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Biology

SOIL BACTERIA AND FUNGI —NEW SOUTH WALES

Key points

- Soil bacteria and soil fungi are the start of the soil food web that supports other soil organisms and the functions of a healthy soil.
- Diverse populations of soil bacteria and fungi can suppress root diseases.
- Soil bacteria and fungi are encouraged by ground cover and organic matter inputs.
- Populations of soil bacteria change rapidly depending on moisture, time of year, type of crop, stubble management, etc.
- Soil fungi are slower to develop, and are strongly set back by cultivation.

Soil bacteria

Bacteria are the most abundant microbes in the soil. They are single celled organisms, and there can be billions of bacteria in a single gram of soil. Populations of bacteria can boom or bust in the space of a few days in response to changes in soil moisture, soil temperature or carbon substrate. Some bacteria species are very fragile and may be killed by slight changes in the soil environment. Others are extremely tough, able to withstand severe heat, cold or drying. Some bacteria are dependent on specific plant species.

Soil fungi

Soil fungi are microscopic plant-like cells that can be single celled (e.g. yeast) or grow in long threadlike structures or hyphae that make a mass called mycelium. They can be symbiotic with plant roots (figure 1). Fungi are generally not as dependent on specific plant species as some bacteria, and populations are slower to develop.

Figure 1: *Hyphae from mycorrhizal fungi emerging from plant roots. Photo: Paula Flynn, Iowa State University Extension*

Types of bacteria

Decomposers: play an important role in the early stages of decomposition of organic materials (in the later stages fungi tend to dominate).

Nitrogen fixers: extract nitrogen gas from the air and convert it into forms that plants can use, and can add the equivalent of more than 100 kg/ha per year of nitrogen to the soil. *Rhizobium* bacteria live in special root nodules on legumes and can be inoculated onto legume seeds. Other free-living nitrogen-fixing bacteria associate with non-legumes, but inoculating with these organisms has not proved effective in increasing nitrogen fixation for non-legume crops.

Disease suppressors: release antibiotic substances to suppress particular competitors. A number of bacteria have been commercialised for disease suppression. Their effect is often specific to particular diseases of particular crops and may only be effective in certain circumstances.

Actinobacteria: help to slowly break down humates and humic acids in soils, and prefer non-acidic soils with pH higher than 5.

Sulfur oxidisers: *Thiobacillus* bacteria can covert sulfides (common in soil minerals but largely unavailable to plants) into sulfates, a form plants can use.

Aerobes and anaerobes: Aerobic bacteria need oxygen, and dominate in well drained soil. Anaerobic bacteria do not need oxygen, and favour wet, poorly drained soils. They can produce toxic compounds that limit root growth and predispose plants to root diseases.

Fungi groups

Decomposers: are essential for breaking down woody organic matter, They play an important role in immobilising

and retaining nutrients in the soil. The organic acids they produce help create soil organic matter that is resistant to degradation.

Mutualists: develop mutually beneficial relationships with plants. Mycorrhizal fungi are the best known, and grow inside plant roots. Arbuscular mycorrhiza (VAM) are the most common, especially in agricultural plant associations. These fungi have arbuscles, growths formed inside the plant root that have many small projections into root cells, as well as their hyphae outside the root (figure 1). This growth pattern increases the plant's contact with the soil, improving access to water and nutrients, while their mass of hyphae protects roots from pests and pathogens.

Pathogens: (including the well known *Verticillium, Phytophthora, Rhizoctonia* and *Pythium* fungi) penetrate the plant and decompose the living tissue, leading to weakened or dead plants. Where disease symptoms are seen, the pathogenic fungi is usually the dominant organism in the soil. Soils with high biodiversity can suppress soil-borne fungal diseases.

Management of soil bacteria

Though largely unaffected by cultivation, bacteria populations are depressed by dry conditions, acidity, salinity, soil compaction and lack of organic matter. Except in the case of certain seed inoculations, it is very difficult to build desirable populations of bacteria just by adding them to the soil. If populations of soil bacteria are low, it is probably because conditions are unfavourable. Effective approaches (that have multiple benefits) to support healthy soil bacteria are to address problems of acidity and compaction, ensure good ground cover and build organic matter.

Management of soil fungi

You can encourage fungi in your soil by providing food (organic matter), water and minimal disturbance of the soil. Growing pastures and crops that support mycorrhizal fungi allow fungi to increase in the soil.

Plant groups that do not form associations with mycorrhizal fungi are the Cruciferae family (eg mustard, canola, broccoli), Chenopodiaceae (eg spinach, beets, saltbush) and Proteaceae (banksia, macadamia). When these plants are included in a rotation, fungi numbers drop. A bare fallow has the same effect.

Tillage has a disastrous effect on fungi as it physically severs the hyphae and breaks up the mycelium. Broad-spectrum fungicides are toxic to most fungi and will result in a decline in beneficial types.

Further reading and references

This factsheet is adapted from the Soil Biology Basics information series. The New South Wales Department of Primary Industries has further soil biology information, including the complete Soil Biology Basics series (online)

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