BIOLOGY

MINERAL NUTRITION

Mineral Nutrition

Carbohydrates, proteins, lipids, water, and minerals are required for all living creatures to survive. Plants, too, require nutrients for growth and development.

Essential Mineral Elements

Mineral needs vary depending on the plant. There is a criterion for determining whether or not an ingredient is necessary.

It contains the following items:

- The element must be required for proper development and reproduction. If such a component is missing, the Plants won't be able to finish their life cycle.
- The element's need must be precise, and no other element should be able to substitute it.
- The element must play a direct role in plant metabolism.

Functions of Mineral Nutrients:

- Carbon, hydrogen and oxygen enter into the cell wall and protoplasm and form the plant body.
- The minerals present in the cell sap maintain the osmotic pressure of the cell.
- Calcium, sodium and potassium maintain the permeability of cell membrane.
- The cations and anions affect the pH of the cell sap.
- A few salts and minerals balance the harmful effect of other nutrients.
- Several elements act as catalyst for biochemical reactions.

Macronutrients

These nutrients are required by the plants in large quantities. These include carbon, hydrogen, nitrogen, oxygen, phosphorus, Sulphur, potassium, etc.

Micronutrients

These nutrients are required by the plants in small quantities. These include iron, copper, manganese, molybdenum, chlorine, etc.

Role of Macro and Micronutrients

Mineral Nutrients	Functions

Nitrogen	Important constituent of nucleic acid, protein, hormones and vitamins.
Phosphorus	Promotes root growth and fruit ripening.
Potassium	It acts as an activator for several enzymes.
Calcium	Facilitates the formation of middle lamella of plants and acts as an enzyme activator.
Magnesium	Plays a vital role in the metabolism of carbohydrates, lipids.
Sulphur	Major constituent of amino acids and vitamins.
Iron	Plays an important role in the energy conversion reaction reactions of respiration and photosynthesis, activates nitrate reductase and aconitase.
Manganese	Essential for chlorophyll synthesis, initiate photolysis of water.
Copper	Plays an important role in photophosphorylation.
Molybdenum	It helps in the synthesis of ascorbic acid.
Chlorine	Helps in the photolysis of water in photosystem-II.

Deficiency of Mineral Nutrients

Mineral Nutrients	Deficiency Symptoms
Nitrogen	Impaired plant growth, chlorosis, delayed flowering, and fruiting.
Phosphorus	Premature leaf fall, necrosis.
Sulphur	Delayed flowering and fruiting, premature leaf fall.
Potassium	Mottled chlorosis, inhibition of protein synthesis and photosynthesis.
Calcium	Chlorosis, distortion of leaf shape.
Magnesium	Interveinal chlorosis, depression of internal phloem.
Iron	Chlorosis, inhibition of protein synthesis and chloroplast formation.
Chlorine	Wilting of leaves, brown edges, leaf spots.
Copper	Causes “die back” disease in leaves, Reduction in vegetative and reproductive growth.

Autotroph

An organism that synthesize its required nutrients from simple and inorganic substance; **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.

Chlorosis

Yellowing of leaves due to loss of chlorophyll.

Nitrification and Denitrification

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

Inhibition of cell division: Deficiency of N, K, S. and Mo.

Necrosis

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

Delayed Flowering: due to deficiency of N, S, Mo.

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.

Active Transport

Absorption occurring 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.

Nitrogen Cycle

Nitrogen Fixation: The process of conversion of nitrogen to ammonia is called nitrogen fixation. In nature lightening and ultraviolet radiation provide energy to convert atmospheric nitrogen into nitrogen oxide (No, NO_2 and N_2O).

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

Nitrification: Ammonia is first oxidized to nitrite by bacteria Nitrosomonas or Nitrococcus which is further oxidized to nitrate with help of bacteria Nitrobactor. These processes are called nitrification.

$$2NH_3 + 3O_2 \xrightarrow{\text{Nitrosomonas}} 2NO_2^- + 2H_2O + 2H^+$$

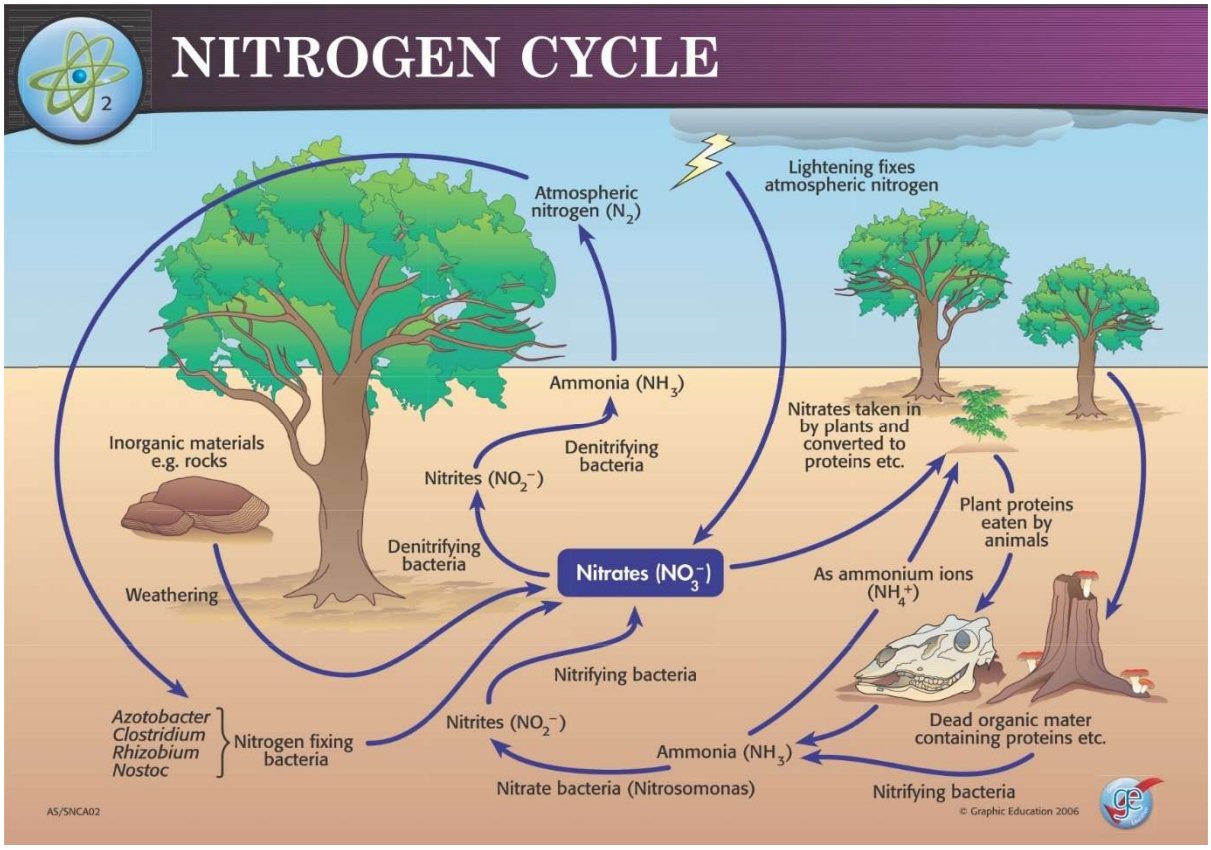
$$2NO_2^- + O_2 \xrightarrow{\text{Nitrobactor}} 2NO_3^-$$

Denitrification: Nitrates formed is absorbed by plants and transported to leaves. Nitrates is converted into free nitrogen by the process called denitrificaion by bacteria Pseudomonas and Thiobacillus.

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

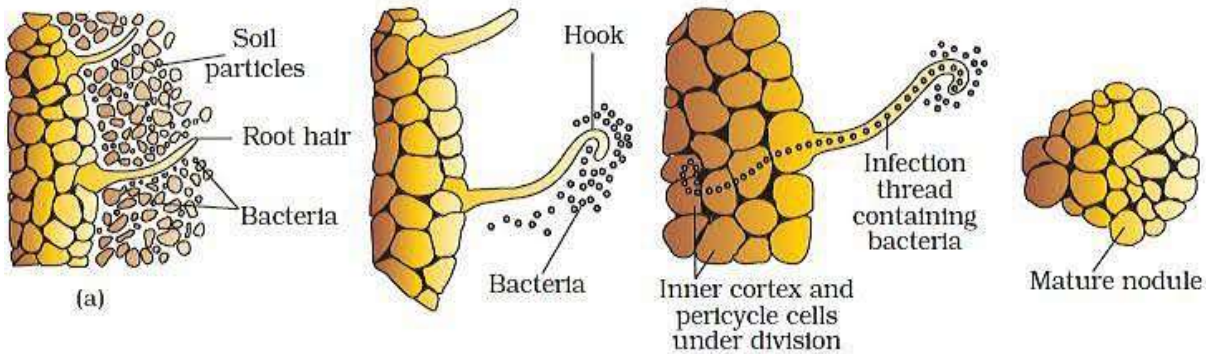
Role of microbes in nitrogen cycle

- Rhizobium, Azotobacter, Rhodospirillum; 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.



Steps of nodule formation

- Rhizobium bacteria present in soil contact a susceptible root hair.
- Infection of the root hair cause it to curve and deformed due to chemical secretion.
- An infection thread is produced carrying the bacteria into the cortex of the root.
- The bacteria get modified into rod-shaped bacteria and cause inner cortical and pericycle cells to divide plant produce cytokinin and auxin to stimulate cell division and enlarge to form nodules.
- Division and growth of cortical and pericycle cells lead to nodule formation.



Mechanisms of N_2 fixation

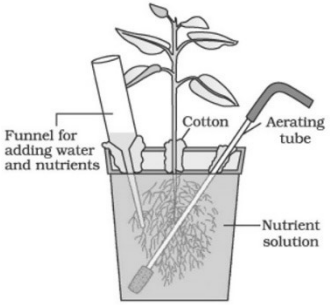
It requires 3 components:

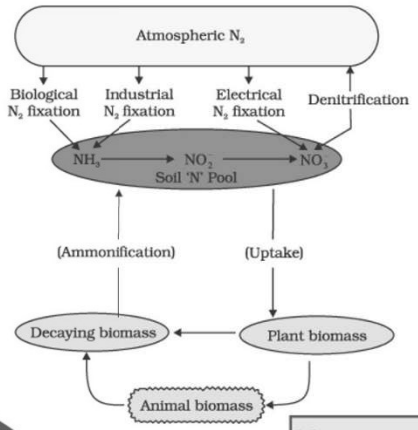
- A strong reducing agent like $FADH_2$, $NADPH_2$.
- Nitrogenase enzyme.
- ATP (as energy service).

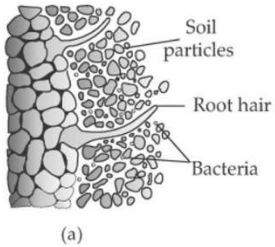
Steps:

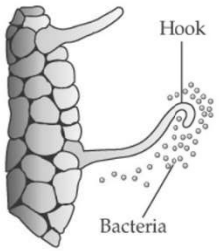
- Formation of Diamide.
- Formation of Hydrazine (N_2H_4).
- Formation of Ammonia.

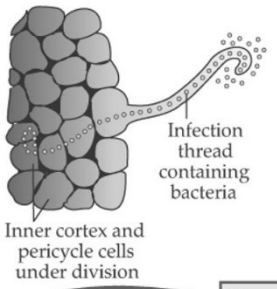
CHAPTER : 12 MINERAL NUTRITION

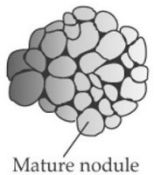












Development of root nodules in Soyabean

Hydroponics

Plant is cultured in soil–free defined minerals solution

Methods to Study the Mineral Requirements of Plants

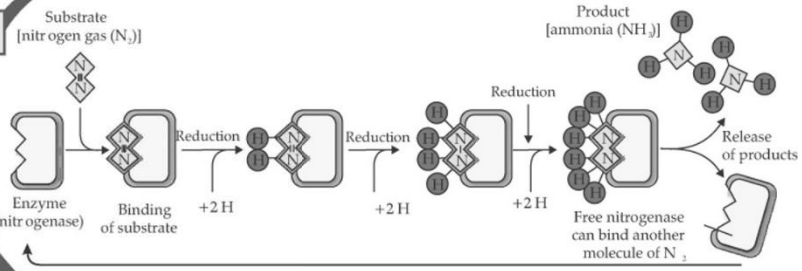
Nitrogen cycle

Metabolism of Nitrogen

Fate of ammonia

Transamination

Reductive amination



Steps of conversion of atmospheric nitrogen to ammonia by nitrogenase enzyme complex found in nitrogen-fixing bacteria

Mineral Nutrition

Toxicity of Micronutrients

In higher dose, micronutrient become toxic. Toxicity of one element may lead to deficiency of other elements since the former may inhibit the uptake of latter.

Essential Mineral Elements

Mechanism of Absorption of Elements

Apoplast

Symplast

Deficiency Symptoms

Criteria

Element must be absolutely necessary for normal growth and development

Element must be directly involved in the metabolism of plant.

Requirement of element must be specific and not replaceable

Two Categories of Elements

Macronutrient

Required in large quantity. E.g. Hydrogen, Oxygen, Nitrogen, phosphorus, sulphur, potassium, calcium and Magnesium

Micronutrient

Required in less quantity. E.g. Cobalt, manganese, Zinc, Iron, Copper, Molybdenum, Boron, chlorine and nickel.

Deficiency symptoms are morphological changes in plants, indicating nutrient deficiency.

Important Questions

➢ Multiple Choice Questions:

Question 1. Name the scientist who first showed that plants obtain minerals from the soil for their growth and development.

(a) Woodward

(b) de-Saussure

(c) Armon

(d) Stout.

Question 2. A mineral element is considered essential for plant if it fulfills the need for

(a) Specific symptoms

(b) Normal growth and development

(c) Direct nutrition of plant

(d) All of these

Question 3. An element which is constituent of every enzyme and is thus essential for ail biochemical reactions in plants is

(a) Nitrogen

(b) Sulphur

(c) Phosphorus

(d) Carbon

Question 4. An element which is constituent of cholrophyll and also acts as a co-factor for various enzymes taking part in cellular respiration is

(a) Magnesium

(b) Nitrogen

(c) Carbon

(d) Iron.

Question 5. Main source of nitrogen for plants is

(a) Atmoshpere

(b) Soil

(c) Nitrifying bacteria

(d) Water soluble nitrites nitrates.

Question 6. Animal and other heterotrophic organisms obtain nitrogen from

(a) Atmosphere

(b) Plants

(c) Nitrifying bacteria

(d) All of these.

Question 7. Elements obtained by plants from the soil are known as

(a) Mineral elements

(b) Non-mineral elements

(c) Both (a) and (b)

(d) None of these.

Question 8. Elements obtained by plants from atmosphere of water are known as

(a) Mineral elements

(b) Non-mineral elements

(c) Gases

(d) Both (a) and (b)

Question 9. Non-mineral elements of plants are

(a) Carbon, hydrogen and sulphur

(b) Carbon, oxygen and nitrogen

(c) Sulphar, chlorine and nitrogen

(d) Carbon, hydrogen and oxygen.

Question 10. An element of plants which is derived both from mineral and non-mineral resources is

(a) Carbon

(b) Sulphur

(c) Nitrogen

(d) Hydrogen.

Question 11. The technique of growing the plants by placing their roots in nutrient solution instead of growing in soil is called

(a) Water culture

(b) Hydroponics

(c) Soilless culture

(d) All of these.

Question 12. Phosphorus is very essential for

(a) Photosynthesis and respiration as carbohydrates taking part in different reactions react in phosphorylated form

(b) It is constituent of NADP which plays crucial role in light reaction of photosynthesis.

(c) Helps in storing chemical energy in glucose.

(d) All of these.

Question 13. Loss of chloropvll that leads to yellowing of entire leaf or part of it is called

(a) Chlorosis

(b) Necrosis

(c) Abscission

(d) Mottling

Question 14. Appearance of patches of green and non-green areas on the leaves are called

(a) Necrosis

(b) Chlorosis

(c) Curling

(d) Mottling.

Question 15. Localised death of tissue of leaf is called

(a) Chlorosis

(b) Necrosis

(c) Mottling

(d) Dieback.

➢ Fill In the Blanks:

1. Julius Sachs technique of growing plants in a nutrient solution is known as …….
2. The element must be ……. necessary for supporting normal growth and reproduction.
3. The requirement of the element ……. and not …….. by another element.
4. The element must be …….. in the metabolism of the plant.
5. ……. must generally be present in plant tissues in concentration of 1 to 10 mg/L of dry matter.
6. ……. or trace elements, are needed in very small amount (equal to or less than 0.1 mg/L of dry matter).

➢ True or False:

1. Chlorine is absorbed in the form of chloride anion (Cl–).
2. Boron is required for uptake and utilisation of Ca2+, membrane functioning, pollen germination, cell elongation, cell differentiation and carbohydrate translocation.
3. Plants obtain it in the form of molybdate ions (MoO22+).
4. The concentration of the essential element below which plant growth is retarded is termed as critical concentration.
5. The toxicity symptoms are very easy to identify.
6. The process of conversion of nitrogen (N2) to ammonia is termed as nitrogen fixation.

➢ Very Short Question:

1. What is tank farming?
2. Name any nitrogen-fixing symbiotic bacteria.
3. What is necrosis?
4. Name the bacteria which convert ammonia into nitrite.
5. What is the major role of calcium?
6. What is chlorosis?
7. From where do the plants get hydrogen?
8. What are hunger signs?
9. What is premature abscission?
10. Name two micronutrients.

➢ Short Questions:

1. What are chelators or chelating agents?
2. What type of condition is created by leghaemoglobin in the root nodules of the legume?
3. What are micronutrients? Give examples.
4. Some bags of fertilizers are labeled 15 – 15 – 15. What does it mean?
5. What do you mean by mineral nutrition?
6. Mention symptoms of any four mineral deficiencies in plants.
7. Write a short note on Industrial Apological Nitrogen fixation.
8. What is ion-exchange absorption?

➢ Long Questions:

1. What is water culture? How will you determine the essentiality of mineral elements experimentally?

2. Make a list of macronutrients and mention their major function.
3. Define the following:

   (i) Nutrients,

   (ii) Nutrition,

   (iii) Micronutrients

   (iv) Macronutrients,

   (v) Active absorption,

   (vi) Passive absorption,

   (vii) Symplastic movement and

   (viii) Apoplastic movement.
4. What do you understand by heterotrophic mode of nutrition? Elaborate your answer with suitable examples.

Assertion Reason Question-

1. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

   (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   (c) If Assertion is true but Reason is false.

   (d) If both Assertion and Reason are false.

   Assertion: Hydroponics is used for solution culture.

   Reason: A balanced nutrient solution contains both essential and nonessential elements.
2. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

   (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   (c) If Assertion is true but Reason is false.

   (d) If both Assertion and Reason are false.

   Assertion: In solution culture of plants, iron is added in the form of Fe-EDTA.

   Reason: Hydroponics setup is costly.

✓ Answer Key-

➢ Multiple Choice Answers:

1. (a) Woodward.
2. (d) All of these.
3. (a) Nitrogen.
4. (a) Magnesium.
5. (a) Atmosphere.
6. (b) Plants.
7. (a) Mineral elements.
8. (b) Non-mineral elements.
9. (d) Carbon, hydrogen and oxygen.
10. (c) Nitrogen.
11. (d) All of these.
12. (d) All of these.
13. (a) Chorosis
14. (d) Mottling.
15. (b) Necrosis.

➢ Fill In the Blanks:

1. hydroponics
2. obsolutely
3. must be specific, replaceable
4. directly involved
5. Macronutrients
6. Micronutrients

➢ True or False:

1. True
2. True
3. True
4. True
5. False
6. True

➢ Very Short Answers:

1. Answer: It is growing plants in water or solution culture.
2. Answer: Rhizobium.
3. Answer: The death of tissues and cells and usually results in holes in the leaves is called necrosis.
4. Answer: Nitrosomonas.
5. Answer: It is a constituent of calcium pectate of the middle lamella of a cell wall.
6. Answer: Yellowing of leaves in a distinctive pattern due to lack of one or two other elements is called chlorosis.
7. Answer: From the water absorbed by the plants.
8. Answer: Morphological abnormalities caused due to the deficiency of one or- the other essential elements.
9. Answer: Fall of leaves, flowers, or fruits before their maturation is called premature abscission.
10. Answer: Boron, Copper

➢ Short Answer:

1. Answer: These are usually organic chemicals that hold or bind iron in the form of soluble complexes to make available iron to the plant. The chelator itself is not taken up by the plant. EDAA (Ethylene Diaminotetra Acetic Acid) is a commonly used chelator in water culture experiments.
2. Answer: Leghaemolobin is an oxygen scavenger, it creates anaerobic conditions in the cells of root nodules and protects the nitrogen-fixing enzyme nitrogenase of the bacteroids.
3. Answer: The elements that are required by the plants in fewer amounts or traces are called micronutrients e.g. B(Boron). Mo (Molybdenum). Mn (Manganese). Cl (chlorine). These elements are present in plant tissues. They mostly act as cofactor or activator of enzymes.
4. Answer: The number 15 – 15 – 15 on the bags indicates the percentage by weight of nitrogen, phosphorus, and potassium in the chemical fertilizer. The majority of the fertilizers contain these elements in bulk such fertilizers are called complete fertilizers. Common fertilizers consist of chemicals either singly or in various compositions like urea, nitrate of soda, ammonium sulfate, etc.
5. Answer: The utilization of minerals by plants for growth and development is called mineral nutrition. The minerals are obtained from the soil for their growth. Plant analysis reveals the presence of a large number of minerals and nutrients in the soil. The number and amount of the mineral elements present varies from plants to plant/
6. Answer:

   i. Chlorosis: Nondevelopment or loss of chlorophyll that leads to yellowing the entire leaf or

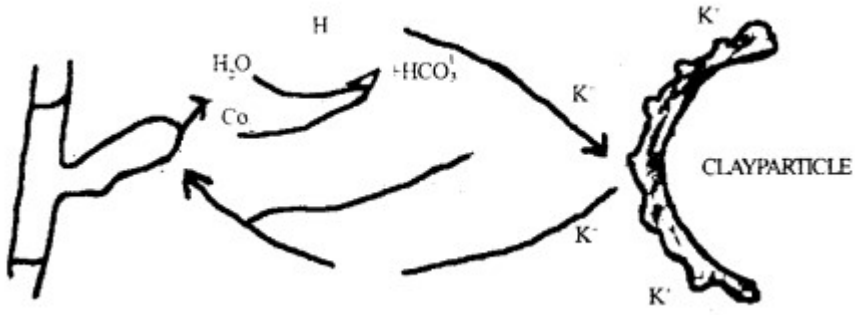
part of it is termed chlorosis.

ii. Mottling: It is the appearance of patches of green and non-green areas on leaves.

iii. Necrosis: It is the localized death of tissue of the leaf.

iv. Curling: It is caused due to unequal growth of the leaf.

7. Answer: Ammonia is produced industrially by a direct combination of nitrogen and hydrogen (obtained from H2O) at high temperatures and pressure. Subsequently, NH3 is converted into various types of fertilizers such as urea, potash, etc which are used for plant growth and protein synthesis. ’
8. Answer: Ions, both cations and anions, have a tendency to get absorbed on the surfaces of the cell walls and exchange with ions present in the soil solution. The process of exchange between absorbed ions and ions in solution is known as ion exchange.



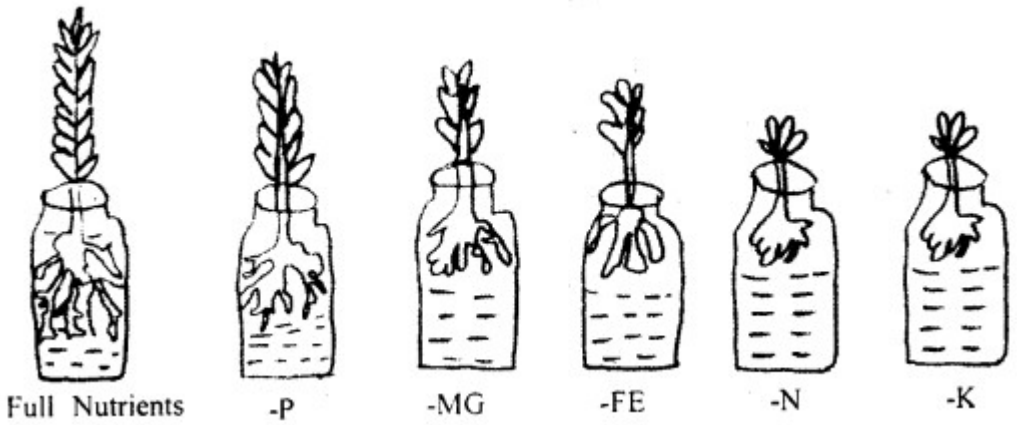
Mode of Iron- absorption carbonic acid exchange

➢ Long Answer:

1. Answer: The technique of growing the plants by placing their roots in different nutrient solutions instead of growing in soil is termed hydroponics or water culture. For determining the essence of the mineral element, seedlings are grown in a balanced nutrient solution, are taken as control solution, lacking one or another element.

   The growth of the plants grown in containers containing nutrient solution deficient in one or the other mineral element is compared to that of seedling grown in the balanced nutrient solution. If the plant shows some deficiency symptoms, it implies that the mineral element which was lacking in that culture set is an essential element.

   However, the mineral element is a non-essential element if by eliminating that element from the nutrient solution, the growth is comparable to that of the control set.



An experiment set up to determine the essentiality of minerals by water-culture technique.

2. Answer: The macronutrients are carbon, hydrogen. oxygen, nitrogen. phosphorus. sulfur, potassium. calcium, magnesium, and silicon.

   Carbon: It regulates the metabolic activities required by meristematic and differentiatiñg tissues.

   Carbon, hydrogen, and oxygen: These elements are absolutely essential for plant growth. These enter into all chemical compositions of all types of organic compounds like carbohydrates, proteins, lipids, organic acids, amino acids. enzymes, nucleic acids, hormones, etc. These are protoplasmic and formwork elements.

   Nitrogen: Nitrogen is essential for all metabolic activities as various biochemical reactions occur in presence of enzymes, It plays an important role in cell division, vegetative, and reproduction growth.

   Phosphorus: It is the structural component of nucleic acids. Phospho-lipids, nucleoproteins, ATP, NADP+, sugar phosphates, and a number of co-enzymes. Phosphorus plays an indispensable role in energy, metabolism. It plays an active role in metabolic processes like photosynthesis, respiration, and protein synthesis.

   Potassium: It is essential for the functioning of a large number of enzymes taking part in different metabolic activities like photosynthesis, respiration, starch synthesis, synthesis of nucleic acids. It controls the closing and opening of stomata.

   Calcium: It is essential for the control of carbohydrate metabolism. It plays some role in binding nucleic acids and proteins in chromosomes.

   Magnesium: It is essential for binding together two subunits of ribosomes. It is essential for fat metabolism, carbohydrate metabolism. It is also an activator of enzymes involved in the synthesis of nucleic acids.

   Silicon: It plays an important role in the Biological activities of the plants.

3. (i) Answer: Nutrients: The chemical substances used by living organisms as raw materials for metabolic activities are termed nutrients.

   (ii) Answer: Nutrition: The uptake and utilization of both inorganic and organic raw materials by a

living organism for their growth, various metabolic activities, and development is called nutrition.

(iii) Answer: Micronutrients: Micronutrients are the essential elements present in plant tissues in relatively lesser amounts i.e. less than 1 mg per gram of dry matter. These mostly act as cofactor or activator of enzymes. These are iron, copper, zinc, manganese, molybdenum, boron, and chlorine.

(iv) Answer: Macronutrients: Macronutrients are the essential elements present in plant tissues in relatively larger concentrations, i.e. at least 1 mg per gram of dry matter. These are carbon, hydrogen, oxygen, nitrogen, sulfur, phosphorus, calcium, magnesium, and potassium.

(v) Answer: Active absorption: It is observed that the concentration of K'ions in vacuolar sap was found to be 1000 times more than the pond water. This can occur by utilization of metabolic energy only. The absorption of minerals by the plant against the concentration gradient involving the expenditure of energy is termed active absorption. Inactive absorption, the minerals move from the soil water from low concentration to higher concentration within the cell.

(vi) Answer: Passive absorption: Passive absorption is the absorption of minerals by physical processes not involving the direct expenditure of metabolic energy. A substance moves passively from higher concentration to lower concentration. Ions can also be absorbed and accumulated against an F.CP (Electro Chemical Potential) gradient without the use of metabolic activities. Several theories have been proposed to explain the movement of ions such as ion exchange. Donnan equilibrium and mass flow of ions.

(vii) Answer: Symplastic Movement: It is the type of movement in which, ions entering the cell wall of the epidermis move across the cell wall of the cortex, cytoplasm of endodermis, the cell wall of the pericycle, and finally in the xylem vessels.

(viii) Answer: In apoplastic transport, water and minerals flow in an upward direction via the apoplast to the xylem in the root. The concentration of solutes transported in aboveground organs is established through a combination of import from the xylem, absorption by cells, and export by the phloem

4. Answer: This is the type of nutrition, in which organisms obtain readymade organic food materials from some other source and are not capable of synthesizing these from inorganic raw materials of their own. The organ¬isms, which show this type of mode is known as Heterotrophs.

   The heterotrophs are divided into two main types:

   i. parasites

   ii. saprophytes.

   Parasites obtain readymade organic food material from other living plants or animals. The plant or animal which provides food to the parasite is termed the host. Many bacteria and fungi are parasites. They cause various diseases in their hosts.

Total Stemparasite

Some flowering plants also show parasitic modes of nutrition. These plants send haustorial or parasitic roots into the host to draw nutrients from it. Depending upon the organ of the host on which parasite is attached, it may be a stem parasite or root parasite.

Saprophytic plants such as Morotropa, bacteria, fungi grow on decaying animal and vegetable matter and absorb the organic food from it.

Heterotrophic plants could be symbiotic and insectivorous also.

Assertion Reason Answer-

1. (c) If Assertion is true but Reason is false.

   Explanation: Solution culture is being used for raising flowers and vegetables at home. This soilless production of plants is called hydroponics. A solution having all the essential elements in proper proportion is called normal or balanced nutrient solution.

2. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   Explanation: In solution culture, iron is added as Fe- EDTA. The agent which keeps metals in the soluble state is called chelating agent or ligand. Fe-EDTA complex is called chelate. The soilless production of plants is called solution culture or hydroponics. The cost of setting up a hydroponic system is very high.