INTRODUCTION

Plant physiology, or phytobiology, is a science that studies the biological, chemical, and biochemical mechanisms of plants, as well as the functioning of their cells, tissues, and organs. It aims to uncover the secrets of plant life in areas such as nutrition, growth, development, reproduction, and germination.

This field is divided into two main parts :

Nutrition and metabolism

Growth and development

Part 1 : Nutrition

1. Basic Concepts

1.1. Plant Organization

The plant kingdom is traditionally subdivided into two main groups based on the structural organization of the plant : Thallophytes and Cormophytes.

A. Thallophytes

Thallophytes are plants with a very simple structure called a thallus. The thallus is made up of cells that are similar and lack physiological differentiation. It has no roots, stems, leaves, or vascular tissues. Some thallophytes are unicellular, while others are multicellular.

B. Cormophytes

Cormophytes are higher plants composed of multicellular organisms. Their eukaryotic cells are organized into tissues that form complex organs, collectively called a cormus.

Cormophytes are divided into several divisions:

Bryophytes

Pteridophytes

Prespermatophytes (Prephanerogams)

Spermatophytes (Phanerogams)

Spermatophyte Divisions

Gymnosperms

The ovules (future seeds) and seeds themselves are not enclosed in a protective covering. Most gymnosperms are trees with needle-like or scaly evergreen leaves, and their fruits are usually cone-shaped (conifers).

Angiosperms

Angiosperms are flowering plants that produce fruits. They represent the majority of terrestrial plant species and include dicotyledons and monocotyledons.

Plant Structures and Their Functions

Roots :

Functions: Anchorage, water absorption (osmosis), nutrient uptake (minerals), storage (reserves), and sometimes reproduction.

Forms: Fasciculate, taproot, tuberous, adventitious, bulbous, with pneumatophores, etc.

Stem :

Functions: Growth (meristems), transport (raw and elaborated sap), support for buds, leaves, flowers, and fruits, storage, reproduction, climbing, creeping, or attachment.

Leaf:

Functions: Respiration (stomata), transpiration (stomata), photosynthesis (nutrition), storage (succulents), reproduction (cuttings), and defense (spines, gas).

Flower and Fruit :

The flower contains the reproductive organs (stamens and pistil) for sexual reproduction. After pollination, the flower transforms into a fruit containing seeds.

1.2. Organization of a Plant Cell

The cell is the fundamental structural and functional unit of all living organisms. Cells are classified into prokaryotic and eukaryotic types.

Eukaryotic Cell Characteristics:

A true nucleus enclosed by a nuclear membrane containing genetic material in the form of DNA.

A highly structured cytoplasm containing specific organelles.

A plasma membrane that separates the cell from its environment and encloses the cytoplasm.

Unique Features of Plant Cells:

Cell Wall:

Provides rigidity while allowing water and solutes to pass through.

Composed of three layers:

Middle Lamella: The outermost layer, pectic in nature, acts as a cement between cells.

Primary Wall: Flexible and extensible, composed of cellulose and hemicellulose, allowing for cell growth.

Secondary Wall: Forms during cell differentiation, thicker than the primary wall, composed of cellulose, hemicellulose, lignin, suberin, and cutin.

Vacuoles:

Regulate physiological functions (pH, ionic concentration, osmotic pressure) and occupy over 40% of total cell volume.

Store water, minerals, organic substances, and pigments.

Plastids :

Chloroplasts: Contain chlorophyll, essential for photosynthesis.

Chromoplasts: Contain carotenoids and xanthophylls, found in colored fruits and flowers.

Amyloplasts: Contain starch grains and have minimal internal membranes.

2. Water Nutrition

Plant nutrition differs significantly from that of animals. Green plants absorb water and minerals from the soil through root hairs. Farmers often irrigate crops and use fertilizers (rich in nitrogen, phosphorus, and potassium) to enhance plant growth.

Water in Soil:

Water exists in three forms:

Hygroscopic Water : A thin film around soil particles, unavailable to plants.

Capillary Water : Found in soil pores (0.2-0.8 mm) and accessible to plants.

Gravitational Water : Temporarily occupies larger soil pores and drains due to gravity.

Water in Plants :

Transported via xylem (raw sap: water + minerals) and phloem (elaborated sap: water + organic substances).

Maintains a balance between water intake (from soil) and loss (transpiration).

Water States in Plants:

The Different States of Water in the Plant

a- Free Water: This is the water involved in general imbibition, easily moving or stagnant in the vacuoles.

b- Bound Water: This is the water immobilized within the cell through hydrogen bonds around alcoholic, amino, or carboxylic groups; cellulose, in particular, binds a significant amount of water molecules along the glucidic residues of these molecular chains.

c- Constitutional Water: This is the water that stabilizes the tertiary structure of certain protein macromolecules and cannot be removed from these proteins without causing denaturation. (Bound water and constitutional water together make up 3 to 5% of the total water content in a tissue).

To measure the water content of plants, the material is generally dried. Drying can be done in an oven at a high temperature (105°C for 24 hours). The amount of water present is determined by the difference in weight between the fresh and dry material.

Variation in Water Content in the Cell:

Turgor :

Turgor is an essential biological phenomenon in plants, manifested by the swelling of plant cells. It is caused by the absorption of water by osmosis, where water enters the cells through the cell membrane, creating an internal pressure called turgor pressure.

Turgor occurs when water moves from outside the cell (where the solute concentration is lower) into the cell (where the solute concentration is higher) across a semi-permeable membrane. The central vacuole of plant cells plays a crucial role in turgor. It stores water and other substances, thereby contributing to the internal pressure of the cell.

Plasmolysis :

Plasmolysis is the opposite of turgor. It occurs when water exits the vacuole by osmosis. This water flow is either caused by a lack of water in the external environment or by the presence of a more concentrated solution in the external environment compared to the cell's internal environment. In these cases, water moves osmotically from the cell's interior to the external medium.

Thus, plant cells exposed to drought or to an external solution with a high salt concentration will lose water and undergo plasmolysis. The soft parts of the plant will shrivel, and the plant may die from water stress if it is unable to quickly reabsorb water.

Hypertonic Solution: A solution with a high concentration of dissolved chemicals (solute), resulting in a low water potential (highly negative). It draws water from another solution by osmosis.

Hypotonic Solution: A solution with a low concentration of dissolved chemicals (solute), and therefore a higher water potential (less negative).

Isotonicity :

Isotonicity refers to the condition where the concentration or osmotic pressure of the external medium is the same as that of the vacuolar fluid.

3. Plant Transpiration

Transpiration is the process of water vapor loss from leaves, primarily through stomata. It maintains the plant's water balance.

Types of Transpiration:

Cuticular Transpiration: Minor (5-10%) water loss through the leaf cuticle.

Stomatal Transpiration: Major (90%) water loss through stomata.

Stomatal Regulation:

Guard cells control stomatal opening and closing based on water content and potassium ion concentration.

Increased potassium levels cause guard cells to swell, opening the stomata.

External Factors Influencing Transpiration:

Soil Type: High ion concentration increases osmotic pressure.

Soil Moisture: Dry soil raises osmotic forces, making water absorption harder.

Air Humidity: Affects stomatal behavior.

Air Movement: Moderate agitation opens stomata; excessive agitation closes them.

Temperature: Increases transpiration up to a threshold (~30°C), after which stomata close.

Light: Promotes stomatal opening through potassium ion activity.