Unit 4: Phosphobacteria and Mycorrhizae biofertilizers

I. Phosphate solubilising Microorganisms (PSM): These Phosphate solubilizing microorganisms participate in the conversion of insoluble phosphates into soluble and usable form of phosphate.

Phosphate solubilizing microorganisms are able to **solubilize** insoluble forms of inorganic P and also **mineralize** organic forms of P, thus improving the availability of P to plants through soil. Thus **PSM biofertilizer** being economical and environmentally safe offers a viable alternative to chemical fertilizers.

Examples of PSM: Several soil bacteria (PSB) and fungi, mostly species of *Pseudomonas, Bacillus, Penicillium, Aspergillus etc.* secret organic acids (formic, acetic, fumaric acids etc.) and lower the pH in their vicinity to bring about dissolution of bound phosphate in soil.

Siderophore production is another mechanism for the solubilization of inorganic phosphates. Some of these acids (hydroxyl acids) may form chelates with cations such as Ca & Fe and results in solubilisation of phosphates.

Siderophores are low molecular-weight, high affinity iron chelators that transport iron into bacterial cells. Siderophores, bind iron tightly to stop its reaction with soluble phosphate and help in release PO_4 fixed as ferric phosphate. It is important in acid soils, where ferric PO_4 is one of the major forms.

II. Mycorrhizae (Fungal symbioses with roots)

Mycorrhiza (fungus root) is the mutualistic association between plant roots and fungal mycelia. **Frank (1885)** gave the name "*mycorrhiza*" to the peculiar association between the plant root system and special soil fungi. 95% of the plant species form mycorrhizae including monocots, dicots, conifers and some bryophytes and pteridophytes. The fungus receives carbohydrates (sugars) and growth factors from the plant, and in turn receives many benefits, including increased nutrient absorption.

Types of mycorrhizae

Mycorrhizal associations vary widely in structure and function. Two main groups of mycorrhizae are recognized; the ectomycorrhizae and endomycorrhizae.

Endomycorrhizae includes Arbuscular Mycorrhizae, Orchid Mycorrhizae and Ericoid Mycorrhizae and **Ectomycorrhizae** includes arbutoid, ectendomycorrhizae and monotropid mycorrhizae.

1. **Ectomycorrhizae (sheathing mycorrhizae):** They are mainly associated with forest and ornamental tree species including coniferous and broad leaved trees. Some common trees include members of the families Pinaceae (*Pinus, Picea, Larix*), Fagaceae (*Quercus*), Betulaceae (*Betula)* and Myrtaceae (*Eucalyptus*).
   The fungi forming Ectomycorrhizal association are members of the Basidiomycotina and Ascomycotina. eg: *Rhizopogon, Amanita, Boletus, Lactarius.*

   Ectomycorrhizal roots are generally short, swollen, dichotomously branched. Root hairs are not developed. The root appears white, orange or yellow in colour.

The fungal hyphae **form a mantle sheath** both outside the root and within the root in the intercellular spaces of the epidermis and cortex. No intracellular penetration into epidermal or cortical cells occurs, but an extensive network called the **Hartig net** is formed between these cells. Sheath or Mantle increases the surface area of absorbing roots and offers protection to the roots. Hartig net can act as storage and transport organ for phosphate and nitrogen.

2. Endomycorrhizae: Endomycorrhizae consists of three sub groups, but the most common are the Arbuscular Mycorrhizal fungi (**AMF**). Endomycorrhizal fungi produce **an internal network of hyphae** between cortical cells that extends out into the soil, where the hyphae absorb mineral salts and water. These fungi **do not form an external mantle** but lives within the root. In all forms of endomycorrhizae, fungal hyphae runs between and inside the root cells which includes,
Arbuscular mycorrhiza - associated with most of the plant families
Ericoid mycorrhiza - Associated with some species of Ericaceous plants
Orchid mycorrhiza - associated with orchid plants

Arbuscular Mycorrhizae (AM): They are associated with majority of agricultural crops. Fungi belong to this are of group Glomeromycota e.g, *Glomus*, *Gigaspora* etc.
Roots associated with **AM** do not show any morphological variation from normal root. These fungi do not form an external mantle, only inter and intracellular fungal hyphae (aseptate) is present within the root.

Colonization Process: It occurs by germination of spore in soil, hyphal growth through soil to host roots, penetration of host roots and spread of infection inter and intracellularly in the root cortex. Colonization occurs under two phases: (1) Extra matrical phase and (2) Intra radical phase.

(1) ***Extra matrical phase***: Events occurring outside the root after the germination of chlamydospores. Once the fungus recognises the plant, penetration in the host root occurs via the formation of appresorium. The hyphae ends with resting spores in soil.

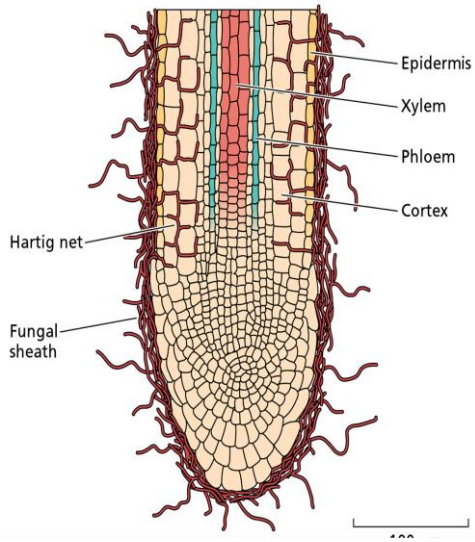
(2) ***Intra radical phase***: Events occurring inside the root cortex. After penetrating the cortex, the fungus may produce intercellular as well as intracellular hyphae in the cortical cells.

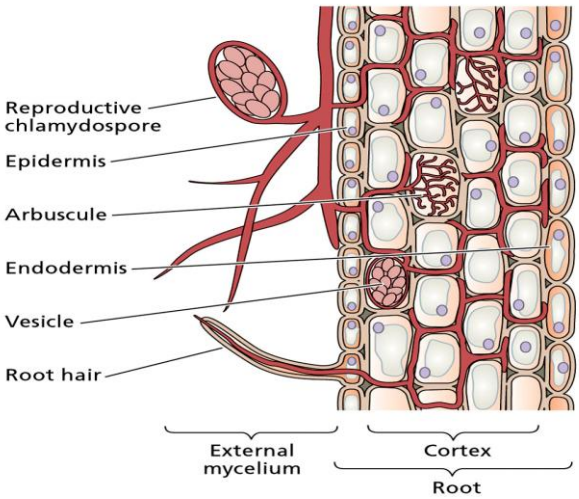
AM forms two morphological structures namely **arbuscules** and **vesicles** inside the cortical cells and play a key role in nutrient transfer particularly in mobilisation of phosphorus.

Arbuscules: Arbuscules are the fine dichotomously branched hyphal filaments formed inside the cortical cells. These are haustoria like structure which helps in exchange of nutrients between the fungus and host root. They are short lived (less than 15 days) and degenerate.

Vesicles: These are oval, spherical, thick -walled multinucleate structures that are formed terminal by swellings of the hyphae inside the cortical cells called vesicles. Vesicles contain lipids and cytoplasm. They act as phosphorous storage organ, where phosphorous can be accumulated as polyphosphates.

Some beneficial effects of Arbuscular Mycorrhizae on plant growth and yields:
(i) improved mineral nutrition, especially P (P, Zn, Cu, K, S, NH_4), (ii) Protection of host roots against pathogen infection (iii) Better tolerance to stress like salinity, heavy metal pollution (iv)Improved water relation (v) reduced fertilizer input.





Ectotrophic Mycorrhizae **Arbuscular Mycorrhizae**