



SILVICULTURE OF TREES AND SILVICULTURE SYSTEMS



DIRECTORATE OF FORESTS
GOVERNMENT OF WEST BENGAL



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PREFACE

As part of the subject Silviculture, the present course materials deal with silviculture of trees and silvicultural systems. It devotes ten lessons to describe silviculture of twenty important tree species that are often raised as forest crop in the state. Further, the materials dwell upon major silvicultural systems to explain the various management procedures being applied to forest crop. Under the JICA project on 'Capacity Development for Forest Management and Training of Personnel' being implemented by the Forest Department, Govt of West Bengal, these course materials on Silviculture of Trees and Silviculture Systems have been prepared for induction training of the Foresters and Forest Guards. The object of this training manual is to help the frontline forest personnel have a better perception about Silvicultural procedures and enhance their capacity to deal with their task.

The subjects covered in these materials broadly conform to syllabus laid down in the guidelines issued by the Ministry of Environment of Forests, Govt of India, vide the Ministry's No 3 - 17/1999-RT dated 05.03.13. In dealing with some of the parts of the course though, the syllabus has been under minor revision to facilitate better understanding of the subjects and to provide their appropriate coverage. The revised syllabus, with such modifications, is appended.

The contents of the course materials have been compiled and edited by A Basu Ray Chaudhuri, IFS (Retd). Many books and literature including those available in internet have been made use of in preparing these course materials and references of such books and documents have been cited in the respective lessons. Shri A Basu Ray Chaudhuri is indebted to many forest officers who have helped in the preparation of these materials.

Efforts that have gone into making of these course materials will be best rewarded if the frontline staff of the forest department find these materials useful in their day-to-day works.

Kolkata, April 2015

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Govt of West Bengal



SYLLABUS

Silviculture of Trees & Silviculture Systems (15 hours), Excursions 1 days, tour 4 days		
1. Silviculture of trees	Study of habitat, distribution, soil and climate requirements, phenology and cultivation technique* of 20* economically important species of the state concerned.	10 hours (+OJT: Silviculture of species)
2. Silvicultural Systems	2-1. High forest and coppice systems 2-2. High forest systems 2-3. clear felling system 2-4. Shelter wood system 2-5. Seed Tree System* 2-6. Selection system 2-7. Coppice Systems 2-8. Simple coppice system 2-9. Coppice with standard system 2-10. Coppice with Reserve system*	5 hours
Field Study	The trainees will be shown the silvicultural systems and silviculture of such species that are met with during the tours and excursions	

* These are modifications with reference to the syllabus prescribed by MoEF, indicating revision/addition of topics.



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2	<ul style="list-style-type: none"> • Lesson Plan • Silviculture of <ul style="list-style-type: none"> ✚ <i>Albizia Lebbeck</i> ✚ <i>Alnus nepalensis</i> 	6-10
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Lesson 1

Time 1 hour

Lesson Plan

Objective:

To study Silviculture of Trees

- *Acacia auriculiformis*
- *Azadirachta indica*

Backward linkage

- Study of Lesson 14 of Forest Botany

Forward linkage

- To see nursery and plantation during tour.

Training materials

- Copy of lesson 1 to be circulated beforehand

Allocation of time

- | | |
|--------------------------------|--------|
| • <i>Acacia auriculiformis</i> | 25 mts |
| • <i>Azadirachta indica</i> | 25 mts |
| • Miscellaneous /Discussion | 10 mts |



1. *Acacia auriculiformis* A. Cunn. ex Benth.

Family: **Fabaceae (Leguminosae)**

Local names: Akashmoni, Sonajhuri

(http://www.fleppc.org/ID_book/Acacia

Ram Parkas Plantation and Nursery Technique of Forest trees 2007)

1.1 Description

Evergreen, unarmed tree to 15 m (50 ft) tall, with compact spread, often multi-stemmed; young growth glaucous. Leaves alternate, simple, reduced to phyllodes (flattened leaf stalks), blade-like, slightly curved, 11-20 cm (5-8 in) long, with 3-7 main parallel veins and a marginal gland near the base; surfaces dark green. Flowers in loose, yellow-orange spikes at leaf axils or in clusters of spikes at stem tips; flowers mimosa-like, with numerous free stamens. Fruit a flat, oblong pod, twisted at maturity, splitting to reveal flat black seeds attached by orange, string like arils.

1.2 Distribution

A strong light demander and excellent seed producer, it is native to Australia, Indonesia, and Papua New Guinea, but has become naturalized in India. It is planted extensively in lateritic soils in south West Bengal.

1.3 Seed

Seeds ripen in January- March. The best time for collection of pods is February – March, by lopping and spreading out for 5-9 days in the open. Seeds can be stored in cool dry place. Seeds remain viable upto 2 years. Germination capacity is about 50%.

1.4 Propagation:

- **Natural propagation:** The species has a remarkable capacity to regenerate naturally. It gives profuse regeneration under its own shade or in nearby areas from wind-dispersed seeds.
- **Artificial Regeneration:** The species can be raised by direct sowing as well as transplanting of nursery-raised seedlings. The latter method is more common. Plantation by transplanting has the advantage that one can be sure of healthy planting stock raised with seeds collected from plus trees or seed stand. Nursery seedlings, 3-4 month old (about 1 foot tall), raised in poly-pots or hykopots, can be planted at the break of monsoon in June-July. Planting is done normally at a spacing of 2.5m X 2.5m or 2m x 2m. Weedings are necessary during early years. However, once established, it outstrips any competition. Fertilization promotes growth of the seedlings. In the year of creation, fertilizer (N, P, K in suitable doses) is applied during weeding/Mulching.

1.5 Nursery Practice: As pre-treatment, seeds are kept immersed in water at room temperature for about 24-48 hours. Seeds are sown directly in polythene pots / hykopots during March to early April. Pots are kept under shade until germination is complete.

1.6 General

It is an extremely useful plant to **reclaim** arid and rocky areas. In south West Bengal Akashmoni forms a part of miscellaneous plantations which are worked under clear-felling system on 12-year rotation. It does not tolerate salinity. The **wood** is heavy and hard and its timber now finds application in the making of furniture. It is in high demand as **firewood**.

The plant fixes Nitrogen in root nodules. It is also used as pulpwood. Seeds contain fat.

The **dry leaves** are also excellent fuel and used extensively in the forest fringe villages.

The **bark** contains sufficient tannin (13-25%) for commercial exploitation and contains 6-14% of a natural dye suitable for the batik industry.



(http://en.wikipedia.org/wiki/Acacia_auriculiformis)

(<http://mgonline.com/media/Images/e/earleafacacia01.jpg>)

Fig.1.1 *Acacia auriculiformis*



2. *Azadirachta indica* A. Juss

Family: Meliaceae

Local names: Neem, Nim

(Source: J. F. Dastur. *Useful Plants of India and Pakistan*

Ram Parkas 2007 Plantation and Nursery Technique of Forest trees

Forest Directorate Govt of West Bengal Forestry Nursery Manual of West Bengal 2005)

2.1 Description: A large evergreen tree; leaves pinnate, crowded near the end of the branchlet; leaflets sub-opposite, obliquely lanceolate, acuminate, serrate. Flowers white, fragrant, shorter than the leaves. Drupe yellow when ripe, 1-seeded.

2.2 Distribution: Throughout south West Bengal, wild and cultivated.

2.3 Seed

Neem flowers from March to May; fruits from June to August. Seeds profusely from an early age of about 5 years. Ripe seeds are collected off the trees during July-August, and sown within about a fortnight after rubbing, depulping, washing and drying. Seeds do not store well and lose their viability after about a couple of months. Number of seeds per kg varies between 3000 and 5000.

2.4 Propagation

- Natural regeneration – Mature Neem trees seed profusely. Seeds are mainly dispersed by birds. Natural regeneration is plentiful under the protection of thorny bushes, hedges or fencing.
- Artificial regeneration – Seeds are sown 1 cm deep, 2.5 cm to 5 cm apart in 15 to 20 cm apart lines. Small seedlings are then pricked out in polypots. Plantable size seedlings, 7 to 10 cm tall, are produced in 2-3 months, which can be retained in nursery for 1 to 2 years. Germination percentage is 70 to 95, and period of germination is 7 to 21 days.

2.5 Injury/damage

It is wind-firm but frost and fire-tender. Seedlings die back in dry season. It is susceptible to browsing. The plant is also prone to damage by certain insects and fungi.

2.6 General

The tree has multifarious use. The **wood** is red or brown, aromatic, durable and takes good polish. It is used for furniture, carts, axles, yokes etc. The **bark** has **medicinal value**. The **leaves** are used in **herbal medicine** and **insect repellent**. The **twigs** are commonly used as **chew sticks** or tooth brushes. The most useful and valuable part is the **seed**. The seed contains **fatty oil**, deep yellow in colour, known as **margosa oil of commerce**. The **main**

active principle of this oil is 'nimbidin', which has many therapeutic uses. (Please see Lesson 15 of Forest Botany).



<http://www.iherbalstore.com/shop/margosa>
<http://commons.wikimedia.org/>

Reference Materials:

1. *J. F. Dastur. Useful Plants of India and Pakistan*
2. Ram Parkas 2007 Plantation and Nursery Technique of Forest trees
3. Lesson 14 & 15 of Forest Botany
4. Forest Directorate Govt of West Bengal Forestry Nursery Manual of West Bengal 2005
5. Websites cited in the lesson





Lesson 2

Time 1 hour

Lesson Plan

Objective:

To study Silviculture of Trees

- *Albizia Lebbeck*
- *Alnus nepalensis*

Backward linkage

- Study of Lesson 14 of Forest Botany

Forward linkage

- To see nursery and plantation during tour.

Training materials

- Copy of lesson 2 to be circulated beforehand

Allocation of time

- | | |
|-----------------------------|--------|
| • <i>Albizia Lebbeck</i> | 25 mts |
| • <i>Alnus nepalensis</i> | 25 mts |
| • Miscellaneous /Discussion | 10 mts |



1. *Albizia Lebbeck Benth.*

Family: *Leguminosae*

Local names : Kalasirish, Kalsish

1.1 Description

A large, deciduous tree; branches spreading; bark brownish-grey, rough with numerous cracks. Leaves twice pinnate ; axis 3-12 inch long, with 2 glands; pinnae 2-4 pairs; reflects 3-9 pairs, 1-2 inch long, unequal sided, dark green. Flowers white fragrant, 1.5 inch long in large, globose, umbellate heads; Calyx small tubular; corolla glabrous; stemens very long, greenish. Pods large, 4-12 inch long, thin, dehiscent; seeds 6-12.

1.2 Distribution

It occurs in the sub-Himalayan tract from the Indus eastwards to the Khasi Hills, West Bengal, Indian Peninsula and the Andamans. It is a component of Tropical Evergreen, Semi evergreen Moist and Dry deciduous forests. In West Bengal, it is found in the lower hill forest (upto 3000 feet).

1.3 seed

Flowers appear from March to May. Pods ripen in December to February. Seed weight is very variable. In West Bengal seed weight is reported to be 12320/kg and germination capacity 80% (Ram Parkash 2007). Pods are collected from the trees in February with the help of a stick or swept from the ground soon after they fall. Pods are dried in the sun and seeds extracted by lightly beating them with stick and then separated by winnowing. Seed viability is more than 2 years.

1.4 Propagation

- **Natural regeneration** – Though abundant seeds are produced annually, seedling regeneration is scanty because of heavy insect damage to seeds.
- **Artificial Regeneration – (i) Direct sowing** - Seeds are sown direct, thickly on lines in May. Excellent results have been obtained from direct sowing.
(ii) Transplanting of seedlings – Planting stock is prepared in the nursery. In nursery beds, seeds are dibbled 8 cm apart or broadcast thinly in February, and covered with leaf mould. Germination commences in 4 days and is complete within 2 months. Seedlings, 7.5 cm tall, can be pricked out in polythene pots. Seedlings reach plantable size in early July.
- **Tending** – Since it is a fast growing species, it requires little tending. Normal weeding-cleaning in the first year is adequate.

1.5 Injury/damage

The species is browsed by cattle and animals. It is liable to be blown down by wind. Sometimes it is badly affected by *Loranthus*.

1.6 General

It is a strong light demander. It is drought resistant, hardy, fast growing. It coppices freely. The **wood** is dark brown, hard, lustrous and durable. It is used for **house building, furniture, agricultural implements, rollers, canoes, boats, picture frames etc.** It is also useful for carving, internal decorations, paneling and flooring. The “Burrs” highly priced for making superior furniture and veneers. **The Bark** is used for tannin and dyeing. The **flowers, bark and the oil from the seed** find use in indigenous medicine.



Fig.2.1 *Albizia lebbek*

Source : <http://commons.wikimedia.org/>

2. *Alnus nepalensis* D.Don

Family: *Betulaceae*

Local name: Utis

2.1 Description

A. nepalensis is a deciduous large tree that reaches up to 30 m in height and 60 cm in diameter. The leaves are shallowly toothed, 7–16 cm long and 5–10 cm broad. Male flowers are in drooping catkins; females in axillary clusters. Fruits are cone-like, black, about 1.5 cm long. In the forest the bark has a dark green colour, and the tree is easily recognized. In open places it is generally silver-grey, resembling that of the birch. The stem is very cylindrical, tall, and grows very rapidly. The tree grows quickly and is sometimes planted as erosion control on hillsides and for land recovery in shifting cultivation. It tolerates a wide variety of soil types and grows well in very wet areas.



2.2 Distribution

It occurs in the middle hill forests (3-6000 feet) of north Bengal hills. It is common in Darjeeling. It is often found in second growth forests on landslides and in old cultivation, especially near streams.

2.3 Seed

Seeds ripen in December-January. One kg of fruit gives 100 gms of cleaned seeds. Seeds are light, and 5, 64,000 seeds make 1 kg. Fruits are collected by lopping the branches, dried in the sun, and then seeds are separated by beating with sticks. Viability of the seeds is short and seeds can be stored for 3 or 4 months.

2.4 Propagation

Artificial Regeneration

- Nursery work – Seeds are broadcast in shaded nursery beds in March; about 225 gms of seeds are required for each bed. Time taken for germination depends on altitude. In general, seeds take 4 to 6 weeks to germinate. Seedlings are pricked out and placed in polythene pots in July-August and planted out in the following rains. At altitudes below 1500 m, the germination is quicker, and seedlings can be pricked out under shade in May, and planted out the same year during the monsoon. Shades may be advantageously removed from the poly-pot beds after the plants have been under the shade for a short time. *Alnus nepalensis* fixes Nitrogen in root nodules with actinomycete *Frankia*. Nursery bed/potting mixture should incorporate soil from mature plantation of *Alnus* to provide necessary *Frankia* inoculants.
- **Transplanting** – Transplanting in the field is done during the first or second rains in standard pits at a spacing of 2m x 2m or 2.5 m x 2.5m. Natural seedlings, 15 cm to 23cm in height have been transplanted into plantation entire without the balls of earth in July and have been reported to give 75% success. The species should be planted in mixture in alternate lines with slower growing shade bearers.
- **Tending** – The plantation may be subjected to normal tending operations during the first three years. Being a fast growing species, no tending is required after the third year.

2.5 Injury/Damage

This tree is damaged by snow-breaks, frost and grazing. It is attacked by a *Lepidopterous* larvae which girdles the young tree. It is also susceptible to attack by stem borers *Batocera horsfieldii* and *B. numitor*. The species is also reported to have been attacked by defoliators.

2.6 General

Uti's plantation is sometimes found pure on land slips. It has been observed that sometimes the whole uti's crop has died out for reasons not known. Growth of pure Uti's plantation has also

been found to be non-uniform. After registering rapid growth in the initial stage the plantation's growth has been noticed to slow down and many pure plantations have been seen to die off. In natural forests *Utis* of any size is found, in scattered population, only in ravines and damp hollows near springs and streams. The preferred site for *Utis* plantation should be shady ravines and hollows and it should be planted in association with shade bearer species.

2.6.1 *Utis* wood is moderately soft. It is occasionally used for making boxes and in light construction, and as firewood.



Fig.2.2 *Alnus nepalensis*

(Source: <http://www.flowersofindia.net/>)

Reference Materials:

1. Cowan and Cowan 1979 The trees of Northern Bengal, International Book Distributors Dehra Dun
2. J. F. Dastur. *Useful Plants of India and Pakistan*
3. Ram Parkas 2007 Plantation and Nursery Technique of Forest trees
4. Forestry Nursery Manual of West Bengal 1994, Research and Working Plan Circle, WB Forest Directorate
5. Lesson 14 of Forest Botany
6. <http://www.forestrynepal.org/>
7. http://en.wikipedia.org/wiki/Alnus_nepalensis
8. Websites cited in the lesson





Lesson 3

Time 1 hour

Lesson Plan

Objective:

To study Silviculture of Trees

- Bamboo
- *Buchanania lanzan*

Backward linkage

- Study of Lesson 15 of Forest Botany

Forward linkage

- To see nursery and plantation during tour.

Training materials

- Copy of lesson 3 to be circulated beforehand

Allocation of time

- | | |
|-----------------------------|--------|
| • Bamboo | 25 mts |
| • <i>Buchanania lanzan</i> | 25 mts |
| • Miscellaneous /Discussion | 10 mts |



1. A general note on Bamboo

(Source: <http://www.bamboobotanicals.ca/html/about-bamboo/bamboo-flowering.html>;
Ram Parkas Plantation and Nursery Technique of Forest trees 2007)

1.1 Introduction

Bamboo is known as poor man's timber. It produces the maximum biomass per unit area and time among the forest plants. It is a popular farm forestry species as it is capable of generating quick income. About 130 bamboo species occur in India of which more than 50% are found in Eastern India. Bamboo has many uses, viz. food, fodder, fuel, fencing, paper pulp, housing, cottage industries etc.

1.2. Characteristic features

- Bamboos are tall arborescent (tree like) woody grasses; belong to the family *Graminae*. Most of the bamboos are hollow, often gregarious in habit.
- Bamboo has three parts – (1) leafy aerial part (culm), (2) rhizome and (3) roots. The rhizome and the roots are underground parts. Rhizome is underground part of the stem. True roots develop profusely from the closely spaced nodes of the rhizome and occasionally from the nodes of the culm.
- Rhizome buds develop into culms. Each internode is covered with a sheath.
- Since the culm has no terminal bud, there is no terminal growth. Culms grow in height due to successive elongation of the internodes. Daily increase in length of each internode is on an average 2.5cm. Generally 5-6 internode grow at a time.
- The flowering of a bamboo is a unique phenomenon and very rare occurrence in the plant kingdom. Most bamboos flower once every 60 to 130 years depending on the species. The long flowering intervals have no definitive explanation. However, not all bamboos exhibit the same flowering characteristics or patterns. Depending on the species, a bamboo can exhibit either gregarious flowering, or sporadic flowering. Gregarious flowering is when all populations of a particular species of bamboo flower all at once. For most species of bamboo, this can happen at intervals anywhere between 60 to 130 years. This flowering cycle is genetically pre-programmed into each species. Once a species reaches its life expectancy, the bamboo will flower and produce seeds. When a bamboo flowers gregariously, it expends a tremendous amount of energy producing flowers and seeds. The mass flowering stresses the bamboo to such an extent that it will die. Since rats eat the bamboo seeds, gregarious flowering of bamboos is often followed by increase in rat population creating the popular concept that gregarious flowering foretells famine. Sporadic flowering is when bamboo flowers sporadically or intermittently. Sporadic flowering is typically brought on by environmental factors rather than genetics. Unlike gregarious flowering, sporadic flowering does not happen on a mass scale and the bamboo seldom dies after flowering. It typically occurs on an individual or a group of plants from a localized area.



1.3. Propagation

Natural Regeneration - Bamboos regenerate naturally from seeds fallen on the ground following sporadic or gregarious flowering. The rhizome buds also throw up culms as annual shoots. The process continues till the clumps produce gregarious flowering and die.

Artificial Regeneration – Bamboos can be propagated artificially by direct sowing of seeds, by transplanting nursery raised seedlings, and by vegetative methods. The most common method of vegetative propagation is by rhizome planting. Other methods are layering, nodal cuttings and culm cuttings.

1.4. Congestion in bamboo clump

Bamboo clumps often suffer from mismanagement. Culms are indiscriminately cut from along the periphery of the clump; young shoots are browsed by the cattle or removed for food; living rhizomes are prevented from spreading outward. The rhizomes thus develop within the clump, and the new culms so produced create congestion. When congestion gets worse, the clumps become tangled mass of twisted and crooked bamboos. The bamboo clumps require proper management.

1.5. Management Practices

Bamboo forests are generally worked on culm selection-cum-thinning on a cutting cycle of 3-4 years. General rules are as follows.

- Immature culms less than one year old are not to be cut;
- In a clump containing 12 culms or more, at least 6 mature culms over one year old should be retained;
- Culms should not be cut below the second node, but in any case not higher than 30 cm from the ground level;
- No felling should be done during the growing season;
- Soil should be heaped around the developing clump to allow and ease shoot production, which takes place mainly in the periphery of the clump;
- No cutting should be done in the year of flowering; flowered clumps should be clear-felled after they have shed their seeds.

1.6 List of bamboo species recommended by National Bamboo Mission and raised in West Bengal:

(Source: National Bamboo Mission in Forest Areas of West Bengal, Monitoring Report 2007-08; http://www.westbengalforest.gov.in/publication_pdf/NBM_Report_07-08.pdf)



Sl. No.	Species	Local name
1	<i>B. balcooa</i>	<i>Bhalki bans / Boro bans</i>
2	<i>B. bambos</i>	<i>Kanta bans</i>
3	<i>B. nutans</i>	<i>Makla bans</i>
4	<i>B. vulgaris</i>	<i>Basin/ basni / kalai makla</i>
5	<i>Dendrocalamus asper</i>	
6	<i>D. giganteus</i>	<i>Koko / Bhalu bans</i>
7	<i>D. hamiltonii</i>	<i>Chawa bans</i>
8	<i>D. strictus</i>	<i>Jaw bans</i>
9	<i>Melocanna baccifera</i>	<i>Muli bans</i>

2. *Buchanania lanzan* Spreng

Syn. *B. latifolia* Roxb

Family: Anacardiaceae

Local names: Piyal, Chironji

2.1 Description

A tall tree; bark very characteristic, dark grey, divided by deep narrow cracks into small quadrangular plates. Leaves thick, leathery, oblong, glabrous, shining above, softly hairy beneath, 5-10 in. long. Flowers small, without stalk, greenish white, in large, dense, many flowered, branched panicles. Drupe black, sub-globose, 0.5 in. long. Seed stonehard.

2.2 Distribution

It occurs in wild (also available in plantation) in forests of south West Bengal. It is one of the common associates of Sal in the lateritic belt of south-west Bengal.

2.3 Seed

Fruits ripen in April-June, and are collected from the trees. Seeds are obtained after removal of pulp. Seeds are dried in shade and stored in airtight tins. The viability period of seeds is one year. Seed weight varies from 3000 – 5000 /kg. Germination capacity of fresh seed is about 70%.

2.4 Propagation

Natural Regeneration: In favourable conditions, natural regeneration appears in plenty with the break of rains.

Artificial Regeneration: Seeds are soaked overnight in cold water. Direct sowing of seeds in the field has been found to be successful. Seedlings may also be raised in nursery for subsequent transplanting in the field. Seeds are shown in polypots and are covered by a layer of hay. Germination starts in 15-20 days. Growth of seedlings is slow. Seedlings of one

or two seasons old may be transplanted in the field. Piyal is raised in small blocks of pure crop or in mixture with other species.

2.5 Tending

Regular weeding of sown lines or transplants is essential.

2.6 Injury /Damage

Parasitic plant like *Loranthus* is reported on Piyal trees. There are reports (i) of insect attack on flower buds, (ii) of attack by defoliators, and (iii) of attack by insects that feed on sap of leaves and shoots.

2.7 General

Piyal is moderate light demander, fairly drought resistant, and is a poor coppicer. The **bark** is used for tanning; both the **bark and the fruit** yield a natural varnish. **The fruit** is sweetish in taste and forms an important article of food amongst the tribes. The **seed** is an **important article of commerce**. It is used as a **substitute for almond in confectionery**. From the **seeds** are extracted a pale, straw coloured, sweet, aromatic oil, known as “**chironji oil**”. The plant has also **medicinal uses**.

2.7.1 It usually occurs as accessory species, main species being Sal. It is therefore worked as per management plan of the main species.



2.

3.

Source : www.mpbd.info

Source : www.mdcdevelopers.in

Fig.3.1 *Buchanania lanzan*



Reference Materials:

1. *J. F. Dastur. Useful Plants of India and Pakistan*
2. Ram Parkas 2007 Plantation and Nursery Technique of Foresttrees
3. Forestry Nursery Manual of West Bengal 1994, Research and Working Plan Circle, WB Forest Directorate
4. Lesson 15 of Forest Botany
5. Websites cited in the lesson



Lesson 4

Time 1 hour

Lesson Plan

Objective:

To study Silviculture of Trees

- *Casuarina equisetifolia*
- *Cryptomeria japonica*

Backward linkage

- Study of Lesson 15 of Forest Botany

Forward linkage

- To see nursery and plantation during tour.

Training materials

- Copy of lesson 4 to be circulated beforehand

Allocation of time

- | | |
|----------------------------------|--------|
| • <i>Casuarina equisetifolia</i> | 25 mts |
| • <i>Cryptomeria japonica</i> | 25 mts |
| • Miscellaneous /Discussion | 10 mts |



1. *Casuarina equisetifolia* Linn.

Family: Casuarinaceae

Local name; Jhau

1.1 Description

A large evergreen tree; bark scaly peeling off in vertical streaks; the ends of branches densely bearing numerous, long, filiform (thread like), slender, green, jointed, pendulous branchlets. Flowers are unisexual, both sexes borne on the same individual. Fruit ovoid or globose, small.

1.2 Distribution: Casuarina is an exotic to mainland India. *The native range of Casuarina equisetifolia includes Malaysia, southern Asia, Australia and Oceania (the islands of the Pacific between Asia and the Americas).* (http://www.sms.si.edu/irlspec/casuarina_equisetifolia.htm) Widely distributed along the sea coasts of India; very common in coastal forests (plantations) of West Bengal.

1.3 Seed

It flowers twice a year, February to April and September to October. Correspondingly, there are two distinct fruiting periods, June and December. Ripe cones are collected from underneath the mother trees or by lopping the trees. Cones are dried in the sun; winged seeds are shed after 3-4 days, are then separated and clean seeds are dried for 2-3 days. Seeds are very minute; one kg of seeds may contain about 6 to 10 lakh seeds. Seeds are sown as early as possible, as seed viability is short. Germination percent is about 50 to 70.

1.4 Propagation

Natural Regeneration: Natural regeneration from seed is poor both in coastal and inland plantations.

Artificial Regeneration: Though direct sowing is possible, better results are obtained with transplanting of nursery-raised seedlings. Casuarina fixes Nitrogen in root nodules with actinomycete Frankia. So nursery soil may be inoculated with soil collected from under casuarina plantations. Gammexane sprinkled around beds to ward off ants. Seed is sown broadcast about 10 gms/m², and lightly covered. Beds are mulched with straw and watered till germination is complete in 20-30 days, when mulch is removed. Seedlings are ready for planting out in 5-6 months when 35-45 cm tall. Transplanting 3-month old seedlings (22-30 cm tall) without ball of earth in thalis has also been reported to be successful. Seedlings in tiny stage may also be pricked out in polythene pots for planting out in field when the seedlings attain proper height. Transplanting (seedlings with naked roots or in polypots) is done at a spacing that may vary from 1mx1m on good soil to 4mx4m on poor sites.

1.5 Tending

Weeding-cleaning is to be done as required. When the purpose of raising the plantation is to obtain fuelwood, it is worked on short rotation of 6-8 years and no thinning is necessary. For production of pole and timber, the plantation is worked on a longer rotation (15 years) and intermediate thinning at 4-6 years is necessary, as *Casuarina* is a strong light demander.

1.6 Injury/ Damage

The seeds are vulnerable to damage by ants. *Arabela tetraonis*, bark eating caterpillar, and *Coelsterna scabrata*, long antennae beetle, are the worst insect pests of *Casuarina*. *Phasus malabaricus* bores into the stem. *Trichosporum vesiculosum* is a serious root-rot fungus that attacks *Casuarina*. *Fomes badius* causes heart rot.

1.7 General

The species is very **suitable as a vegetal cover in coastal areas** and for **reclamation of sand dunes**. The long straight **stem** is in good demand for use as **beams, posts, rafters, mine props, masts of country boats**. The **timber** is useful for making **oars, yokes** and felloes (circular rim) of wheels. The **wood** is also in great demand for use as **fuel**.

The **bark** contains 6-18% **tannin**, and is used for **tanning and dyeing** fishing nets brown, and also for tanning leather. The **astringent bark** has medicinal uses.



(Source: Photo courtesy Shri T K Das WBFS)

(Source: pt.wikipedia.org)

Fig. 4.1 *Casuarina equisetifolia*



2. *Cryptomeria japonica* (Lf) D. Don

Family: Cupressaceae

Local name: Dhupi

2.1 Description

Cryptomeria japonica is an evergreen tree that grows to a height of 35-60 m and attains a bole diameter of 1-3 m. Trunk straight, in old trees massive, buttressed; bark thin on young trees, smooth, purplish-brown, on large trees 2-3 cm thick, reddish-brown, weathering grey, exfoliating in long, shredding strips. Branches spreading to assurgent, forming a conical crown in young trees, self-pruning to leave a clear bole in large trees. Branch foliage dense, with leaves lasting 6-12 years, shedding not individual leaves but ultimate lateral branchlets. (Source: <http://www.worldagroforestry.org/>).

2.2 Distribution

Indigenous to Japan the plant was introduced in India in 1844, and planted in the hills of Eastern Himalayas-Darjeeling and Shillong where it is thriving between 1200 m and 1800 m. Extensive plantations of pure *Cryptomeria* are found in Darjeeling hills.

2.3 Seeds

Cones ripen in July-August at lower elevation and somewhat later at higher elevation. Cones are collected off the trees by lopping branches from end-October to December. Cones are dried in sun and gently threshed to obtain seeds. About 13 kgs of cone (1650 cones per kg) give 1 kg of clean seed. Seeds are minute, about 3, 25,000 to 3, 50,000 seeds weigh 1 kg. Germination capacity is about 80%. Seeds need no pre-sowing treatment.

2.4 Propagation

Natural Regeneration: It is found to have profuse natural regeneration in north Bengal hills. Light ground cover, not-too-dense humus and light canopy help natural regeneration.

Artificial Regeneration: It is raised by planting out nursery raised entire plants with or without a handful of earth around roots in June of the second or third year, in patches spaced 0.9 m x 0.9 m or 1.2 m x 1.2 m. Cold weather planting in December and January with 2-year old plants has also been reported to be successful.

Seeds are sown broadcast, mixed with ash, fine earth or leaf mould in shaded beds in February. The beds are often covered with brushwood to hasten germination. Germination is complete in 3 to 4 weeks. Watering in nursery beds is done daily, but less frequently in pricking out beds. Being slow in growth in nursery, seedlings are kept in the nursery for 1 year, and more often for 2 years before planting out. Seedlings are pricked out in shaded beds at 8 cm x 8 cm or 10 cm x 10 cm spacing in June of the first year. If the seedlings are planned to be kept in the nursery

for more than 2 years, pricking out should be done in beds 15 cm x 15 cm. Shades are removed from the pricking out beds after about 3 months.

2.5 Tending

Too much cleaning of undergrowth in exposed position is harmful. It has been planted in mixture with *Alnus nepalensis* and *Michelia excelsa* in alternate lines 2 m apart. Thinning has to be delayed till about 25th year.

2.6 Injury/damage

In the nursery, insects destroy the seedlings by gnawing them at ground level. The seedling are sometimes damaged by frost. Larvae of a species of Cossidae bore galleries through or around the stem.

2.7 General

A fast growing species *Cryptomeria* coppices well (unusual for a conifer). It is moderately frost resistant, fire-tender and shade-tolerant exotic; not resistant to drought. It is worked under clear-felling system with artificial regeneration by planting.

Timber is soft, straight-grained and fragrant. It produces excellent tea boxes; is very useful as general purpose timber; suitable for pulp, clipboards, packing cases, cheap planking etc. Timber produced here is far inferior in quality to that produced in Japan.

The species is very useful and hardy for beating up blanks in old plantations. However, large scale mono-crop of *Cryptomeria* is no longer encouraged now. Rather blanks in *Cryptomeria* plantations produced naturally or by regulated felling are now planted with indigenous broad-leaved species.



Fig.4.2 *Cryptomeria japonica* (Source:<http://luirig.altervista.org/>)



Reference Materials:

1. *J. F. Dastur. Useful Plants of India and Pakistan*
2. Ram Parkas 2007 Plantation and Nursery Technique of Forest trees
3. Forestry Nursery Manual of West Bengal 1994, Research and Working Plan Circle, WB Forest Directorate
4. Lesson 15 of Forest Botany
5. Websites cited in the lesson



Lesson 5

Time 1 hour

Lesson Plan

Objective:

To study Silviculture of Trees

- *Eucalyptus*
- *Gmelina arborea*

Backward linkage

- Study of Lesson 16 of Forest Botany

Forward linkage

- To see nursery and plantation during tour.

Training materials

- Copy of lesson 5 to be circulated beforehand

Allocation of time

- | | |
|-----------------------------|--------|
| • <i>Eucalyptus</i> | 25 mts |
| • <i>Gmelina arborea</i> | 25 mts |
| • Miscellaneous /Discussion | 10 mts |



1. Eucalyptus sp.

Family: Myrtaceae

Local names: Eucalyptus

1.1 Description

Some 170 species, varieties and provenances of eucalyptus have been tried in India, of which the most outstanding and favoured has been the ***E. hybrid*, a form of *E. tereticornis***. Other species which are grown on plantation scale are *E. grandis*, *E. citriodora*, *E. globulus*, and *E. camaldulensis*.

A tall Tree - erect single-stemmed woody plant with various crown forms.

Each year there is an increment of living **bark** that results in the continual expanding girth of the tree. In all species the outermost layer dies each year. In about half of the species this dead layer completely sheds, exposing a new layer of living bark, and the process continues year after year. These are known as the smooth barks. Often the dead bark comes off in pieces at various times of the year such that the trunk is mottled depending on the amount of time the newly revealed patches of bark are exposed to weathering. Most species have **lanceolate or falcate (curved) and odorous leaves**. The leaves have oil glands (Source: <https://www.anbg.gov.au/>). The woody **fruits** or **capsules** are roughly cone-shaped and have valves at the end which open to release the **seeds**, which are waxy, rod-shaped, about 1mm in length, and yellow-brown in colour. Most species do not flower until adult foliage starts to appear (Source; <http://en.wikipedia.org/>)

1.2 Distribution

Eucalyptus is an exotic species from Australia. Eucalyptus plantations have been raised in West Bengal since 1960s on laterite soils of South and South Western Districts. It has also been a popular farm forestry crop.

1.3 Seed

***E. tereticornis* (Syn *E.hybrid*)** seeds twice a year, once in autumn (October-November) and next in summer (May-June). The summer collection gives cleaner seeds. From the age of 5 years trees seed profusely. Seeds are collected from seed orchards or superior standing trees. Seeds are very minute. About 3,50,000 to 3,65,000 seeds weigh 1 kg. Viability of seeds is 6 to 12 months. Germination capacity of fresh seeds is as high as 90%.

1.4 Propagation

It is propagated artificially. The most common method is planting of nursery seedlings raised in polythene pots or hykopots. In south-west Bengal laterite tract, the practice is to transplant potted seedlings at a spacing of 2.5 m x 2.5 m. Large scale plantations are raised in this laterite zone. While a major part of planting stock is produced out of seeds, vegetative production of

clonal stock by stem cutting of certified superior clones of the species is now a regular practice in south west Bengal. Every year a part of Eucalyptus plantation raised is clonal plantation.

Regarding preparation of clonal stock by stem cutting, it is advised to please go through Lesson 12 of Forest Botany. For raising potted seedlings (out of seeds) the standard procedure adopted in nursery is described below.

1.4.1 Seeds mixed with sand are sown in mother beds in January-March and covered with hay. Time of sowing depends on time of planting and the size of plants required. Beds are watered cautiously by sprinklers or automisers, frequently but lightly. Germination takes place within 5-15 days when thatch is removed. Seedlings are pricked out into polythene pots (or hykopots) when about 10 cm tall, normally 4-6 weeks after germination. Polythene pots are placed in sunken beds. Lately, however it is advised to use raised beds, made of bamboo or iron frame, to contain the polythene pots (or hykopots). Eucalyptus plants attain plantable size in 3-4 months time.

1.5 Tending

At least 3 weeding-cleaning may be necessary in the first year. Tending in fewer frequencies may be required in the second and third year.

1.6 Injury/Damage

Young seedlings in nurseries are liable to damage by rain, strong sunlight and hot winds. In the lateritic zone of south-west Bengal, termites pose a major hazard to young seedling in the field. In south West Bengal, Eucalyptus plantations, on a large scale, were infected by galls in recent past. Galls are abnormal outgrowths of plant tissues and are caused mostly by insects. Often the phenomenon of gummosis – exudation of gum on the outside of the stem- is observed. It is the manifestation of injury to cambium by fire, fungal, termite or borer attack.

1.7 General

In south-west Bengal, in the last few decades Eucalyptus formed a major component of miscellaneous crop in plantations. Such plantations are now worked on a rotation of 12 years. Rotation adopted for Eucalyptus clone plantations is only 7 years. Eucalyptus is a good coppicer and can be regenerated conveniently by coppicing for 3-4 rotations.

The most important characteristics of *E. hybrid* contributing to its popularity under Indian conditions are: it is **fast growing**, capable of overtopping weeds, **coppices well**, is fire hardy, browse-resistant and it has the ability to adapt to a wide range of edaphoclimatic conditions. One of the most important uses of eucalyptus wood so far has been in the paper and pulp industry. The demand for paper and pulp is going to increase many fold in India and eucalyptus, being one of the good pulpwood materials, will be in continuing demand.





(Source: <http://dir.indiamart.com/>)

Fig.5.1 Plantation of Eucalyptus.

2. *Gmelina arborea* Linn.

Family: Verbenaceae

Local names: Gamar, gamari, khamari

2.1 Description

A moderate sized or large deciduous tree; bark grey or brownish white, exfoliating in small scales. Stem rather irregular, but cylindrical. Bark light grey coloured exfoliating in light coloured patches when old. Leaves opposite, broadly ovate or cordate, entire or dentate (toothed margin), having two glands at the junction of the petiole. Flowers in a terminal yellowish, tomentose panicle; corolla brownishyellow.

2.2 Distribution

Found in the mixed plains forest and lower hill forests of north Bengal.

2.3 Seed

Seed time in Northern Bengal is second week of April to end-May, and in Southern Bengal May to second week of June. 1 kg of fruit yields 62 gms of clean seeds; 12500 seeds weigh 1 kg. Fruits are collected from the clean swept forest floor. Brown fruits are the best; black and green fruits should not be collected. Fruits are heaped under shade or buried in pits for 4-5 days for the pulp to rot, which is washed off with water. Seeds are dried in the sun for 2-3 days. Germination percent varies widely from 13% to 90%.

2.4 Propagation

- **Artificial regeneration** – Gamar can be raised artificially by direct sowing, planting out nursery raised seedlings or stump planting.

Seeds can be dibbled direct in lines 15cm apart and 10-20 cm apart in the lines. The species is not tried pure, and rather put out in mixture with other species of comparable growth.

In order to do planting with nursery stock, seeds are sown in drills in nursery beds; shading is not necessary. Beds are regularly watered and weeded; germination starts in 2-3 weeks. Seedlings are pricked out to polypots, and planted out in the second rains after pruning the stem.

2.5 Tending

Weeding is very important in the first two years. Besides, the seedlings also need cleaning/thinning from the third year. Heavy D-grade thinning is normally recommended as it is a strong light demander.

2.6 Injury/Damage

Seedlings are hardy against drought and frost. But the regeneration is prone to following damage:

- Seeds are eaten away by squirrel;
- Saplings are browsed by deer and cattle;
- Attack by boring insects and white ants;
- Attack by the parasitic plant *Loranthus*
- Attack by fungi.

2.7 General

Gamar coppices well. It is advisable to grow it in mixed rather than pure plantations.

The **wood** is yellowish white, strong, light, and is easily worked and does not warp. Wood is used for various purposes, namely, planking, furniture, cabinet work, paneling, agricultural implements etc. It is one of the best of the lower hill timbers. The wood is particularly suitable for match sticks, inside boxes and peeling purposes.





(Source:<http://www.agbiotek.com/>; https://www.flickr.com/photos/shubhada_nikharge)

Fig.5.2 *Gmelina arborea*

Reference Materials:

1. *J. F. Dastur. Useful Plants of India and Pakistan*
2. Ram Parkas 2007 Plantation and Nursery Technique of Foresttrees
3. Forestry Nursery Manual of West Bengal 1994, Research and Working Plan Circle, WB Forest Directorate
4. Lesson 16 of Forest Botany
5. [Eucalyptus in India - R.M. Palanna, at http://www.fao.org/docrep/](http://www.fao.org/docrep/)
6. Websites cited in the lesson

Lesson 6

Time 1 hour

Lesson Plan

Objective:

To study Silviculture of Trees

- *Lagerstroemia parviflora*
- *Michelia champaca*

Backward linkage

- Study of Lesson 16 of Forest Botany

Forward linkage

- To see nursery and plantation during tour.

Training materials

- Copy of lesson 6 to be circulated beforehand

Allocation of time

- | | |
|-----------------------------------|--------|
| • <i>Lagerstroemia parviflora</i> | 20 mts |
| • <i>Michelia champaca</i> | 30 mts |
| • Miscellaneous /Discussion | 10 mts |



1. Lagerstroemia parviflora

Family: Lythraceae

Local name: Sidha

1.1 Description

It is a large deciduous light demanding tree. Bark is light brown, peeling off to leave lighter patches. Leaves are opposite, 5-10 cm long, stalkless or on very short stalks. Flowers are small white, fragrant, in panicles in the leaf axils or at the ends of the branches. Fruit is oval, about 2 cm long; base enclosed in a cup formed by the persistent calyx. (<http://www.forestrynepal.org/resources/trees/lagerstroemia-parviflora>)

1.2 Distribution

It is very common in Sal forests of Darjeeling and Jalpaiguri district and also in Sal forests of South-West Bengal.

1.3 Seed

Fruits (capsules) ripen in December-February and are collected before they open. They are dried in the sun, and the seed extracted and cleaned. Viability is 6-12 months. Seed weight varies from 28200 to 56400/kg. Germination capacity is very poor and is about 5% only

1.4 Propagation

- Natural regeneration – It likes porous bare soil, and natural regeneration comes up profusely in the Sal forests of Northern Bengal. Factors favourable to natural regeneration are (a) seedlings are not browsed, and have good power of recovery from frost, fire and drought; and (b) the tree coppices and pollards vigorously.
- Artificial regeneration- It can be raised by planting nursery raised seedlings and stumps. Twelve to fifteen months old seedlings are planted out in July-August. Stumps prepared from one or two year old plants can also be planted.

1.5 Tending

Normal weeding and cleaning are required in early stages. Since the species is a light demander, adequate thinning from pole stage onward facilitates its growth.

1.6 Injury/Damage

Sidha tree is sometimes attacked by defoliators, borer insect and the lac insect. The tree is also attacked by a number of fungi.

1.7 General

It is a good timber tree if used indoor. The wood is used for door-window frames, as posts, beams, and for agricultural implements. Wood is good for fuel and charcoal. It is a good tasar host plant. The tree is managed as an accessory to species of greater value like Sal and Teak, and treated along with them.



Fig. 6.1 *Lagerstroemia parviflora*

(Source:

http://www.nrsc.gov.in/Earth_Observation_Applications_Environment_Flora_Shadnagar_Conclusions.html)

2. *Michelia champaca* Linn.

Family: Magnoliaceae

Local names: champ, champaka

2.1 Description

A large evergreen tree; stem very cylindrical. Bark dark grey, smooth. Leaves ovate, lanceolate, entire, shining above, blade 8-10 in long. Sapwood yellow soft, heartwood light olive-green with narrow medullary rays, rather large pores, and very distinct annual rings, very durable. Flowers axillary, yellow, strongly scented. Capsules thick, grey-ovoid.

2.2 Distribution

The tree is characteristic of moist evergreen forests, extending into semi-evergreen forests, and occasionally into moist Sal forests. It occurs in the lower hill forests (from the plains upto 3000 feet) of north Bengal. It is raised artificially in mixture with other species.

2.3 Seed

Large, scented yellow flowers appear in the hot and rainy season. Fruits ripen in August or later. Good seeding is expected every year in West Bengal. The best time for collection of seeds is end August to early September. Fruits are heaped in the shade for 2-3 days until they open



completely. Seeds are then removed by gentle beating, red pulp is washed off in water, seeds are then spread out to dry under shade (**never in the sun**). As they lose viability rapidly, seeds cannot stand storage, and should be sown as soon as possible. Number of seeds per kg varies from 14320 to 17290. Germination capacity is in the range 70-80%.

2.4 Propagation

In West Bengal, though some amount of natural regeneration has been reported, the normal practice of propagation of the species is through artificial regeneration.

Artificial regeneration: The most successful method of propagating Champ is by transplanting nearly one year old plants, raised in the nursery, with ball of earth around roots or preferably in polythene pots. Seeds are sown in August-September in shaded nursery beds, either broadcast or in drills 8-10 cm apart, with a thin layer of earth spread over the seeds. The beds may be covered with thatch grass or brushwood to hasten germination. It is desirable to mix seeds with red lead to prevent attack by red ants and rats. Germination starts in 10 to 14 days and may continue upto several months. Since the plant grows very fast in the nursery, it is necessary to retard the growth so that seedlings may be kept in the nursery for a period of about one year. Very little or no manure is applied to the beds; watering frequency is heavily reduced after seed germination. Pricking out is done 10 cm x 10 cm, or 15 cm x 15 cm, if it is planned to transplant seedlings with ball of earth. Otherwise, seedlings may be pricked out in polythene pots kept preferably in raised beds. Transplanting is done in June in the break of rains.

2.5 Tending

Weeding is required upto second or third year, after which the crop closes up rapidly. Champ grows fast and in a well stocked plantation the first thinning may be done in the fifth year.

2.6 Injury/Damage

The plant is very sensitive to fire, even large tree may suffer casualty by low ground fire. Parrots and other birds devour the seeds. Deer damage the bark and browse young plants. Champ is liable to attack by several insects. *Urostylis punctigera* is a serious pest of pure plantations. Leaves attacked by *Urostylis wither* and the branches fall off. Another pest (identified as *Thysanoptera*) which causes browning and dying off of leaves and twigs has been noticed in the plantations, though the latter have been reported to have recovered.

2.7 General

In recent years in north Bengal, Champ is generally not raised as a pure crop, but planted along with other species in the miscellaneous lines in Sal plantations, or in miscellaneous plantations. Spacing of miscellaneous crop of which Champ is a component is 2m 2m.

2.7.1 It is a tall handsome, evergreen tree; very fast-growing, frost-hardy, firesensitive.

The timber is lustrous, smooth, easy to saw, peels easily into excellent veneers. Timber is very suitable for light furniture and all indoor works, for grade - I commercial plywood, for heavy packing cases, boxes, pencils etc. It is widely used for general joinery and carpentry works, cabinet making, boat building etc.

The **flowers** on distillation produce “Champaca oil” of commerce.
The **leaves, bark, roots and flowers** have medicinal use.



(Source: <http://en.wikipedia.org/wiki/Michelia>)



(Source: http://www.biotik.org/india/species/m/michcham/michcham_01_en.html)

Fig.6.2 Michelia champaca

Reference Materials:

1. J. F. Dastur. *Useful Plants of India and Pakistan*
2. Ram Parkas 2007 *Plantation and Nursery Technique of Forest trees*
3. *Forestry Nursery Manual of West Bengal 1994*, Research and Working Plan Circle, WB Forest Directorate
4. Lesson 16 of *Forest Botany*
5. Websites cited in the lesson





Lesson 7

Time 1 hour

Lesson Plan

Objective:

To study Silviculture of Trees

- *Pongamia pinnata*
- *Schima wallichii*

Backward linkage

- Study of Lesson 16 and 17 of Forest Botany

Forward linkage

- To see nursery and plantation during tour.

Training materials

- Copy of lesson 7 to be circulated beforehand

Allocation of time

- | | |
|------------------------------|--------|
| • <i>Pongamia pinnata</i> | 25 mts |
| • <i>Schima wallichii</i> | 25 mts |
| • Miscellaneous / Discussion | 10 mts |



1. *Pongamia pinnata* Linn.

Syn. *P. glabra* Vent.

Family: Leguminosae

Local name: Karanj

1.1 Description

A medium sized, almost evergreen tree, bark soft grey, covered with tubercles (rounded nodules); crown rounded. Leaves odd-pinnate, glabrous, bright green; leaflets 5-9 opposite, shining on both surfaces, ovate or elliptic. Flowers purple and white in axillary racemes. Pods woody, glabrous, oval-oblong, with a short decurved lateral beak.

1.2 Distribution

Found in hotter lateritic zones of south West Bengal.

1.3 Seed

Flowers appear in April to July; pods ripen in February to May in the following year. Ripe pods are collected off the trees in April-June, dried in the sun. Seeds are collected from the pods by light hammering or pressing a knife along the sutures. Weight of dry fruits is 460-530/kg, that of dry seeds 810-1410/kg. Germination capacity is 60-89%. If stored carefully, the seeds remain fertile for about a year. Pre-sowing treatment of seeds is not necessary, though cold water treatment for 24 hours may be helpful.

1.4 Propagation

Natural Regeneration: Karanj regenerates naturally in the forests in abundance. It also coppices and sends out root suckers. However, the usual practice of propagation is through artificial regeneration.

Artificial Regeneration: It can be raised by direct sowing, transplanting of nursery prepared seedlings, or stem cutting. The common practice, however, is to prepare seedlings in the nursery and use them as planting stock.

Direct sowing: Seeds can be sown direct in the previously prepared patches or lines in June at the break of rains.

Transplanting of nursery stock: Seeds are sown in polythene pots in July. Germination starts after about 10 days and completes in about a month. Seedlings attain a height of about 60 cm by the beginning of next rainy season, when they may be planted out in the field. Planting stock may also be prepared from stem cuttings. Semi-hardwood stem cuttings of 1-2 cm diameter and 15-25 cm length can be used for making the stock. The root initiation and sprouting of cuttings can be induced by soaking them in 800 ppm of IBA or NAA. In south-west Bengal forests, Karanj is planted in mixture with other species at a spacing of 2.5 m x 2.5 m.

1.5 Tending

Weeding-cleaning is normally guided by the requirements of the miscellaneous plantation of which Karanj normally becomes a part. However, weeding-cleaning is normally done in the first three years of plantation – thrice in the first year and fewer in the next two years.

1.6 Injury/Damage

Larvae of several insects are reported to cause damage to seeds, flowers, foliage and branches.

1.7 General

Wood is moderately hard, but not durable. It is used for building purposes, ploughs, combs, yokes, fuel etc.

The **ash of the wood** is used for dyeing.

The **bark** yields a coarse fibre.

The plant, however, is known for the oil extracted from its **seeds**. The villagers use the oil as illuminant and insecticide. It is also used in soapmaking.

Karanj is now considered to be one of the potential sources of bio-diesel production, which requires to be explored.



(Source:<http://www.jatropha.pro/pongamia>)

Fig.7.1 *Pongamia pinnata*

2. *Schima wallichii* Choisy

Family: Theaceae

Local name: Chilaune

2.1 Description

A medium to large evergreen tree growing upto 60-100 feet. Bark dark grey with deep vertical clefts. Blaze red, juicy.



Leathery leaves are elliptic-oblong in shape and look somewhat like Champa (*Michelia*) leaves. Leaf margins are entire or slightly toothed. Flowers white, fragrant, 3-4 cm across. Sepals rounded. Five white petals are broadly ovate and rounded. There is a dense bunch of orange-yellow stamens in the center. (Source: <http://www.flowersofindia.net/>).

2.2 Distribution

Schima grows in moist and dry evergreen as well as in mixed deciduous forests. Found in the Sal forest and mixed forest in the Terai, Duars, and in the lower and middle hill forests of north Bengal.

2.3 Seed

Flowering occurs in April-May; fruiting is in February-March. Fruits are placed in the sun for a few days, until they open. Then the seeds can be shaken out, or extracted by gentle threshing. According to most literature, viability of the seed is short, and it should be sown immediately after collection. Seed weight is about 352 seeds per gm.

2.4 Propagation

The usual method of propagation is by artificial regeneration.

Artificial Regeneration: Soon after collection, the seeds are sown in nursery beds under shade. Germination capacity is very poor (about 5%) and commences in three weeks. The seedlings should be pricked out into polythene pots when the seedlings are 5-8 cm high. The seedlings are transplanted in June-July the same year in thalis when the seedlings are 10-15 cm high. Seedlings can be maintained in polythene pots of appropriate size for over a year for transplanting in the next monsoon.

2.5 General

In north Bengal, Chilaune is raised in mixture with other species in the miscellaneous lines in Sal plantations, or in miscellaneous plantations. Spacing of miscellaneous crop of which Chilaune becomes a component is 2 m 2 m.

2.5.1 The plant has a fast growth even under infertile soil conditions. The main value of the plant is its hard and durable **timber**. Timber is used for fence posts and beams and boards for house construction. (Source: <http://www.flowersofindia.net/>).

Good-quality **plywood** can be manufactured from the wood, and it is suitable for the production of wood-wool boards. **Bark** is used for dyeing and its tannin is used in processing skins. Leaves also contain tannin but not in quantity enough for economic use in tanning. (Source: <http://www.worldagroforestry.org/>)





(Source:<http://www.flowersofindia.net/>)

Fig.7.2 *Schima wallichii*

Reference Materials:

1. *J. F. Dastur. Useful Plants of India and Pakistan*
2. Ram Parkas 2007 Plantation and Nursery Technique of Forest trees
3. Forestry Nursery Manual of West Bengal 1994, Research and Working Plan Circle, WB Forest Directorate
4. Lesson 16 and 17 of Forest Botany
5. <http://www.forestrynepal.org/resources/trees/schima-wallichii>
6. Karanja, A potential source of biodiesel, R.S Kureel et al (<http://www.novodboard.com/karanja%20english.pdf>)
7. Websites cited in the lesson





Lesson 8

Time 1 hour

Lesson Plan

Objective:

To study Silviculture of Trees

- *Shorea robusta*
- *Tectona grandis*

Backward linkage

- Study of Lesson 17 of Forest Botany

Forward linkage

- To see nursery and plantation during tour.

Training materials

- Copy of lesson 8 to be circulated beforehand

Allocation of time

- | | |
|-----------------------------|--------|
| • <i>Shorea robusta</i> | 25 mts |
| • <i>Tectona grandis</i> | 25 mts |
| • Miscellaneous /Discussion | 10 mts |



1. *Shorea robusta* Gaertn.F.

Family: Dipterocarpaceae

Local name: Sal

1.1 Description

A large gregarious tree. Bark brown, thick with deep longitudinal cracks. Leaves long, broad ovate. Flowers yellowish, on short stalks, calyx and petals softly grey tomentose outside, petals orange inside. Wood pale brown, darkening on exposure.

1.2 Distribution

Gregarious in the laterite tracts of south West Bengal, in the well drained land in the Terai and the lower hill forests upto 3000 feet in north Bengal. Sal requires well drained sandy loam soil with water retention capacity of 85%. Soil with pH value between 5.6 and 7.8 is best suited for Sal.

1.3 Seed

Flowers appear from late February to April depending on locality and season. Seeds ripen from end May to early June in the plains of north Bengal and south West Bengal, and from mid-June to early July in Tista valley. Weight of seed varies from 880 to 1060 seeds (with wings) per kg. In north Bengal, poor seed years are not uncommon. In fact, in every 6/7th year, it becomes difficult for a forest division to have adequate Sal seeds for all plantations. Seeds should be collected from healthy plus trees or well maintained seed stand. Sal seed loses viability rapidly. Seeds can be stored for 3 or 4 days, may be upto a week, but it is always advisable to sow as soon after collection as possible. Sound fresh seeds have high germination capacity. In North Bengal germination capacity in the range 75 to 90 % has been observed.

1.4 Propagation

The issue of natural regeneration of Sal has engaged the attention of foresters for a long time. Following various experiments it appears that all the attempts to obtain natural regeneration by manipulation of various site factors, have not been successful. Even such results as can be considered positive do not commensurate with the efforts and expenses involved. The common and easy practice has therefore been propagation through artificial regeneration.

Artificial regeneration

In North Bengal Sal is regenerated in clear felled coupes by direct sowing. Seeds are sown on cloudy days when the ground is moist, preferably after rain. Seeds are dibbled with wings sticking up in hoed up lines 30 cm wide. Prescription in Sal plantation is to sow eight lines of Sal alternated by eight lines of Sal associates. Each Sal line (30 cm wide) consists of 3 rows of seeds, the rows being 15 cm apart. Seeds are dibbled 8 cm apart in each row. Sowing of one row is completed first, then followed by sowing in the second and third rows in that order. Since germination capacity is not uniform over the seed time which lasts about 3 weeks, this method

is adopted to ensure equal chance of regeneration throughout the area. The seeds are covered with a light layer of soil. Germination is complete within a week. According to 2012 revision of Working Plan of Baikunthapur Division and Wildlife III Division, Sal plantations are to be worked on a rotation of 50 years under the silviculture system of clear felling followed by artificial regeneration.

In south west Bengal, Sal lies in degraded condition over a large area. A major part of Sal area is managed and regenerated by the method of coppicing. The purpose of Sal coppice forest in south west Bengal is to produce pole crop. It is managed on a rotation of 15 years. The crop is thus felled every 15th year, and one or two healthy shoots from a stool are allowed to grow to pole. Regeneration in Sal coppice forests is thus comparatively easier and less cost intensive. However, where Sal stumps do not have living root stock and thus fail to throw up coppice shoots, such areas are taken up for planting with Sal and its associates. The planting stock consists of nursery raised seedlings. Seeds are sown in polythene pots or hykopots immediately after collection. The pots are placed preferably on raised beds to facilitate air pruning and eliminate the phenomenon of root coiling. Seedlings established in polypots/hykopots can be planted during the same monsoon (provided the seedlings are tall and established), or preferably in the next year.

1.5 Tending

Sal requires intensive tending for establishment of seedlings. These operations involve weeding, cleaning, hoeing, shrub-climber cutting, fencing, and fire protection etc. at various stages. In north Bengal, Sal plantations are seriously affected due to suppression by weeds and climbers. It has therefore been customary to sow Sal with taungya crops between the lines. The taungya crops include cotton, paddy, brinjals, chillies etc. Growing of taungya crop by the villagers requires intensive weeding, and therefore automatically takes care of the menace of suppression by weeds. Even otherwise Sal plantation in north Bengal requires at least 5 weeding/ cleaning during the first year, and such weeding/ cleaning should continue, though on a less frequency, upto 5 years. The plantations are required to undergo thinning, and prescriptions in 2012 WP revision for Baikunthapur Division and Wildlife III Division are: mechanical (C grade) thinning in 5th year and silvicultural thinning in 10th, 25th and 35th year.

In south west Bengal, Sal plantations, raised with seedlings, suffer most from moisture stress during the dry season and biotic damage. The key to successful establishment of Sal seedlings lies in (i) providing fencing to the young plantation for a couple of years, and (ii) making provision of irrigating the Sal blocks in the first two years during the dry season. Normal weeding/cleaning should continue in the first few years.



1.6 Injury/Damage

Sal crops, young and old, are liable to damage by drought. Obnoxious weeds such as *Mikania*, *Eupatorium* and *Lantana* are serious threats to young seedlings of Sal. Sal is also very vulnerable to attack by climbers. In North Bengal, freeing sal crops from climbers forms a routine periodic practice. Wild animals like elephants, bison, pigs, deer, monkeys and rats cause damage to Sal crops at various stages. A large number of borers of bark and wood, defoliators, sap suckers, fruit and seed eaters have been recorded. The most destructive is Sal heart wood borer, *Hoplocerambyx spinicornis*. Serious epidemic attacks by this beetle have been reported from various part of the country. Please consult **lesson 9 of Forest Protection**. Sal is also vulnerable to damage by a large number of fungi.

1.7 General

It is the predominant forest tree and the largest source of forest revenue in the state. **Wood** is very durable and is used for building bridges, for railway sleepers. Resistant to attack of white ants it is in great demand for construction works, mine props, piles, boat building, well construction; the wood is also used for furniture, tent poles and pegs, carriages, wheels etc. It is good firewood and makes very good charcoal.

The **leaves** are made into plates which are in good demand in the market. The well-known 'sal butter' is extracted from the **seeds**; it is used as a luminant, a substitute for butter in chocolates, and as cooking agent.



Source: <http://www.panoramio.com/>



Source: <https://www.flickr.com>

Fig.8.1 Shorea robusta

2. *Tectona grandis* Linn.f

Family: Verbenaceae

Local name: Segun, Teak

2.1 Description

A large deciduous tree. Bark light brown or grayish, peeling off in thin layers. Leaves large obovate-elliptic, stellately yellowish, tomentose beneath. Flowers white, shortly stalked, numerous in terminal large panicles of cymes. Fruit sub-globose, enclosed in the inflated calyx.

2.2 Distribution

Indigenous in the central and southern part of India. Planted extensively in the plains forest and lower hill forests in the northern Bengal. Planted occasionally in the central gangetic plains forest.

2.3 Seed

Seeds ripen in January-March in Northern Bengal. However, every year does not turn out to be good seed year. That is why, it is advisable to collect seeds in quantity more than current year's requirement and thus build up a reserve for the next year. Seeds (fruits) can be stored in gunny bags or sealed tins for at least two years. Weight of the seed is about 1430 seeds per kg. Seeds are collected from the ground which is cleaned beforehand.

2.3.1 Fruits being hard nut require treatment before sowing. Two methods of treatment are described below.

- (1)** Seeds are soaked in water for 48 hours and then dried in the sun for 48 hours. This process of alternate soaking and baking is continued for 12 to 15 days.
- (2)** Pit Treatment – It is the most commonly used method. A pit of dimensions – 60-90 cm deep, and 90-120cm square section- is dug and filled with water. The bottom and the sides of the pit are covered with teak leaves. Seeds are soaked in a tub and placed in the sun for 48 hours. Thereafter the seeds are put in the pits with alternate layers of teak leaves and seeds and a final cover of 15 cm of earth. Before filling the pit, 5 bamboo pipes are put into the pit – one at the centre, one at each corner with holes cut in them – so that in the filled pit water can reach all layers. Seeds are kept in the pit for about 10 days and watering is done every alternate day. When the pit is opened, about 10% of the seeds are normally found germinated.



2.4 Propagation

In general, Teak is propagated by artificial regeneration or plantation.

Artificial Regeneration: Stump planting is the commonly practised method for teak plantation. In this method the teak seedling is raised for up to 2 years in a nursery to produce a straight and unbranched tap-root. The nursery should be unshaded and not laid out in beds. The nursery may be a patch of hoed up land wherein treated seeds may be sown 8cm x 18 cm. One or two rains old nursery seedlings are fit for making stumps. At planting time, the seedling is lifted and the planting stump prepared by cutting off the shoot and lateral roots, leaving only the main tap-root attached to 3- to 5-cm of the lower stem. The main tap root is also pruned and trimmed down to 20-23 cm. About 1.0 to 2.0 cm collar diameter is the optimum size of the stumps.

Stump planting – A hole equal in depth to the length of the root is made in the centre of the thali with the help of a crowbar. The stump is inserted and the soil is firmly pressed by thrusting the crowbar at an angle close to the root and leveling the soil tight against the root. The stump should be planted exactly upto the collar. The stump should be firmly planted so that no air spaces are left below or around the root. Planting is done at 2m x2m spacing.

Lately in north Bengal, raising plantation of pure Teak is not favoured. According to 2012 revision of Working Plan of Baikunthapur Division and Wildlife III Division, Teak should now form a part of planting stock of the Miscellaneous Species Plantation Working Circle. Planting of Teak is also restricted to 50% of the total stock. Teak along with other crops in such plantation is worked on 50 years rotation.

2.5 Tending

Young plantations need at least 3 weeding/cleaning in the first year, 2 in the second and 1 in the third. The frequency of tending will of course be also guided by the requirement of other species in the plantation. In pure teak blocks thinning should not be delayed. Heavy D grade thinning is suggested in the literature. According to literature (Forestry Nursery Manual of WB, Research and Working Plan Circle 1994), Teak should not be allowed to become suppressed, because once suppressed it does not respond to thinning for 3-4 years and much of increment is lost. The 2012 revision of Working Plan for Baikunthapur Division and Wildlife III Division prescribes for Miscellaneous Species Plantation (of which Teak is a part) mechanical thinning (C grade) in 5th year, and silvicultural thinning in the 10th, 25th and 35th year.

2.6 Injury/damage

Seedlings are sensitive to drought and frost, intolerant of shades and suppression by weeds. Rats and pigs cause damage to seedlings; bison, sambhar, cheetal and elephants cause damage

in later stages. Caterpillars of *Hyblea puera* and other defoliators often defoliate Teak over large areas. *Dihamus cervinus*, a borer, is common in young plantations.

2.7 General

It is a very valuable tree as it gives one of the outstanding timbers. The **wood** is dark golden – yellow when freshly cut, ageing to brown or almost black, moderately hard, extremely durable, takes a beautiful polish. The timber is unique for ship building, extensively used for bridges, buildings, piles, cabinet work, beams, poles, decorative paneling, carving, general carpentry etc. Timber is easy to air-season, easy to work and saw, makes excellent plywood. Wood yields tar oil; scraps and rejections are used for this purpose.

The various parts of the tree have medicinal uses.



(Source: <http://thehealingherbsofindia.blogspot.com/>;
<http://luirig.altervista.org/naturaitaliana>)

Fig. 8.2 *Tectona grandis*

Reference Materials:

1. J. F. Dastur. *Useful Plants of India and Pakistan*
2. Ram Parkas 2007 *Plantation and Nursery Technique of Forest trees*
3. *Forestry Nursery Manual of West Bengal 1994*, Research and Working Plan Circle, WB Forest Directorate
4. Lesson 17 of *Forest Botany*
5. Lesson 9 of *Forest Protection*
6. <http://www.forestry.org.au/forestry-theses-abstracts/physiological-studies-of-sprouting-of-teak-tectona-grandis>
7. Websites cited in the lesson





Lesson 9

Time 1 hour

Lesson Plan

Objective:

To study Silviculture of Trees

- *Terminalia alata*
- *Terminalia arjuna*

Backward linkage

- Study of Lesson 17 of Forest Botany

Forward linkage

- To see nursery and plantation during tour.

Training materials

- Copy of lesson 9 to be circulated beforehand

Allocation of time

- | | |
|-----------------------------|--------|
| • <i>Terminalia alata</i> | 25 mts |
| • <i>Terminalia arjuna</i> | 25 mts |
| • Miscellaneous /Discussion | 10 mts |



1. *Terminalia alata* Heyne ex roth.

Syn. *T. tomentosa* W.& A.

Family: Combretaceae

Local names: Pakasaj, Asan

1.1 Description

A large deciduous tree, bark rough black, deeply cracked. Leaves leathery, hard, elliptic or ovate, 3-8 in long, opposite, margin entire or toothed, with two wartlike glands at the junction of the petiole. Flowers dull yellow. Fruit 1-2 in long with five broad wings.

1.2 Distribution

Found in Sal forests in the Terai, but principally on the ridges of lower hill forests (upto 3000 feet) of north Bengal. Also found in south West Bengal, though infrequent. Planted both in northern and southern part of the state.



(Source: <http://www.forestrynepal.org/> ; <http://www.impgc.com/plantinfo>)

Fig.9.1 *Terminalia alata*

1.3 Seed

Fruits ripen in February-March. The best time for collection is April-May from cleared ground or from trees by lopping branches. Fruits are collected late, as early seeds are immature and likely to be insect attacked. Fruits are dried in the sun for 3-4 days and stored in gunny bags. Fruits can be stored for one year. Seed (fruit) weight varies from 530-550 /kg; germination capacity is 36 to 70 %.

1.4 Propagation

While natural regeneration has been reported to be fair to good in many regions of the country, the species is normally propagated by artificial regeneration.

Artificial regeneration: It can be regenerated by direct sowing or transplanting of nursery raised seedlings.

Direct sowing: It is done in worked up soil, where the rains have set in. Seeds are sown in lines 1.8 m apart; seeds are dibbled 15 cm apart in double rows.

Transplanting of nursery raised seedlings: Fruits are soaked in cold water for 2 days and dibbled in polythene pots in April-May. Germination takes place in 2 to 5 weeks. Shades should be provided immediately after germination. If the polythene pots are regularly weeded and watered, the potted seedlings become ready for planting out in July when the plants are 3-4 months old.

1.5 Tending

Pakasaj/Asan needs intense weeding both in nursery and field. If propagation is made by dense line sowing, the resulting crop would require thinning in the 3rd or 4th year.

1.6 Injury /damage

Pakasaj is liable to crown damage by wind storm. It is browsed by deer. A number of defoliators attack the plant, though damage is not found to be serious. Attack by some fungi has also been mentioned in some literature.

1.7 General

Pakasaj is planted as a Sal associate in Sal Conversion working Circle in north Bengal. It is also planted in mixture with other species in miscellaneous plantations both in north and south West Bengal.

1.7.1 Wood is dark brown, hard, fairly durable and very handsome when polished. It is refractory to season, has to be dried slowly to avoid cracking. Timber is widely used for buildings, beams, rafters, door and window frames and boarding; also used in carts, ploughs and boat building, posts, furniture etc. Treated timber is suitable for electric transmission poles, railway sleepers and wagon floor boards. Also used for agricultural implements and decorative plywood.

1.7.2 The bark contains 15-18% of tannin and is used as a cheap tanning material and as cheap dye.

Leaves are lopped for fodder, are also used for feeding tassar silk worm.



2. *Terminalia arjuna* (Roxb.) Wight. Am.

Family: Combretaceae

Local name: Arjun

2.1 Description

A large deciduous tree, trunk thick and often buttressed. Bark silvery grey, flaky. Leaves oblong or elliptic, hard, glabrous leathery, 3-6 in long. Flowers without stalk, yellowish. Fruit dark brown with 5 thick, narrow, striated wings, 1 in or more long.

2.2 Distribution

It occurs in the wild along the banks of rivers and streams. Planted throughout south-west and central part of West Bengal, and also in plains (preferably in low-lying areas) of north Bengal forests.

2.3 Seed

Flowering begins in April and extends to May with the fruit ripening the following February-May, nearly a year after the appearance of the flowers. Generally, every third year is a good seed year. The pattern of flowering and fruiting is not markedly different in different regions. (http://www.worldagroforestry.org/treedb/AFTPDFS/Terminalia_arjuna.PDF). Ripe fruits are collected during April-May from the trees or from the ground swept clean beforehand. Seeds can be stored for a year. About 175-450 seeds weigh 1 kg. Germination capacity of untreated seed is 50-60%, and that of pre-treated seed is about 90%.

2.3.1 For treatment, seeds are soaked in water for 48 hours and then spread out in shallow pits or trenches.

2.4 Propagation

Natural Regeneration: Arjun shows satisfactory natural regeneration by seed as well as coppice. Seeds are dispersed by water. Natural regeneration occurs in loose alluvial soil, along water courses. However, in forests, the species is propagated by artificial regeneration.

Artificial Regeneration: Arjun can be regenerated by direct sowing and transplanting of nursery raised seedlings.

Direct Sowing: Fruits are sown in dug up lines, 2.3 m to 4.0 m apart, in June-July with the onset of monsoon rains. The pits or trenches used for treatment of seeds can be located in the plantation itself when direct sowing in the field is planned. Germination commences in 4 to 7 days.



Transplanting of seedlings: Pre-treated seeds are dibbled in polythene pots in April-May. The pots are watered regularly and weeded as frequently as necessary. Two to three months old seedlings whose shoot and root lengths, on an average, become 12.5 cm and 30 cm respectively are planted out in July-August. Spacing of transplanted seedlings may be 2 m x 2m or 2.5 m x 2.5 m. Plantations raised for tasar sericulture, have a closer spacing, say, 1 x 2 m, and are managed by repeated pollarding.

2.5 Tending

Arjun, an initial slow-grower, later grows very fast to attain 2–3 m height in 3 years. Weeding and protection from fire and frost is needed for the first two years. Thinning is required to remove the weaker shoots when forking takes place due to frost damage.

2.6 Injury/Damage

Young seedlings are sensitive to frost and drought. Literature cites attack by wood borer and defoliator, as also fungal attack.

2.7 General

It is one of the finest avenue and shade trees. Wood is hard, strong, moderately heavy; ornamental, difficult to season; is used for agricultural implements, boat building, cart wheels, mine props, plywood, buildings etc. It makes excellent firewood and good quality charcoal.

Leaves are fed to tasar silk worms.

The most useful part of the tree is its **bark** which contains 20-24 % of tannin. It is extensively used for tanning and dyeing. The bark has **medicinal value**. It is used as styptic, antidiarrhetic, cardiotonic, febrifuge; used in haematemesis, leucorrhoea, and many other ailments.

Fruits and leaves have also medicinal value.



(Source: <http://davesgarden.com/guides/pf> ; http://en.wikipedia.org/wiki/Terminalia_arjuna)

Fig. 9.2 Terminalia arjuna



Reference Materials:

1. *J. F. Dastur. Useful Plants of India and Pakistan*
2. Ram Parkas 2007 Plantation and Nursery Technique of Foresttrees
3. Forestry Nursery Manual of West Bengal 1994, Research and Working Plan Circle, WB Forest Directorate
4. Lesson 17 of Forest Botany
5. Websites cited in the lesson



Lesson 10

Time 1 hour

Lesson Plan

Objective:

To study Silviculture of Trees

- *Taxus baccata*
- *Terminalia myriocarpa*

Backward linkage

- Study of Lesson 17 of Forest Botany

Forward linkage

- To see nursery and plantation during tour.

Training materials

- Copy of lesson 10 to be circulated beforehand

Allocation of time

- | | |
|--------------------------------|--------|
| • <i>Taxus baccata</i> | 25 mts |
| • <i>Terminalia myriocarpa</i> | 25 mts |
| • Miscellaneous /Discussion | 10 mts |



1. *Taxus baccata* Linn

Family: Taxaceae

Local name: Dhengre Salla

1.1 Description

T. baccata is a small to medium-sized evergreen tree, growing 10-20 m tall, has thin scaly brown bark, leaves are lanceolate, flat, dark green, male cones are globose, 3-6 mm diameter, outcrossing, wind-pollinated. Flowering occurs in September and fruiting in October, seeds are surrounded by a unique red fleshy cuplike aril which plays a key role in attracting birds and mammals that disperse the seeds. (Source: Prabha Sharma and P. L. Uniyal 2010)

1.2 Distribution

Taxus baccata is distributed in Himalayas (Khasi and Jaintia Hills, Naga Hills and Manipur). Found in the upper hill forests (altitude 8000-10000 feet) of north Bengal, *Taxus baccata* is a rare and endangered tree species in India. (Source: Prabha Sharma and P. L. Uniyal 2010)

1.3 Seed

The seed, contained in a bright red berry-like fruit, ripens in November. There are about 8000 seeds kg⁻¹, and they can be stored for several years in tins in cold storage. (<http://www.forestrynepal.org/resources/trees/taxus-baccata>)

1.4 Propagation

Artificial regeneration – After the seed has been removed from the pulp it should be stratified in sand over winter, in a cool place, and sown directly into polythene pots in the following spring. Germination often takes a long time, and growth is slow, so that the seedlings will need two years or more in the nursery before they can be planted out. *Taxus baccata* can also be propagated from cuttings. (<http://www.forestrynepal.org/resources/trees/taxus-baccata>)

It is reported that on trial with the branch cuttings after given dip treatment using several growth promoting substances (IAA, IBA, Geradix and Seradix) in raised platform sand beds in the Mist Chamber, the branch cuttings treated with IBA dip treatment were found to be the best method of vegetative propagation of the species. (Himalayan Yew (*Taxus baccata*))

Conservation : a Vegetative Approach K. P. Dubey at

<http://www.indianforester.co.in/index.php/indianforester/article/view/6188>)

Growth of the species regardless of the nature of the planting stock is very slow.



[Regarding slow germination of *T. Baccata* seed, an excerpt of tour note of A Basu Ray Chaudhuri IFS Retd is given below.

“The Sonada nursery is conducting trial on seed germination of recalcitrant *Taxus baccata*. Seeds were sown in March, 2004 in beds of two kinds – sand and sand mixed with soil. The observation made in April 2005 was that out of 50 seeds sown in each, 17 germinated in sand, and 30 germinated in sand & soil.” (Tour Note of A B Ray Chaudhuri, Chief Conservator of Forests, (R&D), WB for the period from 04 June to 09 June, 2005)]

1.5 General

Use of *Taxus baccata* : The tree contains the highly poisonous taxane alkaloids that have been developed as anti-cancer drugs. All parts of the tree are poisonous, with the exception of the bright red arils. (<http://www.kew.org/science-conservation/plants-fungi/taxus-baccata-common-yew>). It has also been reportedly used for the treatment of bronchitis, asthma, epilepsy, snake bites, scorpion stings, aphrodisiac, induce perspiration, internal injuries, lung diseases and diabetes and is also used as a colouring material and as an incense. (Source: Prabha Sharma and P. L. Uniyal 2010)



Fig. 10.1 *Taxus baccata* ripe seeds enclosed by a bright red aril.

(Source: <http://www.kew.org/science-conservation/plants-fungi/taxus-baccata-common-yew>)



2. *Terminalia myriocarpa*.

Family: Combretaceae

Local names: Panisaj

2.1 Description

A large evergreen tree, characterized by paired large narrowly elliptical toothed leaves with one or two glands on leafstalk, many small light yellow flowers in large slender drooping clusters, and two-winged pinkish tinged yellow fruits.

(http://www.ctahr.hawaii.edu/forestry/trees/CommonTreesHI/CFT_Terminalia_myriocarpa.pdf)

2.2 Distribution

The tree is found in plains of northern Bengal upto an altitude of 1500 m. It occurs especially near jhoras between 900 m and 1200 m elevation. It does well on almost every soil, dry sandy to damp low lying areas. It is thus a useful species to put in damper areas in Sal plantation.

2.3 Seed

The best time to collect seeds is December. Seeds are very minute and difficult to count. Approximately, 425 to 560 seeds make 1 kg. Fruits are collected by lopping the small branches and not from the ground. Only ripe fruits turned yellow are collected. Seeds are cleaned off branches and twigs and dried in the sun for a day or two before storing. Seeds can be stored for 2-3 months in a dry ventilated shed. Germination is very poor; germination capacity is 20 to 30 per cent and the seed takes usually 3-4 weeks to germinate.

2.4 Propagation

Artificial regeneration – It can be raised by direct sowing in lines in May-June. Lines are hoed 30cm wide and seeds are sown thickly broadcast over a width of 8 cm in the middle of the line and lightly covered with earth. As soon as the plants are 8 to 10cm tall, they should be pricked out and evenly spaced in the lines. Panisaj is preferably raised in mixture with Toon or Chikrasi.

The species can also be raised by planting out nursery raised seedlings. Seeds are sown on nursery beds and watered regularly. Usual weeding of beds is done after germination of seeds. When the seedlings grow a little, they are pricked out to polypots. The potted seedlings are planted out in the field in July of the same rainy season. Panisaj is an intense light demander, so care should be taken to ensure that Panisaj seedlings in their early stage of growth are not suppressed by Taungiya crop or any other unwanted species.

2.5 Tending

Thinning is required in the 4th or 5th year, and sometimes may be necessary in the third year. A fairly heavy D-grade thinning is recommended.

2.6 Injury /damage

Young plants are prone to be browsed by wild animals. The bark is often damaged by deer while rubbing their horns against the stem. The plants have been reported to be attacked by defoliator and shoot borer.

2.7 General

The heartwood is pale brown, with darker brown zones at the end of each growth ring giving the wood an attractive figure. This heavy hard wood takes an excellent finish and is widely used for furniture, plywood and general construction. Wood is not durable but very permeable to preservatives and so can easily be treated.

Reference Materials:

1. Forestry Nursery Manual of West Bengal 1994, Research and Working Plan Circle, WB Forest Directorate
2. Lesson 17 of Forest Botany
3. Prabha Sharma and P. L. Uniyal 2010 Traditional knowledge and conservation of *Taxus baccata* in Sikkim Himalaya, Department of Botany, University of Delhi, Delhi-110 007, India at http://nebio.in/neceer/NEBIO12010_55-58.pdf
4. Websites cited in the lesson





Lesson 11

Time 1 hour

Lesson Plan

Objective:

To study Silvicultural Systems

- Definition and concept
- Classification – High Forest and Coppice Systems
- High Forest System
 - Clear felling System

Backward Linkage : Nil

Forward Linkage: Study of clear felling system in the field during tour.

Training Materials required: Copy of Lesson 11 to be circulated beforehand

Allocation of time:

Silvicultural Systems

- | | |
|--|--------|
| • Definition and concept | 8 mts |
| • Classification – High Forest and Coppice Systems | 7 mts |
| • High Forest System | |
| ➤ Clear felling System | 35 mts |
| • Discussion/Miscellaneous | 10 mts |



Silvicultural System

1. Definition and concept

(<http://www.forestrynepal.org/notes/silviculture-systems/4>, KFRI Research Report 40, Forest management system in the Tropical mixed forests of India)

Silvicultural system may be defined as a method of silvicultural procedure, worked out in accordance with accepted sets of silvicultural principles by which, crops constituting mature forests are harvested, regenerated, tended and replaced by new crops of distinctive forms. It begins with regeneration felling and includes adoption of some suitable method of regeneration and tending of the new crop throughout of its life.

The main components of a silvicultural system applied to natural stands are (1) harvesting the tree growth that already exists, (2) regeneration of felled areas and (3) tending the regeneration till maturity to fulfill pre-determined objectives. A system is distinguished on the basis of the nature of operations carried out during harvesting, regeneration and tending.

2. Classification – High Forest Systems and Coppice Systems

(<http://www.forestrynepal.org/notes/silviculture-systems/4>)

Silvicultural systems have been classified in a variety of ways. The most commonly used classification is based primarily **on the mode of regeneration**. It is further classified according to the pattern of felling carried out in the forest crop. According to the method of regeneration, silvicultural systems are of following two types: **high forest systems** and **coppice systems**.

1. **High forest systems:** High forest systems are those silvicultural systems in which the regeneration is normally of seedling origin, either natural or artificial or a combination of both and the rotation is generally long. The high forest systems are further classified on the basis of pattern of felling and mode of regeneration as well. A broad schematic classification of High forest systems is given here.
 - High forest systems
 - Systems of concentrated regeneration
 - Clear felling system
 - Shelterwood system
 - Seed tree system
 - Systems of diffused regeneration
 - Selection system

2. **Coppice systems:** The silvicultural system in which the crop originates mainly from coppice and the rotation is short is called coppice system. Coppice systems are further classified into various categories. Important categories of coppice systems are :

- a. Simple Coppice System
- b. Coppice with Standard System
- c. Coppice with Reserve System

The above silvicultural systems belonging to high forest and coppice systems are described in this lesson and in those which will follow.

3. Clear felling system

The clear felling system is a silvicultural system in which equal or equi-productive areas of mature crop are successively clear-felled in one operation to be regenerated, most of the time, artificially but sometimes naturally also. The new crop produced is absolutely even-aged. It requires large sums of money and large number of laborers to regenerate the forest artificially. The area to be clear-felled each year in uniformly productive sites is $1/n$ of the total area allotted to this system, where n = number of years in the rotation. The area clear felled each year is usually referred to as annual coupe. The coupes to be felled every year are made equi-productive to ensure sustained yield. (<http://www.forestrynepal.org/notes/silviculture-systems/4,>)

3.1 Clearfelling system has a long history in India. The system is adopted with the objective of changing the crop composition in favour of commercially and industrially more valuable species. Restocking of felled areas is accomplished either naturally or artificially. However, artificial regeneration is necessary when new species are to be introduced or the composition of the crop is to be significantly improved. Both methods of regeneration are followed in India and the choice is determined by a number of factors (KFRI Research Report 40, Forest management system in the Tropical mixed forests of india). In north Bengal, forests under Sal conversion working circle are operated under clear felling system followed by artificial regeneration.

3.2. Removal or felling of mature crop

(<http://www.forestrynepal.org/notes/silviculture-systems/4,>)

According to definition, the entire crop of the coupe should be felled and removed in one operation but in practices following variations are observed.

- Retention of some mature trees as frost protection measures or as an insurance against failure or as nurse crop to facilitate establishment of frost tender species.
- Retention of promising groups of saplings and poles to prevent unnecessary sacrifice of immature crop of the desired species.

3.3 Methods of obtaining regeneration

(<http://www.forestrynepal.org/notes/silviculture-systems/4,>)

The area can be regenerated sometimes naturally but mostly artificially.



3.3.1 Artificial regeneration is preferred due to following reasons:

1. It is the surest and quickest method of improving crop composition.
2. It facilitates introduction of fast growing and high yielding exotics.
3. It provides better financial returns.
4. The regeneration is established sooner, so the area can be opened for grazing sooner.

3.3.2 Methods of natural regeneration

If reproduction is planned through natural regeneration, it can be obtained by one or more of the following methods.

1. Seeds from trees adjacent to the clear cut area;
2. Seeds lying dormant on the ground or left in the slash and debris;
3. Seeds borne by the trees in the coupe of the year;
4. Advance growth already existing in the annual coupe as a result of previous seed years.

3.4 Advantages of clear felling system

- It is the simplest of all high forest system. It does not require a high degree of skill.
- As felling is concentrated, the yield per unit area is more and consequently the cost of felling and extraction is low.
- Introducing fast growing exotics and regulating composition of new crop through artificial regeneration is advantageous.
- It makes the supervision of all operations easy.
- There is no damage to new crop by felling

3.5 Disadvantages of clear felling system

- The even aged forest that is produced is unnatural and biologically inferior to an irregular forest. It is more susceptible to insect and fungus attack.
- As soil remains open, there is more danger of soil deterioration and erosion, and complete upsetting of soil flora and fauna.
- Introduces danger of weed and grass growth and the consequent fire hazard.
- It is inapplicable for steep slopes and poor soil.
- Has a low aesthetic value.

Reference Materials:

1. <http://www.forestrynepal.org/notes/silviculture-systems/4>,
2. KFRI Research Report 40, Forest management system in the Tropical mixed forests of india
3. A.B Lal 1967 Indian Silviculture



Lesson 12

Time 1 hour

Lesson Plan

Objective:

To study Silvicultural Systems

- High Forest System
 - Shelterwood System

Backward Linkage: Previous lesson

Forward Linkage: Subsequent lessons on silvicultural systems

Training Materials required: Copy of Lesson 12 to be circulated beforehand

Allocation of time:

Shelterwood System

• Definition and concept	7 mts
• Periodic Blocks	10 mts
• Operations in periodic blocks	20 mts
• Advantages/Disadvantages	10 mts
• Regular Shelterwood (Uniform) system	5 mts
Discussion / Miscellaneous	8 mts



1. Shelterwood system

Clear felling system carries the risk of failure of regeneration. Given this risk and the need to intensively exploit the valuable forests led to the search for alternative management systems. Success of shelterwood system in the European continent led to its introduction to India during the first quarter of twentieth century. Under shelterwood system, felling of overwood is regulated to provide favourable conditions for recruitment and establishment of regeneration.

1.1 Definition - Concept

Shelterwood system is a silvicultural system in which the over wood of mature crop is removed in a number of stages depending on the progress of regeneration. The primary intent of this system is to protect and shelter the developing regeneration.

Final fellings are deferred till the regeneration has become completely established and is no longer in need of protection against insolation, frost etc.

The trees which are growing vigorously are retained to provide shelter, seed, rapid diameter increment and value increment and protection of site against deterioration.

Criteria for retaining trees in shelter wood systems are: larger, dominant trees, wind firm trees, desirable species and desirable physical characteristics.

The regeneration period extends over a part of a rotation period, and full advantage is taken of the number of good seed years which occur during this period.

1.2 Periodic Block

To have a clear idea about the system we need to know what a periodic block is.

Periodic block(s) (P.B) are the part or parts of forest containing one age-class, set aside to be regenerated or otherwise treated, during a specified period. The forests managed under shelterwood system are divided into periodic blocks, which may be "Floating" or "single" and "Fixed" or "Permanent". The regeneration block is called "Floating" or "single" when it is the only P.B allotted at each Working Plan revision. When all periodic blocks (P.B) are allotted and retain their identity at working plan revision, they are termed "fixed" or "permanent" periodic blocks.

Number and area of P. B. is calculated as under:

Number of P. B. = Rotation period / Regeneration period.

Area of P. B. = Area of working circle / Number of P. B.

(Source: Michael femi adekunle et al frm 503 lecture notes Forest management techniques)

Example:

If the rotation is 120 years and it takes 30 years to regenerate the area naturally, there will be $120/30 = 4$ periodic blocks. The age class distribution of the periodic blocks is shown in the following table.

Table 12.1

Periodic block	Age Class (Age of crop in years)	
	At the beginning of the period	At the end of the period
I	91-120	1-30
II	61-90	91-120
III	31-60	61-90
IV	1-30	31-60

(Source: <http://www.forestrynepal.org/notes/silviculture-systems/4>)

1.3 Operations in the Periodic Blocks

The following operations are carried out in different periodic blocks.

- **P.B. IV and III** – The crop is tended and subjected to cleaning and thinning. The stress is on proper tending of the crop in early stages so that when it moves on to PB II, the canopy requires minimum interference for production of good seed bearers. Proper tending is necessary also for rapid diameter increment in the final crop and reducing the rotation period.
- **P.B. II** – This is known as the preparatory block. Treatment in this block aims at preparing the crop for production of good seed-bearers, and preparing the soil for reception and germination of seeds. The block undergoes **preparatory felling** which
 - (1) creates more or less permanent gaps in the canopy in such a way as to leave trees with good crowns as seed bearers; and
 - (2) Creates favorable conditions on the forest floor; heavy openings in the canopy bring about decomposition of the humus and thus produce a good seed bed for germination and establishment of seedlings.

Preparatory felling also helps the trees (retained) put on rapid diameter increment and thus a larger proportion of big sized timber in the P.B.I is ensured.

Other operations in P.B.II include undertaking controlled burning and grazing in order to reduce the undergrowth and create conditions suitable for regeneration of desired species.



- **P.B. I** – The P.B.I undergoes what is known as **regeneration felling**. In regeneration felling, the mature crop is removed in three stages, namely (1) **seeding felling**, (2) **secondary felling** and (3) **final felling**.
 - **Seeding felling:** It is the first stage of regeneration felling which consists in opening out the canopy in such a way as to admit light, and provide moisture and nutrients through reduction of root competition for the establishment of germinated seedlings. Poorer stems are removed and only trees with good bole and crown form are retained as mother trees. In order to minimize the damage to young regeneration through subsequent logging and extraction, **seedling felling is carried out to the heaviest possible degree.**
 - **Secondary felling:** It is a regeneration felling carried out between the seeding felling and the final felling under a shelter wood system in order to gradually remove the shelter and admit increasing light to the regenerated crop. Removal of trees in secondary felling depends on progress of regeneration and its light requirement. It also helps in the manipulation of mixture of crop. **In order to minimize damage to the regeneration, the number of secondary fellings is kept to the minimum.**
 - **Final felling:** It is the **final stage in regeneration felling when the area is completely stocked with established regeneration** and when the regeneration is no longer in need of protection against insolation, frost etc. Final felling may be deferred to allow the trees to put on maximum diameter and price increment. By the time of final felling the regeneration attains sufficient height to permit of logging and sawing below its canopy. A few selected stems are still retained in the final felling to act as “insurance trees” or “increment trees”.

1.4 Advantages

- Produces a nearly even-aged crop
- Ensures better regeneration through production of good seed bearers, provision of optimum light, moisture and nutrients for establishment of seedlings, and by taking advantage of many good seed years during the regeneration period.
- Seeds are obtained from the very best selected trees of good bole and crown form.
- Tending operations are facilitated as the age classes occur on separate areas.
- The system is highly flexible and can be made use of for obtaining regeneration of light demanders or shade bearers or a mixture of both by suitable manipulation of the canopy.
- Soil is not completely denuded so there is less risk of soil deterioration and erosion.
- As the regeneration operations are carried out under the shelter of older crop, there is less danger of invasion of the area by weeds and grasses
- The young crop is protected against adverse climatic factors such as cold, frost, etc.
- From aesthetic point of view, the system is superior to clear felling system.



1.5 Disadvantages

- As the over wood is removed in more than one operation, there is likelihood of much damage to the young crop.
- The isolated seed bearers are susceptible to wind damage.
- Heavy seeding felling may invite invasion by weeds and regeneration may be affected.
- Weeding and cleaning have to be done for longer period and the natural regeneration becomes costly.
- Requires a high degree of supervision and skill for management of the forests.

1.6 Regular Shelterwood (or Uniform) System

There are many kinds or variants of shelterwood system. We refer here only to the simplest type, namely, Regular Shelterwood or Uniform system. It is a kind of Shelterwood System aiming at concentrated regeneration in which the canopy is uniformly opened up over the whole area of a compartment to obtain uniform regeneration.

1.6.1 The Uniform System has been tried in Indian conditions with Sal, Teak, Deodar, Fir and Chir with varying levels of success. The system reportedly failed to induce Fir regeneration in Punjab. Chir is the only species for which the system has succeeded under Indian conditions.

Reference Materials:

1. <http://www.forestrynepal.org/notes/silviculture-systems/4>,
2. KFRI Research Report 40, Forest management system in the Tropical mixed forests of india
3. A.B Lal 1967 Indian Silviculture
4. The Irregular Shelterwood System: Review, Classification, and Potential Application to Forests Affected by Partial Disturbances Patricia Raymond, Steve Be´dard, Vincent Roy, Catherine Larouche, and Ste´phane Tremblay
http://sfec.cfans.umn.edu/prod/groups/cfans/@pub/@cfans/@sfec/documents/article/cfans_article_340179.pdf
5. Dr. Michael Femi Adekunle Associate professor And Professor S A Oluwalana Frm 503 lecture notes Forest management techniques, Department of forestry and Wildlife Management, University of Agriculture, Abeokuta, Ogun state, Nigeria.
6. Introduction to Silvicultural Systems British Columbia Ministry of Forests
(<https://www.for.gov.bc.ca/hfp/training/00014/varselec.htm#varselec>)
7. Ram Parkash 1986 Forest Management International Book Distributors Dehra Dun





Lesson 13

Time 1 hour

Lesson Plan

Objective:

To study Silvicultural Systems

- High Forest System
 - Seed Tree System
 - Selection System

Backward Linkage: Previous lessons

Forward Linkage: Subsequent lessons on silvicultural systems

Training Materials required: Copy of Lesson 13 to be circulated beforehand

Allocation of time:

Seed Tree System

- | | |
|--------------------------|--------|
| • Definition and concept | 10 mts |
| • Seed trees | 7 mts |
| • Advantages | 5 mts |

Selection System

- | | |
|----------------------------|--------|
| • Definition and concept | 9 mts |
| • Effect of Felling Cycle | 8 mts |
| • Thinning | 3 mts |
| • Advantages/Disadvantages | 10 mts |

Discussion / Miscellaneous	8 mts
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1. Seed tree system

While clear felling system has many advantages including early return of revenue, easy operation, option of easy manipulation of species in the new crop, it also carries risk of regeneration, if planned to be natural, under one or more of the following circumstances.

1. Dispersal of seeds from the adjacent stand is inadequate.
2. Lack of mobility of seeds
3. Lack of good seed years
4. Fire hazard to the young regeneration.

When conditions of regeneration are found to be adverse, clear felling system is replaced by the **seed tree system**. In this method, the stand is clear felled except for a few seed trees, which are left standing singly or in groups to produce seeds for regeneration. **Ordinarily, not more than 10% by volume of the original stand is retained as seed trees.** After a new crop is established, these seed trees are removed or left indefinitely. The chief distinction from shelter wood system is that the seed trees are retained only for seed production and not to provide shelter.

1.1 Seed trees

While the primary object of the seed trees is to provide seeds for stocking the regeneration area, they incidentally also serve the following purposes.

- **Insurance value** – In the event of destruction of the regeneration due to fire or any other reason, the area can still be restocked with the seeds to be dispersed from the seed trees.
- **Increment value** – The seed trees put on rapid growth and price increment and produce big-sized timber that can fetch good revenue in future.

Seed trees should have the following **characteristics**.

- Seed trees should be dominant individuals of the original crop.
- They should have large crown with good bole form
- Seed Trees should be wind firm, and have the ability to produce abundant seeds.

Number and distribution of seed trees depend on following factors:

- Seed production per tree
- Requirement of seed
- Conditions facilitating or obstructing seed dissemination
- Prospect of seed germination and seedling establishment

1.2 Advantage

- Provides better regeneration conditions in respect of seed supply than the clear felling system.
- Composition of the crop can be improved by leaving seed trees of desired species.
- The system may fetch more revenue than the clear felling system in view of the rapid diameter and price increment of the reserved trees.
- The system can supply both small and big sized timber.

2. Selection system

It is a silvicultural system in which felling and regeneration are distributed over the whole of the area and the resultant crop is so uneven-aged that trees of all ages are found mixed together over every part of the area. Such a crop is referred to as selection forest or all-aged forest.

Regeneration operation is carried out throughout the life of crop.

(<http://www.forestrynepal.org/notes/silviculture-systems/4>)

2.1 Concept

The true selection system is applicable to selection type of forest where normal distribution of age classes ranging from one year old seedlings to trees of rotation age are present. Selection system, in its simplest form, consists in **harvesting trees of rotation age from the whole forest every year** and allowing regeneration to come up in the gaps created by felling of selection trees.

Application of the above simplistic system is, however, not feasible on account of following reasons.

- Vast areas of forests cannot be gone over every year.
- In view of lack of normality of age classes selection trees of the same number may not be available every year and thus sustainability in yield may be disrupted.
- Cut per unit area being very low, harvesting operation is likely to be uneconomic.

Since such annual working of entire area of the Felling Series is neither practicable nor desirable, the usual practice is to divide the area into a number of coupes (cutting sections) each of which is worked at an interval of a planned number of years, known as Felling Cycle (F.C.). [In selection forests, F.C. is the time that elapses between successive main fellings on the same area.] It may vary depending on the intensity of working. The number of coupes will obviously be equal to the number of years in the F.C., and they may be made up of one or more forest compartments. The whole felling series is gone over completely during a felling cycle.



2.2 Effect of Felling Cycle

Let us now try to understand the implication of felling cycle in a selection forest. Consider that rotation age is 100 years and a felling cycle of 5 years is adopted. It would mean the forest will be divided into 5 coupes; turn of entry for harvest in each coupe will come at an interval of 5 years. In the year of harvest in a coupe, trees ranging from 95 to 100 years in age would be felled, and the coupe will be revisited after 5 years to do the same operation. With a 50-year felling cycle, there will be 50 coupes and trees 50 to 100 years old would be taken out at each cut in a coupe. In the extreme case when the felling cycle is 99 years, all trees except one year old seedling would be cut which means clear felling in the coupe. Thus longer the felling cycle, the more does the crop deviate from the selection forest and more nearly it approaches even-aged forest.

It is also to be understood that while working on a felling cycle, the annual increment of the total felling series is taken out from one coupe. If the felling cycle is N years, annual increment is taken from one coupe whose area is $\frac{1}{N}$ th of the area of felling series. Intensity of felling in the coupe is N times heavier compared to the degree of opening which would take place if the whole felling series would have gone over every year under the true selection system. [Please note that in the example of 5-year felling cycle cited above, trees in the age range 95 to 100 years would be taken out from the coupe (area $\frac{1}{5}$ th of felling series) in a year, whereas in the true selection system only 100-year old trees would have been removed annually from the whole area of felling series.]

2.3 Thinning

Selection system requires not only harvesting of selection or exploitable sized trees, but also undertaking of simultaneous thinning in all the age classes in the coupes so that normal distribution of age classes is maintained.

2.4 Advantages

- The uneven-aged or irregular forest maintained by the system is biologically superior to the even-aged or regular forests.
- By maintaining continuous leaf cover, the selection systems conserve soil and moisture to the fullest extent possible.
- The selection forest produced is more resistant to injuries by insect pests and adverse climatic factors.
- It prevents invasion of grass and weeds.
- Felling cycle may be manipulated to obtain a desired crop. For example, selection system with a short felling cycle is suitable for regeneration of climax shade-bearing species, while

a long felling cycle may be utilized for securing regeneration of sub-climax light demanding species.

2.5 Disadvantages

- The selection system requires the highest degree of professional skill..
- As the annual output per unit area is low, cost of logging and extraction is high.
- It is difficult to prevent damage to young regeneration during felling, logging and extraction, as regeneration comes up all over the area.
- Seed is obtained from good as well as bad trees; there is a chance of genetic deterioration of future crop.
- It is difficult to enforce closure to grazing and ensure rigid fire protection over the large area of young regeneration.

Reference Materials:

1. <http://www.forestrynepal.org/notes/silviculture-systems/4>,
2. KFRI Research Report 40, Forest management system in the Tropical mixed forests of India
3. A.B Lal 1967 Indian Silviculture
4. Dr. Michael Femi Adekunle Associate professor And Professor S A Oluwalana From 503 lecture notes Forest management techniques, Department of forestry and Wildlife Management, University of Agriculture, Abeokuta, Ogun state, Nigeria.
5. Introduction to Silvicultural Systems British Columbia Ministry of Forests (<https://www.for.gov.bc.ca/hfp/training/00014/varselec.htm#varselec>)





Lesson 14

Time 1 hour

Lesson Plan

Objective:

To study Silvicultural Systems

- Coppice Systems
 - Simple Coppice
 - Coppice with Standard
 - Coppice with Reserve

Backward Linkage: Previous lessons

Forward Linkage: To observe and study, during tour, application of coppice system

Training Materials required: Copy of Lesson 14 to be circulated beforehand

Allocation of time:

Coppice System

- | | |
|--------------------------------|--------|
| • Coppice reproduction | 10 mts |
| • Simple Coppice System | 5 mts |
| • Coppice with Standard System | 25 mts |
| • Coppice with Reserve system | 10 mts |

Discussion / Miscellaneous

10 mts



1. Coppice System

It is the silvicultural system in which the crop is regenerated mainly from stool coppice and where the rotation of the coppice is short. Reproduction is obtained from the shoots arising from the adventitious buds of the stump of the felled trees.

1.1 Coppice Reproduction

It is a vegetative method of reproduction originating from adventitious buds which usually appear on broadleaved species where a wound or injury is made. Among the conifers the power of coppice reproduction is almost absent. The coppicing power of the broadleaved species again varies considerably. Species with good coppicing power are better equipped in the struggle for existence in nature.

There are many kinds of coppice reproduction, namely, stool shoots, root-collar shoots, pollard shoots, root suckers and seedling coppice. The reproduction through stool shoots is made use of in coppice system. When a tree is cut, shoots may arise near the top of the stump, and they are called stump or stool shoots. Stool shoots grow fast, but are likely to be weakened by decay of the stump and effect of the wind.

1.1.1 Factors influencing coppice reproduction

(A.B.Lal 1967 Indian Silviculture)

- Coppicing power of the species – Some examples of strong coppicer are Sal, Teak, Sissoo, khair, *Albizia* spp, Eucalyptus etc.
- Size or age of stump – The larger and older the stump, poorer is the coppicing power. Young saplings and poles coppice readily and more profusely.
- Season of cutting – The best season for coppicing is the later part of resting season when the roots have large food reserves. The rule is that felling should be over before the growing season starts.
- Height and method of cutting – Generally, stumps should be cut reasonably low. However, very low cutting should be avoided. The best coppice shoots are produced from smooth stumps cut with a slant to drain off water.
- Rotation – Since the coppicing power is most vigorous during the first few decades of life of tree, coppice forests should be worked on short rotation.
- Silvicultural system – The coppice shoots are strong light demanders and they must be worked under systems involving concentrated felling, e.g. simple coppice which involves clear felling, or, coppice with standards, which involves clear felling with standards.
- Need for rejuvenation – Coppice forest cannot retain its coppicing power indefinitely. An appreciable percentage of stools either die or fail to coppice, and this proportion increases with successive felling. It is thus necessary to rejuvenate coppice crop, after a few rotations, by substituting plants of seed origin or supplementing coppice regeneration by sowing or transplanting.

1.2 Classification

Coppice systems are further classified on the basis of pattern of felling and mode of regeneration as well.

1.3 Simple coppice system

It is defined as the Silviculture System based on stool coppice, in which the old crop is, clear felled completely with no reservation for shelter wood or any other purpose.

Pattern of felling in simple coppice system consists in clear felling a fixed area annually. Area of annual coppice coupe = $\frac{A}{n}$, where n is the number of years in rotation.

1.4. Coppice with standard system

Coppice-with-standards is a silvicultural system that produces a multi-storied stand consisting of a lower storey of an even-aged coppice underwood and an uneven-aged partial upper storey of standard trees grown at wide spacing which is treated as high forest. The lower storey is cut regularly to produce small material while the objective of the upper storey is to produce large timber. (Source: Possible silvicultural systems for use in the rehabilitation of poorly performing pole-stage broadleaf stands – Coppice-with-standards by Short, I. and Hawe, J.)

1.4.1 Management

(Source: Possible silvicultural systems for use in the rehabilitation of poorly performing pole-stage broadleaf stands – Coppice-with-standards by Short, I. and Hawe, J.)

The management of coppice-with-standards requires greater silvicultural skill than the majority of other silviculture systems. Generally, the forest is arranged into a number of coupes, also, corresponding to the rotation length of the coppice, such that one coppice coupe can be harvested annually. The coppice rotation length is dependent on the species, site productivity and product size required, but is normally from 10-30 years. The overstorey rotation is a multiple of the coppice rotation such that, if the coppice rotation is r years, the overstorey rotation could be 2r, 3r, 4r, 5r years etc. As each annual coupe in turn becomes due for felling, the following operations should be carried out in it.

- 1 the coppice is clear cut;
2. Some existing standards are reserved for at least one more coppice rotation, whilst the remainders are felled;
3. a number of new standards of similar age as the coppice are selected from natural regeneration, preferably from seed origin, and reserved. If there is insufficient natural regeneration, then transplants can be used.
4. Vacancies caused by the removal of standards or the death of coppice stools are filled up using seedling of natural regeneration or transplanted seedlings to ensure a future supply of both coppice and standards.



The result of the above operations, after numerous coppice rotations, is a multiaged stand that consists of an even-aged coppice understorey with a multi-aged overstorey.

[Please see Lesson 3 of Forest Management]

1.4.2 Species selection

Ideally, the underwood should consist of species that can tolerate some shade, produce satisfactory stool shoots and also be marketable in small dimensions. The overstorey is suited to light-demanding species with rapid growth and sufficiently good, valuable timber that can compensate for the loss of increment in the underwood and may be the same as, or different from, the understorey species.

1.4.3 Purpose of standards

(i) To supply large size timber (ii) To provide protection against frost (iii) To provide seedling regeneration (v) To increase the revenue

1.4.4 Advantages

- There is greater protection to the soil than simple coppice system;
- Standards serve as seed bearers and provide seed.
- The system can serve the local demands better as it produces materials of various sizes;
- Inclusion of coppice ensures early return on investment
- Aesthetically superior to simple coppice.

1.4.5 Disadvantages

- It requires great skill in maintaining correct balance between standards and coppice and between standards of different age classes.
- It has an exhaustive effect on soil.
- Felling and extraction cost is higher than high forest

Example: In south West Bengal Sal coppice forests are managed under the “coppice with standard system”. The coppice rotation is fixed at 15 years. Both the coppice crop and the standards belong to Sal. It is prescribed to retain 100 standards per ha. In practice, however, the standard crop is often not retained or managed in the manner that the ideal system demands. Protection of oversized standard trees is a difficult problem. Further, inclination to have more income as early as possible sometimes leads to a situation where number of standards falls short of what is required under ideal situation or as per prescription. Fewer the standard trees, more close does the system approach to simple coppice system.

1.5 Coppice with Reserve System

It is a coppice silvicultural system in which felling is done only in suitable areas likely to benefit, after reserving (a) all financially immature growth of principal as well as other valuable miscellaneous species, either singly or in optimally spaced groups, (b) trees yielding products of economic importance and (c) crop for protective reasons. The reservation is done with the

object of improving the condition of the crop, providing protection against frost and erosion, supplying seed, protecting valuable species as well as species with edible fruits etc.

1.5.1 Pattern of felling

In this system, felling is done keeping the requirements of the crop in view, and may range from clear felling in certain portions to practically no felling in others. Thus the regeneration of the area is not only by coppice but also from saplings and poles grown from seed.

1.5.2 Tending

Tending operation namely, cleaning, climber cutting, and reduction of coppice shoots etc. should be done as in other systems.

1.5.6 Character of the crop

The resultant crop under this system comprises of irregular groups of even aged coppice with uneven aged reserve crop scattered irregularly. Thus, taking the crop as whole, it is uneven aged.

1.5.7 Sal coppice forests in south-west Bengal

While Sal coppice forests in south-west Bengal is worked on **Coppice with Standard system**, the felling prescription **forbids** felling of certain indigenous species that yield non-wood forest produce, and are important from conservation viewpoint. For example, in Paschim Medinipur district, the Working Plan prescribes –

‘Coppice with standard system will be adopted in areas where there are viable root stock i.e. more than 200 stumps / ha & 100 stems per ha will be retained & some restricted trees like Mahua, Kend, Peasal, Amloki, Bahera, Haritaki, Kusum, Bat, Dumur & all fruit species are also to be retained.’

Reference Materials:

1. <http://www.forestrynepal.org/notes/silviculture-systems/4>,
2. 3. A.B Lal 1967 Indian Silviculture
3. Dr. Michael Femi Adekunle Associate professor And Professor S A Oluwalana Frm 503 lecture notes Forest management techniques, Department of forestry and Wildlife Management, University of Agriculture, Abeokuta, Ogun state, Nigeria.
4. Introduction to Silvicultural Systems British Columbia Ministry of Forests (<https://www.for.gov.bc.ca/hfp/training/00014/varselec.htm#varselec>)
5. Possible silvicultural systems for use in the rehabilitation of poorly performing pole-stage broadleaf stands – Coppice-with-standards by Short, I. and Hawe, J
6. <http://www.agriinfo.in/?page=topic&superid=2&topicid=1624>
7. L.S Khanna 1999 Principles and Practice of Silviculture, Milton Book Company, Dehra Dun





Lesson 15

Time 1 hour

Lesson Plan

Objective:

To hold Group Discussion on any of the following subjects

- Clear felling System – merits and demerits
- Shelterwood System – merits and demerits
- Selection System – merits and demerits
- Coppice with Standards System – merits and demerits

Backward Linkage: Lessons 11 to 14.

Forward Linkage: To observe and study, during tour, application of silvicultural systems.

Training Materials required: Copy of Lessons 11 to 14 to be circulated beforehand

Allocation of time:

Discussion and expression of views	45 mts
Recording emergent views	15 mts



