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Chapter 7
Topic – Symbiotic association: Mycorrhiza & their significance

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Mycorrhiza:

Vitadini (1842) was the first to recognise the possible beneficial role of fungal mycelia which mantle the root of higher plants, and this association is named as mycorrhiza (pl. mycorrhizae) i.e., the fungal root, by Frank(first coined the term) in 1885.

Thus mycorrhizae are the symbiotic associations between plant root and fungi, with bidirectional nutrient exchange between the partners.

The autotrophic host plant acts as the carbon source for the fungus, while the fungus supplies mineral nutrients to the plant. About 90% of all land plants are associated with mycorrhiza.

Features of Mycorrhiza:

(i) Absence of any phytopathological symptoms in the partners during the active phase of mutualism,

(ii) Presence of complex interfaces between cells of the partners with a predominant type of perisymbiotic membrane, surrounding intracellular symbionts,

(iii) Presence of various types of phagocyte-like structures during establishment of symbionts and during harvesting phase to control the symbiotic population by the host.

Types of Mycorrhiza:

Peterson and Farquhar (1994) classified the mycorrhizae into seven (7) distinct types.

These are :

(1) Ectomycorrhizae,
(2) Vesicular-arbuscularmycorrhizae,
(3) Ectendomycorrhizae (Arbutoid),
(4) Ericoid mycorrhizae,
(5) Centianoidmycorrhizae,
(6) Orchidoidmycorrhizae, and
(7) Monotropoidmycorrhizae.

(1) Ectomycorrhizae:

Ectomycorrhiza is commonly called “sheathing mycorrhiza”. They occur in 3% of all seed plants in forests of temperate regions, especially on pine, beech, spruce, birch etc.

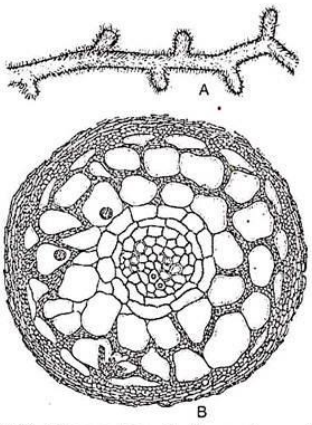
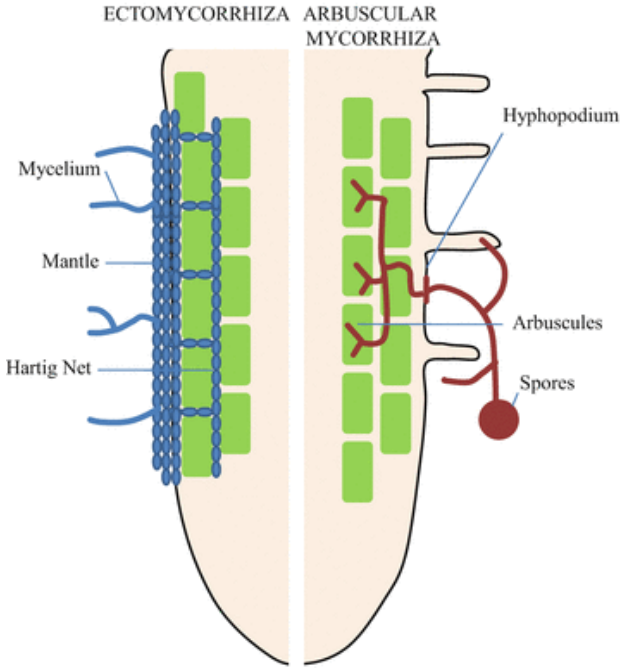


Fig. 4.103 : Ectomycorrhiza : A. *Pinus* root covered w mycorrhizal fungi, B. T.S. of *Pinus* root sho ing ectotrophic mycorrhizal fungi forming mantle covering and growth of fungi betwe cortical cells

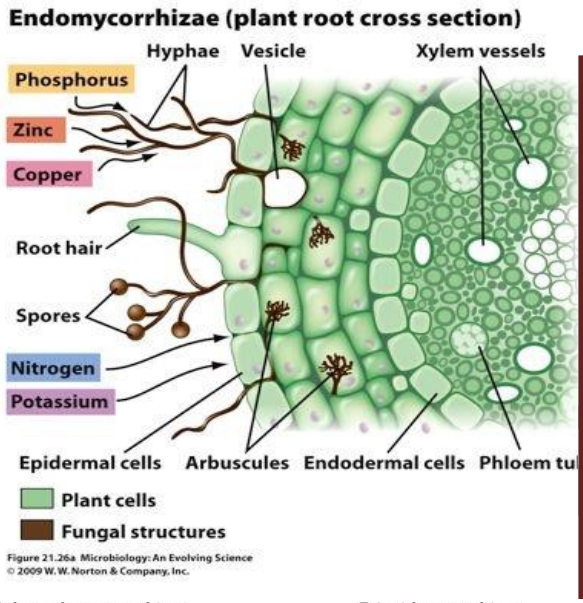
- Ectomycorrhizae are mutualistic associations between fungi and gymnosperms or angiosperms belonging to certain families.
- These associations consist of a soil-mycelium system linking mycorrhizal roots and reproductive or storage structures.
- Ectomycorrhizal roots are characterized by the presence of a mantle and Hartig net.
- The Hartig net consists of entangled hyphae between the root epidermis and cell cortex.
- It is estimated that over 5,000 fungi species are capable of forming ectomycorrhizal symbiosis.
- These symbionts are found in four divisions: Basidiomycota, Ascomycota, Zygomycota and Deuteromycota



(2) Vesicular-arbuscularmycorrhizae (VAM):

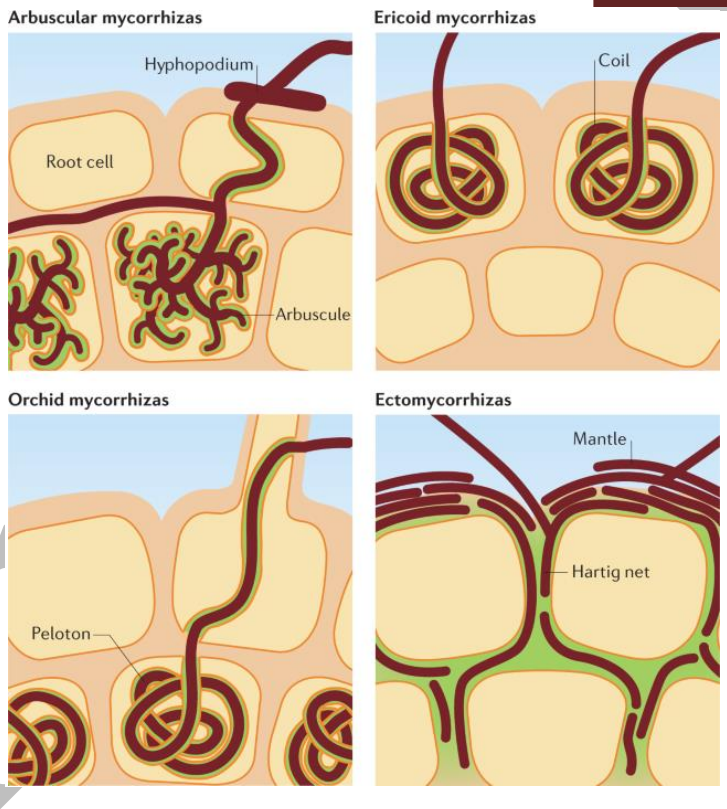
- It is a type of endomycorrhizal association, where both vesicles and arbuscles are developed together.
- VAM has been reported in more than 90% of land plants.
- They are found in bryophytes, pteridophytes, gymnosperm (except Pinaceae) and most of angiosperms, commonly in Leguminosae (Fabaceae), Rosaceae, Gramineae (Poaceae) and Palmae (Arecaceae).

- VAM is produced by aseptate mycelial fungi belong to Endogonaceae under Mucorales of Zygomycotina and those members produced zygospores. The important genera involved in VAM are Glomus, Gyrospora, Acaulospora etc.
- **The VAM is so named because of the presence of two characteristic structures i.e., vesicles and arbuscles:**



(i) The vesicles are thin or thick walled vesicular structures produced intracellularly and stored materials like polyphosphate and other minerals

(ii) The arbuscles are repeated dichotomously branched haustoria which grow intracellularly. The arbuscles live for four days and then get lysed releasing the stored food as oil droplets, mostly polyphosphate.



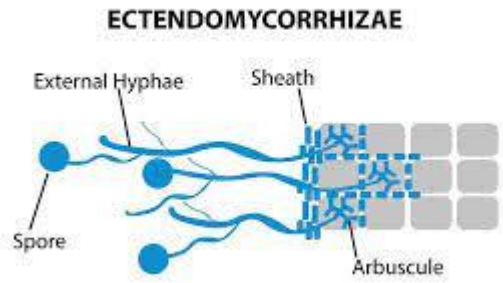
- There is no fungus mantle, but only a loose and very sparse network of septate hyphae spread into the soil.
- These hyphae bear different types of spores, chlamydospores, or aggregation of spores in sporocarp or zygospores.
- The superficial hyphae bear branches that penetrate the epidermis and then grow intercellularly only in cortex.
- Intercellular hyphae form arbuscles inside the parenchyma of cortex by repeated dichotomous branching of the penetrating hyphae. The cell membrane of the penetrated cell is invaginated and covers the arbuscles.
- The hyphae also develop both inter- and intracellular thick-walled vesicles.

(3) Ericoid mycorrhizae:

- It is a a type of endomycorrhiza.
- Ericoid mycorrhizae are found in the different members of Ericaceae like Erica, Calluna, Vaccinum, Rhododendron etc.
- The fungi are slow-growing, septate and mostly sterile. They are mostly culturable.
- During this association the rootlets of the plants are covered by very sparse, loose, dark, septate hyphae that penetrate the cortex forming intercellular coils.
- After 3-4 weeks the coils degenerate like arbuscles of vesicular-asbuscularmycorrhiza (VAM).
- Most of the members of Ericaceae grow in acid soil with less amount of P and N nutrition. The fungus gets the photosynthate from the host and improves the mineral uptake and nutrition of the host, especially P and N.
- Many mycotrophs of Ericaceae show high resistance to metals like Zn and Cu. The mycorrhizal plants also show high tolerance to these metals, which is totally absent in non-infected plants.

(4) Ectendomycorrhizae (Arbutoid):

Some members of the family Ericaceae and members of other families of Ericales have mycorrhizae intermediate in form between ecto- and endomycorrhizae types, called ectendomycorrhizae. Arbustus and Arctostaphylos of Ericaceae show this type of mycorrhizal association.



In Arbustus, the root system is differentiated into long and short roots. The short roots are swollen and covered by hyphal mantle. Hartig net is absent in this association, but intercellular coils develop in the outer cortical cells.

(5) Gentianoidmycorrhizae:

Seedlings of some members of Gentianaceae (Biackstoniaperfoliata, Gentianellaamarella, etc.) get infected within 2 weeks of germination. In root, the cortical cells become full of irregular coils of aseptate hyphae. With time the hyphae become lysed. Vesicles are occasionally seen attached to these coils.

(6) Orchidoidmycorrhizae:

Orchids produce millions of tiny seeds per capsule, weighing about 0.3-14µg. The embryo of seeds contains 10-100 cells and there is virtually no storage of food. The embryo is encircled in a thin-walled net-like testa that helps in their dispersal.

Thus, majority of seeds are unable to germinate without exogenous supply of carbohydrates. Therefore, mycorrhizal association is obligatory for the seeds to germinate. The fungus provides the nutrition to the seeds.

Initially the fungus enters the embryo and colonises, being restricted to the cortical cells and provides the nutrition. For non-green orchids, this is obligatory throughout their lives. Apparently, it is a case of parasitism by orchids on the mycorrhizal fungi.

Fungi like Rhizoctonia (Basidiomycotina), are recognised by hyphal characteristics. Corticium, Ceratobasidium etc., of Aphylloporales are associated in this type of mycorrhiza.

(7) Monotropoidmycorrhizae:

Monotropahypopitys is a non-green saprophytic herb. It has short fleshy roots that are invested with a hyphal sheath and often forming Hartig net in the cortical zone. Due to absence of chlorophyll, they are unable to synthesise and supply carbohydrate to the fungus. Boletus is a mycorrhizal fungus associated with roots of both pine and Monotropa.

Role of Mycorrhizae in Agriculture and Foresty:

Role in Agriculture:

1. The mycorrhizal association helps in the formation of dichotomous branching and profuse root growth, thus enhances plant growth.
2. Ectotrophicmycorrhiza helps in uptake of mineral ions and also acts as reservoir.
3. They also help in absorption of nutrients.
4. In nutrient deficient soil, the mycelial association helps in the absorption of N, Ca, P, Zn, Fe, Na and others.
5. Mycorrhizal association is obligatory for the germination of orchid seeds.

Mycorrhizal growth in orchids (Rhizoctoniarepens with Orchismilitaris tuber tissues) causes the synthesis of phytoalexins — orchinol and hirsinol. Both the compounds act as a barrier to protect infection by other pathogens.

6. Inoculation of VAM as biofertiliser provides a distinct possibility for the uptake of P in phosphorus-deficient soil.

Significance

Role in Foresty:

1. Mycorrhiza plays an important role to establish forest in unfavourable location, barren land, waste lands etc.
2. Trees with facultative endomycorrhiza act as first invader in waste lands as pioneer in plant succession.
3. The application of mycorrhizal fungi in forest bed enhances the formation of mycorrhizal association that prevents the entry of fungal root pathogens. This method is very much effective in the root of Pinusclausa against Phytophthoracinnamoni infection.
4. Mycorrhiza mixed nitrogenous compounds such as nitrate; ammonia etc. is available to the plants. Thus it helps in plant growth, especially in acid soil.

References:

1. https://www.biologydiscussion.com/
2. Cryptogamic Botany textbook, Nirali prakashan.
3. Images from internet.