal, a lot of seed is destroyed by insects, birds and rodents. The others germinate provided they are deposited on suitable soil. Germination of seed depends upon:

a) Internal factors b) External factors

a) Internal factors

The internal factors are the factors pertaining to the seed itself. The following internal factors affect germination:

i) Permeability to water

Moisture is very essential for germination; if the seed has a hard coat, it prevents moisture reaching the seed embryo and therefore prevents germination. Such seeds germinate only when the hard coat weathers due to exposure to sun and rain or when it has been partially eaten up by insects.

ii) Permeability to oxygen

Oxygen is necessary for germination. Factors which inhibit moisture reaching the seed, also prevent oxygen reaching it.

iii) Development of embryo

The embryo should be fully developed at the time of seed fall. If it is not developed, the seed lies dormant, till it is fully developed. A typical example of this is seen in *Fraxinus floribunda* in which the seeds lie dormant on the ground for the whole year.

iv) After ripening

Even if the embryo is fully developed, seeds, sometimes, do not germinate because the embryo is not chemically ready for germination. Such seeds germinate only when they have undergone a process of after-ripening. Delayed germination of *Juniperus macropoda* is due to after-ripening.

v) Viability

Viability is defined as the potential capacity of a seed to germinate. Some seeds lose their viability soon while others retain their viability for a year or more. Thus, in case of seeds which lose their viability soon, if the environmental conditions are not favourable for germination at the time of their fall, they die.

(vii) Germinative capacity and germinative energy

1. **Germinative capacity –** (a) The percentage, by number, of seeds in a given sample that actually germinate within twice the energy period (Baldwin). (b) The total number of seeds that germinate in a germinator, plus the number of sound seeds remaining at the end of the test, expressed as a percentage of the total sample (Holmes).

2. **Germinative energy**-The percentage, by number, of seeds germinating within a given **period, e.g., seven or fourteen days, under optimum conditions**

(viii) Plant percent

Plant percent which is defined as **'percentage of the number of the seeds in a sample that develop into seedlings at the end of the first growing season'**.

(b) **External factors**

External factors are the factors of environment which affect germination. These are:

(i) Moisture

An adequate quantity of moisture is very essential for germination. Moisture activates the dormant embryo and by softening the seed coat helps it to come out. Moisture is also necessary for dissolving the food material collected in the cotyledons and for translocating it in solution to the radicle and the plumule. Diffusion of oxygen for respiration also takes place in aqueous solution.

(ii) Air

The germinating seeds require oxygen and this is supplied by air. Seeds buried in the deeper layers of the soil often remain dormant for want of oxygen. In the germinating seed, respiration is very rapid and therefore, a constant supply of oxygen is very essential.

(iii) Temperature

Temperature is essential for germination but range of temperature within which seeds of various species germinate varies with species. Within this range, the higher the temperature the better the germination.

(iv) Light

Most species are indifferent to light conditions for their germination but some, e.g., *Cassia fistula, Albizzia procera*, require light.

(v) Seed bed

It is necessary that the seed should be deposited on proper seed bed for germination.

Seedling year – Seedling year is defined as a year **'in which a given species produces abundant first year seedlings.' It is 'also used to designate a year, in terms of the amount of natural seedling regeneration produced by a particular species, as good, fair, poor or very poor.'**

(4) Seedling establishment

Establishment is defined as the **'development of a new crop, naturally or assisted, to a stage when the young regeneration, natural or artificial, is considered safe from normal adverse influences such as frost, drought or weeds and no longer needs special protection or tending operations other than cleaning, thinning and pruning.'**

The following factors affect establishment of seedlings:

i) Development of roots

For some time after germination, the seedlings depend upon the food reserves of the cotyledons but soon they have to depend on their own resources. For this, it is essential that the seedling may develop a long tap root soon so that it reaches a depth where there is permanent moisture in the soil. If the development of roots does not reach that depth in the first growing season, the seedling may be killed by drought after the rains or in the summer season. Thus, in the species in which the development of root is fast, the seedling mortality is less.

(ii) Soil Conditions – As the tiny seedling has to depend upon the soil for its food, moisture and air, its establishment depends upon favourable soil conditions. The soil should have adequate moisture. Excess of moisture or its deficiency are both injurious for plant growth. Deficiency of nutrients has adverse effect on the development of seedlings

iii) Light - Light is a very important factor in seedling establishment but its requirement varies from species to species and even in the same species according to climatic conditions and age.

(iv)Other climatic factors - Extremely high or extremely low temperature are both harmful for seedling establishment. In extremely high temperature, seedlings are killed due to insolation while in extremely low temperature they are killed by frost. For seedling establishment, only adequate rainfall is not essential but its proper seasonal distribution is

also essential. Otherwise, the long dry season after the monsoon rains, kills most of the seedlings.

(v) Condition of grass, and other competing weed growth-The effect of grass and other competing weed growth depends upon the nature of weed growth and the climatic conditions.

(vii) Drip – Drip from the large leaves of species such as sal, teak is very harmful for seedling establishment because it removes soil from the roots of the tiny seedlings in splash erosion thereby exposing the roots resulting in the death of plants

(viii) Composition of the crop – The composition of the crop affects soil conditions and therefore affects the establishment. A mixed crop is believed to create more favourable condition for seedling establishment than pure crops.

NATURAL REGENERATION FROM VEGETATIVE PARTS

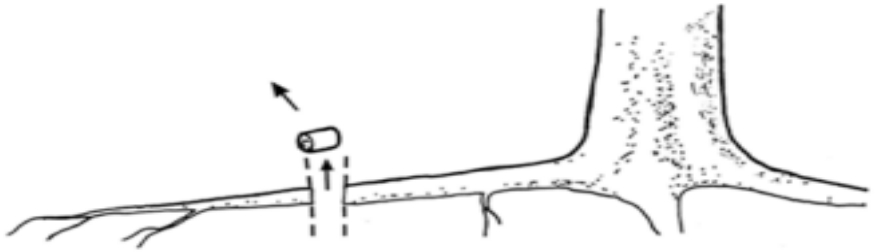
METHODS OF VEGETATIVE REPRODUCTION

Vegetative reproduction can be obtained by any of the following methods:

i) **Coppice** – Coppice is that method of vegetative reproduction in which the tree, plants or the seedlings of a species when cut from near the ground level, produce coppice shoots.

Coppice shoot is defined as **'a shoot arising from an adventitious bud at the base of a woody plant that has been cut near the ground or burnt back'**.

ii) Root sucker – Root sucker is that method of vegetative reproduction in which a root of a plant is partially or wholly cut to produce a shoot called root sucker.



NATURAL REGENERATION BY COPPICE

Natural regeneration by coppice can be obtained either by:

(1) Seedling coppice; or (2) Stool coppice.

(1) **Seedling coppice is defined as the 'coppice shoots arising from the base of seedlings that have been cut are burnt back'**.

- ✓ This method of obtaining natural regeneration is used for cutting back woody shoots and established reproduction which is not making any progress so that they may produce vigorous shoots and soon develop into saplings and later into poles.
- ✓ It is generally used in case of sal and teak.

(2) **Stool coppice** is the coppice arising from the stool or a living stump.

✓ In this method, regeneration is obtained from the shoots arising from the adventitious buds of the stump of felled tree.

✓ The coppice shoots generally arise either from near the base of the stump or from its top.

✓ Of the two, those arising from near the base are better because they get established easily.

✓ The shoots arising from near the top of the stump are liable to be damaged by the rotting of the upper portion of the stump as well as by wind, etc.

FACTORS AFFECTING NATURAL REGENERATION BY COPPICE

The following factors affect natural regeneration by coppice:

(1) Species – All species do not coppice and even in the species that coppice, the power varies with species. On the basis of their power to coppice, species are classified into following four categories, some examples of each being given against them:

(i) **Coppice strongly** – *Acacia catechu, Albizzia spp., Anogeissus spp., Azadirachta indica, Broussonetia papyrifera, Butea monosperma, Casia fistula, Cleistanthus collinus, Dalbergia spp., Diospyros tomentosa, Emblica officinalis, Eucalyptus globules, , Melia azedarach, Morus alba,, Prosopis juliflora, Salix spp., shorearobusta, Syzygium cumini, Tectona grandis,* etc.

(ii) **Coppice firly** – *Aesculus indica, Chloroxylon swietinia, Hrdwickia binata, Jglans regia, Pterocarpus marsupium, Terminalia belerica, Terminalia tomentosa,* etc.

(iii) **Coppice badly** – *Adina cordifolia, Bombax ceiba, Casuarina equisetifolia, Madhuca latifolia, Populus ciliate,* etc.

(iv) **Do not coppice** – *Abies pindrow, Cedrus deodara, Picea smithiana, Pinus roxburghii, Pinus wallichinana,* etc.

In some species, e.g., Acacia Arabica, Boswelliaserrata, Quercusdilatata, etc., coppicing power varies, sometimes, with locality to locality.

(2) Age of tree – The older the tree, the lesser is the coppicing power because old bark prevents the emergence of dormant buds. Youngers saplings and poles, as a rule, coppice readily and profusely.

(3) Season of coppicing – The best season for coppicing is a little before growth starts in spring because delay results in reducing the growing period. This season has another advantage that at this time there is large reserve of food material in the roots and all of it is utilized in the growth of coppice shoots.

OTHER OPERATIONS OF VEGETATIVE GROWTH

The following operations, though they are not methods of obtaining natural regeneration, are, sometimes, carried out for obtaining new vegetative growth on trees for various purposes:

1. **Pollarding – Pollard** is defined as **'a tree whose stem has been cut off in order to obtain a flush of shoots, usually above the height to which the browsing animals can reach'.**

Thus pollarding is an operation in which the stem of a tree is cut off at a height beyond the reach of browsing animals with the object of producing a crown of new shoots from buds below the cut. The flush of new shoots is cut down periodically so that the pollard may produce fresh shoots again.

Examples:

(i) *Salix* is pollarded in the Kashmir valley to produce shoots for wicker work.

(ii) *Hardwicki binata* is pollarded in Andhra Pradesh to produce shoots suitable for fibre extraction.

(iii) Some species of mixed dry deciduous forests in North Coimbatore (Tamil Nadu) are pollarded to provide fuel of preferred dimensions for boiling jaggery.

(iv) *Grewia oppositifolia* is pollarded in Kumaon and Garhwal hills (U.P.) to provide shoots for fibre and fodder.

Lecture-6 Artificial regeneration, Objectives - Nurseries - Types of nurseries, Quality seedling and production techniques

Artificial regeneration

- ✓ **Artificial regeneration** is defined as 'the renewal of a forest crop by sowing, planting or other artificial methods.
- ✓ It also refers to the crop so obtained.'
- ✓ Normally such a crop is called by another term '**plantation**' which is defined as **'a forest crop raised artificially,** either by sowing or **planting.**'
- ✓ **Sowing** refers to direct sowing which is defined as the '**sowing of seed directly on an area where a crop is to be raised as opposed to sowing in a nursery'**
- ✓ The planting stock may be procured from some other forest, and in that case it is referred to as wilding which is defined as 'a natural seedling (in contrast to a nursery grown seedling) used in forest planting.

OBJECTS OF ARTIFICIAL REGENERATION

Artificial regeneration is mainly carried out for the following two objects:

(A) Reforestation (B) Afforestation.

Reforestation may be defined as the '**restocking of a felled or otherwise cleared woodland' by artificial means.** In other words, reforestation is the raising of a forest artificially in an area which had forest vegetation before. On the other hand, afforestation is the 'establishment of a forest by artificial means on an area from which forest vegetation has always or long been absent.'

REFORESTATION

OBJECTS OF REFORESTATION

Reforestation is carried out with the following objects:

(1) **To supplement natural regeneration** – This has already been described in the last chapter.

(2) **To give up natural regeneration in favour of artificial regeneration** – When natural regeneration of the desired species is very slow and uncertain, it is not economical to regenerate areas by natural regeneration.

(3) **To restock forests destroyed by fire and other biotic factors** – Even in case where natural regeneration can be ensured, artificial regeneration has to be adopted if the forests are destroyed by fire and no seed bearers are left in the area to supply seed for natural regeneration.

(4) **To change the composition of the crop** – Sometimes, the natural forests are of low value as the proportion of the valuable species in the crop is low.

(5) **To introduce exotics** – Sometimes, the indigenous species are so slow-grown that they cannot satisfy the objects of management or the requirements of any industry. In such circumstances, it becomes necessary to introduce some exotics which can be raised successfully

FOREST NURSERY

Nursery is defined as 'an area where plants are raised for eventual planting out' has both ordinarily both seedlings and transplants. It comprises of nursery beds, paths, irrigation channels etc.

SEEDLING BEDS

A nursery which has only seedling beds, where only seedlings raised, is called seedling nursery. A nursery bed is a prepared area in nursery where seeds are sown for the production of seedlings. There are two types of nursery beds;

1. Seedling beds/germination beds

Seedling beds are those nursery beds in which seedlings are raised either for transplanting in other beds or for planting out.

2. Transplanting beds

Are those nursery beds in which pricked out seedlings are raised, after they have been transplanted from the seedling/germination beds.

TYPES OF FOREST NURSERY

1. On the basis of irrigational facility nurseries are classified into:

I. **Dry nursery:** It is a nursery that is maintained without any irrigation or other artificial watering.

II. **Wet nursery:** It is a nursery that is maintained by irrigation or other artificial watering during the dry periods.

2. On the basis of duration of their use nurseries are classified into:

I. **Temporary nursery:** It is nursery that is maintained for supplying nursery stock for a short period after which it is abandoned. Normally it is made in the plantation area referred to as field nursery.

II. **Permanent nursery:** It is a nursery that is maintained for supplying nursery stock for a long time on a permanent basis. The duration of service life of permanent nursery is long and it is maintained till seedlings can be raised in it at reasonable cost.

ESSENTIAL PRELIMINARY CONSIDERATIONS

After deciding in favour of artificial regeneration, decision has to be taken on the following essential preliminary considerations:

I. Choice of species;

II. Selection of site;

III. Choice of method of artificial regeneration viz., sowing or planting, and choice between the various methods;

IV. Spacing; and

V. Arrangement of staff and labour.

I. CHOICE OF SPECIES

The success of artificial regeneration depends upon correct choice of species. Slightest error in this regard may result in failure of the plantation and consequently loss and wastage of money and time. Choice of species depends on the following factors:

(1) **Climate and micro-climate** – The general climate of the region as well as the micro climate of the plantation site are very important factors governing the choice of species. Only those species which can grow in the regional climate as well as the micro-climate of the plantation site, should be selected

(2) **Soil conditions** – Suitability of the species to the soil and moisture conditions of the proposed plantation area is the most important factor governing the success or failure of plantation. Only the species which are suited to soil and moisture conditions should be elected to avoid failure.

(3) **Stage of succession** – Along with the factor of locality, the stage of succession which the soil has reached should also be noted to decide the species which can grow in it. Neglect of this important factor often leads to failure

(4) **Object of management** – Choice of species is also affected by the object of the plantation. For example, if a plantation is being raised for pulpwood, only the species which can give required quality of pulp should be raised.

(5) **Consumer's requirement** – There was a time when there was a craze for solid wood but the use of solid wood is being given up gradually for various reasons, e.g., natural growth defects, alternate swelling and shrinkage, lack of strength in compression and sheer, short supplies, high prices, etc., and the demand for light, decorative composite wood is increasing. This change in taste of consumer has to be kept in view while selecting species.

(6) **Growth rate** – The choice of species is also affected by their rate of growth. The following are some indigenous and exotic fast-growing species:

Indigenous – *Acrocarpus fraxinifolius, Ailanthus excelsa, Albizzia spp.,Anthocephalus cadamba, Bomax ceiba, Casuarina equisetifolia, Gmelinaarborea, Michelia champaca, Populus ciliate, Sterculia alata, Sterculia companulata, Terminalia myriocarpa, Toona ciliate,* etc.

Exoic –, *Eucalyptus* hybrid, *Eucalyptus grandis, Eucalyptus globules;* Tropical pines, e.g., *Pinus patula, Pinus caribaea, Pinus pseudostrobulus, Pinus kesiya;* Poplars, e.g., *Populus deltodies, P. casale* 488, *Populus yunnanensis, Populus robusta, Populus rubrapoiret.*

II. SELECTION OF SITE

- ✓ Sometimes, the species to be raised are already known and the sites in which they are to be raised are to be selected.
- ✓ Such species are generally those which as a result of experiments, have proved their usefulness for a particular purpose, e.g., meeting the requirement of industries and therefore, large scale plantations of those species are to be raised.

- ✓ Out of sheer enthusiasm, often such species are raised in any site without verifying its suitability for the species in question, and therefore, many such attempts result in failure.
- ✓ This causes not only waste of public money but also discouragement to staff.
- ✓ Therefore, selection of site is a very important essential preliminary consideration.

III. CHOICE OF METHOD OF ARTIFICIAL REGENERATION

After selection of species or site, as the case may be, method of artificial regeneration has to be decided. Artificial regeneration can be accomplished either by sowing of seed directly in plantation area or by planting seedlings or cuttings obtained from some nursery.

Advantages of sowing – Sowing costs less and the work is completed soon. As the seed is sown directly on the site, the result seedlings grows without any disturbance to its roots as happens in planting, consequently, there is no adverse effect on the growth of plant.

Disadvantages of sowing – Sowing requires large quantities of seed, the birds and animals may destroy or eat up the seed sown. The seedling mortality is heavy. As weeding have to be done for relatively longer period, they become costly.

Advantages of planting – The quantity of seed required is much less; the damage to seed by birds is completely eliminated while that of animals is reduced. Success is relatively ensured and weeding are cheaper.

Disadvantages of planting – Planting is costlier than sowing; it requires more labour, particularly skilled labour and a nursery.

The choice between the two methods of artificial regeneration depends upon the species to be raised, conditions of site, availability of seed and cost.

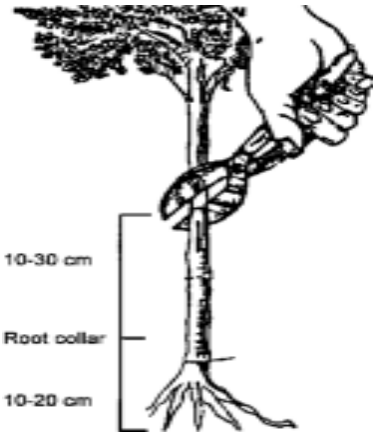
Stump planting

- ✓ Stump is a specially prepared seedlings in which shoots are cut above the collar region and roots are pruned leaving primary roots at defined length.
- ✓ Stump planting refers to the **planting of stump in a field**

Stump preparation

- ✓ Seedlings of 1-2cm diameter or pencil size collar thickness are suitable for stump preparation.
- ✓ The seedlings should have only one tap root system with 30cm or more length.
- ✓ Seedlings with two or more tap roots are discarded.
- ✓ The shoots of selected seedlings are cut at 2cm above the collar region and removed.
- ✓ Thereafter the tap root is cut at a length of 22cm from the collar region.
- ✓ This stump can be treated with bio fertilizers inoculants and or pesticides for better protection. This stump are ready for planting.

Advantages of stump planting



✓ It is easier and cheaper one

✓ Transport of planting stock is simple

✓ It requires less labour

✓ Soil preparation in the field is easier

✓ Seedling establishment and growth is faster

✓ Root development is good and deep

KINDS OF SOWINGS

Sowing may be done in any of the following ways:

i) **Broad cast sowing** – Broad cast sowing is defined as the scattering of seed more or less evenly over the whole area, either that on which the crop is to be raised directly or a nursery bed. The seed is scattered after ploughing or digging up soil over the entire area and leveling it roughly, though sometimes, soil preparation may not be done at all.

ii) **Line sowing** – Line sowing is the sowing of seed in drills or a single lines. The drills or lines are made at predetermined interval after digging the soil in those places

iii) **Strip sowing** – Strip sowing is defined as the sowing of seed in narrow strips prepared for the purpose usually at definite intervals from one another. Strips are usually 45 cm to 90 or even 120 cm wide

iv) **Patch sowing** – Patch sowing is defined as 'sowing a number of seeds in specially prepared patches', either circular or rectangular, made at regular interval. The size of patch varies from place to place depending on local conditions. In order to make patches, soil is dug up to a depth of 15 to 25 cm and filled back after weathering. Sufficient number of seeds are sown in each patch depending on its size though only one plant is expected in each.

In high rainfall areas or in places liable to water logging patch sowing is done on mounds and in that case it is called mound sowing. The mounds are usually **1.2 m x 1.2 m** at the base and **60 cm x 60 cm** at the top and their height is about 60 cm higher than the usual submergence level.

v) Dibbing – Dibbing is defined as sowing of seeds in shallow holes made with suitable instruments at definite intervals. For this sowing, soil is dug up with some iron or wooden instrument in small patches, *viz.*, 8 to 10 cm long, 8 to 10 cm wide and equally deep at regular interval.

IV. SPACING

In order to reduce cost of formation, plants are raised at some distance. This is called spacing; it is defined as the distance between the plants put out in a plantation or standing in a crop.

Advantages of wide spacing

- ✓ Wider spacing results in a saving in seed and plants.
- ✓ The cost of plantation is reduced and less labour is required to complete the work.

Disadvantages of wide spacing

- ✓ The canopy takes a long time to close resulting in the danger of soil deterioration.
- ✓ If one of the plants dies, there is a big gap in the plantation and it is usually infested with grass and weeds.
- ✓ The trees tend to become branchy, resulting in timber becoming knotty. As the number of plants is less, thinning become difficult
- ✓ Wide spacing results in rapid diameter increment and wider annual rings; this may affect the strength of wood.

Advantages of close spacing

- ✓ With close spacing, canopy closes soon and this keeps a check on growth of grass and weeds.
- ✓ As the number of plants is more, thinning becomes easier and natural pruning makes the boles of trees cleaner.

Disadvantages of close spacing

- ✓ Close spacing requires large quantities of seeds or large number of plants.
- ✓ It increases the cost of plantation and requires more labour to complete the work.

V. ARRANGEMENTS OF STAFF AND LABOUR

ARRANGEMENT OF STAFF

Arrangement of labour, labour on daily wages, and work through contractors

METHODS OF CLONAL PROPAGATION

1. Cuttings

1. Cuttings are parts of plants that are cut and separated from the mother tree and brought to form roots and/or shoots and eventually develop into entire plants.
2. Cuttings can be formed from roots, leaves or stems. Propagation from stem cuttings is the most important method in forestry.
3. The age of the tree and branch from where cuttings are collected has a very strong effect on rooting.
4. Cuttings taken from young trees usually have a much better rooting than cuttings from older material.

Types of stem cuttings

There are two main types of stem cuttings:

Softwood cuttings (leafed cuttings) are young soft succulent cuttings with leaves (sometimes pruned).

Hardwood cuttings are made of matured, dormant hardwood after the leaves have been shed. Tip cuttings possess terminal buds; basal cuttings are without terminal buds.

2. Air Layering

1. Air layering or marcotting has several advantages in that large plants can be produced quickly by relatively unskilled workers and with fewer operations than are required for budding or grafting.
2. Also they can be brought into fruit production much quicker than budded or grafted trees or plants produced from seed.
3. In air layering the branch to be propagated is girdled by removal of a ring of bark 25 to 38 mm in width.
4. It is advisable to scrape the surface of the wood in the girdled area to remove the cambium; otherwise the area can heal over quickly and fail to make roots.
5. The girdled area is then covered with a ball of sphagnum or coir dust which has been soaked in water and squeezed by hand.
6. The wet sphagnum or coir dust is covered with a sheet of plastic tied at each end with twine or with a sheet of aluminium foil tightly twisted closed at both ends.
7. Callus and roots will form at the upper end of the girdled area in six to eight weeks.
8. When the roots are well formed, the marcots are cut from the tree and either planted direct in the field or first planted in containers of soil and later set in the field.

3. Grafting

Grafting is the **joining of parts of plants together in such a way that they unite and continue to grow as a single plant.** The part of the plant that becomes the upper portion or top of the new plant is called the scion and the part which becomes the lower portion that includes the root is called the stock or root stock.

Grafting can be done in the **nursery** in which case the **stock is growing in a container**. For some species grafting can take place under field conditions, provided the graft union is well protected after the grafting. Many different types of grafts are possible including veneer, cleft, arching, bottle, tongue, whip, and root grafting.

4. Budding

A modified form of grafting in which, only a bud is inserted in the root stock. The method is widely used in horticulture, but can also be used for forest trees.

Several methods of budding are used. Some of the most common methods are;

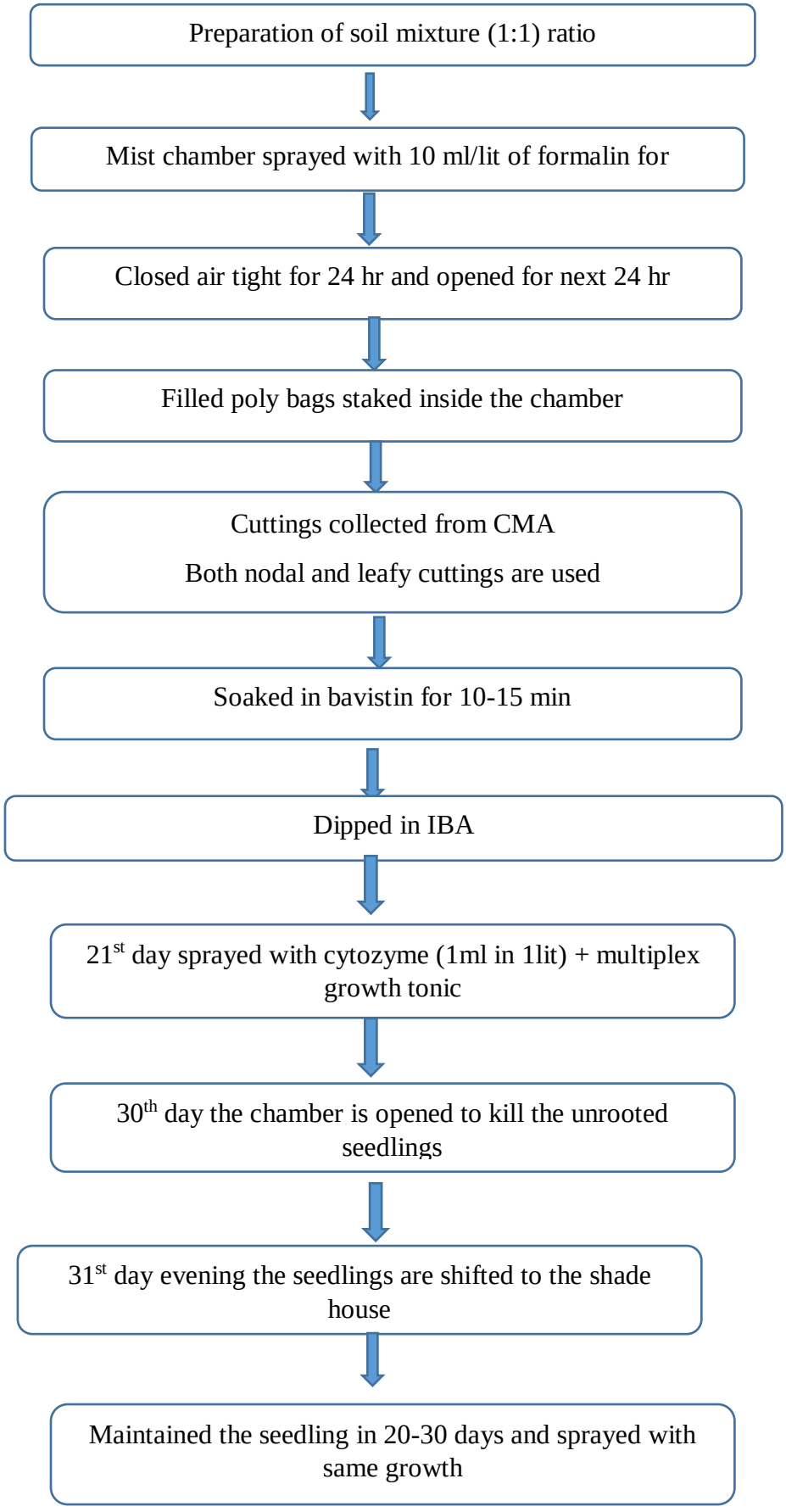
a) T-budding

b) Patch budding

c) I-budding

d) Chip budding

Production of Quality Seedlings



Shifted to open hardening area and hardened for 30 days

Planted in poly bags inside the chamber

Same day evening sprayed with bavistin (1g/lit H20) & dithane M 45 (1g/lit H2O) to avoid fungal infection - For 500 bags

Watering (intermittent mist) done once in a day

Temp-35 to36 c & RH- 85 to 90%

7th day sprayed with bavistin & Dithane M 45 (1g in 1 lit

Repeated for 14th day also

PLACE	DURATION
Mist Chamber	30 days
Shade House	20-30 days
Open hardening area	30 days
Total	80 – 90 days

Lecture -7. Silvicultural practices for *Eucalyptus spp, Casuarina equisetifolia, Tectona grandis, Ailanthus excelsa,*

Eucalyptus

Botanical Name : *Eucalyptus tereticornis*

Family : Myrtaceae

Common Name : Eucalyptus hybrid

Tamil Name : Thaila maram

Distribution

Native to Australia, *E. tereticornis* was first introduced in the Nandi hills (Karnataka) by Tiuppu Sultan between 1782 - 1790. Now it is grown over one lakh ha in Peninsular India. Extensive plantations have been raised to meet the needs of fuel wood, small timber and pulpwood in Punjab and Haryana, where area under forest is negligible. It has been planted in strips, 3-6 rows deep along highways, canals and railways. Large scale plantations of the species were taken up in Uttar Pradesh from 1962 onwards.

Species	Common name	Altitude	Rainfall
Eucalyptus tereticornis	Mysore gum	Upto 500 m MSL	750-1000m
E. camaldulensis	River red gum	Upto 500 m MSL	750-1000m
E. grandis	Red gum	1400 m MSL	1200-1500m
E. globulus	Blue gum	2500 m MSL	1200-1800m
E. citriodora	Lemon scented gum	2500 m MSL	1200-1800m

Physiognomy

- ✓ It is a tall tree with stout trunk, attains a height of 50 m. It is an evergreen, glabrous tree usually secreting an aromatic gum.
- ✓ **The leaves** and flowers contain conspicuous oil glands. Leaves of the saplings are generally opposite, sessile, cordate and held horizontal; those of the adult tree as a rule are alternate, petiolate and held vertical.
- ✓ **Flowers** are borne in umbels usually pedunculate.
- ✓ **Calyx tube** encloses the ovary which is covered with a deciduous operculum.
- ✓ The operculum is much longer than calyx and is formed by the union of the petals and falls off entire when the stamens emerge. Flowers are white in colour.
- ✓ **Fruit** consisting of the enlarged calyx-tube is usually hard and woody, full of resin sacs.
- ✓ **Seeds** are numerous but a large proportion of these are abortive and sterile seeds outnumber fertile ones. Bark is grey, exfoliating in long flakes.

Nursery Technique:

Seed Collection time **:** September – December

No. of Seeds per kg **:** Seeds number around 2000 seeds/g, around 20,00,000 seeds/kg

Viability **:** Dry seeds at 5-8% moisture content can be stored in air tight container under refrigerated conditions (3-5 ^{0}C) for more than 10 years without losing viability.

Germination % **:** 40-90%

Seed Treatment **:** The seeds are very minute and pre-treatment is not necessary.

Seed Rate **:** 5g/m^2

Phenology

It flowers almost throughout the year. The capsules are collected six months after anthesis when they just turn dark brown. If the capsule is left for long on the tree it will burst and shatter the seeds. Hence capsules are collected and kept in trays / tarpaulins. After sun-drying for 3 or 4 days, the empty capsules are removed. Mature seeds are dark brown / black in colour. The seeds retain viability for up to 5 years.

Silvicultural Characters

- ✓ It is a light demander.
- ✓ It produce good coppices freely and vigorously.
- ✓ It is a fast growing species and adaptability to a wide range of soil and climatic condition

Climate and Soil

It grows up to an altitude of 500 m. It is sensitive to frost. It grows in alluvial, black cotton, gravelly, lateritic, skeletal rocky and murram soils and even on shifting sand dunes. Highly calcareous, very saline and alkaline soils, clay and kantar pan is limiting. Deep, fertile and well-drained loamy soil gives best growth. Temperature range tolerated is 0-48°C. It is suited for the plains receiving a rainfall of 800-1000 mm. The tree prefers sandy loam to loamy soils within a pH range of 6.00 - 7.5.

Nursery Techniques

Seeds are sown in raised beds measuring 1 x 1 x 0.15 m. after wetting the bed, sieved seeds @ 5 g m-2 are mixed with a small quantity of sand and evenly spread on the bed. The seeds are covered with a film of soil.

The nursery beds need to be kept moist by watering at least twice daily. A mulch of hay prevents soil erosion during watering. Watering is done through a fine rose. BHC 10% has to be applied on the bed to prevent ants/termites. Five and 10 days after sowing 2% copper fungicide must be applied.

Germination starts on the 5thday. Since seedlings are sensitive to extreme sunlight, the bed has to be protected by a shade-screen during the first fortnight. Thirty day old seedlings are gently lifted from the bed and containerized in 200 gauge polypots measuring 20 x 10 cm.

The polypots are filled with 4: 1:1 mixture of red soil, sand and FYM. After wetting the filled polybags seedling are pricked one per polypot. The pricked out seedlings should be provided shade for a week and watered twice a day. Six month old seedlings are used for planting. The containers must be shifted once every fortnight from the second month to prevent rooting.

Planting

The seedlings are field planted at a spacing of 2 x 2 m in pits measuring 30 cm3. Quality of seedlings is determined by the thickness of the root collar region than by height. The trees are felled at the end of seven years. Thereafter two coppices are taken at intervals of five year each. Coppice management is important in eucalyptus.

Hundreds of new shoots develop on the margin of the cut stem. Felling of the trees prior to or immediately after the monsoon helps in rapid callus formation and thicker coppice shoots. Care should be taken to fell the trees with a gentle slope at the cut so that rainwater does not collect as a pool and cause decay of the callus tissue.

Though hundreds of coppice shoots develop yet only four to five stems ultimately remain on the stump and the others are edged out in natural competition. There is no need to manually regulate the number of coppices as nature itself does the job. The health and number of coppice stems are positively related to the diameter of the stump.

The productivity of coppice plantation is generally higher by 20 -25 % than the first seedling plantation. At the end of the second coppice growth it is necessary to uproot the roots. Its rotation is about 8 - 10 years. The productivity of rainfed plantations in Tamil Nadu Plains ranges from 50 -75 t per ha at the end of seven years. The ratio of first, second and third harvests is 1:1.2:0.8.

Utilization

Eucalyptus wood is the main stay of paper industry in Tamil Nadu. Currently, it is used for making packing cases and 70% of the requirement in Himachal Pradesh for apple transport is met by this species. Leaves contain oil. Bark yields oxalic acid. It is preferred by the farmers by virtue of several desiderata like

(i) fast growth;
(ii) not browsed by cattle;
(iii) immunity to pests and diseases;
(iv) good coppicing ability.

2. Casuarina

ScientificName : *Casuarina equisetifolia*

English Name : Beaf wood

Tamil Name : Savukku

Family : Casuarinaceae

Distribution

Casuarina is indigenous on the sandy shores and dunes along the Bengal coast, Andaman and Nicobar islands, etc. It has been raised in many parts of the country as a coastal plantation, an ornamental garden tree and an inland sand dune plantation.

Physiognomy

It is a large evergreen tree with a straight stem. The foliage is feathery and comprises of a number of long, slender, drooping, jointed, angled, leafless branches rising from rough, woody branches. The jointed branchlets are green and perform the function of leaves. They are partly deciduous. Casuarina resembles a feathery, coniferous tree in appearance. The bark is brown, fibrous, rough and exfoliates in longitudinal stripes. The tree may grow upto a height of about 35 m or so; though it generally does not have a life of more than 50 years, becoming hollow and unsound in about 35 years. By habit, casuarina is gregarious in its natural state, forming pure crops. There is little or no undergrowth except grassy patches and a few coastal shrubs.

Phenology

It is generally evergreen. Pieces of the jointed branchlets are shed all round the year. Flowering occurs twice a year once from February to April and again from September to October. Fruit ripening occurs in June and again in December. Seeds are viable for about six months or so, though it is always better to use fresh seed

Silvicultural Characters

- ✓ Strong light demander and drought resistant.
- ✓ Susceptible to fire.
- ✓ Coppices badly.
- ✓ Young plants susceptible to browsing

Climate and Soil

Absolute maximum and minimum temperature is 35°C-49°C and -4° to 18°C. Normal annual rainfall 750-4,500 mm. Best suited soil is alluvial soil having a considerable proportion of sand and good moisture supply. Also survive on poorly drained sites.

Nursery Technique

Seed is sown in the nursery in May, 5 cm apart in lines 23 cm apart and watered till the break of rains. Seedlings should be shaded during the hot weather. They are suitable for making stumps and/or entire transplanting when I year old. In Assam, 2 year old plants are transplanted, when 1-2 m high even taller. In West Bengal, practice is to plant out seedlings about 30 cm high, with ball of earth. One year old stock is used for making stumps.

Planting

Direct sowing may be done in raised patches 3.7 m x 3.7 m, just before the commencement of rains, using 3 to 6 seeds per patch. In taungya plantations of Uttar Pradesh direct sowing are done in continuous lines.

It has been successful in comparatively high rainfall region of Assam, West Bengal and Kerala. For stump planting, stumps are prepared from 1 or 2 years old nursery raised seedlings, keeping only 4 cm of shoot and 30 cm of root and running all side roots. Planting may be done in crow-bar holes or in pits of 30 cm3 Utilization.

Semal wood is very soft and light. Untreated wood is highly perishable and extremely durable under water. It is in great demand as matchwood; is very suitable for light plywood containers. It is also used for packing-cases, shingles, well-curbs, brush handles, dug-outs, etc. Floss from semal seeds is the Silk Cotton or Indian Kapok of commerce, which is used for stuffing cushions, pillows upholstery, packing, etc. Bark exudes a gum, known as mocha-ras, which is of great medicinal value. Inner bark yields a good fibre suitable for cordage.

3. Teak

Scientific Name :***Tectona grandis***

English Name : Thekku

Tamil Name : Teak

Family : Verbenaceae

Distribution

Native to Southeast Asia (India, Myanmar, Thailand and Western Laos), Teak, is the most important of the three species in the genus *(T. hamiltoniana, T.phillipensis).* A Tare combination of durability, dimensional stability and strength properties make Teak a paragon of timber and as of date faces no threat of being eclipsed by any other timber species. Its latitudinal limits are 9 N - 25° N and its longitudinal limits 70 E - *100*° E. In its natural habitat, teak occurs in mixed deciduous forests normally constituting a small number of individuals but occasionally in pure stands. Since 1840 it is raised in plantations in India and Myanmar.

Physiognomy

A large, deciduous tree, it may reach a height of 30 to 40 m under favourable conditions. On good sites, clean boles of 15 to 30 m length are obtained. Fluting and buttresses are often found at the base of the trees.

Bark is thick, grey or lightish brown, fibrous with shallow longitudinal fissures, peeling off in long thin narrow flakes on older trees. Leaves are large (25 - 50cm in length and 15-35 cm in width), elliptic or obovate; upper side green to dark green in colour; underside dense has whitish to tawny matt of wooly hairs.

Leaf arrangement is opposite.

The flowers are small, whitish and appear in large panicles containing upto a few thousand flower buds which open only a few at a time during the flowering period of 2 to 4 weeks.

The fruit is a hard, irregularly rounded drupe containing 4 seed chambers.

The pericarp consists of a thin papery exocarp, a thick felty, brown mesocarp and a stony endocarp. Only rarely do all the four seed chambers contain developed seed. Generally in a sample one seeded fruits abound (42-64%);

2 seeded account for 12-25%; 3 seeded vary from 2 to6%. 4 seeded account for 1-2%. Large numbers (11-35%) are also found to be completely seedless. The teak fruit varies from 11 to 18 mm in cross section and average 2000 in a kg.' '

Phenology Age of trees at first flowering varies markedly depending on site, climate, silvicultural management and genetic linkage. Its natural habitat it comes to flowering in 6-8 year. But under plantation conditions size or height of the trees rather than age exercises a profound influence on flower initiation.

Flowering generally occurs during June - July. The fruits attain full size and mature in about four months after fertilization (i.e. during October- November). A sign of maturity is their facile fall to the ground when the tree is agitated.

Silvicultural Characters

- ✓ Teak seedlings are sensitive to frost and drought.
- ✓ It is a strong light-demander, intolerant of suppression and weeds.
- ✓ It is a fire resistant; seedlings and saplings killed back by fire and frost.
- ✓ It coppices and pollards vigorously, up to about middle age.

Climate and Soil

The tree grows under a wide climatic situation from sea level up to an altitude of 1200m and in a precipitation range of less than 900 mm to more than 2500 mm. The most suitable soil for teak is the deep, well drained alluvium having relatively high contents of calcium and phosphorus. It tolerates a pH range of6.5 to 8.0 but good growth is attained on soils of pH 6.5 and an annual rainfall or 1500 mm. Teak is a pronounced light demander and does not tolerate suppression at any period of its growth. It is also fairly fire tolerant.

Nursery Technique

The unit of sowing is the fruit (drupe) which for practical reasons is termed seed; seeds that have been stored for at least one year germinate better than fresh seed. If use of seeds of the same year is necessitated they before sowing are subjected to a process of alternate wetting and drying of 24 hour duration each for 14 days. Use of large seeds more than 14mm in diameter gives better germination. Seeds are sown @ 1 kg m-2on raised nursery beds 10m long, 1 m wide and 0.5m in height and covered with soil to a depth equivalent to the fruit diameter.

To prevent soil erosion beds are reinforced on the sides with bamboo splits or other such material. Germination commences in about 15 days, accelerates during the next 15 days, declines thereafter. Majority of germinates will have appeared in 40 days, when the germinability is around 40 per cent. The beds are watered twice daily for the first two months, once daily for the next three months and on alternate days thereafter. Supersized seedlings called "wolf' smother others.

For field planting only stumps prepared from one year old seedlings are used as these promote faster growth and ideal bole form. Stumps are prepared by cutting away

from the seedling everything except 2.5 cm of the shoot and 22.5 cm of the root. The stem portion receives an oblique cut and the root portion an horizontal cut. All laterals from the tap root are pruned away. The stumps should preferably be planted within 2 to 3 days.

Planting

Stumps are flush planted (in level with the ground) at a spacing of **2 x 2 m** in crow bar pits. The initial plant density of 2500 ha-t is reduced in a phased manner to an ultimate 80 to 100 ha-t by an operation called thinning. A total of four thinning is given in the 5th, 10th, 18thand 28th years and at each thinning the existing population is reduced by half. The first two thinning are mechanical and are done according to a rule of thumb, in the first thinning alternate diagonal rows are removed; in the second thinning alternate rows are felled. The 3rd and 4th are silvicultural thinning in that they are restricted only to diseased and malformed trees. Trees possessing clean bole, cylindrical bole, straight bole, less taper, small crown and less fluting are retained. Final felling is done at the end of60 years. A single tree will yield 1.5 m^3 of timber. Its rotation is 40-60 years'; its yield is about 6500 cu.ft of stem wood per acre.

Utilization

1. Teak wood is globally renowned for its strength, durability, dimensional stability, working quality and non-corrosive property when in contact with metal.
2. The durability is attributable to the deposition of polyphenols in its heartwood.
3. On account of these **outstanding properties**,
4. Teak is sometimes hailed as the **Queen of timbers.**
5. Increasingly large quantities of Teak are used by the plywood industry for **high grade commercial** and tea-chest categories of plywood.
6. Lops and tops and other rejects serve as fuel wood.
7. The seeds contain oil to the extent of **44.5%** and the oil is used in soap manufacture.
8. Teak leaves are often used as **platters.**

4. Ailanthus

Scientific Name : *Ailanthus excelsa*

English name : Tree of Heaven

Tamil name : Pimaram, Pinari, and Perumaram

Family : Simarubiaceae

Distribution

Ailanthus excelsa is considered a native of the Indian peninsula, but occurs throughout the tropical and subtropical regions of India, especially in the dry districts of Gujarat, Rajasthan, Haryana, Punjab, Uttar Pradesh, Bihar, Orissa and the Deccan plateau. It is not found in the high rainfall regions of the West Coast.

Physiognomy

It is a large deciduous tree, attains a height of 18-24 m.

Bark is light grey and smooth in young trees, with large conspicuous leaf scars, rough, granular and greyish brown in older ones. Leaves are pinnately compound, up to 1m long, with 8-14 pairs of leaflets and an unpleasant smell when crushed.

In seedlings and saplings imparipinnate leaves are the rule for the first three or four years, after which the terminal leaflet becomes reduced in size or is represented by a mere prolongation of the rachis and finally the typical abruptly paripinnate leaves are formed about the fourth or fifth season.

The fruit is a red one-seeded samara 5-7.5 cm long and 1.2-1.5 cm wide, prominently veined, acute at both ends and twisted at the base; about 9 to 10 fruits weigh one g. The fruit being winged is adapted for dissemination by wind.

Phenology

The panicles of small yellowish flowers appear in **February - March** and the fruits ripen in May - June. Old leaves fall during February and new ones appear in **March - April**. In Central India, flowers appear during **February and March** and in the North during April.

Silvicultural Characters

- ✓ It is a strong light demander and is susceptible to frost and prolonged drought, though poles and trees are resistant.
- ✓ It coppices well and produces root suckers freely.
- ✓ It is very susceptible to water-logging and wind break.

Climate and Soil

It grows well in semi-arid and semi moist regions, both in the plains and the hills. In Rajasthan, it grows in areas with an average annual rainfall of 400 mm. It avoids moist areas with high monsoon rainfall. The average mean temperature is about 10 ◦ C and maximum about 30oe. Average annual temperature is above 27°e. Though it can grow on a wide variety of soils, it thrives best on porous sandy loams. It avoids clay with poor drainage and waterlogged areas. It can be grown on shallow dry soils but growth is poor.

Nursery Techniques

For maximum viability and vigour, fruits are collected when the colour of the pericarp changes from yellowish brown to brown.

The samaras are dried in the sun. These lose their viability in about four months. Nicked samaras are kept in wet gunnies for 48 hour.

At the end of storage sprouted samaras are separated and sown in polybags. By this method, the number of empty containers is considerably minimized.

Samaras number about 9600 in a kg.

Germination takes about 5-12 days and is completed in about 30 days. The radical and plumule emerge through the winged covering, the cotyledons being carried up and the testa usually left inside the fruit. The hypocotyl arches somewhat at first, soon straightening. The cotyledons usually persist for about 2-3 months after which they turn yellow and fall.

Planting

Nine month old seedlings are planted at a spacing of 5 x 5m. Seedling growth is fairly fast attaining a height of 0.2, 0.6, 2.4 and 4.2 m at the end of first, second, third and fourth growing seasons respectively.

Utilization

- ✓ A ten year old tree approximately yields 50-75 tonnes of match wood.
- ✓ The wood is soft, white, very light but fairly strong and easy to saw.
- ✓ It is used for match splints, packing cases, fishing catamarans and floats.
- ✓ It is also used for commercial plywood.
- ✓ The wood is perishable in the open but not under water.
- ✓ It is grown as shade and avenue tree in hotter parts of India.
- ✓ It yields an inferior type of gum.
- ✓ Its bark and gum are of medicinal value.
- ✓ Leaves are highly palatable and nutritious fodder for sheep and goats; and extensively used in Rajasthan.
- ✓ The green fodder yield is 500-700 kg twice a year.
- ✓ The chemical composition of the leaves shows that the leaves are rich in crude protein, ether extract and calcium but poor in phosphorus when dry or when chaffed with twigs.
- ✓ The crude fibre content is also low.
- ✓ Green leaves are considered highly palatable and animals relish them more than dry leaves even when the latter are treated with molasses.
- ✓ Digestibility coefficients are fairly high for all nutrients except ether extract whose digestion from leaves in the ruminants is low.

Lecture-8 Silvicultural practices for *Melia dubia, Leucaena leucocephala*. Tending operations - Weeding, Cleaning, Thinning and pruning.

Melia dubia

Botanical Name : *Melia dubia*

Family **:** Meliaceae

Common Name **:** Malabar Neem

Tamil Name **:** Malai Vembu.

Distribution:

It occurs in tropical moist deciduous forests of Sikkim, North Bengal and upper Assam, Khasi hills of Odisha, Deccan and Western Ghats at altitudes ranging from 1,500 to 1800 m above mean sea level.

Climate and Soil:

This species is found to grow in regions with a temperature range of 32 - 40^{0}C and annual rainfall of 800 – 1000 mm. It grows in a wide variety of soils. However, the best growth is found in deep, well drained sandy loam soils while in shallow gravelly soils its growth is stunted.

Botany:

It is a fast growing, deciduous tree attaining a height of 20.m with a spreading crown and a cylindrical straight bole of 9 m length and 1.2 – 1.5 m girth.

Silvicultural characteristics

- ✓ The tree is a light demander and seedling are suppressed under shade.
- ✓ Seedlings tolerate frost to certain extent but severe and recurrent frost kills them.
- ✓ It is susceptible to damage by fires and saplings suffer from browsing.

Natural Regeneration

Natural propagation is mostly through seeds; however, germination potential is less. It coppices well and produce root suckers when the roots are injured. It pollards well and clusters of new shoots are thrown out from the dormant buds on the stem and branches.

Artificial Regeneration

It can be raised either by direct sowing or planting for producing seedlings or stumps. Direct sowing without seed treatment results in poor germination (20%) and hence treating the seeds with 100 PPM Gibberellic acid helps in increasing the germination percentage to the tune of 40 – 47%

Phenology: Fruits ripen during January – February.

Nursery Technology

Seed Collection time	**:**	January – February
Viability	**:**	Upto one year
Germination percentage	**:**	20% without seed treatment; 40 - 47% after seed treatment
Seed Treatment	**:**	Mechanical scarification of the seed coat followed by soaking in 100 PPM Gibberellic acid overnight.

Seeds are collected from ripened fruits (Jan. – Feb.) and are stored in sealed tins. The germinative capacity of the seed is less than 20%. In nursery, the seeds are sown in raised nursery beds. Then the treated seeds are sown over the raised nursery bed. It takes one or two months for the seeds to germinate. Irrigation should be done for nursery beds regularly. The seedlings take 6 months to complete their nursery stage.

Vegetative Propagation: Carried out through branch cuttings and grafting

Yield:

- ✓ This species can be grown for pulpwood and plywood.
- ✓ For pulpwood, wood yield of 25 – 30 tonnes/ha is possible in 2 – 3 years
- ✓ Plywood, wood yield of 100-120 tonnes/ha is obtained in a rotation of 5 – 6 years.

Uses

- ✓ The wood is an excellent raw material for making plywood besides its use as pulp in paper industry and for making matchsplints in match industry.
- ✓ It is also used for making packing cases.
- ✓ The leaves are a good source of fodder besides their medicinal use in siddha and ayurvedic systems of medicine.

Pests and Diseases:

- ✓ Termite is a major pest especially in red soils which can be controlled by application of Chlorpyriphos 2 %.
- ✓ Rootrot caused by *Macrophomina phaseolina* can be managed by drenching with Carbendazim 0.1%

LEUCAENA LEUCOCEPHALA

Botanical Name : *Leucaena leucocephala*

Family **:** Fabaceae

Common Name **:** River tamarind

Tamil Name **:** Periya takarai

Distribution

Leucaena leucaena ssp. *leucocephala* has become the fourth-most-rampant tree weed in Singapore, after *Acacia auriculiformis*, *Falcataria mollucana*, and *Spathodea campanulata*. The spread of the species around the island in recent times is believed to have been established from seed-contaminated soil, brought in from Malaysia or Indonesia for land reclamation and soil works.

Soil:

The species grows well in loamy soils, clayey loam and sandy loam. It has a long strong tap root and can penetrate deep in compacted soils. The species has foliage which fertilizes the soil, as the fallen leaves decompose fast and form good humus to add soil nutrients. The species is an excellent nitrogen fixer thereby helps to augment the soil fertility.

Temperature:

The species tolerates high temperature of the tropics. Heavy frost kills the plant, light only defoliates the tree. It is a light demander and grows slowly under the shade, though tolerates partial shade.

Rain fall:

The species grows best where the rainfall is between 1000 to 3000 mm. It however tolerates dry season extending 8 to 10 months, but the productivity is reduced.

Utilization:

- ✓ All parts of the tree are useful.
- ✓ Foliage is a good fodder for cattle, though due to mimosine, which form 3-5% of the dry matter, there is a fear of its ill effects on the health of the cattle.
- ✓ However upto 10 to 15% of the diet of cattle can be lucaena fodder without ill effects.
- ✓ Even curry is made of this leaf.
- ✓ The seeds are safe as a coffee beverage.
- ✓ The pods can be spread on roofs to insulate from heat.
- ✓ The wood is good for small furniture, as poles and for plywood core etc. Unripe pods are also eaten by goats and cattle.
- ✓ It is a good fuel with heating value of 4640 k/cal per kg, when harvested from plantations of 2 to 5 years age and the heating value increases with maturity of trees.
- ✓ As pulpwood, subabul is among the best tropical hard woods.
- ✓ The pulp is high in holocellulose and low in silica, ash, lignin, alcohol benzene solubles and hot water solubles.
- ✓ All these are important for pulp and rayon.
- ✓ The pulp yield is as high as 50 to 52%.
- ✓ The fibre is shorter than in softwoods, but is within the acceptable range.
- ✓ It has however low tearing strength, low folding endurance and average tensile strength, compared to others softwood pulps.

PLANTATION TECHNIQUES AND PRACTICES

SEEDS:

Seeds come out of pods which grow in clusters, from mostly self-pollinated flowers, which look like fluffy white ball. The seed has a waxy white coat, and needs to be treated. In a KG, giant types have about 20,000 seeds. In general there are 30,000 seeds in a Kg of 100% purity with about 6% moisture.

SEED COLLECTION:

Ripe pods should be collected before they split and dried in the sun for 3 to 4 days. The pods then split, when seeds can be gathered by sieving. Seeds are viable for three to four years.

PRETREATMENT:

As the seed coat is hard, they need pretreatment before sowing: This can be done with any of the following ways.

Soaking the seed in hot water (800) for Two to Three minutes, or in cold water for 3 to 4 days.

Concentrated Sulphuric acid can also be applied for 15 minutes to soften the seed. Germination occurs in seven days with 70 to 80% germinating.

Planting:

Direct sowing of seed during monsoons gives good result, but the plants grow slower than nursery raised seedlings and if there is prolonged drought the germinated seed may dry up.

NURSERY TECHNIQUES

BAG CULTURE:

Pretreated seed should be sown in poly gags of 5" x 8 " (12.5 x 20 Cms), filled with soil mixture to which Rhizobium inoculum (Soil from older plantations) is added at 250 gms for 20 Kgs of seed.

Pretreated seed can be sown in nursery beds of 40' x 4' thinly covered with soil (soil cover should be 3/4th the thickness of seed). Seedlings when 10cms tall, can be pricked out and planted in poly bags filled with soil mixture.

STUMP PLANTING:

As the species is a good coppicer, recent trails with stump planting has given good success. Good pretreated seed be sown on nursery beds.

Beds should be formed with red earth, sand, farmyard manure and local soil, to which soil from the older plantation is added.

When the seedlings are 3 to 4 months old, and when the collar thickness is that of an index finer, they be taken out of the beds and stumps formed by cutting the shoots and roots.

The stump should be of the thickness between thumb and index finer. The length should be between 9" to 12" (22.3 to 30 cm.). The hair roots and the long thin tail of the tap root should be cut with a sharp tool. The stump should have only about 20 cm of the shoot.

This stump can be transported in wet Hessian bags. Before bagging, the stumps be made into bundles of 50-100, and dipped in a puddle of red loamy soil to which a little quantity of Gum is added. This soil coat will prevent drying of the stumps during transport and storage. They should be planted within 3 days of formation.

Stump planting has advantages in costs and handling and transport. As planting can be done in crow bar holes, costs on digging of pits for bags can be saved. Once the stump establishes and puts on growth, the plantation will be as good as that raised with bag plants.

SPACING

Spacing can be varied to suit the end use. For purposes of fodder, the spacing can be 50 x 50 cm. For fuel wood the spacing can be 1m x 1m; for Pulpwood, as the minimum girth is 10 cm, and if harvesting is done in the fourth year, the best spacing will be 3 m x 1.5 m. Farmers are planting in general at 50" x 50" spacing.

In general, the spacing should be closer in poorer soils and wider in fertile rich soils.

Season of Planting:

Planting should be done during rains when the moisture is available at depths of 12". Bagged seedlings be planted in 30 cm cube pits.

Stumps should be planted in crow bar holes. The planted stump should be firmed up on all sides. Care should be taken to see that no hollow is allowed to remain in the crow bar hole.

After Care:

Weeds are a major cause of failure or slow establishment. Regular weeding, till plants are one to two meters tall, gives best results.

Weeding with soil working round the plants to a radius of 0.5 m should be done at least thrice in the first year, and as many times as needed in the subsequent years.

If the planting is done at 3 x 1.5 m spacing, the space in between rows, can be ploughed with a tractor. Such operation gives very good result. Irrigation if possible accelerates the growth.

Singling of multiple shoots, by retaining one or two at each plant, will give good girth increment of the retained shoot.

If pruning is to be done to collect green manure or cattle fodder, it should be limited to 2/3rd the bole, leaving intact the 1/3rd crown.

Tending operation

Tending is defined as an operation carried out for the benefit of a forest crop at any stage of its life between the seedlings and the mature stages. This included weeding, cleaning, thinning, improvement felling, pruning, climber cutting and girdling. This does

not include regeneration felling, soil working, drainage, irrigation and controlled burning. Tending helps in producing higher quality timber and thus by maximizes income.
Tending differs from the cultural operation in the following means.

	Tending	Cultural operations
1	Tending is carried out for the benefit of forest crop by creating better environment	It is done for assisting regeneration, promote development and to decrease felling damage
2	This is not aims at natural regeneration	This is t aims at natural regeneration
3	It includes pruning but not controlled burning	It includes controlled burning but not pruning
4	Tending carried out from seedling stage	Cultural operations carried out after felling
5	It is carried out in both natural as well as artificial regeneration	This is carried out in silvicultural system relying primarily on natural regeneration

Limitation in Tending

1. It has to be done for several times from seedling to maturity
2. It requires considerable funds and staff
3. This creates labour shortage problem which in turn creates supervising problem

Importance of tending:

Tending helps to producing high quality timber and maximizing returns per unit area; it is, therefore, an important silvicultural operation. The above objects can, however, be achieved only when tending operations are done properly and on time.

1) Weeding

Weeding may be defined as a tending done in the seedlings stage in nursery or in a forest crop that involves the removal or cutting back of all weeds.

Objects of weeding:

- To reduce root competition for nutrients
- To reduce water loss through transpiration
- To facilitate cultural operations
- To improve light conditions to main crop

Weeding process:

- Weeding must be done in plantations during the rains and stopped by the end of September
- It should be done before the suppression of seedlings by the weeds.
- It is carried out for 3 years from planting
- Fast growth species requires less weeding than the slow growing species.

2) Cleaning

Cleaning is defined as a tending operation done in a sapling crop which involves removal of inferior growth including individuals of favoured species. This is normally carried out when the inferior crop interfere with the main crop.

Objects of cleaning:

- To improve light conditions
- To reduce root competition
- To reduce water loss through transpiration

Operations in cleaning:

- Clearing of shrubs and herbaceous growth
- Removal of individuals of inferior species
- Cutting back of the malformed or diseased individuals of the desired species
- Cutting and removal of climbers
- Singing of coppice shoots of the favoured species

3) Thinning

Thinning is defined as 'a felling made in an immature stand for the purpose of improving growth and form of the trees that remain, without permanently breaking the canopy'.

Object of thinning:

- To distribute growth potential of a site among the trees retained
- To increase the net yield of timber and money from a stand
- To obtain earlier returns from capital invested in a stand
- Utilization of thinned material
- Shortening the rotation
- To produce a different smaller size of timber this can meet a different object of management
- To maintain hygienic conditions in the stand
- To obtain timber of the desired quality and mechanical strength

Kinds of thinning:

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

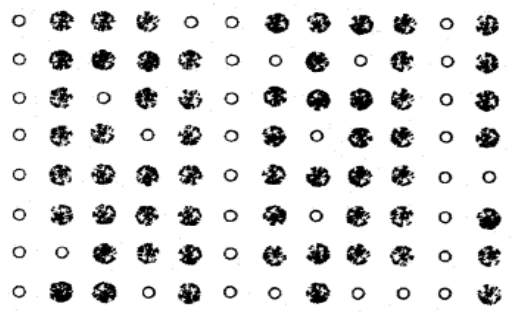
1. Mechanical thinning

It is defined as a kind of thinning in which the trees to be cut is selected by some common thumb rule.for examble, trees in alternate diagonals or rows, alternate trees in a row,etc are removed. Trees are retained according to the predetermined spacing. There is no consideration of growth potentialities and site characteristics.

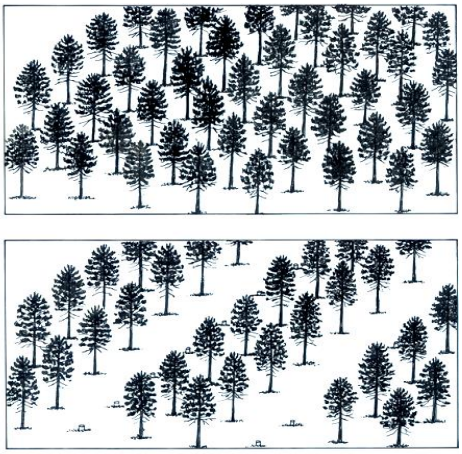
The diseased, damaged and badly affected trees are removed even it obstructs the predetermined spacing. Stick thinning is a special kind of mechanical thinning in which a stick having length of desired spacing is used for marking the trees to be cut.trees that fall within the stick length are marked for removal.

Application of mechanical thinning

This is normally applicable during the earlier stages of crop where there is no differentation of crown. In teak, the initial spacing is 1.8 m *1.8m. the first mechanical thinning is done when teak attains a height of 7.5 to 9m. in this alternate plants are removed and thus the total plant population is reduced to 50% from the original.this resulted the spacing of 2.5 *2.5 m. after 5 years, again alternate plants are removed and population reduced by 50%.this results a spacing of 3.6m*3.6 m.



Fifth row thinning with removal of selected trees from the other rows



2. Ordinary thinning

This is also called as low thinning from below and German thinning. In this, inferior individuals of a crop, starting from the suppressed class are removed followed by some dominated and some of the dominant trees removed.

Principle

This principle is based on the survival of the fittest (i.e., it considers only the fittest or dominant trees inside the forest). The removal of inferior trees such as suppressed and dominated reduces the competition which enhances the superior trees (dominant trees). Secondly, the week suppressed trees are more liable to infected by diseases and insect. Thirdly it increases the fire possibility. Hence it is better to remove the inferior vegetation.

Advantages of ordinary thinning

1. It is simple and easy to execute

2. This is useful in areas where small sized timber is needed.

Demerits of ordinary thinning

- ✓ The dominant trees suffered due to competition because of delayed thinning
- ✓ In case teak plantation, thinning of dominants is not appreciable
- ✓ Small woods obtained from thinning are not saleable in many cases
- ✓ Fire hazard danger is higher
- ✓ There is a possibility for soil deterioration.

Grades of ordinary thinning

Thinning grades refers to the relative extent to which a crop is opened up in thinning. The grades of thinning clearly explains which kind of tree (refer tree classification) to be removed. There are five grades of ordinary thinning which are described below;

1. **Light thinning (A grade) :** Removal of dead, dying, diseased and suppressed trees (class V,IV and III)

2. **Moderate thinning (B grade)** : Removal of dead, dying, diseased, suppressed and some defective trees in dominated class (class V,IV,III, II b and I a)

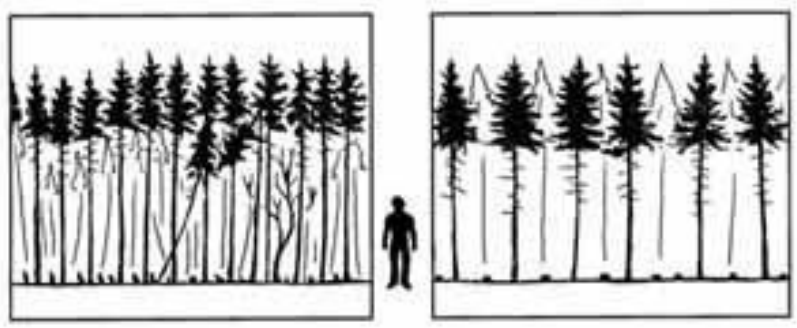
3. **Heavy thinning : (C grade)** : Removal of dead, dying, diseased, suppressed and some defective dominated as well as co-dominated trees (class V, IV, III, II, I b, I c and Id)

4. **Very Heavy thinning (D grade) :** C grade thinning along with some good dominated trees also removed to create a larger gap (class V,IV,III, II, Id, I c, I b and I a)

5. **Very Heavy thinning (E grade)**: C grade thinning along with more good dominated trees are removed .This is carried mainly for research purpose.

Application of ordinary thinning

- ✓ It is applicable to light demanding species
- ✓ It is applicable to areas where small sized timbers are marketable
- ✓ It is applicable to areas infested with climbers
- ✓ It is applicable to areas where there is no danger of soil degradation



3. Crown thinning

This thinning is also called as French thinning, High thinning and thinning from above.in this method, thinning is carried out mainly on dominant trees.in this diseased, malformed and less promising dominant trees are removed mostly the less promising trees are removed in the interest of the best available individual, the dominated and suppressed stems are retained. Because it has a potential to grow further the diseased, suppressed and malformed woods are removed in this interest of growing dominated species.

Principle

The retention of dominated and suppressed trees has a potential for further growth compared to retention of diseased dominant tree.

Merits of crown thinning

- ✓ Growth of retained dominant trees is faster.
- ✓ The suppressed and dominated trees suppress the growth of dominant trees.
- ✓ Production of bigger sized timber.
- ✓ This thinning will protect the soil from deterioration.

Demerits of crown thinning

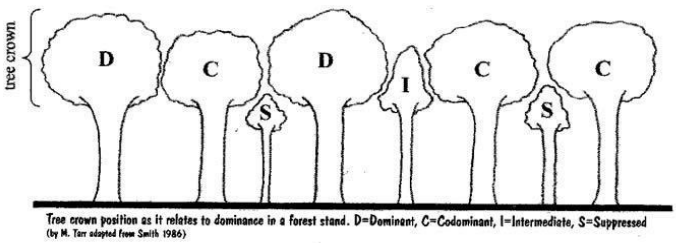
- ✓ It is a cumbersome process.
- ✓ Suppressed and dominated trees compete with dominant trees and affect it
- ✓ Suppressed and dominated trees acts as a obstacles in felling.
- ✓ Suppressed and dominated trees make conversion of felled wood more complex.

Grades of crown thinning

1. **Light crown thinning (LC grade)** : in this all the dead,dying,diseased and few defective dominant trees (V,IV,Id,Ic,Ib and few Ia) are removed.but the dominated and suppressed trees (III and II) are retained for future growth
2. **Heavy crown thinning (HC grade):** except dominanted and suppressed class trees,all the remaining trees are removed.

Application of crown thinning

- ✓ It is applicable to moderately shade tolerant species such as deodar and sal
- ✓ It is applicable to dry regions
- ✓ It is applicable to areas liable to soil detoriation due to exposure
- ✓ It is applicable to the areas where relativity large sized timber is needed
- ✓ It is applicable to areas where which are prone to frost, snow, drought and wind damage.



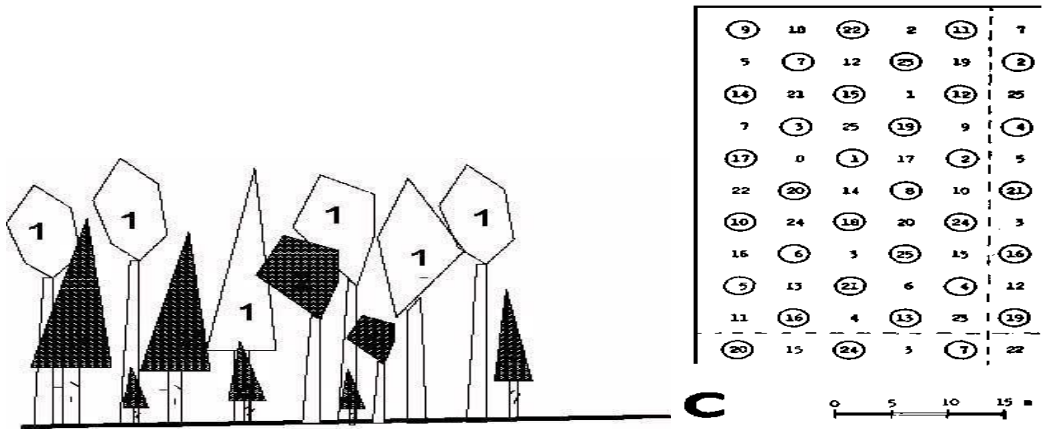
Tree crown position as it relates to dominance in a forest stand. D=Dominant, C=Codominant, I=Intermediate, S=Suppressed
(by M. Tarr adapted from Smith 1986)

4. Advance thinning

It is defined as thinning done in a regular crop in anticipation of suppression as it is developed by craib and O ' Connor,it is called as craib thinning.

Principle

These trees to be thinned before the actual competition takes place and reduces the growth of desired one. This is done based on some numerical schedules such as number of stems per unit area at different ages, etc. but this method is not suitable under tropical conditions and light demanding species.



Improvement felling

It refers to the removal of less valuable trees in a crop in the interest of valuable individuals. It is applicable to mixed as well as irregular crops.

Operations includes; removal of dead, dying and diseased individuals, felling of saleable unsound and over mature trees, cutting back damaged seedlings and saplings, removal of undesirable under growth and climber cuttings.

Girdling

Girdling is defined as cutting through bark and other living layers of woods in a continuous incision all around the pole of a tree. This is the economical method of killing of inferior trees inside the forests. Girdling of stem restricts flow of photosynthates from leaves to roots by starvation. This is restricted to certain species only. Girdling enhances more fire hazard inside the forests.

Lopping and pruning

Lopping means cutting of branches of a tree. Incidentally the lopped trees produce new shoots which are annually or periodically lopped for various purposes. Though pruning means cutting of branches from the bole of trees for improvement of timber of trees, this term is, sometimes, used for cutting branches to produce new shoots.

Examples: (i) *Butea monosperma, Schleichera oleosa, Ziziphus mauritiana, Ziziphus oxylopyra, Acacia Arabica, Acacia catechu, Albizzia lucida,* etc., are regularly pruned to produce succulent shoots with thin back not only to provide proper feeding ground for the lac larvae but also to improve the general crown structure of the host plant.

Lecture 10. Forest Mensuration - Objectives- Diameter measurements, instruments used in diameter measurement

Forest Mensuration

Forest mensuration is that branch of forestry which deals with the determination of dimensions (e.g., diameter, height, volume, etc.), form, age and increment of single trees, stands or whole woods, either standing or after felling.

It includes measurements of felled and standing trees, sawn wood and round logs and various other products referred to as minor forest products such as bamboos, charcoal, bark, fruits, etc.

Forest mensuration, therefore, concerns with linear, area, volume and weight measurements. While volume is the most important measurement from the point of view of forest management, weight, which is also referred to as biomass is being increasingly used now in place of volume.

Objectives of Forest Mensuration

1. Basis for sale

Forest mensuration forms the basis of every transaction involving sale of forests or their products. Before any sale, the forest department prepares estimates of the quantity of timber or other produce contained in various sale lots and the value which each lot is likely to fetch.

Similarly, the contractors or other purchasing agencies estimate the materials they would receive from the lots and the maximum price they could pay to the forest department to earn a reasonable profit after meeting working costs. This has resulted in development of methods of measurements and calculations which give reasonably accurate estimates of timber and other forest produce in the lots and their prices.

2. Basis of management

With proper management, forests can meet the demand of timber and other forest produce in perpetuity. For this purpose, knowledge of the quantity of timber standing in forest and the increment it is putting on every year or in a period of years is necessary. This led to the development of methods of preparing forest inventories using satellite imageries, aerial photographs and various optical and electronic techniques so that forests could be harvested without depleting the capital.

3. Measurement for research

In order to find out which treatment and method of management would maximize production, it is necessary to layout experiments to compare the results of different treatments. This required the laying out of sample plots and their periodic measurements.

4. Measurement for planning

With the steeply increasing population and rising standards of living every year, the gap between the demands and supplies of timber and other forest products is widening fast and therefore, the forest manager has to plan to reduce this gap. For this purpose, fast-

growing tree species have to be introduced. This requires not only reasonably accurate estimates of future yields but also the cost of production so that such projects may be financially sound. Thus, forest mensuration supplies basic statistical data to plan for the future and serves as a yardstick to check the viability of projects.

Scope:

Forest mensuration has a very wide scope. It concerns not only the forester contractors sawyers and transport labour working in the forest but also the saw miller and wood using public in the cities, towns and villages. It comes into play every time the wood is sold, converted or used. While it deals with the measurement of cubical contents of trees and crops at present, it also helps in the forecast of yields at any time in their life. It applies not only to standing trees and crops but also to felled timber and its subsequent conversion till it is used in some work.

In short, forest mensuration should be regarded as the branch of forestry which provides foundations of measurement principles applicable to any forest measurement problem. The application of statistical theory and the use of electronic computer for data processing have brought about revolutionary changes in forest measurement problems. Forest mensuration should make full use of these tools but its principles must be based on sound biological knowledge.

Object of Diameter and Girth Measurement

The main object of measurement of individual trees is to estimate the quantity of timber, firewood or any other forest produce (e.g., Katha from Khair trees) which can be obtained from them. While weight is generally used to estimate quantity of firewood, pulpwood and other non-wood forest products, volume in cubic metres or cubic feet is usually calculated for timber.

Volume of a tree is dependent on diameter or girth at breast height, total tree or bole height and form factor which is a measure of form or shape of the tree. Diameter or girth measurement and length are similarly necessary for calculation of volume of logs.

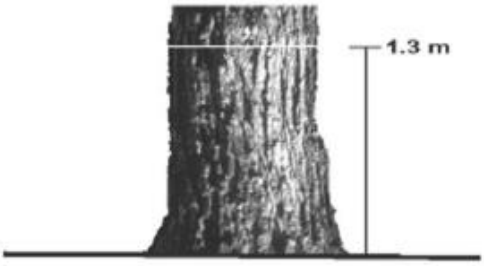
Place of measurement:

Breast height (B.H. or b.h.) is defined as almost universally adopted standard height for measuring girth, diameters and basal area of standing trees. In India, Burma, America, Union of South Africa, Malaya and some other former British Colonies it is taken as 1.37 m (4 ft 6 in) above ground level while 1.3 metre (4 ft 3 inches) have been recommended for Europe, UK, FAO and common wealth countries. **The breast height has been accepted as the standard height for diameter or girth measurement because of the following reasons:**

It is a convenient height for taking measurements and therefore avoids the fatigue unnecessarily caused in taking large number of measurements at any other lower or higher point.

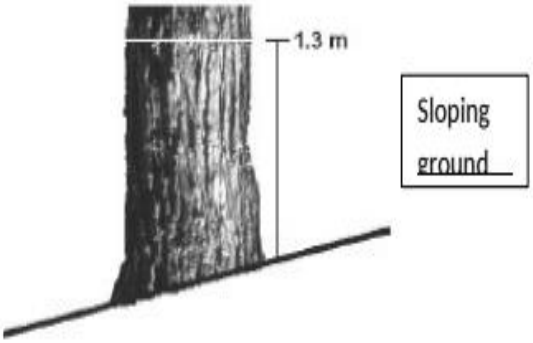
STANDARD RULES GOVERNING BREAST HEIGHT MEASUREMENT

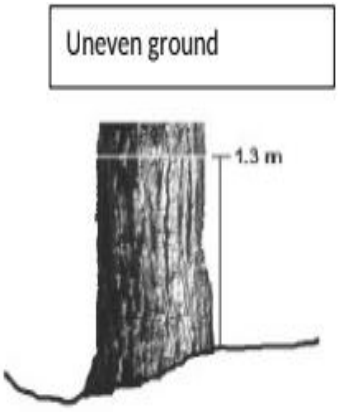
1. Breast height should be marked by means of a measuring stick on standing trees at 1.37 m (4 ft 6 in) above the ground level



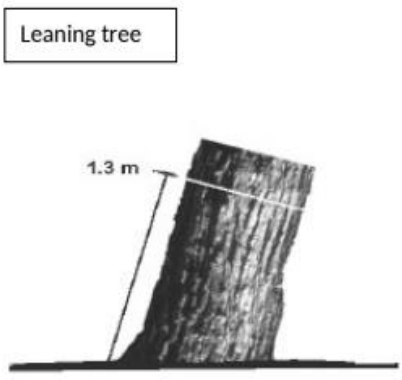
2. The breast height point should be marked by intersecting vertical and horizontal lines 12 cm long, painted with white paint. This is referred to as cross mark

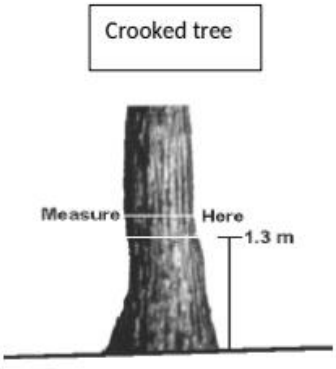
3. On **sloping ground, the diameter at breast height should be measured on the uphill side,** after removing any dead leaves or needles lodged there



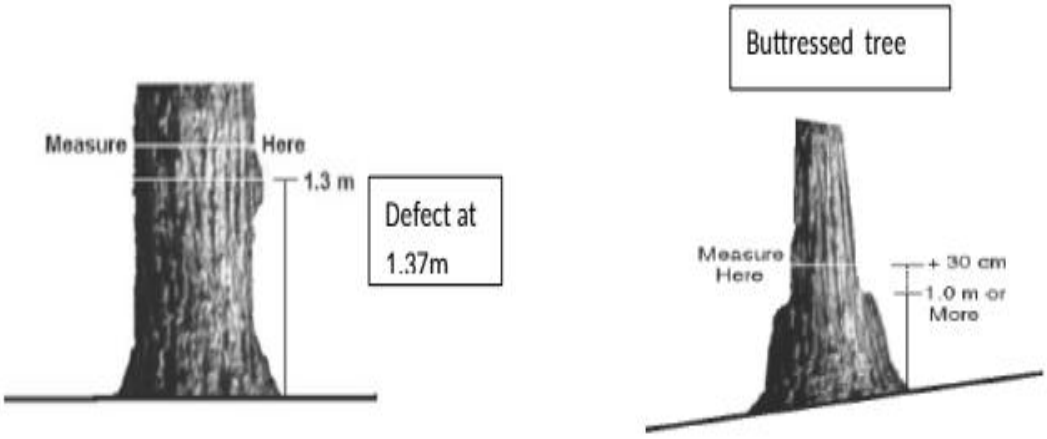


4. In case the tree is leaning, dbh is measured along the tree stem and not vertically, on the side of the lean for trees growing on flat ground and on the uphill side, for trees growing on sloping ground.

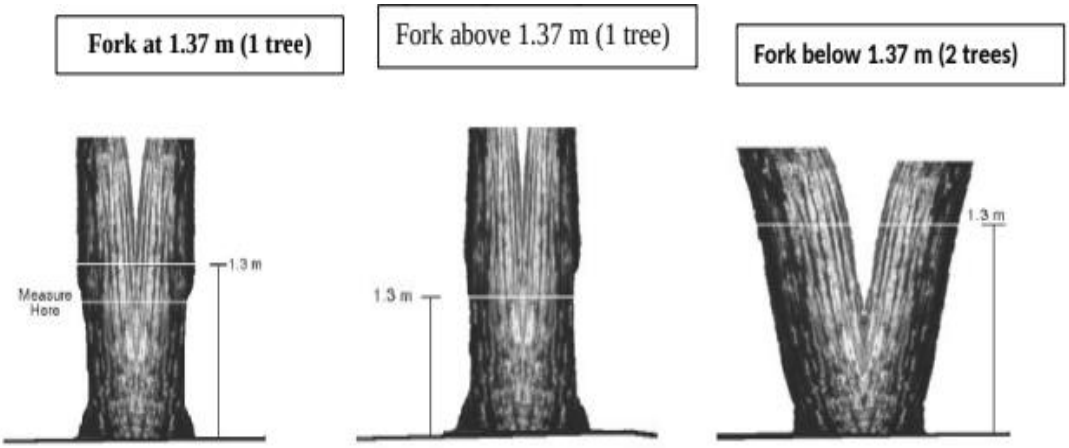




5. **The dbh should not be measured at 1.37 m (4ft 6 in) if the stem is abnormal at the level.** Breast height mark should be shifted up or down as little as possible to a more normal position of the stem and then diameter measured



6. **When the tree is forked above the breast height,** it is counted as **one tree** but when it is **forked below breast height, each form should be treated as though it were a separate tree.** It forking renders the breast height point abnormal, the foregoing rule should be applied and the tree counted as one or two depending on the place of measurement.



7. When **buttress formation is the characteristic of the species** and is known or is likely to **extend upwards with the development of the tree**, the breast height should be taken at the lowest point above which the abnormal formation is not likely to extend.

8. The **height of the cross mark above ground level should always be recorded** for each tree measured.

9. **Moss, creepers, lichens and loose bark found on the tree must be removed before measuring the diameter or girth over bark.**

10. Diameter measurements should be recorded in centimetres and to the nearest multiple of two millimetres (and in British system in inches and to the nearest tenth of an inch).

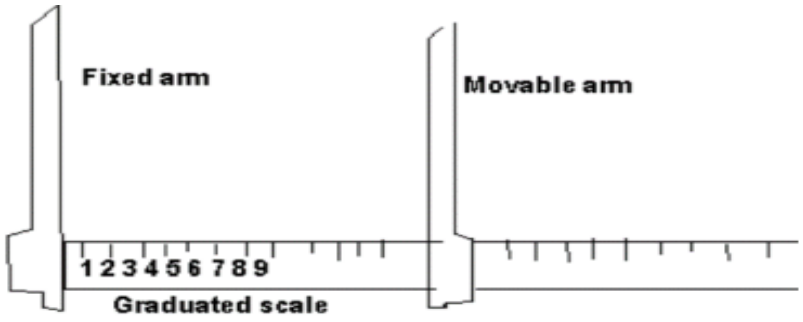
- **Girths should be measured in metres and to the nearest centimetre** (and in British system, in feet and to the nearest inch). Diameter or girth of each tree measured is recorded separately.

Instruments used in Diameter measurement

The most commonly used instruments for diameter or girth measurement at breast height in case of standing trees and for logs of felled trees are

i) Wooden scale
ii) Callipers and
iii) Tape

CALLIPERS



Callipers are used to measure diameter of standing trees and logs. They consist of a graduated rule and two arms. Of the latter, one is fixed at right angles to one end of the rule so that its inner edge lies on the starting point of the graduated scale. The other arm moves along the rule parallel to the fixed arm. The lengths of the rule and the arms depend on the sizes of trees to be measured. Each arm should be at least half the length of rule.

Callipers exceeding 120 cm in length are rarely used. The rule is divided into units, the size of which depends upon the desired degree of accuracy. Callipers used for research or sample plot work are generally marked to show centimetres and millimetres. But those used for routine forest works are marked in centimetres and show diameter classes painted in different colours to facilitate their reading by illiterate workers.

Callipers are generally made of wood. In humid conditions, wood absorbs moisture and the movable arm gets jammed. The slot of the movable arm in which the scale arm fits should, therefore, be of a size that avoids jamming but not so big as to make it difficult to keep it parallel to the fixed arm. This is usually done by making the slot oblique so that the arm could be tilted inwards but not outwards. In some callipers, the arms are made parallel by screw adjustment. Metal callipers made of aluminium allow are in use. They are not heavier than wooden callipers and easy to keep clean and adjustment

- ✓ Calipers are often used to measure tree dbh or when diameters are less than about 60 cm.
- ✓ A calipers may be constructed of metal, plastic or wood, consists of a graduated beam/rule with two perpendicular arms

- ✓ One arm is fixed at the origin of the scale and the other arm slides. When the beam is pressed against the tree and the arms closed, the beam of the caliper can be read on the scale.
- ✓ For an accurate reading, the beam of the caliper must be pressed against the tree with the beam perpendicular to the axis of the tree stem and the arms parallel and perpendicular to the beam.

Diameter measurement using calipers

- ❖ Place the calipers over the stem at the required height.
- ❖ Record the diameter then take another measurement at a right angle to the first and record this measurement and
- ❖ Calculate the average of the two measurements and record to the nearest to 0.1cm.

Precautions in use

- ❖ The calipers must be placed on the tree with movable arm well opened and must not be forced on the tree
- ❖ The reading must be taken before the caliper is removed from tree.
- ❖ If the cross section of the stem is more or less elliptical, it is necessary to measure two diameters.
- ❖ Calipers must be placed at right angles to the axis of the tree.
- ❖ The two arms of the caliper must be in contact with the tree and the movable arm should be at right angles to the scale arm.
- ❖ Not only should the two arms of the caliper be in contact with the tree but the scale arm must also touch it.

Advantages

- ❖ Diameters can be read directly in centimeters and millimeters, thus making the instrument applicable for precise scientific work.
- ❖ By pressing the arms against the tree bole, the loose swollen bark is crushed out and irregularity from this source is avoided.
- ❖ It is adaptable for use by unskilled labour.
- ❖ The errors are both positive and negative and therefore the chances are that they may neutralize to give more accurate results than the tape.

Disadvantages

- ❖ They are not accurate when not in adjustment.
- ❖ Calipers sufficient in size to measure large trees are very awkward to carry and handle.
- ❖ Two measurements must be taken on every tree to get the correct diameter.
- ❖ Movable arms often stick when the scale is wet or dirty, thus wasting a lot of time.

TAPE

It is a band of cloth, reinforced cloth, plastic or steel about 1.5 cm wide and of varying length and is used to measure girths of trees and logs. It is usually graduated on one side in centimetres and millimetres but sometimes it is graduated on both sides to give measurements in metric system on one side and those in British system on the other. The ends of the tape are usually plated with some metal to prevent their tearing off but in case of longer tapes which are kept encased in some cover by winding it in, or in some other cases too, the beginning of the tape has a metal ring to hold it. In western countries tapes are often provided with hook at the extremity to fix in the bark, an arrangement which enables one person to measure large trees with tapes lying flat in correct position on the tree.

The cloth tapes are made of cloth, though they may be painted with some paint on both sides to give a better look and to protect them from the influence of water. These are cheap but are not very durable. They are also affected by fluctuations in length due to expansion in use. The better quality cloth tapes are usually reinforced inside by metal wires and are, therefore, called metallic tapes. They are also painted with some durable paint. So they are more durable and more reliable. Steel tapes are used for precise work and are mostly used in forests for measurements in sample or research plots. In western countries nylon coated tapes and fiberglass tapes are also available.

Advantages

- Tape is convenient to carry
- It does not require constant adjustment
- Only one measurement is needed even with irregular trees
- In case of logs lying on ground, it is not possible to measure two diameters a right angles to each other by calliper and the diameter measurement by tape is the easiest
- The errors in case of tape are always positive and systematic and so if an adjustment is needed, it can be done easily
- Tape negotiates the whole circumference of the tree while calliper touches only three points on it. So a tape measures the size of the tree better than a calliper
- Callipers give different reading for the same tree when different men use the as measurements are not always taken in the same direction unless these directions are marked. Tapes do not suffer from this defect. Their readings are therefore more consistent.

The choice of the instrument to be used for diameter or girth measurement depends upon

• Whether the tree is standing or felled

• If felled, the condition in which the logs are lying and

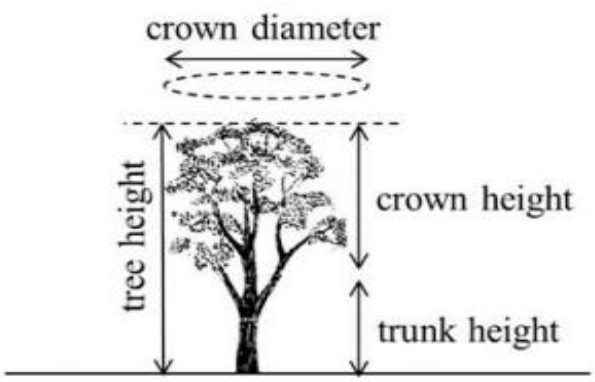
• The degree of accuracy required

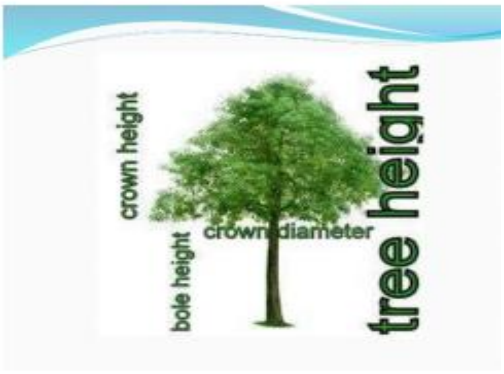
Lecture 11. Height measurement, instrumental methods of height measurement – Tree form, form factor, Volume estimation of standing and felled trees.

Measurement of Height

Total height of a standing tree is the straight line distance from the tip of the leading shoot (or from the highest point of the crown where there is no leader) to the ground level, usually measured on slopes from the uphill side of the tree. The total height of a felled tree is measured (after restructuring the tree in case the tip or leading shoot has broken off in the fall) from the top in a straight line, no allowance being made for curvature of the stem, to the base taking care to include the stump.

Bole height : It is the distance between ground level and crown point. The crown point is the position of the first crown forming living or dead branch. Bole height expresses the height or length of the clear main stem of a tree.





Commercial bole height: It is the height of bole that is usually fit for utilization as timber.

Height of standard timber bole: It is the height of the bole from the ground level upto the point where average diameter over bark is 20 cm.

Stump height: It is the height of the top of the stump above ground. It gives the height of the tree stem which is left attached to the ground after felling.

Crown length: It is the vertical measurement of the crown of a tree from the tip to the point half way between the lowest green branches forming green crown all round and the lowest green branch on the bole.

Crown height: It is the height of the crown as measured vertically from the ground level to the point half way between the lowest green branch and the green branches forming green crown all round.

Measurement of Height:

Height measurement is a more time consuming operation than diameter measurement because the measurement of height of standing tree with instruments takes about 10 times more time than it takes to measure its diameter. Therefore, heights of all trees are measured only in small permanent sample plots. For all other purposes, heights of a few trees are measured with instruments and for the others, it is estimated by eye or by some other non-instrumental method. Thus, the methods of measurement of height may be classified into

• ocular,

• non-instrumental and

• instrumental methods.

Instrumental methods

The instruments used in height measurement of trees are called hypsometers, altimeters and clinometers. Hypsometer is an instrument used for determining the height of standing tree from observation taken at some distance from the tree. Though altimeters are generally altitude measuring instruments, one instrument has been devised to determine heights of trees. Similarly, clinometers are instruments which measure angle of slope.

Any instrument which measures angles of slope can be used for determining the heights of trees by trigonometrical methods and as such clinometers are also used for height measurement of trees. But some clinometers are specially designed for this purpose by addition of a scale which directly gives the value of tangent of angle of inclination as percentage of horizontal distance, i.e., slope per cent. These clinometers may, then, be called hypsometers. All these instruments are based either on geometric principles of similar triangles or on trigonometric principles based on relations between the sides of right angled triangles.

GEOMETRIC PRINCIPLES OF SIMILAR TRIANGLES

• Two triangles are said to be similar, when the corresponding angles are equal and the corresponding sides are proportional. The fact that two triangles are similar is established by one of the following conditions

• Each angle of a triangle is equal to its corresponding angle of the other triangle

• Each side of a triangle is proportional to the corresponding side of the other triangle and

• One angle of triangle is equal to one angle of the other and the corresponding sides which subtend the equal angles are proportional

These principles have been made use of by some instruments in measuring the heights of trees directly. The basic assumptions in applying these principles for measuring the heights of trees are that

i) **the tree is vertical and**

ii) **the tip and the base of the tree are simultaneously visible**

• Christen's Hypsometer

• Smythies Hypsometer

Trigonometric principles

• Sine = Perpendicular /Hypotenuse

• Cosine = Base/ Hypotenuse

• Tangent = Perpendicular /Base

• AB is assumed to be a tree and C, the position of observer, then AB can be found out from tangent ratio as BC x tan ∠ ACB where BC is the horizontal distance of the observer from the tree and ∠ ACB can be measured by any angle measuring instrument. This is known as the tangent method.

• Trigonometry also tells us that in any triangle sines of angles are proportional to the opposite sides. The knowledge of this relationship can also be used in calculation of heights of trees and is known as the sine method.

• Trigonometrical ratios can be used for calculation of heights of trees by one of the following methods:

i) Tangent method ii) Sine method

Tangent method: Tangent method means that the height of the tree is calculated with the help of the tangents of the angles to the top and base of the tree and the distance of the observer from the tree. As the position of the observer with respect to the tree will differ according to the terrain, the procedures of calculating heights of trees have to be modified accordingly.

Instruments based on Trigonometric principles

- ✓ Brandis hypsometer ,
- ✓ Abney's level
- ✓ Haga altimeter
- ✓ Topographical Abney's level
- ✓ Relaskop,
- ✓ Tele Relaskop
- ✓ Barr and Stroud dendrometer
- ✓ Blume-Leiss hypsometer

HAGA ALTIMETER

It is a portable instrument for measuring heights of trees or other vertical objects without the trigonometric tables and formulae as required for determination of heights by Abney's level. It consists of a gravity controlled, damped, pivoted pointer and a series of rotatable scales on a hexagonal bar in a metal, pistol shaped case. The top of the case is slightly rounded at the rear end of which is an eye piece S with a pinhole and towards the front end a sight vane, consisting of a hollow metal tube 1.5 cm long and 2 cm in diameter and having two prongs R protruding from the opposite sides inside the tube.

The prongs are in a horizontal line with a light gap between the two. A little below the rounded top, the instrument has inside it a hexagonal bar which can be rotated by a turning knob K on the front face of the instrument in line with the bar inside. The bar has a separate scale on each of its face. The usual scales are 15, 20, 25, 30 and the per cent. 15, 20, 25 and 30 are the unit horizontal distances from the tree where the observer must stand to get height of the tree above the eye level directly. The per cent scale gives the height as percentage of the distance.

The sixth scale is some times topographic and indicates heights directly for one chain horizontal distance. Since the scales are in units, the height of the tree is indicated in the same unit in which the horizontal distance is taken. The scale is marked on the extreme left of the bar in a circle and the rest of the bar is graduated to indicate heights. The scale and height readings can be read through a longitudinal narrow slit or window L in the metal case, which is covered by glass F.

The bar and the slit are so arranged that only the scale being used and its height graduations can be read and not others, eliminating the possibility of error in reading. A gravity controlled pointer moves along the scale and indicates the heights above or below the eye level when the top or base of the tree is sighted through the sight vane. The pointer is narrow in width and wider in depth. The narrow width at the tip of the pointer is painted white while the sides are painted red.

This is done to avoid error of parallax in reading the scale at an angle from which red colour is not visible on the pointer. As the pointer is gravity controlled, it has to be locked by depressing trigger. The pointer is released by depressing the button D at the side of the case when the instrument is to be used.

The small hole O at the bottom of the butt allows a lanyard to be attached to instrument for suspending it from the shoulder if required. The instrument is kept in a leather case when going to or coming from forest and this case is also provided with a leather strip for suspending it from shoulder

Tree form, form factor

Hypsometer

Clinometer

Tree form, form factor

Even a superficial observation of trees reveals that the stems of trees are not cylindrical and therefore calculation of volume of trees or logs requires knowledge of diameter from which cross sectional area can be calculated, height (or length in case of logs) and stem form. Form is defined as the rate of taper of a log or stem. Taper is the decrease in diameter of a stem of a tree or of a log from base upwards. The taper varies not only with species, age, site and crop density but also in the different parts of the same tree.

METZGER'S THEORY OF GIRDER THEORY

Several theories have been put forward to explain variations in taper from tree to tree and in the same tree as well but the most plausible theory is that of Metzger, a German forester. According to him the tree stem should be considered as cantilever beam of uniform size against the bending force of the wind. In other words, the stem of the tree is built up in such a way as, with the minimum of material, to offer uniformly the greatest resistance to the stresses to which it is subjected. The wind pressure acts on the crown and is conveyed to the lower parts of the stem in an increasing measure with the increasing length of the bole. Thus the greatest pressure is exerted at the base and there is a danger of the tree snapping at that place. To counteract this tendency, the tree reinforces itself towards the base. The limited growth material is so distributed along the tree stem that it affords a uniform resistance all along its length to that pressure. As the pressure in the upper part of the tree is less, due to smaller length of the level in that portion it is allocated lesser growth material than the lower part where the pressure gets increased with the increased length of the bole. The pressure of wind on crowns keeps on changing as the tree is growing in open or crowded portion. Trees growing in complete isolation have larger crowns and so the pressure exerted on them is the greatest. If such a tree is to exist, it should allocate most of the expense of height growth. Allocation of more growth material for height will have double disadvantage in such cases.

While the pressure will be increased with the increased arm of the lever, there will not be enough material at the base to counteract it. That is why trees growing in complete isolation or exposed situations have short but rapidly tapering boles while the trees growing in dense crops, which are therefore subjected to lesser wind pressure have long and nearly cylindrical boles. According to this logic, the tree stem must have the shape of a cubic paraboloid.

METHODS OF STUDYING FORM

The study of form is beset with difficulties because it cannot be fixed by one or two measurements. This is due to the fact that the form varies not only from tree to tree but also in the different parts of the same tree. Variation in bark thickness not only from stand to stand and tree to tree but also in the different parts of the same tree adds another dimension to the problem. However, the form of a tree can be studied in one of the following ways:

a) By comparison of standard form ratios

b) By classification of form on the basis of form ratios and

c) By compilation of taper tables

A) By comparison of standard form ratios

For this purpose two form ratios are in vogue:

1) Form factor and 2) Form quotient

FORM FACTOR

Form factor is defined as the ratio of the volume of a tree or its parts to the volume of a cylinder having the same length and cross section as the tree. In other words, form factor is the ratio between the volume of a tree to the product of basal area and height. Depending on the height of measurement of basal area and on the parts of the tree considered, the following classes of form factors are distinguished.

i) Artificial form factor - This is also known as breast height form factor. For this form factor, the basal area is measured at breast height and the volume refers to the whole tree both above and below the point of measurement.

The artificial form factor is not a reliable guide of the tree form. The point of diameter measurement is fixed and as this bears no fixed relation to the height of the tree which is that of the whole tree and not of the portion above the breast height, the trees of same form but different heights will have different form factors. Notwithstanding its unreliability as a measure of tree form, the artificial form factor is universally used because its computation involves handy measurement and because with the standardization of diameter measurement at breast height, it is just the factor needed to convert height and breast height sectional area into the tree volume.

ii) Absolute form factor - For this form factor basal area is measured at any convenient height and the volume refers only to that part of the tree above the point of measurement. In other words, it is the ratio between the volume of the tree above the point of diameter or basal measurement with the cylinder which has the same basal area and whose height is equal to the height of the tree.

iii) Normal (or true) form factor - In this form factor basal area is measured at a constant proportion of the total height of the tree, e.g., 1/10th, 1/20th, etc., of the total height and the volume refers to the whole tree above ground level.

This form factor has several disadvantages, viz., (i) the height of the tree has to be determined before the point of measurement can be fixed and (ii) the point of measurement may be very inconvenient in case of very tall as well as very short trees. Experience has shown that the factors thus obtained are by no means as regular as had been expected.

Absolute form factor and normal form factor are no longer used. Unless otherwise stated, form factor in India implies artificial form factor with basal area calculated at 1.37 m above ground level. Expressed as an equation, this form factor may be described as:

$F = V/ Sh$

Where F is the form factor

V is the tree volume in cubic units S is the basal area of breast height in area units and h is the height of the tree in linear units

Uses of form factors - The form factors may be used for following purposes:

i) To estimate volume of standing trees - Form factors may be compiled into tabular form giving average form factor of trees of different dimensions by diameter and height classes. These tables can be used to estimate the volume of standing trees by measuring their diameter and height. As these tables are prepared from data of large number of trees, their application to individual trees is not likely to give satisfactory results. They can, however, be used for estimation of volume of a group of trees. Their use is also limited to trees growing under same conditions as the samples on which the tables are based.

ii) To study laws of growth - Form factor along with form point and form quotient (to be described later) give an insight into the laws of growth, particularly the stem form, of trees.

Kinds of form factor - Depending on the volume represented, form factors are classified into following kinds:

i) Tree form factor

ii) Stem timber form factor and

iii) Stem small wood form factor

FORM HEIGHT

Form height is defined as the product of form factor and total height of tree. This can be expressed as a formula as follows:

$$\text{Form factor } F = \frac{V}{Sh}$$

$$\text{Form height } Fh = \frac{V}{S}$$

Where Fh is form height

V is the volume of the tree and S is the basal area

Volume is calculated from under bark measurements and the basal area is calculated from d.b.h. (o.b.). Form height is used to determine how far is it reasonable to assume that volume is proportional to the basal area. It form height remains constant with increasing diameter, then it is clear that the assumption is justified.

FORM QUOTIENT

An Austrian forester A. Schiffel postulated that taper depends on what he called as form quotient (F.Q. or f.q.) and defined it as the ratio between the mid-diameter and the d.b.h. Thus, according to him,

$$\text{F.Q.} = \frac{\text{mid-diameter}}{\text{d.b.h.}}$$

This was, obviously, not always true because in case of a tree of 2 x 1.37 m height, the mid-point will be breast height and therefore F.Q. will be 1. To remove this defect, Tor Jonson, a Sweedish forester, redefined form quotient as the ratio between the mid-diameter above breast height and d.b.h. To differentiate it from Schiffel's F.Q. which is known as normal form quotient, he called his form quotient as absolute form quotient. In other words, normal form quotient is defined as the ratio of mid-diameter or mid girth of a tree to its diameter or girth at breast height and absolute form quotient is defined as the ratio of diameter or girth of a stem at one half its height above the breast height to the diameter or girth at breast height.

Normal form quotient is now of historical interest only and unless otherwise stated, form quotient now means absolute form quotient.

B) By classification of form on the basis of form ratios

There are two ways to classify form on the basis of form ratios: i)

Form class and ii) Form point ratio

FORM CLASS

Form class is defined as one of the intervals in which the range of form quotients of trees is divided for classification and use. It also applies to the class of trees which fall into such an interval. Trees may be grouped into form classes expressed by form quotient intervals such as 0.50, 0.55 to 0.60 and so on or by mid-points of these intervals such as 0.525, 0.575 and so on.

FORM POINT RATIO

Another basis of classification of tree form is the form point ratio. Form point is defined as the point in the crown as which wind pressure is estimated to be centred.

Therefore form point ratio (or height) is defined as the relationship, usually expressed as a percentage, of the height of the form point above ground level to the total height of the tree. It is claimed that form point ratio bears a consistent relation to the form quotient and that by means of a table showing these relations, the form quotient and form class of a tree can be determined if the form point ratio is known.

C) By compilation of taper tables

Another method of studying form of trees is by compilation of taper tables, which show the actual form by diameters at fixed points from the base to the tip of a tree. They are used for the following purposes.

i) Volume of the average tree for each diameter and height class can be found readily in office without direct measurement. The only measurement that will be needed is the d.b.h. (o.b.) and the height of standing tree.

ii) Volume tables can thus be prepared from taper tables in desired units.

The following kinds of taper tables are generally met with:

1. Ordinary taper tables or diameter taper tables - These tables give the taper directly for diameter at breast height without reference to the tree form. Thus they enable computation of volumes without reference to the tree form.

2. Form class taper tables - These tables give for different form classes the diameters at fixed points on the stem expressed as percentages of d.b.h. (u.b.).

VOLUME OF STANDING TREES

The processes of management and sales frequently require estimation of volume of trees without felling them. It is therefore necessary to know the methods by which volume of standing trees can be estimated. The following are some of the methods used:

i) Ocular estimate : The first possible method of estimating the volume of standing trees is the ocular estimate. Experienced persons can make fairly accurate estimate of volume of standing trees marked in felling lots by careful inspection on the basis of records of past fellings. But this method is too subjective for reliable results. Not only do different workers produce different results for the same tree but even the same worker may estimate differently under the influence of fatigue, hunger, etc. All the same every forester must train his eye to make a fair estimate of the cubical contents of standing trees. To be approximately correct, the estimator requires great practice and occasional opportunity to compare his estimate with the actual measurement after the trees have been felled. Even then the results are subject to considerable errors.

Partly ocular and partly by measurement

The uncertainty of purely ocular estimate can be overcome by measuring the diameter and height of the tree and then estimating the volume keeping the tree taper in view. In this method, the estimator estimates the diameters of subsequent logs after the basal log and from them the volume till whole length is covered. This method also requires lot of experience and practice without which estimates may not be correct.

Direct measurement

The unreliability of the ocular estimate is completely removed if the diameters of tree at different heights are measured by a man climbing the tree with the help of a ladder to some height and there after by his own effort. This method then becomes similar to the method of calculating volume of trees after they have been felled, with the difference that in this case the tree is not felled but a man climbs it and measures the diameters at different heights on the tree. This method, is however, very time consuming and tiring and cannot be used, when large number of trees are involved.

Volume in standing trees

The volume of trees was estimated using the formula given by Chaturvedi and Khanna, (1982). It was expressed in cubic centimetre (m3).

$V=\pi r2h$

Where,

V= Volume

r= Radius

h= Total height

Indirect measurement (Volume)

It is no longer necessary to climb trees for measurement of volume. These instruments are Spiegel Relaskop, Tele Relaskop, Wheeler Pentaprism Calliper and Barr and Stroud dendrometer. The principle on which these instruments are based and the methods of measuring upper stem diameters, with the help of these instruments, the volume of the standing trees can be estimated fairly accurately.

Volume tables:

A table showing for a given species the average contents of trees, logs or sawn timber for one or more given dimensions. The given dimensions may be (i) d.b.h. alone, (ii) d.b.h. and height or (iii) d.b.h., height and some measure of form or taper.

The main object of these tables is to estimate the volume of an average standing tree of known dimensions and thus to estimate the volume of a given crop or of marked trees in a given coupe. These tables are based on the actual measurement of sufficiently large number of trees and have been prepared on the assumption that the trees of the same species with the same dimensions will have the same volume.

The volume table approach can be truly applied only to a group of trees, e.g., coupe, but not to individual trees

Classification of volume tables and Volume tables can be classified in three ways,

(i) according to the number of variables on which they are based,

(ii) according to the scope of their application and

(iii) according to the kind of outturn given by them.

Classification on the basis of the number of variables

Volume table based on one variable, viz., diameter, alone In this kind of volume tables, the trees are classified by d.b.h. (o.b.) only. Since it is cumbersome and at the same time not very useful to show average volumes against individual diameters, diameter classes are used. Thus, these volume tables show average volumes of trees by diameter classes. Such volume tables cannot be used for extensive areas. They can be used only locally and hence these are called local volume tables

Volume tables based on two variables, i.e., diameter and height - As trees of the same diameter may have different heights and different volumes in different localities, **volume tables based on these two variables, are applicable to larger areas**. Thus, these volume tables give volumes of trees by diameter classes as well as by height classes pertaining to the total height of the trees.

Volume tables based on three variables - These tables are based on diameter, height and form quotient and are called the form class volume tables. Though these are more accurate, these are expensive and difficult to prepare and inconvenient and time consuming in their application. Such tables have not been prepared in India.

Classification on the basis of scope of application

General volume tables - These volume tables are based on the average volume of trees growing over a large geographical area. These are, therefore, applicable to a wider range of distribution of the species. These tables are usually based on two variables, viz., diameter at breast height and total tree height. These tables show volumes of trees by diameter classes and in each diameter class by height classes

Regional Volume tables - These are compiled from measurement of trees growing in a region and therefore have a limited application when compared to general volume tables.

Local volume tables - These volume tables are compiled from the measurements of trees growing in restricted locality. These are generally based on one independent variable, viz., d.b.h. (o.b.).

Standard volume tables - These volume table give separately the estimated outturn in the form of standard timber, i.e., from ground level to the limit of the portion of tree stem or branch where diameter is 20 cm measured over bark, and small wood, i.e., the volume between the diameter limits of 20 cm and 5 cm both measured over bark.

Commercial volume tables - These are volume tables in which the contents of round timber are given as volume measured down to a thin end diameter to which conversion is done, the stump volume being omitted

Sawn outturn tables - These are volume tables in which contents of sawn timber are given as volume measured down to a thin end diameter to which conversion is done, the stump volume being omitted. Thus these are, similar to commercial volume

Assortment tables - These are volume tables which give volume in round down to various stated thin end diameters. For example, it will be possible to find out volume of a tree of given linear dimensions when the conversion was done upto 25 cm, 20 cm or 15 cm diameter limit. Thus the standard volume table and commercial volume table are special cases of assortment tables.

Sawn outturn assortment tables - These tables are similar to assortment tables except that they give sawn outturn in the number of standardized pieces instead of volume in round.

Method of preparation of volume tables

The volume tables are prepared by the following methods.

- Graphical method
- Regression equations method or the method of least squares fit and
- Alignment chart method

PREPARATION OF LOCAL VOLUME TABLE

The local volume tables which give tree volume in terms of d.b.h. only may be prepared by one of the following methods:

• Graphical method or

Regression equation method

Lecture 12. Social Forestry and its branches - Extension Forestry and Urban forestry.

By early seventies, the problem of deforestation and environmental degradation were expressed at International Conference at Stockholm during 1972 bringing in to sharp focus the changes required in policies towards environment and the crisis of tree depletion.

The World Congress (1978) added the dimension of forestry for the people and by the people. Food and Agricultural Organization also brought the programme of forestry for local community development.

Although it was recognized at most forums that local community forestry was the only solution to the problem of tree depletion but support, both financial and technical was negligible. It was only in the early eighties that several International organizations and agencies agreed to aid rapid tree development programme.

Social forestry was first recognized as an important component of forestry development and meeting the rural need in the Interim Report of the National Commission on Agriculture on social forestry during 1972. The commission stressed on the socioeconomic importance of social forestry for rural community as well as in the management of forest resources. It was felt that by taking up the programme of raising trees, grasses and fodder in the farmers own lands, village commons, wastelands and degraded forests close to habitations, it would be possible to meet the requirements of fuel wood, fodder, small timber for rural housing and agricultural implements etc.

In our country the concept of social forestry is not new. It is found in the preachings of Buddha about 2500 years ago. Lord Buddha preached that every good Buddhist should plant one tree and look after it over five years so that it grows to a full tree and in this way he should plant about 5 trees in his life time.

The Great Emperor Ashoka is credited to have got planted shade trees and fruit trees long the roadsides for the benefit of travellers. During early period of British rule, need for industrial expansion and communication required timber from the forests. Attempts made by the British were simply to reserve and demarcate forests for their industrial needs. No significance was attached to important role of trees to the local population.

In the monumental Report on Improvement of Indian Agriculture (1893) Voelcker observed that forests had not been preserved. His observation on keeping aside village forests for the local people was probably the first observation of importance of forests to people's economy.

Afforestation in the post-independence period can be divided in to three phases. In the first phase **'Van Mahotsav'** was started in fifties **(K.M.Munshi, Agrl. Minister)** which failed to attract attention largely due to ignorance at all levels. In the **second phase, farm forestry was started in some states in the 1970's.** The third phase was the period when social forestry programme actually took off in eighties with massive programmes and ambitious targets.

Concept of Social forestry

The word Social forestry was coined by Westoby and used in the Ninth Commonwealth Forestry Congress in 1968. According to Prasad (1985) **"Forestry outside the conventional forests which primarily aims at providing continuous flow of goods and services for the benefit of people.** This definition implies that the production of forest goods for the needs of the local people is Social forestry. Thus, social forestry aims at growing forests of the choice of the local population.

Shah (1985) stated that Conceptually Social forestry deals with poor people to produce goods such as fuel, fodder etc. to meet the needs of the local community particularly underprivileged section.

Objectives of Social forestry

The objectives of Social forestry adopted by the Commission (1976) were based on the economic needs of the community aimed at improving the conditions of living.

The main objectives are

i) Fuel wood supply to the rural area and replacement of cow dung

ii) Small timber supply

iii) Fodder supply

iv) Protection of agricultural fields against wind and recreational needs

v) Creation of recreational forests for the benefit of the rural as well as urban population

Social forestry –

Social forestry is the practice of forestry on lands outside the conventional forest area for the benefit of the rural and urban communities. Supply of fuel wood to divert cow dung from village hearths to village fields, small timber for rural housing and agricultural implements, fodder for the cattle of the rural population living far away from the forest areas, protection of agriculture by creation of diverse ecosystem and arresting wind and water erosion and creation of recreational forests for the benefit of the rural as well as urban population are the basic economic and cultural needs of the community without which there can be no improvement in the conditions of their living. The application of forestry technology to achieve this social objective is known as social forestry. This is new dimension recently added to the concept of forestry and includes within its scope the following:

1) Farm forestry – Farm forestry is the practice of forestry on farms in the form of raising rows of trees on bunds or boundaries of field and individual trees in private agriculture land as well as creation of wind breaks, which are protective vegetal screen created round a farm or an orchard by raising one at two lines of trees fairly close with shrubs in between.

2) Extension forestry – Extension forestry is the practice of forestry in areas devoid of tree growth and other vegetation and situated in places away from the conventional forest

areas with the object of increasing the area under tree growth. It includes within its scope the following:

i) Mixed forestry – Mixed forestry is practice of forestry for raising fodder grass with scattered fodder trees, fruit trees and fuelwood trees on suitable wastelands, panchayat land and village commons.

ii) Shelterbelts – Shelterbelt is defined as a belt of trees and/or shrubs maintained for the purpose of shelter from wind, sun, snow drift, etc. They are generally more extensive than the wind breaks covering areas larger than a single farm and sometimes whole regions on a planned pattern.

iii) Linear strip plantations – These are plantations of fast growing species on linear strips of land on the sides of public **roads, canals and railway lines.**

3) Reforestation of degraded forests

4) Recreational forestry – Recreational forestry is the practice of forestry with the object of raising flowering trees and shrubs mainly to serve as recreation forests for the urban and rural population. The main object is not to produce timber, grass or leaf fodder but to raise ornamental trees and shrubs in some area to meet the recreational needs of the people. This type of forestry is also known as aesthetic forestry which is defined as the practice of forestry with the object of developing or maintaining a forest of high scenic value.

Benefits of Social forestry

i) Increase the supply of fuel wood and fodder

ii) Generate rural employment

iii) Maintain ecological balance

iv) Appropriate use of wastelands

v) Promote village and cottage industries

vi) Induce environmental and tree consciousness among people

vii) Relieve pressures from natural forests

viii) Stabilize agricultural production

EXTENSION FORESTRY (It includes Railway line plantations, Canal bank plantations and Road side plantations)

Railway line plantations

Objectives

- Stabilization of railway track and protection of railway tract against erosion
- Optimum utilization of the land for tree cultivation
- Checking of illicit encroachment on this land
- Incidental shelter belt effect of these plantations

- Checking of the shifting sand in desert areas getting on to the railway track
- Position of telephone & electrical line should be considered while planting
- The first row of tree should be planted at a distance of about 7.5 m
- Unmanned level crossing a length of about 100 m should be left unplanted
- Height of tree in the first row not more than distance from railway track
- Ornamental trees–towns, stations, brittle stem should not planted
- Wind firmness, resistant to accidental fire
- Choice of species depends on climatic and site factors & prod. Requirement

Canal bank plantations

Objectives

- ✓ Stabilization of canal banks against erosion
- ✓ Checking of shifting of sand getting into the canal in desert
- ✓ Utilization of the available land for tree cultivation
- ✓ Provision of comfort to travellers using canal side road
- ✓ Checking water logging in strips along canals& adjoining areas
- ✓ Shelterbelt effect on adjoining areas
- ✓ Improvement of aesthetics in the area

- First row of trees planted about 7.5 m from the berm of canal
- First row of trees preferably of shade trees
- Ornamental trees planted in first row near town, village, rest house, picnic spots, tourist interest and crossing the roads.
- For planting first row, trees with a strong taproot preferred
- Subsequent lines may be selected for tree products
- For water logged areas, species tolerant to logging selected

Road side plantations

Objectives

- ✓ Provision of comfort to the travellers
- ✓ Aesthetics and landscape improvement
- ✓ Stabilization of roadsides & checking of the shifting of sand to the road from adjoining areas in the desert
- ✓ Improvement of ecological conditions
- ✓ Maximizing the productivity of site to meet req. of people

- Main aim is to provide comfort to the travellers
- Selected places used for rest
- Noise abatement – 6-8 decibel each 3 0 m width of the tree
- National highways – 20-30 wide belt of trees established
- Moderate traffic areas – 7-15 m wide belts of trees
- Evergreen better for noise abatement than deciduous trees
- Design: Balance line & unbalanced continuous line system widely practiced
- Single row planting along village roads & other district roads
- National High way roads – Multiple row planting
- First row 6 metre away from electric /telephonic line
- Spacing – broad crown trees 12-14 m suggested

Urban Forestry

Urban forestry is the care and management of single trees and tree population in urban settings for the purpose of improving the urban environment. Urban forestry advocates the role of trees as a critical part of the urban infrastructure.

Urban forests bring many environmental and economic benefits to cities. Among these are energy benefits in the form of reduced air conditioning by shading buildings, homes and roads, absorbing sunlight, reducing ultraviolet light, cooling the air, and reducing wind speed – in short improvement of the microclimate and air quality.

There are also economic benefits associated with urban trees such as increased land, property, and rental value

Well-maintained trees and landscaped business districts have been shown to encourage consumer purchases and attract increased residential, commercial and public investments

Trees located in business areas may also increase worker productivity, recruitment, retention and satisfaction

Urban forests also improve air quality, absorb rainwater, improve biodiversity and potentially allow recycling to 20% of waste which is wood-based.

Trees and their soils work to filter runoff pollution and soil contaminants by absorbing them and processing them into less harmful substances

The social and even medical benefits of nature are also dramatic

Trees are usually selected, planted, trimmed, and nurtured by people, often with specific intentions, as when a tree is planted in a front yard to shade the driveway and frame the residence. The functional benefits provided by this tree depend on structural attributes,

such as species and location, as well as management activities that influence its growth, crown dimensions, and health.

Urban forestry is a practical discipline, which includes tree planting, care, and protection, and the overall management of trees as a collective resource.

The urban environment can present many arboricultural challenges such as limited root and canopy, space, poor soil quality, deficiency or excess of water and light, heat, pollution, mechanical and chemical damage to trees, and mitigation of tree-related hazards.

Among those hazards are mostly non-immediate risks like the probability that individual trees will not withstand strong winds (as during a thunderstorm) and damage parking cars or injure passing pedestrians urban trees undergo from automobile exhaust, constraining hardscape and building foundations, and physical damage

Constraints

- ✓ Loss of green space is continuous as cities expand; available growing space is limited in city centres. This problem is compounded by pressure to convert green space, parks, etc. into building sites.
- ✓ Inadequate space is allowed for the root system.
- ✓ Poor soil is used when planting specimens.
- ✓ Incorrect and neglected staking leads to bark damage.
- ✓ Larger, more mature trees are often used to provide scale and a sense of establishment to a scheme. These trees grow more slowly and do not thrive in alien soils whilst smaller specimens can adapt more readily to existing conditions.
- ✓ Lack of information on the tolerances of urban tree cultivars to environmental constraints.
- ✓ Poor tree selection which leads to problems in the future
- ✓ Poor nursery stock and failure of post-care
- ✓ Limited genetic diversity
- ✓ Too few communities have working tree inventories and very few have urban forest management plans.
- ✓ Lack of public awareness about the benefits of healthy urban forests.
- ✓ Poor tree care practices by citizens and untrained arborists.

Lecture-13 Agroforestry, definition- Importance- Agroforestry systems - Shifting Cultivation, Taungya, Alley cropping, Wind break, Shelter belt, Home garden

Definition

Agroforestry is a sustainable land-use system that maintains or increases total yields by combining food crops (annuals) with tree crops (perennials) and/or livestock on the same unit of land, either alternately or at the same time, using management practices that suit the social and cultural characteristics of the local people and the economic and ecological conditions of the area.

Or

Agroforestry is a collective name for a land-use system and technology whereby woody perennials are deliberately used on the same land management unit as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence. In an agroforestry system there are both ecological and economical interactions between the various components.

Importance

Benefits of agroforestry

i) Environmental benefits

- Reduction of pressure on forest
- More efficient recycling of nutrients by deep-rooted trees on the site
- Better protection of ecological systems
- Reduction of surface run-off, nutrient leaching and soil erosion through impeding effect of tree roots and stems on these processes
- Improvement of microclimate, such as lowering of soil surface temperature and reduction of reduction of evaporation of soil moisture through a combination of mulching and shading
- Increment in soil nutrients through addition and decomposition of litter-fall.
- Improvement of soil structure through the constant addition of organic matter from decomposed litter.

ii) Economic benefits

- Increment in an outputs of food, fuel wood, fodder, fertilizer and timber
- Reduction in incidence of total crop failure ,which is common to single-cropping or monoculture systems
- Increase in levels of farm income due to improved and sustained productivity

iii) Social benefits

- Improvement in rural living standards from sustained employment and higher income
- Improvement in nutrition and health due to increased quality and diversity of food outputs

- Stabilisation and improvement of communities through elimination of the need to shift sites of farm activities.

Constraints in Agroforestry

1. Depression in crop yields due to interference effects caused by the tree
2. Delayed liquidation of planting investments due to long gestation period
3. Increased damage to crops due to birds which the tree attract
4. Increased damage to crops due to pests for which the tree serve as alternate hosts
5. Allelopathy

Limitations of Agroforestry

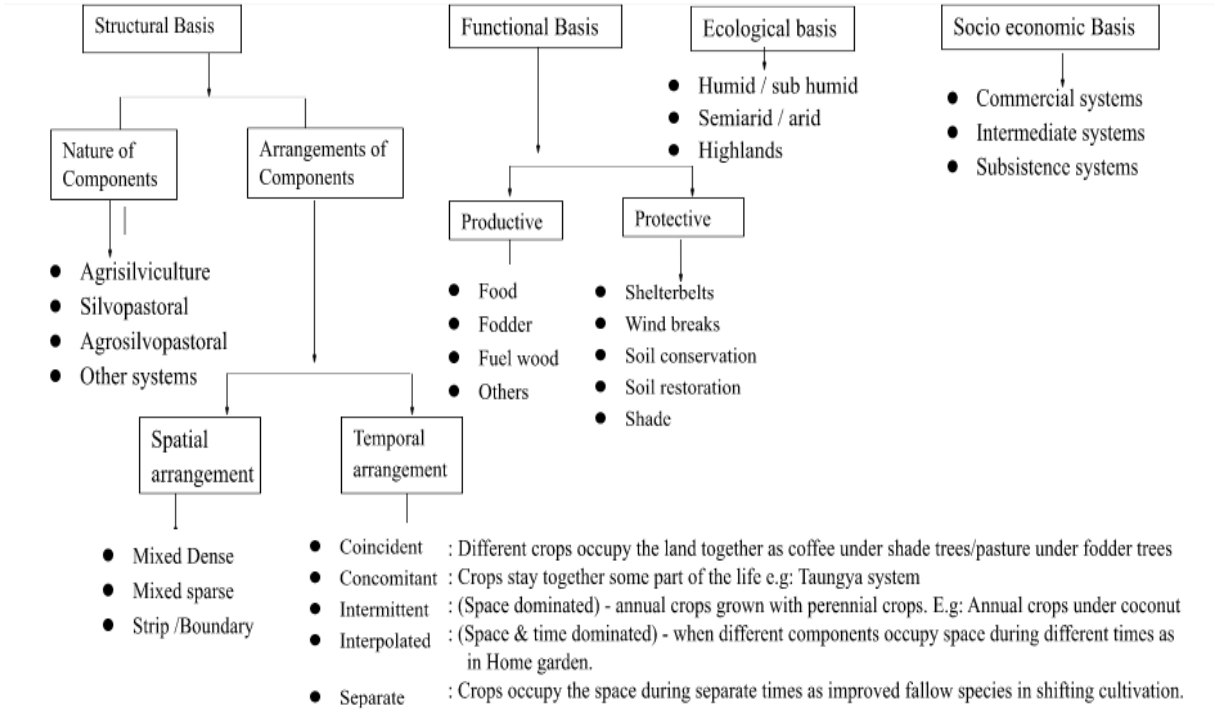
An integrated food-tree farming system, while advantageous, does have certain negative aspects.

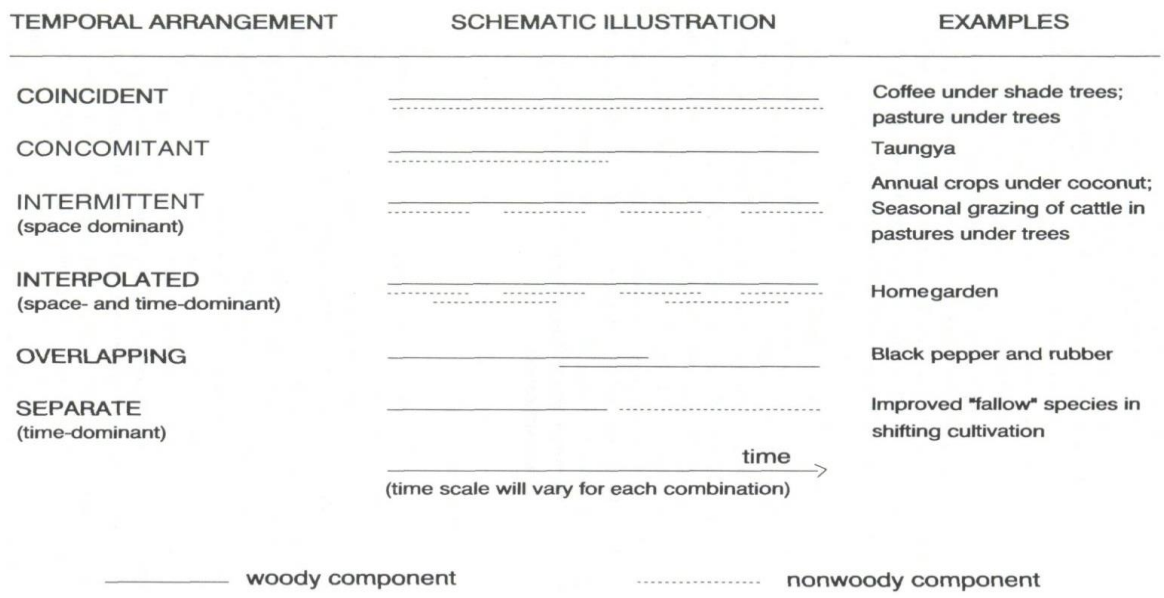
Environment Aspects: (i) possible competition of trees with food crops for space, sunlight, moisture and nutrients which may reduce food crop yield; (ii) damage to food crop during tree harvest operation; (iii) potential of trees to serve as hosts to insect pests that are harmful to food crops; and (iv) rapid regeneration by prolific trees, which may displace food crops and take over entire fields.

Socioeconomic Aspects: (i) Requirement for more labour inputs, which may causes scarcity at times in other farm activities; (ii) Competition between food and tree crops, which could cause aggregate yields to be lower than those of a single crop; (iii) Longer period required for trees to grow to maturity and acquire an economic value; (iv) Resistance by farmers to displace food crops with trees, especially where land is scarce; and (v) The fact that agroforestry is more complex, less well understood and more difficult to apply, compared to single-crop farm.

CLASSIFICATION OF AGROFORESTRY SYSTEMS

P.K. Nair (1987) has classified the agroforestry systems based on the following four criteria.





AGRISILVICULTURAL SYSTEMS

Agrisilvicultural system involves the conscious and deliberate use of land for the concurrent production of agricultural crops including tree crops.

Based on the nature of the components this system can be grouped into various forms.

1. Improved fallow species in shifting cultivation
2. The taungya system
3. Multispecies tree gardens
4. Alley cropping
5. Multipurpose trees and shrubs on farmlands
6. Crop combinations with plantation crops
7. Agroforestry fuel wood plantations
8. Shelter belts
9. Wind breaks
10. Soil conservation hedges

I) Improved Fallow Species in Shifting Cultivation

Fallows are cropland left without crops for periods ranging from one season to several years. The objective of improved fallow species in shifting cultivation is to recover depleted soil nutrients. Once the soil has recovered, crops are reintroduced for one or more seasons.

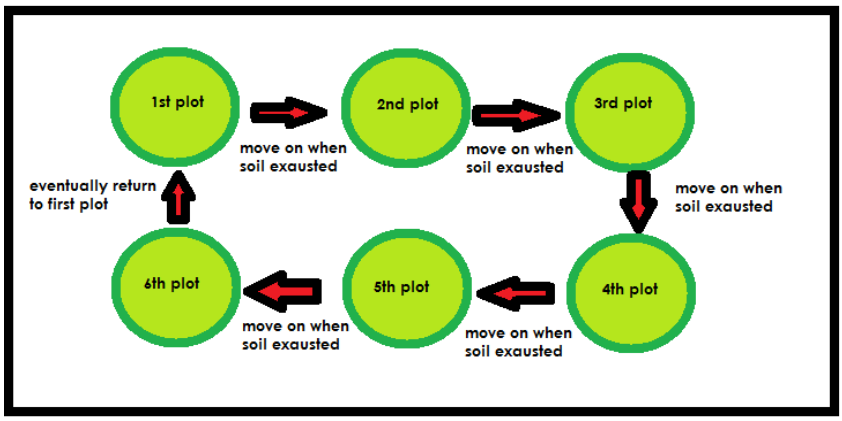
Shifting cultivation is a pattern of land use and a system of production of crops under which plots of land are cleared, cultivated for a short period for raising one, two or three crops, after which the land is allowed to rest longer than the period of cultivation. However, during the period of rest the land reverts to some modified form of its original cover

This system is practiced extensively in the north-eastern hill region comprising the states of Assam, Meghalaya, Manipur, Nagaland and Tripura and the two Union territories of Arunachal Pradesh and Mizoram and to some extent Andhra Pradesh, Bihar, Madhya Pradesh, Orissa and Karnataka states. It is called **'jhum'** in the north-eastern hill region and **'podu'** in AP and Orissa states and considered most destructive for forest areas.

The main feature of the improved fallow system of agroforestry is that trees and shrubs are not grown with crops on the same plot at the same time. The fallow periods vary from region to region but are presently becoming shorter due to an increasingly acute land shortage. The best species for the fallow system should induce good nitrogen fixation in the soil.

Species: While the main function of the fallow is to maintain or restore soil fertility and reduce erosion, some plants can be introduced primarily for their economic value. Species choice should not be exclusively confined to **'soil improvers';** plants with marketable products should also be considered. Plants included in improved fallows should be compatible with future crops, free of any negative physical or chemical effects on the soil

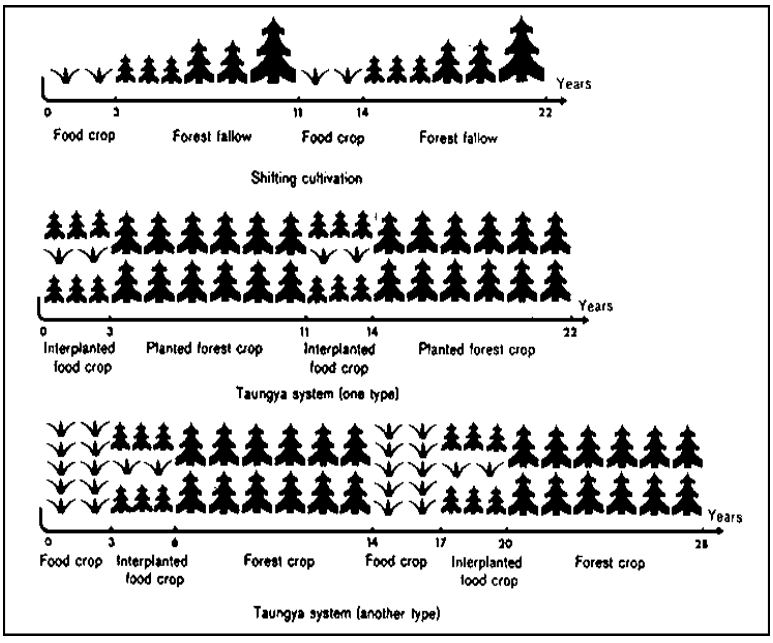
and not in competition with the crops to be planted later on the same site.



II. Taungya System:

The taungya (taung = hill, ya = cultivation) is a Burmese word coined in Burma in 1850s.

The taungya system was introduced into India by **Brandis in 1890** and the first taungya plantations were raised in 1896 in North Bengal. It is practiced in the states of Kerala, West Bengal and Uttar Pradesh and to a lesser extent in Tamil Nadu, Andhra Pradesh, Orissa, Karnataka and the north-eastern hill region. In southern India, the system is called '**kumri**'. It is practised in areas with an assured annual rainfall of over 1200-1500 mm.



This is a modified form of shifting cultivation in which the labour is permitted to raise crops in an area but only side by side with the forest species planted by it. This labour is responsible for the upkeep of a plantation. The practice consists of land preparation, tree planting, growing agricultural crops for 1-3 years, until shade becomes too dense, and then moving on to repeat the cycle in a different area. In some cases crops may be grown one year before the trees are planted. Large variety of crops and trees are depending on the soil and climatic conditions.

Crops and trees grown in Tamil Nadu

a) Trees

Tectona grandis, Dendrocalamus strictus, Santalum album,Tamarindus indica, Acacia nilotica, Acacia mearnsii, Ceiba pentandra, Cashew, Rubber etc.

b) Crops

Millet, pulses, groundnut, cotton,

Types of Taungya systems

(a) *Departmental Taungya:* Under this, agricultural crops and plantation are raised by the forest department by employing a number of labourers on daily wages. The main aim of raising crops along with the plantation is to keep down weed growth.

(b) *Leased Taungya*: The plantation land is given on lease to the person who offers the highest money for raising crops for a specified number of years and ensures care of tree plantation.

(c) *Village Taungya*: This is the most successful of the three taungya systems. In this, crops are raised by the people who have settled down in a village inside the forest for this purpose. Usually each family has about 0.8 to 1.7 ha of land to raise trees and cultivate crops for 3 to 4 years.

Advantages offered by the taungya system are:

- ✓ Artificial regeneration of the forest is obtained cheaply
- ✓ Problems of unemployment are solved
- ✓ Helps towards maximum utilization of the site
- ✓ Low cost method of forest plantation establishment
- ✓ In every case highly remunerative to the forest departments
- ✓ Provision of food crops from forest land
- ✓ Weed, climber growth etc. is eliminated.

Disadvantages of the taungya system

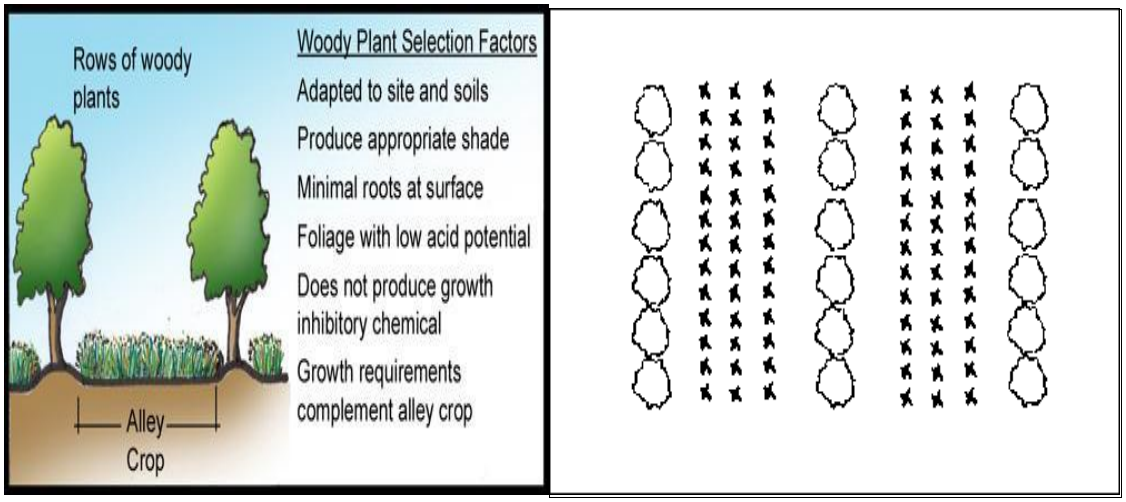
- ✓ Loss of soil fertility and exposure of soil
- ✓ Danger of epidemics
- ✓ Legal problems created
- ✓ Susceptibility of land to accelerated erosion increases
- ✓ It is a form of exploitation of human labour.

(III) Alley Cropping (Hedgerow Intercropping):

Alley cropping, also known as hedgerow intercropping, involves managing rows of closely planted (within row) woody plants with annual crops planted in alleys in between hedges. The woody plants are cut regularly and leaves and twigs are used as mulch on the cropped alleys in order to reduce evaporation from the soil surface, suppress weeds and/or add nutrients and organic matter to the top soil. Where nitrogen is required for crop production, nitrogen-fixing plants are the main components of the hedgerows.

The primary purpose of alley cropping is to maintain or increase crop yields by improvement of the soil and microclimate and weed control. Farmers may also obtain tree products from the hedgerows, including fuel wood, building poles, food, medicine and fodder and on sloping land, the hedgerows and pruning may help to control erosion. Alley

cropping usually works best in places where people feel a need to intensify crop production but face soil fertility problems. This situation is often characteristic of crowded, densely populated areas, but may also occur wherever some farmers wish or forced to increase production on a plot of limited size.



Design: Woody plants are introduced as hedgerows in farm fields to maximize the positive and minimize the negative effects of trees on crop management and yields. Without doubt, trees compete with farm crops for soil nutrients, soil moisture and light. However, the right kind of trees at the right spacing, with proper management, may actually produce a net increase in yields from croplands. Trees may also provide new products such as fuel wood, fodder or food, in addition to the annual crops.

The position and spacing of hedgerow and crop plants in an alley-cropping system depend on plant species, climate, slope, soil conditions and the space required for the movement of people and tillage equipment. Ideally, hedgerows should be positioned in an east-west direction so that plants on both sides receive full sunlight during the day. The spacing used in fields is usually 4 to 8 m between rows and 25 cm to 2 m between trees within rows. The closer spacing is generally used in humid areas and the wider spacing in sub-humid or semi-arid regions.

The position and spacing of hedgerows may also be affected by slope and the placement and design of soil and water conservation structures when these are combined with alley cropping. On sloping land hedgerows should always be placed on the contour. If this means that they do not have the desirable east-west orientation, then they may need regular thinning to prevent excessive shading of adjacent crops.

Species for hedgerow intercropping: Alley cropping usually includes leguminous trees to improve soil fertility through nitrogen fixation; hence an ideal alley-cropping tree or shrub species should have following characteristics

- It should have a sparse, small crown to permit sunlight penetration or should re-sprout rapidly after pruning, coppicing, pollarding or lopping.
- It should form a deep taproot system with few lateral root branches near the surface so as not to compete with crop roots.

- It should have shallow lateral roots that are easily 'pruned' by ploughing along the hedgerow, without serious damage to the plants.
- The leaf litter or some portion of it, should decompose at *a* rate that makes nutrients available when they are needed in the cropping cycle.
- Ideally, trees and shrubs used for alley cropping should fix nitrogen and should also produce wood, food, fodder, medicine or other products used by farmers or other local community.
- The species selected should grow well under the specific limitations of the site such as saline or acid soils, drought, flooding, heavy winds, insect pests or other hazards.

Eg.Cassia siamea, Leucaena leucocephala, Gliricidia sepium, Callianda calothyrsus and *Sesbania sesban are* commonly used tree species for alley cropping.

(IV) Shelter-belt:

These are belts/blocks consisting of several rows of trees established at right angles to the prevailing wind. The purposes are:

a) to deflect air currents,

b) to reduce the velocity of prevailing winds,

c) to provide general protection to the leeward areas against the effects of wind erosion,

d) to protect the leeward areas from the desiccating effects of hot wind,

e) to provide food, fodder, timber etc.

The following are the main characteristics of shelter-belts:

i) Shape and composition: Shelter-belts have a typical triangular shape. This can usually be brought about by raising tall trees in the centre.

ii) Density and width: A certain degree of penetration by winds is planned as by raising a solid wall, the protection decreases very fast on the leeward side. Shelter-belts up to 50 m width are considered ideal under Indian conditions.

iii) Height and spacing: The ratio of height and width should be roughly 1:10. However, this figure may vary with local conditions.

iv) Orientation: Orientation of shelter-belts depends on the direction and velocity of the prevailing winds. Shelter-belts may be raised in quadrangles if the wind direction tends to change very often.

v) Length: Length is an important consideration as far as shelterbelts are concerned. The minimum length of a shelter-belt should be about 25 times its height,

vi) Choice of species: The following species are recommended:

Grasses: *Saccharum spontaneum, S. munja, Panicum antidotale, Cencnrus* sp.

Shrubs: *Calotropis procera, Clerodendron phlomoides, Cassia auriculata, Dodonaia viscosa*

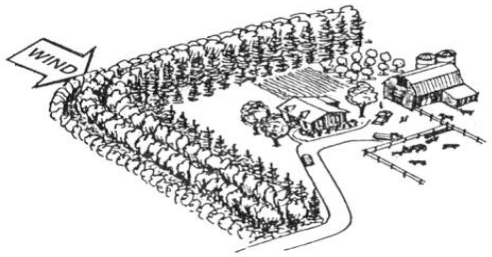
Trees: *Acacia arabica, A. leucopholea, Dalbergia sissoo, Lannea coromandelica, Eucalyptus* spp., Tamarix*, articulata, Parkinsonia aculeata, Prosopis juliflora, Prosopis, Spicigera, Casuarina equisetifolia.*

V) Wind-break:

Wind-breaks are strips of trees and/or shrubs planted to protect fields, homes, canals or other areas from wind and blowing soil or sand.

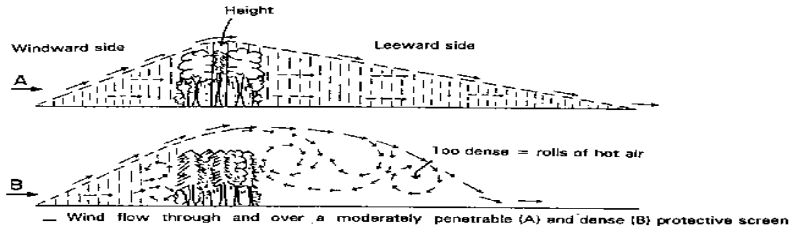
The important reasons for which wind-breaks are planted include:

- to protect livestock from cold winds
- to protect crops and pastures from hot, drying winds
- to reduce/prevent soil erosion and reduce evaporation from farmlands
- to provide habitat for wildlife
- to improve the microclimate for growing crops and to shelter people and livestock,
- to retard grass fire
- for fencing and boundary demarcation

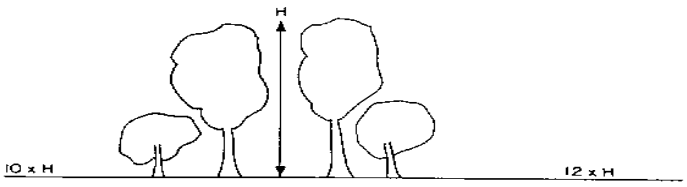


In addition, wind-breaks can provide wide range of useful products, from poles and fuel wood to fruit, fodder, fibre and mulch.

The following are the main characteristics of wind breaks:



i) Permeability: *A* wind-break works by filtering and breaking the force of the wind. For most purposes, permeable wind-breaks which allow some wind to pass through are the most suitable. This deflects the main volume of wind upwards and prevents it from descending for some distance. Thus, the wind velocity in the protected area may be reduced to between 25 and 75 per cent of the wind speed.



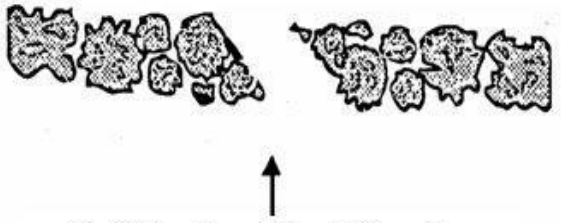
a) Orientation: Wind-breaks at right angles to winds from which protection is needed. Wind-breaks planted north-south are a good compromises as they provide protection from winds coming from the western quarter.

b) Height: The wind-break height determines the size of the sheltered area. The taller the wind-break, the greater the area it protects. A wind break 20 m tall will give some protection from 100 m on the upwind side to 500 m on the downwind side.

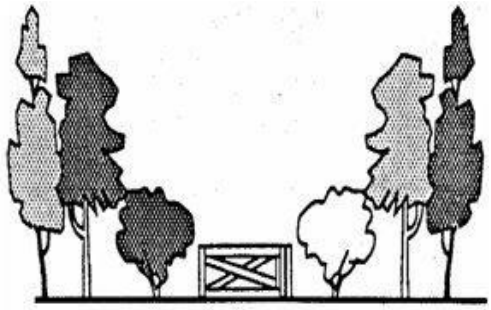
c) Length: Wind breaks are most effective when they stretch without major gaps for distances exceeding 12 times the mature height of the trees.

d) Number of rows: A single row wind break should be used only where land is so valuable that only a small amount of space can be spared for tree planting. If a single row wind break is to be planted, tree species that retain their foliage to the ground and give a fairly dense growth should be selected. ***Eucalyptus spp*** **are generally unsuitable as single-row wind-breaks** because of their habit of losing their lower limbs. **Wind breaks of three to five rows are more effective** for most farm situations and are less affected by gaps caused by mission trees.

e) Gaps: Gaps are required for gates and tracks, but because of the funneling effect through gaps, wind velocity in these areas can be substantially increased. In multi row wind breaks this can be eliminated by angling the gap at about 45 degrees to the prevailing wind direction. Alternatively, a few plant, trees or shrubs can be used on either side of the gate or track to broaden the gap and reduce the funneling effect. Other solutions are to plant five or six trees at an angle to the main belt as a wing or to plant a second short row to cover the gaps.



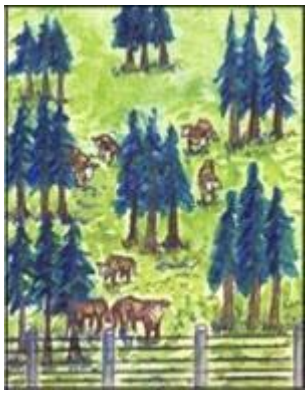
Angle the sides of the windbreak to minimise effect of gap.



Alternatively a few short trees or shrubs can be planted on either side of the gap.

f) Species: In general, trees with narrow, vertical growth are ideal for wind breaks to minimise the land removed from crop production. Some fast-growing species should be used to establish the desired effect as rapidly as possible. Some of the tree species used for wind-breaks are *Eucalyptus, Cassia, Prosopis, Leucaena, Casuarina, Acacia, Grevillea, Syzygium, Dalbergia* etc.

SILVOPASTURE SYSTEM



The production of woody plants combined with pasture is referred to silvipasture system. The trees and shrubs may be used primarily to produce fodder for livestock or they may be grown for timber, fuel wood, fruit or to improve the soil.

This system is classified in to three categories

- ✓ Protein bank
- ✓ Live fence of fodder trees and hedges
- ✓ Trees and shrubs on pasture

i) Protein bank

In this Silvipastural system, various multipurpose trees (protein rich trees) are planted on or around farmlands and range lands for cut and carry fodder production to meet the feed requirement of livestock during the fodder deficit period in winter.

Example: *Acacia nilotica, Albizia lebbeck, Azadirachta indica, Leucaena leucocephala, Gliricidia sepium, Sesbania grandiflora*

ii) Live fence of fodder trees and hedges

In this system, various fodder trees and hedges are planted as live fence to protect the property from stray animals or other biotic influences.

Example: *Gliricidia sepium, Sesbania grandiflora, Erythrina sp, Acacia sp.*

iii) Trees and shrubs on pasture

In this system, various tree and shrub species are scattered irregularly or arranged according to some systemic pattern to supplement forage production.

Example: *Acacia nilotica, Acacia leucophloea, Tamarindus indica, Azadirachta indica.*

AGRISILVOPASTURAL SYSTEMS

The production of woody perennial combined with annuals and pastures is referred Agrisilvopastural system.

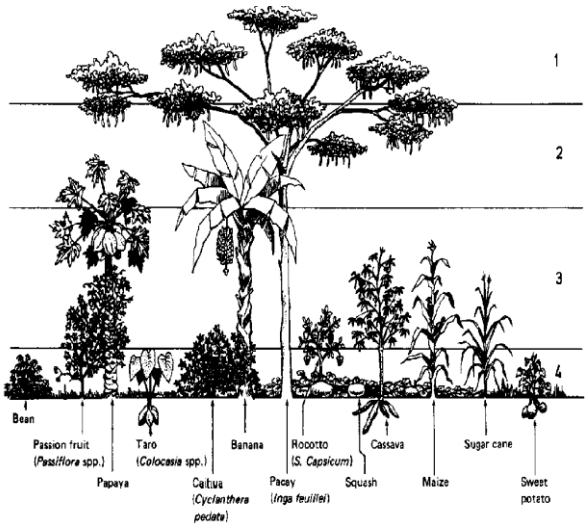
This system is grouped into two categories.

- ✓ Home gardens
- ✓ Woody hedgerows for browse, mulch, green manure, soil conservation

i) Home gardens

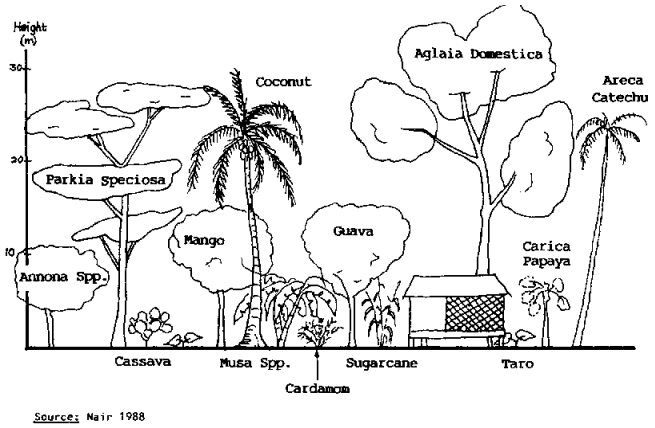
This system is found extensively in high rainfall areas **in tropical South and South East Asia**. This practice finds expression in the states of **Kerala and Tamil Nadu with humid tropical climates** and where coconut is the main crop. Many species of trees, bushes, vegetables and other herbaceous plants are grown in dense and in random or spatial and temporal arrangements. Most home gardens also support a variety of animals. Fodder grass and legumes are also grown to meet the fodder requirement of cattle. In India, every homestead has around 0.20 to 0.50 ha land for personal production.

Home gardens represent land use systems involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and livestock within the compounds of individual houses. The whole tree- crop- animal units are being intensively managed by family labour. Home gardens can also be called as



Multitier system or **Multitier cropping**

Home gardens are highly productive, sustainable and very practicable. Food production is primary function of most home gardens.



Structure of Home Gardens: Home gardens are characterized by high species diversity and usually 3-4 vertical canopy strata. The layered configuration and compatible species admixture are the most conspicuous characteristics of all home gardens. Generally all home gardens consist of an herbaceous layer near the ground, a tree layer at the upper levels and an intermediate layer. The lower layer can be partitioned in to two, the lowermost being at less than 1.0m in height, dominated by different vegetables and the second layer of 1.0 -3.0/m height comprising food crops such as banana, papaya and so on. The upper tree layer can also be divided into two, consisting of emergent, full grown timber and fruit trees occupying the upper most layers of 25m height and medium size trees of 10-20m occupying the next lower layer. The intermediate layer of 5-10m height is dominated by various fruit trees.

Choice of species:

a) Woody species: *Anacardium occidentale, Artocarpus heterophyllus, Citrus sp, Psiduim guajava, Mangifera indica, Azadirachta indica, Cocus nucifera etc.*

b) Herbaceous species: Bhendi, Onion, cabbage, Pumpkin, Sweet potato, Banana, Beans, etc.

OTHER SYSTEMS

Apiculture with trees: In this system various honey (nector) producing trees frequently visited by honeybees are planted on the boundary of the agricultural field.

Aqua forestry: In this system various trees and shrubs preferred by fish are planted on the boundary and around fish ponds. Tree leaves are used as forage for fish. The main role of this system is fish production and bund stabilization around fish ponds

Mixed wood lots: In this system special location specific multipurpose trees (MPTs) are grown mixed or separately planted for various purposes such as wood, fodder, soil conservation, soil reclamation etc.

Lecture 14. Tree and crop combination in Agroforestry- Tree crop interaction in Agroforestry

- ✓ The success of agroforestry relies heavily on the exploitation of component interactions.
- ✓ Component interactions represent another critical aspect of agroforestry; its importance has been frequently recognized, but knowledge about it is rather limited.

Component interactions refer to the influence of one component of a system on the performance of the other components as well as the system as a whole.

- ✓ Nature of biological interactions in agroforestry system

Complementary: Agroforestry system provides a greater yield than the yield of their corresponding sole crops

Supplementary: The yield of one component exceeds the yield of corresponding to its sole crop without affecting the yield of other component.

Competitive: In this system the tree and crop components interact in such a way that the increase in the yield of one component leads to decrease in the yield of other component

Below ground and above ground interactions

Tree Crop interactions (TCI) – Tree crop interface

Tree animal interactions (TAI) – Tree animal interface

Various interactions take place between the woody trees and herbaceous plants (Crops or pastures) which is referred to as tree-crop interface

Possible interactions at TCI and TAI

Type	At Tree-crop interaction(TCI)	At Tree –animal interaction
Positive	Shading trees (Stress reduction)	Shading
	Biomass contribution	Manure deposition
	Water conservation	
	Soil conservation	
	Microclimate amelioration	
	Balanced of utilization of nutrients	
	Efficient use of aerial space	
	Water conservation	
	Weed suppression	
	Efficient use of light or reduce waste of light resources	
Negative	Light competition	Phytoxins
	Nutrient competition	Browsing damage
	Water competition	Trampling
	Allelopathy	Disease/ pest hosts

Positive interactions

- Increased productivity
- Improved soil fertility
- Nutrient cycling
- Soil conservation
- Water conservation
- Weed control
- Microclimate improvement

Negative interactions

- Competition for light
- Competition for water
- Microclimate modification for pests/Diseases
- Allelopathic interactions

Positive Interactions

- The beneficial effects of one component on another, but also the manipulation of negative effects to minimize their influence on the productivity of the overall system.

At the tree-crop interface

- ✓ The major types of positive or complementary interactions at the tree-crop interface (TCI) are those relating to microclimate amelioration and nutrient balance.
  - ✓ In agroforestry systems, microclimate amelioration involving soil moisture and soil temperature relations results primarily from the use of trees for shade, or as live supports, live fences, or windbreaks and shelterbelts. The provision of shade causes a net effect of complex interactions, which extend far beyond the mere reduction of heat and light (Willey, 1975). Temperature, humidity, and movement of air, as well as temperature and moisture of the soil, directly affect photosynthesis, transpiration, and the energy balance of associated crops (Rosenberg et al., 1983), the net effect of which may translate into increased yields.
  - ✓ In general, shading causes a reduction of temperature and temperature fluctuations as well as the vapor pressure deficit2 (VPD) under tropical conditions. For example, comparing shaded versus open-grown coffee plantations in Mexico, Barradas and Fanjul (1986) found that, in a coffee plantation under the shade of Ingajinicuil(205 trees/ha; average tree height: 14 m), the average maximum temperature was 5.4°C lower and the minimum temperature 1.5°C higher, and that both VPD and Piche evaporation were substantially reduced as compared to open-grown coffee.
  - ✓ a combination of coconut and cacao in India
  - ✓ (Nair and Balakrishnan, 1977) and
  - ✓ for an alley cropping system of millet and Leucaena in India
- ✓ alley-cropping systems in Nigeria, Yamoah et al. (1986) found that weed yield was positively correlated with available radiation. Cassia siamea was reported to control weeds

better than Gliricidia sepium or Flemingia macrophylla. This was attributed to the greater shade under Cassia. Similarly, Jama et al. (1991) attributed weed reduction under closely spaced Leucaena alleys in Kenya to shading.

- ✓ In an alley-cropping trial in Costa Rica, Rippin (1991) reported a reduction of weed biomass of over 50% in alleys of Erythrina poeppigiana and Gliricidia sepium a compared with nonalley-cropped plots,
- ✓ At tree-animal interface
- ✓ some herbaceous crop plants, animals in the tropics generally benefit from the shade provided by trees. To reduce heat stress, which is one of the main constraints to animal production in the tropics,
- ✓ animals in shade generally show higher feed conversion and ultimately higher weight gain or milk production (Campbell and Lasley, 1985; Payne, 1990). Furthermore, shade may have a beneficial effect on animal reproduction (Campbell and Lasley, 1985).
- ✓ In Malaysia, the shade of rubber trees reduced air temperature by 1-5℃ which, in turn, contributed to a more favorable environment for sheep and poultry production
- ✓ In summary, it is evident that shade and high quality fodder are important requirements for better productivity and higher reproduction of animals in the tropics; both can be provided through the inclusion of trees into agricultural systems.
- ✓ 15 months of grazing sheep in a rubber plantation increased soil fertility and decreased weed competition, thereby resulting in larger diameter growth of the trees.

Negative interactions

- ✓ At the tree-crop interface
- ✓ The major yield decreasing effects at the TCI arise from competition for light water, and nutrients, as well as from interactions via allelopathy

Competition for light

1. In another Nigerian study, Kang et al. (1981) attributed low yields from maize rows adjacent to Leucaena hedgerows to shade. crops such as coffee, cacao, vanilla, and black pepper, which are traditionally grown under partial tree shade, can be expected to exhibit depressed yields as the intensity of shade increases unless they are subjected to nutrient or water stress.

Competition for nutrients

- ✓ There are innumerable studies indicating how competition for nutrients can reduce crop yields. In most cases, the yield of the agricultural crop is the criterion by which the merit of an agroforestry system is assessed; yield depressions of this component therefore receive more attention than those of the associated tree species.
- ✓ Since the crop is usually the smaller component (when compared individually), it root system will usually be confined to soil horizons that are also available to the roots of the trees; but the trees can exploit soil volume beyond reach of the crop. Therefore, the effects of nutrient competition will probably be more severe for th crop components.

Competition for water

- ✓ With the exception of areas with well-distributed rainfall, or azonal sites with a continuous supply of below-ground water, water competition is likely to occur in most

agroforestry systems at some period of time; this period may be as short as a dry spell of one or two weeks. The effect of these events depends on the severity of the drought and the drought tolerance of the plants. It also depends on the degree of competition for other resources, especially nutrients alley-cropping trials of Leucaena with cowpea, castor, and sorghum under semiarid conditions in India, competition for water appeared more important than shading effects (Singh et al., 1989).

- ✓ Examining soil moisture effects of 3.5 year-old *Eucalyptus tereticornis* on mustar and wheat yields next to the tree line in semiarid India, Malik and Sharma (1990) reported reductions of over 30% for the crops growing at a distance of less than 10 m from the tree line
- ✓ Thus, despite the use of drought-adapted plants, water competition is likely to play a major role in the productivity of agroforestry systems, especially in dry areas.

Allelopathy

- ✓ Allelopathy refers to the inhibition of growth of one plant by chemical compounds that are released into the soil from neighboring plants. A large number of studies have been undertaken in recent years on such allelopathic interactions between plants
- ✓ Allelopathic properties have been reported for many species, especially tree (Table 13.2). Although allelochemicals are reported to be present in practical all plant tissues, including leaves, flowers, fruits, stems, roots, rhizomes, and seeds, information on the nature of active chemicals and their mode of action is lacking.

Tree species	Effect on	References
Casuarina equisetifolia	cowpea, sorghum, sunflower	Suresh and Rai, 1987
Eucalyptus tereticornis	cowpea, sorghum, sunflower	Suresh and Rai, 1987 Basu et al., 1987
Leucaena leucocephala	maize/rice seedlings	Akobundu, 1986 Suresh and Rai, 1987

Microclimatic modification for pests/diseases

The effect of plant associations on pest and disease incidence is a potentially important but rather unexplored area. Bacterial and fungal diseases may increase in shaded, more humid environments (Huxley and Greenland, 1989). For example, the incidence of *Phytophthora palmivora* on cacao increases greatly under conditions of heavy shading (Alvim, 1977). The main reasons for this are probably greater relative humidity and decreased wind, both of which tend to favor fungal growth.

At the tree-animal interface

The most important negative interactions between animals and plants can be classified as direct effects. Low quality of, or toxic components within, tree fodder can adversely affect livestock production. Conversely, mechanical damage of trees or deterioration of soil properties, e.g., through compaction, can have a negative impact on the woody perennial component. While tree fodder holds great promise, particularly as a dry-season supplement in semiarid areas, its value should not be overestimated. Many species contain secondary compounds that reduce the feed value. The presence of high levels of phenolic

compounds (tannins) or strong odors found in the leaves of species such as *Cassia siamea* and *Gliricidia sepium* may reduce palatability or acceptability of the fodder. The toxic compound mimosine found in Leucaena fodder. Other particularly harmful compounds include cyanogenic glucosides in Acacia species, or robitin in Robinia (Ivory, 1990).

Component management

The magnitude of interactive effects between trees and other components of agroforestry systems depends on the characteristics of the species, their planting density, and spatial arrangement and management of the trees. Manipulating densities and arrangements is probably the most powerful method for capitalizing on beneficial effects of trees while reducing negative ones. However, in some cases, for example, when trees are used as supports for crop plants, the planting density of the trees is determined by the planting density of the crops. Tree crowns and roots can be manipulated through management operations, mainly by pruning and thinning. Other common management operations such as fertilization, application of mulch and manure, cut-and-carry fodder systems, and confinement or rotation of the animals can also be employed. The different manipulations can be grouped as growth enhancing or growth-reducing according to their effect on the targeted component

Different management options to manipulate the growth of components in agroforestry systems

Management options to achieve

(1) Increased growth	(2) Decreased growth
- Microclimate amelioration –	-Pruning
- Fertilization	- Pollarding
- Application of mulch/manure	- Root pruning
- Irrigation	- Trenching
- Soil tillage	- Excessive shading
- Adapted species	- Herbicides
Supplemental feeding -	Grazing/browsing

Pruning of trees in alley cropping and apply the biomass to the soil. While the removal of parts, or all of the crown will obviously reduce the tree's competitive ability, it will automatically increase the growth of the associated intercrop by providing green manure and by allowing more light to penetrate to the crop. Below-ground competition may also be reduced as a result of pruning-induced root die-back Application of pruning or pollarding operations on trees grown for shade or as live supports, such as legumes of the genera Erythrina, Inga, or Gliricidia. Species such as *Erythrina berteroana*, which have large thick leaves and high rates of biomass production when grown as a shade tree, will require more intensive pruning than trees with a less dense canopy such as *Gliricidia sepium*

Under conditions of severe below-ground competition, root pruning operations or trenching may eliminate, or at least strongly reduce, the negative effects of the trees on the intercrop. In an alley cropping system with *Leucaena leucocephala* in a semiarid area of

India, Singh et al. (1989) demonstrated that the construction of a root barrier completely eliminated any yield reduction of cowpea, castor, and sorghum grown in the 10 m-wide alleys

Lecturte-15. National Agroforestry Policy 2014, objectives and salient features

National Agroforestry Policy-2014

Agroforestry is defined as a land use system which integrates trees and shrubs on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability. It is a dynamic, ecologically based, natural resource management system that, through integration of woody perennials on farms and in the agricultural landscape, diversifies and sustains production and builds social institutions.

Major policy initiatives, including the National Forest Policy 1988, the National Agriculture Policy 2000, Planning Commission Task Force on Greening India 2001, National Bamboo Mission 2002, National Policy on Farmers, 2007 and Green India Mission 2010, emphasize the role of agroforestry for efficient nutrient cycling, organic matter addition for sustainable agriculture and for improving vegetation cover. However, agroforestry has not gained the desired importance as a resource development tool due to various factors.

A policy which deals with problems faced by agroforestry sector, including adverse policies, weak markets and a dearth of institutional finance was approved by the Cabinet in February 2014. India became the world's first country to adopt a comprehensive agroforestry policy.

Basic objectives

- Encourage and expand tree plantation in complementarity and integrated manner with crops and livestock to improve productivity, employment, income and livelihoods of rural households, especially the small holder farmers.
- Protect and stabilize ecosystems, and promote resilient cropping and farming systems to minimize the risk during extreme climatic events.
- Meet the raw material requirements of wood based industries and reduce import of wood and wood products to save foreign exchange.
- Supplement the availability of agroforestry products (AFPs), such as the fuel-wood, fodder, non-timber forest produce and small timber of the rural and tribal populations, thereby reducing the pressure on existing forests.
- Complement achieving the target of increasing forest/tree cover to promote ecological stability, especially in the vulnerable regions.
- Develop capacity and strengthen research in agroforestry and create a massive people's movement for achieving these objectives and to minimize pressure on existing forests.

Strategy

1. ***Establishment of Institutional Setup at National level to promote Agroforestry***

- An institutional mechanism, such as a Mission or Board is to be established for implementing the agroforestry policy. It will provide the platform for the multi-stakeholders to jointly plan and identify the priorities and strategies, for inter-ministerial

coordination, programmatic convergence, financial resources mobilization and leveraging, capacity building facilitation, and technical and management support.

- The Ministry of Agriculture has the mandate for agroforestry. Agroforestry Mission / Board will be located in the Department of Agriculture and Cooperation (DAC) in the Ministry of Agriculture (MoA).
- The actual implementation may involve convergence and dovetailing with a number of programmes.
- Agroforestry research and development (R&D), including capacity development and pilot studies / testing and action research should be the responsibility of the ICAR
- In the proposed institutional arrangement the current stakes of the key ministries are to be respected and utilized.

2. ***Simple regulatory mechanism*** - There is a need to create simple mechanisms / procedures to regulate the harvesting and transit of agroforestry produce within the State, as well as in various States forming an ecological region. There is also the need to simplify procedures, with permissions extended on automatic route as well as approval mode through a transparent system within a given time schedule. There are regulations imposed by multiple agencies of State governments (viz. Department of Forest, land revenue, other local bodies) on harvesting and transit which have negative implications on the 8 growth of agroforestry. All these restricting regulations need to be identified and aligned with the proposed simplified mechanism.
3. Development of a sound database & information system
4. Investing in research, extension and capacity building and related services
5. Improving famers' access to quality planting material
6. Providing institutional credit and insurance cover for agroforestry
7. Facilitating increased participation of industries dealing with agroforestry produce
8. Strengthening farmer access to markets for tree products.
9. Incentives to farmers for adopting agroforestry
10. Promoting sustainable agroforestry for renewable biomass based energy

Lecture-16. Forest Utilization - Definition - Wood products - solid wood and composite wood.

Forest Utilization

Forest utilization is the process of harvesting, conversion and disposal of standing produce of forest. It includes felling of forest crops, transportation to market, their manufacture into various usable commodities and distribution to their ultimate use.

Major Forest Produce: Wood

Wood is one of the most widely used products of nature. It is very variable in texture, appearance and utility. Indian flora, with more than 3500 woody species, is "perhaps the richest, and certainly the most varied, on the surface of the globe".

From very early times, forest and forest produce have so intimately associated with man and his activities that it is difficult to isolate them for an objective study. Early man obtained almost everything from the forest; food, housing, clothing, fire, tools and other equipment. During the past years many industries based on forest products have been established. Among the industries established may be mentioned, firewood and charcoal, saw-milling, packing case, cabinet ware, boat and ship building, aircraft, textile, sports goods, battery separators, pencils, matches, plywood, building, paper and pulp, bamboo and cane articles, essential oils, drugs, etc.

Uses of wood

Suitability of wood for various purposes on its technical properties such as (i) Anatomical (ii) structure (iii) Weight (iv) Strength (v) Flexibility (vi) Elasticity (vii) Toughness (viii) Durability (ix) Colour (x) Grain (xi) Figure etc.,

Structural uses of Timber

Timbers used in superstructures

Super structure includes buildings, bridges, scaffoldings, derricks, etc., which are not actually in contact with ground or water.

Buildings:

Wood used in construction purpose various properties required such as strength, durability, steadiness, hardness etc.

Suitable species

Acacia nilotica (babul)	*Dalbergia sissoo*
Albizia spp	*Dalbergia latifolia* (rosewood)
Adina cordifolia (haldu)	*Mesua ferea* (iron wood)
Artocarpus spp	*Mangifera indica*
Anogeissus species	*Picea smithiana* (Spruce)
Abies pindrow (silverfir)	*Pinus roxsburgii* (chir)
Terminalia spp	*P. wllichiana* (kail)

Xylia xylocarpa (irul)	*Toona ciliate* (toon)

Bridges:

Timber should be very strong, durable, hard, elastic and able to stand strain of traffic and continual wear and tear.

Suitable species

Acacia nilotica (babul)	*Dalbergia sissoo*
Shorea robusta (sal)	*Mesua ferea* (iron wood)
Cedrus deodara (cedar)	*Tectona grandis* (teak)
Pterocarpus spp	*Anogeissus species*
Xylia dolabriformis	*Terminalia spp*

Timbers for use in contact with the ground

Railway sleepers:

The wood of sleepers should have strength, including transverse strength to resist breakage by centre binding and compressive strength to resist rail pressure. It should hard to resist rail abrasion and easy impregnation of preservatives.

Suitable timbers

Shorea robusta (sal)	*Dalbergia sissoo*
Cedrus deodara (cedar)	*Mesua ferea* (iron wood, Tadinangu)
Pterocarpus marsupium (vengai)	*Tectona grandis* (teak)
Legerstroemia parviflora (ven-thekku)	*Anogeissus species*
Dipterocarpus spp (gurjan)	*Picea smithiana* (Spruce)
Terminalia spp	*Pinus roxsburgii* (chir)
	P. wllichiana (kail)

Composite wood

Composite wood is a general term for "build up, bonded products, consisting either wholly of natural wood" e.g. plywood or core board or a combination of wood with metals, plastics etc.

Classification

1. Plywood
2. Laminated board
3. Core boards
4. Sandwich board
5. Fibre board

6. Particle board

Plywood

Plywood is a “glued wood construction build of veneers in such a manner that the grain of each veneer is at right angle to that of adjacent in the assembly”. Wood is a main raw material. Veneers are peeled out from wood.

Important timber species used in plywood manufacturing

Terminalia spp	*Sysygium cumini*
Mangifera indica	*Lanea coromandalica*
Ailanthus excelsa	*Terminalia bellerica etc.*
Tectona grandis	*Dalbergia sissoo*
Dalbergia latifolia	*Melia dubia*

Manufacturing process

1. Preparation of veneer
2. Drying of veneers
3. Mixing & spreading glued adhesive
4. Pressing the glued lay-up into a panel
5. Conditioning of the panels
6. Trimming, sanding and storage

1. Preparation of veneers

First logs should make as very soft, easy pliable and spread the moisture throughout the logs by boiling or steaming. After softening, logs are cut into veneers by rotatory peeling machines like roll of papers. Maximum length of longs are used for peeling is 2.5 to 3m. Thickness of slicing veneer is 1.25, 1.5 &2.5mm.

2. Drying of veneers

Freshly cut veneers are very wet and unfit for gluing and also liable for attacking mould, blue stain fungi. Therefore veneers are quick as possible dried on steam heated mechanical dryers.

3. Mixing and spreading the glue

Animal glues, starch glues and subsequently blood albumen and protein glues were used as adhesives in composite wood industry but with the development of modern synthetic resin adhesives like U.F (Urea Formaldehyde), P.F (Phenol-formaldehyde), etc. are commonly used for bonding.

4. Pressing

The glue coated veneers are assembled in a proper order and subjected to pressure to ensure alignment of components and intimate contact between the wood and the glue. The pressing is done in hydraulic presses and, depending on the type of glue, it is either

done at room temperature (cold pressing) or at high temperature (hot pressing), using pressures ranging from 7 to 18 kg/sq cm.

5. Conditioning of panels

After the plywood is pressured, it need to condition in a conditioning chamber in order to bring moisture content about 12%.

6. Trimming, sanding and storage

After conditioning, the panels are trimmed to the exact dimensions required and sanded. The finished panels are then packed for dispatch and storage.

Properties

- Ordinary wood has the tendency to shrink and swell at varying humidity and temperature conditions. Further it has other defects –knots, irregular grains etc these defects are removed in plywood
- It is dimensionally stable in changing atmosphere condition due to cross lamination of the veneers.

Uses

- Construction purpose
- Sports good manufacturing
- Manufacture of radio, wireless, tv cabins
- In packaging eg: Tea chest plywood

Core boards

Core composed strips of wood in various dimensions glued together or otherwise jointed together to form a slab.

Properties & uses

Core board construction aims at lightness of weight, economy in the use of wood, consistent with strength. It also helps in the utilization of saw mill waste.

Laminated wood

Laminated wood may be defined as a buildup product made of wood layers (called *laminea*), all laid with their grain parallel and glued or otherwise fastened together.

Sandwich board

SB is a general term for buildup boards having a core of light material, face d on both sides with a relatively thin layer of material having high strength properties.

Fibre boards

It is a sheet of material made from fibres of wood. Wood is de-fibrated or pulped and fibres are then inter-felted into a mat and consolidation (by pressure or heat).

Raw materials– agricultural or forest waste

Purpose

- Building board
- Insulating board
- Wall board

Particle boards

A board or sheet constituted from fragments of wood and other ligno-cellulosic materials, bonded with organic binders with the help of one or more agents like heat, pressure, humidity, catalyst, etc

Raw materials– chips, flakes, splinters. Etc

Purpose

- Interior application in housing or furniture.
- Generally not recommended for external application- bcz they shrink and swell appreciably.

Lecture-17. Forest Utilization - Non Wood Forest Products - fibres , floss, bamboo, tan, dye, resin, oleoresin

Minor Forest products (MFP)/Non Timber Forest Products (NTFP)

MFP covers all forest products other than 'Major forest Products' which consist of timber, small wood and fuel wood.

Classes of NTFP

- Fibres and Flosses
- Grasses, bamboos and Canes
- Oil seeds
- Tans and Dyes
- Gums, Resins and Oleo Resins
- Animal, Mineral and Miscellaneous Products
- Drugs, Spices, Edible Products and Poisons

1. Fibres

Fibres of both animal and vegetable origin been used long before the dawn of history, for the spinning of thread and cordage and weaving of coarse fabrics. Fibres generally occur as sclerenchyma cells and serve to impart rigidity to the plant. Fibres are obtained from bast tissue of many woody species, some of which yield long strong fibres which are suitable for twisting into ropes, whereas others yield silky fibres which are fine enough for textile purpose. They are found in various parts of the plant such as stems, leaves, roots, fruits and even seeds.

- Fibres can be classified by origin and structure into;

1. Soft fibres from bast or stem
2. Hard fibres (leaf or structural fibres)
3. Surface fibres borne on the surface of stems, leaves, seeds, etc

"Retting"

- The method of extracting fibres from one another is technically known as 'retting'.
- It is done by soaking the fibres in water to soften the tissues, the fibres afterwards being beaten and scraped clean.

Sources

Fibre from stem	Fibre from leaves
Grewia tiliaefolia (Dhanu virksha)	*Caryota urens* (Fishtail Palm,)
Bauhinia vahii (Camel's Foot Climber, Adda, Kattumandarai, Mandarai)	*Musa spp*

Hardwickia binate (Anjan) *Calotropis gigantea* *Trema orientalis* (Indian Charcoal Tree, Pigeon wood, Yerralai, Tachaamaram) *Ficus spp*	*Pandanus spp* *Agave spp (A.America, A. cantala, A.sisalana)*

2. Flosses

There are several forest trees and plants which produce silky flosses in their fruits.

- *Ceiba pentandra*-kapok
- *Bombax ceiba* – Indian kapok, semul
- *Cochlospermum religiosum* – yellow silk cotton tree
- *Calotropis gigantea*

3. Grasses

Eulaliopsis binata (bhabar or baib grass) *Saccharum munja* (munj) *S. spontaneum* (ekra) *Vetiveria zizanioides* (khus-khus)	*Cynodon dactylon* *Panicum spp* *Pennisetum spp* *Cenchrus ciliaris* (Buffel grass, koluk katai)

4. Canes

Canes (‘**rattans’** of commerce) are the stems of climbing palm of the genus ***Calamus.*** The genus Calamus consists of about 30 spp identified in India from Himalayas, Assam, Kerala, Karnataka, TN and Andaman. The stems in the climbing species are long, often upto 100m, usually cylindrical and of uniform thickness, solid, straw-yellow in colour. They are exceedingly strong, tough and elastic. The outer surface is hard, smooth and shinning and the core is spongy. The canes can reach maturity in about 5 years.

Process of Canes

Mature culms are pulled out by hand → Soft terminal portions and sheaths are removed

↓

Dried in sun or over a fire

↓

The silica layer removed by rubbing by using knife after steeping the cane in water

↓

After desilication, the cane is bleached by fumigation with burning sulphur

↓

After that the canes are polished with a woolen rag or a soap stone

↓

Treated by smoking over a fire and polishing with coconut oil – reddish brown

Important canes spp

Calamus guruba, C. Acanthospathus, C. Tenuis, C. Viminalis, C. Rotang

5. Distillation and extraction products including grass oils

Grass Oils

These are mostly obtained from tropical grasses rich in aromatic essential oils. There are five well known commercially recognized aromatic oils, which are distilled from grasses. These are found in the genus *Cymbopogon.*

Cymbopogon martini (motia and sofia)- palmrosa grass oil	*C. martini* (Ginger grass oil)
C. flexosus – lemon grass oil	*Vetivera zizaniodes* - Khus oil
	C. nardus – citronella grass oil

Wood Oils

Santalum album – Sandal wood oil	*Cedrus deodara*– Deodar wood grass oil
Aquilaria agallocha– Agar wood oil	*Pinus spp*- pine oil

Leaf Oils

Eucalyptus globulus- Eucalyptus oil	*Cinnamomum camphora*– *Camphore* oil
E. citriodora– Citriodora oil	*C. Zeylanicum* - *Cinnamon* oil

6. Oil Seeds

There are a very large number of forest plants bear's seeds yielding oils of varying commercial importance. The oils are chiefly used for cooking, lighting and adulteration of more expansive oils.

There are two methods extracting seed oil: Expression and extraction with volatile solvent.

Expression: in expression the clean seeds are pressed between chilled iron rollers, the oil is forced out by the pressure between the rollers. A high yield obtained by the heating the seeds. The oil expressed from the heated mass in hydraulic presses.

Extraction: the other method of obtained oil from seeds is extraction with volatile solvents which give a higher yield of oil but the resultant cake is unfit for consumption by cattle because traces of solvents remain behind and are difficult to remove. The crushed seeds are placed in an extractor and are subjected to the solvent, the oil is separated by distillation and the solvent used again. The solvents commonly used are petroleum, ether and carbon disulphide.

Sources:

Azadirachta indica	*Shorea robuta* (sal)
Calophyllum inophyllum (Punnai)	*Vateria indica* (vellapine)
Madhuca longifolia (Illupai/mahua)	*Momusops elangi*
Garcinia indica (Kokam butter)	*Schleichera oleosa* (Kusum)
Pongamia pinnata (Pungam)	*Mesua ferea* (Ironwood)

Essential oil vs Seed oil

Essential oils	Seed oils/fixed oils
It is a volatile oil, it will evaporate/volatile in contact with air.	Non-volatile oil, do not evaporate/volatile in contact with air.
It consists chemically of a variety of organic substances.	These are components of glycerine with certain complex organic acid – fatty acids.
Typically liquid and possess a pleasant taste and strong aromatic odour.	These are solid/semi-solid at ordinary temperature.
Soluble in water but less soluble in organic solvent.	In-soluble in water but soluble in organic solvent.
Generally non-edible oils.	It is edible oils.

7. Tans and Dyes

Tannins and Dyes are secretion products found in plant tissues in small or large quantities. These are simple chemical components of C, H & O along with some nitrogen. The name tannin is given to organic substances which have the property of combining with insoluble albumen and gelatine will resistant against decay. These properties useful in treating animal skin and hides against decomposition and improves wearing quality. Dyes are widely used in textile industry, also for colouring paints, varnishes, ink, paper, medicine and foods etc.

Tannin sources

Bark tans: *Acacia nilotica* (Babul), *Cassia auriculata* (Avaram), *Shorea robusta* (sal), *Terminalia arjuna* (Neer maruthu), *Cassia fistula* (Konnai).

Fruit tans: Myrobalans (*T. chebula* (kaddukai), *T. bellirica* (Thanikkai), *Emblica officinalis* (Amla), *Acacia nilotica* (Babul), *Caesalpinia sappan* (*Divi-divi*).

Leaf tans: *Anogeissus latifolia* (Axlewood), *Emblica officinalis* (Amla), *Lawsonia inermis* (Henna).

Dye sources

Wood dyes: *Pterocarpus santalinus* (Red sander), *Caesalpinia sappan* (Brazilin), *Artocarpus heterophyllus* (Jack), *Acacia catechu* (Khair), *Acacia catechu* (Khair).

Bark dyes: *Acacia spp, Casuarina equisetifolia, Manilkara littorialis* (Andaman Bullet-wood), *Terminalia alata* (Indian Laurel).

Flower and fruit dyes: *Mallotus philippensis* (Kamela), *Bixa orellana* (Annatto), *Wrightia tentoria* (veppalai).

Leaf dyes: *Indicofera spp* (Indigo dye), *Lowsonia inermis* (Henna).

8. Gums

Gums are a group of plant products related to sugars and carbohydrates, and consist of polysaccharides or their derivatives. True gums are formed as a result of disintegration of internal plant tissues, chiefly decomposition of cellulose, through a process – **"Gummosis".** Gums are **s**oluble in water but insoluble in organic solvents. On heating they decompose completely without melting.

Sources of Gums

Acacia gums (Gum Arabic)- *A.catechu, A.nilotica, A.senegal, A.modesta*	Bengal kino – *Butea monosperma* (flame of the forest)
Ghatti gum – *Anogeissus latifolia*	Katira gum - *Cochlospermum religiosum*
Gum kino – *Pterocarpus marsupium* (Vengai)	Selma gum – *Bauhinia retusa*
Salai gum – *Boswellia serrata*	Gum karaya – *Sterculia urens* (Senthanukku, Kutiraippitukkan)

Uses of Gums

- Clarification of liqueurs
- Fining of silk
- Quality water colour preparations
- Confectionary, pharmaceuticals, printing inks, and in sizing and finishing textile fabrics.
- Adhesives, calico printing, sizing of paper, painting industry.
- Food stuffs and commercial ice creams.

9. Resins

Resins are **exudation** products of plants normally ooze out through the bark, hardening on exposure. Resins originate through reduction and polymerization of carbohydrates. Resins are insoluble in water but soluble in organic solvents. They are brittle, amorphous and more or less transparent.

Three types of resins

1. **Hard resins**: little essential oil, solid, no odour & taste
2. **Oleo resins**: considerable amount of essential oils, liquid, distinct aroma & flavour.
3. **Gum resins**: mixture of both gums & resins.

Sources of Resins

Hard resin	Oleo resin	Gum resin
Black dammar- *Canarium strictum* White dammar – *Veteria indica* Sal dammar– *Shorea robusta*	Turpentine – *Pinus roxburgi, P. wallichiana, P.kesiya*	Indian gamboge tree – *Garcinia morella* Indian myrrh – *Commiphora mukul*

Uses of Resins

- Manufacture of varnishes and lacquers
- Water proof coating
- Soap manufacturing
- Medicine and pharmacy, for sizing paper, for incense & in preparation of sealing wax & several other products.

10. Shellac (Lac)

- Lac, familiarly known as shellac.
- It is a valuable resin secreted by the lac insect *Laccifer lacca*.
- This insect feeds on the sap of certain plants & continuously secrets the resin as a protective covering throughout its life.

Manufacturing Shellac (Lac)

1. Crushed lac

Lac encrustation are removed from the branches- scrapped by knife – **Raw lac** – powdered – '**crushed lac'**

2. Seed lac

Crushed lac in immersed water – often stirred – colour liquid drained out – materials settled bottom – transfer to large vats – add **lime 1kg/160kg** of material – lac dye settle down & collected – wastes are removed – filtered with cloth- repeat the process 2-3 times – dried ("**Seed lac/ grain lac**")

3. Shellac

By solvent method: Dissolve seed lac in alcohol – filtered out impurities – extracting shellac by evaporating the solvent.

Host trees for Lac insects

Butea monosperma (Rangeeni)	*A.nilotica*
Schleichera oleosa (kusum)	*Albizia lucida*

Zizphus mauritiana	*Cajanus cajan* *Ficus spp etc*

Uses of Shellac (Lac)

- Manufacturing of gramophone records
- Decorative & insulating varnishes & lacquers of various kinds.
- Manufacturing of laminated paper insulation, mica insulation products, spark shields.
- Leather dressing & finishing in felt hats & straw hats.
- Ingredient of sealing wax
- Sizing paper, nail polishes, dental plates, bangles, jewelry fittings, grinding wheels & confectionaries.

11. Bidi/tendu leaves

- The leaves obtained from *Diospyros melanoxylon* are commercially called as bidi leaves.
- The bidi leaf tree is commonly known as "**Tendu**" – used for bidi wrapping.

Production of Tendu leaves

a. Cultural operations:

- Pruning
- Trenching for root suckers
- Coppicing (15 cm girth & cut near the ground)

b. Collection of leaves:

- Manually from standing trees & bushes (not collected from large trees)
- Leaves plucked just after they turn from crimson to green colour & leathery texture.
- **Season**: April- May
- Leaves are made into bundles of 50, 70, or 100 leaves.

c. Drying & curing of leaves: maintain optimum moisture content. If excess moisture leaves get blackened & mould growth will develop and leaves become too brittle.

d. Packing & storage: gunny bags used, water sprinkle over bundles before packing.

e. Production & trade: 3 lakh tonnes produced in India/annum (MP, Orissa, Maharashtra – 80%). Average price Rs. 15000/tonne

12. Cutch & Katha

- Cutch and katha are obtained by boiling heartwood of Acacia catechu (Khair) tree.
- The chief constituents of the heartwood are catechin (Katha) and catechu – tannic acid (Cutch).

Extraction of cutch and katha

Heartwood chips placed in copper vessel ⟶ Boiled with water ⟶

Liquid poured into another vessel ⟶ Remove impurities through apiece of muslin cloth

Add fresh water – again boiled ⟶ Liquid obtained required density (1.07-1.08)

Allowed cool sufficiently (seeded with crystals of katha)

Crystals of katha settled at bottom of vessel ⟶ separate the crystals from mother liquid by

Straining the liquid through a fine muslin

Cutch solution pass through muslin **Leave the catechin on the muslin**

<u>Uses of cutch & katha</u>

Cutch

- Used for dyeing cotton and silk and in calico printing.
- Preserving fishing nets and ropes – give resistant against sea water.
- Raw material for plywood adhesives.
- Used as medicine – astringent.

Katha

- Ingredient in the preparation of chewing pan.
- Medicine – astringent, digestive and externally it is employed as a cooling application to ulcers, boils and eruptions of the skin.