Chapter 12 Mineral Nutrition

CBSE Class 11 Biology Notes Chapter 12 focuses mainly on inorganic plant nutrition, wherein students will study the methods to identify elements essential to the growth and development of plants and the criteria for establishing their essentiality. Students will also study the role of the essential elements, their major deficiency symptoms and the mechanism of absorption of these essential elements.

Minerals Definition

Minerals are essential nutrients required by plants for various physiological functions. Deficiencies or excesses of these minerals can lead to various physiological disorders in plants, affecting their growth, yield, and overall health.

What are Essential Mineral Elements?

Essential mineral are those substances that a plant requires for normal functioning but cannot synthesize in sufficient quantities and must be obtained from the environment.

Criteria for Essentiality

Below are the criteria for an element to be considered essential:

- The element must be important for normal growth and reproduction. If the element is absent, plants cannot complete their life cycle or produce seeds.

- The need for the element must be specific and cannot be substituted by another element.
- The element must play a direct role in the plant's metabolism.

Classification of Minerals Based on Quantitative Requirements

Elements are further divided into two broad categories based on their quantitative requirements, which are mentioned below:

Macronutrients: Macronutrients are typically found in plant tissues in significant quantities, exceeding 10 mmol/kg of dry matter. These macronutrients include carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, and magnesium. Carbon, hydrogen, and oxygen are primarily derived from carbon dioxide and water, while the rest are absorbed from the soil as mineral nutrients.

Micronutrients: Micronutrients, also known as trace elements, are required in very small amounts, less than 10 mmol/Kg of dry matter. Copper, zinc, Iron, manganese, boron, nickel, and molybdenum are among them.

Classification of Minerals Based on Functions

Based on the variety of roles that they perform, essential elements can also be divided into four major categories. These categories are:

- Those elements which are fundamental components of biomolecules serve as structural elements within cells. Examples include carbon, hydrogen, oxygen, and nitrogen.

- Those elements which are the main parts of energy-related chemical compounds within plants. For example, magnesium is a component of chlorophyll, while phosphorus is found in ATP (adenosine triphosphate).
- Those elements which play roles in enzyme activation or inhibition. For example, magnesium ions (Mg^2+) activate key enzymes involved in photosynthetic carbon fixation, while zinc ions (Zn^2+) activate alcohol dehydrogenase.
- Some essential elements can influence the osmotic potential of cells. Potassium, for instance, is essential for regulating the opening and closing of stomata, thereby affecting the plant's water balance.

Roles of Macronutrients and Micronutrients

Essential elements provide multiple functions, various roles and functions of essential nutrients are provided below.

Nitrogen:

- Plants require nitrogen in the largest quantity.
- It is absorbed primarily as nitrate (NO3-) but also as nitrite (NO2-) or ammonium (NH4+).
- Nitrogen is essential for all plant parts, especially meristematic tissues and metabolically active cells.
- It is a major component of proteins, nucleic acids, vitamins, and hormones.

Phosphorus:

- Plants absorb phosphorus as phosphate ions (H2PO4- or HPO4^2-).

- It is required for cell membranes, certain proteins, nucleic acids, and phosphorylation reactions.

Potassium:

- Absorbed as potassium ions (K+)
- Potassium is needed in higher quantities in meristematic tissues, buds, leaves, and root tips.
- It helps maintain cell ion balance, protein synthesis, stomata regulation, enzyme activation, and cell turgidity.

Calcium:

- Plants take up calcium as calcium ions (Ca2+).
- Required for meristematic and differentiating tissues
- Calcium helps in cell wall synthesis, mitotic spindle formation, membrane function, enzyme activation, and metabolic regulation.

Magnesium:

- Absorbed as divalent Mg2+ ions, magnesium activates enzymes for respiration, photosynthesis, DNA, and RNA synthesis.
- It is a component of chlorophyll and maintains ribosome structure.

Sulfur:

- Plants obtain sulfur as sulfate ions (SO4^2-).
- It is present in amino acids, coenzymes, vitamins, and ferredoxin.

Iron:

- Absorbed as ferric ions (Fe3+), iron is crucial for electron transfer proteins, catalase activation, and chlorophyll formation.

Manganese:

- Absorbed as manganese ions (Mn2+), manganese activates enzymes for photosynthesis, respiration, and nitrogen metabolism, particularly in water-splitting during photosynthesis.

Zinc:

- Plants absorb zinc as Zn2+ ions, which activate various enzymes, especially carboxylases, and aid in auxin synthesis.

Copper:

- Absorbed as cupric ions (Cu2+), copper is essential for overall plant metabolism, involved in redox reactions and enzyme activation.

Boron:

- Plants take up boron as borate ions (BO3^3- or BO4^2-), necessary for Ca2+ uptake, membrane function, pollen germination, cell elongation, differentiation, and carbohydrate transport.

Molybdenum:

- Absorbed as molybdate ions (MoO4^2-), molybdenum is a component of enzymes like nitrogenase and nitrate reductase crucial for nitrogen metabolism.

Chlorine:

- Absorbed as chloride ions (Cl-), chlorine along with Na+ and K+
- Calcium helps regulate solute concentration and anion-cation balance in cells.
- It is essential for water-splitting in photosynthesis.

What is Nutrient Deficiency?

The concentration below which plant growth is slowed is termed the critical concentration, and if the element falls below this level, it's considered deficient. When the supply of an essential element is limited, plant growth is hindered.

Deficiency Symptoms

Each essential element has specific roles in plants, and their absence leads to morphological changes known as deficiency symptoms.

- Deficiency symptoms vary depending on the element and disappear when the lacking nutrient is supplied, but prolonged deprivation can lead to plant death.
- Elements actively mobilized and exported to young tissues show symptoms first in older tissues. For example, nitrogen, potassium, and magnesium deficiencies manifest in senescent leaves first.

- Elements relatively immobile within mature organs exhibit symptoms first in young tissues. Examples include sulfur and calcium, which are structural components of cells.

Types of Deficiency Symptoms

Chlorosis: Loss of chlorophyll leading to yellowing of leaves, caused by deficiencies of N, K, Mg, S, Fe, Mn, Zn, and Mo.

Necrosis: Death of tissue, particularly leaf tissue, due to deficiencies of Ca, Mg, Cu, and K.

Stunted Growth: Caused by lack or low levels of N, K, S, and Mo, which inhibit cell division.

Premature Leaf and Bud Fall: Caused by deficiencies of certain elements.

Delay in Flowering: Low levels of N, S, Mo delay flowering in plants.