

15. Plant Growth and Development

POINTS TO REMEMBER :

Growth :

- An irreversible permanent increase in size of an organ or its parts or even of an individual cell.
- Growth is accompanied by metabolic process that occurs at the expense of energy.

Plant growth is generally is indeterminate :

- Plants retain the capacity of unlimited growth throughout their life.
- This ability is due to the presence of meristems at certain locations in their body.
- The cells of such meristems have capacity to divide and self-perpetuate.
- The product eventually loses the capacity to divide and differentiated.
- Apical meristems responsible for primary growth of the plants and principally contribute to the elongation of the plants along their axis.
- The lateral meristem, vascular cambium and cork cambium appears later and responsible for the increase in the girth.

Phases of growth :

- The period of growth is generally divided into three phases
 - **Meristematic.**
 - **Elongation.**
 - **Maturation.**
- Root apex and shoot apex represent the meristematic phase of growth.
- The cells of this region are rich in protoplasm, possesses large conspicuous nuclei.
- Their cell walls are primary in nature, thin and cellulosic with abundant plasmodesmatal connection.
- The cells proximal to that region are the phase of elongation.
- Increased vacuolation, cell enlargement and new cell wall deposition are the characteristic of the cells in this phase.
- Further away from the zone of elongation is the phase of maturation.
- The cells of this zone attain their maximal size in terms of wall thickening and protoplasmic modifications.

Condition of growth :

- Water, oxygen and nutrients as very essential element for growth.
- Turgidity of cells helps in extension growth.
- Water also provides the medium for enzymatic activities needed for growth.
- Oxygen helps in releasing metabolic energy essential for growth activities.
- Nutrients are required by plants for synthesis of protoplasm and act as source of energy.

Differentiation, dedifferentiation and redifferentiation :

- The cells derived from root apical and shoot apical meristems and cambium differentiate and mature to perform specific functions.

- This act of maturation is termed as **differentiation**.
- During differentiation major changes takes place in their cell wall and protoplasm.
- Differentiated tracheary element cells loose their protoplasm, develop a very strong, elastic lignocellulosic secondary cell walls.
- The living differentiated cells, that by now have lost the capacity to divide can regain the capacity of division under certain condition is **dedifferentiation**.
- Development of interfascicular cambium and cork cambium from fully differentiated parenchymatous cells is the example of dedifferentiation.
- Cells produced by the dedifferentiated tissues again loose the capacity to divide and mature to perform specific function is called **redifferentiation**.

PLANT GROWTH REGULATORS :

Characteristics :

- The plant growth regulators are small, simple molecules of diverse chemical composition.
- They could be:
 - Indole compounds (indole-3-acetic acid, IAA);
 - adenine derivatives (N6-furfurylamino purine, kinetin)
 - derivatives of carotenoids (abscisic acid, ABA)
 - terpenes (gibberellic acid, GA₂)
 - Gases (ethylene, C₂H₄)
- One group of PGRs are involved in growth promoting activities such as cell division, cell enlargement, pattern formation, tropic growth, flowering, fruiting and seed germination. These are called plant growth promoters, e.g. auxin, gibberellins and cytokinin.
- Another group of PGRs play important role in plant responses towards to wounds and stresses of biotic and abiotic origin. They involved in inhibitory responses like dormancy and abscission, e.g. abscisic acid.

Discovery of plant growth regulators :

- Auxin was isolated by **F.W. Went** from tips of oat seedlings.
- The 'bakane' (foolish seedling) a disease of rice seedlings, was caused by a fungal pathogen **Gibberella fujikuroi**.
- **E. Kurosawa** reported the appearance of the symptom of the disease in uninfected rice seedlings when treated with sterile filtrate of the fungus. The active substance was later identified as **Gibberellic acid**.
- **Skoog and Miller** identified and crystallized the cytokinesis promoting active substance that they termed as **kinetin**.

- During mid 1960s three different kinds of inhibitors purified, i.e. inhibitor-B abscission II and dormin. Later all the three proved to be chemically identical and named as Abscisic acid (ABA).
- **Cousins** discovered a gaseous PGR called **ethylene** from ripened orange.

Physiological effect of plant growth regulators :

Auxin :

- The term auxin is applied to indole-3-acetic acid
- Generally produced by growing apices of the stems and roots.
- IAA and IBA have been isolated from plants.
- NAA and 2, 4-D (2, 4-dichlorophenoxyacetic acid) are synthetic auxin.
- Promote rooting in stem cutting.
- Promote flowering.
- Inhibit fruit and leaf drop at early stages.
- Promote abscission of older mature leaves and fruits.
- The growing apical bud inhibit the growth of lateral bud, the phenomenon is called **apical dominance**.
- Auxin induces parthenocarpy.
- Used as herbicides.
- Controls xylem differentiation.
- Promote cell division.

Gibberellins :

- Ability to cause an increase in length of axis is used to increase the length of grapes stalks.
- Gibberellins cause fruits like apple to elongate and improve its shape.
- Delay senescence
- GA3 is used to speed up the malting process in brewing industry.
- Gibberellins promote to increase length of stem in sugar cane.
- Promote early seed production.
- Promote bolting (internodes elongation) in beet, cabbages.

Cytokinins :

- Cytokinins have specific effects on cytokinesis.
- Zeatin isolated from corn-kernels and coconut milk.
- Promote cell division.
- Help to produce new leaves, chloroplast in leaves, lateral shoot growth
- Promote formation of adventitious shoot.
- Cytokinins help to overcome apical dominance.
- Promote nutrient mobilization.
- Delay senescence.

Ethylene :

- Ethylene is a simple gaseous PGR.
- Synthesized in the tissue undergoing senescence and ripening fruits.
- Promote horizontal growth of seedling.
- Promote swelling of axis and apical hook formation in dicot seedlings.
- Promote senescence and abscission of plant organs like leaf and flower.
- Increase rate of respiration during ripening of fruits, called **respiratory climactic**.
- Breaks seed and bud dormancy.
- Initiate germination.
- Promote rapid internodes elongation.
- Promote root growth and root hair formation.
- Used to initiate flowering and for synchronizing fruit-set.
- Induce flowering in mango.
- The source of ethylene is **ethephon**.
- Promote female flower in cucumbers thereby increasing the yield.

Absciscic acid :

- Regulates abscission and dormancy.
- Acts as general plant growth inhibitor and an inhibitor of plant metabolism.
- Inhibit seed germination.
- Stimulates the closure of stomata and increases the tolerance of plants to various kinds of stresses, hence called **asstress hormone**.
- Important role in seed development, maturation and dormancy.
- Inducing dormancy, ABA helps seeds to withstand desiccation and other factors unfavourable for growth.
- Acts as antagonist to Gas.

PHOTOPERIODISM :

- Some plants require a periodic exposure to light to induce flowering.
- Response of plants in terms of day/night in relation to flowering is called **photoperiodism**.
- **Long day plant:** plant requires the exposure to light for a period exceeding critical period.
- **Short day plant:** plant requires the exposure to light for a period less than critical period.
- **Day neutral plant:** there is no such correlation between exposure to light duration and induction of flowering response.
- The site of perception of light/dark duration is the leaves.

VERNALISATION :

- **Vernalisation:** There are plants for which flowering is either quantitatively or qualitatively dependent on exposure to low temperature.
- It prevents precocious reproductive development late in the growing season.
- Vernalisation refers to the promotion of flowering by a period of low temperature.