Chapter 9

PLANT PHYSIOLOGY

Autotrophic Mode of Nutrition: Organisms that can prepare their own food by obtaining water, carbon dioxide and minerals from their environment have autotrophic mode of nutrition. For example: some bacteria, all algae and all plants.

Heterotrophic Mode of Nutrition: Organisms that cannot prepare their own food. They obtain food from other organisms have heterotrophic mode of nutrition. For example: Most bacteria, all protozoans, fungi and animals.

9.1 Nutrition in Plants

Nutrition: The process in which food is prepared or obtained and converted into body substances for growth and energy is called nutrition.

Nutrients: The substances required by organisms for energy, growth, repair and maintenance are called nutrients. For example: carbon, hydrogen and oxygen.

Mineral Nutrition in Plants

Plants can prepare their own food by photosynthesis. **Photosynthesis** is the process in which plants prepare their own food by using carbon dioxide and water.

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

Plants need some materials from soil to prepare some biomolecules. These materials are called **mineral nutrients**. For example: hydrogen, carbon and oxygen.

Macronutrients: Nutrients which are required in larger quantities are called macronutrients. For example: carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulphur, calcium and magnesium etc.

Micronutrients: Nutrients which are required in lower quantities are called micronutrients. For example: iron, molybdenum, boron, copper, manganese, zinc, chlorine and nickel etc

9.2 Transport In Plants

Transport: Movement of substances such as water, nutrients, hormones and waste products within an organism is called transport. This is essential for cellular function, growth and responses to environmental changes.

- Plants transport water and mineral from soil to the aerial parts of the plant.
- Food is prepared in leave and transported to the other parts of the plant.
- In all plants except mosses and liverworts, minerals and water is transported by xylem and phloem to all parts of the plants.

Xylem: It is responsible for the transport of water and salts

Phloem: It is responsible for the transport of food.

Some Important Definitions

Passive Transport: It is the movement of ions and molecules across cell membrane from a region of higher concentration to a region of lower concentration. This movement does not require energy. For example: diffusion and osmosis.

Active transport: It is the movement of ions and molecules across cell membrane from a region of lower concentration to a region of higher concentration. This movement requires energy.

Osmosis: It is the movement of water molecules through a semi-permeable membrane from a region of lower concentration to the region of high solute concentration. It does not require energy.

Internal Structure of Root and Uptake of Water and Salts

Roots uptake water and salts from soil in plants.

Epidermis: Epidermis is the outermost covering of the root. It is a single layer of cell.

Root Hairs: Many cells of epidermis have hair-like extensions into the spaces among soil particles called root hairs. They are in direct contact with soil water. They have large surface area. Concentration of salt is low in soil water and high in root hairs. Root hairs take in more salt by active transport. Concentration of water is high is soil and low in root hairs. Water moves from soil to the root hairs by passive transport (osmosis). Now, salt and water is dissolved and it moves to the other cells of epidermis.

Cortex: It is broad zone of cell just inside the epidermis. Water moves from epidermis to cortex.

Endodermis: It is the innermost boundary of cortex that receive water from cortex.

Epicycle: It is the narrow layer of cells present on the inner side of epidermis.

Vascular tissues: xylem and phloem are collectively called vascular bundle. They are in the form of pipe. Water from the epicycle moves into the xylem of roots which will be transported to the xylem of the stem.

9.3 Transpiration:

The loss of water from the plant surface in the form of vapours is called transpiration.

Sources of water loss:

Water loss can be from one of these:

i. Through stomata in leaves.
ii. Through cuticle present on leaf epidermis.
iii. Through special openings called lenticels present on stems of some plants.

Most of the transpiration takes place through stomata called stomatal transpiration.

Stomatal Transpiration:

In leaves, water moves from xylem into the cell walls of mesophyll cells. From the moist walls of mesophyll cells, water evaporates into air spaces of the leaf. These water vapours then move towards the stomata and then pass to the outside air.

Mechanism of Opening and Closing of Stomata:

Stomata open and close due to changes in turgor pressure of their guard cells. Guard cells are sausage shaped. They are the only epidermal cells that contain chloroplasts. Their cell wall is thicker and other parts are thinner. When guard cells become turgid, they become bean-shaped. In this condition the inner walls of guard cells move away from each other and stomata between them opens.

Events during day time:

The guard cells take in potassium from other cells by active transport. Solute concentration in guard cells increases as compared to other cells in epidermis. So, water move from epidermal cells to the guard cells by osmosis. In this way, guard cells become turgid and its inner walls move away from each other and stomata opens. Solute concentration remains high in the cell because of photosynthesis. So water stays in it and they remain turgid.

Events during night time:

At evening, glucose concentration decreases in guard cells and potassium goes back to other cells and water moves out of the guard cells. In this way, guard cell loose turgidity. Inner sides of the guard cells touch each other and thus stomata closed.

Factors Affecting the Rate of Transpiration:

- Temperature: Transpiration increases with the increase in temperature because water evaporates more rapidly.
- Wind: Wind carried away humid air surrounding the leaves, thus, cause in increase in transpiration.
- Humidity: When humidity is high, transpiration will be low.
- Surface area: Leaves with large surface area has more transpiration and the leaves with small surface area have less transpiration.
- Distribution of stomata: Number of stomata on the lower surface of leaves is greater than the number of stomata on upper surface. Therefore, transpiration is high on lower surface of the leaves.

9.4 Transport of Water in Plants

Roots cannot pull water. Leaves give pulling force to the roots. Evaporation of water from the surface of the leaves is called **transpiration**. This transpiration creates the pulling force in leaves. This force is called **transpiration pull**.
When there is loss of water in the mesophyll cells, more water enters in mesophyll cells by the xylem vessels. There is continuous water column in xylem vessel. This water column extends from leaves to stem and to the roots. Following are the reasons of water column:

- Force of attraction between water molecules.
- Narrow diameter of xylem vessels.
- Force by which water molecules adhere to the walls of xylem vessels.

When one water molecule moves up the xylem vessel, it creates a tension in entire water column. As a result, entire water column is pulled upwards.

9.5 Translocation of Food in Plants

In plants, food is transported by phloem tissues by a mechanism called pressure flow mechanism. In most plants for the transport of food, glucose is converted into sucrose.

Pressure Flow Mechanism

Dissolved food flow from source to sink. Source includes photosynthetic tissues (mesophyll), storage tissues (roots). Sink are the sites where food is utilized such as growing tips of roots and stems and storage tissues.

At source site:

At the source, food is actively loaded into the sieve tubes of the phloem. The companion cells provide energy for this process. Because the sieve tubes have more solute than the nearby xylem, water enters the sieve tubes by osmosis. This increases the pressure inside the sieve tubes, and the food solution then flows towards the sink.

At sink site:

At the sink, sucrose is actively removed from the sieve tubes into the sink tissues. Water then moves out of the sieve tubes into the xylem by osmosis. This reduces the pressure in the sieve tubes at the sink, so food flows in bulk from the source (high pressure) to the sink (low pressure).

9.6 Gaseous Exchange in Plants

During day time, plant cells carry out respiration and green parts carry out photosynthesis:

- In respiration, plants use oxygen (from photosynthesis and from environment) and release carbon dioxide.
- In photosynthesis, plants use carbon dioxide (from respiration and from environment) and release oxygen.

At day time, there is photosynthesis and respiration. Thus, the oxygen produced during photosynthesis is used by respiration and the carbon dioxide produced by respiration is used by photosynthesis.

At night time, there is only respiration and no photosynthesis. Thus, plant use oxygen from environment and release carbon dioxide in environment.

Process of gaseous exchange

Plants exchange their gases from the surface of the plants.

Gaseous exchange in inner cells of plants: Epidermis is present on stems, roots and leaves and it allows the gaseous exchange between inner cells and environment. In some parts of the plants, thick layer of cuticle is present which also allow exchange of gases.

In leaves and young stems: exchange of gases takes place through stomata. Inside body, gaseous exchange occurs between cells and air.

In woody stems: Entire surface of stem is covered with bark; bark has small pores called lenticels. Gaseous exchange takes place through these lenticels.

9.7 Mechanism for Excretion in Plant

a. Excretion of Extra Carbon dioxide and Oxygen:

During day time, plant cells carry out respiration and green parts carry out photosynthesis:

- In respiration, plants use oxygen (from photosynthesis and from environment) and release carbon dioxide.
- In photosynthesis, plants use carbon dioxide (from respiration and from environment) and release oxygen.

At day time, there is photosynthesis and respiration. Thus, the oxygen produced during photosynthesis is used by respiration and the carbon dioxide produced by respiration is used by photosynthesis.

At night time, there is only respiration and no photosynthesis. Thus, plant use oxygen from environment and release carbon dioxide in environment.

b. Excretion of Extra Water

Plants store large amount of water in the vacuoles of their cells. It causes turgor. Turgor gives support to soft bodies of plants. If plants have extra water, they remove it in two ways: transpiration and guttation.

i. Transpiration:

Loss of extra water from the surface of plant is called transpiration. It occurs during day in the presence of sunlight. There are three types of transpirations:

- **Stomatal transpiration**
- **Cuticular transpiration**
- **Lenticular transpiration**

ii. Guttation:

It is the release of extra water in the form of droplets through small pores located at the tips or edges of the leaves. It occurs at night time. For example: grasses have this special mechanism.

c. Excretion of Other Metabolic Wastes

Some plants can store their metabolic waste in the form of harmless crystals. Some plants keep their wastes in their leaves. When leaves fall from the body, they get rid of this waste.

Some plants excrete their waste through special pores by applying force. For example rubber plant excretes latexes, Acacia (keekar) tree excrete gums, coniferous trees excrete resins and ladyfinger excretes mucilage.

9.8 Osmotic Adjustment in Plants

On the basis of their habitat, there are four types of plants:

Mesophytes:

Mesophytes are terrestrial plants that live in moderate environments, which are neither too dry nor too wet. They have a well-developed root system that absorbs water efficiently. A cuticle on their surface reduces water loss during hot and dry conditions. They can also close their stomata to reduce transpiration. Examples of mesophytes include maize, clover, and rose.

Hydrophytes:

Mesophytes are terrestrial plants that live in moderate environments, which are neither too dry nor too wet. They have a well-developed root system that absorbs water efficiently. A cuticle on their surface reduces water loss during hot and dry conditions. They can also close their stomata to reduce transpiration. Examples of mesophytes include maize, clover, and rose.

Xerophytes:

Xerophytes live in very dry environments, like deserts. They have deep roots to absorb water from dry soil. Their body has few stomata and a thick waxy cuticle to reduce water loss. Some xerophytes, like cactus, store water in their special stems or roots. These soft and juicy stems or roots are called succulent organs.

Halophytes:

Halophytes live in salty habitats, like the sea or salty marshes. Normally, water would move out of their less salty (hypotonic) bodies into the salty (hypertonic) environment. These plants absorb salts and make their bodies hypertonic, so water does not leave their cells. Extra salt is either stored in cells or removed through salt glands on the leaves. Many seagrasses are examples of halophytes.