सत्यमेव जयते

FOREST BOTANY

(Training Material)

Part - I & II

DIRECTORATE OF FORESTS
GOVERNMENT OF WEST BENGAL

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PREFACE

Botany is one of the core subjects of forestry. Scientific management of plant resources of forests requires a forest manager to familiarize himself with the fundamentals of the plants – their internal and external structure, diverse physiological functions, interaction with the environment in which they grow, their uses and other aspects related to plant life. As part of the JICA project on 'Capacity Development for Forest Management and Training of Personnel' being implemented by the Forest Department, Govt of West Bengal, this course material on Forest Botany has been prepared for induction training of the Foresters and Forest Guards. The object of this training manual is to present the basic aspects of ForestBotany.

The subjects covered in this material 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 undergone minor revision to facilitate better understanding of the subjects and to provide their appropriate coverage. The revised syllabus, with such modifications, isappended.

As the material is meant for the training of frontline staff of the Department, effort has been made to present the subject in simple and easy language. However, as the subject unavoidably brings many scientific terms to make proper and precise presentation of the topics, it has been felt necessary to deal with and include such botanical terms in the lessons, particularly those on plant morphology.

The contents of the course material have been compiled and edited by A Basu Ray Chaudhuri, IFS (Retd),while working for and on behalf of project consultant Indian Institute of Bio-Social Research & Development (IBRAD). Many books, documents and information have been made use of in preparing the course material and references to such books, documents,etc. have been cited in the respective lessons. Thanks are due to many forest officers who have helped in the preparation of this material. A special word of thanks goes to Dr. Kana Talukder, IFS, CCF for helping with valuable suggestions andinputs.

Efforts that have gone into making of this course material will be best rewarded if the frontline staff of the forest department find it useful in their day-to-daywork.

Kolkata, 2016

(N K Pandey, IFS)
Principal Chief Conservator of Forests (General), West Bengal
&
Chairman, State Project Management Unit

SYLLABUS

Forest Botany (17* hours) Excursion 1day		
1. basics	1.1 External morphology (bark, branching pattern, phyllotaxy, leaf form, flower & inflorescence, fruit and seeds) ◆ parts of aplant ◆ roots types and functions ◆ stem –functions ◆ Leaf parts functions ◆ Inflorescence types ◆ Flowers-unisexual and bisexual-parts and functions ◆ fruits simple, aggregate and multiple ◆ seeds dispersal germination 1.2 anatomy ◆ cells and tissues ◆ heartwood and sapwood ◆ annual rings 1.3 physiology ◆ photosynthesis ◆ transpiration ◆ translocation ◆ respiration 1.4 taxonomy ◆ binomial nomenclature ◆ species, genus, family 1.5 vegetative propagation 1.6 ecology ◆ basic concepts ◆ plant succession ◆ eco-system ◆ related energy in ecological system, food chain and ◆ foodweb, ◆ ecological balance*	13* hours (4* hours practicalin laboratory)
2. Economic botany	◆ local names of 47* timber and NW FP species, their description*, distribution*, economic importance and uses. ◆ Preparation of herbarium sheet for 10 important species (to be done during tour)*	4 hours
3. Field botany	During JFM fieldwork, the trainees will learn to identify the local species from the villagers and learn their local names and uses. ◆ it is sufficient if the trainee assimilates local and common names of 50 important species. However, the course material should give the botanical names. During on the job training RFO/DFO should test their field knowledge, teach the trainees the local and botanical names of the important species. ◆ Identification of plants from morphology will be continued during Saturday excursions and tours/with villagers during collaborative walk during PRA exercise.	

* These are modifications to the MoEF-prescribed syllabus, indicating revision/addition of topics and change in lesson hours.

Contents

Forest Botany
Lesson - 1

Lesson Plan **Time 1 hour**

Objective:

- To know about scope of the subject Botany
- To know about the groups of plants
- To study Plant Morphology – The Root

Backward Linkage: Nil

Forward Linkage:

- Plant Morphology and Physiology discussed in subsequent lessons

Training Materials Required:

- Copy of lesson 1 to be circulated beforehand

Allocation oftime:

- Scope of Botany – 5 min
- Groups of plants – 8 min
- Plant morphology – diversity of plant life – 5 min
- Parts of a flowering plant – The root 32 min
- Discussion/ Miscellaneous – 10 min

1. Scope of Botany

The subject of Botany deals with the studyof plants. The scope of this study includes –

- Internal and external structure of plants.
- Various physiological functions like respiration, manufacture of food, conduction of food and water, reproduction etc.
- Adaptation to diverse conditions
- Geographical distribution of plants
- Relationship with other plants
- Classification in natural groups
- Evolution from lower and simple forms to the higher and more complex ones
- Uses.

2. Main groups ofplants

Plant kingdom has two main divisions –

(1) C**ryptogams** - lower plants which do not **bear flowers or seeds**; flowerless or seedless plants. (2) P**hanerogams**- higher plants which **always bear flowers and seeds;**flowering or seed bearing plants.

2.1 Cryptogams comprise **three** groups,namely

- **Thallophyta** – lower cryptogams; those with no leaves, stems, or roots.Examples are Algae, Bacteria, Fungi, Lichens (associations of algae andfungi).
- **Bryophyta** – higher cryptogams; have root-like (not true roots) structure called rhizoids.
- **Pteridophyta** – the highest group of cryptogams; plant body shows root, stem and leaves, but there is no flower and seed formation. Common examples are ferns.

2.2 Phanerogams

Phanerogams are divided into two groups–

(1) **Gymnosperms** (gymnos – naked, sperma – seed) – Their seeds are not enclosed in the fruit. They have simple and unisexual (either male or female) flowers. Common example isconifers.

(2). **Angiosperms** – Their seeds are enclosed in the fruit.

Angiosperms comprise two big groups–

- **Dicotyledons –** Bigger group of angiosperms;the embryo of the seed has **two cotyledons.** Other characteristics are
  - Flower normally has five petals or multiples of five
  - Root system has taproot
  - Leaves have reticulate (net like)venation
- **Monocotyledons** - Smaller group of angiosperms; the embryo of the seed has only one cotyledon. Other characteristics are
  - Flower normally has three petals or multiples of three ;
  - Root system has fibrous roots;
  - Leaves have parallel venation.

3. PlantMorphology

Morphology deals with the study of forms and features of different plant organs such as roots, stems, leaves, flowers, seeds and fruits.

3.1. A few terms relating to diversity of Plan tlife

3.1.1. Habitat- The habitat is the natural home or environment in which a plant (or animal) lives. Each habitat is characterized with a typical climate, soil and flora and fauna.

3.1.2. Habits- The habit of a plant is determined by factors like nature of the stem, height, its life span and mode of life. Habit is normally described by the following terms.

- **Herbs**- Small seed bearing plants with soft, rather than woody, stem.
- **Shrubs**- Medium–sized plant with a hard and woody stem, and several branches at the base of the stem.
- **Trees**- A tall woody plant with a clear stem.
- **Creepers**-Plants with soft stem and creep on the ground
- **Climbers**- Plants with soft stem that climb neighbouring objects
- **Twiners**- Plants that bodily twine about a support.
- **Lianes**- Woody climbers that climb up the tops of large trees

3.1.3. Duration of life- Life span of plants is limited.

Herbs have a short span of life. They are of following types-

- **Annuals**-Herbs that live for a few month or at the most a year.
- **Biennials**- Herbs which live for two years. Vegetative growth takes place in the first year and flowers and fruits are produced in the second year.
- **Perennials**- Some herbs continue to grow over the years. While the aerial parts of such plants die down every year after flowering or in winter, a fresh life begins after the onset of monsoon.

Shrubs generally have life for a few years. Trees however have the longest life.

4. Parts of a flowering plant

The plant body normally has two distinct parts - the underground root system and the aerial shoot system. The root system comprises **main root** and **lateral roots,** and the aerial shoot system has distinct organs like **stem, branches, leaves** and **flowers.** Of these various parts, root, stem, branches and leaves constitute **vegetative parts,** and the flowers constitute **reproductive parts**.

4.1 Root

The root is that part of a plant which grows underground. The root system consists of the main root and the lateral roots. Root-ends are protected either by root caps or root pockets.

4.1.1. Types of roots

Roots are of two types- (1) Tap roots (Normal or main) and (2) Adventitious root

- **Tap root**- The root that develops from the radicle (a little root being the part of axis within the embryo) is called normal root. As the radicle becomes long, it forms the **primary root. T**he primary root on being stronger and persistent forms **tap root.** Tap root produces lateral branches known as the secondary roots which in turn produce the tertiary roots.

- **Adventitious root-** Adventitious roots are those that grow from any part of the plant body other than the radicle. Adventitious roots are of following types-
  1. Fibrous roots of monocotyledons- When the primary root goes off, a cluster of slender roots grow from the base of the stem; such roots are called fibrous root.
  2. Foliar roots- Roots that develop directly from the leaves
  3. True adventitious roots-Roots that develop from the nodes and inter nodes of the stem.

4.1.2. Regions or parts of theroot

The root either belonging to a tap root system or adventitious root system shows the following distinct regions or zones.

- **Root cap region**- As the root tip makes way through thes oil, it is protected by a thin cushion or cap of tissue known as root cap.
- **Growing region or zone of elongation**- This is the region that lies just behind the root cap region. Growth of roots takes place in this region by cell divisions and cell elongation. According to some authors, this region consists of two zones, namely, (a) zone of cell division, and (b) zone of cell elongation.
- **Root hair region**-Unicellular root hairs occupy this region. It is located just above the growing region. The root hairs absorb water and solute from the soil besides providing a little anchorage.
- **Permanent region**- All the remaining portions of the root beyond the root hair zone are the permanent region. The permanent region conducts upward the substances absorbed by root hair besides providing anchorage.

4.1.3. Modifiedroots

Both tap roots and adventitious roots may undergo modification in order to carry out some special functions.

4.1.3.1Modified tap root (for storage of food)- These roots are fleshy and swollen due to accumulation of food. Modified tap roots are of fourtypes.

- Fusiform Root- The tap or primary root is swollen in the middle and tapering at both ends, e.g.Radish
- Conical Root- Broad at the base the root gradually tapers towards the apex like a cone, e.g.Carrot.
- Napiform Root-Being largely swollen at the upper part the root becomes almost spherical and sharply tapers at the lower part, e.g. Turnip and Beet.
- Tuberous or Tubercular Root-While being thick and fleshy the root does not maintain any particular shape; e.g. Mirabilis, Ruellia tuberose, Tapioca, some species of Dahliaetc.

4.1.3.2 Modified branch Root (for respiration)

Pneumatophores or breathing roots – These are modified branches of tap root system. They grow from underground roots of the plant but rise up above the soil. They have pores to allow entry of atmospheric air for respiration. Many plants in estuaries and salt lakes are found to develop pneumatophores.

4.1.3.3 Modified Adventitious Root

(a) For Storage of Food

- **Tuberous roots- A** swollen root having no definite shape, e.g. sweet potato. These roots arise from the nodes of the prostrate (growing along the ground) stem.
- **Fasciculated roots – A** cluster or fascicle of several tubercular roots, which occur at the base of the stem,; e.g. Dahlia, Asparagus etc.
- **Nodulose roots-** Some roots that are slender suddenly become swollen near the apex; e.g.mango-ginger (amada) turmeric (holud)etc.
- **Moniliform or beaded roots-** In this case,roots are alternately swollen and constricted at regular intervals presenting a beaded appearance; e.g. Indian spinach (Basella;pui) ,Momordica (kakrol), Wild vine (amal lota), Dioscorea alataetc.
- **Annulated roots-** The root has ring-like swellings in a series on its body.e.g.Ipecac.

(b) For mechanical support

- **Prop or Stilt Roots –** These adventitious roots are produced from the main stem and often from the branches. These aerial roots grow vertically or obliquely downwards. On reaching ground they penetrate the earth. Gradually, they become stouter and act as pillars to support the weight of the main stem and the branches of the plant.Example, many species of Ficus (e.g banyan), india-rubber plant, screwpine, Rhizophora etc.
- **Climbing Roots –**Developing from nodes and internodes these roots act like foothold for the climber plants and help the plants climb up walls or any other support. Examples are Piper betel, long peeper, black peeper, pothos etc.

(c) For vital functions

- **Assimilatory Roots – After** climbing on neighbouring trees branches of Tinospora (Gulancha) produce long slender hanging roots. These roots develop chlorophyll and turn green in colour. These green roots are called assimilatory roots as they carry out carbon assimilation by photosynthesis.

Fig. 1.1 Prop roots of Ficus benghalensis

(Source: http://floridata.com/plantlist/)

- **Sucking Roots, Parasitic Roots or Haustoria –** Rootlets, called haustoria or sucking roots, which are small adventitious root-like structures, develop from stem in some parasitic plants like species of Cuscuta (Swarnalata). These roots penetrate the tissues of the host plant and draw nourishment. Thus the parasite lives by sucking the host plant with the help of sucking roots.
- **Epiphytic Roots –** Certain plants, commonly orchids, grow on tree branches. These plants, known as epiphytes, do not suck the host plant. Rather they develop aerial roots of special kind which hang freely in the air. Such hanging roots have spongy tissue to absorb moisture from the atmosphere. These roots also have chloroplast and thus serveas assimilatory organs.
- **Mycorrhizal or saprophytic roots –** Plants growing in humus have mycorrhizal roots which are infested with fungal mycelia. These plants are called mycorrhizal saprophytes, e.g Pinus sp. Betula sp.etc. Mycorrhizal saprophytes draw nutrition from humus soil with the help of fungal mycelia.

4.1.4 Functions of Root

Functions may be broadly classified into two categories – (1) Mechanical and (2) Physiological. Besides, roots have special functions which they perform by adaptation to modified forms which have been discussed earlier.

4.1.4.1 Mechanical Function – Roots serve the mechanical function of **fixation**, that is, to anchor the plant to the soil. The tap root that goes deep into the soil and the lateral roots spreading out in all directions provide the anchorage to the substrate. The fibrous roots provide anchorage in case of monocotyledons.

4.1.4.2 Physiological Function

- **Absorption** – This is the most important physiological function. With the help of root- hairs the roots absorb water and dissolved minerals.
- **Conduction –** The roots take part in the process of conduction of water and mineral salts upwards to the stem and leaf.
- **Storage –** The roots store food reservein the mature or permanent region. This stored food is utilized for growth.

Source of Lesson Materials:

1. A.C.Dutta ,2000, A Class-book of Botany, Oxford UniversityPress.
2. J.N.Mitra et.al.2014, Studies in Botany, volume one, Moulik Library,Kolkata
3. http://floridata.com/plantlist/

Forest Botany
Lesson - 2

Lesson Plan **Time 1 hour**

Objective:

- To study plant morphology - the stem
  - ➢ Thebud
  - ➢ Kinds ofstem
  - ➢ Functions of the stem
  - ➢ Modifications of the stem
- To study types of branching of stem

Backward Linkage:

- Plant morphology dealt with in lesson1

Forward Linkage:

- Plant Morphology and Physiology discussed in subsequent lessons
- Field botany during tour

Training Materials Required:

- Copy of lesson 2 to be circulated beforehand
- Specimens of plant parts wherever possible

Allocation of time:

- Description of stem and bud– 5 min
- Kinds of stem – 8 min
- Functions of stem– 5 min
- Modifications of stem – 25 min
- Branching of stem– 12 min
- Discussion/Miscellaneous- 5 min

1. The Stem

The stem is the rising organ of the plant. It is the direct extension of plumule (part of the axis within the embryo which lies between the cotyledons) upwards. Sometimes, the stem is sub-aerial or underground. The stem bears branches (there are exceptions like palms, cycas etc.) leaves and flowers. The stem along with branches, leaves etc. is called **shoot**. While young, the stem is green in colour.

1.1 Nodes and Internodes

The place on the stem or branch from which one or more leaves grow is known as **node.** The space between two successive nodes is called the **internode**. The angle formed between a leaf and the internode is called axil.

1.2 The Bud

A bud is a young undeveloped (condensed) shoot. It has a short stem in which the internodes have not developed and the leaves are crowded together over a conical mass. The**axillary bud** grows in the axil of a leaf and the **terminal bud** grows at the apex of a stem or branch.

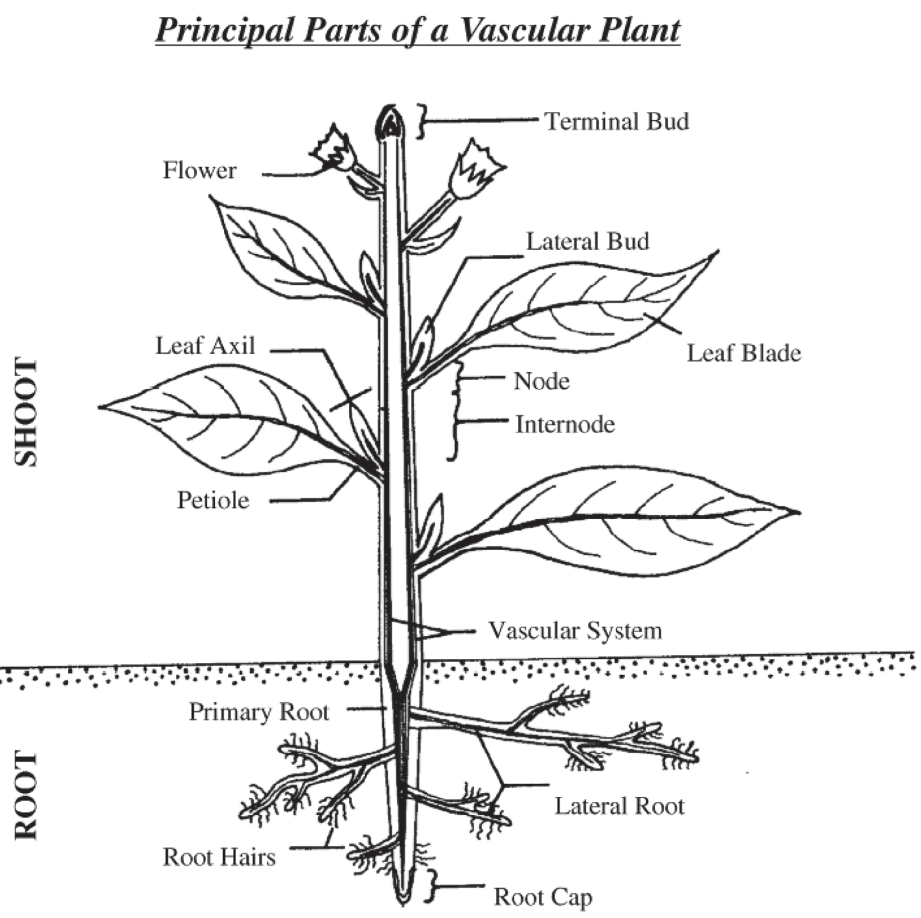


Fig.2.1

https://ag.arizona.edu/pubs/garden/mg/botany/plantparts.html

1.2.1 Kinds of buds

- **Normal Buds–** Axillary buds and terminal buds are known as **normal buds.**
- **Accessory Buds–** Buds that develop sometimes by the side of the axillary bud are called **Accessory buds.**
- **Adventitious Buds –** Those buds which develop from any part of plant body other than apex of the axis and axil of a leaf are known as adventitious buds.

1.3 Kinds of Stem

Aerial Stems may be (a) **strong (erect)** or (b)**weak.**

1.3.1 Types of strong stem

- **Excurrent** – The tree is of pyramidal form, e.g species of Abies, Pinus, *Polyalthia longifolia*;
- **Deliquescent**–The tree is of dome shaped form,e.g. Mangifera indica(Mango)
- **Caudex** – The unbranched, erect, cylindrical stem, e.g Palms
- **Culm** – Joined stems with solid nodes and hollow internodes, e.g. Bamboo
- **Scape** – In some herbs, particularly monocotyledons, the suppressed underground stem produces an erect unbranched aerial shoot which is known as **scape.** Coming out through the cluster of leaves, it bears at its apex a solitary flower or a cluster of flowers.

1.3.2 Kinds of weak stem

a) **Trailer –** trails over the ground without rooting at the nodes. Trailer stem is again of two kinds:
   - ➢ **Procumbent or Prostrate–** Its stem including the apex lies flat on the ground, e.g. *Basella rubra , Ipomoea reptans* etc.
   - ➢ **Decumbent**- After trailing for some distance, the stem lifts its head, that is, with the stem lying on the ground the apex turns upwards, e.g. *Tridax procumbens*

b) **Creepers**- The plant grows horizontally on the ground, while spreading branches profusely in all directions. The plant gets rooted at each node, e.g. *Ipomea batatas* (Sweet potato).

c) **Climbers**-
   - ➢ **Stem climbers or Twiners –** Long and slender stems of some plants climb up other plants or objects by twining round the support, e.g. Clitoria (Aparajita), Abrus (Kunch).
   - ➢ **Lianes**- Long and woody perennial stem climbers which climb up tall forest trees,e.g. *Bauhinia vahlii*
   - ➢ **Tendril climbers**- Plants which develop special type of climbing organs called tendrils, which help the plant climb up other plant or object. Different organs of the plant may be modified into tendrils; viz., modified axillary stem (in Passiflora or Passion flower); modified stem apex (in Vitis sp); modified leaf (in Lathyrus sp. or wild pea); modified leaf tip (in Gloriosa).

1.4. Functions of the stem

1) **Normal Functions**

- **Mechanical function**- Bearing the crown and weight of the entire plant, production and bearing of foliage leaves, branches and reproductive structures like flowers and fruits.
- **Physiological function**- Conduction of mineral salt sand water from the roots and translocation of prepared food to various parts.

2) **Special Functions**

- Storage of water, e.g. many Cactus sp.
- Storage of food– Food is stored in underground stems like Rhizomes,Tubers.
- Photosynthesis – Manufacture of carbohydrate food
- Self defense– Development of thorns, prickly stems, e.g. Duranta sp., Alangium sp., Rosasp.
- Supporting organs– Examples are tendrils of species of Vitis, Passiflora etc.
- Propagation– Sub-aerial modified stems like runner, stolon, sucker help in vegetative propagation.

1.5. Modifications of Stems

Stems or Branches of certain plants undergo modifications into various shapes to do special functions. The special functions include–

- Perennation – Survival from year to year under unfavorable conditions.
- Vegetative propagation – Creation of new plants from vegetative parts.
- Storage of food and water.

1.5.1. How underground stems are different from roots

- Underground stems have nodes and internodes
- Presence of small dry, scale leaves and development of adventitious roots from the nodes.
- Presence of buds at the axils of such leaves
- Internal structures are like those of stems

1.5.2. Types of underground modified stems

1) **Rhizome –** It is a thick, prostrate, underground stem having distinct nodes and internodes. It bears scaly leaves at the nodes, a bud in the axil of such leaves and a terminal bud.

2) **Tuber**- It is the swollen body borne at the end of a special underground branch. Originating from the axil of a leaf, the branch grows underground horizontally and ends in swelling at the apex owing to deposit of food matters. Round or oval in shape,it bears on its surface a number of "eyes" or buds which develop into new plants. Examples are *Solanum tuberosum* (Potato), *Cyperous rotundus* etc.

3) **Corm–**A condensed form of rhizome, the Corm is a short vertical fleshy, underground stem. Round in shape, it is often flattened from top to bottom. Its size is often big because it contains a heavy deposit of food material. One or more buds appear in the axils of scale leaves. Some of these buds develop into daughter corms. Examples are Amorphophallus (B. Ol), taro (Colocacia, B.Kachu)etc.

4) **Bulb** – It is a modified shoot having a shortened, usually globe-shaped, stem. It has a terminal bud (single, often large) and numerous scale leaves which normally surround the stem. Cluster of fibrous roots appear at the base. The inner scales are fleshy, as they store water and food, and the outer ones which are dry protect the stem. The terminal bud develops into aerial shoot. Examples are onion, garlic etc.

1.5.3 Sub-aerial modifications of Stems

Certain plants under go sub-aerial modification of stems for the purpose of vegetative propagation. There are **four types** of sub-aerial modification.

(1) **Runner** – It is a creeping branch with long internodes. It arises from the axillary bud of a mother plant and as it strikes roots at the nodes, a new plant comes up. A mother plant often produces a number of runners that spread on ground on all sides. Examples are wood-sorrel (*Oxalis*), Indian pennywort (*centella*), Marsilea (B. Sushnishak), strawberry (*Fragaria*) etc.

(2) **Stolon –** It is a slender lateral branch. Originating from the base of the stem of the mother plant, It bends down onto the ground, strikes roots and develops a bud and the lattergives rise to a new plant. The stolon may continue to moveover varying distances, and on its way, it will strike roots producing a bud at each node. Example: Wild strawberry (*Fragaria indica*)

(3) **Offset –** It is ashort thick runner. After originating from the axil of a leaf it grows as a horizontal branch. After travelling a short distance the apex turns up and a tuft of leaves is produced above and a cluster of roots below. Common examples are found in aquatic plants like water lettuce (*Pistia)*, and water hyacinth.

(4) **Sucker –** It is alsoa horizontal branch like stolon, and it originates from the underground part of the stem. However, after moving a short distance under the soil it emerges obliquely upwards and develops a leafy shoot or a new plant. Common examples are *Chrysanthemum*, rose, mint (B. Pudina), pine apple, banana etc.

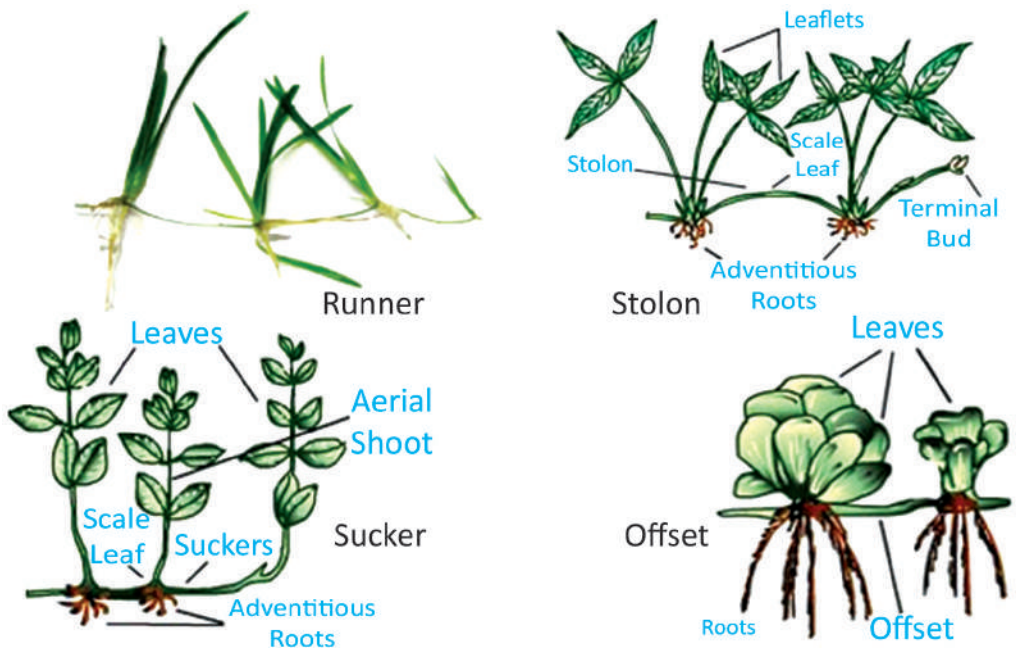


Fig.2.2
Sub-Aerial modifications of stem

1.5.4 Aerial Modifications :

Vegetative and floral buds normally develop into branches and flowers. However, incertain plants they undergo extreme modification or metamorphosis for some specific purposes. Such aerial metamorphosed organs are of the following types

- Stem-tendril – for climbing, e.g.vine
- Thorn – for protection, e.g. Duranta
- Phylloclade and Cladode – for food manufacture (function of foliage leaves), e.g. cacti (phylloclade) and Asparagus (Cladode)
- Bulbil – for vegetative reproduction, e.g. Dioscorea, Agave.

1.6 Branching

The manner in which branches are arranged on the stem is called **branching**. There are two principal types of branching – (**1**) **lateral** and (**2**) **dichotomous.**

1.6.1 Lateral Branching

When the branches are given off laterally from the lateral buds of the main axis, that is, from the sides of the stem, the branching is called lateral. Lateral branching is again of two types, namely (1) **racemose** or indefinite, and (2) **cymose** or **definite**.

- **Racemose branching** – This type of branching is seen in most of the angiosperms. Here the main stem continues to grow indefinitely by the terminal bud, and branches grow laterally in acropetal succession (i.e lower branches are older and longer than the upper ones). Examples are *Casuarina* (Jhau), *Polyalthia* (Debdaru). The shape of the plant becomes conical or pyramidal.

- **Cymose branching** – In this type, the growth of the main stem is definite, i.e. the terminal bud ceases to grow beyond a point. However, one or more branches originate from the main stem down below and grow more vigorously than the terminal one. As this process is repeated, the plant spreads out above and takes a dome shape. **Cymose** branching may again be of following types–

  - **Biparous Cyme** – two lateral axes emerge at a time in this type, also called **true cyme.** Examples are mistletoe (*Viscum)*, Carissa (B.karanja), temple or pagoda tree (*Plumeria*, B.katchampa)

  - **Uniparous Cyme** – In this type only one lateral branch emerge sat a time. It has two distinct forms, namely,

    (a) helicoid, or one-sided cyme, in which successive branches develop on the same side forming a helix structure. Examples are *Saraca indica (*B.ashok)

    (b) scorpioid, or alternate-sided cyme, in which lateral branches grow on alternative sides by turn forming a zig zag structure. Examples are *Vitis* (Vine) ,*Cissus quadrangularis (*Harjora)

  - **Multiparous Cyme** –In this type more than two branches develop at a time. Examples are *Croton sparsiflorus* and *Euphorbia tirucalli.*

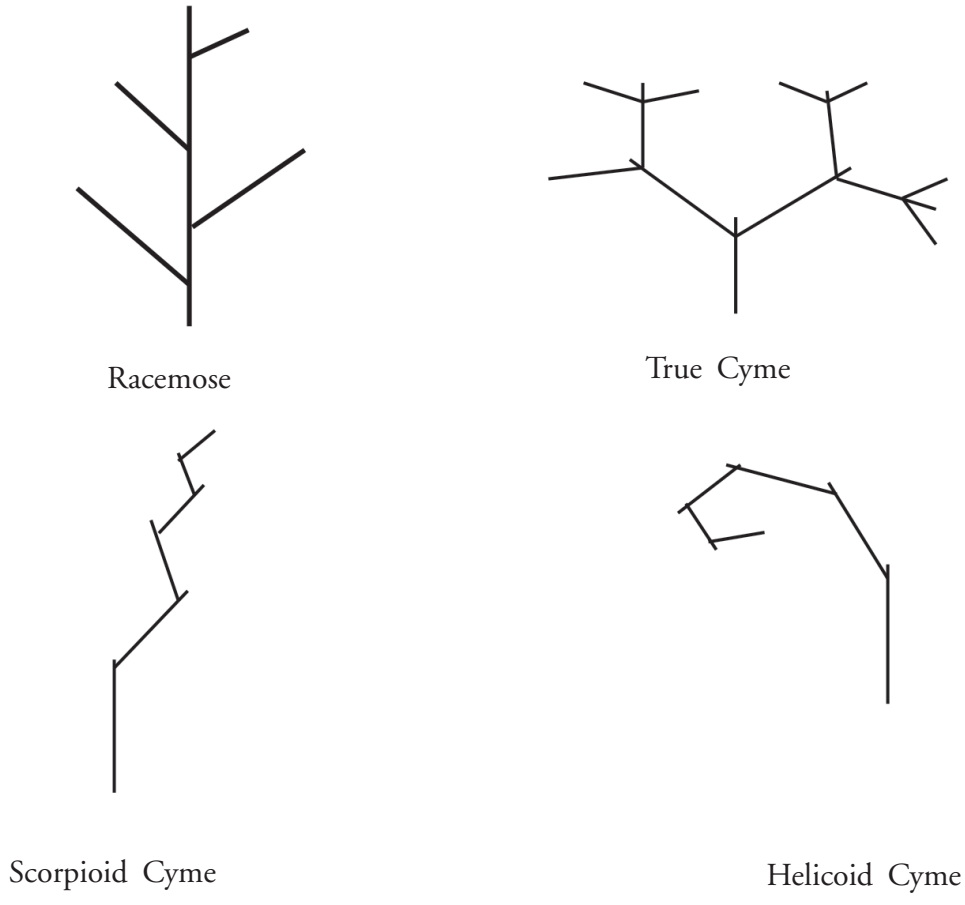


Fig. 2.3 Branching

1.6.2 Dichotomous Branching

Common among flowerless plants, this branching occurs when the terminal bud is forked giving rise to two branches.

Source of Lesson Materials:-

1. A.C.Dutta, 2000, A Class-book of Botany, Oxford University Press.
2. J.N.Mitra et.al.2014, Studies in Botany, volume one, Moulik Library, Kolkata
3. Websites cited in the Lesson.

Forest Botany
Lesson - 3

Lesson Plan **Time 1 hour**

Objective:

- To study the leaf as part of plant morphology
  - ➢ Parts of a leaf
  - ➢ Venation of a leaf
  - ➢ Compound leaf
  - ➢ Phyllotaxy
  - ➢ Functions of the leaf

Backward linkage

- Study of stem in lesson 2

Forward linkage

- Plant morphology in subsequent lessons

Training materials

- Copy of lesson 3 to be circulated beforehand
- Specimens of leaves

Allocation of time

- Parts of a leaf – 5 min
- Duration of leaf – 3 min
- Apex of the Leaf – 6 min
- Margin of the Leaf – 5 min
- Surface of the leaf – 5 min
- Shape of the leaf – 8 min
- Venation – 3 min
- Simple leaf and Compound leaf – 10 min
- Phyllotaxy – 5 min
- Functions of Leaf – 5 min
- Discussion/Miscellaneous – 5 min

Plant Morphology (Continued)

1. The Leaf

The leaf is the flattened lateral outgrowth of the stem or the branch. Green in colour the leaf develops from the node and has a bud in its axil.

1.1 Parts of a Leaf

A typical leaf has three parts – (1) Leaf base, (2) Petiole or the stalk of the leaf, and (3) Leaf lamina or leaf blade. Please see Fig.3.1.

1.1.1 Leaf base

It is the point of attachment of the leaf to the stem. In many plants, particularly **monocotyledons,**the leaf-base expands into a **sheath** which clasps the stem partly or wholly. The sheathing leaf-base is frequently found among. Stem of a banana plant is made up of leaf sheaths. In **dicotyledons**, the leaf-base normally displays ***two lateral outgrowths,*** **called stipules**.

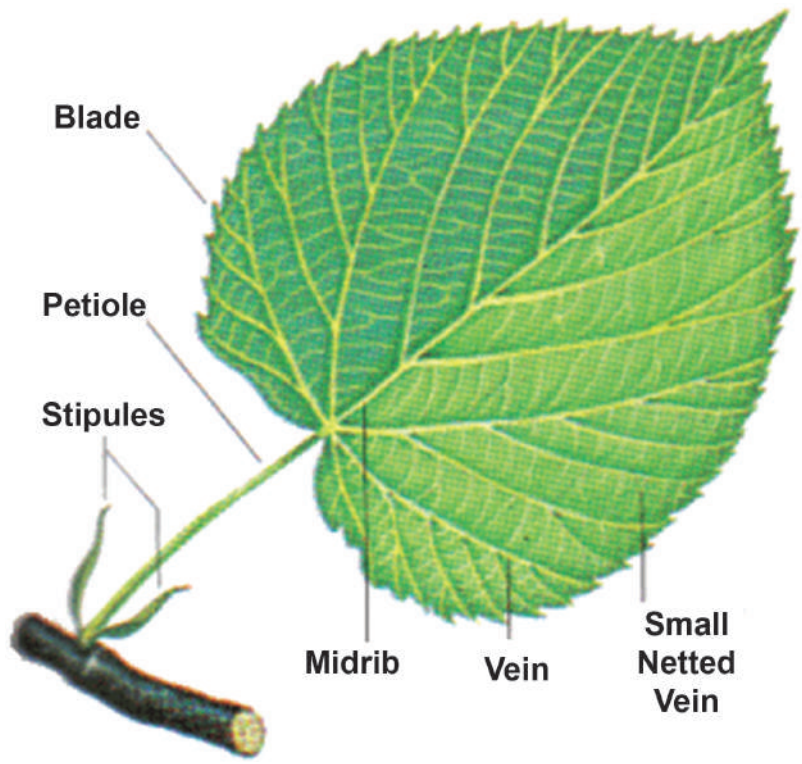


Fig.3.1 parts of aleaf

(Source: http://www.robinsonlibrary.com/science/botany/anatomy/leafparts.htm)

1.1.2 Petiole

Petiole is the stalk that attaches leaf blade to the stem. When the leaf bears no petiole, the leaf is said to be **sessile**. If petiole is present the leaf is called **petiolate or stalked**.

1.1.3 Leaf blade orlamina

Lamina is the thin, membranous, green expanded portion of the leaf and comprises the greater part of the leaf. It is the most important part of leaf since food for the entire plant is manufactured in the lamina. The strong vein which runs centrally through the leaf blade from its base to the apex is known as **mid-rib**. The mid-rib produces thinner lateral veins which again give rise to even thinner veins or veinlets.

1.2 Duration of leaf

- **Caducous** – The leaf falls off soon after it appears;
- **Deciduous or annual** – The leaf lasts one season; normally falls off in winter;
- **Persistent or evergreen** – The leaf lasts more than one season, usually a number of years.

1.3 Apex of the Leaf

Apex of the lamina or leaf blade assumes various shapes. Some are mentioned below.

- **Obtuse** – The leaf apex is rounded. Example: banyan (*Ficus bengalensis*)
- **Acute–**The leaf apex is pointed in the form of an acute angle. Examples: Mango, *Hibiscus rosa-sinensis*.
- **Acuminate or Caudate –** It is a longer acute apex. The apex is drawn into a long slender tail. Example: peepul (*Ficus religiosa*), lady's umbrella (*Holmskioldia*).
- **Cuspidate –** The leaf apex ends in a long rigid, sharp (spiny) point. Example: date palm, screw pine and pineapple.
- **Emarginate –** The apex is provided with deep notch. Example: *Bauhinia* (B. Kanchan), wood sorrel (*Oxalis* sp.)

1.4 Margin of the Leaf

Leaf margins are of various types. Some are described below.

- **Entire** – The leaf margin is even and smooth. Example: Mango (*Mangifera*), Jack fruit (Artocarpus *sp.*), Banyan (*Ficus sp.*)
- **Serrate** – Margin is incised like the teeth of a saw. Example : *Hibiscus* (B.Jaba), *Margosa* (B.Neem)
- **Crenate**- The margin is toothed, but the teeth are rounded. Example : *Centella asiatica (*Indian Pennywort*), Kalanchou pinnata* (Patharkuchi)
- **Spinous** – The margin is provided with spines. Example : Prickly poppy (*Argemone*)

1.5 Surface of the leaf

Leaf surface is also of various types. Some of the types are as follows.

- **Glabrous** – The leaf surface is smooth Example : *Mangifera indica* (Mango), *Syzygium jambos* (Roseapple)
- **Scabrous or Rough** – The leaf surface is rough to touch due to the presence of short rigid points. Example : *Ficus cunia*
- **Spiny** –The surface is covered by spine like prickles. Example : *Solanum ferox*
- **Pubescent or Hairy**- The leaf surface is covered, densely or sparsely, with hairs.

1.6 Shape of the leaf

Leaf blade shows wide variation in shape. Some of the shapes of the leaf blade are as follows

- **Acicular** –The leaf blade is very long, narrow, needle shaped. Example: *Pinus sp.*
- **Lanceolate** - The shape is like that of lance or spear. Example: Bamboo, Oleander etc.
- **Ovate**-The leaf blade is egg shaped; wider at the base than apex.Example: *Hibiscus rosa-synensis*(Jaba), *F. benghalensis* (Banyan)
- **Oblong –**The leaf blade is wide and long; the two margins run parallel up. Example : *Musa sp*.(Banana)
- **Rotund or Orbicular**- The leaf blade is more or less circular. Example: Lotus.
- **Cordate**- The leaf blade is heart shaped. Example : Betel, *Sida cordifolia* (Bala, Berela)
- **Reniform**- The leaf blade is kidney shaped, that is the apex of the leaf blade is rounded above with a deep notch at the base. Example: *Centella asiatica (*Indian Pennywort*).*

1.7 Venation

The arrangement or pattern of the veins and the veinlets in the leaf blade or lamina is called **venation**. Broadly, there are two types of venation – 1) **Reticulate Venation** and 2) **Parallel Venation.**

- **Reticulate Venation–**A net like arrangement of theveinlets.
- **Parallel Venation–**The veins are in straight lines parallel to one another.

Dicotyledons have reticulate venation and monocotyledons have parallel venation, though there are exceptions. Further subdivision of reticulate and parallel venation is not discussed *here*.

1.8 Simple Leaf and Compound Leaf

Simple Leaf – A leaf is said to be simple if it consists of a single blade which, even if lobed, is not incised **down to the mid-rib or petiole.**

Compound Leaf – A leaf is said to be compound when **the incision of the leaf blade is down to the**

mid-rib or to the petiole, leading to division of the leaf into a number of segments, called **leaflets**. The leaflets are free from one another and arranged on the axis, i.e. mid-rib known as **rachis**. A bud (axillary bud) is present in the axil of a simple or compound leaf, but there is no such axillary bud at the axil of leaflet of acompound leaf.

1.8.1 Types of Compound Leaf

Compound leaves are of two types – (1) **Pinnate and** (2) **Palmate.**

Pinnately Compound leaf – The leaflets are arranged, either alternately or in an opposite manner, on both sides of the rachis (mid-rib) directly or on the branches of the rachis. Pinnately compound leaves may be of the following types. Please see **Fig.3.2.**

- **Unipinnate –** When the mid-rib (rachis) of the pinnately compound leaf **directly bears the leaflets**, it is said to be **unipinnate**. Unipinnate leaves may again be of two types –
  - **Paripinnate –** When the leaflets are even in number, that is, arranged in pairs, it is said to be paripinnate. Examples: Sesbania (Bakphul), *Saraca indica* (Ashok), *Tamarindus indica* (Tentul),etc.
  - **Imparipinnate –** When the leaflets are odd in number, and the apex of the rachis bears an unpaired odd leaflet, it is said to be imparipinnate. Examples: *Rosa centifolia*, *Azadirachta indica* (Neem),etc.

- **Bipinnate –** When the compound leaf is twice pinnate, that is, when the rachis produces secondary axes and the leaflets are borne on the secondary axes, it is said to be bipinnate. Example: *Acacia arabica, Mimosa pudica* (Lajjabati), *Caesalpinia pulcherrima* (dwarf Gulmohur, Krisnachura)
- **Tripinnate –** When the leaf is thrice pinnate, that is, the secondary axes produce the tertiary axes and it is the tertiary axes that bear the leaflets, the leaf is said to be tripinnate. Example: *Moringa* (Drumstick, Sajina), *Oroxylum indicum* (Totola)
- **Decompound –** The leaf which is more than thrice pinnate is said to be decompound. Example: *Daucus carota* var.sativa (Cultivated carrot), *Coriandrum sativum* (Dhania) etc.

Palmately Compound Leaf – It is defined as one in which the petiole bears at its tip a number of leaflets which seem to be radiating from a common point like fingers from the palm. Leaflets are commonly five or more and such palmate leaf is called multifoliate or digitate. Example: *Bombax ceiba* (Simul). Sometimes the number of leaflets is three (trifoliate), as in *Vitex negundo* (Nishinda) and *Aegle marmelos* (Bel).

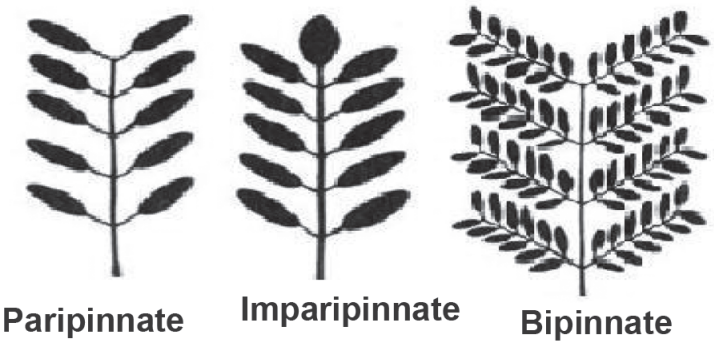


Fig. 3.2 Pinnately compoundleaves

(Source: http://eflora.library.sydney.edu.au/glossary/image/)

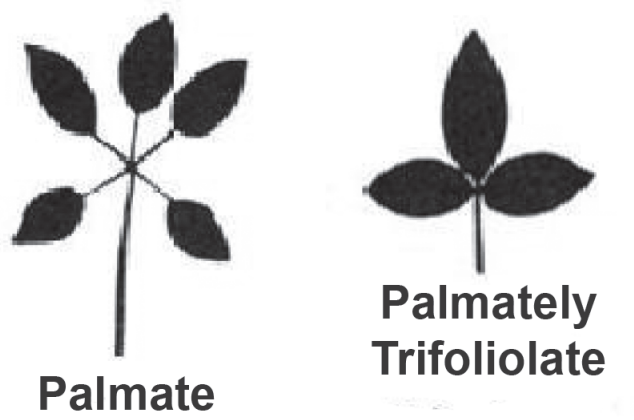


Fig. 3.3. Palmately compound leaf

(Source: http://eflora.library.sydney.edu.au/glossary/image/)

1.9 Phyllotaxy

Phyllotaxy is the mode of arrangement of leaves on the stem or the branch. The phyllotaxy aims to avoid suppression of one leaf by the other and to ensure that each leaf gets optimum amount of sunlight to perform its normal function. Plants exhibit three principal types of phyllotaxy.

- **Alternate or Spiral** – Each node bears a single leaf and the leaves are seen to be spirally arranged round the stem. Example: Tobacco, China rose, Mustard, Sunflower etc.
- **Opposite – E**ach node bears two leaves standing opposite to each other. This opposite phyllotaxy is again of two kinds–
  - **Opposite decussate –** One pair of leaves of one node stands at a right angle to the next upper and lower pair of leaves. Example: *Ocimum* (Tulsi), *Ixora* (Rangan), *Calotropis* (Akanda) etc.
  - **Opposite Superposed –** A pair of leaves stands directly over the lower pair in the same plane. Example: *Psidium guajava* (Peyara), *Quisqualis indica* (Sandhyamalati) etc.
- **Whorled – E**ach node bears three or more leaves arranged in a circle or whorl. Example: *Alstonia scholaris* (Chatim or Chatian), *Nerium* (Karavi). Please see **Fig. 3.4.**

Fig.3.4 Whorled phyllotaxy of Alstonia scholaris(Chatian)

(Source: http://toptropicals.com/cgi-bin/garden_catalog/cat.cgi?uid=Alstonia_scholaris)

1.10 Functions of the Leaf

Following are the normal functions of green foliage leaves.

- **Manufacture of food –** Primary function of leaf is to manufacture food. It produces food in presence of sunlight which is the original source of energy to the plant
- **Interchange of gases –** It is by regular exchange of Oxygen and Carbon dioxide with the atmosphere that the plants perform two important functions, namely, (1) respiration when the living cells absorb oxygen and give out carbon dioxide, and (2) food manufacture when green cells absorb carbon dioxide and give out oxygen. This exchange of gases takes place through numerous minute openings called stomata located on the lower surface of the leaf.
- **Evaporation of Water –** The excess water absorbed by root hairs evaporates mainly through the stomata during day time.
- **Storage of food –** Fleshy leaves of some species like Aloe (Ghritakumari), fleshy scales of onion store up water and food for future use.
- **Vegetative Propagation –** Leaves of certain plants like *Bryophyllum, Begonia* etc. develop buds on them for vegetative propagation.

Source of Lesson Materials:-

1. A.C.Dutta, 2000, A Class-book of Botany, Oxford University Press.
2. J.N.Mitra et.al.2014, Studies in Botany, volume one, Moulik Library, Kolkata
3. Websites cited in the lesson

Forest Botany
Lesson - 4

Lesson Plan **Time 1 hour**

Objective:

- To study the following of plant morphology
  - ➢ Inflorescence
    Types of Inflorescence
  - ➢ Bract, Bracteole
  - ➢ Flower
    Parts of a flower
  - ➢ Some terminologies

Backward linkage

- Study of plant morphology in lessons 2 and 3.

Forward linkage

- Study of plants in subsequent lessons
- Study of inflorescence during tour

Training materials

- Copy of lesson 4 to be circulated before hand
- Specimens of flowers/inflorescence

Allocation of time

- Inflorescence – 2 min
- Types of inflorescence and their descriptions
  Racemose Inflorescence – 20 min
  CymoseInflorescence – 10 min
- Bract–Bracteole – 3 min
- Flower –differentparts – 15 min
- SomeTerminologies – 5 min
- Discussion/Miscellaneous – 5 min

1. Inflorescence

It is the branch system of the floral region bearing a group of flowers. The stalk or the main axis of the inflorescence is known as **peduncle**. The stalk of the individual flower of the inflorescence is called the **pedicel**. In certain plants the peduncle is short and dilate, and it forms a kind of convex platform (example: Sunflower) or becomes hollow and pear- shaped (example: Ficus).The structure of this kind is called **receptacle**.

1.1 Kinds of Inflorescence

Different types of inflorescence that are found may be classified into **two** distinct groups, namely, (1) **Racemose or Indefinite,** and (2) **Cymose or Definite.**

1.1.1 Racemose Inflorescence

In this type the main axis of inflorescence does not terminate in a flower, but continues to grow producing flowers laterally. Some of the **common types of racemose inflorescence** are decribed below.

(A) With the main axis elongated

1.1.1.1 Raceme

Raceme or simple raceme has long peduncle and bears a number of pedicellate flowers in acropetal succession. The lower or older stalks have longer stalks than the upper or younger ones. Example: *Brassica juncea* (Mustard), *Caesalpinia pulcherrima* (dwarf gulmohur).

Panicle or Compound Raceme

Panicle is a branched raceme. The peduncle produces a number of branches. On these branches pedicellate flowers are produced..

Example: *Mangifera indica* (mango), *Delonix regia* (goldmohur) etc. Please see **Fig.4.1**.

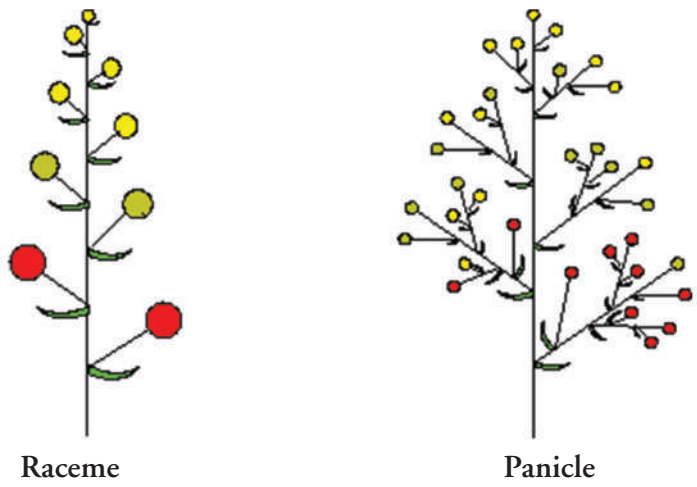


Fig.4.1 Simple Raceme and Compound Raceme (Panicle)

(Source:http://www.biotik.org/laos/defs/245_en.html)

1.1.1.2 Spike

Like raceme this type has also long peduncle or main axis and the flowers are produced in acropetal succession (lower flowers are older, opening earlier than the upper ones). But the flowers in a spikeare sessile, that is, without any stalk. Example: *Adhatoda vasic*a (Basak), Amaranth (Nate-sak), *Achyranthes aspera* (Apang) etc. Please see **Fig.4.2.**

Fig.4.2 Spike of Achyranthes aspera
(Source: https://commons.wikimedia.org/wiki/File:Achyranthes_aspera_at_Kadavoor.jpg)

1.1.1.3 Catkin

Catkin is a type of spike inflorescence with a pendulous peduncle. The flowers in this type of inflorescene are unisexual. Example: *Acalypha hispida* (foxtail), *Morus alba* (Mulberry), *Betula* (Birch), *Quercus* (Oak), etc..

Fig. 4.3 Spathe of *Typhonium trilobatum* (Araceae)
(Source: http://www.amjbot.org/content/99/10.cover-expansion)

1.1.1.4 Spadix

This is also a type of spike with a fleshy peduncle. The peduncle is enclosed by a single or many large, often brightly coloured, bracts, called **spathe**. Spadix is found only in monocotyledons. Example: Aroids (members of *Araceae*), Banana, Palmetc.

B. With the main axis shortened

1.1.1.5.Corymb

Corymb is a racemose inflorescence with a slightly shortened axis. The older flowers have the longer and the younger flowers have the shorter pedicels. As a result, all the flowers of the corymb inflorescence are found more or less at the same level (**Fig.4.4**) *Example: Cassia sp. (Caesalpinaceae).*

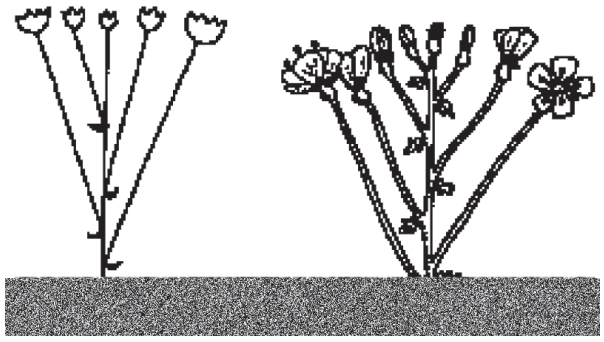


Fig. 4.4 Corymb Inflorescence

(Source: http://botany.csdl.tamu.edu/FLORA/201Manhart/repro/inflor/inflor.html)

1.1.1.6 Umbel

This inflorescence has a short floral axis at the tip of which pedicellate flowers are arranged in a radiating manner. Example: Species of *Foeniculum* (Anise or fenel, Panmouri), *Coriandrum* (Dhania). In certain plants, however, the umbel is simple or unbranched and is called **simple umbel**. Example: *Centella asiatica* (Brahmi). *Eryngium* (Wild coriander).

C. With the main axis flattened

1.1.1.7 Head or Capitulum

In this type of inflorescence, characteristic of sunflower family, the main axis or receptacle is suppressed and almost flat. The flat receptacle bears a mass of small sessile flowers (florets) on its surface. Example: sunflower, margold, zinnia, Acacia (gum tree), Mimosa (sensitive plant), *Anthocephalus* (Kadam), *Adina* (Kelikadam)

1.1.2 Cymose Inflorescence

In Cymose Inflorescence the main axis as well as the lateral axis ends in a flower. The terminal flower is older and open searlier than the lateral ones. Cymose Inflorescence is of the following types.

(1) **Uniparous or Monochasial Cyme –** In this type, as the main axis ends in a flower, it produces only one lateral branch at a time ending in a flower. The process is repeated. There are two kinds of Uniparous Cyme, namely-

- **Helicoid Cyme-** The lateral axis develops successively on the same side,forming a sort of helix. Example : *Drosera* (Sundew)
- **Scorpioid Cyme-** Here the lateral branches develop on alternate sides, forminga zig zag structure. Example: *Heliotropium* (Hatisur)

(2) **Biparous or Dichasial Cyme-** Here the primary axis ends in a central flower which opens first, and at the same time at the base of the primary axis two lateral branches bearing flowers arise. The lateral flowers are younger. Each lateral branch may again give rise to succeeding flowers in the same manner. This is called **True Cyme**. Example : *Jasminum* (Jasmine), *Tectona grandis* (Teak) *Ixora* (Rangan).

(3) **Multiparous or Polychasial Cyme –** Here ast he main axis ends in a flower, it again produces a number of lateral flowers around. Example: *Calotropis* (Akanda), *Asclepias.*

2. Bracts

Bracts are special leaves. From their axil, flowers, solitary or in clusters, are developed. There are many kinds of Bracts like leafy bracts, spathe, Petaloid bracts, involucres, scaly bracts etc.

2.1. Bracteoles

Bracteoles are smaller than bracts. They are either thin leafy or scaly structures developing on flower stalks between bracts and calyx.

The Flower

The flower is a modified shoot meant for reproduction of the plant.

3.1. Parts of a flower

The flower is borne on an axis which has two regions–(1) **Pedicel**–Stalk of the flower, and

(2) **Thalamus** –Swollen end of the axis on which floral leaves (whorls) are inserted. A flower has the following four whorls arranged in a definite order, one above the other.

(a) The outermost or the first whorl, called **Calyx** consists of a number of green leafy s**epals**

(b) The second whorl above the calyx is called **Corolla** which consists of a number of usually bright and coloured p**etals.**

(c) The third whorl is the male whorl called **Androecium** which consists of **stamens**.

(d) The fourth or the female whorl is called **Gynoecium** or **Pistil** which consists of c**arpels.**

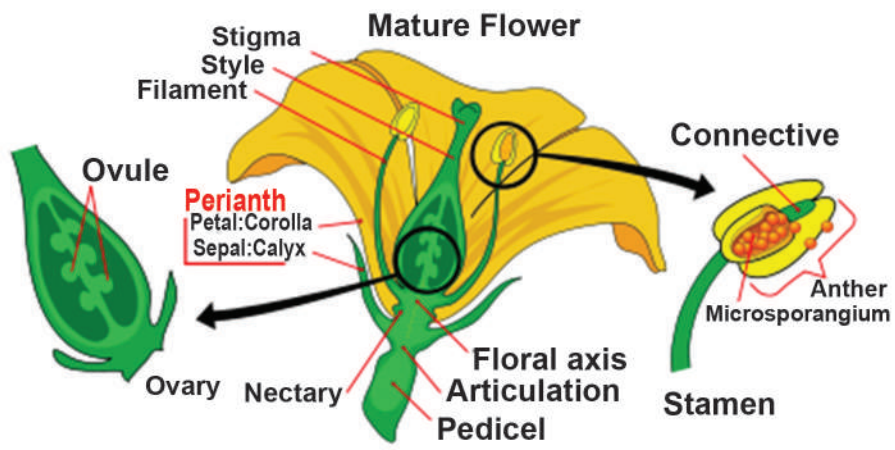


Fig.4.5 Parts of aflower

(Source: https://en.wikipedia.org/wiki/Flower)

Descriptions of the various parts of a flower and their functions are given below.

3.1.1. Calyx – It consists of a number of sepals. It is usually green, but in certain flowers it is coloured, as in Goldmohur. The sepals may be united together (**Gamosepalous**) or free from each other (**Polysepalous**). Examples of Gamosepalous Calyx: Brinjal, Chili, Potato. Example of Polysepalous Calyx: Mustard , Radish etc.

Functions-

- **Protection-** Protects the flower in bud condition.
- **Assimilation-** When green in colour, it manufactures food.
- **Attraction –** When coloured, it attracts insects.

3.1.2 Corolla

The corolla consists of a number of **petals**. Often brightly coloured and sometimes scented the petals attract insects for **pollination**. The corolla may be **gamopetalous** (petals areunited) or **polypetalous** (petals are free).

Functions–

- Attract insects and help pollination
- In the bud stage protect the essential organs like stamens and carpels from heat, rain and insect attack.

3.1.3 Androecium

It consists of individual members known as **stamens.** The number of stamens may be one to many. Each stamen consists of-

- **Filament** – It is the slender stalk of stamen
- **Anther** – It is the expanded head on the tip of filament. Usually, each anther comprises two lobes. Each anther lobe has within it two chambers called **pollen-sacs** or **microsporangia** . Each pollen sac contains fine, powdery or granular mass of cells, called the **pollen grains or microspores**. **Pollen grains** are the male reproductive bodies of a flower.
- **Connective–** It is the midrib connecting the two lobes that comprise the anther.

3.1.4. Gynoecium or Pistil

It consists of one or more **carpels**. The carpels are modified leaves; they bear ovules and an embryo sac within each ovule.

A carpel consists of three parts–

- **Ovary** – the basal swollen portion containing one or more little egg-like bodies which are the rudiments of seeds, and are known as ovules.
- **Style** – short or long stalk-like protrusion of the ovary.
- **Stigma** – the receptive end (for the pollen grains) of the style which is knob-like in appearance.

3.2 Some Terminologies

- **Complete and Incomplete Flowers –** A flower is said to be **complete** when all the four floral whorls are present. Absence of any of the floral whorls makes the flower **incomplete**.
- **Bisexual and Unisexual Flowers –** A flower is called **bisexual or hermaphrodite** when it contains both androecium and gynoecium. When a flower contains either androecium or gynoecium, that is, either the male or female whorl is absent, it is called **unisexual ordiclinous**.
- **Dioecious, Monoecious and Polygamous plants –** Plants bearing **flowers of one sex** only, either female or male, are called **dioecious**. Plants bearing **unisexual flowers of both sexes** (on the same plant) are called **monoecious**. **Polygamous** are those plants which bear **unisexual flowers of both sexes, i.e. male and female flowers, in addition to bisexual flowers.**

Source of Lesson Materials:

1. A.C.Dutta, 2000, A Class-book of Botany, Oxford University Press.
2. J.N.Mitra et.al.2014, Studies in Botany, volume one, Moulik Library, Kolkata
3. Websites cited in the lesson

Forest Botany
Lesson - 5

Lesson Plan **Time 1 hour**

Objective:

- To study the following of plant morphology
  - Pollination
    - Types and agents of pollination
  - Fertilization
  - The fruit
    - Parts of fruit
    - Functions
    - Classification
  - Dispersal of seeds and fruits

Backward linkage

- Study of plant morphology in lessons 2, 3 and 4.

Forward linkage

- Study of plants in subsequent lessons
- Study of fruits / seeds during tour

Training materials

- Copy of lesson 5 to be circulated beforehand
- Specimens of fruits /seeds

Allocation of time

- Pollination– 8 min
- Fertilization– 4 min
- The Fruit
  - Parts of fruit– 4 min
  - Functions/True and False fruit– 5 min
  - Classification– 20 min
- Dispersal of Fruits / Seeds– 14 min
- Miscellaneous /Discussion– 5 min

1. Pollination

Pollination is the act of transferring pollengrains from the male anther of a flower to the female stigma of the same flower or of another flower of the same or sometimes allied species.

2. Types of Pollination

Pollination is of two kinds-

- **Self Pollination or Autogamy –** Pollination takes place within a single flower (bisexual) or between two flowers (bisexual or unisexual) of the same plant. In self pollination the offspring are produced by one parent plant.
- **Cross pollination or Allogamy –** Pollination takes place between two flowers (bisexual or unisexual) borne by two separate parent plants of the same or allied species.

Cross pollination is believed to be advantageous for the plant because the seeds produced by the flower will contain another source of genetic material which may contain genes which are advantageous to the survival of the seedlings. Plants that self pollinate are said to be **inbreeding** whereas plants which only cross pollinate are said to be **outcrossing**. However, most plant species are not strictly inbreeding or outcrsossing but a combination of the two.

3. Agents of Pollination

The agents that bring about pollination are–

- Wind
- Water
- Animals that include insects, snails, birds and bats.

Based on pollinating agents, pollination is classified into the following types–

- **Anemophily**– Pollination brought about **by wind** is called anemophily. **Anemophilous** plants bear small and inconspicuous flowers. Examples are maize, rice, grasses, bamboo etc.
- **Hydrophily** – In this case, pollination is brought about by water. Typical hydrophilous flowers are found in many submerged monocotyledons, like species of *Vallisneria*, *Hydrilla*, *Najas*, *Zostera* etc.
- **Zoophily** – In this case pollination is brought about by animals. The pollination agents here include insects, birds, snails and slug and bats. One subdivision of zoophily is entomophily where pollination is brought about by insects like bees (the most common insect pollinators), butterflies, moths, beetles and wasps. Entomophilous flowers have various adaptations by which they attract insects and use them as carriers of pollen grains. Principal adaptations are colour, nectar and scent.

4. Fertilization

It is the union of two **dissimilar sexual cells, that is, the male and female gametes,** resulting in the formation of a **zygote.**

When pollen grains land on the stigma of a flower of the correct species, they germinate. A pollen tube grows through the tissues of the flower until it reaches an ovule inside the ovary. The nucleus of the pollen grain (the male gamete) then passes along the pollen tube and joins with the nucleus of the ovule (the female gamete). This process is called **fertilization**. After fertilization the female parts of the flower develop into a fruit. The ovules become seeds and the ovary wall becomes the rest of the fruit.

5. The Fruit

A fruit may be defined as a seed bearing structure produced usually after fertilization from the ovary of a flower or from an entire inflorescence. The fruit is considered a mature or ripened ovary.

5.1 Parts of the Fruit

A fruit consists of **two** parts, namely-

- **The Pericarp –** the part developing from the wall of the ovary.
- **The seed or seeds –** developing from the ovule or ovules.

The **pericarp** may be thick or thin. When thick, it exhibits **three** layers or parts. These parts are–

- **Epicarp** – the outer thin layer which forms the skin of the fruit.
- **Mesocarp** – the middle layer which forms the pulp;
- **Endocarp** – the inner layer, often very thin and membranous (example: orange), or hard and stony (example: many palms, mango etc).

5.2 Functions of the Fruit

- Protects the seed and therefore the embryo.
- Stores food material
- Helps in the dispersal of seed.

5.3 True and False Fruit

Normally the ovary grows into fruit, and the fruit which develops from the ovary is known as **true fruit.** However, in certain plants other floral parts, the thalamus or sometimes the calyx may grow and form a part of the fruit, and such a fruit is called **false fruit**. Some common examples of false fruit are apple, cashew nut, Dillenia (Chalta)etc.

5.4 Classification of the Fruit

Fruits may be broadly classified into three groups. They are–

(1) **Simple Fruits –** When the ovary of a single flower with or without accessory parts matures into a single fruit, it is called **simple fruit**. Simple fruit may be dry or fleshy. The dry fruit again may be of three types **(a) dehiscent, (b) indehiscent and (c) schizocarpic**.

(a) Dehiscent fruits - When these fruits mature, the pericarp bursts to liberate the seeds. There are **different types of dehiscent fruits–Legume or Pod, Follicle, Siliqua** and **Capsule.**

(b) Indehiscent fruits – Indehiscent fruits do not burst or split open on maturity. The seeds are liberated by decaying or accidental destruction of the pericarp. There are many types of indehiscent fruits, like **Achene, Caryopsis, Samara, Nut** etc.

(c) Schizocarpic or Splitting Fruits – Schizocarpic fruits break up into a number of indehiscent bits, called maricarps, generally equal to the number of component carpels. The pericarp does not burst or break down; the seeds are liberated only by the decomposition of the pericarp or by its splitting. There are many types of schizocarpic fruits, e.g. **Lomentum, Cremocarp, Double Samara** etc.

(d) Fleshy Fruits – There are various types of fleshy fruits, e.g. **Drupe, Berry, Pepo, Pome, etc.**

(2) **Aggregate Fruits**

An aggregate fruit or **etaerio** is a collection of simple fruits (or fruitlets). It forms when many ovaries inside the same flower fuseinto one.

Common forms of etaerios are–

1) An etaerio of follicles; example: *Magnolia grandiflora*, *Michelia champaca* (B. Champ) etc.
2) An eaterio of achenes; example: rose, lotus, *Naravelia* etc.
3) An eaterio of drupes; example: raspberry
4) An eaterio of berries; example: custard apple, *Polyalthia longifolia* (Debdaru)

(3) **Multiple or Composite Fruits**

An inflorescence where the flowers are crowded and often fused gives rise to a multiple or composite fruit. There are two types of multiple fruits.

1) Sorosis – develops from a spike or a spadix. Example: jackfruit, mulberry.
2) Syconus – develops from a hollow pear shaped fleshy receptacle which encloses a number of minute male and female flowers. As it grows, the receptacle becomes the so-called fruit which in fact contains the true fruits originating from the female flowers. Example: banyan, peepul etc.

6. Dispersal of Seeds and Fruits

Seeds contained within fruits need to be dispersed far from the mother plant so that they may find favorable and less-competitive conditions in which they may germinate and grow. We discuss here dispersal of seeds and fruits by various external agents.

6.1 Dispersal by wind

Wind is one of the best carriers of seeds. Fruits and seeds need to have certain properties or adaptations to be carried away easily by wind. We see many adaptations of fruits and seeds that facilitate their dispersal. Some of the adaptations are discussed here.

- **Wings** – Seeds and fruits of certain plants develop membranous wings. Examples of seeds developing wings are: *Oroxylum indicum* (Sona, Totola), *Lagerstroemia* (Jarul), Moringa (Sajina). Likewise, fruits of certain plants develop one or more wings. Example: *Shorea robusta* (Sal), *Dipterocarpus* (Garjon) *Dioscorea* etc.
- **Parachute Mechanism- Pappus,** a hair like structure, develops due to modification of calyx of mini plants of the sunflower family or *compositae***.** Persistent in the fruit the papus opens out like an umbrella and gets carried away to a longdistance.
- **Censer Mechanism**- In certain plants, the fruit dehisces and liberates the seeds, and when it is shaken by wind, the seeds are dispersed to a distance. Example : *Aristolochiya gigas* (Pelicun flower, Hangshalata), *Orgemone mexicona* etc.
- **Hairs**-In certain plants, seeds develop a tuft of hairs or a dense coating of hairs to facilitate dispersal by wind. Example: *Calotropis* (Madar), *Alstonia* (Devil tree), *Gossypium* (Cotton) etc.
- **Persistent styles** - In certain plants like *Clematis, Naravelia,* the styles are persistent and very feathery. This structure thus helps the fruits to float in air.
- **Light Weight** - If the fruits or seeds are small and light in weight (example, orchids and grains), they are easily carried by wind.

6.2. Dispersal by water

In aquatic plants and the plants growing by water side, seeds and fruits usually develop floating devices in the form of spongy or fibrous outer coats so that they are carried by water current to a long distance. For example the fibrous mesocarp in *cocos nucifera* (Coconut) is a floating device. Such device is also seen in *Areca catechu* (Supari) and *Nipa fruticans*.

6.3. Dispersal by Explosive mechanism

Explosive and dehiscence mechanism of capsules of many plants help the seeds to disperse through certain distance.The fruits of *Impatines balsamina* and *Oxalis species*, when touched, burst with sudden jerk and a little sound resulting in scattering of the seeds. Mature fruits of Andrographis paniculata (Kalmegh), *Barleria* (Jhanti) etc. burst suddenly in dry air. The long pods of *Bauhimia vahlii* (Latakanchan) explode suddenly with a loud noise and scatter the seeds.

6.4. Dispersal by human beings and animals

Dispersal by Human beings and animals such as grazing cattle, birds etc. is also a common phenomenon. Dry indehiscent fruits develop various devices to facilitate dispersion.

Common examples of such devices are–

- **Hooked fruits**- Certain fruits are provided with hooks, barbs, spines, bristles by means of which they get attached to animal bodies or clothing of mankind and thus get carried to other places. Examples: Fruits of *Xanthium* (Okra) and *Urena* (Bonokra) develop curved hooks; seeds (fruits) of *Aristida* (Spear grass) have a cluster of stiff hairs.
- **Sticky fruits**- Fruits of *Boerhaavia* (Punarnava) are provided with sticky glands so that they stick to the bodies of grazinganimals.
- **Edible fruits**- Many fruits are regularly and widely distributed by animals over a long distance. Human beings and birds are the more active agents in this respect. The edible or pulpy portion of the fruits are eaten away, and the seeds are rejected which therefore get a chance to germinate and grow into new plants. Common examples are Guava, Papaya, mango, custard appleetc.

Source of Lesson Materials:

1. A.C.Dutta, 2000, A Class-book of Botany, Oxford University Press.
2. J.N.Mitra et.al. 2014, Studies in Botany, volume one, Moulik Library, Kolkata

Forest Botany
Lesson - 6

Lesson Plan **Time 1 hour**

Objective:

To study the following of plant Anatomy

- The Cell
  - Definition
  - Cell wall
  - The Protoplast
  - Protoplasmic components
  - Non protoplasmic components
- The Tissue
  - Definition
  - Meristematic tissue-Classification of Meristems
  - Permanent Tissue-Classification of Permanent tissues
- Secondary Growth
- Annual Rings
- Heartwood and Sapwood

Backward linkage

- Study of plant morphology in previous lessons.

Forward linkage

- Study of plants in subsequent lessons
- Study of Annual Rings during tour

Training materials

- Copy of lesson 6 to be circulated before hand

Allocation of time

- Definition of Cell-Cell wall– 3 min
- The Protoplast– 3 min
- Protoplasmic components– 12 min
- Non protoplasmic components– 7 min
- Definition of Tissue– 3 min
- Meristematic tissue-Classification of Meristems– 6 min
- Permanent Tissue-Classification of Permanent tissues– 9 min
- Secondary Growth– 4 min
- Annual Rings– 4 min
- Heartwood and Sapwood– 4 min
- Discussion / Miscellaneous– 5 min

Plant Anatomy–

1. The Cell-The plant body is composed of cells which are its fundamental structural and functional units. A typical plant cell consists of a centrally situated mass or unit – the **protoplast** and a surrounding membrane or wall known as the cell wall.

1.1 Cell wall – It is the **non living** boundary wall of a cell. It is mainly composed of cellulose. It is formed by the protoplast to maintain its form and to protect it from external injury. The cell wall has a laminated structure.

1.2 The protoplast – It is the organized mass that lies within the wall and has, as its constituents, **(i) protoplasmic components**, i.e, **Protoplasm (living),** and **(ii) Non- Protoplasmic components.** The protoplasmic components or protoplasm include bodies, namely, **Cytoplasm, Endoplasmic Reticulum, Nucleus, Plastids** etc. It is noteworthy that these living bodies never originate afresh in the cells but they develop from pre-existing ones by divisions, and thus a living body gives rise to bodies of its own kind only.The non-protoplasmic components include (i) Ergastic substance i.e. Non-living cells like reserve food material, excretory material and (ii) The Vacuole.

1.3 Protoplasmic components or protoplasm–

(i) Cytoplasm- It comprises the living, hyaline, jelly-like and viscous transparent semi-fluid portion of the protoplast, in which nucleus, plastids and other cell inclusions; both living and nonliving are embedded. At the young stage of the cell the cytoplasm occupies the whole cavity, i.e, the space between the cell wall and the nucleus. As the cell increases rapidly, the cytoplasm cannot keep pace with the growth of cell wall. As a result, a number of small (Non-Protoplasmic) cavities, called **vacuoles** appear in the cytoplasm. With further increase in cell size, these small vacuoles combine to form a large one, occupying the greater space of the cell. In the process the cytoplasm is pushed outward as a thin lining layer against the cell wall. The cavities or vacuoles formed within the cytoplasm are filled up with a fluid, called the cell-sap.

(ii) Endoplasmic Reticulum – It is a network of tube like structures distributed throughout the cytoplasm, and is revealed by the Electron microscope. They appear to have functions in enzyme formation, protein synthesis, storage and transport of metabolic products.

(iii) Nucleus- Commonly spherical or oval in shape, the nucleus is a specialized protoplasmic body, much denser than the cytoplasm. The nucleus is present in all living cells. Normally the nucleus lies in the central position and occupies a considerable portion of the cell wall. However, as described earlier, with development of the cell size, the nucleus along with the cytoplasm moves to the periphery.

Structure of a nucleus- Following are the components that form a nuclear structure.

- **Nuclear Membrane** –separates the nucleus from the surrounding cytoplasm.
- **Nuclear sap or Nucleoplasm or karyolymph** –a colourless jelly-like dense but clear mass of protoplasm, filling the cavity of nucleus.

- **Nuclear reticulum or Chromatin network –** Numerous fine crooked threads, connected loosely, forming a network or reticulate structure, present in the nucleoplasm in a dispersed state.
- **Nucleoli (sing. Nucleolus)** – One or more spherical, thick, prominent and highly refractory bodies, found in dispersed condition with in the nuclear sap.

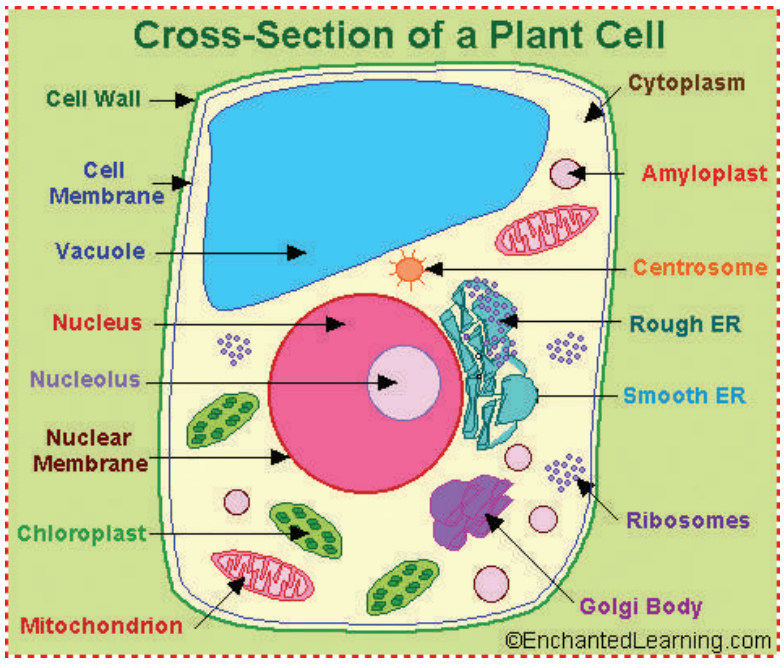


Fig 6.1 Typical plantcell

(**Source:** http://www.enchantedlearning.com/subjects/plants/cell/)

- **Plastids** - Plastids are cell organelles, spherical or ovoid in shape, which store specific things found only in plant cell but absent in animal cells. They are involved in manufacture and storage of certain important chemical compounds.. According to their colour the plastids are of three types– **Leucoplasts or Amyloplast** (colorless plastids; function is to convert sugar into starch), **Chloroplasts** (elongated or disc-shaped organelle containing chlorophyll, involved in photosynthesis) and **Chromoplast** (colored plastids, found commonly in flowers and fruits).

(iv) Mitochondria- Minute bodies occurring present often in large numbers in the cytoplasm of all plant and animal cells. They are described as the 'power plants' of the cell as they convert glucose to energy molecules.

(v) Golgi Bodies– They are minute net like structure, and more common in animal cells than plants. Their main function is to process and package macromolecules synthesized from other parts of the cell.

(vi) Centrosomes– They are found to occur in cells of some lower plants like algae and fungi. A minute body the centrosome occurs close to the nucleus. They have an important role during cell division.

(**viii**) **Ribosomes**– The small, sub-spherical particulate components of the cytoplasm. Ribosomes are sites for protein synthesis. They are found in all cells because protein is necessary for the survival of the cell.

(**ix**) **Lysosomes**–Spherical in shape they occur as tiny particles in the cytoplasm. They digest excess or worn out organelles, food particles and any foreign bodies.

1.4 Non-protoplasmic components

Then on protoplasmic components of a plant cell include the following

(i) **Vacuoles –** This has already been described in sub para (i) in para1.3.

(ii) **Ergastic matters that is non-living cell contents** - Ergastic matters are divided into three groups

- Reserved materials – These are substances manufactured by the protoplasm and stored up in particular cells for utilization as food. These materials consist of three maingroups namely, (a) Carbohydrates,(b) Nitrogenous materials and (c) Fats and oils.
- **Secretory materials**–These are various products secreted by the protoplasm to perform some special functions. Secretory materials are (a) Plant pigments, (b) Enzymes and (c)Nectar
- **Excretory materials –** These are substances that are formed during metabolism as mere by-products. These excretory materials are (a) alkaloids (b) organic acids (c) resins (d) gums (e) tannins (f) essential oils (g) latex and (h) mineral crystals.

2. The Tissue

Cells grow and assume specific shapes. Cells of the same shape combine into a group to perform a common function. Each group of mature cells forms a tissue. A tissue is thus defined as a continuous mass of cells of common origin and performing an identical function. Tissues are primarily classified into **two groups – meristematic and permanent**.

2.1 Meristematic tissue

Meristematic tissue, also called meristem, is defined as the embryonic tissue in the mature plant body, the cells of which continue to divide indefinitely, and as a result new cells are added continuously to the plant body. Some cells produced by meristematic tissue stop dividing and become permanent tissues of the plant.

2.1.1 According to their position in the plant body, there are three types of meristems: **Apical Meristems, Lateral Meristems** and **Intercalary Meristems.**

- **Apical meristem**is found at the tips of roots, stem and branches. It is responsible for increase in length of plant.

- **Lateral Meristem**- The meristem that is present along the longitudinal axis of stem and root is called **lateral meristem**. It produces secondary permanent tissues, which result in the thickening of stem and root.
- **Intercalary meristem** - It is present in the nodal region and is prominently found in monocotyledons, eg. grasses. It is derived from the apical meristem and is responsible for the elongation of internodes.

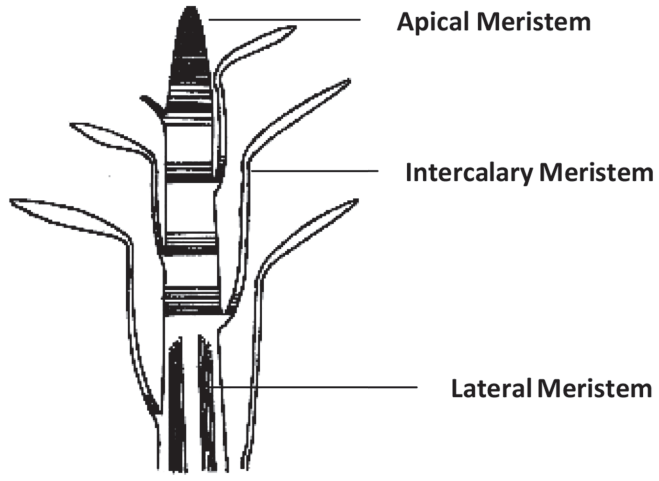


Fig.6.2 L.S of shoot - showing the positions of meristems

(Source: Biology, Botany, HS Second Year,TamilnaduTextbook Corporation)

2.2 Permanent Tissues– These are composed of cells that have attained their definite form and size, and have lost the power of dividing,. They may be living or dead.

2.2.1 Classification of permanent tissue - Based on the constituent cells, the permanent tissue is classified into two types – simple tissue and complex tissue.

- **Simple tissue** - A tissue with the cells of similar structure and function is called simple tissue. It is of three types - **parenchyma, collenchyma** and **sclerenchyma.**
  - **Parenchyma**–A living tissue, generally present in all organs of the plant. Its function is mainly storage of food material.
  - **Collenchyma**– A living tissue, generally occurring in the dicot stems. It gives strength to young organs. Collenchyma may contain chloroplasts and carry out photosynthesis.
  - **Sclerenchyma** - A dead tissue, fibre like in appearance, they provide strength and rigidity to the plantbody.
- **Complex Tissue**- A tissue that consists of several kinds of cells functioning together as a single unit is called complex tissue. It is of two types – **xylem** and **phloem.**

- **Xylem** is a complex tissue that is mainly responsible for the conduction of water and mineral salts from roots to other parts of the plant. **Xylem** is made up of four kinds of cells - **tracheids, vessels or tracheae**, **xylem fibres** and **xylemparenchyma.**
    - **Tracheids** - Tracheids are elongated dead cells having thick lignified walls and large cavity.
    - **Vessels –** They are rows of elongated tube-like dead cells, placed end to end, resembling much like a series of water pipes forming a pipe line.
    - **Xylem (wood) Fibres –**They are **t**he fibres of sclerenchyma that give additional mechanical support to the plant body.
    - **Xylem (Wood) Parenchyma** –They are the only living tissue amongst the constituents of xylem; besides assisting in conduction, they store food reserves in the form of starch and fat.

- **Phloem** -Like xylem, phloem is also a complex tissue. It conducts food materials to various parts of the plant. Phloem is composed of four kinds of cells: **sieve tubes**, **companion cells**, **phloem parenchyma** and **bast fibres**.
    - **Sieve Tubes – They are s**lender tube-like structure comprising elongated cells placed end to end; each transverse wall is perforated by a number of pores, which give it a sieve like appearance. Sieve elements are the conducting elements of the phloem. In matured sieve tube, nucleus is absent.
    - **Companion cells** - The thin-walled, elongated, specialised parenchyma cells, which are associated with the sieve tubes, are the companion cells. In contrast to sieve tubes, the companion cells have cytoplasm and a prominent nucleus. They assist the sieve tubes in the conduction of food materials.
    - **Phloem parenchyma** - The parenchyma cells associated with the phloem are called phloem parenchyma. These are living cells. They store starch and fat, and also resins and tannins in some plants.
    - **Bast Fibres –**They are fibres of sclerenchyma associated with phloem. They are narrow, vertically elongated cells with very thick walls and a small lumen (the cell cavity). Among the four kinds of phloem elements, phloem fibres are the only dead tissue. These are the strengthening and supporting cells.

3. Secondary Growth

Increase in the circumference/girth of the plant organs due to the formation of secondary (new) tissues in stellar (central part) and extra stelar regions, is called secondary growth. The secondary growth takes place in sturdy herbs and in all shrubs and trees. Secondary tissues are formed by two lateral meristems

– cambium (plant tissue located between xylem and phloem) in the stelar region and cork-cambium in the extra stellar region. Normally, secondary growth takes place in roots and stem of dicotyledons and gymnosperms.

4. Annual Rings

Activity of the cambium in producing secondary tissues is influenced by the climatic conditions. In spring, under favourable conditions, the activity of the cambium increases. It then produces a greater number of vessels with wider cavities (large pitted vessels). However, in winter the cambium's activity slows down and it produces narrower elements (narrow pitted vessels). The wood formed in spring, called **spring wood**, and that formed in winter, called **autumn wood**, appear together as a concentric ring in a cut section of the stem. This ring is known as **annual ring** or **growth ring**. Each annual ring reflects one year's growth. The annual rings are visible in the naked eye in the logs of tree trunks of pines and many other timber trees. A count of the number of the annual rings gives an estimation of age of the tree.

5. Heartwood and Sapwood

In a stem, two types of wood zone appear following the formation of considerable amount of secondary Xylem during secondary growth. The recently formed outer zone of such secondary Xylem (i.e, wood) which is of lighter colour is known as the Sapwood. Sapwood contains living cells and is functional in conduction of water and salt solutions from the root to the leaf. However, the centrally situated Xylem, which has been formed earlier gets filled up with tannins, resins, gums, and essential oils etc. which make it hard and durable. This region of secondary wood is known as heartwood whose cells become non functional in conduction and storage. The heartwood is generally darker in colour. Composed of dead Xylem elements, heartwood simply gives mechanical support to the stem. Heart wood is more durable and forms commercial timber.

Source of Lesson Materials:-

1. A.C.Dutta,2000, A Class-book of Botany, Oxford University Press.
2. J.N.Mitra et.al.2014,Studies in Botany, volume one, Moulik Library, Kolkata
3. Botany, Higher Secondary, Second Year, Tamilnadu Textbook Corporation
4. Websites cited in the lesson

Forest Botany
Lesson - 7

Lesson Plan **Time 1 hour**

Objective:

To study the following of Plant Physiology

- Photosynthesis
  - Significance
  - Site
  - Mechanism
  - Two mainreactions
  - Factors affecting photosynthesis
- Transpiration
  - Types
  - Significance
  - Factors affecting Transpiration
- Translocation
  - Mode
- Respiration
  - Endproducts
  - Mechanism of respiration

Backward linkage

- Study of plant anatomy dealt with in Lesson 6.

Forward linkage

- Study of plants in subsequent lessons

Training materials

- Copy of lesson 7 to be circulated beforehand

Allocation of time

- Photosynthesis– 20 min
- Transpiration– 12 min
- Translocation– 8 min
- Respiration– 10 min
- Discussion/Miscellaneous– 10 min

1. Plant Physiology

Plant physiology is the branch of biological science, which deals with the functioning, and inter relationships of cells, tissues and organs of plants.

2. Photosynthesis

It is the process in which carbohydrates are synthesized in green cells in presence of light from carbon dioxide and water absorbed from air and soil respectively.

2.1 Significance of photosynthesis

Photosynthesis provides all our food and fuel. It is the only biological process that sustains the whole animal kingdom and the non-photosynthetic organism. It provides organic substances, which are used in the production of fats, proteins, nucleoproteins, pigments, enzymes, vitamins, cellulose, organic acids, etc. Some of them become structural parts of the organisms. From simple raw materials such as CO_2, H_2O and inexhaustible light energy, it produces energetic organic compounds.

2.2 Site of photosynthesis

Chloroplasts are the actual sites for photosynthesis. While all green parts of a plant take part in photosynthesis, leaves are the most important organs involved in the process. Over half a million chloroplasts are present in one square millimetre of a leaf. It measures about 4 to 6 micron. A typical chloroplast of higher plants is discoid shaped.

2.3 Mechanism of Photosynthesis

The mechanism of photosynthesis can be described by the following equation

$$6CO_2 + 12\ H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6\ H_2O + 6O_2$$

Thus the process of photosynthesis liberates Oxygen from water and causes reduction of carbon dioxide into Glucose. The above equation however indicates merely the beginning and the end of the process, but does not tell us anything about the complicated intermediate steps that take place.

2.3.1 Two main reactions

Photosynthesis has two main reactions – (1) **Light-dependent reactions** or **Light Reactions** - which need light to work, and (2) **light-independent reactions or Dark Reactions** - which do not need light to work.

- **The Light Reactions: $H_2O \rightarrow O_2$ + ATP +NADPH**
  - Light energy from the sun is used to split water (**photolysis**). W**ater is split** to produce oxygen, electrons (e–), and hydrogen ions(H+).
  - This system depends on sunlight for activation energy.
  - Light is absorbed by *chlorophyll* which "excites" the electrons in the chlorophyll molecule.
  - Electrons are passed through a series of carriers to produce adenosine triphosphate, **ATP** (that transports chemical energy within cells for metabolism) and **NADPH** (a coenzyme that carries electrical energy used in cellular processes and is used in the dark reactions).
  - Oxygen diffuses out of the plant as a waste product of photosynthesis.
- **Light-independent or Dark reactions: $ATP + NADPH + CO_2 \rightarrow C_6H_{12}O_6$**
  - The reactions that catalyze the reduction of CO_2 to carbohydrates with the help of ATP and NADPH generated by the light reactions are called the dark reactions. The enzymatic reduction of CO_2 by these reactions is also known as carbon fixation. These reactions that result in CO_2 fixation take place in a cyclic way and was discovered by Melvin Calvin. Hence the cycle is called Calvin Cycle.
  - During the dark reactions, sugars are built up using carbon dioxide and the products of the light-dependent reactions (ATP and NADPH) and various other chemicals found in the plant in the Calvin Cycle. Carbon dioxide diffuses into the plant and glucose is made.
  - The dark reactions continue as long as the light reactions supply energy in the form of ATP and NADPH
  - The ultimate product is glucose ($C_6H_{12}O_6$) - a stable, transportable, and storable form of chemical energy.

2.4 Main factors affecting Photosynthesis

There are three main factors affecting photosynthesis:

- Lightintensity
- Carbon dioxide concentration
- Temperature

1) **Light intensity:** If the light intensity is low, the light-dependent reactions will not work efficiently. This means that photolysis will not happen quickly, and therefore little NADPH and ATP will be made. This shortage of NADPH and ATP will not allow the light-independent reactions to work, as NADPH and ATP are needed for the light-independent reactions.
2) **Carbon dioxide levels:** Carbon dioxide is used in the light-independent reactions. It combines with NADPH and ATP and various other chemicals (such as Ribulose Biphosphate) to form glucose. Therefore, if there is not enough carbon dioxide, enough glucose will not be formed even with a build up of NADPH and ATP,.

3) **Temperature:** There are many enzymes working in photosynthetic reactions - such as the enzyme in photolysis. These enzymes will stop working properly at high or low temperatures and therefore, so will do the light-dependent and light-independent reactions.

3. Transpiration

Plants absorb a large quantity of water from the soil with the help of root hairs. However, plants utilize only a small part (1-2%) of water that they absorb. A major part (98-99%) of water intake is lost in the form of water vapour. **Transpiration** is the loss of water from the aerial parts of the plant in the form of water vapour.

3.1 Types of transpiration

Transpiration may be of the following types.

- **Stomatal** - transpiration taking place through the stomata (minute openings on the under surface of the leaves).
- **Cuticular** - transpiration taking place through cuticle, a thin layer covering the surface of the plant.
- **Lenticular** - transpiration taking place through the lenticels (pores in woody plants) of stems and fruits.

Of the three types, **maximum transpiration (80-90%) is accounted through the stomata.** At night when the stomata are closed, transpiration is checked.

3.2 Significance of transpiration

- Excess water is got rid of.
- Movement of water through xylem vessels is favoured by active transpiration.
- Helps the intake of inorganic salts from the soil.
- Reduces the temperature of the leaves and helps the latter function normally.

3.3 Factors affecting transpiration

- **Light** – Rate of transpiration greatly increases with light and decreases in darkness.
- **Humidity** – Rate of transpiration increases when the air is dry, that is, when humidity decreases.
- **Temperature** – The higher the temperature, the greater is the transpiration.
- **Wind velocity**– increase in the wind velocity usually increases the rate of transpiration.

4. Translocation

Translocation is the process by which food stuff move from leaves to other parts of plant. Plant food, that is, carbohydrates (sugars) is produced in leaves. Mature leaves are rich in plant food. By the process of translocation, food is moved to stems, roots, flowers and young leaves which need food for their growth.

4.1 Mode of Translocation

The tissue through which translocation takes place is **phloem.** Please refer to Lesson 6. The sieve tubes which are the conducting cells of phloem carry out the translocation.

4.1.1 In order to facilitate the flow of sap, the sieve tubes undergo major changes in their internal structure. As they mature, the sieve tubes lose many cell elements like nucleus, vacuoles, etc. and provide open space within the cell.

4.1.2 The pace or rate of translocation is reported to be faster in angiosperms (flowering plants) than that in conifers. As sugar moves into phloem, pressure is generated in the sieve elements, and the difference in pressure that develops down the sieve tube causes flow of material.

5. Respiration

Living cells require a continuous supply of energy for maintaining various life activities. This energy is obtained by oxidizing the organic compounds (carbohydrates, proteins, and lipids) in the cells. This process of harvesting chemical energy for metabolic activities by oxidising the food molecules is called 'respiration'. The compounds that are oxidized during this process are known as respiratory substrates.The most common respiratory substrate is glucose.During oxidation within a cell, all the energy contained in respiratory substrates is not released free into the cell, or in a singlestep. It is released in a series of slow step-wise reactions controlled byenzymes, and it is trapped as chemical energy in the form of ATP.

5.1 End Products

In normal aerobic respiration, the complete combustion of glucose yields energy, while producing CO_2 and H_2O as the end products. Most of the energy produced during respiration is given out as heat.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6\,H_2O + \text{Energy}$$

In order that this energy is to be useful to the cell, it should be able to utilise it to synthesise other molecules that the cell requires. So the plant cell catabolizes the glucose molecule in such a way that all the liberated energy does not go out as heat. Glucose is oxidized in several small steps. Some steps are large enough to ensure that the released energy can be coupled with ATP synthesis.

5.2 Mechanism of Respiration

Respiration happens in two main steps in all living beings, viz. glycolysis and processing of pyruvic acid. Glycolysis occurs in the cytoplasm of the cell and is present in all living organisms. In this process, which does not require oxygen, glucose undergoes partial oxidation to formtwo molecules of pyruvic acid. Further processing of pyruvic acid depends on the aerobic or anaerobic nature of an organism. Anaerobic respiration takes place in the absence of free oxygen molecules (example: fermentation), and chiefly occurs in

microorganisms such as bacterial and yeast cells. In fermentation by yeast, the incomplete oxidation of glucose is achieved under anaerobic conditions and pyruvic acid is converted to carbon dioxide and ethanol. Again, some bacteria in anaerobic respiration produce lactic acid from pyruvic acid. Normally, free oxygen is used in respiration, which is known as aerobic respiration. In aerobic respiration, pyruvic acid is further processed to produce carbon dioxide and water along with energy. In this type of respiration, glucose is completely oxidized and one molecule of glucose yields 38 ATP molecules. In contrast, in anaerobic respiration, glucose is partially oxidized, and very little energy is released, as partial oxidation of one molecule of glucose yields only 2 ATP molecules.

Source of lesson materials:

1. A C Dutta 2000, A Class-book of Botany, Oxford University Press
2. DMitra et.al 2014, Studies in Botany, Vol2, Moulik Library, Kolkata,
3. Botany, Higher Secondary, Second Year, Tamilnadu Textbook Corporation
4. http://www.biologyreference.com/Ta-Va/Translocation.html
5. http://kea.kar.nic.in/vikasana/bridge/biology/chap_07.pdf;
6. Respiration in Plants at http://ncert.nic.in/NCERTS/l/kebo114.pdf
7. http://crescentok.com/staff/jaskew/ISR/botzo/class7.htm

Forest Botany
Lesson - 8

Practical class on Plant Morphology

Lesson Plan **Time 1 hour**

Objective:

- To help the trainees familiarize themselves with following of plant morphology
  - Stem, Leaf
  - Phyllotaxy
- To have better understanding of these topics dealt with in theoretical classes.

Backward Linkage:

- Topics of plant morphology dealt with in Lesson 2 and 3.

Forward Linkage:

- During tour the trainees will have opportunities to see and refresh what they have learnt about plant morphology in theoretical and practical classes.

Methodology:

- Practical classes should be with examples/specimens of forestry species.
- Venue of class may be field or a combination of laboratory and field
- Trainees may be divided into groups. Each group may be assigned a couple of plants in the field and briefed about the species, characteristic features, branching, phyllotaxy, etc.The trainees should observe and note and collect specimens of leaves. Then they may record their observations on data sheet.

Allocation of Time:

- Briefing, observation, collection of specimens of leaves – 25 min
- Recording of observations – 35 min

Practical Class:

Subject:

- Familiarisation with plant morphology -Stem, Leaf, Phyllotaxy

  To demonstrate and elucidate the above aspects of plant morphology with specimens of forestry species

Observations: Trainees may record general description of the plant, noteworthy characteristics of stem, special features like branching, phyllotaxy etc. on data sheet

Name _____ Date _____

Class Period _____

Familiarization with Stem, Leaf and Phyllotaxy
Data Sheet

Part A.Plant

1. Describe the plant
(General descriptions about habit, size, stem, crown, foliage etc.)
Specimen #1

a) Species _____

b) Description _____

_____

_____

Diagram Specimen #1

Diagram Specimen #2

Specimen #2

a) Species _____

b) Description _____

_____

_____

Part B.Stem

1. Describe the characteristics, including branching.
   Specimen#1

   a) Species _____

   b) Description _____

   _____

   _____

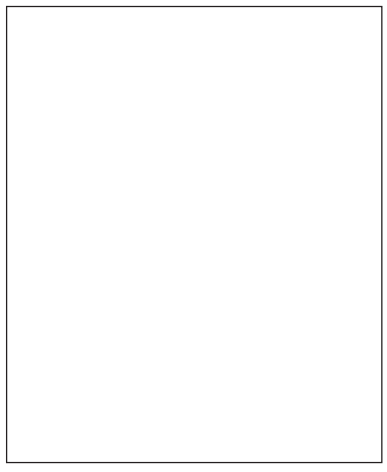


Diagram Specimen #1

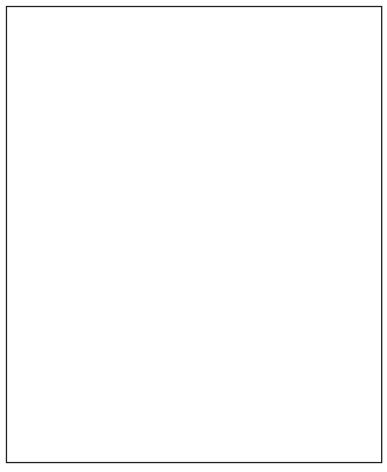


Diagram Specimen #2

Specimen #2

a) Species _____

b) Description _____

_____

_____

Part C. Leaf

Describe the characteristics Specimen #1

Specimen #1

a) Species _____

b) Description _____

_____

_____

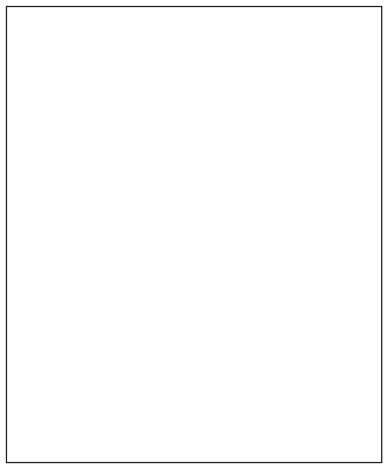


Diagram Specimen #1

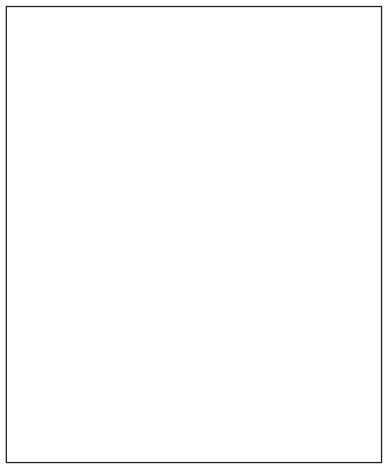


Diagram Specimen #2

Specimen #2

a) Species _____

b) Description _____

_____

_____

Part D. Phyllotaxy

Describe the characteristics

Specimen #1

a) Species _____

b) Description _____

_____

_____

Diagram Specimen#1

Diagram Specimen#2

Specimen #2

a) Species _____

b) Description _____

_____

_____

Specimen #3

a) Species _____

b) Description _____

_____

_____

Diagram Specimen#3

Diagram Specimen#4

Specimen #4

a) Species _____

b) Description _____

_____

_____

Forest Botany
Lesson - 9

Practical class on Plant Morphology
(Inflorescence and Flowers)

Lesson Plan **Time 1 hour**

Objective:

- To help the trainees familiarize themselves with in florescence and flowers
- To have better understanding of topics dealt with in theoretical classes.

Backward Linkage:

- Topics (Inflorescence and flowers) of plant morphology dealt with in Lesson 4.

Forward Linkage:

- During tour the trainees will have opportunities to see and refresh what they have learnt about inflorescence and flowers in theoretical and practical classes.

Methodology:

- Practical classes should be with examples/specimens of forestry species.
- Venue of class may be field or a combination of laboratory and field
- Trainees may be asked to identify various kinds of inflorescence in the field.

Allocation of Time:

- Observation/demonstration– 40 min
- Recording on data sheet– 20 min

Practical Class:
Subject:

- Familiarisation with plant morphology –Inflorescence
- Familiarisation with plant morphology - Parts of a Flower

To demonstrate and elucidate the above aspects of plant morphology with specimens of forestry species

Observations: Trainees may record their observations on data sheet.

Name _____ Date _____

Class Period _____

Familiarization with Inflorescence and flowers
Data Sheet

Part A. Inflorescence

1. Describe the inflorescence

Specimen #1

a) Type _____
b) Description _____
_____
_____

c) Species_____

Diagram Specimen #1

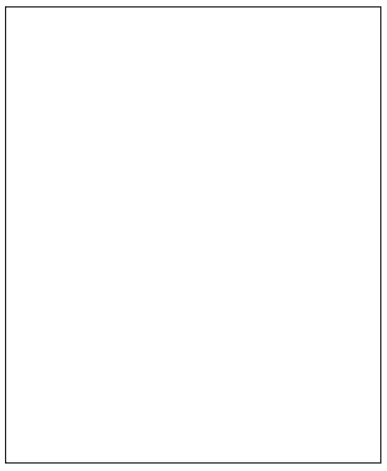
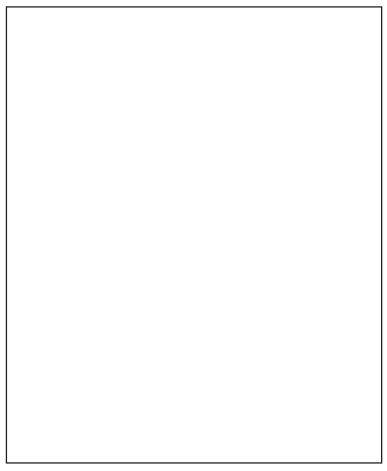


Diagram Specimen #2



Specimen #2

a) Type _____
b) Description _____
_____
_____

c) Species_____

Diagram Specimen #3

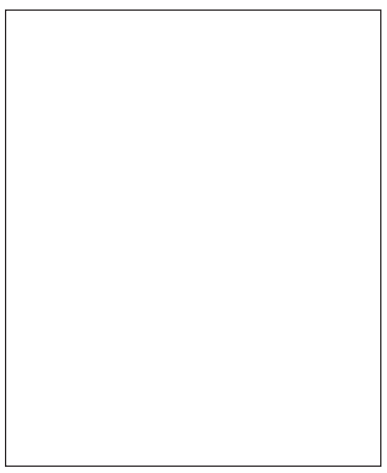
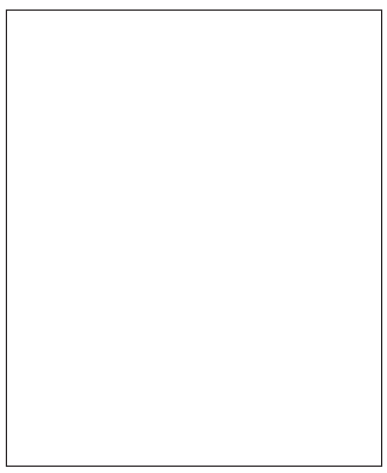


Diagram Specimen #4



Specimen #3

Specimen #4

Part B. Flower

1. Describe the parts of flower

Specimen #1

a) Description _____

_____

_____

_____

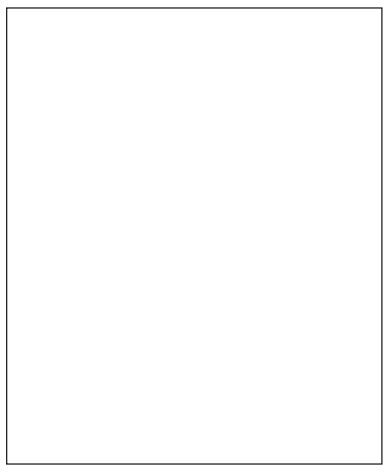


Diagram Specimen #1

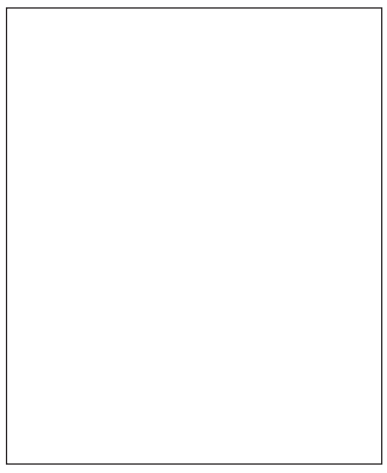


Diagram Specimen #2

b) Species _____

Specimen #2

a) Description _____

_____

_____

_____

b) Species _____

Forest Botany
Lesson - 10

Practical class on Plant Morphology
(Flower Dissection)

Lesson Plan **Time 1 hour**

Objective:

- To help the trainees familiarize themselves with the parts of a flower and their function

Backward Linkage:

- Topics (Inflorescence and flowers) of plant morphology dealt with in Lesson 4.

Forward Linkage:

- During tour the trainees will have opportunities to see and refresh what they have learnt about inflorescence and flowers in theoretical and practical classes.

Methodology:

- Practical classes should be with examples/specimens of forestry species.
- Venue of class may be a laboratory.
- Trainees may be asked to identify record their observations on data sheet.

Allocation of Time:

- Dissection– 30 min
- Recording on data sheet– 30 min

Practical Class:

Subject: Flower Dissection

In this class, the trainees will learn the parts of a flower and their reproductive function.The trainees may record their observations and draw the diagrams on the data sheet.

Materials:

- Razor blade
- Dissecting needle (one per table)
- Magnifying glass (one per pair)
- One fresh flower as specimen

Procedure:

Part A. Sepals and Petals

Examine the respective whorls of sepals and petals, identify the characteristic features. Draw diagrams and write descriptions on the data sheet.

B. Androecium

Carefully strip away the sepals and petals with the blade. Examine the male whorl and parts of a stamen with a magnifying glass. Draw and describe the stamen on the data sheet.

C. Pistil

Identify the pistil and its component parts – style, stigma and ovary. Cut the ovary longitudinally, and gently open it. Inside there will be one or more ovules. Draw and describe the different parts.

Name _____ Date _____

Class Period _____

Flower Dissection
Data Sheet

Part A. Sepals and Petals

1. Describe the sepals and petals -

Number, shape, size and colour

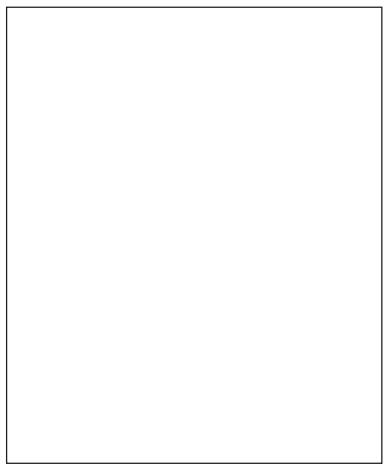


Diagram sepal

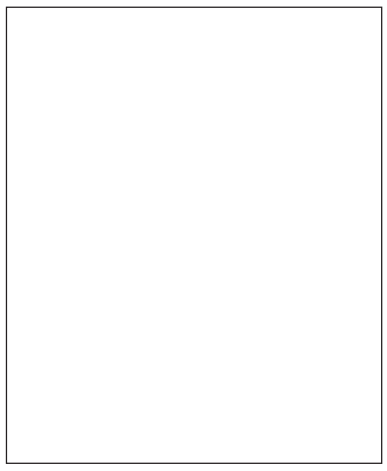


Diagram petal

.

Part B. Androecium

2. State number of stamens;
Describe one stamen

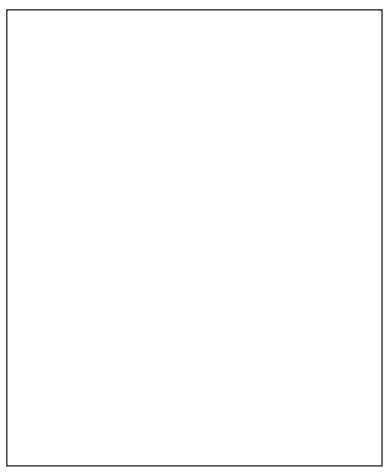


Diagram Stamen

Part C. Pistil and Ovary

3. Describe the Pistil and Ovary

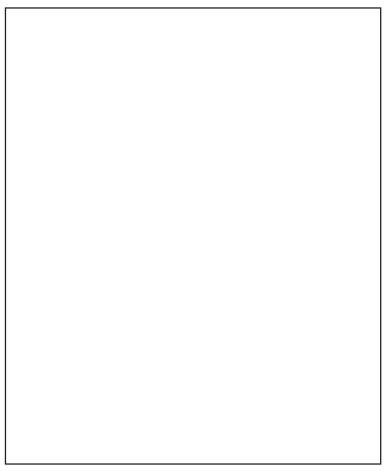
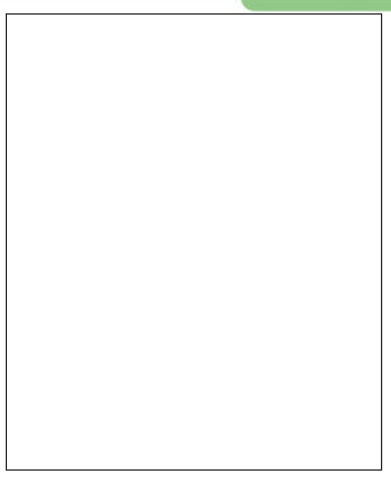


Diagram Pistil



Ovary & Ovule

Forest Botany
Lesson - 11

Practical class on Plant Morphology (Fruits)

Lesson Plan **Time 1 hour**

Objective:

- To help the trainees familiarize themselves with fruits
- To have better understanding of topics dealt with in theoretical classes.

Backward Linkage:

- Topics (fruits) of plant morphology dealt with in Lesson 5.

Forward Linkage:

- During tour the trainees will have opportunities to see and refresh what they have learnt about fruits in theoretical and practical classes.

Methodology:

- Practical classes should be with examples/specimens of forestry species.
- Venue of class may be field or a combination of laboratory and field
- Trainees may be asked to identify various kinds of fruits in the field.

Allocation of Time:

- Observation/demonstration– 30 min
- Recoding ondatasheet– 30 min

Practical Class:
Subject:

- Familiarisation with plant morphology –fruits

To demonstrate and elucidate fruits of different types (Simple dry, Simple fleshy, Aggregate, and Multiple) with specimens of forestry species

Observations: Trainees may record their observations on data sheet.

Name _____ Date _____

Class Period _____

Familiarization with Fruits
Data Sheet

Describe the Fruits

Specimen #1

Specimen #1

a) Type _____
b) Description _____
_____
_____

c) Species_____

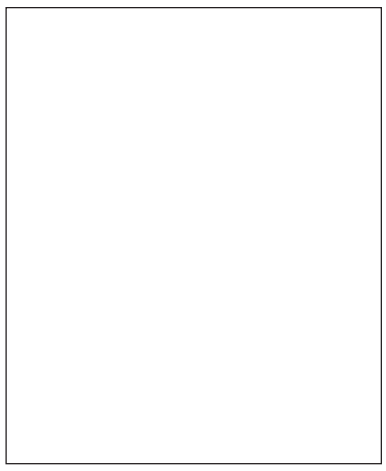


Diagram Specimen #1

Specimen #2

a) Type _____
b) Description _____
_____
_____

c) Species_____

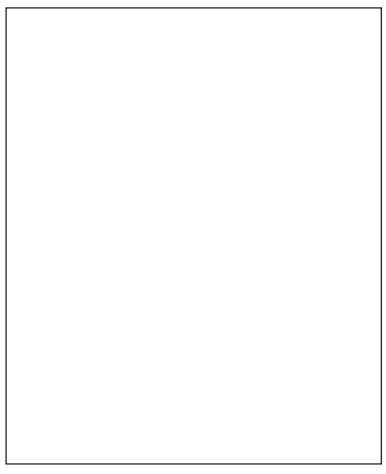


Diagram Specimen #2

Describe the Fruits

Specimen#3

a) Type _____

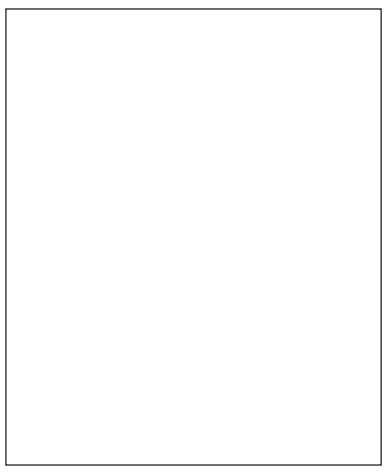
b) Description _____

_____

_____

c) Species_____

Diagram Specimen #3



Specimen #4

a) Type _____

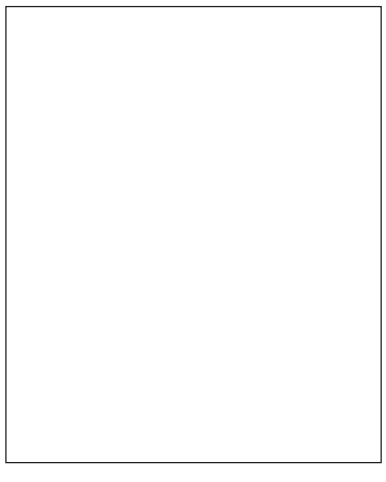
b) Description _____

_____

_____

c) Species_____

Diagram Specimen #4



Specimen#5

a) Type _____

b) Description _____

_____

_____

c) Species_____

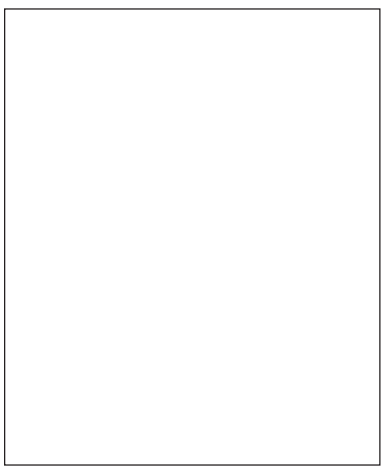


Diagram Specimen#5

Specimen#6

a) Type _____

b) Description _____

_____

_____

c) Species_____

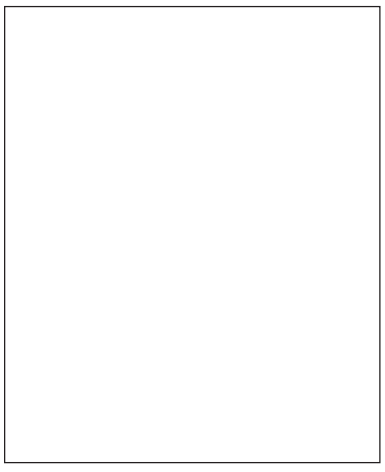


Diagram Specimen#6

Forest Botany
Lesson - 12

Lesson Plan **Time 1 hour**

Objective:

- To study the following of Taxonomy
  - Definition – what is taxonomy
  - Binomial Nomenclature
  - Classification
- To study the following of vegetative propagation
  - Definition
  - Artificial methods
    -Stemcutting
    -Grafting

Backward linkage

- Study of plant morphology in lessons 2, 3 and 4.

Forward linkage

- Study of plants in subsequent lessons
- Study of artificial vegetative propagation during tour

Training materials

- Copy of lesson 12 to be circulated beforehand

Allocation of time

- Taxonomy
  Definition, concept– 5 min
  Binomial Nomenclature, classification– 10 min
- Vegetative Propagation
  Definition– 5 min
  Artificial methods– 30 min
    -Stemcutting
    -Grafting
- Miscellaneous/Discussion– 10 min

1. Taxonomy

Taxonomy is the science of naming, describing and classifying organisms and includes all plants, animals and microorganisms of the world. Using morphological, behavioural, genetic and biochemical observations, taxonomists identify, describe and arrange species into classifications, including those that are new toscience.(Source: http://www.cbd.int/gti/taxonomy.shtml)
When the taxonomy is concerned with plants, it is often referred to as **systematic botany**.

1.1 Carl Linnaeus (1707-1778), a Swedish physician and botanist, was the founder of modern taxonomy. He originated a system called binomial nomenclature which is used for naming living things and grouping similar organisms into categories.

1.2 Units of Classification

Species – A species is a group of individuals (plants or animals) of one and the same kind. They resemble one another in almost all important morphological characteristics. Thus all mango plants constitute a species. Similarly all Amlaki plants, all Sal plants constitute different and distinct species. Occasionally owing to variation in climatic or soil factors, **individuals of a species** may varyin form, size, colour and other **minor characteristics. Such variants are said to form varieties**. A species **may or may not have** variety(ies).

Genus – A genus is a collection of species which have close similarity in the morphological characters of the floral or reproductive parts. For example, consider the three species, namely, Asan (Pacasaj), Bahera, and Arjun. They are **different species** because they **differ in their vegetative characters**, like the shape, size and surface of the leaf etc. But these species have close resemblance in their reproductive characters, namely, inflorescence, flower, fruit and seed. Therefore they belong to the same genus *Terminalia.*

1.3 Binomial Nomenclature

Binomial Nomenclature, also called binary nomenclature, is the formal system of naming organisms, and it consists of **two Latinized names**, the **genus** and the **species**.

1.3.1 The binomial aspect of this system means that each plant (in case of botanical nomenclature) is given a name which consists of two parts. The first part refers to the genus and the second to the species. The universal system of binomial nomenclature eliminates the confusion of multiple names of the same species, which may differ based on region, culture or native language.

1.3.2 When written, a scientific name is always either **italicized**, or, if hand-written, underlined. The genus is capitalized and the species name is lower case. For example, the scientific or the botanical name of the mango plant is *Mangifera indica. Mangifera* is the generic, i.e. genus name, while the *indica* is the specific or speciesname.

1.3.3 To complete the name of a plant, the name of the author who has given the name of the particular plant, is appended. For example, in case of *Mangifera indica* L., the L. at the end indicates the name of the author Linnaeus in abbreviation.

1.4 Classification

Classification is the arrangement i.e placement of a plant or a group of plants in a series of groups or categories according to a particular system and in accordance with the rules of nomenclature.

1.4.1 Systems of Classification

There are two systems of classification – **artificial** and **natural**. In the **artificial system**, only one or at most few characters, selected arbitrarily, form the basis of classification into groups. In the natural system, all the important characteristics are taken into consideration to classify the plants.

1.4.1.1 Natural System of Classification

According to the natural system of classification –

- **Plant kingdom** divided into two divisions – **cryptogams** (flowerless plants) and **phanerogams** (flowering plants);
- **phanerogams** divided into two subdivisions – **gymnosperms** (naked seeded plants) and **angiosperms** (closed seeded plants);
- **angiosperms** divided into two classes – **dicotyledons** and **monocotyledons**;
- Classes divided into sub-classes, series, and orders;
- orders into families,
- families into genera and species.

1.4.1.2 Bentham and Hooker's System – This natural system of classification is in practice in India. According to these authors,

- **dicotyledons** have been divided into three subclasses-

  Polypetalae, Gamopetalae and Monochlamydeae.
- monocotyledons are divided into seven series.

  These details are not discussedhere.

2. Plant Propagation by vegetative methods

Vegetative reproduction is a form of asexual reproduction in plants. It does not involve flowers, pollination and seed production. Instead, a new plant grows from a vegetative part, usually a stem, of the parent plant. Since no gametes are involved, plants propagated using a vegetative part have the same characteristics as the parent or source plant. The offspring produced by vegetative methods from the same source plant have identical genomes, and form what is known as a clone. The principal types of vegetative reproduction structures by natural methods are bulbs, corms, rhizomes and runners.

2.1 Artificial Methods of Vegetative Reproduction

There are various artificial methods of vegetative propagation, namely, propagation by **cutting**, **budding**, **grafting** etc. Although many of the techniques can be used for a range of different types of plants, it is important to know that some plants root better at a particular stage of growth, at a specific time of year or using a particular technique. We restrict our discussion to only **stem cutting,** and **grafting** as they are often employed in forestry practices.

2.2 Objectives: Following are the main objectives for vegetative propagation.

- One basic objective is simply to make multiple plants from a single plant.
- To make a young plant from an old plant.
- To propagate a particular plant because of its unique features.
- To be reasonably sure to have healthy young plants and reduce the chance of false breeding which often happens with plants of seedorigin.

2.3 Prerequisites: Regardless of the reason for propagating plants, there are some basic factors that are useful to ensuresuccess:

- use only healthy, vigorous sourceplants;
- use the most appropriate method, growth stage, and timing for theplant;
- protect propagation material from heat and from drying; use the material as quickly as possible after it isprepared;
- give newly propagated plants extra attention and care during their establishment phase.

2.4 Stem cutting

Any portion of a plant, a piece of stem, leaf or root, which has been removed from a plant with the object of inducing it to strike roots and thus lead to a new plantis called cutting**.** Stem cutting is the most common method for vegetative propagation. Stem cuttings can be taken at different stages of development.

2.4.1 Procedure

- Cuttings are to be taken at the time appropriate for the particular plant to be propagated;
- Polythene tube or hykopots of the appropriate size may be collected; the pots are open at bothends.
- The rooting medium may be prepared with suitable material (for Eucalyptus the common rooting medium is vermiculite); this should be moist but not wet; the pots may be filled with the medium;
- Suitable source plant may be identified and selected terminal shoots may be cut from the source plant using a sharp, clean knife;
- The leaves near the cut end should be removed, while ensuring that a few leaves remain on the cutting;

- A thin slice of tissue about ½ - 1 inch long may be removed on two opposite sides of the cut end or base of the cutting by using clean razor blade; this provides a surface for root development;
- The cut sides of the cutting may be dipped into rooting hormone, as necessary;
- The cuttings may be placed into the pots' prepared rooting medium; the medium around the base of each cutting may be firmed with fingers without any injury to the stem;
- The hykopot (ramet) trays or polypots are normally placed on a raised metal wire frame while ensuring bottom end of the pots are not blocked so that adventitious roots that will eventually grow find space through the bottom end and are selfpruned;
- The frames containing the pots are kept in a mist chamber having provision of sprinklers for watering. If the scale of production is low, smaller poly chambers or hygropits (poly tunnels) without sprinkler system but having some means of watering arrangement can be used. The purpose of using mist chamber or low cost rooting chamber is to cut off a portion (pre-envisaged) of direct sunlight, and create a micro climate of very high humidity and moderately high temperature. (The chambers at Arabari nursery, while producing Eucalyptus ramets, operate at a temperature ranging between 30 and 35 degree and at a humidity level around 90%.);
- The pots may be inspected regularly and watered as necessary to keep the potting medium moist but notwet;
- After 5-8 weeks (depending upon the plant being propagated), roots should have started to form (In south West Bengal the rooting time for Eucalyptus clone is about 45days.);
- When the cuttings have developed sufficient root system, they are taken out of rooting chamber and placed in hardening chamber and thereby exposing the cuttings (new plants) to increasing light levels (in south west Bengal the Eucalyptus clones are normally kept in hardening chamber for about 15 days before they are considered ready for transplanting in the field);

2.4.2 Clonal Multiplication Area

It is obvious that if vegetative propagation by stem cutting, that is, clonal plantation of a species is taken up on a large scale in successive years, a sustainable source of stem cuttings has to be available. Stem cuttings in large number are provided by clonal hedge or clonal multiplication area. Protocol for creation and management of Eucalyptus clonal multiplication area adopted in Arabari may be seen in the **Appendix** (a note prepared by A Basu Ray Chaudhuri, former Addl PCCF Finance,WB)

2.5 Grafting:

It is an operation in which two cut surfaces of the same or different plants are placed in such a manner that theyunite and grow together. The plant on which grafting is done is called **stock** and the plant part that is inserted on a stock, is called a **scion** or the **graft**. The best season for grafting is from February to June, which is the growing season for the tree.

2.5.1 Depending upon the shape of the cut given to stock and scion, there are different types of grafting. However, the principle involved remains the same i.e. bringing together the cambia of stock and scion forunion.

- **Splice Grafting:** In splice grafting, both scion and stock are cut across obliquely at the same angle and then tied firmly with plastic tape.
- **Whip Grafting:** In whip grafting, both scion & stock are cut diagonally. One end of the scion is trimmed into the shape of a wedge. After making a vertical incision in the stock, the wedge shaped scion is inserted into the vertical incision of the stock. The outer surface is then covered with grafting clay and wrapped with rags. After about a month, a new plant develops from this graft.

Source of Lesson materials:

1. Basic Techniques for Propagating Plants S. M. Douglas The Connecticut Agricultural Experiment Station (http://www.ct.gov/caes/lib/caes/documents/publications/fact_sheets/plant_pathology_and_ecology/basic_techniques_for_propagating_plants_06-27-08r.pdf)
2. http://www.abhinav.ac.in/DoV/
3. J.N Mitra et.al 2014, Studies in Botany, Volume one, Moulik Library, Kolkata
4. http://www.cbd.int/gti/taxonomy.shtml
5. A C Dutta, 2000, A Class Book of Botany, Oxford University press.

CLONAL MULTIPLICATION AREA (CMA) OF EUCALYPTUS

– CREATION & MANAGEMENT

Introduction

A Clonal Multiplication Area (CMA) is a living collection of asexually propagated plants belonging to a selected clone (same genetic origin), which is managed to ensure regular production of juvenile materials for mass multiplication. The standard cloning technology for production of eucalyptus ramets involves a few steps that include (a) preparation of cuttings from juvenile materials obtained from CMA, (b) rooting the cuttings in root trainers placed in mist propagation unit and (c) hardening the rooted cuttings in shaded and open nurseries. The CMA thus serves as a steady source of juvenile materials for mass production of Eucalyptus ramets.

Location

Ideally, the CMA should be located close to the mist propagation facilities and nurseries. It not only reduces the carrying cost of cuttings from the CMA to the nursery site, but also increases the rooting percentage by containing evapotranspiration from the cuttings during the carriage.

Ready for Production

CMA of Eucalyptus is ready for exploitation at the end of third year, that is, after three years of growth in the field.

First Year-Creation:

1. **The site** to be chosen should be of superior quality having favourable soil depth and properties, and should not be prone to water logging.
2. **Spacing** of pits is 1mt x 1mt, permitting a stock of 10000 plants per hectare. If at subsequent stage, mechanized weeding – cleaning is considered preferable or unavoidable, a spacing of 1.5m x1.5m may be adopted.
3. **Size** of the pits is **(1/2(60 + 45) × 45 × 45)**.

4. **The CMA sites for each clone should be separate and clearly demarcated.**
5. The planting pits are **filled up** with application of **50 grams of neem oil cake** per plant.
6. Planting of ramets is done in the normal planting season. The ramets/rooted cuttings, chosen for planting in the CMA, should have bushy or well-ramified roots for better survivability and health of the crop.
7. In order to prevent the attack of termites, which is very common in Eucalyptus in South West Bengal, **termiticides** like Chloropyrophos 25% EC (Dursban etc.), may be applied at the time of planting itself.
8. During the year **weeding, cleaning, hoeing, mulching** etc., are done **twice** like any other plantation. At the time of mulching, hoeing etc., **20 grams of DAP** per plant is applied, and this is done twice in the first year.
9. At every mulching, hoeing etc., about 5 grams (per plant) **systemic insecticides** like Phorate, Thymate etc., may be applied, as an added preventive measure.
10. It is very important to maintain **hygienic and healthy** conditions in the area of plantation for better growth and hence **regular weeding** must be done.
11. In case of **causalities**, the infilling of the clonal seedlings should be done in the **same year** with the **same batch** of (ramets) clonal seedlings maintained in the nursery to ensure homogeneity in the crop.
12. **Regular irrigation or watering** is done up to next rainy season. However, care must be taken to avoid water logging in the planted site. Therefore effective drainage system should be laid out before the area is prepared for planting and pits are laid.
13. **Fire line** should preferably be laid for the newly created CMA and in case the CMA is in fire prone area, it is important that fire line is laid out carefully and continuously managed.

Second Year Operations:

1. **Weeding, cleaning and other related maintenance** works are done regularly for the plantation.
2. **Mulching, hoeing, fertilization** etc., is done twice with **20 gram of DAP** per plant. The insecticides (5 gram per plant) and termiticides (5 gram per plant) are also applied twice simultaneously.
3. Some **fungicides** may also be applied, if required. During the rainy season, sometimes black spots start appearing on both the leaf surfaces from the leaf base and then spread towards the leaf tip. During severe attack the plant becomes leafless.
4. **Watering** is done regularly as per the requirement, while keeping the plantation site properly drained and free from water logging.

5. **Pruning and throwing away of unwanted side branches** from each plant, as per the requirement, is done very carefully avoiding any damage to the plants. This facilitates growth of apical bud and prevents any bend in the mainstem.

Third Year Operations:

1. The regular activities and operations as done in the second year are **repeated in the third year** till the CMA reaches harvestable stage and becomes established at the end of third year.
2. **Felling (coppicng) of CMA** is done in the months from **November to January**.

Maintenance of CMA (Post establishment stage)

Good maintenance and management increase the CMA productivity and the latter's life span. The main steps to be followed during the maintenance and management of the CMA are as follows:

- **Felling of trees**

1. **It is suggested that the CMA should be allowed to grow upto 3 years and then harvested towards the end of third year.** The **stem girth** is ideal for cutting if it is **20cm or more** for its use ascoppicer.
2. The stems in CMA are **cut** at the base **at a height of 6-8 inches** above ground in a **slanted and single cut** by using a sharp edged cutter. Care should be taken so that the stumps thus obtained are not damaged in the slashing process and that the top surface of the resulting stumps is even and slightly slanted.
3. The slightly slanting even surface is preferred, as it would help in draining of excess water immediately and thus remove the possibility of infection by microbes on the surface. The height is preferred at 6-8 inches, as beyond this height the stem would produce epicormic sprouts that are not useful for production of ramets subsequently. The epicornic branches do not form good cutting material for rooting, as their polarity is not well defined
4. Proper **systemic fungicide** is essentially applied at the cut portion of the stump to prevent any future fungal attack.
5. Further **irrigation** for watering and **application of DAP, insecticides, termiticides**, etc. are required regularly along with maintenance of proper drainage to prevent water logging near the stumps.

- Typical Harvest Schedule

THIRD YEAR–

November (early) – First Coppice Felling

November – December : First Harvest

45 days allowed for flush of coppice shoots to come up;
Next 15 days - the shoots are harvested with sharp cutter.

While harvesting the shoots, both the leading shoots and the unwanted side branches are cut off the stools. The leading shoots are transported to the nursery, and the branches (unwanted side branches) are removed from thesite.

January – February : Second Harvest

45 days allowed for second flush of coppice shoots;
Next 15 days - the shoots are harvested with sharp cutter

March : Third flush of coppice shoots grows;

FOURTH YEAR

April : Third Harvest

Coppice shoots grow till mid-April
During the last 15 days, shoots are harvested;

May– June : Fourth harvest

45 days allowed for the fourth flush of coppice shoots;
Next 15 days - the shoots are harvested with sharp cutter;

During the fourth harvest, a couple of leading shoots per stool is left to grow. These shoots grow till October and render the CMA ready for second coppice felling.

November (early) – Second Coppice Felling

The same cycle of four harvests continues till June of the FIFTH YEAR; and the Third Coppice Felling follows in November.

In this manner one CMA can undergo four coppice felling in successive years and it is possible to harvest four times after each felling. After the fourth felling, the stumps are uprooted and the site is tractor- ploughed for creation of fresh CMA.

- **Production Capacity**

A 3 -year old well-managed CMA can produce about **40 to 50 cuttings** of optimum size (out of about 10 shoots) per stump/stool during each harvest after the 1st coppice felling. Subsequently during the 2nd felling to the 4th felling, an average of **20 numbers of cuttings** (out of 5 -7 shoots) are obtained per stool at each harvest, if the CMA is managed properly.

- **Watering /Irrigation**

Continuous production of clones in modern nurseries requires supply of abundant and superior shoots on a regular basis. As in normal plantation, coppicing is vigorous and better if watering is done regularly as and when the need arises. It is more crucial in the dry parts of South West Bengal than in other areas. Watering can be done by various means viz., by flooding of ground in the CMA site along with proper drainage or by use of sprinklers. **Ridge and furrow method** applied in these parts is considered as the most economical method. By this method watering is done during **November to May**, annually during the harvesting season to facilitate coppicing of shoots.

- **Cleaning, Mulching and Hoeing**

1. The CMA area is regularly cleaned off the invading weeds especially grasses, and the debris is removed from the site immediately.
2. Hoeing, mulching etc. is done at the base of the stumps at least **2 to 3 times a year**. During the process, **50 grams of DAP and 10 grams of Phorate** per plant are applied simultaneously each time. However, application of very high quantity of nitrogenous fertilizer is not advised, as it affects the rooting of eucalyptus ramets adversely and also invites rampant fungal attack in the nursery.

- **Weeding, Cleaning, General Maintenance**

As tiny ramets grow quickly to trees during the period (first three years) of establishment of the CMA, they do not permit much sunlight to reach the forest floor and thus contain the invasion of undergrowth. However, as soon as the CMA is slashed to the ground, the site receives sunlight in abundance. This on the one hand promotes vigorous coppice growth, on the other it leads to invasion by weeds and grasses. The slashed Eucalyptus stumps often get covered by the weeds. The CMA in the harvest stage thus needs **thorough and frequent weeding and cleaning**. In case the weeding-cleaning operation becomes too labour-intensive or uneconomic, power tiller can be utilized for hoeing and weeding the area between the stumps during the maintenance of CMA.

In short, maintenance of Eucalyptus CMA in south West Bengal should include (i) watering on a regular basis, (ii) regular removal of weeds and grasses, (iii) taking preventive steps against termite attack and (iv) giving regular inputs of fertilizers.

A write-up on CMA received from the Silviculture South Division and information provided by Shri Abhijit Kar, FR, Range Officer, Arabari Research Rrange form the basis of this note.
-A Basu Ray Chaudhuri, Addl PCCF, Finance,WB.

Forest Botany
Lesson - 13

Lesson Plan **Time 1 hour**

Objective:

- To study the following of Ecology
  - ➢ Introduction and definition
  - ➢ Objective and scope
  - ➢ Ecological factors
  - ➢ Plant community
  - ➢ Plant succession
  - ➢ Ecosystem – definition, components, food chain, food web, trophic level, flow of energy
  - ➢ Ecological balance

Backward linkage

- Study of plant physiology in lesson 7.

Forward linkage

- Study of ecosystems during tour

Training materials

- Copy of lesson 13 to be circulated beforehand

Allocation of time

- Ecology

Introduction, Definition–	5 min
Objective and scope–	3 min
Ecological factors–	5 min
Plant community–	5 min
Plant succession–	12 min
Ecosystem	
–definition, components–	5 min
- food chain, food web,	
trophic level, flow of energy–	15 min
Ecological balance–	5 min

- Miscellaneous/Discussion– 5 min

1. Ecology – Introduction and Definition

The term 'Ecology' is derived from the Greek words 'Oikos' meaning house, or dwelling place and 'logos' meaning study. Thus literally, ecology is the study of 'house', 'home conditions', 'habitat' or more broadly 'environments' of plants and animals.

1.1 There are many definitions available for ecology. According to Earnest Haeckel, ecology is defined as 'the **study of the reciprocal relationship between the living organisms and their environments.'** In essence, ecology is the detailed study of **biotic community** (**comprising both** flora and fauna) of a particular region and also the various conditions of the environment prevailing in that region.

1.2 Objective and Scope of plantecology

Plants grow in diverse habitats that include high mountains, deserts, dry rocks, river banks, marshy areas, etc.While the plants have an impact on the various factors of the habitat, their behavior is regulated by the environmental conditions in which they grow. Plant ecology studies how the environments and plants interact with each other. Since ecological issues have direct linkage with soil conservation, flood control, deforestation, orcharding, town planning etc., the scope of ecology is now vast and useful in the large arena of applied sciences.

1.3 Ecological / Environmental factors

Environmental or ecological factors that affect the growth of plants and determine the nature of plant communities can be grouped under the following categories.

- **Climatic factors –** These include temperature, light, water (precipitation), wind, humidity etc. These factors primarily affect the shoot system of the plant.
- **Physiographic factors –** Physiographic or topographic factors include altitude, steepness or slope, exposure, direction or placement of mountain valleys. Type of vegetation is largely influenced by these factors.
- **Edaphic factors**- This constitutes all the characteristics of the soil such as physical, chemical and biological properties, soil moisture, etc. These factors affect primarily the root system of the plants.
- **Biotic factors**- These factors constitute effects of the activities of living organism viz. plants, animals and soil microorganisms like bacteria. The effects of biotic factors include interactions among plants growing in a community, and those between flora and fauna.

2. Plant Community

In nature plants do not live in isolation. It is rather common that plants occur in groups and live together in a particular place. A **population** comprises all the individuals of a given species in a specific area or region at a certain time.

(http://www.physicalgeography.net/fundamentals/9d.html) Again a plant **community** includes all the populations in a given, that is, limited geographical area at a certain time.

3. Plant Succession

Plant communities in a particular area keep on changing and go through the processes of migration, colonization and extinction of various plant species. **Plant succession** is the natural process by which a locality becomes successively colonized by different groups or communities of plants. The process of plant succession of an area from the beginning to **final or climax** stage is continuous and marked by appearance and extinction of a series of communities. The communities in the intermediate stages in the process of succession are called **seral communities** or **seral stages**. The final steady state or stage in the succession is called **climax**.

3.1 Process of succession

First of all, plants migrate to a bare area from the neighbouring areas and aggregation takes place. The migrants which try to adapt themselves with the local climatic conditions become **pioneer plants**. As pioneers begin to multiply, and initiate the struggle for survival and supremacy, number of pioneer plants decreases. At the same time, the pioneer plants continuously interact with the environment, and the latter undergoes change. The changed environment becomes unfavourable for establishment and propagation of the existing plant communities. The death and decay of pioneer plants renders the soil more fertile and more suitable for new invaders. As a result, new communities start colonizing.Thus community development progresses and number of new-comers decreases at each stage. In the climax stage, hardly any new species colonizes the area, as the existing plants establish a good equilibrium with the environment.

3.1.1 Primary Succession

(Source: Undergraduate Program in Plant Biology, University of Maryland http://www.life.umd.edu/classroom/bsci124/lec34.html)

Primary succession occurs when plants become established on land completely devoid of soil and vegetation. Primary succession is essentially the development of soils. The plant communities will generally change as the soil develops.

Stages of possible primary succession on barren rock for a forest habitat:

- Lichens (pioneer species) —> mosses & ferns —> grasses —> shrubs —>trees

- Each stage alters the habitat and develops the soil in such a way that it prepares the way for the next invasion of species. As succession proceeds, soil is formed and thickens-the result of decomposition;
- When the changes in the composition of plants stop and the plant community remains generally the same for many years, the community is mature or at climax. A climax community is the relatively stable community at the end of succession.

3.1.2 Secondary succession

(Source: Undergraduate Program in Plant Biology, University of Maryland http://www.life.umd.edu/classroom/bsci124/lec34.html)

A plant community may be disturbed causing some plants to be destroyed, as from a fire or from human logging or cultivation. If the disturbance stops, the community will begin a **secondary succession**, changes in the vegetation that will lead back to a climax community.

- In secondary succession, the progression of plant communities occurs on areas where there has been previous vegetation (destroyed by fire, farming, or other).
- Since the soil is already in place, secondary succession can take place five to ten times faster than primary succession.

4. Ecosystem

The term ecosystem was first coined by Tansley in the year 1935. All the population of a given area, that is, the community or the grouping cannot be separated functionally from the environment. An **ecosystem** is a community of living things (plants, animals, microorganisms) in conjunction with the nonliving components of their environment (air, water and mineral soil, etc.), interacting as a system.

4.1 Components of ecosystem

From the structural point of view, an ecosystem has the following components.

- **Abiotic components** – It includes the nonliving elements of the environment, such as water, soil, air, gases, inorganic elements, organic compounds, etc.
- **Biotic Components** – Living things which may be classified as
  - **Producers** – include green plants, which synthesise food.
  - **Consumers** – include mostly animals which take as food other organisms or foods synthesised by producers.
  - **Decomposers** – include mainly the bacteria and fungi which break down the complex dead tissues of producers and consumers.

5. Food Chain

Every organism needs to obtain energy in order to live. For example, plants get energy from the sun, some animals eat plants, and some animals eat other animals. A **food chain** is the sequence of who eats whom in a biological community (an ecosystem) to obtain nutrition. (**Source:** http://www.enchantedlearning.com/subjects/foodchain/) A food chain thus shows interrelationship among the different categories of consumers (from primary to top) starting from producers indicating successive nutritional dependency.

Following is an example of food chain.

It shows who is eating who. The arrow means "is eaten by".





Grass——> Grasshopper ——> Toad——> Snake ——> Hawk

Grass is eaten by Grasshopper is eaten by Toad is eaten by Snake is eaten by Hawk

Please note:

A food chain always starts with a green plant...
(All plants are PRODUCERS.)

..... which is eaten by ananimal.
(All the animals in a food chain are CONSUMERS)

A food chain ends with a predator.
(The predator is at the top of the food chain)

(Source: http://resources.woodlands-junior.kent.sch.uk/)

6. **Food Web**

In nature independent and linear food chains are very rare. Instead several food chains are linked together forming a complicated and interconnected pattern known as food web.

6.1 Difference between food chain and food web

A food chain only follows just one path as animals find food. eg: A hawk eats a snake, which has eaten a frog, which has eaten a grasshopper, which has eaten grass. However, a **food web shows the many different paths plants and animals are connected,** eg: A hawk might also eat a mouse, a squirrel, a frog or some other animal. The snake may eat a beetle, a caterpillar, or some other animal, and so on for all the other animals in the food chain. **A food web is several food chains connected together.** (http://resources.woodlands-junior.kent.sch.uk/)

7. **Trophic level**

Trophic level of an organism is the **position** it occupies in a **food chain**. A food chain represents a succession of organisms that eat another organism and are, in turn, eaten themselves. The number of steps an organism is from the start of the chain is a measure of its trophic level. (**https://en.wikipedia.org/wiki/Trophic_level**)

The various trophic levels in the food chain are as follows.

- Trophic level 1 - primary producers (plants)
- Trophic level 2 – Primary consumers (herbivores) that eat primary producers
- Trophic level 3 – Secondary consumers (carnivores and omnivores) that eat primary consumers.
- Trophic level 4 – Tertiary consumers that eat secondary consumers.

8. **Energy Flow in Ecosystem**

The organisms of an ecosystem sustain themselves by cycling energy and nutrients through the various trophic levels. At trophic level 1, the **primary producers** (plants)harness energy from the sun through photosynthesis. **Herbivores (primary consumers) which occupy the second trophic level feed on plants, thereby energy is passed on to primary consumers. Carnivores (secondary consumers)** that occupy the **third trophic level** eat herbivores, and thus receive energy from primary consumers. In this manner, energy flow takes place in the ecosystem along the food chain from one trophic level to the next.

8.1 The energy produced at a trophic level is not entirely transmitted to the next trophic level. Only a part (**about 10 percent**) of net energy production at one trophic level gets transmitted to the next level. The reduction in energy transfer between trophic levels is due to many factors like respiration, growth and reproduction, defecation, and death without predation.

8.2 Energy flow in the food chain is also accompanied by flow of nutrients. In terms of nutrient flow, the role played by the decomposers is very crucial. Decomposers, comprised of bacteria, fungi, insects, etc. decompose wastes and dead organisms and return nutrients to the soil so that plants can absorb them. The process of decomposition does not involve recycling of energy, but it makes the nutrient cycle complete in the ecosystem.

9. Ecological balance

Ecological balance has been defined as a stable balance in the numbers of each species in an ecosystem. This balance may be disturbed due to the introduction of new species, the sudden death of some species, natural hazards or man-made causes.
(Source:http://wwf.panda.org/about_our_earth/teacher_resources/webfieldtrips/ecological_balance/)
The man-made cause sinclude

- pollution of the environment by unscientific use of natural resources;
- growing consumption rate ofenergy;
- rapid increase of demand on ecosystem services (that is, supply of food, nutrition, fuel, fodder, fibres-cloth, medicine etc.);
- deforestation, shrinkage and fragmentation of natural habitat of wildlife (both flora and fauna);
- unscientific disposal of chemical and toxic waste etc.

Source of Lesson materials:

1. *D Mitra et.al 2014, Studies in Botany, volume two, Moulik Library,Kolkata*
2. *A C Dutta, 2000, A Class Book of Botany, Oxford University Press.*
3. *Undergraduate Program in Plant Biology, University of Maryland http://www.life.umd.edu/classroom/bsci124/lec34.html*
4. *https://en.wikipedia.org/wiki/Ecosystem*
5. *http://www.enchantedlearning.com/subjects/foodchain*
6. *http://www.learner.org/courses/envsci/unit/text.php?unit=4&secNum=3*
7. *http://wwf.panda.org/about_our_earth/teacher_resources/webfieldtrips/ecological_balance*
8. *https://en.wikipedia.org/wiki/Trophic_level*

Forest Botany
Lesson - 14

Lesson Plan **Time 1 hour**

Objective:

To study the following of Economic Botany

- Introduction – what is economic botany
- Classification of economically important plants
- Basic information about some plants

Backward linkage

- Study of plant morphology in previous lessons.

Forward linkage

- Identification and observation of the plants during tour

Training materials

- Copy of lesson 14 to be circulated before hand

Allocation of time

- Economic Botany

Introduction–	2 min
Classification of plants of economic importance–	3 min
Study of some plants of economic importance–	50 min
Miscellaneous/Discussion–	5 min

1. Economic Botany –Introduction

Economic Botany forms the applied part of plant science. It deals with botany of the various plants applied toman's well-being. For survival and livelihood man has been deriving a wide range of benefits from plants. These benefits include food, clothing, shelter, animal feed, fuel, medicine, wood, gums, resins, starch, sugaretc.

2. Classification of plants of Economic importance

Economically important plants may be classifies as follows:

a) Food Plants – plants yielding food of various kinds. These include (1) cereals, (2) millets, (3) pulses, (4) vegetables and (5) fruits.

b) Food Adjuncts - plants yielding spices, flavouring materials, beverages etc

c) Medicinal Plants – plants yielding medicines;

d) Industrial Plants and Plant Products –plants yielding fibres, timber, rubber, tannin, essential oils, sugar etc.

3. Some Forest Species of Economic Importance

Forests are vast repositories of plants of diverse kinds. Many of these plants have economic importance.We shall restrict our discussion to some of the species, found in forests (including man-made) of West Bengal, which are known for their economic importance and use.

3.1 Abroma augusta Linn.F

Family: Sterculiaceae

Local name: Ulatkambel, Kumal,Olak.

Description: An evergreen shrub or small tree. Leaves large, cordate, narrowed to 3-7 nerved base;. Flowers purple-red.

Distribution: A native of Malaya, but established throughout plains of West Bengal.

Uses:

Bark– yields a **fibre**, superior to jute and also sunn hemp.

Bark and the **root bark** have **medicinal use;** have wide application in treating **female disease**.

Fig. 14.1 – *Abroma augusta*

Source: http://www.natureloveyou.sg/Abroma%20augusta/Main.html

3.2 Abrus precatorius Linn.

Family: Papilionaceae (Fabaceae)

Local name: Kutch, rakti, ratei

Description: Shrubby climber, leaves compound, leaflets 12-20 pairs. Flowers in axillary, many-flowered raceme, corolla white tinged with purple. Pods silky pubescent with a narrow deflexed beak. Seeds 3-5 round, hard, scarlet with a terminal black spot.

Distribution: Throughout the plains of West Bengal.

Uses:
Seeds -used by the jewelers as a **unit of weight**.
Medicinal use -The **leaves, roots and seeds** have **medicinal uses**. **Leaves, fruits and roots** are used to cure **colic, cough, eye disease** etc. **Leaves** are also used to cure **dyspepsia.**

Fig.14.2 *Abrus precatorious*

Source: http://www.banana-tree.com/

3.3 Acacia auriculiformis A. Cunn. ex Benth.

Family: Fabaceae (Leguminosae)

Local names: Akashmoni, Sonajhuri

Description: Evergreen, unarmed tree to 15 m (50 ft) tall, with compact spread, often multi- stemmed; young growth glaucous. Leaves alternate, simple, reduced tophyllodes (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. Fruit a flat, oblong pod, twisted at maturity, splitting to reveal flat black seeds.

(http://www.fleppc.org/ID_book/Acacia%20auriculiformis.pdf)

Distribution: It is native to Australia, Indonesia, and Papua New Guinea, but has become naturalized in India. It is planted extensively in lateritic soil sin south West Bengal.

Uses: It is an extremely useful plant to **reclaim** arid and rockyareas.

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

The **bark** contains sufficient tannin (about 13%) for commercial exploitation and contains a natural dye suitable for the batik industry.

Fig.14.3 ***Acacia auriculiformis***

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

3.4 Acacia Catechu Willd

Family: Fabaceae

Local Name: Kath, Khair, Khair-Babul

Description: A moderate-size deciduous tree; bark dark-greyish brown, rough; spines short and hooked. Leaves twice pinnate. Flowers in axillary spikes, white to pale yellow.

Distribution: Common in most of the drier part of India and in northern plains of the state.

Uses:

Wood - dark or light red, **very hard, durable**, takes a **fine polish;** used for **house-posts, agricultural implements, tool handles etc.;** highly preferred as **fire wood**, specialy by goldsmiths; considered very good for production of **charcoal**. The articles of commerce, namely, **Cutch and Kath** are obtained by boiling the softer parts of the wood. **Cutch**has extensive use in **dyeing** cotton, silk and in calico printing. **Kath** has many **medicin aluses** and is used with **pan** or **betel leaf**.

3.5 Adhatoda Vasica Nees.

Family: Acanthaceae

Local Names: Vasaka

Description: A gregarious, evergreen, densely branched shrub. Leaves opposite, elliptic, pointed at ends, entire, 5-8 inch long. Flowers white with red spots and streaks in axillary spikes.

Distribution: Common in plains of north Bengal.

Uses:

Plant is used for **reclaiming waste lands**, as it is not grazed or browsed.

Wood makes very good **charcoal for gun powder**.

Leaves- used as a **green manure** in rice fields, and also as **weedicide, insecticide and fungicide.**

Medicinal use - The plant has many **medicinal uses**. The **leaf decoction/ juice** is used to treat **asthma, stomachache, cough and fever.**

3.6 Adina Cordifolia (Roxb.) Brandis. (Syn. **Haldina cordifolia**)

Family: Rubiaceae

Local Names: Haldu,Karam

Description: A large deciduous tree, often buttressed. Leaves opposite, heart shaped, pubescent beneath, leathery. Flower heads long-stalked, yellow. Fruit head a collection of numerous very small capsules.

Distributions : Occurs in deciduous forests. Found in the forests of south west Bengal.

Uses :

Wood– It is **yellowish**, when freshly cut, but the colour later turns reddish brown. **Wood** is moderately strong and takes a **good polish;** good for **interior use**, but not suitable for external work. It has other miscellaneous uses in making canoes, packing cases, cigar boxes, furniture, toys, handles for brushes, agricultural implements, carving, picture frames etc. It has a great demand for making good quality **combs and bobbins,** and for **flooring and paneling**.

Fig.14.4 ***Adina cordifolia***

(Source: https://commons.wikimedia.org/wiki/Category:Haldina_cordifolia)

3.7 Aegle marmelos (L.) Correa

Family: Rutaceae

Local names: Beltree

Description: A moderate sized deciduous tree, young stems armed with axillary, hard thorns. Leaves tri- foliate, alternate, glabrous. Flowers greenish-white, fragrant. Fruit woody usually globose, grey-yellow or greenish, 2-6 inch diameter; seeds numerous, embedded in orange or yellow sweet pulp.

Distribution: Occurs throughout the plains of West Bengal.

Uses:

Twigs and leaves - used as **fodder**.

Bark – exudes a **gum** that makes good adhesive paste.

Medicinal use -Almost **every part** of the tree has medicinal use. The sweet aromatic **fruit pulp** is very **nutritious**.Unripe fruits are used to cure dysentery. Ripe fruits are used as tonic, restorative and laxative.

Fig.14.5(a) *Aegle marmelos*

Source:http://thehealingherbsofindia.blogspot.com/

Fig. 14.5(b) *Aegle marmelos*

Source:http://www.sanjiviniherbals.co.in/

3.8 Albizia Lebbeck (L.) Benth.

Family: Fabaceae

Local names : Kalasirish, Kalsish

Description: A large, deciduous tree with spreading branches; bark brownish-grey, rough with numerous cracks. Leaves twice pinnate. Flowers white, fragrant. Pods large, 4-12 inch long, thin, dehiscent; seeds 6-12.

Distribution: Occurs in plains of West Bengal.

Uses :

Wood - dark brown, hard, lustrous and durable; has multifarious use, e.g. **house building,** making **furniture, agricultural implements, rollers, canoes, boats, picture frames etc.;** also useful for carving, internal decorations, panelling and flooring.

Bark - used for tannin and dyeing.

Flowers, bark and the oil from the seed find use in indigenous medicine

Fig.14.6 ***Albizia lebbeck***

Source :https://commons.wikimedia.org/wiki/File:Albizia_lebbeck_pods.JPG

3.9 Agave Americana Linn.

Family: Amaryllidaceae

Local Name: Bans keora

Description: Stout, shrubby, rhizomatous plant with short aerial stem, more or less concealed by the leaf bases, and with thick fleshy spine-tipped leaves. The inflorescence is branched, 20-30' tall, and bears large (3-4") yellow-green flowers.

Distribution: Occurs in plains of WB.

Fig.14.7 ***Agave americana***

Source:http://www.biodiversityexplorer.org/plants/asparagaceae/agave_americana.htm)

Uses: The plant has many **medicinal uses**. The **sap** of century plant is used as a diuretic and a laxative. The juice of the leaves is applied to bruises and taken internally for indigestion, flatulence, constipation, jaundice and dysentery.

The **leaves** also yield **fibres**, which are suitable for making rope, matting, and coarse cloth. (http://www.cactus-art.biz/schede/AGAVE/Agave_americana/)

3.10 Andrographis paniculata (Burm.f.) Wall.ex Nees

Family : Acanthaceae

Local name: Kalmegh

Description: Erect Annual bitter herb; stem branched, quadrangular. Leaves lanceolate, glabrous. Flowers in axillary and terminal horizontal effuse panicles of racemes. Corolla white with purple tinge.

Distribution: Throughout south west Bengal.

Uses: The plant has many medicinal uses. The **whole plant** is used in fever, general debility, dysentery etc.The **leaves** are used to improve digestion and liver function.

Fig. 14.8 ***Andrographis paniculata***

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

3.11 Anthocephalus cadamba (Roxb.)Miq.

Family : Rubiaceae

Local names: Kadam

Description: A large, deciduous tree having horizontal branches and smooth, dark-grey bark. Flower heads single, terminal, yellow, globose, 1.5-2 inch diameter.

Distribution: Available in the plains of north Bengal forest.

Uses:

Wood - white or light yellowish-grey and soft; makes excellent **veneers;** suitable for match **boxes** and **splints, cheap paper, furniture, boxes, tea-chests etc.**

Fig 14.9 ***Anthocephalus cadamba***

Source: https://commons.wikimedia.org/wiki/File:Neolamarckia_Cadamba_Flower.jpg

Source of Lesson materials:

1. *D Mitra et.al 2014, Studies in Botany, volume two, Moulik Library, Kolkata*
2. *J. F. Dastur. Useful Plants of India and Pakistan, D. B. Taraporevala Sons & CO. LTD. Bombay*
3. *Research Wing, Directorate of Forests, Govt of West Bengal, 2005. Medicinal Plant Resources of South West Bengal*
4. http://www.iucnredlist.org/
5. http://www.cabi.org/isc/datasheet/2157
6. *Websites cited in the lesson*

Forest Botany
Lesson - 15

Lesson Plan **Time 1 hour**

Objective:

- To study some plants of economic importance

Backward linkage

- Study of plant morphology in previous lessons.

Forward linkage

- Identification and observation of the plants during tour

Training materials

- Copy of lesson 15 to be circulated beforehand

Allocation of time

- Economic Botany
  Study of some plants of economic importance -54 min.
  Miscellaneous/Discussion - 6 min.

1 Some plants of Economic importance

1.1 Avicennia officinalis Linn

Family : Avicenniaceae

Local names : Baen

Description : A small ever green tree; bark thin, grayish brown. Leaves simple, in opposite decussate arrangement, ovate or elliptic-oblong, 2-4 inch long, glabrous and shinning above, white or brownish pubescent beneath. Flowers yellow.

Distribution: Throughout the salt marshes and tidal forests of the state.

Uses:

Bark - used as a **tan;**

wood ashes – used for washing and cleaning clothes;

wood – used as **fuel;**

fruit – edible.

Fig 15.1 ***Avicennia officinalis***

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

1.2 Azadirachta indica A. Juss

Family : Meliaceae

Local names: Neem, Nim

Description: A large evergreen tree; leaves pinnate, crowded near the end of the branchlet. Flowers white, fragrant, shorter than the leaves. Drupe yellow when ripe,1-seeded.

Distribution: Throughout south West Bengal, wild and cultivated.

Uses:

Wood - red or brown, aromatic, durable, used for furniture, carts, axles, yokes etc.

Medicinal uses – all the parts of the tree have considerable therapeutic uses in indigenous medicine. **Bark is used i**n vomiting, cough, intermittent fever etc., **leaves** used to treat ophthalmia, jaundice, skin disease, etc., neem seed oil used in skin disease, ulcer, etc.

Twigs - used as **chew sticks** or tooth brushes.

Seed - contains **fatty oil**, deep yellow in colour, known as **margosa oil of commerce**, which constitutes about 40% of the seed. The **main active principle** of this oil is '**nimbidin**', which has many therapeutic uses, and has application in several pharmaceutical preparations.Unrefined margosa oil is used as a luminant and in the manufacture of soap.

Seed cake – used as fertilizer.

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Fig.15.2 ***Azadirachta indica***

(Source:https://commons.wikimedia.org/wiki/File:Neem_(Azadirachta_indica)_in_Hyderabad_W_IMG_6976.jpg)

1.3 Berberis aristata DC

Family : Berberidaceae

Local names: Chitra, daru haridra, kashmal

Fig.15.3 ***Berberis aristata***

(Source:http://en.hortipedia.com/wiki/Berberis_aristata;

Description: A small shiny shrub, bright shining, slightly drooping. Flowers golden-yellow, in large, drooping, long–stalked racemes. Berries spindle shaped, red.

Distribution: A native of the Himalayas at a height of 2000-3000 metres; found in forests of Darjeeling hills.

Uses:

Root -A valuable **yellow dye** extracted from the **root**, which is soluble in water and alcohol; a brown extract called "rasaunt" obtained from the roots and the lower parts of the stem, which, when added to water, makes the latter cool;

Medicinal use -The stem, the berries and the root have many **medicinal uses;** the plant is used to treat liver, ulcers, fever, infection in intestine, inflammation, cuts, wounds, eye and skin diseases, diarrhoea etc.

1.4 Bischofia javanica Blume

Family : Phyllanthaceae

Local names: Kainjal, Paniala

Description: A large evergreen tree. Bark brown, slightly scaly; blaze deep and pale pink in alternate layers. Leaves long-stalked, alternate, 3-5foliate; leaflets serrate, shiny, dark green. Flowers greenish-yellow, male and female flowers on different individuals.

Distribution : The plant grows near water in the mixed plains forest, and in the lower and middle hill forests (altitude up to 6000 feet) of North Bengal.

Uses :

Wood - red, hard and durable; best used for pile foundations because of its durability in contact with water; suitable for railway sleepers, bridges, buildings and other works of constructions.

Bark- contains tannin.

Leaves - **juice of the leaves** has medicinal properties.

The plant is highly suitable for reclamation of low-lying waste lands prone to water logging.

Fig.15.4 ***Bishcofia javanica***

(Source :https://commons.wikimedia.org/wiki/File:Starr_060810-8496_Bischofia_javanica.jpg)

Attribution: Forest & Kim Starr

1.5 Bixa orellana Linn.

Family: Bixaceae

Local names: Sindure, Latkan

Description : Large spreading shrub or small trees. Leaves alternate, cordate, petioled. Flowers showy, white or purple. Capsules ovoid, reddish-brown, 1.5 inch long, softly bristly. Seeds enclosed in a red pulp.

Distribution: A native of America, naturalized in India, cultivated in plains of West Bengal.

Uses:

Fruit - sred pulp yields a valuable **dye; t**he dye extensively used for **colouring** cotton and silk and also butter, cheese, confectionary, hair oils, floor polishes and pharmaceutical ointments.

Medicinal use - diverse **medicinal uses; fruits** used in dysentery, kidney disease; the **root bark** useful in treatment of fever; **leave**s used to treat jaundice, fever; the **entire plant** also used in dysentery, kidney disease and other ailments.

Fig. 15.5 ***Bixa orellana***

Source :https://commons.wikimedia.org/wiki/File:Bixa_orellana_with_fruits_in_Hyderabad,_AP_W_IMG_1456.jpg

1.6 Bombax ceiba L.

Syn :*B. malabaricum* DC

Family : Malvaceae

Local names: Simul, semal

Description: A tall deciduous tree; young stem covered with big conical prickles; the stem is cylindrical, except at the base, where, when old, it forms large buttresses. The branches are in whorls spreading horizontally. Leaves compound with 5-7 radiating leaflets. The flowers are large red in the axils of fallen leaves. Fruit a woody capsule enclosing seeds covered in silky fibre.

Distribution: Found in plains of West Bengal and also in the lower hill forests of north Bengal.

Uses:

Wood - light, soft, and perishable; commonly used for match boxes and match splints; often used for tea boxes, packing cases, etc.

Bark - exudes a yellowish gum.

Fruit - gives the "**simul**" cotton which is extensively used for stuffing mattresses, pillows etc.

Fig 15.6 *Bombax ceiba*

Source: https://en.wikipedia.org/wiki/Bombax_ceiba

1.7 Bucklandia populnea (R. Br. ex Griff.) R. W. Brown

Family : Hamamelidaceae

Local name: Pipli

Description: A large evergreen tree growing in height upto 60-100 feet. Bark brown, rough. Blaze reddish-white. It is easily recognized by its thick poplar–like leaves with big fleshy conspicuous stipules. The tree bears flower and fruit all the season.

Distribution : Found in the middle and upper hill forest (Altitude 3000-8000 feet) of North Bengal.

Uses: It is the most ornamental tree of the upper hills. The **timber** is considered to be very valuable. The **wood** is reddish brown, close grained, hard and extensively used for planking, beams and rafters; wood gives good charcoal.

1.8 Buchanania Lanzan Spreng Syn. B. latifolia Roxb

Family: Anacardiaceae

Local names: Piyal, Chironji

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, terminal panicles. Drupe black, sub-globose. Seedstone hard.

Distribution: Occurs in wild (also available in plantation) in forests of south West Bengal.

Uses:

Bark - used for tanning; both the **bark and the fruit** yield a natural varnish.

Fruit - sweetish in taste;

Seed - an **important article of commerce;** used as a **substitute for almond in confectionery;** yields a pale, straw coloured, sweet, aromatic oil, known as "**chironji oil**".

Medicina luses - The seeds are used to treat burning sensation of the body; **seed oil** applied to treat baldness, ulcer etc. **Leaves** are used to purify blood, and treat diarrhoea.

1.9 Casuarina equisetifolia Linn.

Family: Casuarinaceae

Local name: Jhau

Description: A large evergreen tree; bark scaly peeling off in vertical streaks;drooping branches bearing slender branchlets with whorls of 6-8 scale like leaves. Flowers are unisexual, both sexes borne on the same individual. Fruit ovoid or globose, small.

Distribution: Very common in coastal forests (plantations) West Bengal.

Uses: The species is very **suitable as a vegetal cover in coastal areas** and for **reclamation of sand dunes.**

Stem - long and straight; in good demand for use as **beams, posts, rafters, mine props, masts of country boats.**

Timber – used in making **oars, yokes** and felloes (circular rim) of wheels.

Wood - in great demand for use as **fuel**.

Bark - contains 6-18% **tannin;** used for **tanning and dyeing** fishing nets brown, and for tanning leather.
Medicinal use – Extract of bark is an excellent astringent in the treatment of chronic diarrhea and dysentery.

Fig. 15.7 ***Casuarina equisetifolia***
(Source: Photo courtesy Shri T K Das WBFS)

1.10 Chukrasia tabularis Adr. Juss. Syn.: Chikrassia tabularis Adr. Juss.

Family: Meliaceae

Local Names: Chickrassy

Description: A large deciduous tree. Leaves pinnate, alternate; leaflets, usually alternate, unequal sided. Flowers white, in panicles with spreading branches. Fruit ovoid capsule; seeds winged, numerous.

Distribution: Found in mixed plains forest and lower hill forest (altitude upto 3000 feet) of North Bengal.

Uses:

Wood - reddish or yellowish-brown, hard, richly veined, scented when fresh; takes a fine polish; one of the finest timbers for ornamental veneers; largely used for high class furniture, piano cases, panelling etc.

Leaves - young **leaves** contain 22% of tannin;
Bark–contains 15% tannin; astringent bark has medicinal uses.

Fig.15.8 ***Chukrasia tabularis***

Source:https://commons.wikimedia.org/wiki/File:Chukrasia_tabularis_leaves.jpg

1.11 Cinnamomum cecidodaphne Meisn.

Family : Lauraceae

Local name: Malagiri

Description: A large evergreen tree; bark dark grey, outside corky, highly scented. Leaves elliptic, blade 3-4 inch long. Flowers in crowded axillary, densely tomentose panicles. Fruit oblong.

Distribution : Found in mixed plains forest and lower hill forest (upto 4000 feet) of North Bengal.

Uses:

Wood - yellowish brown, soft, easily worked and durable, strongly scented and takes a good polish; valuable timber and being highly aromatic considered to be very good for furniture and boxes, as it keeps off insects; also suitable for planking, oars, ploughs, yokes etc.

1.12 Cryptomeria japonica (Thunb. ex L.f.) D.Don

Family : Cupressaceae

Local name : Dhupi

Description: A tall evergreen tree; trunk straight, in old trees massive, buttressed; bark on large trees reddish-brown, weathering grey, exfoliating in long, shredding strips. Branches form a conical crown in young trees, self-pruning to leave a clear bole in large trees. Cones ripen in July-August at lower elevation, and somewhat later at higher elevation. Seeds can be collected from the cones by gentle thrashing.

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 metreand 1800 metre. Extensive plantations of pure Cryptomeria are found in Darjeeling hills.

Uses:A fast growing species Cryptomeria coppices well (unusual for a conifer). It is moderately frost resistant, fire-tender and shed-tolerant exotic; not resistant to drought.

Timber - soft, straight-grained and fragrant; produces excellent tea boxes; very useful as general purpose timber; suitable for pulp, clipboards, packing cases, cheap planking etc.

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.

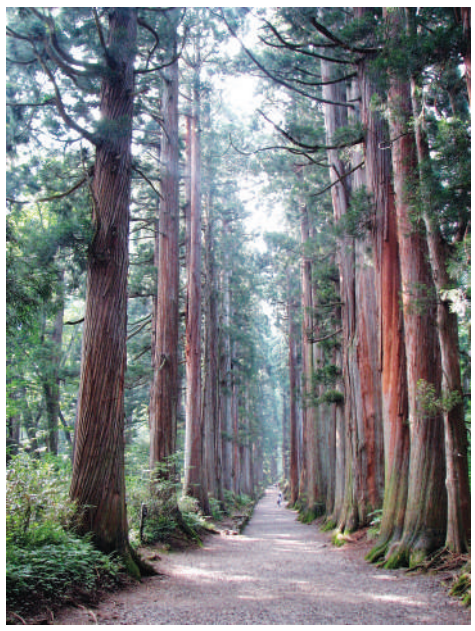

Fig.15.9 ***Cryptomeria japonica***

(Source: https://en.wikipedia.org/wiki/Cryptomeria)

Source of Lesson materials:

1. *J. F. Dastur. Useful Plants of India and Pakistan, D.B. Taraporevala Sons & CO. LTD. Bombay*
2. *Research Wing, Directorate of Forests, Govt of West Bengal, 2005. Medicinal Plant Resources of South West Bengal*
3. *A.M Cowan and J.M Cowan 1979 , The Trees of Northern Bengal*
4. *Ram Parkash 2007 Plantation and Nursery Technique of Forest Trees, International Book Distributors, Dehradun.*
5. *http://www.worldagroforestry.org/*
6. http://www.iucnredlist.org/
7. *Websites cited in the lesson*

Forest Botany
Lesson - 16

Lesson Plan **Time 1 hour**

Objective:

- To study some plants of economic importance

Backward linkage

- Study of plant morphology in previous lessons.

Forward linkage

- Identification and observation of the plants during tour

Training materials

- Copy of lesson 16 to be circulated before hand

Allocation of time

- Economic Botany
  Study of some plants of economic importance -54 min.
  Miscellaneous/Discussion - 6 min.

1. Some plants of Economic importance

1.1 *Dalbergia sissoo* Roxb.

Family : Papilionaceae (Fabaceae)

Local name: Sisoo, Shisham

Description: A large deciduous tree. Leaves alternate; leaflets 3-5. Flowers yellowish-white in short axillary panicles. Pods strap–shaped, glabrous and narrowed at base, 2-4 seeded.

Distribution: Planted in south West Bengal

Uses:

Wood- brown, hard, strong and durable; **timber** in great demand for all structural works, frames, furniture, carts, ploughs, oars etc.; has considerable use in manufacture of sports equipments, for carving inlaid work and lacquered ware.

The **roots, leaves, bark and heart woods** have **medicinal uses**.

1.2 Diospyros Melanoxylon Roxb.

Family: Ebenaceae

Local names: Kend, Tendu

Description : A middle sized deciduous tree ; bark black, exfoliating in rectangular scales; young parts yellowish tomentose. Leaves alternate, elliptic-oblong, softly tomemtose on both sides when young. Fruit yellow when ripe, globose.

Distribution: Found in deciduous forests of South West Bengal

Uses:

Wood - light roseate-grey or roseate brown with a jet black core - the ebony, which is extremely hard; both the lighter and darker portions are durable and take a good polish; poles are used for building purposes, shafts and poles of carts and carriages; the outer lighter coloured wood is suitable for toolhandle, golf sticks, carpenter's mallets etc.; the ebony used for combs, toys, snuff boxes, carving, fancy work, walking sticks etc.

Leaves - largely used as" "bidi patta", that is wrappers for "bidis".

Fruit is edible.

Bark - has **medicinal use** and used as astringents, and to treat diarrhea and dyspepsia.

Fig 16.1 ***Diospyros Melanoxylon***

Source:https://commons.wikimedia.org/wiki/File:Diospyros_melanoxylon.jpg

1.3 Emblica officinalis Gaertn. Syn. Phyllanthus emblica Linn.

Family: Euphorbiaceae

Local names: Amlaki, amla, aonla

Description: A small or medium-sized deciduous tree, thinly branched. Foliage feathery, light green. Leaves 0.5 in. long, narrowly linear, closely borne on deciduous branchlets. Flowers small, greenish-yellow, densely clustered along the branches. Fruit fleshy, large.

Distribution: Found and planted in deciduous forests of south West Bengal, and in mixed plains forest and lower hill forests of north Bengal.

Uses:

Tannin content – 22% in **Leaves**, 28% in fruit, 8-9% in bark from the trunk, and 21% in bark from the tender twig; used for **tanning** leather.

Fruit - edible and has many **medicinal uses; dried fruits** with fruits of bahera and haritaki, soaked in water overnight, taken in the morning to cure dyspepsia; **ripe fruit** with common salt is given to children to treat diarrhea.

The **leaves, seeds and roots** have also many therapeuticuses.

Fig. 16.2 ***Emblica officinalis***

(Source: https://commons.wikimedia.org/wiki/File:Phyllanthus_officinalis.jpg)

1.4 Eucalyptus sp.

Family: Myrtaceae

Local names: Eucalyptus

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.*

It is an erect single-stemmed woody plant with various crown forms.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**) **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 1 mm in length, and yellow-brown in colour. Most species do not flower until adult foliage starts to appear. (Source*; http://en.wikipedia.org/)*

Distribution: 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.

Uses: (Source: Eucalyptus in India - R.M. Palanna, at http://www.fao.org/docrep/005/ac772e/ac772e06.htm)

The most important characteristics of *E*. hybrid contributing to its popularity under Indian conditions are: it is **fast growing**, capable of over topping weeds, **coppices well**, is fire hardy, browse resistant and it has the ability to adapt to a wide range of edaphoclimatic conditions.

Fuel - Eucalyptus is a very good substitute for **firewood** because of its calorific value and moderate burning qualities. Eucalyptus gives good **charcoal.**

Poles - Eucalyptus poles are good for **transmission purposes** and are also used in construction of **dwelling houses**, work sheds and in **mines.** Eucalyptus poles have good demand near cities for use as **scaffolding material**.

Timber - Earlier, eucalyptus **wood** was not considered a good timber. Considering the cost of eucalyptus timber, it is found to be **quite economical** to use in **low cost houses,** as **mine timber** and in other **construction p**urposes. It is also being used as **furniture wood**.

Honey and oil - Several eucalyptus species are rich in **nectar and pollen**. **Bee keeping** is profitable and this activity is improving. Leaves of *Eucalyptus globulus* and *E. citriodora* are used for **extraction of oil.** It is a cottage industry providing employment in some parts of India.

Paper and pulp: 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.

Fig.16.3 ***Plantation of Eucalyptus.***

(Source : eucalypts clones.com)

1.5 Gloriosa superba Linn.

Family: Liliaceae

Local names: Bishalanguli, Ulatchandal

Description: Rambling herb. Root-stock a chain of cylindric fleshy tubers with fibrous roots. Leaves sessile or sub-sessile, entire, tip modified into coiled tendril-like structure and used in climbing. Flowers solitary, petals yellowish-red. Fruits capsule, linear oblong, seeds brown.

Distribution: Occurs in wild, though infrequent, throughout south west Bengal, and also in the plains forest and lower hill forests of north Bengal.

Uses: It is a very valuable medicinal plant.

Leaves used as antiasthmatic.

Tubers used as anticancer, antimalarial, febrifuge, purgative, stomachic; used in skin diseases, chronic ulcers etc.

Roots used as diuretic; beneficial in gout and rheumatism.

Fig. 16.4 ***Gloriosa superb***

(Source; https://commons.wikimedia.org/wiki/File:Flame_Lily.jpg)

1.6 Gmelina arborea Roxb. ex Sm.

Family: Lamiaceae

Local names: Gamar, gamari, khamari

Description: A moderate sized or large deciduous tree. 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 brownish yellow.

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

Uses:

Wood - yellowish white, strong, light, easily worked, and does not warp; used for various purposes, namely, planking, furniture, cabinet work, paneling, agricultural implements etc.; considered one of the best of the lower hill timbers. The wood is used in the manufacture of matches; also used for match sticks, inside boxes and peeling purposes.

The **bark, root and the fruit have medicinal** use.

1.7 Lagerstroemia speciosa (L.) Pers

Syn. L. flos-reginae Retz.

Family: Lythraceae

Local names: Jarul

Description: Alarge deciduous tree; bark smooth, grayish or cream coloured, peeling off in broad, irregular flakes. Leaves glabrous, elliptic or lanceolate, dark green above, pale beneath. Flowers purple. Capsule ovoid, woody.

Distribution: Common in plains forest in north Bengal, mostly as ashrubby tree beside stream. Planted frequently in low-lying forest blocks.

Uses: An important timber species of north Bengal.

Wood -light red to reddish-brown, shining, hard, very durable under water; suitable for ship building, boats, canoes, carts etc.; used for constructional works, furniture (preferably treated timber), planking, etc.; of ten used as a substitute for walnut.

Leaves and fruit contain 12-17% of **tannin**.

Medicinal use - various parts have **medicinal uses**. The roots, stems and leaves contain **hydrocyanic acid**.

Fig. 16.5 ***Lagerstroemia speciosa***

Source:https://commons.wikimedia.org/wiki/File:Jarul.jpg

1.8 Madhuca indica J.F. Gmel.

Family: sapotaceae

Local names: Mahua, mahul

Description: Alarge deciduous tree with short straight trunk and rounded crown. Bark thick, dark coloured, fissured, scaly. Leaves in cluster borne near the end of branches, elliptic or oblong-elliptic, leathery. Flowers in dense clusters borne at or near the ends of branches; calyx leathery, corolla cream coloured, fleshy, sweet. Fruit ovoid, green, fleshy, 1-2 in long.

Distribution: Indigenous in deciduous forests over lateritic soil in south West Bengal.

Uses:

Flowers and **fruits** - valuable commercially; fleshy corolla contains sugar and pleasant to taste; fallen flowers are collected, and besides beingan important part of **diet**, extensively used for **distilling spirit**.

Fruit- has considerable importance; the outer part eaten raw or cooked; the inner part made into flower for cakes etc.

Seed - the most valuable part of the fruit; contains oil, which is used in cooking, and for burning lamps; dried seeds used in the manufacture of margarine and soap; **oil cake** makes a valuable fertilizer.

Gum exuding from the tree is a natural substitute for gutta-percha.

Bark - used a sa dye.

Medicinal use - **Flowers**, the **spirit distilled from flowers**, and the **seed**-oil have medicinal use.

Fig.16.6 ***Madhuca indica***

(Source: http://opendata.keystone-foundation.org/madhuca-indica-j-gmelin)

1.9 Michelia champaca Linn.

Family: Magnoliaceae

Local names: Champ, Champaka

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, verydurable. Flower saxillary, yellow, strongly scented. Capsules thick, grey ovoid.

Distribution: The tree is characteristic of most 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.

Uses: It is a tall handsome, evergreen tree; very fast-growing, frost-hardy, fire sensitive.

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

Flowers - on distillation produce "Champaca oil" of commerce.

Leaves, bark, roots and flowers have medicinal use.

Fig.16.7 ***Michelia champaca***

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

1.10 Oroxylum indicum Vent

Family: Bignoniaceae

Local names: Shona, Bhaluksukti, Totala

Description: Medium sized tree. Leaves very large with a stout main axis, opposite, 2-3 pinnate; leaflets stalked, ovate or elliptic. Flowers large in erect, terminal, 1-2 ft long cymes, purple, foetid (disagreeable odour). Capsules 1-2.5 ft long, tapering at both ends, flat woody, fruits are conspicuous when the tree is leaf less; seeds numerous, winged.

Distribution: Available in hotter parts of south West Bengal, and in mixed plains forest and lower hill forest (upto 2000 ft) of north Bengal.

Uses:

Bark and the pods are of value in dyeing and tanning.

Medicinal use – The plant is of considerable medicinal value. The **root bark** is used to treat diarrhea, dysentery, asthma, bronchitis, vomiting etc. The **stem bark** paste is applied in rheumatism, gout and swelling. **Fruits** are useful in heart disease, bronchitis and dyspepsia.

Stem and root bark are in demand in the market.

Fig.16.8 ***Oroxylum indicum***

(Source: https://commons.wikimedia.org/wiki/File:Oroxylum_indicum_W_IMG_3169.jpg)

1.11 Pongamia pinnata (L) Pierre

Syn. ***P. glabra*****Vent.**

Family: Leguminosae

Local name: Karanj

Description: A medium sized tree, bark soft grey, covered with tubercles (rounded nodules); crown rounded. Leaves pinnately compound (imparipinnate), glabrous, bright green. Flowers purple and white in axillary racemes. Pods woody, glabrous, oval-oblong, with a short decurved lateral beak.

Distribution: Found in hotter lateritic zones of south West Bengal.

Uses:

Wood - moderately hard, but not durable; used for building purposes, ploughs, combs, yokes, fuel etc.; **ash of the wood** used for dyeing.

Bark yields a coarse fibre.

Seed - 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 **soap making**.

1.12 Pterocarpus marsupium Roxb.

Family: Leguminosae

Local names: Piyasal, Bijasal

Description: A large deciduous tree with widely spreading branches. Leaves alternate imparpinnate; leaflets 5-7, leathery, shining above, paler beneath, glabrous when fully grown. Flowers pale yellow or white. Pods nearly round, glabrous, winged,1-seeded.

Distribution: Throughout the hotter parts of south West Bengal.

Uses:

Wood - yellowish-brown, very hard, durable, and takes a good polish; highly valued for constructional and ornamental work and superior class of furniture; also used for agricultural implements, carts, boats, oars etc.

Bark – exudes valuable red **gum**"kino" of commerce which is used as a medical gum.

Leaves - good cattle fodder.

Medicinal uses- The **bark** is used in diarrhoea, leucorrhoea. **Heartwood** soaked in water overnight and taken to treat diabetes. **Gum** is used in diarrhea, toothache. **Leaves** applied to boils, sores.

Fig.16.9 ***Pterocarpus marsupium***

(Source:http://opendata.keystone-foundation.org/;

Source of Lesson materials:

1. *J. F. Dastur. Useful Plants of India and Pakistan, D.B. Taraporevala Sons & CO. LTD. Bombay*
2. *Research Wing, Directorate of Forests, Govt of West Bengal, 2005. Medicinal Plant Resources of South West Bengal*
3. *A.M Cowan and J.M Cowan 1979 , The Trees of Northern Bengal*
4. *Ram Parkash 2007 Plantation and Nursery Technique of Forest Trees, International Book Distributors, Dehradun.*
5. http://www.iucnredlist.org/
6. *Websites cited in the lesson*

Forest Botany
Lesson - 17

Lesson Plan **Time 1 hour**

Objective:

- To study some plants of economic importance

Backward linkage

- Study of plant morphology in previous lessons.

Forward linkage

- Identification and observation of the plants during tour

Training materials

- Copy of lesson 17 to be circulated beforehand

Allocation of time

- Economic Botany
  Study of some plants of economic importance -54 min.
  Miscellaneous/Discussion - 6 min.

1. Some plants of Economic importance

1.1 *Quercus lamellosa* Smith

Family: Fagaceae

Local name: Buk

Description: A tall evergreen tree growing upto 100-120 feet height. Bark grey-brown with rough spots. Leaves large, serrate, glaucous beneath. The flowers are monoecious (individual flowers are either male or female, but both sexes can be found on the same plant) and are pollinated by Wind (Source: http://www.pfaf.org). Cupules (cup shaped whorl of bracts) very large with circular lamellae.

Distribution: It is usually a gregarious plant and found in the upper hill forests (altitude 6000-9000 ft) in north Bengal.

Uses:

Wood- hard, heavy, with broad medullary rays; extensively used for building purposes in the hills. **It is a good firewood.**

Medicinal Use - The **bark and acorns** (ovoid fruit) are astringent. Any galls produced on the tree are strongly astringent and can be used in the treatment of haemorrhages, chronic diarrhoea, dysentery etc.
(Source: http://www.pfaf.org/)

Fig.17.1 *Quercus lamellosa*

(Source: http://www.forestrynepal.org/resources/trees/quercus-lamellosa)

1.2 Rauvolfia serpentine Benth. ex Kutz

Family: Apocynaceae

Local name: Sarpagandha

Description: Sparingly branched, glabrous shrub. Leaves in whorls, smooth, shinning green above. Cymes

many flowered. Calyx glabrous , bright red. Corolla rose or pinkish white. Drupe single or didymous, purplish black when ripe.

Distribution: Occurs occasionally under forest cover in the plains in West Bengal, also cultivated.

Uses: The plant is very important for its **medicinal values. Roots** are used to treat high blood pressure, rheumatism, epilepsy, snake bite. **Leaves** are used in removal of opacity of the cornea; paste and decoction of black peeper used to treat pneumonia.

Dry roots are in demand in the market.

Fig. 17.2 ***Rauvolfia serpentina***

(Source: https://commons.wikimedia.org/wiki/File:Rauvolfia_serpentina_01.JPG)

1.3 Schima wallichii (DC) Korth

Family: Theaceae

Local name: Chilaune

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/catalog/slides/Schima.html)

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.

Uses: The plant has a fast growth even under infertile soil conditions. The main value of the plant is its hard and durable **timbe**r. Timber is used for fence posts and beams and boards for house construction.
(Source: http://www.flowersofindia.net/catalog/slides/Schima.html)

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/treedb/AFTPDFS/Schima_wallichii.PDF)

Fig.17.3 ***Schima wallichii***
(Source: https://commons.wikimedia.org/wiki/File:Schim_walli_081205-4283_F_stgd.jpg)

1.4 Schleichera oleosa (Lour.) Oken

Syn. S. tririjuga Willd & Klein

Family: ***Sapindaceae***

Local name: ***Kusum***

Description: A large deciduous tree; trunk fluted, thick; bark smooth, grey; young shoots silky. Younger leaves bright red. Flowers white or yellowish. Fruits ellipsoid, spinous or smooth.

Distribution: Found throughout the hotter parts of south West Bengal. The plant grows in red lateritic soil.

Uses:

Wood - strong, durable, red, heavy and hard; used in making oil and sugarcane mills, carts and agricultural implements; also useful as firewood; makes excellent charcoal.

Seed - **Kusum oil of commerce,** yellowish-brown oil, extracted from the seeds. It is much used for lighting and cooking and as hair oil. It is also used for soap making. The pulp round the seed is edible.

Flowers - A dye is extracted from the **flowers**.

Bark - contains 9% of tannin.

Leaves and twigs - lopped for fodder.

The tree is one of the best **hosts** for culture of **lac insects**.

Medicinal use- The bark is used for skin disease, ulcers, inflammation and malaria. The seed oil is also used for skin disease and ulcer.

Fig.17.4 ***Schleichera oleosa***

(Source: https://commons.wikimedia.org/wiki/File:Schleic_oleos_080320-5971_rgn.JPG)

1.5 Shorea robusta Gaertn. F.

Family: Dipterocarpaceae

Local name: Sal

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.

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.

Uses: It is the chief forest tree and the major source of forest revenue in south West Bengal as well as in the northern part (plains forest and lower hill) of the state.

Wood - very durable, used for building bridges, making railway sleepers. Resistant to attack of white ants it is in great demand for construction works, mine props, piles, boat building, well construction; also used for furniture, tent poles and pegs, carriages, wheels etc.; a good firewood and makes very good charcoal.

Bark -contains 9% of tannin and is used as tanning material.

Gum - The **stem** exudes an oleo-resinous gum. The gum is burnt as incense and as a disinfectant fumigant.

Seed –produces 'sal butter' which is used as a luminant, a substitute for butter in chocolates, and as cooking agent.

Leaves – used in making plates which are in good demand in the market.

Fig.17.5 ***Shorea robusta***

(Source: https://commons.wikimedia.org/wiki/File:Sal_(Shorea_robusta)-_new_leaves_with_flower_buds_at_Jayanti,_Duars_W_Picture_120.jpg)

1.6 Strychnos nux-vomica Linn.

Family: Loganiaceae

Local name: Kuchila.

Description: A medium-sized or large deciduous tree. Bark smooth, greyish and thin. Leaves opposite, broadly elliptic. Flowers greenish-white in short, terminal downy cymes. Fruit globose, orange red when ripe. Seeds immersed in white pulp, covered with silky hairs.

Distribution:Throughout south West Bengal. It is now infrequent in the wild.

Uses:

Seed - The most important part of the tree is its **seeds**. The seed contains valuable **alkaloids** Strychnine and brucine. The seeds are highly poisonous. All parts of the plant except the pulp of the fruit are poisonous.

Medicinal use – The plant has **many medicinal uses. Paste of leaves** is applied to wounds and ulcers. **Root bark** is used in cholera, diarrhea, vomiting, dysentery, fever. **Seed** is used to treat nervous breakdown, blood dysentery, paralysis, dyspepsia, cold and cough, intermittent fever, low blood pressure and many other ailments.

Fig.17.6 ***Strychnosnux-vomica***

(Source: https://commons.wikimedia.org/wiki/File:Strychnos_nux-vomica_in_Kinnarsani_WS,_AP_W_IMG_6021.jpg)

1.7 Taxus baccata Linn

Family: Taxaceae

Local name: Dhengre Salla

Description: *T. baccata,* is a small to medium-sized evergreen tree, has thin scaly brown bark. Flowering occurs in September and fruiting in October, seeds are enclosed in red fleshy cuplike aril.

Distribution: Distributed in Himalayas, the tree is found in the upper hill forests (altitude 8000-10000 feet) of north Bengal. However, due to over-exploitation, the species has become rare in north Bengal.

Medicinal use of Taxus baccata : Except for the arils, all parts of the tree are stated to be poisonous. It is reported that anti-cancer drugs have been developed from this tree.

Fig. 17.7 ***Taxus baccata.***

(Source:https://commons.wikimedia.org/wiki/File:Taxus_baccata_01_ies.jpg)

1.8 Tectona grandis Linn. f

Family: Lamiaceae

Local name: Segun,Teak

Description: A large deciduous tree. Bark light brown or greyish, 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.

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.

Uses: It is a very valuable tree as it give sone of the outstanding timbers.

Wood is dark golden–yellow when freshly cut, turns over timeto 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 iseasy to air-season, easy to work and saw, makes excellent **plywood**. Wood (scraps and rejections of saw mill) yields tar oil which is used as a varnish.

Fig. 17.8 ***Tectona grandis***

(Source: https://commons.wikimedia.org/wiki/File:Starr_010304-0485_Tectona_grandis.jpg; Attribution: Forest & Kim Starr)

1.9 Terminalia alata Heyne ex Roth.

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

Family: Combretaceae

Local names: Pakasaj, Asan

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.

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 in frequent. Planted both in northern and southern part of the state.

Uses:

Wood - dark brown, hard, fairly durable, takes good polish; 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.

Bark contains 15-18% of tannin and is used as a tanning and dyeing material.
Leaves are lopped for fodder, are also used for feeding tassar silk worm.
The tree is widely used as **tassar host plant in south West Bengal**.

1.10 Terminalia arjuna (Roxb.) Wight. Am.

Family: Combretaceae

Local name: Arjun

Description: A large deciduous tree, trunk thick and often buttressed. Bark silvery grey, flaky. Leaves elliptic-oblong, hard, glabrous, leathery, 3-6 in long. Flowers without stalk, white or cream-coloured. Fruit dark brown with projecting hard wings.

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 are as) of north Bengal forests.

Uses: 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; makes excellent firewood and good quality charcoal.

Leaves are fed to tassar silkworms.The tree is widely used as **tassar host plant in south West Bengal**.

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

Fruits and leaves have also medicinal value.

Fig. 17.9 ***Terminalia arjuna***

(Sourcehttps://commons.wikimedia.org/wiki/File:Terminalia_arjuna_trunk_02_by_Line1.JPG)

1.11 Terminalia bellirica (Gaertn.)Roxb

Syn. T. belerica Roxb.

Family: Combretaceae

Local name: Bahera

Description: A large deciduous tree often buttressed at the base. Bark thick, silvery grey or brownish with vertical cracks. Leaves at the end of branchlets, alternate, glabrous, pubescent when young. Flowers greenish-yellow. Fruit ovoid, 1 in long, gently 5-ridged.

Distribution: Occurs throughout hotter parts of south West Bengal, and in Sal forests, mixed plains forest and lower hill forests of north Bengal.

Uses:

Wood - hard, strong, moderately heavy, coarse textured, easy to kiln season, not durable; used in petty construction, heavy packing cases, tea chests, commercial plywood, blackboards etc.

Fruit is astringent and is one of the well-known commercial myrobalans. Tannin content of the fruit without the stone is 25 %. It is used for tanning leather and also for dyeing cloth and leather.

Medicinal use - The plant has many **medicinal uses**. The **fruit** is one of the constituents of ayurvedic medicine 'triphala', used to treat dyspepsia. The fruit is also used as antipyretic, antileprotic and purgative. The **bark** is used as diuretic, paste used to treat leucoderma.

1.12 Terminalia chebula Retz.

Family: Combretaceae

Local names: Haritaki, Harra

Description: A large deciduous well-branched tree. Bark thick, dark brown, having numerous vertical cracks. Leaves often opposite, elliptic or ovate, mature ones glabrous, leaf-stalk with a large glandon each side at the top. Flowers all bisexual, whitish or yellowish. Drupes ovoid, pendulous, 5-ribbed when ripe; stones bony.

Distribution: Occurs through put hotter parts of South West Bengal, and available in Sal forests, mixed plain forests (chiefly near rivers) and the lower hill forest ridges and plateau of north Bengal. Infrequent in the wild.

Uses:

Wood- dark purple, very hard, fairly durable, and takes a good polish; used for house building, furniture, carts, shafts, axles, agricultural implements etc.

Fruit - the most valuable part of the plant, the black myrobalan of commerce. It is a good tanning material for dyeing cotton, wool and leather.

Medicinal use - The plant has valuable medicinal properties. The **fruits** are used as laxative, astringent, stomachic, and tonic. The **fruit** is one of the constituents of ayurvedic medicine 'triphala', used to treat dyspepsia. The **bark** is used as diuretic and cardiotonic.

Source of Lesson materials:

1. *J. F. Dastur. Useful Plants of India and Pakistan, D.B. Taraporevala Sons & CO. LTD. Bombay*
2. *Research Wing, Directorate of Forests, Govt of West Bengal, 2005. Medicinal Plant Resources of South West Bengal*
3. *A.M. Cowan and J.M Cowan 1979, The Trees of Northern Bengal*
4. *Ram Parkash 2007 Plantation and Nursery Technique of Forest Trees, International Book Distributors, Dehradun.*
5. *http://www.kew.org/science-conservation/plants-fungi/taxus-baccata-common-yew*
6. http://www.iucnredlist.org/
7. *Websites cited in the lesson*
8. *Prabha Sharma and P L Uniyal (Department of botany, University of Delhi, Delhi-110007, India) 2010,Traditional knowledge and conservation of Taxus baccata in Sikkim Himalaya*