MINERAL NUTRITION

- Absorption and utilisation of minerals by plants is called as **mineral nutrition.**
- **Aristotle** suggested that plants are made of soil material.
- **John Woodward** conducted experiments on spearmint plant and established the **essentiality of soil** for plant growth.
- **De Saussure** observed that plants grown in dilute soil solution gained more weight than the plants grown in distilled water.
- **Julius Sachs** and **W. Knops** discovered some of the essential elements required for plant growth by water culture experiments.

Criteria of Essentiality

- A given plant has about **30 – 40** elements. In various plants of the plant kingdom about **70** elements are present.
- **Daniel Arnon** and **Perry Stout** proposed three criteria to determine the essentiality of elements.

1. An element is essential for the completion of vegetative or reproductive growth or both forms of growth.
2. The requirement of the element is **specific** and **not replaced** by some other element.
3. The element must be directly involved in the **metabolism**.

- By applying the above criteria, **16** elements were found to be essential. They are C, H, O, N, P, K, Ca, Mg, S, Fe, Mn, Zn, B, Cu, Mo and Cl. All other elements are non-essential elements.
- Those essential elements present in more than 1ppm concentrations in the plant body are called as **Macro elements** or **Major elements**. These are C, H, O, N, P, K, Ca, Mg and S.
- Those essential elements present in less than 1 ppm concentrations in the plant body are called as **Microelements** or **Trace elements** or **Minor elements**. These are Fe, Mn, Zn, B, Cu, Mo and Cl.

Absorption of Ions

- **13** elements are absorbed in the form of **ions**.
- **Hoagland**, **Knops**, **Epstein** carried out ion absorption experiments.
- Roots, leaf discs, storage roots, giant algal cells are used as experimental materials to study ionic absorption.
- Ions are absorbed by passive and active absorption.

Passive absorption

- It is absorption of ions according to concentration gradient without utilising metabolic energy.
- It is propelled by physical forces and also known as **non-metabolic type** of ion absorption.

Active absorption

- It is absorption of ions against concentration gradient by utilising metabolic energy.
- It helps in maintaining high solute concentration in the plant than soil solution.
- **Nitella** shows high K^+ concentration in its cells than soil solution.
- Non-accumulation of ions in plant cells, when metabolic inhibitors such as **cyanide** and **Azide** are used is evidence for active absorption of ions.
- Unit membrane of plants have specific ion carrying proteins known as **carriers**. These are **ion specific.**
- Carrier proteins are of two types known as **Uniporters** and **Co-transporters.**
- If a carrier carries one ion either form inside to outside or outside to inside, it is known as **Uniporter**. The phenomenon of carrying the ions is known as Uniport. e.g. **H^+ATP ase** and **Na^+ ATPase.**
- If a carrier carries two different ions, it is known as co-transporter and the phenomenon is known as co-transport.
- Co-transporters are of two types known as 1.Symporters and 2. Antiporters
- Symporter carries ions (Cat ions, Anions) in the same direction. The phenomenon is called as symport.
  E.g. the movement of H^+ coupled with **NO_3^-, Cl^-, PO_4^{--},** Sucrose and Amino acid.
- An antiporter carries one ion in one direction and the other ion in opposite direction. This transport is called as Antiport. Ex: Inward movement of **H^+** coupled with outward movement of **Na^+.**
- Binding of ion to the carrier brings about confirmational **change** in the carrier and the ion (substance) is exposed to the solution of other side. Now the ion is released from the **binding** site.

Active Transport of Ions mediated by H^+ ATPase pump

- H^+ are extruded out of the cell by H^+ ATPase of plasma membrane by utilising the energy liberated during the hydrolysis of ATP. This results in establishing H^+ gradient across the membrane. This movement of H^+ by utilising the energy liberated during the hydrolysis of ATP is called as **Primary active transport.**
- Proton gradient causes **Proton Motive Force**. This energy is reason for flow back of **H^+** into cytosol and it is associated with transport of other substances by the same carrier. This is known as **secondary active transport.**
- During secondary transport, a confirmational change in the bound carrier proteins takes place and finally the substance is released towards the other side. It involves either symport or antiport.
- H^+ are transported out by primary active transport. It utilises ATP.

- Flow back of H^+ into cytosol takes place by secondary active transport. It utilises the energy of Proton Motive Force.
- Salt resistant plants extrude out Na^+ by antiport.

Bio-fertilisers

- These are the living organisms used as nutrient inputs for plant growth.

1. Rhizobium Inoculants

- These are used to increase legume crop production.
- Rhizobium inoculants are industrially produced in several countries.
- There are several strains of Rhizobia.
- Rhizobium inoculants are applied to the legume seeds with **gum** or **Carboxy Methyl Cellulose** and the seeds are sown in the field.
- Plants developed from Rhizobium applied seeds show better growth and yield due to the formation of more and large root nodules.

2. *Azospirillum*

- It is an **associated symbiont** in Maize, Sorghum, Wheat, Barley and Finger millet.
- It fixes atmospheric nitrogen and secretes some **growth promoting substances.**
- Seed dressing with bacteria (*Azotobacter, Azospirillum* and *Rhizobium*) is known as *Bacterisation*. It reduces environmental pollution.
- *Azotobacter* is free living and *Azospirillum* is associate bacterium.
- **Peat, Lignite, Farmyard** manure and **Charcoal** powder are used as Carriers to mix the cultures of bacteria.

3. Cyanobacteria

- BGA such as *Nostoc* and *Anabaena* fix atmospheric nitrogen either independently or in symbiotic association.
- Blue Green Algae are used in **Japan** to increase Rice production.
- Farmers can develop cyanobacterial inoculents in their field by following simple procedures. These develop as dense mats.
- These mats are to be cut into small fragments of blocks and can be introduced into rice fields.
- **10 kg** of BGA per hectare gives better yield.
- Algalisation was the term used by **Venkataraman** for use of **BGA** culture in the field. He introduced algalisation technology in our country.
- It is practiced in A.P., Karnataka, Tamil Nadu, Haryana, Jammu and Kashmir and **Maharashtra.**

4. Azolla

- It is a water fern. Mesophyll of its leaves has *Anabaena azollae* as endosymbiont.
- Its importance as endosymbiont was first demonstrated in *Vietnam.*
- It adds **30 – 40 kg** of nitrogen per hectare in Paddy fields.
- It can be inoculated to rice fields prior to transplantation.
- After transplantation, water is drained and **Azolla** is incorporated.
- **Azolla pinnata** has tolerance to heavy metals such as **Cd, Hg, Pb** and **Cr**. It is used as **green manure** in paddy fields of heavy metal polluted areas.

Mycorrhiza

- Association of roots of higher plants with fungal mycelia is known as Mycorrhiza.
- In **Ecotmycorrhiza**, fungi are present on the surface of roots. Usually root hairs are absent. Fungi help in absorption of water.
- In **Endomycorrhizae**, the fungus enters into the cortical cells.
- In **Ectendomycorrhizae**, the fungi are present externally and internally.
- Endomycorrhizae form vesicles and arbuscules inside the host. They are known as VAM. All mycorrhizae do form arbuscules but not form vesicles. Hence these are called as AM fungi. These increase phosphate absorption. Yield of potato, red gram, wheat, soybean, maize etc. is increased by using AM fungi. Eg. **Glomus.**
- VM inoculum increases plant growth, yield, **resistance** to **environmental stress** and **pests.**

Importance of Biofertilisers

1. The use of harmful chemical fertilisers can be decreased.
2. These are eco-friendly and do not cause any environmental pollution problem.
3. These are economical and even farmers can prepare by following some simple procedures.
4. Its production does not require any energy in the form of fossil fuels.
5. Crop produce does not contain any fertiliser residue.
6. Some bio-fertilisers like Azolla are resistant to heavy metal pollution and can be used in polluted areas.
7. Some bio-fertilisers not only increase the yield but also resistance against environmental stress and pests.