Phytohormones

Tridip Boruah
Assistant Professor
Department of Botany
M.C College, Barpeta

Phytohormones are naturally occurring small organic molecules or substances which influence physiological processes in plants at very low concentrations. In other words, phytohormones are chemical messengers that coordinate cellular activities of plants.

Physiological roles of some of the phytohormones are discussed here-

Auxin

It is the 1st plant hormone which is discovered by Went (1928) from Avena curvature test. The most common naturally occurring Auxin is IAA (Indole-3 -acetic acid). IAA synthesized in shoot apical meristem and transport basipetally through both polar and non polar transport. Primary roles/function of Auxins are listed below-

i. **Respiration:** Auxin stimulates respiration most probably by increasing availability of respiratory substrate in the respiration pathway.

ii. **Cell division and Cell enlargement:** It is one of the primary functions of Auxin. Auxin is known to promote division in the cells of vascular cambium. Cell enlargement is caused by solubilisation of carbohydrates, loosening of wall micro-fibrils, synthesis of more wall materials, increased membrane permeability and respiration.

iii. **Apical dominance:** Auxin promotes apical dominance. Apical dominance is the phenomenon by which presence of apical bud does not allow the nearby lateral buds to grow. Only when the apical bud is removed, the lateral buds sprout.

iv. **Root Formation:** Auxin promotes root initiation at concentration which is inhibitory for growth of intact root.

v. **Cambial activity:** Degree of cambial activity is directly proportional to Auxin concentration. Auxin also controls xylem differentiation.

vi. **Callus formation:** In tissue culture, the development of callus or mass of undifferentiated cells is promoted by auxin. Differentiation of callus occurs in the presence of both Auxin and Cytokinin.

vii. **Inhibition of Abscission:** Auxin delays abscission of young leaves and fruits. Its effect is through non-formation of abscission zone below a leaf or fruit. Abscission zone cuts off nutrients and water supply. However, auxin promotes the abscission of mature or older leaves and fruits.

viii. **Production of seedless fruit:** The carpels producing seedless or parthenocarpic fruits have a higher internal production of Auxin that supports the development of fruits, e.g., Banana.

ix. **Production of dwarf shoots:** In Apple, flowers and fruits are formed on dwarf shoots. Application of naphthalene acetic acid (Which is a synthetic Auxin) increases the number of dwarf shoots as well as the number of fruits.

x. **Tropic movements:** Differential distribution of indole 3-acetic acid in the plant body causes bending of coleoptiles towards light (phototropism) and control geotropism (growth in response to gravity).

Cytokinins

Cytokinins are plant growth hormones which either amino purine or phenyl urea derivatives, basic in nature, and promote cytokinesis either alone or in conjunction with Auxin. The first cytokinin was discovered from degraded autoclaved Herring sperm DNA by Miller 1955. The first natural cytokinin was obtained from unripe maize grains or kernels by Letham (1964). It is known as zeatin (6-hydroxy 3-methyl trans 2-butenyl amino-purine). Primary roles/function of Cytokinins are listed below-

i. **Cell division:** Cytokinins are essential for cytokinesis. In the presence of auxin, cytokinins bring about division even in permanent cells. Cell division in callus (unorganised, undifferentiated irregular mass of dividing cells in tissue culture) is found to require both the hormones.

ii. **Morphogenesis:** Both Auxin and cytokinins are essential for morphogenesis or differentiation of tissues and organs. Buds develop when cytokinins are in excess while roots are formed when their ratios are reversed.

iii. **Cell differentiation:** Cytokinins induce formation of new leaves, chloroplasts in leaves, lateral shoot formation and adventitious shoot formation. They also bring about lignification and differentiation of inter-fascicular cambium.

iv. **Senescence:** Cytokinins delay the senescence of leaves and other organs by mobilisation of nutrients in the source sink relationship. This phenomenon is more popularly termed as Richmond-Lang Effect.

v. **Prevent Apical dominance:** Cytokinins act antagonistically to auxin which promotes apical dominance. Presence of cytokinin in an area causes preferential movement of nutrients towards it. When applied to lateral buds, they help in their growth despite the presence of apical bud.

vi. **Overcome seed dormancy:** Cytokinins helps in overcome seed dormancy of various types, including red light requirement of Lettuce and Tobacco seeds.

vii. **Induction of parthenocarpy:** In an experiment conducted by Crane (1965), it has been reported that induction of parthenocarpy is possible through cytokinin treatment.

viii. **Resistance:** Cytokinins are known to exhibit increased resistance towards various abiotic stresses including temperature and drought stress along with biotic stresses including bacterial diseases.

ix. **Phloem transport:** Cytokinins induce accumulation of salts inside the cells thus they help in phloem transport through phloem loading and phloem unloading mechanism.

x. **Shelf life:** Application of cytokinins to marketed vegetables can keep them fresh for several days. Shelf life of cut shoots and flowers is prolonged by employing the hormones.

Gibberellins (GA)

Chemically GAs is tetracylic diterpenoids consists of 4 isoprene units (C5H8). Gibberellins (GAs) first isolated from the ascomycetes fungus *Gibberella fujikuroi* that causes 'bakanae' or foolish seedling disease of rice. Gibberellins are synthesised in the apical shoot buds (young leaves), root tips and developing seeds. The precursors for their synthesis is mevalonic acid. Primary roles/function of Gibberellins are listed below-

i. **Stem elongation and leaf growth:** Gibberellins help in cell growth of stem, leaves and other aerial parts. Therefore, they increase the size of stem, leaves, flowers and fruits.

ii. **Dwarf shoot:** Besides general increase in stem length, gibberellins specifically induce intermodal growth in some genetically dwarf varieties of plants like Pea and Maize. It appears that dwarfness of such varieties is due to internal deficiency of gibberellins.

iii. **Breaking seed dormancy:** Gibberellins overcome the natural dormancy of buds, tubers, seeds, etc. and allow them to grow. In this function they are antagonistic to abscisic acid (ABA).

iv. **Bolting:** Gibberellins induce sub-apical meristem to develop faster. This causes elongation of reduced stem or bolting in case of rosette plants (e.g., Cabbage) and root crops (e.g., Radish). Normally bolting occurs at the onset of reproductive phase. It is favoured in nature by either cold nights or long days.

v. **Stimulates seed germination:** During seed germination, especially of cereals, gibberellins stimulate the production of some messenger RNAs and then hydrolytic enzymes like amylases, lipases ribonucleases and proteases. The enzymes solubilize the reserve food of the seed. The same is transferred to embryo axis for its growth.

vi. **Fruit Development:** Along with auxin, gibberellins control fruit growth and development. They can induce parthenocarpy or development of seedless fruits from unfertilized pistils, especially in case of pomes (e.g., Apple, Pear).

vii. **Vernalization:** The cold climate required for growth and development of some specific plan species can be replaced by Gibberellin treatment.

viii. **Sex expression:** Gibberellins promote the formation of male flowers on genetically female plants of Cannabis. They can also replace female flowers with male flowers on monoecious plants of cucurbits.

ix. **Tropic movement:** Gibberellins are also responsible for some distinguishable tropic movement of plants. In Sunflower, phototropic and geotropic responses of shoot tips are due to redistribution of gibberellins.

x. **Delayed ripening:** Gibberellins delays senescence so that fruit can be left on the tree for longer period It extends period of marketing. Ripening of Citrus fruits can be delayed with the help of gibberellins. This is useful in storing the fruits.

Abscisic Acid (ABA)

Abscisic acid is a natural growth inhibitor synthesized in all cells of vascular plants and mosses that contain plastids. The hormone was first isolated by Addicott (1963) from Cotton bolls. ABA is transported through xylem and phloem. Chemically, ABA is a 15-C terpenoid compound (sesquiterpene) derived from the terminal part of the carotenoid precursor. It is also called stress hormone because the production of hormone is stimulated by drought, water logging and other adverse environmental conditions. Primary roles/function of Abscisic acid are listed below-

i. **Growth regulation:** It is antagonist to gibberellins and counteracts the effect of other growth promoting hormones (auxins and cytokinins) and therefore, keeps their activity under check.

ii. **Induction of Root:** Abscisic acid promotes growth of roots in the stem cuttings when applied externally in very minute concentrations.

iii. **Induce Seed and Bud Dormancy:** It is mainly caused by abscisic acid. Dormancy allows seeds to tolerate desiccation and extremes of temperature better. The buds as well as seeds sprout only when abscisic acid is overcome by gibberellins. Because of its action in inducing dormancy, abscisic acid or ABA is also named as Dormin.

iv. **Cambium activity:** Abscisic acid plays a vital role in the regulation of mitosis in vascular cambium towards the end of the winter season.

v. **Abscission:** This is one of the most important functions of Abscisic acid. It stimulates the formation of Abscission layer and promotes abscission of leaves from the tress when they are matured.

vi. **Leaf Senescence:** Excessive presence of Abscisic acid stops protein and RNA synthesis in the leaves and hence stimulates their senescence.

vii. **Transpiration:** During desiccation and other stresses, abscisic acid is rapidly synthesised. The inhibitor causes closure of stomata and hence prevents transpiration.

viii. **Resistance to biotic and abiotic stress:** Whenever a plant is under any biotic or abiotic stress, the concentration of Abscisic acid increases significantly. Therefore it is also known as stress hormone. It helps the plans to survive under extreme environmental conditions.

ix. **Flowering:** When applied externally in very small quantities, abscisic acid is known to promote flowering in some short day plants, e.g., Strawberry, Black Currant.

x. **Membrane potential:** ABA inhibits proton pumping by the action of H+ ATPase and maintains the membrane potential to depolarized state, allowing the continuous effluxes of these ions to the external environment of the cellular compartments.

Ethylene

Ethylene is a gaseous hormone which stimulates transverse or isodiametric growth but retards the longitudinal one. Cousins (1910) found that ripe oranges produced a volatile substance that hastened ripening of unripe bananas nearby. With the help of gas chromatography, R. Gane (1934) found that the ripening causing volatile substance was ethylene. Ethylene was recognised as a plant hormone by Crocker (1935). It is biologically active at a concentration or 1 μl<1 per liter. Primary roles/function of Ethylene are listed below-

i. **Growth:** Ethylene inhibits longitudinal growth but stimulates transverse or horizontal growth and swelling of the main axis.

ii. **Sensitivity to Gravity**: It decreases the sensitivity to gravity. Roots become Apo-geotropic while stems turn positively geotropic. Leaves and flowers undergo drooping. The phenomenon is called epinasty. Seedlings develop tight epicotyl hook.

iii. **Senescence:** Ethylene is responsible for hasten up the senescence of leaves, flower and fruit through stimulating increased activity in the abscission layer.

iv. **Apical dominance:** Ethylene promotes apical dominance by prolonging the dormancy of the lateral buds. It works simultaneously in a synchronous manner with Auxin to promote apical dominance.

v. **Elongation of stem:** Ethylene promotes rapid elongation of leaf bases and internodes in deep water rice plants. As a result leaves remain above water.

vi. **Root initiation:** In low concentration ethylene helps in root initiation, growth of lateral roots and root hairs. This increases the absorption surface of the plant roots.

vii. **Ripening of fruit:** It aids in ripening of climacteric fruits and dehiscence of dry fruits. Climacteric fruits are fleshy fruits which show a sudden sharp rise of respiration rate at the time of ripening. They are usually transported in green or unripe stage. Ethylene is used to induce artificial ripening of these fruits, e.g., Apple, Mango, Banana, etc.

viii. **Flowering:** It stimulates flowering in Pineapple and related plants as well as mango though in other cases the gaseous hormone causes fading of flowers. This helps in synchronizing fruit set.

ix. **Sex expression:** The genetically male plants of Cannabis can be induced to produce female flowers in the presence of ethylene. The number of female flowers and hence fruit is enhanced in monoecious plants like Cucumber.

x. **Storage organ:** Rhizomes, corms, tubers, seeds (e.g., Peanut) and other storage organs can be made to sprout early by exposing them to ethylene.