12

Mineral Nutrition

Multiple Choice Questions (MCQs)

Q. 1 Which one of the following roles is not 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
(d) activation or inhibition of enzymes

Ans. *(b)* Changing the soil chemistry is not a role of the essential element. Whereas rest all are the characteristics of an essential element. These are directly involved in the metabolism of plants.

Q. 2 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 the plant growth is retarded is termed as critical concentration. Plants start showing deficiency symptoms if a particular element is present below the critical concentration.

Q. 3 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

Thinking Process

Plants show deficiency symptoms of the elements when that particular nutrient is not available to the plants or if it is available, the plant is not able to use it.

Ans. *(a)* The sulphur is needed by young leaves, stem and root tips. If it is not available, *these parts would show the deficiency symptoms which include*

(i) reduced growth
(ii) extensive root growth
(iii) hard and woody stem
(iv) chlorosis of young leaves.

The immobile elements are transported in plant upto the tip level, so their deficiency appear first at the tips of growing apices of roots and shoot.

Q. 4 Which one of the following symptoms is not due to manganese toxicity in plants?

(a) Calcium translocation in shoot opex is inhibit
(b) Deficiency in both iron and zitrogen induced
(c) Appearance of brown spot surrounded by chlorotic veins
(d) None of the above

Ans. *(d)* Manganese is an essential micronutrient which is mainly required by the leaves and seeds of plants. Manganese becomes toxic when absorded by plants in higher amounts. Its toxicity cause reduced uptake of Fe^{2}, Mg^{2+} and N, inhibition of Ca^{2+} translocation in shoot apex, brown spots surrounded by chlorotic veins etc.

Q. 5 Reaction carried out by N_2 fixing microbes include

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

(b) $2NO_2 + O_2 \longrightarrow 2NO_3$ ...(ii)

Which of the following statements about these 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)* Option (d) is not true because the bacteria involved in the process are not photoautotrophs but are chemoautotrophs. These bacteria oxidise inorganic substances like NH_3 and NO_2 and use the released energy hence are called **chemoautotrophs**.

Simultaneously, they help in the conversion of ammonia (NH_3) to absorbable form (NO_2^- and NO_3^-) of nitrogen.

Q. 6 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 for its functioning.
(b) Nitrogenase is Mo-Fe protein
(c) Leg-haemoglobin is a pink coloured pigment.
(d) Nitrogenase helps to convert N_2 gas into two molecules of ammonia.

Ans. *(a)* The enzyme, nitrogenase which is capable of nitrogen reduction is present exclusively in prokaryotes (*e.g., Rhizobium*). It is highly sensitive to O_2 and gets inactivated when exposed to it, thus does not require oxygen for its functioning. Other statements (b), (c) and (d) are true.

Q. 7 Match the element with its associated functions/roles and choose the correct option among given below

A.	Boron	1.	Splitting of H_2O to liberate O_2 during photosynthesis
B.	Manganese	2.	Needed for synthesis of auxins
C.	Molybdenum	3.	Component of nitrogenase
D.	Zinc	4.	Pollen germination
E.	Iron	5.	Component of ferredoxin

Codes

(a) 1, 2, 3, 4, 5 (b) 4, 1, 3, 2, 5
(c) 3, 2, 4, 5, 1 (d) 2, 3, 5, 1, 4

Thinking Process

The plants require few minerals in large quantities and few in small quantities. Thus, they are called macro and microelements respectively. The B, Mn, Zn and Fe are the elements required by the plants in smaller quantities but are very much essential for normal growth, development and reproduction of the plants.

Ans. *(b)* Correct match is as follows

A.	Boron	Pollen germination
B.	Manganese	Splitting of water to liberate O_2 during photosynthesis
C.	Molydenum	Component of nitrogenase
D.	Zine	Needed for synthesis of auxins
E.	Iron	Component of ferrodoxin.

Q. 8 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. *(c)* The plants can be grown in any medium either water or soil if it is supported with all essential elements. Medium does not affect the plant growth but availability of all elements does affect the growth of the plants.

Very Short Answer Type Questions

Q. 1 Name a plant, which accumulate silicon.

Thinking Process

There are few macro elements and micro elements needed by all plants for the completion of their life cycle in a normal way. But few plants have some specific requirements for some elements like Na, Si, Cl *and* Ni.

Ans. *Oryza sativa* and *Triticum aestivum* are silicon accumulators. These plants actively absorb silicon and accumulate them in their biomass.

Q. 2 Mycorrhiza is a mutualistic association. How do the organisms involved in this association gain from each other?

Ans. A mycorrhiza is a symbiotic association between a fungus and the roots of vascular plants (mainly gymnosperms). This mutualistic association provides fungus a constant and direct supply of carbohydrates (glucose and sucrose).

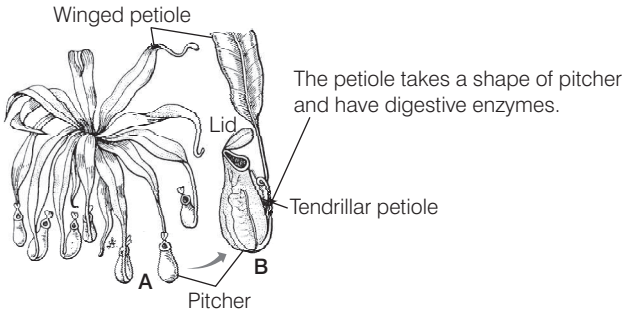
In return, plant gains the benefit of the mycelium of fungus which enhances its absorptive capacity for water and minerals due to the large surface area of mycelium.

Q. 3 Nitrogen fixation is shown by prokaryotes and not eukaryotes. Comment.

Ans. Few prokaryotes like *Rhizobium, Anabaena* and *Nostoc* contains the enzyme nitrogenase, needed for the biological nitrogen-fixation. Eukaryotes do not possess this enzyme, therefore are unable to fix nitrogen.

Q. 4 Carnivorous plants like *Nepenthes* and venus fly trap have nutritional adaptations. Which nutrient do they especially obtain and from where?

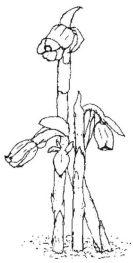
Ans. *Nepenthes* and venus fly trap grow in nitrogen deficient soil. So, they make up their nitrogen deficiency by trapping insects for which they have developed special adaptations.



Pitcher plant – *Nepenthes*

Q. 5 Think of a plant which lacks chlorophyll. From where will it obtain nutrition? Give an example of such a type of plant.

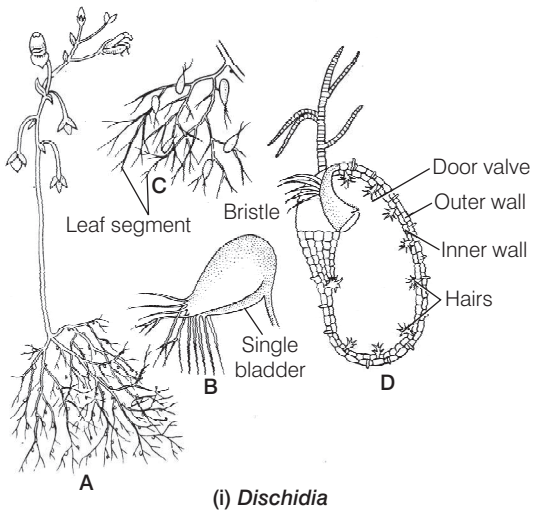
Ans. An angiospermic plant called *Monotrapa* do not contain chlorophyll. It grows on some other plant as a parasite and derive nutrition from the host plant. This plant is commonly known as ghost plant.



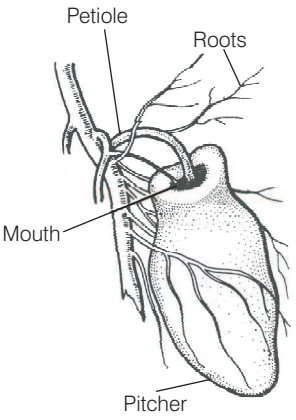
Indian pipe *Monotrapa uniflora* (ghost plant)

Q. 6 Name an insectivorous angiosperm.

Ans. (i) *Dischidia* (ii) *Utricularia*



(i) ***Dischidia***



(ii) ***Utricularia***

Q. 7 A farmer adds *Azotobacter* culture to soil before sowing maize. Which mineral element is being replenished?

Ans. *Azotobacter* is a free living bacteria in the soil. It helps some cereal crops like maize (*Zea mays*) in nitrogen fixation. The farmer adds *Azotobacter* culture to the maize field for enhancing the nitrogen element in the soil by the process of biological nitrogen-fixation.

Q. 8 What type of conditions are created by leghaemoglobin in the root nodule of a legume?

Ans. Leghaemoglobin is responsible for creating anaerobic conditions in the root nodules of the legume plant. It acts as an oxygen scavenger, protecting enzyme nitrogenase to come in contact with oxygen and help in the proper functioning of enzyme, *i.e.*, conversion of atmospheric nitrogen to ammonia (NH_3).

Q. 9 What is common to *Nepenthes, Utricularia* and *Drosera* with regard to mode of nutrition?

Ans. All the above mentioned plants are carnivorous (insectivorous) plants. These trap insects and digest them by proteolytic enzymes and thus, make up their nitrogen deficiency.

Q. 10 Plants with zinc deficiency show reduced biosynthesis of

Ans. Plant with zinc deficiency shows, reduced biosynthesis of auxin. Zinc is the microelement that is absorbed by almost all parts of the plant in the form of Zn^{2+} ion.

It functions as a constituent of carbonic anhydrase and auxin. It also activates various enzymes especially carboxylases and dehydrogenases.

Q. 11 Yellowish edges appear in leaves deficient in.

Ans. Yellowish edges or chlorosis appears in the leaves, deficient in nitrogen. Nitrogen deficiency also causes delaying of flowering, interference in protein synthesis and dormacy of lateral buds.

Q. 12 Name the macronutrient which is a component of all organic compounds but it not obtained from soil.

Ans. Carbon is an essential element. Plant take it from atmosphere in the form of CO_2. It's concentration in atmosphere is about 0.03%. Plants use CO_2 for photosynthesis (as a source of carbon) to synthesises glucose.

Q. 13 Name one non-symbiotic nitrogen fixing prokaryote.

Ans. *Azotobacter* is a non-symbotic nitrogen fixing prokaryote. It flourishs in the rice fields.

Q. 14 Rice fields produce an important green house gas. Name it.

Ans. Rice fields remain logged with excess water which harbour the great microbial activity. Many anaerobic bacteria also grow in these areas and release methane which is a green house gas.

Q. 15 Complete the equation for reductive amination ..... .

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

Ans. **Reductive Amination** Ammonia combines with a keto acid (like α-ketoglutaric acid or oxaloacetic acid) to form amino acid in presence of a reduced coenzyme (NADH, NADPH) and enzyme dehydrogenase (*e.g.,* glutamate dehydrogenase, aspartate dehydrogenase).

$$\alpha\text{-ketoglutaric acid} + NH_4^+ + NAD\,(P)\,H \xrightarrow[\text{dehydrogenase}]{\text{Glutamate}} \text{Glutamate} + H_2O + NAD\,(P)$$

$$\text{Oxaloacetic acid} + NH_4^+ + NAD(P)H \xrightarrow[\text{dehydrogenase}]{\text{Aspartate}} \text{Asparatate} + H_2O + NAD(P)$$

Q. 16 Excess of Mn in soil leads to deficiency of Ca, Mg and Fe. Justify.

Ans. Manganese (Mn^{2+}) becomes toxic when absorbed by plants in higher amounts. The toxicity expressed in form of brown spots surrounded by chlorotic vein.

It is due to the following reasons

(i) Reduction in uptake of Fe^{3+} and Mn^{2+}.

(ii) Inhibition of binding of Mn^{2+} to specific enzymes.

(iii) Inhibition of Ca^{2+} translocation in shoot apex.

Thus, excess of Mn^{2+} causes deficiency of iron, magnesium and calcium.

Short Answer Type Questions

Q. 1 How is sulphur important for plants? Name the amino acids in which it is present.

Thinking Process

Sulphur is a macronutrient and is important for normal plant growth and development. It is an integral part of some amino acids and proteins and helps in deciding the secondary structure of proteins as it forms disulphide bonds.

Ans. Sulphur (S) is an important macronutrient in plants that is absorbed by the plants as SO_4^{2-} ion. It mainly functions as a component of vitamins (biotin, thiamine), proteins, coenzyme-A, amino acid (cystein and methionine) etc. It is also an essential component of ally sulphide (onion, garlic) and sinigrin (mustard).

Deficiency of sulphur can lead to chlorosis in young leaves, extensive root growth, formation of hard and woody stem. It also causes the reduction in juice content of citrus fruit and tea yellow disease of tea.

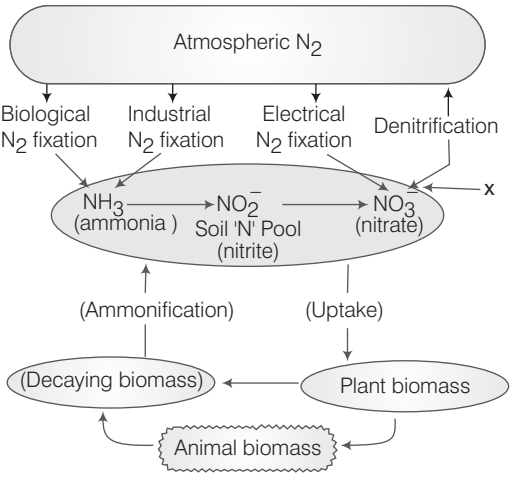
Sulphur is found in amino acids systeine, methionione, etc.

Q. 2 How are organisms like *Pseudomonas* and *Thiobacillus* of great significance in nitrogen cycle?

Thinking Process

Biological nitrogen fixation is a process is which gaseous nitrogen is converted to nitrogen which can be used by the plants as a nutrient.

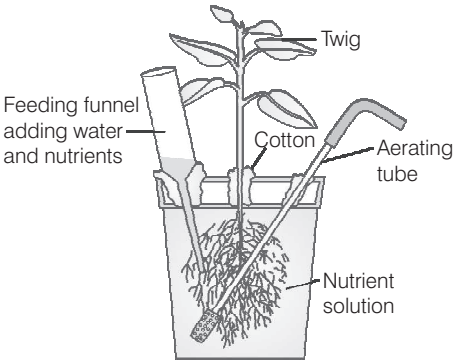
Ans. In biological nitrogen fixation, the atmospheric N_2 gets reduced to NH_3 by nitrogenase reductase present in some prokaryotes. NH_3 is then oxidises to NO_2 and NO_3 by some other bacteria (*Nitrosomonas* and *Nitrobacter*). *Various steps involved in nitrogenfixation are as follows*



Nitrogen fixation

Pseudomonas and *Thiobacillus* are involved in the process of denitrification. They convert nitrate (NO_3^-) and nitrite (NO_2^-) into free nitrogen (N_2), which is released into the atmosphere.

Q. 3 Carefully observed the following figure



(a) Name the technique shown in the figure and the scientist who demonstrated this technique for the first time.

(b) Name atleast 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 (1860)

(b) (i) *Solanum lycopersicum* (tomato)
(ii) *Hibiscus asculentus* (ladiesfinger)
(iii) *Solanum melongena* (brinjal)

(c) **Aerating tube** Provides oxygen for the normal growth and development of the roots growing in the liquid solution. Feeding funnel is used to add water and nutrients in the hydroponic system when required.

Q. 4 Name the most crucial enzyme found in root nodules for N_2-fixation? Does it require a special pink coloured pigment for its functioning? Elaborate.

Ans. Nitrogenase is the most crucial enzyme found in the root nodules for N_2-fixation. It is a Mo – Fe protein that catalyses the conversion of atomospheric nitrogen to ammonia. Pink coloured pigment called leghaemoglobin creates anaerobic conditions for the functioning of nitrogenase enzyme.

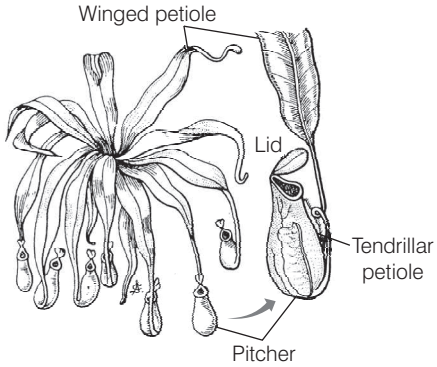
Q. 5 How are the terms 'critical concentration' and 'deficient' different from each other in terms of concentration of an essential element in plants? Can you find the values of 'critical concentration' and 'deficient' for minerals—Fe and Zn?

Ans.

Critical Concentration	Deficient
A concentration of a nutrient measured in tissue, just below the level that gives maximum growth is defined as critical concentration. *e.g.,* N, P and K are known as critical elements.	The concentration that is below the critical concentration and the deficiency of nutrient element can lead to a gradual fall in the plant growth is called deficient.

	Critical concentration	Deficient
Zn	0.5 - 1%	less than 0.5%
Fe	3.5 - 5%	less than 3.5%

Q. 6 Carnivorous plants exhibit nutritional adaptation. Citing an example explain this fact.



***Nepenthes* showing Pitcher shaped leaf**

Ans. Carnivorous (insectivorous) plants are mainly found in nitrogen deficient soil. To make up the nitrogen deficiency, they have developed insect trapping mechanism in which leaves have taken the shape of a pitcher containing insect digesting proteolytic enzymes. They trap insect and absorb the nitrogen derived from them.

Q. 7 A farmer 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. Plant can tolerate a specific amount of micronutrients. A slight lesser amount of it can cause deficiency symptoms and a slight higher amount can cause toxicity. The mineral ion concentration which reduces the dry weight of the tissues by 10% is called toxic concentration.

This concentration is different for different micronutrients as well as for different plants, *e.g.*, Mn^{2+} is toxic beyond 600 $\mu g g^{-1}$ for soyabean and beyond 5300 $\mu g g^{-1}$ for sunflower.

It has also been observed that the toxicity of one micronutrient causes the deficiency of other nutrients. To overcome such problems, farmers should use these nutrients in prescribed concentration so that the excess uptake of one element do not reduce the uptake of other element.

Long Answer Type Questions

Q. 1 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)** The plants try to supply more nutrients to its younger leaves than the older leaves. When nutrients are mobile, the deficiency symptoms are shown by the older leaves first because that particular nutrient reaches the top first and lower leaves does not get that nutrient.

(b) Highly mobile elements are P, K and Mn. Less mobile elements are Ca^+ and K^+.

(c) The aspect of mobility of essential elements is important in horticulture and agriculture *in the following* ways

(i) A crop in which older leaves are harvested if show deficiency symptoms, will decrease its economic value.

(ii) The crops in which flowers, fruits and inflorescence are harvested, the immobile nutrients will not reach to the apex/tip because of immobility, so this will reduce the yield.

Q. 2 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 mycorrhiza 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)** Artificial induction in leguminous and non-leguminous plants have been tried by scientists. It's success rate is very low because gene expression is highly specific phenomenon.

Even if desired gene is introduced, it may not work because conditions for its expressions are very specific.

(b) Symbiotic mutualistic relationship (mutualism) is found between the pine roots and mycorrhiza as both are benefitted mutually.

(c) *Yes*, microbe has to be in close association, to develop a physical relationship for example *Rhizobium* gets into the root and involve root tissues, then only helps in nitrogen-fixation.

Q. 3 What are essential elements for plants? Give the criteria of essentiality? How are minerals classifieds depending upon the amount in which they are needed by the plants?

Ans. An element is essential to plants if it is necessary for supporting its normal growth and reproduction. The requirement of this element must be specific and is not replaceable by any another element in the soil. They must be directly involved in the metabolism of the plant.

Criteria for Essentiality

An element can not be considered as essential merely on the basis of its presence in the plant. *It is considered essential on the basis of the following criteria*

(i) The plant is unable to grow normally and complete its life cycle in the absence of the element.

(ii) The element is specific and can not be replaced by another element.

(iii) The element plays a direct role in the metabolism of the plants.

The essential elements are further classified into two categories

(a) **Macroelements** These are the elements required by plants in larger quantities. These are C, H, O, N, P, K, Mg, Ca and S.

(b) **Microelements** (Trace elements) These are required by plants in low quantities (often less than 1 ppm). These include B, Zn, Mn, Cu, Mo, Cl, Fe and Ni.

Q. 4 With the help of examples describe the classification of essential elements based on the function they perform.

Ans. Essential elements are involved in performing variety of functions in plants. *Some of the major functions are enlisted below*

(i) **Frame work elements** Essential elements as components of biomolecules and hence are structural elements of the cell. Carbon, hydrogen and oxygen are considered as framework elements because they constitute carbohydrates which form cell wall.

(ii) **Protoplasmic elements** N, P and S are considered as protoplasmic elements as they form protoplasm along with C, H and oxygen.

(iii) **Catalytic enzyme** Essential elements that activates or inhibit enzymes, *i.e.,* without the presence of these elements some enzymes can not function *e.g.,* Mg^{2+} acts as an activator for both ribulose biphosphate carboxylase oxygenase (Rubisco) and phosphoenol pyruvate carboxylase (PEP carboxylase).

Both are the critical enzymes involved in photosynthetic carbon fixation in plants.

(iv) **Balancing elements** Elements counteract the toxic effect of other minerals by causing ionic balance (*e.g.,* calcium, magnesium and potassium).

(v) **Influencing on the osmotic pressure of the cell** Some essential elements alters the osmotic potential of the cell. Plant cells contain dissolved mineral elements in the cell sap influencing osmotic pressure of the cell, *e.g.,* K is involved in opening and closing of stomata.

Q. 5 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. Plants can tolerate a specific amount of micronutrient. A slight lesser amount of it can cause deficiency symptom and a slight higher amount can cause toxicity. The mineral ion concentration which reduces the dry weight of a tissue by 10% is called toxic concentration.

This concentration is different for different micronutrients as well as for different plant, *e.g.,* Mn^{2+} is toxic beyond 600 $\mu g g^{-1}$ for soyabean and beyond 5300 $\mu g g^{-1}$ for sunflower.

It is very difficult to identify the toxicity symptoms of mineral ion. It is because excess uptake of one element can reduces the uptake of other element at a time.

e.g., manganese (Mn^{2+}) becomes toxic when absorbed by plants in higher amounts. The toxicity is expressed in form of brown spots surrounded by chlorotic vein.

It is due to the following

(i) Reduction in uptake of Fe^{3+} and Mg^{2+}.

(ii) Inhibition of binding of Mg^{2+} to specific enzymes.

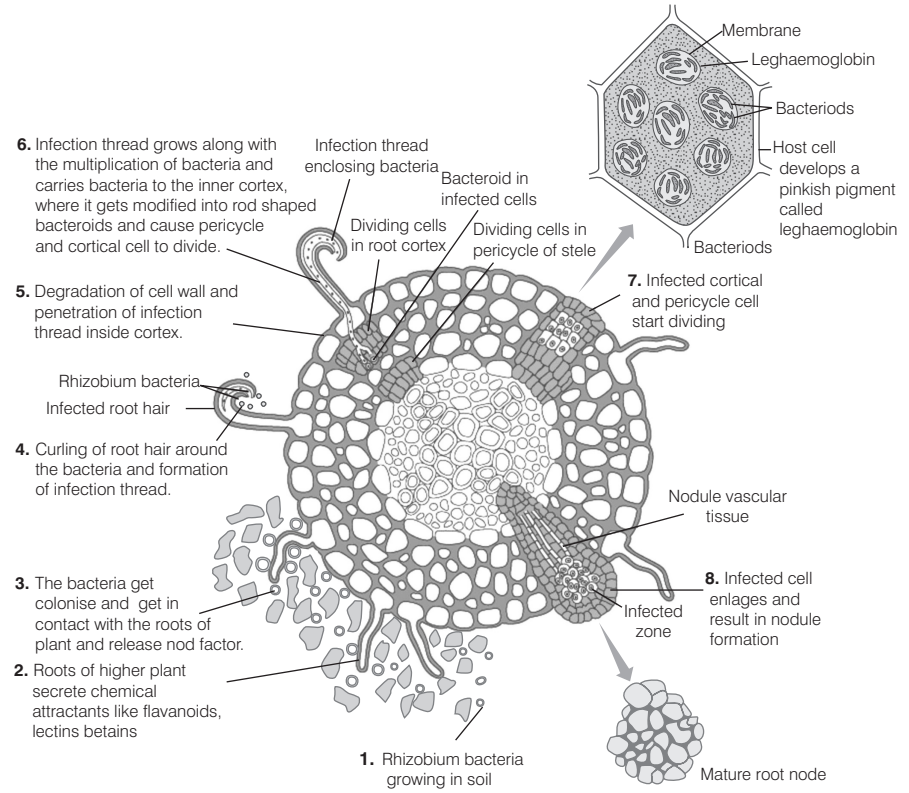
(iii) Inhibition of Ca^{2+} translocation in shoot apex.

Thus, excess of Mn^{2+} causes deficiency of iron, magnesium and calcium.

Q. 6 Trace the events starting from the coming in contact of *Rhizobium* to a leguminous root till nodule formation. Add a note on importance of leg haemoglobin.

Ans. **Formation of Root Nodule** The coordinated activities of the legume and the *Rhizobium* bacteria depend on the chemical interaction between the symbiotic partners.

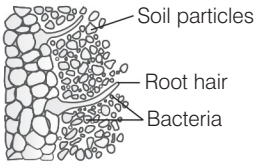
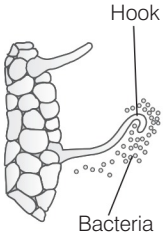
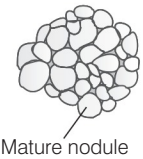
The principle stages in the nodule formation are summerised in the following diagram



Leg haemoglobin is an oxygen scavenger, it protects nitrogenase enzyme from O_2 and also creates anaerobic conditions for the reduction of N_2 to NH_3 by *Rhizobium*.

Q. 7 Give the biochemical events occurring in the root nodule of a pulse plant. What is the end product? What is its fate?

Ans. Formation of root nodule in pulse plant is the result of infection of roots by *Rhizobium*.
The following figure shows the process of nodule formation

	(a) *Rhizobiun* divide near the root hair
	(b) Successful infection of the root hair causes it to curl
	(c) Infected thread carries the bacteria to enter the cortex. Bacteria cause cortical and pericycle cells to divide, lead to nodule formation.
	(d) Mature nodule with vascular tissues continuous with those of the roots.

The chemical reaction is as follows

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

The reaction takes place in presence of enzyme nitrogenase which acts in anaerobic conditions created by leghaemoglobin.

Fate of Ammonia

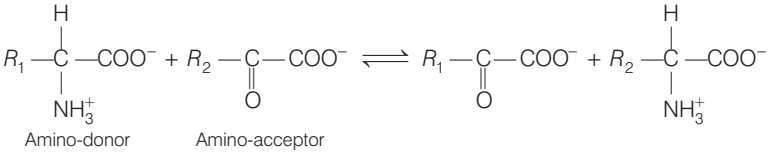
There are two ways by which ammonia is further used

(a) **Reductive Amination**

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

Ammonia reacts with α-ketoglutaric acid to form glutamate.

(b) **Transamination**



In this process, transfer of NH_2 group take place from one amino acid to other amino acid; enzyme transaminase catalyses this reaction.

Q. 8 Hydroponics have been shown to be a successful technique for growing of plants. Yet most of the crops are still grown on land. Why?

Thinking Process

Hydroponics is a soil less culture of plants. Many plants have been grown in nutrient rich solutions but it has certain drawbacks too.

Ans. Although, hydrophonics is a successful technique for plants still many crops are grown on land *because*

(i) The cost is the major concern. The setting and handling of hydrophonics requires much more investment than that of the soil based production.

(ii) Sanitization is extremely important especially with indoor hydroponic environments. Water borne disease can spread quickly through some methods of hydroponic production.

(iii) Hydroponics is relatively a new technique and not used by the traditional farmers due to lack of knowledge.

(iv) Plants are less adaptable to the surrounding atmosphere. Hot weather and narrow oxygenation may minimise the production and quality of plant produce/yield.