

MINERAL NUTRITION

Mineral nutrition is the study of source, mode of absorption, distribution and metabolism of various inorganic substances (minerals) by plants for their growth, development, structure, physiology and reproduction.

Methods to Study the Mineral Requirement of Plants

- Hydroponic is the technique of growing plants in nutrient solution in complete absence of soil. This method is used to determine the nutrients essential for plants.
- Essential elements are identified and their deficiency symptoms are discovered by hydroponics methods.

Various forms and function of essential nutrients

- Nitrogen** - required by plants in greatest amount, it is absorbed by plants as NO_3^- , NO_2^- and NH_4^+ . It is one of the major constituent of proteins, nucleic acids and vitamins.
- Phosphorus** - Absorbed by plants from soil in form of phosphate ions. It is the constituent of cell membrane, all nucleic acids and nucleic acids require phosphorus.
- Potassium** - absorbed as potassium ions (K^+). Help to maintain cation-anion balance in cells. It is involved in protein synthesis, opening and closing of stomata.
- Calcium** - absorbed by plants from soil in form of Calcium ions. Used in synthesis of cell wall. It activates certain enzymes.
- Magnesium** - absorbed by plants in form of Mg^{2+} ions. It activates the enzymes for respiration, photosynthesis, and involved in DNA and RNA. Constituent of chlorophyll.
- Sulphur** - plants obtain sulphur in form of sulphate (SO_4^{2-}). Present in amino acids (cysteine, methionine) and is main constituent of coenzymes and vitamins.
- Iron** - obtained in form of ferric Iron (Fe^{3+}). It is important constituents of protein involved in transport system.
- Manganese** - absorbed in form of Mn^{2+} ions. Main function is splitting of water to liberate Hydrogen and Oxygen during photosynthesis.
- Zinc** - obtained as Zn^{2+} ions. Activate enzymes like Carboxylases. Needed in formation of Auxin.
- Copper** - absorbed as cupric ions (Cu^{2+}). Involved in various metabolic activities and redox reactions.
- Boron** - absorbed as BO_3^{3-} or $\text{B}_4\text{O}_7^{2-}$ ions. Required for uptake of calcium, cell elongation and pollen germination.
- Chlorine** - it is absorbed in form of Cl^- ions. Determine the solute concentration and splitting of water during photosynthesis.

Deficiency Symptoms of Essential elements

- The concentration of essential elements below which plant growth is retarded is called critical concentration. In absence of any particular element shows certain morphological changes. These morphological changes are called deficiency symptoms. The parts of plant that show deficiency symptoms depend upon mobility of elements in the plants. Elements that are actively mobilized (N, P, K, Mg, S, Ca) shows deficiency in older regions. On the other hand, symptoms appear first in young region if the elements are relatively immobile (Fe, Mn, Zn, Cu, B, Mo) and not transported out of mature tissues. Kinds of deficiency syndrome are as follows-

Deficiency Disease	Symptoms	Deficient elements
Chlorosis	Yellowing of leaves due to loss of chlorophyll	N, K, Mg, S, Fe, Mn, Zn, Mo
Necrosis	Death of tissue (leaf)	Ca, Mg, Cu, K
Stunted plant growth	Less height of plant	Fe, K
Premature fall of leaves and buds	Falling of leaves and buds	N, Mg, Cu
Inhibition of cell division	Less elongation in stem	Low level of N, K, S, halo

- Mechanism of absorption of elements takes place in two phases. In first phase, rapid intake of ions occurs in free space or outer space of the cells, apoplast. In second phase, ions are taken slowly into inner space, the symplast of the cells.
- Passive movement of ions in apoplast occurs through ion channels and trans-membrane protein. On the other hand, movement of ions into symplast occurs by expenditure of energy by active process.
- The movement of ion is called flux. The inward movement is called influx and outward movement is called efflux.

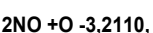
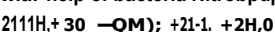
Metabolism of Nitrogen

■ Nitrogen is the most prevalent elements in living world Along with C, H And a It is the main constituent of proteins, nucleic acids, fats, hormones, enzymes etc,

• The process of conversion of nitrogen to ammonia is called nitrogen fixation. In nature lightning and ultraviolet radiation provide energy to convert atmospheric nitrogen into nitrogen oxide (NO , NO_2 and N_2O)

• The decomposition of organic nitrogen of dead plants and animals into ammonia is called ammonification.

■ Ammonia is first oxidized to nitrite by bacteria Nitrosomonads or Nitrococceis. Which is further oxidized to nitrate with help of bacteria Nitrobacter. These process are called nitrification.



■ Nitrates formed is absorbed by plants and transported to leaves. Nitrates is converted into free nitrogen by the process called denitrification by bacteria *Pseudomonas* and *Thiobacillus*.

■ Reduction of nitrogen to ammonia by living organism is called Biological Nitrogen Fixation. The enzyme nitrogenase, present in prokaryotic organism called nitrogen fixer.

$\text{N}=\text{N}$

• Nitrogen fixing microbes may be symbiotic (Rhizobium) or free living (Nostoc, Azotobacter, Cyanobacteria).

• Symbiotic biological nitrogen fixation includes legume. bacteria relationship in which rod shaped Rhizobium lives with symbiotic relation with nodules of Leguminous plants.

• Central portion of nodule is pink or red due to presence of leguminous haemoglobin or leghaemoglobin.

• Nodule contain all necessary biochemical components like enzyme nitrogenase and leghaemoglobin

Enzyme nitrogenase is a Mo-Fe protein and catalyzes the conversion of atmospheric nitrogen into ammonia.

The reaction is as follows-



The enzyme nitrogenase is highly sensitive to molecular oxygen and needs anaerobic condition. To protect this enzyme from oxygen, the nodules contain an oxygen scavenger called leghaemoglobin.

4. The ammonia synthesized by nitrogenase enzyme require large amount of energy (16ATP) for each N_2 produced.

Fate of ammonia- at physiological pH, ammonia is converted into ammonium ions (NH_4^+). It is toxic for plants in larger concentration and ammonium ion is converted into amino acids by two methods.

Reductive amination- in this process ammonia reacts with α -ketoglutaric acid to form glutamic acid.



Transamination Involves the transfer of amino group from amino acids to keto group of keto acid. Glutamic acid is the main amino acid from which transfer of NH_3 takes place and another amino acid is formed by transamination.

Two important amides asparagine and glutamine found in plants in proteins. They are formed from aspartic acid and glutamic acid by addition of another amino groups to it.