Chapter 12 (MINERAL NUTRITION)

Multiple Choice Questions

Q1. Which one of the following roles is not a characteristic of an essential element?

(a) Being a component of biomolecules

(b) Changing the chemistry of soil

(c) Being a structural component of energy-related chemical compounds

(d) – Activation or inhibition of enzymes

Ans: (b)

(i) Essential elements as components of biomolecules and hence structural elements of cells.

(ii) Essential elements that are components of energy-related chemical compounds in plants.

(iii) Essential elements that activate or inhibit enzymes.

(iv) Some essential elements can alter the osmotic potential of a cell.

Q2. Which one of the following statements can best explain the term critical concentration of an essential element?

(a) Essential element concentration below which plant growth is retarded

(b) Essential element concentration below which plant growth becomes enhanced

(c) Essential element concentration below which plant remains in the vegetative phase

(d) None of the above

Ans: (a) The concentration of the essential element below which plant growth is retarded is termed as critical concentration.

Q3. Deficiency symptoms of an element tend to appear first in young leaves. It indicates that the element is relatively immobile. Which one of the following elemental deficiency would show such symptoms?

(a) Sulphur (b) Magnesium (c) Nitrogen (d) Potassium

Ans: (a) The deficiency symptoms tend to appear first in the young tissues whenever the elements are relatively immobile and are not transported out of the mature organs, e.g., S and Ca.

Q4. Which one of the following symptoms is not due to manganese toxicity in plants?

(a) Calcium translocation in shoot apex is inhibited

(b) Deficiency in both Iron and Nitrogen is induced

(c) Appearance of brown spot surrounded by chlorotic veins

(d) None of the above

Ans: (b) Excess of manganese may, in fact, induce deficiencies of iron, magnesium and calcium.

Q5. Reaction carried out by N2 fixing microbes include

$$2NH_3 + 3O_2 \rightarrow 2NO_2^- + 2H^+ + 2H_2O \quad ...(i)$$

$$2NO_2^- + O_2 \rightarrow 2NO_3^- \quad ...(ii)$$

Which of the following statements about those equations is not true?

(a) Step (i) is carried out by Nitrosomonas or Nitrococcus

(b) Step (ii) is carried out by Nitrobacter

(c) Both steps (i) and (ii) can be called nitrification

(d) Bacteria carrying out these steps are usually photoautotrophs

Ans:(d) Bacteria carrying out these steps are usually chemoautotrophs.

Q6. With regard to the Biological Nitrogen Fixation by Rhizobium in association with soyabean**, which one of the following statement/statements does not hold true?**

(a) Nitrogenase may require oxygen to its functioning

(b) Nitrogenase is Mo-Fe protein

(c) Leghaemoglobin is a pink coloured pigment

(d) Nitrogenase helps to convert N2 gas into two molecules of ammonia

Ans:(a) Nitrogenase is highly sensitive to molecular oxygen (02), thus requires anaerobic conditions. Nodules have adaptations that ensure that the enzyme is protected from 02. To protect nitrogehase, nodule contains an 02-scavenger celled leghaemoglobin.

Q7. Match the element with its associated functions/roles and choose the correct option among the given below.

A.	Boron	(i) V	Splitting of H_20 to liberate 0_2 during photosynthesis
B.	Manganese	(ii)	Needed for synthesis of auxins
C.	Molybdenum	(iii)	Component of nitrogenase
D.	Zinc	(iv)	Pollen germination
E.	Iron	(v)	Component of ferredoxin

Options:
(a) A—(i), B—(ii), C—(iii). D—(iv), E—(v)
(b) A—(iv), B—(i), C—(iii), D—(ii), E—(v)
(c) . A—(iii), B—(ii), C—(iv), D—(v), E—(i)
(d) A—(ii), B—(iii), C—(v), D—(i), E—(iv)
Ans: (b)

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Q8. Plants can be grown in (Tick the incorrect option).
(a) Soil with essential nutrients
(b) Water with essential nutrients
(c) Either water or soil with essential nutrients
(d) Water or soil without essential nutrients
Ans: (d) Plants can be grown in soil with essential nutrients, water with essential nutrients and either water or soil with essential nutrients.

Very Short Answer Type Questions
Q1. Name a plant, which accumulates silicon.
Ans: Rice, sugarcane, etc.

Q2. Mycorrohiza **is a mutualistic association. How do the organisms involved in this association gain from each other?**
Ans: Mycorrhiza is a symbiotic association between a fungus and the roots of a vascular plant. Through mycorrhization, the plant obtains phosphate and other minerals, such as zinc and copper, from the soil. The fungus obtains nutrients, such as sugars, from the plant root.

Q3. Nitrogen fixation is shown by prokaryotes and not eukaryotes. Comment?
Ans: Very few living organisms can utilise the nitrogen in the form N2, available abundantly in the air. Only certain prokaryotic species are capable of fixing nitrogen. The enzyme, nitrogenase which is capable of nitrogen reduction is present exclusively in prokaryotes. Such microbes are called N2-fixers.

Q4. Carnivorous plants like Nepenthes and Venus fly trap have nutritional adaptations. Which nutrient do they especially obtain and from where?
Ans: Carnivorous plants grow in nitrogen deficient soil but they utilise their nitrogen by killing the insect by some special structure.

Q5. Think of a plant which lacks chlorophyll. From where will it obtain nutrition? Give an example of such a type of plant.
Ans: Cuscuta, a parasitic plant that is commonly found growing on hedge plants, has lost its

chlorophyll and leaves in the course of evolution. It derives its nutrition from the host plant which it parasitises.

Q6. Name an insectivorous angiosperm.
Ans: Nepenthes, Utricularia, Drosera, Dionea, etc.

Q7. A farmer adds Azotobacter culture to soil **before sowing maize. Which** mineral element is **being replenished?**
Ans: Nitrogen

Q8. What type of conditions are created by leghaemoglobin in the root nodule of a legume?
Ans: Anaerobic condition

Q9. What is common to Nepenthes, Utricularia and Drosera with regard to mode **of nutrition?**
Ans: All are carnivorous plant (angiosperms).

Q10. Plants with zinc deficiency show reduced biosynthesis of .
Ans: Auxin

Q11. Yellowish edges appear in leaves deficient in .
Ans: K (potassium)

Q12. Name the macronutrient which is a component of all organic compounds but is not obtained from soil.
Ans: Carbon

Q13. Name one non-symbiotic nitrogen fixing **prokaryote.**
Ans: (i) Free-living (non-symbiotic) and non photosynthetic aerobic N2-fixing microbes: Azotobacter and Beijernickia.
(ii) Free-living and anaerobic N2-fixing microbes: Rhodospirillum, Bacillus polymyxa and Clostridium.

Q14. Rice fields pr**oduce an important green house gas. Name it.**
Ans: CH4 (methane) .

Q15. Complete the equation for reductive amination

$$......?...... + NH_4^+ + NADPH \xrightarrow{?} \text{glutamate} + H_2O + NADP$$

Ans. $$\alpha\text{-ketoglutaric acid} + NH_4^+ + NADPH \xrightarrow[\text{dehydrogenase}]{\text{Glutamate}} \text{glutamate} + H_2O + NADP$$

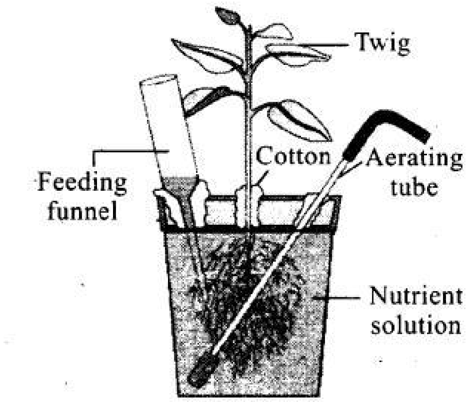
Q16. Excess of Mn in soil leads to deficiency **of Ca, Mg and Fe. Justify.**
Ans: Manganese competes with iron and magnesium for uptake and with magnesium for binding with enzymes. Manganese also inhibits calcium translocation in shoot apex. Therefore, excess of manganese may, in fact, induce deficiencies of iron, magnesium and calcium. Thus, what appears as symptoms of manganese toxicity may actually be the deficiency symptoms of iron, magnesium and calcium.

Short Answer Type Questions

Q1. How is sulphur important for plants? Name the amino acids in which it is present.
Ans: Sulphur, besides being present in some amino acids essential for protein synthesis, is also a constituent of several coenzymes, vitamins and ferredoxin which are involved in some biochemical pathway.

Q2. How are organisms like Pseudomonas and Thiobacillus of great significance in nitrogen cycle?
Ans: Pseudomonas and Thiobacillus carry out denitrification process wherein the nitrate present in the soil is reduced to nitrogen thus contributing to the atmospheric nitrogen.

Q3. Carefully observe the following figure:



a. Name the technique shown in the figure and the scientist who demonstrated this technique for the first time.
b. Name at least three plants for which this technique can be employed for their commercial production.
c. What is the significance of aerating tube and feeding funnel in this setup?
Ans: a. Hydroponics, Julius von Sachs.
b. Tomato, seedless cucumber, lettuce.
c. Aerating tube ensures adequate aeration of the root for optimum growth of the plant. The funnel is used to release water and nutrients into the container with nutrient solution. This solution needs to be replaced every day or two for maximum growth.

Q4. Name the most crucial enzyme found in root nodules for N2 fixation. Does it require a special pink coloured pigment for its functioning? Elaborate.
Ans: Nitrogenase. Yes, it does require the presence of a pink-coloured pigment in the nodule called leghaemoglobin for its functioning. This pigment helps in scavenging oxygen as nitrogenase functions under anaerobic condition.

Q5. How are the terms 'critical concentration' and 'deficient' different from each other in terms of concentration of an essential element in plants? Can you find the values of 'critical concentration' and 'deficient' for minerals – Fe and Zn?
Ans: The concentration of the essential element below which plant growth is retarded is termed as critical concentration. The element is said to be deficient when present below the critical concentration. Yes. one can find the values of 'critical concentration' and 'deficient' for minerals – Fe and Zn through the hydroponics technique.

Q6. Carnivorous plants exhibit nutritional adaptation. Citing an example explain this fact.
Ans: Carnivorous plants have green leaves so they are autotrophic but they grow in nitrogen deficient soil. For nitrogen requirement they capture and digest the insects so they are partially heterotrophic nature.

Q7. A farrper **adds/supplies Na, Ca, Mg and Fe regularly to his field and yet he observes that the plants show** deficiency **of Ca, Mg and Fe. Give a valid reason and suggest a** way to **help the farmer improve the growth of plants.**
Ans: This is due to the manganese toxicity. Many a times, excess of an element may inhibit the uptake of another element. For example, the prominent symptom of manganese toxicity is the appearance of brown spots surrounded by chlorotic veins. Manganese competes with iron

and magnesium for uptake and with magnesium for binding with enzymes. Manganese also inhibits calcium translocation in shoot apex. Therefore, excess of manganese may, in fact, induce deficiencies of iron, magnesium and calcium.
• The farmer should not supplies Mn to his field.

Long Answer Type Questions

Q1. It is observed that deficiency of a particular element showed its symptoms initially in older leaves and then in younger leaves.
a. Does it indicate that the element is actively mobilised or relatively immobile?
b. Name two elements which are highly mobile and two which are relatively immobile.
c. How is the aspect of mobility of elements important to horticulture and agriculture?
Ans: a. It is actively mobilised.
b. Highly mobile—nitrogen, magnesium Relatively immobile—calcium, boron
c. Symptoms of deficiency of mobile elements are more pronounced in older leaves and symptoms of deficiency of relatively immobile element appear first in younger leaves. This information can be utilised by horticulturist and agriculturist to get a broad idea of the deficiency elements in plants.

Q2. We find that Rhizobium forms nodules on the roots of leguminous plants. Also, Frankia another microbe forms nitrogen fixing **nodules on the roots of non-leguminous plant Alnus.**
a. Can we artificially induce the property of nitrogen fixation in a plant —leguminous or non-leguminous?
b. What kind of relationship is observed between mycorrihiza **and pine trees?**
c. Is it necessary for a microbe to be in close association with a plant to provide mineral nutrition? Explain with the help of one example.
Ans: a. Yes, one can artificially induce the property of nitrogen fixation in a plant—leguminous or non-leguminous through genetic engineering which involves introduction of specific genes to the host plant that synthesises nitrogenase enzymes.
b. Symbiotic relationship
c. Yes, it is necessary for a microbe to be in close association with a plant to provide mineral nutrition as seen in leguminous plants. Species of rod-shaped Rhizobium has such relationship with the roots of several legumes such as alfalfa, sweet clover, sweet pea, lentils, garden pea, broad bean, clover beans, etc. The most common association on roots is as nodules. The nodule contains all the necessary biochemical components, such as the enzyme nitrogenase and leghaemoglobin. The enzyme nitrogenase is an Mo-Fe protein and catalyses the conversion of atmospheric nitrogen to ammonia.

Q3. What are essential elements for plants? Give the criteria of essentiality. How are minerals classified depending upon the amount in which they are needed by the plants?
Ans: Essential elements: carbon, hydrogen, oxygen, nitrogen, phosphorous, sulphur, potassium, calcium, magnesium, iron, manganese, copper, molybdenum, zinc, boron, chlorine and nickel.
Criteria for Essentiality:
The criteria for essentiality of an element are given below:
(a) The element must be absolutely necessary for supporting normal growth and reproduction. In the absence of the element, the plants do not complete their life cycle or set the seeds.
(b) The requirement of the element must be specific and not replaceable by another element. In other words, deficiency of any one element cannot be met by supplying some other element.
(c) The element must be directly involved in the metabolism of the plant. Based upon the above criteria only a few elements have been found to be absolutely essential for plant growth and metabolism. These elements are further divided into two broad categories based on their

quantitative requirements.
(i) Macronutrients and
(ii) Micronutrients
Macronutrients are generally present in plant tissues in large amounts (in excess of 10 mmole kg~' of dry matter). The macronutrients include carbon, hydrogen, oxygen, nitrogen, phosphorous, sulphur, potassium, calcium and magnesium. Of these, carbon, hydrogen and oxygen are mainly obtained from C02 and H20, while the others are absorbed from the soil as mineral nutrition.
Micronutrients or trace elements are needed in very small amounts (less than 10 mmole kg-1 of dry matter). These include iron, manganese, copper, molybdenum, zinc, boron, chlorine and nickel.

Q4. With the help of examples describe the classification of essential elements based on the function they perform.
Ans: Essential elements can also be grouped into four broad categories on the basis of their diverse functions. These categories are:
(i) Essential elements as components of biomolecules and hence structural elements of cells (e.g., carbon, hydrogen, oxygen and nitrogen).
(ii) Essential elements that are components of energy-related chemical compounds in plants (e.g., magnesium in chlorophyll and phosphorous in ATP).
(iii) Essential elements that activate or inhibit enzymes, for example Mg2+ is an activator for both ribulose bisphosphate carboxylase/oxygenase and phosphoenol pyruvate carboxylase, both of which are critical enzymes in photosynthetic carbon fixation; Zn +is an activator of alcohol dehydrogenase and Mo of nitrogenase during nitrogen metabolism.
(iv) Some essential elements can alter the osmotic potential of a cell. Potassium plays an important role in the opening and closing of stomata. Minerals also play role as solutes in determining the water potential of a cell.

Q5. We know that plants require nutrients. If we supply these in excess, will it be beneficial to the plants? If yes, how/ If no, why?
Ans: No, excess supply of nutrients is not beneficial for the plants. It is toxic to the plants. Any mineral ion concentration in tissues that reduces the dry weight of tissues by about 10% is considered toxic. Such critical concentrations vary widely among different micronutrients. The toxicity symptoms are difficult to identify. Toxicity levels for any element also vary for different plants. Many a times, excess of an element may inhibit the uptake of another element. For example, the prominent symptom of manganese toxicity is the appearance of brown spots surrounded by chlorotic veins. It is important to know that manganese competes with iron and magnesium for uptake and with magnesium for binding with enzymes. Manganese also inhibits calcium translocation in shoot apex. Therefore, excess of manganese may, in fact, induce deficiencies of iron, magnesium and calcium.

Q6. Trace the events starting from the coming in contact of Rhizobiwn **to a leguminous root till nodule formation. Add a note on** importance **of leghaemoglobin.**
Ans: Nodule Formation: Nodule formation involves a sequence of multiple interactions between Rhizobium and roots of the host plant. Principal stages in the nodule formation are summarised as follows: Rhizobia multiply and colonise the surroundings of roots and get attached to epidermal and root-hair cells. The root-hairs curl and the bacteria invade the root-hairs. An infection thread is produced carrying the bacteria into the cortex of the root, where they initiate the nodule formation in the cortex of the root. Then the bacteria are released from the thread into the cells which leads to the differentiation of specialised nitrogen fixing cells. The nodule thus formed, establishes a direct vascular connection with the host for exchange of nutrients.
Importance of leghemoglobin: The enzyme nitrogenase is highly sensitive to the molecular oxygen; it requires anaerobic conditions. The nodules have adaptations that ensure that the

enzyme is protected from oxygen. To protect these enzymes, the nodule contains an oxygen scavenger called leghaemoglobin. It is interesting to note that these microbes live as aerobes under free-living conditions (where nitrogenase is not operational), but during nitrogen-fixing events, they become anaerobic (thus protecting the nitrogenase enzyme).

Q7. Give the biochemical events occurring in the root nodule of a pulse plant. What is the end product? What is its fate?

Ans: The nodule contains all the necessary biochemical components, such as the enzyme nitrogenase and leghaemoglobin. The enzyme nitrogenase is an Mo-Fe protein and catalyses the conversion of atmospheric nitrogen to ammonia, the first stable product of nitrogen fixation.

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

- In the above reaction,the ammonia synthesis by nitrogenase requires a very high input of energy (8 ATP for each NH_3 produced). The energy required, thus, is obtained from the respiration of the host cells.

Fate of NH_3:

NH_3 produced through N_2 fixation is incorporated into amino acids as the amino group. At physiological pH the NH_3 is protonated to form NH_4^+ (ammonium) ion. While most of the plants can assimilate NH_3^- as well as NH_4^+ lions. But NH_4^+ ion is quite toxic to plants, hence cannot accumulate in them

- There are two main ways in which NH_4^+ ion is used to synthesise amino acids in plants:

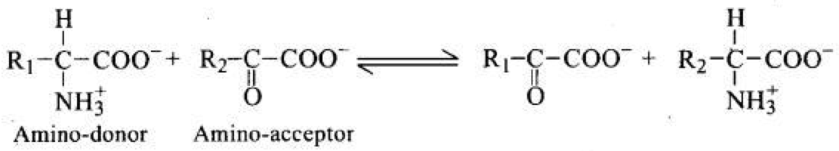
(I) **Reductive amination:** In these processes, ammonia reacts with α-ketoglutaric acid and forms glutamic acid as indicated in the equation given below:

α-ketoglutaric acid + NH_4^+ + NADPH

↓ Glutamate dehydrogenase

Glutamate + H_2O + NADP

(II) Transamination: Transfer of amino group from one amino acid to the keto group of keto acid.



- Glutamic acid is the main amino acid from which transfer of NH_2 (amino group) takes place and other amino acids are formed through transamination. Enzyme transaminase catalyses all such reactions.

• Glutamic acid is the main amino acid from which transfer of NH2 (amino group) takes place and other amino acids are formed through transamination. Enzyme transaminase catalyses all such reactions.

For example, the two most important amides (asparagine and glutamine) found in plants are a structural part of proteins.

• Asparagine formed from aspartic acid and glutamine is formed from glutamic acid by addition of amino group to each. The hydroxyl part of the acid is replaced by another NH2 radicle.

Q8. Hydroponics have been shown to be a successful technique for growing of **plants. Yet most of the crops are still grown on land. Why?**

Ans: The technique of growing plants in anutrient solution is known as hydroponics. Since, then a number of improvised methods have been employed to try and determine the mineral nutrients essential for plants. The essence of all these methods involves the culture of plants in a soil-free, defined mineral solution. These methods require purified water and mineral

nutrient salts. Hydroponics has been successfully employed as a technique for the commercial production of vegetables such as tomato, seedless cucumber and lettuce.
Yet most of the crops are still grown on land because it must be emphasised that the nutrient solutions must be adequately aerated to obtain the optimum growth. On land no such conditions are required.