Chapter-12

MINERAL NUTRITION

POINTS TO REMEMBER

Autotroph : An organism that synthesize its required nutrients from simple and inorganic substances. Example - plants, blue green algae (cyanobacteria)

Heterotroph : An organism that cannot synthesise its own nutrients and depend on others. Example - Bacteria, protists, members of animalia

Biological nitrogen fixation : Conversion of atmospheric nitrogen into organic compounds by living organisms.

Nitrification : Conversion of ammonia (NH_3) into nitrite and then to nitrate.

Denitrification : A process of conversion of nitrate into nitrous oxide and nitrogen gas (N_2).

Leg-hemoglobin : Pinkish pigment found in the root nodules of legumes. It acts as oxygen scavenger and protects the nitrogenase emzyme from oxidation.

Flux : The movement of ions is called flux. Influx is inward movement of ions into the cells and efflux is the outward movement of ions.

Necrosis : Death of tissues particularly leaf tissue due to deficiency of Ca, Mg, Cu, K.

Mineral Nutrition : Plants require mineral elements for their growth and development. The utilization of various absorbed ions by a plant for growth and development is called **mineral nutrition** of the plant.

Hydroponics : Soil-less culture of plants, where roots are immersed in nutrient solution (without soil) is called hydroponics. The result obtained from hydroponics may be used to determine deficiency symptoms of essential elements

Essential Elements

Macronutrients	Micro-nutrients
Macronutrients are present in plant tissues in concentrations of more than 10 m mole Kg^{-1} of dry matter.	Micro-nutrients are needed in very low amounts : less than 10m mole Kg^{-1} matter.
C, H, O, N, P, K, S, Ca, Mg,	Fe, Mn, Cu, Mo, Zn, B, Cl, Si,

Chlorosis : Yellowing of leaves due to loss of chlorophyll.

Active Transport : Absorption occuring at the expense of metabolic energy.

Passive Transport : Absorption of minerals with concentration gradient by the process of diffusion without the expense of metabolic energy.

Role of Minerals Elements in Plants

MACRO NUTRIENTS

Element	Obtained as	Functions	Deficiency symptoms
Nitrogen (N)	Mainly as NO_3^- some as NO_2^- or NH_4^+.	Constituent of proteins, nucleic acids, vitamins and hormones.	Stunted growth. Chlorosis, dormancy of casual buds.
Phosphorus (P)	Phosphate ions ($H_2PO_4^-$ or HPO_4^{2-})	Constituent of cell membrane. Required for the synthesis of nucleic acids, nucleotides, ATP NAD and NADP and for phosphorylation reactions.	Poor growth of plant. Leaves dull green, delay in seed germination purple or red spots on leaves, premature leaf fall.
Potasium (K)	K^+	Helps to maintain an anion-cation balance in cells. Involved in protein synthesis, in opening and closing of stomata; activation of enzymes; maintenance of turgidity of cells.	Stunted growth; yellow leaves edges of leaves; mottled appearance of leaves. Premature death.
Calcium (Ca)	Ca^{2+}	Required in formation of mitotic spindle; involved in normal functioning of cell membranes; activates certain enzymes; as calcium pectate in middle lamella of the cell wall.	Stunted growth, chlorosis of young leaves.
Magnesium (Mg)	Mg^{2+}	Activates enzymes in phosphate metabolism, constituent of chlorophyll; maintains ribosome structure.	Chlorosis between the leaf veins necroticon purple colours spots on older leave
Sulphur (S)	SO_4^{2-}	Constituent of two amino-acids-Crysteine and methionine and proteins, coenzymes, vitamins and [illegible]	Chlorosis of younger leaves, stunted growth

MICRO-NUTRIENTS

Element	Obtained as	Functions	Deficiency symptoms
Iron (Fe)	Fe^{3+}	Constituent of Ferredoxin and cytochrome; needed for synthesis of chlorophyll.	Chlorosis of leaves
Manganese (Mn)	Mn^{2+}	Activates certain enzymes involved in photosynthesis, respiration and nitrogen metabolism.	Chlorosis, grey spots on leaves.
Zinc (Zn)	Zn^{2+}	Activates various enzymes like carboxylases. Required for synthesis of auxins.	Malformation of leaves. Stunted growth, inter-veinal chlorosis in leaves. Necrosis of the tip of young leaves, die back of shoot.
Copper (Cu)	Cu^{2+}	Activates certain enzymes. Essential for overall metabolism	
Boron (B)	BO_3^{3-}, $B_4O_7^{2-}$	Required for uptake of water and Ca, for membrane functioning, pollen germination, cell elongation carbohydrate translocation.	Death of stem and root apex. loss of a foical dominance, abscission of flowers, small size of fruits
Molybdenum (Mo)	MoO_2^{2+} (molybdate ions)	Activates certain enzymes in nitrogen metabolism.	Nitrogen deficiency inter-veinal chlorosis retardation of growth
Chlorine (Cl)	Cl^-	Maintains solute concentration along with Na^+ & K^+; maintain anion-cation balance in cells; essential for oxygen evolution in photosynthesis.	Wilted leaves, stunted root growth and reduced fruiting.

Role of microbes in nitrogen cycle :

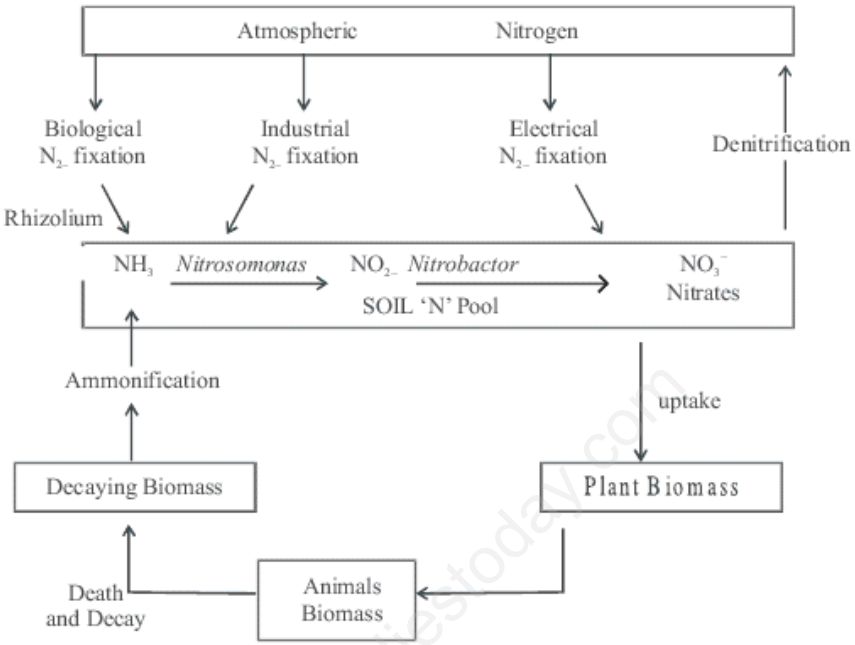
Rhizobium, Azotobacter, Rhodospirielum : Fix atmospheric nitrogen

Nitrosomonas and / or *Nitrococcus* :- Conversion of ammonia to nitrite

Nitrobacter : Conversion of nitrite into nitrate.

Pseudomonas and Thiobacillus : reduce nitrate into nitrogen.

Nitrogen Cycle :



Enzyme nitrogenase : The enzyme nitrogenase is a Mo-Fe protein and catalysis the conversion of atmospheric nitrogen to ammonia (First stable product of nitrogen fixation)

$N_2 + 8e^- + 8H^+ + 16ATP \rightarrow 2NH_3 + H_2 + 16\ ADP + 16\ Pi$

Steps of nodule formation :

a) *Rhizobium* bacteria present in soil contract a susceptible root hair.

b) Infection of the root hair cause it to cure.

c) An infection thread is produced carrying the bacteria into the cortex of the root.

d) The bacteria get modified into rod-shaped bacteriods and cause inner cortical and pericycle cells to divide.

e) Division and growth of cortical and pericycle cells lead to nodule formation.

(Refer Figure 12.4, page 203 NCERT Text Book).

Fate of Ammonia :

Ammonium ions (NH_4^+) are used to synthesize amino acids in plants. It can be taken place by two main ways.

(i) Reductive amination : ammonia reacts with α-ketoglutaric acid and forms glutamic acid. This reaction is catalysed by enzyme glutamatic dehyotrogenase.

(ii) Transamination : Other aminoacides are formed by the transfer of amino group (NH_2) mainly from glutamic acid to the keto group of a ketoacid. The enzyme trans-aminase catalyses these reactions

QUESTIONS

Very Short Answer Questions (1 mark each)

1. Name one symbiotic nitrogen-fixing bacteria.
2. Give two examples of photosynthetic micro-organisms, which also fix atmospheric nitrogen.
3. Name two organisms each which fix nitrogen asymbiotically and symbiotically.
4. Which substance imparts pink colour to the root nodule of a leguminous plant and also mention its role?
5. What is the term used for mineral deficiency symptom in plants in which leaves become yellow in different pattern ?
6. Define hydroponics.

Short Answer Questions-II (2 marks each)

7. Differentiate between two types of absorption of minerals in plants from soil.
8. Name the following :
   (a) Bacteria which converts ammonia into nitrite.
   (b) Bacteria which oxidises nitrite into nitrate.
9. How does Leghemoglobin protect the enzyme nitrogenase ?

Short Answer Questions-I (3 marks each)

10. Write the deficiency symptoms of the following three elements :
    (a) Phosphorus
    (b) Magnesium
    (c) Potassium

11. Describe the following three deficiency symptoms and co-relate them with concerned mineral deficiency :
    (a) Chlorosis
    (b) Necrosis
    (d) Stunted plant growth
12. Explain the steps in biological nitrogen fixation in brief.
13. Describe the two main processes of synthesis of amino acids from Ammonium ion (NH_{4+}) in plants.

Long Answers (5 marks each)

14. Describe all the steps of nitrogen cycle in nature.
15. Describe with diagrams how root nodules are formed in leguminous plants.

ANSWERS

Very Short Answers (1 mark each)

1. *Rhizobium*
2. *Anabaena, Nostoc*
3. Asymbiotically - *Azotobacter, Bacillus polymyxa*
   Symbiotically - *Rhizobium, Anabaena.*
4. Leghemoglobin. It is an oxygen scavenger, which protects the enzyme nitrogenase.
5. Necrosis.
6. The technique of growing plants in a nutrient solution without soil is called hydroponics.

Short Answers-II (2 marks each)

7. Refer to NCERT Book, Page no. 200 (12.3).
8. (i) Nitrifying Bacteria - *Nitrosomonas.*
   (ii) Nitrifying Bacteria - *Nitrobacter*
9. Refer to page no. 203.

Short Answers-I (3 marks each)

10. Refer to 'Points to Remember'.
11. Refer to 'Points to Remember'.
12. Refer to Page no. 201.
13. Refer to Page no. 204.

Long Answers (5 marks each)

14. Refer to Page no. 201.
15. Refer to Page no. 203.