

UNIT –II Morphology of Angiosperms

Synopsis

Root system and Root Modifications

- Dicots show tap root system and monocots show fibrous root system.
- Adventitious roots develop both in dicots and monocots. Fibrous roots of monocots are adventitious.
- Branches on roots are endogenous in origin.
- Primary roots geotropic. Secondary roots are plagiotropic. Secondary roots at the surface of the soil are diageotropic.
- On roots nodes, leaves, normal buds are absent.
- Root apex is protected by calyptras or root cap. Root cap regenerates periodically. Root caps are absent in aquatic plants, velamin roots, haustorial roots and Mycorrhizal roots.
- Roots store different substances and are called storage roots.
E.g. *Daucus carota*, *Raphanus sativus*, *Beta vulgaris*. *Ipomea batatas*, *Ruellia tuberosa*, *Asparagus*, *Mirabilis jalapa*.
- *Beta* stores sugars. *Dahlia* stores inulin, a polyfructose sugar.
- Many storage roots are biennials.
- Nodulated roots or Tuberculate roots are present in some leguminosae plants like Lucerne (alfalfa), *Cajanus*, *Dolichos*, *Arachis*.
- Plants growing in saline swamps (mangroves) show pneumatophores, mycorrhizal roots and vivipary.
Eg: *Sonneratia*, *Bruguiera*, *Heritiera*(sundari tree), *Rhizophora*, *Avicennia*.
- In *Momordica* moniliform(beaded) roots are present.
- The apex of the roots are swollen (nodulose roots) in *Curcuma amada*.
- In *Vanda*, an epiphyte shows velamin roots which absorb moisture from the atmosphere. A dead velamin tissue is present covering the roots. Velamin is modified epidermis. These roots will not help in anchorage.
- Roots are green and photosynthetic in *Taeniophyllum*(an epiphyte), *Tinospora*, *Trapa*(aquatic plant)(Singhara)(water chest nut).
- Parasitic roots or haustorial roots obtain nutrients from the host. They are root or stem parasites. Complete or incomplete. Complete parasites are without photosynthetic pigments. *Cuscuta* (complete stem parasite). *Viscum*, *Cassytha* are partial stem

parasites obtaining only water and nutrients from the host. *Striga* is partial root parasite. *Santalum* entirely depends on roots of host at seedling stage. *Balanophora* (on tobacco plants) *Orobanche* on many vegetable crops are complete root parasite.

- Prop are mechanical roots developing from large horizontal branches and enter into soil (*Ficus* spp).
- Stilts roots develop from lower nodes in Gramineae members for additional support as stem is thin and hollow (culm).
- Climbing roots develop from nodes (*Piper betel*), or internodes (*Pothos, Tecoma, Ivy*).
- Root buds (adventitious) develop in *Murraya, Millingtonia* and *Moringa*.

Shoot system and its modifications

- Shoot system shows underground, aerial and sub aerial modifications.
- Rhizome, corm, stem tubers and bulbs are underground stem modifications. Under stems generally stores food material except in bulbs. Sclerophytes are underground stems without storage substance.
- Rhizomes grow parallel to the surface. Corms grow vertical in the soil.
- Ginger, *Curcuma* (haldi), *Musa* and *Canna* are rhizomes. These are perennating bodies.
- In bulbs stem is discoid. Leaf bases are swollen. Leaf may arrange in concentric circles (*Allium cepa*) or imbricate (*Allium sativum*). Dry scaly leaf (tunic) protects in scaly bulbs (*Allium cepa* and *Allium sativum*). Scaly leaf absent in naked bulbs in *Lillium*.
- In corms contractile roots may be present which maintain the depth of the corm in the soil-*Gladiolus, Amorphophallus* (zamikand), *Colocasia* (kachalu).
- Potatoes are stem tubers. Brown periderm protects potatoes. Eye like structure represent nodes. Potatoes are terminal swollen portions of underground branches. Roots are not present on this modified portion.
- Aerial stem modifications are thorn- *Carissa carandus, Duranta, Bougainvillea, Citrus*. Thorn may be hook like in *Hugonia, Artabotrys*.
- Tendrils are present in *Passiflora, Cucurbita, Vitis* (grape vine). Branched tendrils are present in *Cucurbita*. In *Antigonon* and *Cardiospermum* inflorescence axis is tendrillar.
- Sometimes aerial stems are swollen like in knoll-kohl, Sugar cane storing food material.
- Axillary buds stores food material, detach and help in propagation.
E.g. Century plant (*Agave*). These are called as bulbils.
- Sub-aerial stem modifications help in vegetative modifications. These are runners, stolons, suckers and offsets.

- In *Cynodon dactylon* runners are present. Rosa, Jasminum, *Centella* (Brahmi) are other examples.
- Strawberry, chrysanthemum, mentha are examples for stolon.
- In *Pistia*(water lettuce),*Eichornia*(water hyacinth)offsets are present.
- In *Muehlenbeckia* , *Euphorbia tirucalli* stems are photosynthetic(phylloclade).

Leaf and Leaf Modifications

- Leaves present on the aerial stems are called cauline leaves.
- Leaves present on branches are ramal leaves
- Leaves present on underground stems are radical leaves.eg; *Allium* (all bulbs). Rhizomes, corms also show scaly radical leaves.
- Leaves are protected by stipules at young stages. Leaves without stipules are exstipulate. Cauducous (short lived) stipules are present in *Michelia*.
- Stipules may modify into spines (*Acacia*), tendrils (*Smilax*), foliaceous (*Lathyrus*, *Pisum*).
- Leaf base is swollen (pulvinus) in leguminosae. This is responsible for sleeping movements in Leguminosae.
- Leaves may show petioles (petiolate) or no petiole (sessile).
- All leaves show axillary buds in their axils.
- Simple leaves are dissected and mid ribs are branched to become compound leaves.
- They may be pinnately dissected or palmately dissected. Each dissected lamina is called as leaflet. Stalk of the leaflet is called petiole.
- In pinnately compound leaves leaflets are arranged in pairs on either side of the rachis. Rachis may be single (unipinnate) or branched (bipinnate, tripinnate, decompounds). In palmate compound leaves leaflets arise from a single point. Leaflets may be one to many (unifoliate, bifoliate, trifoliate etc).
- In dicot leaves reticulate venation and monocots show parallel venation. Some exceptions are seen.
- In *Eryngium*, *Caulophyllum* (dicots) parallel venation and in *Smilax*,*Dioscorea* , *Colocasia* (monocots) reticulate venation is seen.
- If many prominent mid ribs are present they are multicostate venation. If leaves are lobed with many prominent ribs all of them diverge from the base into the lobes

(*Cucurbita*- dicot, *Borassus*-monocot). If they are not lobed they converge at the apex. *Oryza*(monocot), *Hibiscus*(dicot).

- Arrangement of the leaves on the stem is called phyllotaxy. In alternate or spiral phyllotaxy one leaf is present at each node and arranged spirally on the stem. The number of rows on the stem is a genetic character. Each row is called Orthostichy (distichy, tristichy etc).
- In opposite phyllotaxy two leaves are arranged opposite at each node. At each node the pair may superposed or at right angles to the lower pair (decussate) *Quisqualis* – opposite superposed, *Calotropis* – opposite decussate.
- In whorl phyllotaxy many leaves appear at each node.

E.g.: *Alstonia*, *Nerium*, *Plumeria*.

- They appear as mosaic to longer petioles of lower leaves in *Acalypha*, *Ricinus*, *Carica*.
- Photosynthetic petioles are called as phyllodes. Leaflets fall off early but petiole is persistent.

E.g.; *Acacia melanoxylon* (Australian acacia), *Parkinsonia*.

- Scaly leaves are xerophytic adaptations. (*Allium*).
- Entire leaf is tendrillar in *Lathyrus* and terminal leaflets in *Pisum*. Leaf apex in *Gloriosa*.
- Reproductive leaves with adventitious buds developing on the lamina are seen in *Bryophyllum* (marginal) *Scilla* (terminal) *Begonia* (at injured portions).
- In insectivorous plants trap leaves are present.

E.g.: *Nepenthes* (pitcher plant), *Dionaea* (venus fly trap) *Utricularia*(bladder wort) *Drosera* (sundew plant), *Pinguicula*.

UNIT-2-MORPHOLOGY-II

Inflorescence

Synopsis

- Inflorescence is a modified branch developing from terminal or axillary buds. In *Datura* and *Gossypium* terminal and in *Hibiscus* axillary inflorescences are present.
- Inflorescence axis is called as peduncle. In compound inflorescences peduncle is branched.
- Inflorescences develop from the axils of modified leaves called involucre. Branches develop from involucels.
- Sometimes inflorescences appear on large stems (cauliflory).
Eg: *Ficus*(fig), *Theobroma* (cacao), *Polyalthia*, *Artocarpus*(jack fruit).
- In *Callistemon* (*bottle brush*) intercalary inflorescence is seen.
- Inflorescences may be racemose or cymose. Peduncle growth is indefinite and flower number is also indefinite. Flower anthesis is acropetal. (Centripetal). *Delphinium*, *Brassica*.
- In cymose inflorescence apical bud modifies into flower. Flower anthesis is basipetal. Number of flower are definite.
- Some inflorescences cannot be classified in any category classified as special types. Verticillaster, Cyathium, Hypanthodium.
- Racemose inflorescences are grouped into two types based on presence or absence of pedicel.
- Simple racemes are seen in Fabaceae members (*Crotalaria*, *Tamarindus*, *Dolichos*). Compound racemes or panicles are found in (*Mangifera*, *Yucca*).
- In corymbose inflorescences all the flower heads are brought to same height due to longer stalks of the older flowers. Simple corymbs are found in members of Caesalpiniaceae(*Cassia*, *Delonix*, *Caesalpinia*), *Gynandropsis*, *Iberis*. Compound corymb in *Pyrus* and cauliflower.
- In Umbels peduncle is condensed to a disc. All the flowers have more or less same length of the pedicels. Simple umbels in *Allium* and *Smilax*. Compound umbels in *Coriandrum*, *Daucus*, *Carum* (jeera). In all umbels involucre bracts are prominent.
- Spikes are like simple raceme but flowers are without pedicels. Found in Amaranthaceae members. Compound spikes are present in Poaceae members. It is the

most advanced inflorescence in plant kingdom. Some bracts do bear flowers they are glumes. Bracts and bracteoles are termed as lemma and palea respectively. Perianth reduced to small structures called lodicules. In maize unisexual flowers are present. Each branch of a compound spike is a spikelet and stalk is rachilla.

- Catkins or amentums have drooping inflorescence axis. *Morus alba*, *Casuarina*, *Acalypha*, *Quercus suber*.
- Simple spadix is seen in members of Aroideae. Pedicel is fleshy bearing unisexual flowers. *Colocasia*, *Amorphophallus titanum* (largest spadix) , *Pistia*, *Lemna* (smallest spadix) , *Anthurium*. A leathery spathe (modified bract) protects the inflorescence which is also attractive.
- Compound spadix examples are *Cocos nucifera*, *Musa*.
- Head inflorescence or anthodium is a typical inflorescence of Asteraceae members. Peduncle is condensed covered by prominent involucre. Two different flowers are present in heterogamous heads (ray florets and disc florets). Single type of florets in homogamous heads. Ray florets in heterogamous heads are female flowers. Homogamous head examples are *Chrysanthemum*, *Tagetes* (all ray florets). *Vernonia*, *Ageratum* (all disc florets). Heterogamous heads are seen in *Tridax*, *Helianthus*, *Cosmos*, *Zinnia* etc. Compound heads are seen in *Sphaeranthus* , *Echinops*.
- Single flower cymes are solitary cymes, a characteristic feature of Malvaceae.
- Three flowered simple cymes are seen in *Bougainvillea*, *Jasminum*
- In Monochasial or uniparous cymes a single branch develops after terminal bud modification. Two types- helicoid(*Hamelia*, *Begonia*, *Drosera*) and scorpioid cymes (*Heliotropium*, *Solanum*). In all monochasial cymes due to sympodial axis flower appear opposite bracts.
- Dichasial cymes in *Clerodendron*, *Ixora*, *Dianthus* and Polychasial cymes in *Nerium*, *Plumeria* are present.
- Cymose heads or globose heads are present in *Anthocephalus*, *Acacia*. *Parkia*, *Mimosa* etc.
- Inflorescence in *Ocimum* (thyrsus) is classified as a mixed type.
- In special types Verticillaster is seen Lamiaceae members(*Leucas*, *Leonitis*, *Salvia*). At each node two inflorescences appear like a false whorl. It cannot be classified into dichasial or monochasial cyme.

- In *Cyathium* (typical of Euphorbiaceae) involucre is cup shaped, a single female flower (solitary cyme) many male flowers (monochasial scorpioid) are present. It looks like a small flower. A large nectar gland is present on involucre's cup.
- *Hypanthodium* is seen in Moraceae family. It looks like a fruit. Peduncle is fleshy cup shaped. Male flowers are present at the apex and female at the bottom. Flowers open irregularly. Gall wasp (*Blastophaga*) pollinates the flower. Insect's lays eggs in ovaries of some female flowers making them sterile (gall flowers) after pollination peduncle becomes fleshy and edible (developing into compound fruit Syconus).

Flower

Synopsis

- Flower is considered as a modified shoot with limited number of nodes by taxonomists like Linnaeus, de Candolle, Goethe, Gaspard Bauhin,
- Monocarpic plants flower only once in their life time and polycarpic many times.
- Flower is a reproductive branch.
- Flowers may be bracteate with a bract or ebracteate without a bract. Pedicel may be present or may not be present.
- At each node leaves are modified into floral leaves.
- Complete flower is with calyx, corolla, stamens and carpels.
- Monochlamydeous flowers with a single whorl of perianth (*Euphorbia*, *Amaranthus*, *Croton*), Achlamydeous(*Poinsettia*) or naked flowers without any perianth are incomplete.
- Unisexual flowers are also incomplete. Plants are monoecious if unisexual flowers are present on the same plant (*Acalypha*, castor, maize). If unisexual flowers are present two different plants they are dioecious (*Vallisneria*, *Borassus*, *Casuarina* *Cycas*).
- Polygamous plants show more than two types of flowers-male, female, bisexual or neuter flowers.*Mangifera*, *Polygonum*, *Anacardium*.
- Actinomorphic flowers are radially symmetrical (*Hibiscus*, *datura*). Zygomorphic flowers are biradially symmetrical. Zygomorphy is due to unequal perianth or staminodes.(*Ocimum*, *Dolichos*,*Cassia*).
- *Canna* shows Asymmetrical flower.

- Isomerous flowers show each whorl with similar number or multiples of that number of floral parts. Flowers can be trimerous (monocots), tetramerous (Brassica), pentamerous (*Hibiscus, Datura*).
- Hypogynous flowers have superior ovary with floral parts arising below the Gynoecium. It is primitive. Thalamus is conical or discoid.
- In perigynous and epigynous flowers thalamus is cup shaped. In preigynous flowers thalamus is not fused with ovary wall. Thalamus position may be superior, inferior or half inferior (*Dolichos, Crotalaria, Rosa*). In epigynous ovary is fused with thalamus, thalamus is inferior (*Tridax, Cucurbita, Ixora*).
- Arrangement of perianth in bud condition is called as aestivation. Aestivations may be valvate, Twisted (petals of *Hibiscus*), Ascendingly imbricate (Fabaceae members), Descendingly imbricate (in petals of Caesalpiniaceae). Quincuncial (sepals of *Ipomoea, Catharanthus*).
- Stamens are modified leaves bearing microsporangia. They may be bitheous with two theca or monothecous with single theca (Malvaceae). Sterile stamens are staminodes (*Cassia*).
- Length of stamens may be different. In tetradynamous four longer and two shorter (Brassicaceae). In didynamous two short and two long (*Ocimum*). In *Ipomoea* all stamens are of different height.
- Attachment of the filament with theca is fixation. Adnate (*Nelumbo, Magnolia*), Basifixed (*Datura*), Dorsifixed (*Hibiscus*), Versatile (Poaceae).
- Dehiscence may be longitudinal, Transverse (*Hibiscus*), Porus (*Solanum, Cassia*), Valvular (*Cassya*).
- Cohesion of stamen result in monadelphous (Malvaceae), diadelphous (Fabaceae) or Polyadelphous (*Citrus, Ceiba*). Syngenesious (union of theca) in *Tridax, Helianthus*. Synandrous (total union) in *Cucurbita*.
- Adhesion results in epipetalous (all gamopetalous flowers), episepalous (*Grevillea*) or epiphyllous in *Allium*. Stamens unite with gynoecium (gynostegium) in *Calotropis*.
- Carpels are modified leaves with megasporangium. They may be united (syncarpous) or free (apocarpous). Apocarpous in *Annona, Polyalthia, Nelumbo*.
- Placentation may be marginal (Fabaceae) parietal (*Brassica, Cucurbita*), basal (*Tridax*) freecentral (*Dianthus*) superficial (*Nymphaea*).
- Locule number and carpel number is not equal always. Due to false septum (replum) locule number increases (*Brassica, Datura*).

- Style is gynobasic in Lamiaceae(*Ocimum*).

Fruit

Synopsis

- After fertilization ovary forms into fruit and ovules into seeds. Without fertilization results parthenocarpic fruits.
- If any part other than ovary becomes fleshy those are false fruits. *Pyrus malus*(edible thalamus), *Anacardium occidentale* (fleshy peduncle).
- Simple fruits develop from syncarpous ovaries. Aggregate fruits develop from apocarpous ovaries. *Annona*, *Polyalthia*(etaerio of berries), *Magnolia*(etaerio of follicles), *Rubus*(drups), *Naravelia*, *Nelumbo*(achenes).Composite or multiple fruits develop from entire inflorescence (Sorosis- *Artocarpous*, *Morus*, *Casuarina*) Syconus (from hypanthodium-*Ficus*).
- Simple fruits may be fleshy or dry. Fleshy fruits are berry (banana, tomato, brinjal , date), Pome(*Pyrus*) Pepo (cucurbits) Hesperidium (*Citrus*) or Drupe(coconut,mango). Drupes are stony fruit with pericarp stony.
- Dry fruits are dehiscent or indehiscent. Dehiscent fruits are Legume (fabaceae), Silique (*Brassica*) or capsules. Capsules may loculicidal (Malvaceae- *Gossypium*) septicidal(*Aristolochia*, *Gloriosa*, *Viola*(pansy)) septifragal in *Datura* and *Nicotiana*.
- Dry indehiscent fruits are always single seeded. They are achenes(*Nelumbo*, *Naravelia*), Caryopsis (cereals) Cypsela (Asteraceae) Nut (*Anacardium*).In Caryopsis fruit wall and seed coat is fused (endosperm is edible). Cypsela develops from inferior ovary.
- Winged fruits are called as samara. (*Hiptage*, *Gyrocarpus*, *Ptelea*).
- Sometimes both dehiscent and indehiscent characters are seen – Schizocarpic fruits or splitting fruits. They break down into single seeded mericarps. They are Cremocarp-2(*Coriandrum*), Lomentum-many (*Mimosa*), Regma-3 (*Ricinus*) Carcerulus-4 (*Ocimum*).
- Seeds without endosperm are non endospermic. Seeds with left over nucellus are perispermic (*Piper nigrum*, *Nymphaea*, Coffee).
- Aril may be present in some seeds. *Pithacalobium*, *Myristica*, Litchi.
- Caruncle is present in seeds of Euphorbiaceae (*Ricinus*).
- Embryonal axis is called tigellum.

- Single cotyledon in monocot seeds is Scutellum.

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