Subject: Botany (M)
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Paper: DSE1
Topic: Mycorrhiza

According to Frank (1885) Mycorrhiza can be defined as (Myco- fungi, rhiza- root)) structure which is developed as a result of symbiotic association between fungi and higher plant roots. It can be seen in stems (e.g. orchids) also. These specialized fungi colonize plant roots in a symbiotic manner and extend far into the soil. Fungi may either form extraradical mycelium which grows inside the soil for nourishment or form intraradical mycelium that grow in between and inside the parenchyma cells of plant roots. It also forms structures like vesicles and arbuscules. Mycorrhizal fungi can colonize plants from the sources of inoculums, spores, colonized root fragments, and vegetative hyphae. These inoculants are called "propagules".
There are numerous benefits of mycorrhizal fungi to plants. Improved Soil Structure, Greater Transplant Success, Increased Stress Tolerance, Reduced Nutrient Runoff.

Types of Mycorrhiza:

Mycorrhizae can be classified the into seven (7) distinct types according to Peterson and Farquhar (1994)
These are:
(1) Ectomycorrhizae,

(2) Vesicular-arbuscular mycorrhizae,

(3) Ectendomycorrhizae (Arbutoid),

(4) Ericoid mycorrhizae,

(5) Centianoid mycorrhizae,

(6) Orchidoid mycorrhizae, and

(7) Monotropoid mycorrhizae.

ECTOMYCORRHIZA: Ectomycorrhiza is commonly called "sheathing mycorrhiza".They mainly belong to Basidiomycota. e.g.- *Amanita muscaria, Scleroderma citrinum*. Plant type- Pinus, Oak, Eucalyptus. They usually exist in temperate and semi-arid regions. Nutrients absorbed by the fungal mantle are transported to roots through the formation of **Hartig's net**. The fungus enters the cortex forming 'Hartig net', but never goes inside the endodermis or stele. They form a mantle of varying thickness. They cause extensive branching and growth of roots

and modification of branching pattern. They appear in various colours like white, brown, yellow, black etc., depending on the colour of the fungus.

VESICULAR-ARBUSCULAR MYCORRHIZAE: They are most widely distributed (70-90%) type. VAM is produced by aseptate mycelial fungi belong to Endogonaceae under Mucorales of Zygomycotina and those members produced zygospores, e.g. *Acaulospora*, *Gigaspora, Glomus*, They are found in bryophytes, pteridophytes, gymnosperm (except Pinaceae) and most of the angiosperms, These are aseptate and forms intracellular hyphae in cortex. 2 characteristic structures are present. The arbuscules are repeated dichotomously branched haustoria which grow intracellularly and live for four days and then get lysed releasing the stored food as oil droplets, mostly polyphosphate. Arbuscules transfer mineral nutrients from fungi and transfer sugars from host to fungi. The vesicles are thin or thick walled vesicular structures produced intra-cellularly. Vesicles act as storage organ of P as phospholipids. 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. The cell membrane of the penetrated cell is invaginated and covers the arbuscles.

ECTENDOMYCORRHIZAE (ARBUTOID): Mycorrhizae intermediate in form between ecto- and endomycorrhizae types, called ectendomycorrhizae. In *Arbutus*, 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. Plant type- *Pinus* (pines), *Picea* (spruce). Fungi type- Ascomycetes (*Wilcoxina*)

ERICOID MYCORRHIZA: This is actually a type of endomycorrhiza. Fungi type- Ascomycetes (*Rhizoscyphus*), *Clavaria vermiculata* (Basidiomycotina). Plant type- family Ericaceae, tribe Ericoidae. The fungi are slow-growing, septate and mostly sterile. They are mostly culturable. In this association the rootlets of the plants are covered by very sparse, loose, dark, septate hyphae that penetrate the cortex forming intercellular coils and after 3-4 weeks the coils degenerate like arbuscules of VAM. The fungus digests polypeptides saprotrophically and passes absorbed nitrogen to the host plant.

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

ORCHIDOID MYCORRHIZAE:

Mycorrhizal association is obligatory for the seeds of orchids to germinate. The fungus provides C-nutrition to the seeds. Initially the fungus enters the embryo and colonises, being restricted to the cortical cells and provides the nutrition. Forms internal coils. For non-green orchids, this is obligatory throughout their lives. Fungi like *Rhizoctonia* (Basidiomycotina), are recognised by hyphal characteristics.

MONOTROPOID MYCORRHIZAE: It 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. Plant type- Family Monotropaceae (*Monotropa hypopitys*). Neighbouring plants- beech, oak, spruce, pine Carbohydrates pass from conifer to *Monotropa* via their common mycorrhizal partner. *Boletus* is a mycorrhizal fungus associated with roots of both pine and *Monotropa*.

Colonization in plant roots:

Arbuscular mycorrhizae appear to be the most common type of mycorrhizal association with respect to the number of plant species that form them and widely distributed in annuals, perennials, temperate and tropical trees, crop and wild plants. Arbuscular mycorrhizal fungi belong to Zygomycota in the Glomales or newly proposed phylum Glomeromycota. They all are obligate biotrophs and form large spores that superficially resemble zygospores, but not formed from fusion of gametangia. Fossils of spores found that are as old as first land plants. They exhibit low specificity. Thus one fungal species may form association with many different plant species and different from biotrophic parasites that have a limited host range. Fungi form both intercellular and intracellular hyphae. Intracellular hyphae analogous to haustoria – called arbuscules and show tree like branching pattern. Arbuscules surrounded by plant cell membrane. Vesicles are intercellular hyphae may also form large swellings and formed at the ends of hyphae or intercalary in position. In Arbuscular mycorrhizae root is not altered in morphology and thus difficult to determine when roots are infected.

For colonization in plant roots, these propagules must be present in the substrate and in close proximity to actively growing roots of a compatible plant. The growing root tips secrete root exudates as they push through the substrate and signal the fungi to colonize the roots and establish the symbiosis. Once the roots are colonized, mycelia continue to grow with the plant's root system and additional spores and hyphae are produced. The following events are associated with the colonization process.

Development of mycorrhiza-host root symbiosis: It is a programmed sequence of phenotypic changes and depends on specific recognition between the two partners- host plant and fungal symbiont. This involves 2 stages- **Asymbiotic stage and Symbiotic stage.**

In **asymbiotic stage** fungal symbiont exist as multi-nucleated round shaped resting spores and uses its triglyceride and glycogen reserves. In suitable water and temperature conditions the spores germinate & nuclei from the spore move into the extending mycelium. If host root absent further growth ceases.

Symbiotic stage begins with the colonization of hyphae with compatible root. After attachment **Appresorium** formed and fungus enters in cortex. After that some specialized structures formed such as inter & intra cellular hyphae, coils, arbuscules.

In **pre- symbiotic phase** fungi respond to plant signals as well as plant respond to signals of fungi. Strigolactones, forms a conc. Gradient and stimulates spore germination. On the other hand 5-deoxy-strigol is identified by fungi which lead to induction of branching, enhanced fungal growth and increased mitochondrial activity. Fungus signaling molecule induces transcriptional activation of plant symbiosis related genes and induce Ca oscillations in root epidermal cells.

Whereas, in case of **early symbiotic phase** appresorium forms. Appresorium is a flattened, hyphal organ that facilitates the penetration of cells or tissues of other organisms. AM fungi forms a special type of appresoria called as hyphopodia, developed from mature hyphae. Penetration of AM fungi is also achieved. Due to sequential chemical and mechanical stimulation, plant cells produce a PPA. Fungal hypha enters the PPA, guides the fungus through root cells towards the cortex.. In inner cortex, the fungus leaves the plant cell, enters the apoplast, branches and grows laterally along the root axis.

Mature symbiotic phase is characterized by Arbuscule development and nutrient transfer. Hyphae induce the development of PPA-like structures in inner cortical cells, enter the inner cortical cells and branch to form arbuscules. Vesicles, function as storage organs of the fungus. New spores are typically synthesized.

Role of Mycorrhizae:

Role in Agriculture:

1. The mycorrhizal association facilitates the formation of dichotomous branching and profuse root growth thereby enhances plant growth.
2. They also assist in absorption of nutrients.
3. The mycelial association helps in the absorption of N, Ca, P, Zn, Fe, Na
4. Ectotrophic mycorrhiza promote uptake of mineral ions.
5. Mycorrhizal association is required for the germination of orchid seeds.
6. Inoculation of VAM as biofertiliser provides an opportunity for the uptake of P in phosphorus-deficient soil.

Role in Foresty:

1. Mycorrhiza help in establishment of forest in unfavourable location, waste lands etc.
2. Trees with facultative endomycorrhiza act as first invader in waste lands as pioneer succession process.
3. The use of mycorrhizal fungi in forest bed stimulates the formation of mycorrhizal association thus prevents the entry of fungal root pathogens.

N.B. Add relevant diagram from text book or reference book.