

## Soil fungi

Soil fungi are microscopic plant-like cells that grow in long threadlike structures or hyphae that make a mass called mycelium. The mycelium absorbs nutrients from the roots it has colonised, surface organic matter or the soil. It produces special hyphae that create the reproductive spores. Some fungi are single celled (eg yeast). Fungi have many different structures but they can act in similar ways and thus are not as plant specific in their needs as some soil bacteria such as *Rhizobia*.

### Fungi groups

There are three functional groups of fungi.

#### Decomposers

Decomposers or saprophytic fungi convert dead organic matter into fungal biomass (ie their own bodies), carbon dioxide and organic acids. They are essential for the decomposition of hard woody organic matter. By consuming the nutrients in the organic matter they play an important role in immobilising and retaining nutrients in the soil. The organic acids they produce as by products help create organic matter that is resistant to degradation. Fungi are capable of degrading cellulose, proteins and lignin, some of which are highly resistant to breakdown.

#### Mutualists

These fungi develop mutually beneficial relationships with plants. They colonise plant roots where they help the plant to obtain nutrients such as phosphorus from the soil. Their mass hides roots from pests and pathogens, and provides a greater root area through which the plant can obtain nutrients.

#### Mycorrhizal fungi

Mycorrhizal fungi are perhaps the best known of the mutualists. Mycorrhiza means fungus root, and mycorrhizal fungi grow inside plant roots. Up to 5m of living hyphae of mycorrhizal fungi can be extracted from 1g of soil. The four groups of mycorrhizal fungi are arbuscular, ectomycorrhizal, ericoid and orchid. Arbuscular mycorrhiza (VAM) are the most common form of mycorrhiza, especially in agricultural plant associations. This fungi has arbuscles which are growths formed inside the plant root that have many small projections going into the cells. About 150 arbuscular mycorrhiza species are known. Most plants (90%) have some sort of

association with these fungi except for groups such as the *Cruciferae* family (eg mustard, canola, broccoli), *Chenopodiaceae* (eg spinach, beets, saltbush) and *Proteaceae* (banksia, macadamia).

#### Pathogens

This group includes the well known fungi such as *Verticillium*, *Phytophthora*, *Rhizoctonia* and *Pythium*. These organisms penetrate the plant and decompose the living tissue, creating a weakened, nutrient deficient plant, or death. The pathogenic fungi is usually the dominant organism in the soil. Soils with high biodiversity have been shown to suppress soil-borne fungal diseases. Suppression mechanisms include the suite of native organisms out-competing the pathogenic organisms, physically protecting roots and providing better nutrition to the plant.

#### What do fungi do?

Fungi perform important functions within the soil in relation to nutrient cycling, disease suppression and water dynamics, all of which help plants become healthier and more vigorous.

#### Decompose woody organic matter

Along with bacteria, fungi are important decomposers of hard to digest organic matter. They use nitrogen in the soil to decompose woody carbon rich residues low in nitrogen and convert the nutrients in the residues to forms that are more accessible for other organisms.

#### Increase nutrient uptake

Mycorrhizal fungi are well known for their role in assisting plants in the uptake of phosphorus. Ectomycorrhizal fungi can benefit plants by promoting root branching and increasing nitrogen, phosphorus and water uptake due to their large surface area and internal cellular mechanisms. .

#### Improve plant resilience

The sheer size and mass of fungal hyphae help decrease plant susceptibility to pests, diseases and drought.

#### Improve soil structure

Fungal hyphae bind the soil particles together to create water-stable aggregates which in turn create the pore spaces in the soil that enhance water retention and drainage.



## Where are fungi found?

Fungi are found wherever there is hard, carbon-rich woody organic matter. This could be dead rotting trees in a forest, leaf litter on the surface of orchard soils, or plant roots.

Mycorrhizal fungi are found naturally in all soils. Techniques to determine their presence usually focus on indirect methods or look at the colonisation of plant roots and are therefore not that reliable. It is difficult to get mycorrhizal fungi to grow outside their natural state, but staining techniques and microscopy have been useful in identifying mycorrhiza from soil and plant samples.

Fungi tend to dominate over bacteria and actinomycetes in acid soils as they can tolerate a wide pH range.

Fungi can survive in the soil for long periods even through periods of water deficit by living in dead plant roots and/or as spores or fragments of hyphae.

## Management of soil fungi

There are several things you can do to encourage fungi in your soil.

### Provide a hospitable environment

To ensure fungi remain in the earth the soil environment must be kept as hospitable as possible. This means there must be enough food (organic matter), suitable host plants (if necessary), water and minimal disturbance of the soil.

### Reduce tillage

Tillage has a disastrous effect on fungi as it physically severs the hyphae and breaks up the mycelium.

### Reduce fungicide use

Broad-spectrum fungicides are toxic to a range of fungi. Their use will result in a decline in the numbers of beneficial types. Herbicides are not generally thought to affect fungi directly, though the removal of some plant types may affect the distribution of different fungi types.

## Grow plants that encourage mycorrhizal fungi

There are certain plant groups that do not form associations with mycorrhizal fungi. When these plants are included in a rotation, fungi numbers drop due to the lack of host plants and this reduces fungi colonisation in the following crop. A bare fallow has the same effect. Mycorrhiza increase under pasture because pasture includes highly mycorrhizal plants such as grasses and legumes. VAM numbers reduce under wheat, canola and lupin. A low level of mycorrhizal colonisation in plants is also associated with high available phosphorus levels in the soil.

## More information

*Soil biology basics* is an information series describing basic concepts in soil biology. For more detailed information we recommend the Australian book *Soil biological fertility: A key to sustainable land use in agriculture* (2003), edited by Lyn Abbott & Daniel Murphy.

NSWDPI has online soil biology information at <http://www.agric.nsw.gov.au/reader/soil-biology>.

The University of WA has online soil biology information at <http://ice.agric.uwa.edu.au/soils/soilhealth>.

Also see:

- US Department of Agriculture, Soil Biology Unit. Jan 2004. *Soil biology and land management* [http://soils.usda.gov/sqi/concepts/soil\\_biology/index.html](http://soils.usda.gov/sqi/concepts/soil_biology/index.html)

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