NOTES:

Definitions-

Hydroponics- The technique of growing plants in the complete absence of soil in a nutrient solution. It was first demonstrated by Julius von Sachs in 1860.

Macronutrients- These are required by plants in relative abundance than micronutrients. They are generally present in plant tissues in amounts in excess of 10 mmole Kg^{-1} of dry matter.

Micronutrients- These are also known as trace elements as they are needed in very small amounts by the plant. Their amount is less than 10 mmole Kg^{-1} of dry matter.

Essential elements- Essential elements are the elements that cannot be synthesized by the plant and are required to be taken up from the environment.

Critical concentration- The concentration of the essential element below which plant growth is retarded is termed as critical concentration and the element is said to be deficient if it is present below the critical concentration.

Toxicity- It is a condition where a particular nutrient is present in excess quantities (more than that required by the plant), such that it causes a negative effect on the plant.

Apoplast – It is the space outside of the plasma membrane in which the materials can diffuse freely without entering inside the plant cell. Transport through this space is restricted by the presence of Casparian strip in the roots of plants.

Symplast- It refers to the space on the inner side of the plasma membrane of the plants. It is linked between plant cells through cytoplasmic connections known as plasmodesmata.

Nitrogen fixation- The process of conversion of atmospheric nitrogen to a form that is utilizable by the plants (generally ammonia) is known as nitrogen fixation.

Ammonification- It is the decomposition of organic nitrogen of dead plants and animals into ammonia.

Nitrification- The conversion of atmospheric nitrogen to nitrite and further into nitrate by the action of chemoautotrophs is known as nitrification.

Denitrification- The process of reduction of nitrate present in the soil to nitrogen.

Biological nitrogen fixation- It refers to the reduction of nitrogen to ammonia by living organisms.

Symbiosis- It is a type of social interaction which involves a close physical association between the interacting partners. It is usually a mutually beneficial relationship.

Symbiotic nitrogen fixation- It is a mutually beneficial relationship in which the plants provide with shelter and fixed food to microbes in exchange for fixed nitrogen. Eg- association between leguminous plants and *Rhizobium.*

Diagrams to refer from NCERT (2021-22)

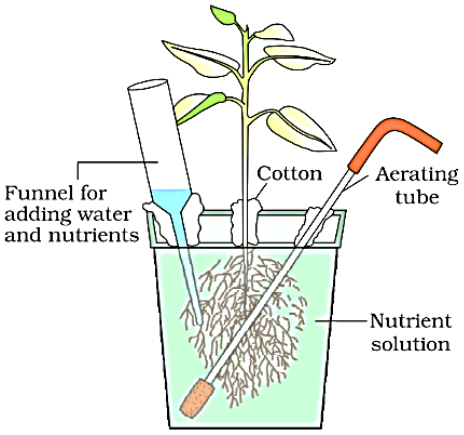

Figure 12.1 Diagram of a typical set-up for nutrient solution culture

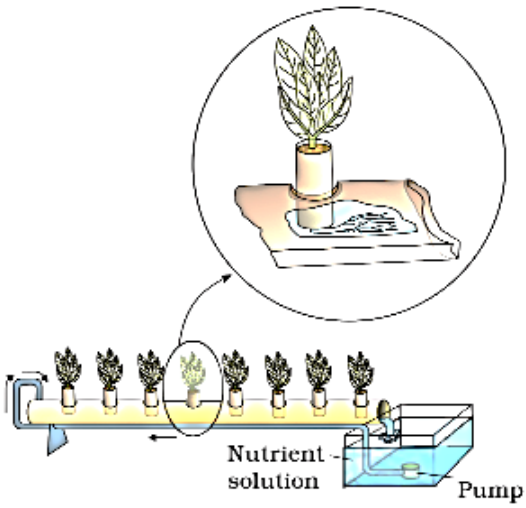

Figure 12.2 Hydroponic plant production. Plants are grown in a tube or trough placed on a slight incline. A pump circulates a nutrient solution from a reservoir to the elevated end of the tube. The solution flows down the tube and returns to the reservoir due to gravity. Inset shows a plant whose roots are continuously bathed in aerated nutrient solution. The arrows indicates the direction of the flow.

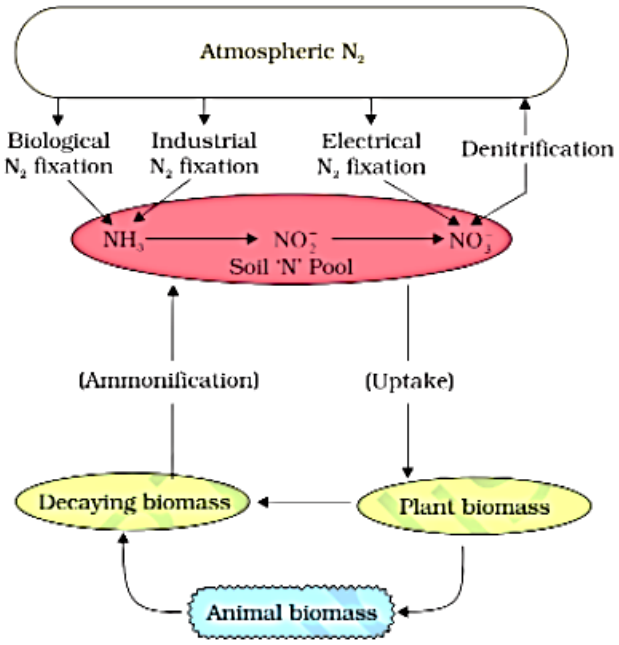

Figure 12.3 The nitrogen cycle showing relationship between the three main nitrogen pools – atmospheric soil, and biomass

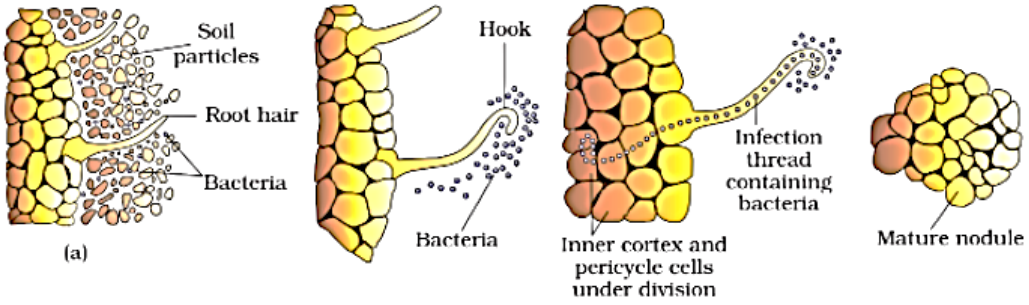

Figure 12.4 Development of root nodules in soyabean : (a) *Rhizobium* bacteria contact a susceptible root hair, divide near it, (b) Successful infection of the root hair causes it to curl, (c) Infected thread carries the bacteria to the inner cortex. The bacteria get modified into rod-shaped bacteroids and cause inner cortical and pericycle cells to divide. Division and growth of cortical and pericycle cells lead to nodule formation, (d) A mature nodule is complete with vascular tissues continuous with those of the root

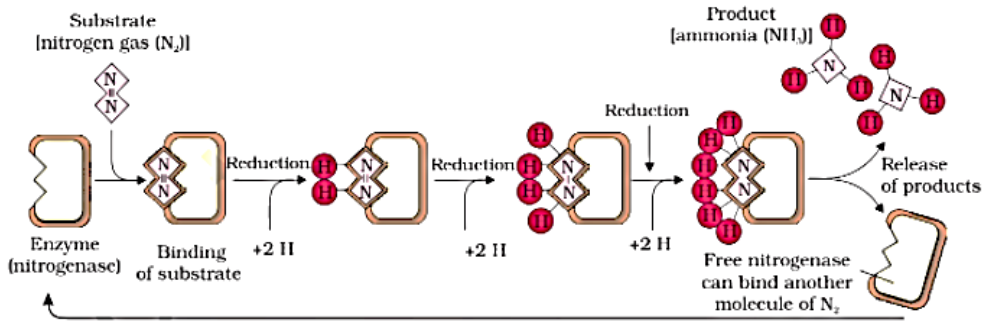

Figure 12.5 Steps of conversion of atmospheric nitrogen to ammonia by nitrogenase enzyme complex found in nitrogen-fixing bacteria

Read the captions and the explanations for these in the texts.

Also, do the equations from the 'Concepts and formulas' section.

Tables-

Mobile elements:	Immobile elements:
Nitrogen	Calcium
Potassium	Copper
Chlorine	Sulphur
Phosphorous	Iron
Sodium	Boron
Zinc	
Magnesium	
Molybdenum	

Mobility of an element determines whether its deficiency would affect the younger leaves and parts of the plant or the older leaves and more mature parts.

Deficiency of immobile elements occurs first in younger leaves while deficiency of mobile elements is visible in older leaves first.

Nutrients-

Nitrogen:

- Required in greatest amounts.
- Major constituents of proteins, nucleic acids, vitamins and hormones.
- Required by all plant parts, particularly essential for meristematic and metabolically active parts.
- Mainly absorbed as nitrate.

Phosphorus:

- Absorbed as phosphate ions.
- Constituent of cell membranes, certain proteins, all nucleic acids and nucleotides.
- Required for all phosphorylation reactions.

Potassium:

- Absorbed as potassium ions.
- Abundantly required in meristematic tissues, buds, leaves and root tips.
- Maintains an anion-cation balance in cells and is involved in protein synthesis, opening and closing of stomata, activation of enzymes and in the maintenance of the turgidity of cells.

Calcium:

- Absorbed as calcium ions.
- Required by meristematic and differentiating tissues.
- Used in the synthesis of cell wall during cell division, particularly as calcium pectate in the middle lamella.
- Needed during the formation of mitotic spindle.
- Involved in the normal functioning of the cell membranes.
- Activates certain enzymes and plays an important role in regulating metabolic activities.

Magnesium:

- Absorbed by in the form of divalent Mg^{2+}.
- It activates the enzymes of respiration, photosynthesis and is involved in the synthesis of DNA and RNA.
- It is a constituent of the ring structure of chlorophyll.
- Helps to maintain the ribosome structure.

Sulphur:

- Absorb in the form of sulphate.
- Constituent of two amino acids – cysteine and methionine and several coenzymes, vitamins (thiamine, biotin, Coenzyme A) and ferredoxin.

Iron:

- Absorbed in the form of ferric ions.
- Constituent of proteins involved in the transfer of electrons like ferredoxin and cytochromes.
- Reversibly oxidised from Fe2+ to Fe3+ during electron transfer.
- Activates catalase enzyme, and is essential for the formation of chlorophyll.

Manganese:

- Absorbed in form of manganous ions.

- Activates many enzymes involved in photosynthesis, respiration and nitrogen metabolism.
- Required in splitting of water to liberate oxygen during photosynthesis.

Zinc:

- Absorbed in the form of zinc ions.
- It activates various enzymes, especially carboxylases.
- Required in synthesis of auxin.

Copper:

- Absorbed in the form of cupric ions.
- Essential for the overall metabolism in plants.
- Associated with certain enzymes involved in redox reactions and is reversibly oxidized from Cu+ to Cu2+.

Boron :

- Absorbed as absorbed as BO_3^{3-} or $B_4O_7^{2-.}$
- Required for uptake and utilisation of Ca2+, membrane functioning, pollen germination, cell elongation, cell differentiation and carbohydrate translocation.

Molybdenum:

- Absorbed in the form of molybdate ions.
- Component of several enzymes, including nitrogenase and nitrate reductase both of which participate in nitrogen metabolism.

Chlorine:

- Absorbed in the form of chloride anion.
- Helps in determining the solute concentration and the anion-cation balance in cells along with sodium and potassium.
- Essential for the water-splitting reaction in photosynthesis, a reaction that leads to oxygen evolution.

Deficiency-

Deficiency symptoms shown in plants include chlorosis, necrosis, stunted plant growth, premature fall of leaves and buds, and inhibition of cell division.

Chlorosis is the loss of chlorophyll leading to yellowing in leaves. This symptom is caused by the deficiency of elements N, K, Mg, S, Fe, Mn, Zn and Mo.

Necrosis, or death of tissue, particularly leaf tissue, is due to the deficiency of Ca, Mg, Cu, K.

Inhibition of cell division is caused by the lack or low level of N, K, S, Mo.

There is delay in flowering if the concentration of some elements like N, S, Mo in plants is low.

Deficiency of any element can cause multiple symptoms and that the same symptoms may be caused by the deficiency of one of several different elements.

Different plants also respond differently to the deficiency of the same element.

Refer the question materials uploaded in the resources section.