Unit V: Plant Physiology (Functional Organisation)

Chapter 12

Mineral Nutrition

Learning Objectives

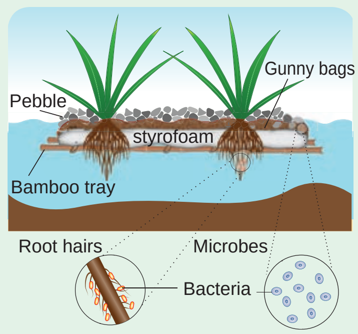
The learner will be able to,

- *Recognise the need of mineral nutrition.*
- *Analyse the classification and criteria for essential minerals.*
- *Learn the techniques of Hydroponics and Aeroponics.*
- *Correlate different types of special modes of nutrition.*
- *Ability to recall and analyse nitrogen fixation.*

Chapter Outline

CN6S1T

A solution to Pollution



A new solution has come up for high nutrient pollution and eutrophication in surface waters. Floating Treatment Wetlands (FTWs) offer promising solution and it is a built structure which measures around 3,000 sq.ft and comprises four layers: floatable bamboo at base, styrofoam second layer, a third layer of gunny bags with gravels and final layer to support cleaning agents (plants). Native plants including Vetivers, *Citronella*, Tulsi and *Withania* are being researched for use as cleaning agents. FTW works on the principle of Hydroponics which is explained in this chapter. Microbes grown on the roots of these plants break down and consume organic matter in water and reduce pollution.

As a traveller you would have got a chance to observe the plants. It is an interesting fact that all plants are not alike. Just spend some time to observe the nature. You can notice plants with attractive leaves, flowers and fruits.

Can you say all plants are healthy and uniform in growth? Some plants are not healthy and show symptoms like texture changes, stunted growth, chlorosis, necrosis and so on. Can you tell what is the reason for all these symptoms? It may be due to infection of microbial pathogens or climatic factors or due to mineral deficiency.

In this chapter we are going to learn about classification of minerals, their functions, deficiency diseases and symptoms, nitrogen metabolism and special modes of nutrition. Further, how can these ideas help us to improve productivity in agriculture?

Plants naturally obtain nutrients from atmosphere, water and soil. Carbon, hydrogen and oxygen are called as skeletal elements and constitute about 94% of dry weight. These elements play an important role in the formation of organic compounds such as carbohydrates, fats and protein. These non-mineral elements are obtained from air and water. Minerals are classified based on essentiality. **Arnon** and **Stout** (1939) gave criteria required for essential minerals:

1. Elements necessary for growth and development.
2. They should have direct role in the metabolism of the plant.
3. It cannot be replaced by other elements.
4. Deficiency makes the plants impossible to complete their vegetative and reproductive phase.

12.1 Classification of minerals

12.1.1 Classification of minerals based on their quantity requirements

Essential elements are classified as **Macro-nutrients, Micronutrients** and **Unclassified minerals** based on their requirements. Essential minerals which are required in higher concentration are called Macronutrients. Essential minerals which are required in less concentration called are as Micronutrients.

Minerals like Sodium, Silicon, Cobalt and Selenium are not included in the list of essential nutrients but are required by some plants, these minerals are placed in the list of unclassified minerals. These minerals play specific roles for example, Silicon is essential for pest resistance, prevent water lodging and aids cell wall formation in Equisetaceae (*Equisetum*), Cyperaceae and Gramineae (Table 12. 1).

12.1.2 Classification of minerals based on mobility

If you observe where the deficiency symptoms appear first, you can notice differences in old and younger leaves. It is mainly due to mobility of minerals. Based on this, they are classified into 1. Actively mobile minerals and 2. Relatively immobile minerals (Figure 12.1).

a. Actively mobile minerals

Nitrogen, Phosphorus, Potassium, Magnesium, Chlorine, Sodium, Zinc and Molybdenum.

Deficiency symptoms first appear on old and senescent leaves due to active movement of minerals to younger leaves.

b. Relatively immobile minerals

Calcium, Sulphur, Iron, Boron and Copper shows deficiency symptoms first that appear

Table 12.1: Mineral Types

Macro nutrients	Micro nutrients	Unclassified minerals
Excess than 10 mmole Kg-1 in tissue concentration or 0.1 to 10 mg per gram of dry weight.	Less than 10 mmole Kg-1 in tissue concentration or equal or less than 0.1 mg per gram of dry weight.	Required for some plants in trace amounts and have some specific functions.
Example: C, H, O, N, P, K, Ca, Mg and S	Example: Fe, Mn, Cu, Mo, Zn, B, Cl and Ni	Example: Sodium, Cobalt, Silicon and Selenium

on young leaves due to the immobile nature of minerals

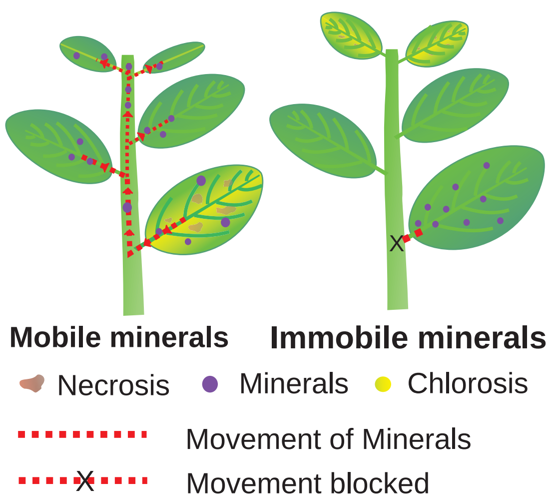


Figure 12.1: Mobility of Minerals

12.1.3 Classification of minerals based on their functions

a. **Structural component minerals**: Minerals like Carbon, Hydrogen, Oxygen and Nitrogen

b. **Enzyme function**: Molybdenum (Mo) is essential for nitrogenase enzyme during reduction of atmospheric nitrogen into ammonia. Zinc (Zn)is an important activator for alcohol dehydrogenase and carbonic anhydrase. Magnesium (Mg) is the activator for RUBP carboxylase-oxygenase and PEP carboxylase. Nickel (Ni) is a constituent of urease and hydrogenase.

c. **Osmotic Potential:** Potassium (K) plays a key role in maintaining osmotic potential of the cell. The absorption of water, movement of stomata and turgidity are due to osmotic potential.

d. **Energy components**: Magnesium (Mg) in chlorophyll and phosphorous (P) in ATP.

12.2 Functions, mode of absorption and deficiency symptoms of macronutrients

Macronutrients, their functions, their mode of absorption, deficiency symptoms and deficiency diseases are discussed here:

1. **Nitrogen (N):** It is required by the plants in greatest amount. It is an essential component of proteins, nucleic acids, amino acids, vitamins, hormones, alkaloids, chlorophyll and cytochrome. It is absorbed by the plants as nitrates (NO_3).

   Deficiency symptoms: Chlorosis, stunted growth, anthocyanin formation.

2. **Phosphorus (P):** Constituent of cell membrane, proteins, nucleic acids, ATP, NADP, phytin and sugar phosphate. It is absorbed as $H_2PO_4^{+}$ and HPO_4^{-} ions.

   Deficiency symptoms: Stunted growth, anthocyanin formation, necrosis, inhibition of cambial activity, affect root growth and fruit ripening.

3. **Potassium (K):** Maintains turgidity and osmotic potential of the cell, opening and closure of stomata, phloem translocation, stimulate activity of enzymes, anion and cation balance by ion-exchange. It is absorbed as K^+ ions.

   Deficiency symptoms: Marginal chlorosis, necrosis, low cambial activity, loss of apical dominance, lodging in cereals and curled leaf margin.

4. **Calcium (Ca):** It is involved in synthesis of calcium pectate in middle lamella, mitotic spindle formation, mitotic cell division, permeability of cell membrane, lipid metabolism, activation of phospholipase, ATPase, amylase and activator of adenyl kinase. It is absorbed as Ca^{2+} exchangeable ions.

   Deficiency symptoms: Chlorosis, necrosis, stunted growth, premature fall of leaves and flowers, inhibit seed formation, Black heart of Celery, Hooked leaf tip in Sugar beet, *Musa* and Tomato.

5. **Magnesium (Mg):** It is a constituent of chlorophyll, activator of enzymes of carbohydrate metabolism (RUBP

Carboxylase and PEP Carboxylase) and involved in the synthesis of DNA and RNA. It is essential for binding of ribosomal sub units. It is absorbed as Mg^{2+} ions.

Deficiency symptoms: Inter veinal chlorosis, necrosis, anthocyanin (purple) formation and Sand drown of tobacco.

6. **Sulphur (S):** Essential component of amino acids like cystine, cysteine and methionine, constituent of coenzyme A, Vitamins like biotin and thiamine, constituent of proteins and ferredoxin. plants utilise sulphur as sulphate (SO_4^-) ions.

   Deficiency symptoms: Chlorosis, anthocyanin formation, stunted growth, rolling of leaf tip and reduced nodulation in legumes.

> DO YOU KNOW?
>
> **NPK Fertilizers**
>
> It consists of nitrogen, phosphate with potassium in different proportions. The number labelled on the bags as 15:15:15 indicates N, P & K in equal proportions.

12.3 Functions, mode of absorption and deficiency symptoms of micronutrients

Micronutrients even though required in trace amounts are essential for the metabolism of plants. They play key roles in many plants. Example: Boron is essential for translocation of sugars, molybdenum is involved in nitrogen metabolism and zinc is needed for biosynthesis of auxin. Here, we will study about the role of micro nutrients, their functions, their mode of absorption, deficiency symptoms and deficiency diseases.

1. **Iron (Fe):** Iron is required lesser than macronutrient and larger than micronutrients, hence, it can be placed in any one of the groups. Iron is an essential element for the synthesis of chlorophyll and carotenoids. It is the component of cytochrome, ferredoxin, flavoprotein, formation of chlorophyll, porphyrin, activation of catalase, peroxidase enzymes. It is absorbed as ferrous (Fe^{2+}) and ferric (Fe^{3+}) ions. Absorbtion of Fe^{2+} ions are comparitively more than Fe^{3+} ions. Mostly fruit trees are sensitive to iron.

   Deficiency: Interveinal Chlorosis, formation of short and slender stalk and inhibition of chlorophyll formation.

2. **Manganese (Mn):** Activator of carboxylases, oxidases, dehydrogenases and kinases, involved in splitting of water to liberate oxygen (photolysis). It is absorbed as manganous (Mn^{2+}) ions.

   Deficiency: Interveinal chlorosis, grey spot on oats leaves and poor root system.

3. **Copper (Cu):** Constituent of plastocyanin, component of phenolases, tyrosinase, enzymes involved in redox reactions, synthesis of ascorbic acid, maintains carbohydrate and nitrogen balance, part of oxidase and cytochrome oxidase. It is absorbed as cupric (Cu^{2+}) ions.

   Deficiency: Die back of citrus, Reclamation disease of cereals and legumes, chlorosis, necrosis and Exanthema in *Citrus*.

4. **Zinc (Zn):** Essential for the synthesis of Indole acetic acid (Auxin), activator of carboxylases, alcohol dehydrogenase, lactic dehydrogenase, glutamic acid dehydrogenase, carboxy peptidases and tryptophan synthetase. It is absorbed as Zn^{2+} ions.

   Deficiency: Little leaf and mottle leaf due to deficiency of auxin, Inter veinal chlorosis, stunted growth, necrosis and Khaira disease of rice.

5. **Boron (B):** Translocation of carbohydrates, uptake and utilisation of Ca^{++}, pollen germination, nitrogen metabolism, fat metabolism, cell elongation and differentiation. It is absorbed as (borate) BO^{3-} ions.

   Deficiency: Death of root and shoot tips, premature fall of flowers and fruits, brown heart of beet root, internal cork of apple and fruit cracks.

6. **Molybdenum (Mo):** Component of nitrogenase, nitrate reductase, involved in nitrogen metabolism, and nitrogen fixation. It is absorbed as molybdate (Mo^{2+}) ions.

   Deficiency: Chlorosis, necrosis, delayed flowering, retarded growth and whip tail disease of cauliflower.

7. **Chlorine (Cl):** It is involved in Anion – Cation balance, cell division, photolysis of water. It is absorbed as Cl^{-} ions.

   Deficiency: Wilting of leaf tips

8. **Nickel (Ni):** Cofactor for enzyme urease and hydrogenase.

   Deficiency: Necrosis of leaf tips.

DO YOU KNOW?

Calmodulin

Calmodulin is a Ca^{2+} modulating protein in eukaryotic cells. It is a heat stable protein involved in fine metabolic regulations.

Activity

Collect leaves showing mineral deficiency. Tabulate the symptoms like Marginal Chlorosis, Interveinal Chlorosis, Necrotic leaves, Anthocyanin formation in leaf, Little leaf and Hooked leaf. (Discuss with your teacher about the deficiency of minerals)

12.4 Deficiency diseases and symptoms

The following table (Table 12.2) gives you an idea about Minerals and their Deficiency symptoms:

Table 12.2: Deficiency diseases and Symptoms

Name of the deficiency disease and symptoms	Deficiency minerals
1. Chlorosis (Overall)	Nitrogen, Potassium, Magnesium, Sulphur, Iron, Manganese, Zinc and Molybdenum.
a. Interveinal chlorosis	Magnesium, Iron, Manganese and Zinc
b. Marginal chlorosis	Potassium
2. Necrosis (Death of the tissue)	Magnesium, Potassium, Calcium, Zinc, Molybdenum and Copper.
3. Stunted growth	Nitrogen, Phosphorus, Calcium, Potassium and Sulphur.
4. Anthocyanin formation	Nitrogen, Phosphorus, Magnesium and Sulphur
5. Delayed flowering	Nitrogen, Sulphur and Molybdenum
6. Die back of shoot, Reclamation disease, Exanthema in citrus (gums on bark)	Copper
7. Hooked leaf tip	Calcium
8. Little Leaf	Zinc
9. Brown heart of Beet root and Internal cork of apple	Boron
10. Whiptail of cauliflower and cabbage	Molybdenum
11. Curled leaf margin	Potassium

12.5 Critical concentration and toxicity of minerals

12.5.1 Critical Concentration

To increase the productivity and also to avoid mineral toxicity knowledge of critical concentration is essential. Mineral nutrients lesser than critical concentration cause deficiency symptoms. Increase of mineral nutrients more than the normal concentration causes toxicity. A concentration, at which 10 % of the dry weight of tissue is reduced, is considered as toxic. Figure 12.2 explains about Critical Concentration.

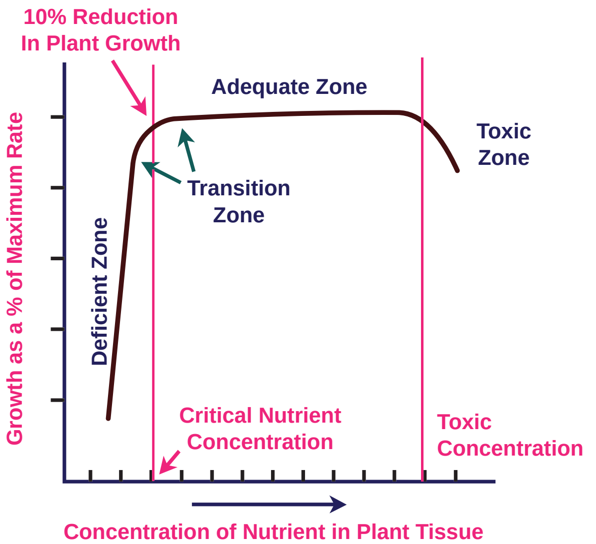


Figure 12.2: Critical Concentration

12.5.2 Mineral Toxicity

a. Manganese toxicity

Increased Concentration of Manganese will prevent the uptake of Fe and Mg, prevent translocation of Ca to the shoot apex and cause their deficiency. The symptoms of manganese toxicity are appearance of brown spots surrounded by chlorotic veins.

b. Aluminium Toxicity

Aluminium toxicity causes precipitation of nucleic acid, inhibition of ATPase, inhibition of cell division and binding of plasma membrane with Calmodulin.

For theories regarding, translocation of minerals please refer Chapter- 11.

12.6 Hydroponics and Aeroponics

1. **Hydroponics or Soilless culture: Von Sachs** developed a method of growing plants in nutrient solution. The commonly used nutrient solutions are **Knop solution** (1865) and **Arnon** and **Hoagland Solution** (1940). Later the term Hydroponics was coined by **Goerick** (1940) and he also introduced commercial techniques for hydroponics. In hydroponics roots are immersed in the solution containing nutrients and air is supplied with help of tube (Figure 12.3).

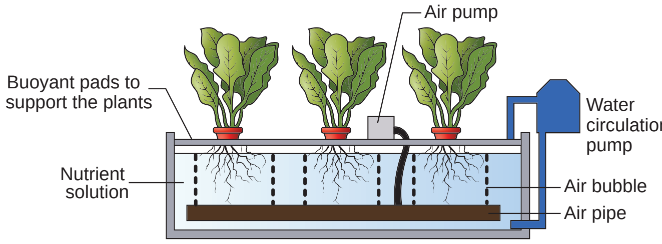


Figure 12.3: Hydroponics

Aeroponics: This technique was developed by **Soifer Hillel** and **David Durger**. It is a system where roots are suspended in air and nutrients are sprayed over the roots by a motor driven rotor (Figure 12.4).

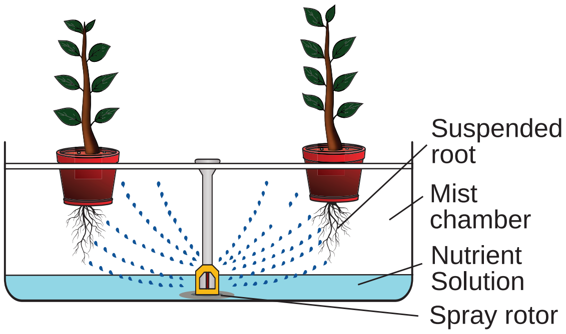


Figure 12.4: Aeroponics

12.7 Nitrogen Fixation

Inspiring act of nature is self-regulation. As all living organisms act as tools for biogeochemical cycles, nitrogen cycle is highly regulated. Life on earth depends on nitrogen cycle. Nitrogen occurs in atmosphere in the form of N_2 (N≡N), two nitrogen atoms joined together by strong triple covalent bonds. The process of converting atmospheric nitrogen (N_2) into ammonia is termed as nitrogen fixation. Nitrogen fixation can occur by two methods: 1. Biological; 2. Non-Biological (Figure 12.5).

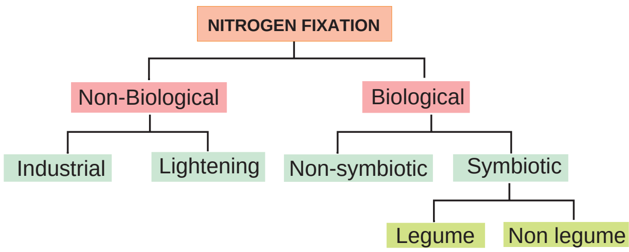


Figure 12.5: Nitrogen fixation

Activity

Preparation of Solution Culture to find out Mineral Deficiency

1. Take a glass jar or polythene bottle and cover with black paper (to prevent algal growth and roots reacting with light).
2. Add nutrient solution.
3. Fix a plant with the help of split cork.
4. Fix a tube for aeration.
5. Observe the growth by adding specific minerals.

12.7.1 Non – Biological nitrogen fixation

- Nitrogen fixation by chemical process in industry.
- Natural electrical discharge during lightening fixes atmospheric nitrogen.

12.7.2 Biological nitrogen fixation

Symbiotic bacterium like *Rhizobium* fixes atmospheric nitrogen. Cyanobacteria found in Lichens, *Anthoceros, Azolla* and coralloid roots of *Cycas* also fix nitrogen. Non-symbiotic (free living bacteria) like *Clostridium* also fix nitrogen.

a. Symbiotic nitrogen fixation

i. Nitrogen fixation with nodulation

Rhizobium bacterium is found in leguminous plants and fix atmospheric nitrogen. This kind of symbiotic association is beneficial for both the bacterium and plant. Root nodules are formed due to bacterial infection. *Rhizobium* enters into the host cell and proliferates, it remains separated from the host cytoplasm by a membrane (Figure 12.6).

Iron and Manganese toxicity

Iron and Manganese exhibit competitive behaviour. Deficiency of Fe and Mn shows similar symptoms. Iron toxicity will affect absorption of manganese. The possible reason for iron toxicity is excess usage of chelated iron in addition with increased acidity of soil (PH less than 5.8) Iron and manganese toxicity will be solved by using fertilizer with balanced ratio of Fe and Mn.

Stages of Root nodule formation:

1. Legume plants secretes phenolics which attracts *Rhizobium*.
2. *Rhizobium* reaches the rhizosphere and enters into the root hair, infects the root hair and leads to curling of root hairs.
3. Infection thread grows inwards and separates the infected tissue from normal tissue.

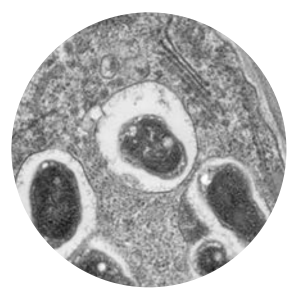


Figure 12.6: Rhizobium (Bacteroid) in root nodule

4. A membrane bound bacterium is formed inside the nodule and is called **bacteroid**.
5. Cytokinin from bacteria and auxin from host plant promotes cell division and leads to nodule formation

Activity

- Collect roots of legumes with root nodules.
- Take cross section of the root nodule.
- Observe under microscope. Discuss your observations with your teacher.

Non-Legume

Alnus and Casuarina contain the bacterium *Frankia. Psychotria* contains the bacterium *Klebsiella.*

ii. Nitrogen fixation without nodulation

The following plants and prokaryotes are involved in nitrogen fixation.

Lichens	-	*Anabaena* and *Nostoc*
Anthoceros	-	*Nostoc*
Azolla	-	*Anabaena azollae*
Cycas	-	*Anabaena* and *Nostoc*

b. Non-symbiotic Nitrogen fixation

Free living bacteria and fungi also fix atmospheric nitrogen.

Aerobic	*Azotobacter, Beijerinckia and Derxia*
Anaerobic	*Clostridium*
Photosynthetic	*Chlorobium and Rhodospirillum*
Chemosynthetic	*Disulfovibrio*
Free living fungi	Yeast and *Pullularia*
Cyanobacteria	*Nostoc, Anabaena and Oscillatoria.*

12.8 Nitrogen cycle and nitrogen metabolism

12.8.1 Nitrogen cycle

This cycle consists of following stages:

1. Fixation of atmospheric nitrogen

CNFN3G

Di-nitrogen molecule from the atmosphere progressively gets reduced by addition of a pair of hydrogen atoms. Triple bond between two nitrogen atoms (N≡N) are cleaved to produce ammonia (Figure 12.7).

Nitrogen fixation process requires Nitrogenase enzyme complex, Minerals (Mo, Fe and S), anaerobic condition, ATP, electron and glucose 6 phosphate as H^+ donor. Nitrogenase enzyme is active only in anaerobic condition. To create this anaerobic condition a pigment known as **leghaemoglobin** is synthesized in the nodules which acts as oxygen scavenger and removes the oxygen. Nitrogen fixing bacteria in root nodules appears pinkish due to the presence of this leghaemoglobin pigment.

Overall equation:

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

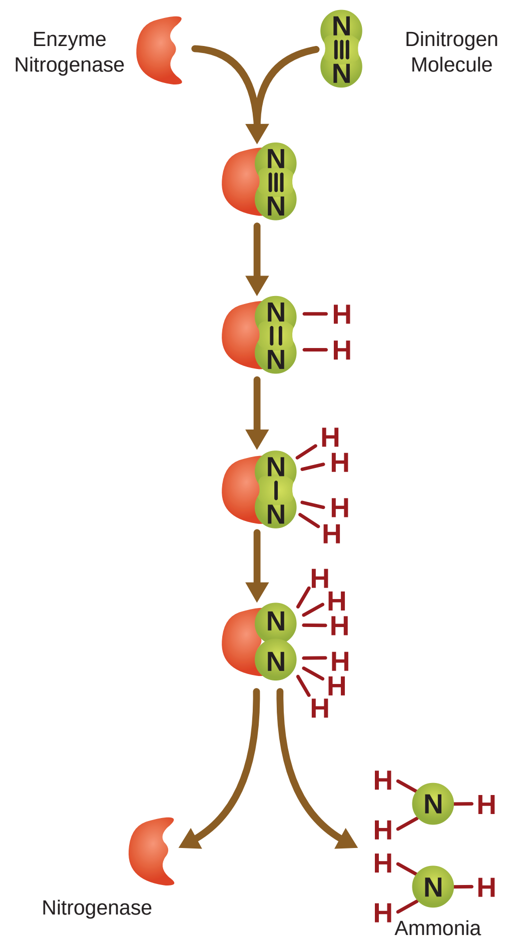


Figure 12.7: Nitrogenase enzyme function

2. Nitrification

Ammonia (NH_3^+) is converted into Nitrite (NO_2^-) by *Nitrosomonas* bacterium. Nitrite is then converted into Nitrate (NO_3^-) by *Nitrobacter* bacterium.

Plants are more adapted to absorb nitrate (NO_3^-) than ammonium ions from the soil.

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

$$2\ NO_2^- + O_2 \xrightarrow{\textit{Nitrobacter}} 2\ NO_3^-$$

3. Nitrate Assimilation

The process by which nitrate is reduced to ammonia is called **nitrate assimilation** and occurs during nitrogen cycle.

$$NO_3^- \xrightarrow[\text{Mo}]{\text{Nitrate reductase}} NO_2^-$$

$$NO_2^- \xrightarrow[\text{Cu, Fe}]{\text{Nitrite reductase}} NH_3^+$$

4. Ammonification

Decomposition of organic nitrogen (proteins and amino acids) from dead plants and animals into ammonia is called **ammonification**. Organisim involved in this process are *Bacillus ramosus* and *Bacillus vulgaris*.

5. Denitrification

Nitrates in the soil are converted back into atmospheric nitrogen by a process called **denitrification**. Bacteria involved in this process are *Pseudomonas*, *Thiobacillus* and *Bacillus subtilis*.

$$\text{Nitrate } (NO_3^-) \xrightarrow{\textit{Pseudomonas}} \text{Molecular Nitrogen } (N_2)$$

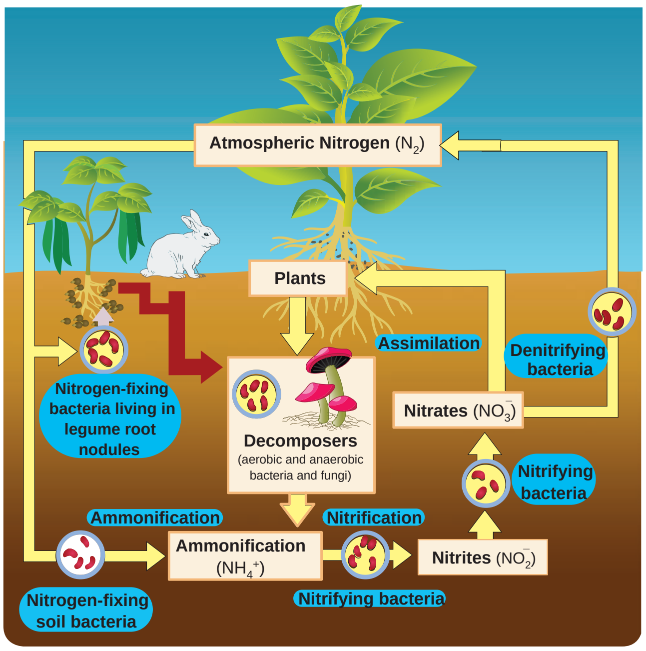


Figure 12.8: Nitrogen Cycle

The overall process of nitrogen cycle is given in Figure 12.8.

12.8.2 Nitrogen Metabolism Ammonium Assimilation (Fate of Ammonia)

Ammonia is converted into amino acids by the following processes:

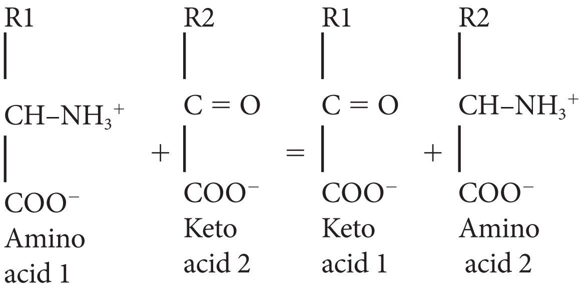
1. Reductive amination

Glutamic acid or glutamate is formed by reaction of ammonia with α-ketoglutaric acid.

$$\alpha\text{-Ketoglutaric acid} + NH_4^+ \xrightarrow[NADPH+H^+ \;\to\; NADP^+]{\text{Glutamate dehydrogenase (GDH)}} \text{Glutamate} + H_2O$$

2. Transamination

Transfer of amino group (NH_3^+) from glutamic acid (glutamate) to keto group of keto acid. Glutamic acid is the main amino acid from which other amino acids are synthesised by transamination. Transamination requires the enzyme transaminase and co enzyme pyridoxal phosphate (derivative of vitamin B6 -pyridoxine)



3. Catalytic Amination: (GS/GOGAT Pathway)

Glutamate amino acid combines with ammonia to form the amide glutamine.

$$\text{Glutamate} + NH_4^+ \xrightarrow[ATP \;\to\; ADP + Pi]{\text{Glutamine Synthetase (GS)}} \text{Glutamine.}$$

Glutamine reacts with α ketoglutaric acid to form two molecules of glutamate.

$$\text{Glutamine} + \underset{\text{(2- oxoglutarate)}}{\alpha\text{ Ketoglutaric acid}} \xrightarrow[NADH+H^+ \;\to\; NAD^+]{\text{GOGAT (enzyme)}} 2\text{ Glutamate}$$

(GOGAT- Glutamine-2-Oxoglutarate aminotransferase)

12.9 Special modes of nutrition

Nutrition is the process of uptake and utilization of nutrients by living organisms. There are two main types such as **autotrophic** and **heterotrophic** nutrition. Autotrophic nutrition is further divided into **photosynthetic** and **chemosynthetic** nutrition. Heterotrophic nutrition is further divided into saprophytic, parasitic, symbiotic and insectivorous type. In this topic you are going to learn about special mode of nutrition.

12.9.1 Saprophytic mode of nutrition in angiosperms

Saprophytes derive nutrients from dead and decaying matter. Bacteria and fungus are main saprophytic organisms. Some angiosperms also follow saprophytic mode of nutrition. Example: *Neottia*. Roots of *Neottia* (Bird's Nest Orchid) associate with mycorrhizae and absorb nutrients as a saprophyte. *Monotropa* (Indian Pipe) grow on humus rich soil found in thick forests. It absorbs nutrient through mycorrhizal association (Figure 12.9).

Neottia (Bird's Nest Orchid) ***Monotropa*** (Indian Pipe)

Figure 12.9: Saprophytic Mode of nutrition

12.9.2 Parasitic mode of nutrition in angiosperms

Organisms deriving their nutrient from another organism (host) and causing disease to the host are called parasites.

a. **Obligate or Total parasite** - Completely depends on host for their survival and produces haustoria.

i. **Total stem parasite**: The leafless stem twine around the host and produce haustoria. Example: *Cuscuta* (Dodder), a rootless plant growing on *Zizyphus*, *Citrus* and so on.

ii. **Total root parasite**: They do not have stem axis and grow in the roots of host plants produce haustoria. Example: *Rafflesia*, *Orobanche* and *Balanophora*.

b. **Partial parasite** - Plants of this group contain chlorophyll and synthesize carbohydrates. Water and mineral requirements are dependent on host plant.

i. **Partial Stem Parasite**: Example: *Loranthus* and *Viscum* (Mistletoe) *Loranthus* grows on fig and mango trees and absorb water and minerals from xylem.

ii. **Partial root parasite**: Example: *Santalum album* (Sandal wood tree) in its juvenile stage produces haustoria which grows on roots of many plants (Figure 12.10).

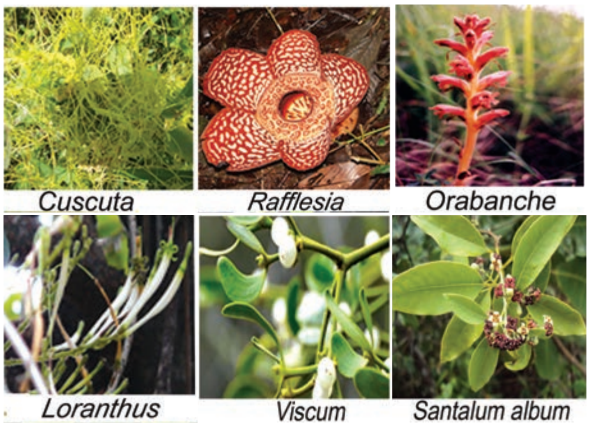


Figure 12.10: Parasitic Mode of Nutrition

12.9.3 Symbiotic mode of Nutrition

a. **Lichens**: It is a mutual association of Algae and Fungi. Algae prepares food and fungi absorbs water and provides thallus structure.

b. **Mycorrhizae**: Fungi associated with roots of higher plants including Gymnosperms. Example: *Pinus*.

c. ***Rhizobium* and Legumes**: This symbiotic association fixes atmospheric nitrogen

d. **Cyanobacteria and Coralloid Roots**: This association is found in *Cycas* where *Nostoc* associates with its coralloid roots. (Figure 12.11).

Figure 12.11: Symbiotic mode of nutrition

12.9.4 Insectivorous mode of nutrition

Plants which are growing in nitrogen deficient areas develop insectivorous habit to resolve nitrogen deficiency. These plants obtain nitrogen from the insects

a. ***Nepenthes*** (Pitcher plant): Pitcher is a modified leaf and contains digestive enzymes. Rim of the pitcher is provided with nectar glands and acts as an attractive lid. When insect is trapped, proteolytic enzymes will digest the insect.

b. ***Drosera*** (Sundew): It consists of long club shaped leaves with tentacles that secrete sticky digestive fluid which looks like a sundew and attracts insects.

c. ***Utricularia*** (Bladder wort): Submerged plant in which leaf is modified into a bladder to collect insect in water.

d. ***Dionaea*** (Venus fly trap): Leaf of this plant modified into a colourful trap. Two folds of lamina consist of sensitive trigger hairs and when insects touch the hairs it will close and traps the insects.(Figure 12.12).

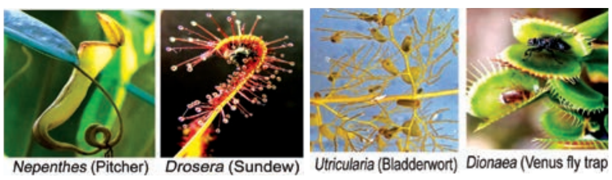


Figure 12.12: Insectivorous mode of nutrition

> **DO YOU KNOW?**
> Lichens are indicators of SO_2 pollution and a pioneer species in xeric succession.

> **Check your grasp!**
> Mineral X required for the activation of enzyme nitrogenase, Mineral Y involved in transport of sugar and Mineral Z required for maintaining ribosome structure. Identify X, Y and Z.

Summary

Sources of minerals for plants are atmosphere, water and soil. Minerals are classified based on their quantity, mobility and functions. Macro nutrients (C, H, O, N, P, K, Ca, Mg and S) are required in higher concentration and micro nutrients (Fe, Mn, Cu, Zn, B, Mo, Cl and Ni) are required in lesser concentration. Minerals like Sodium, Cobalt, Silicon and Selenium are required by some plants for specific functions and such minerals are grouped as unclassified minerals. Actively mobile elements are N, P, K, Mg, Cl, Na, Zn and Mo. The deficiency symptoms for these minerals first appear on old and senescent leaves due to active movement of minerals to younger leaves. Relatively immobile elements are Ca, S, Fe, B and Cu. In such minerals, deficiency symptoms first appear on young leaves due to immobile nature. Minerals and their deficiency symptoms include chlorosis (loss of chlorophyll pigments), necrosis (death of tissue), anthocyanin formation, die back of shoot, exanthema, hooked leaf tip, whiptail and so on. A concentration at which 10% of dry weight is reduced is considered as critical concentration. Minerals used in excess concentration become toxic.

Soil less cultivation alleviates problems due to mineral deficiency. It includes hydroponics and aeroponics. Hydroponics is a method of growing plants in a nutrient solution. Aeroponics is the technique in which roots are suspended in air and nutrient sprayed over the roots by motor driven rotor. Nitrogen is an important requirement for normal growth and functioning of a plant. Nitrogen fixing organisms fix nitrogen from atmosphere naturally through symbiotic and non-symbiotic modes. Special modes of nutrition are seen in plant which grew in nutrient deficient soils and the character becomes permanent.

Evaluation

1. Identify correct match.

   1. Die back disease of citrus - (i) Mo
   2. Whip tail disease - (ii) Zn
   3. Brown heart of turnip - (iii) Cu
   4. Little leaf - (iv) B

a.	1 (iii)	2 (ii)	3 (iv)	4 (i)
b.	1 (iii)	2 (i)	3 (iv)	4 (ii)
c.	1 (i)	2 (iii)	3 (ii)	4 (iv)
d.	1 (iii)	2 (iv)	3 (ii)	4 (i)

2. If a plant is provided with all mineral nutrients but, Mn concentration is increased, what will be the deficiency?
   a. Mn prevent the uptake of Fe, Mg but not Ca
   b. Mn increase the uptake of Fe, Mg and Ca
   c. Only increase the uptake of Ca
   d. Prevent the uptake Fe, Mg, and Ca

3. The element which is not remobilized?
   a. Phosphorous b. Potassium
   c. Calcium d. Nitrogen

4. Match the correct combination.

	Minerals		Role
A	Molybdenum	1	Chlorophyll
B	Zinc	2	Methionine
C	Magnesium	3	Auxin
D	Sulphur	4	Nitrogenase

a. A-1 B-3 C-4 D-2
b. A-2 B-1 C-3 D-4
c. A-4 B-3 C-1 D-2
d. A-4 B-2 C-1 D-3

5. Identify the correct statement
   i. Sulphur is essential for amino acids Cystine and Methionine
   ii. Low level of N, K, S and Mo affect the cell division
   iii. Non-leguminous plant Alnus which contain bacterium *Frankia*
   iv. Denitrification carried out by nitrosomonas and nitrobacter.

   a. I, II are correct
   b. I, II, III are correct
   c. I only correct
   d. all are correct

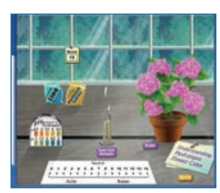
CNPJ54

6. The nitrogen is present in the atmosphere in huge amount but higher plants fail to utilize it. Why?
7. Why is that in certain plants deficiency symptoms appear first in younger parts of the plants while in others, they do so in mature organs?
8. Plant A in a nutrient medium shows whiptail disease plant B in a nutrient medium shows a little leaf disease. Identify mineral deficiency of plant A and B?
9. Write the role of nitrogenase enzyme in nitrogen fixation?
10. Explain the insectivorous mode of nutrition in angiosperms?

ICT Corner

Role of Minerals In Plant Growth

Let's try to make the **plant blossom** →

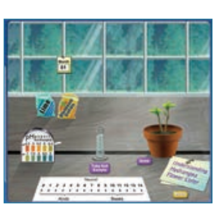


Steps

- Scan the QR code
- Start a new game
- Add lime
- Test the Soil pH by test the sample press grows
- Do it for combination of minerals

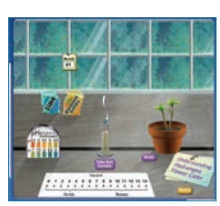
Activity

- Change the combination of minerals and test the soil samples
- Find the correct proportion of chemical and specific pH for flowering
- Conclude your observations.

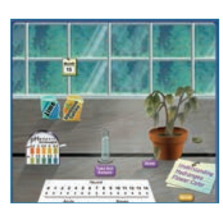


Step 1

Step 2



Step 3



Step 4

Web URL:
http://www.glencoe.com/sites/common_assets/science/virtual_labs/BL04/BL04.html

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* Pictures are indicative only