What is soil microbiology?

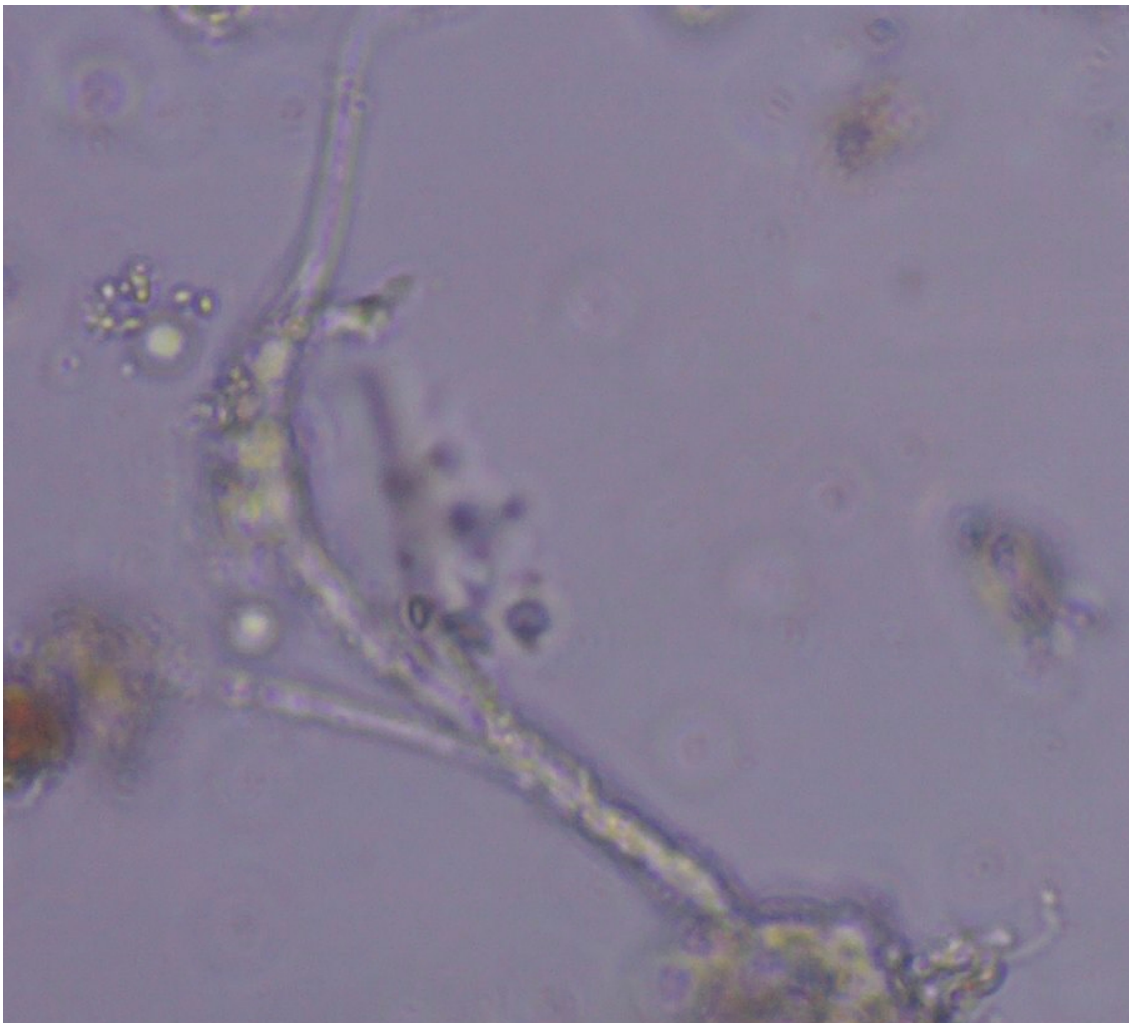
Soil microbiology refers to the function of microorganisms, their interaction with each other and other soil properties such as plants and minerals. While microorganisms include bacteria, and viruses, only a small portion are harmful and most undertake beneficial services for soil and plant health.

Microbiology is all around us – in the air we breathe and the ground we walk on. Each person contains trillions of microorganisms, outnumbering human cells by a ratio of 10 to 1. Microbes are found in the most extreme environments, like volcanoes and in glaciers in the oceans. Microbes are the start of the soil food web as they are consumed by each another and by larger soil fauna like worms and slaters bugs.

Soil microbes include bacteria, nematodes, fungi, archaea, viruses, protozoa, nematodes, ciliates and amoebae, and are found near the soil surface and in and around the roots of the plants (rhizosphere). Generally speaking, soils with a high diversity of microorganisms tend to be healthier than those with low levels of diversity.

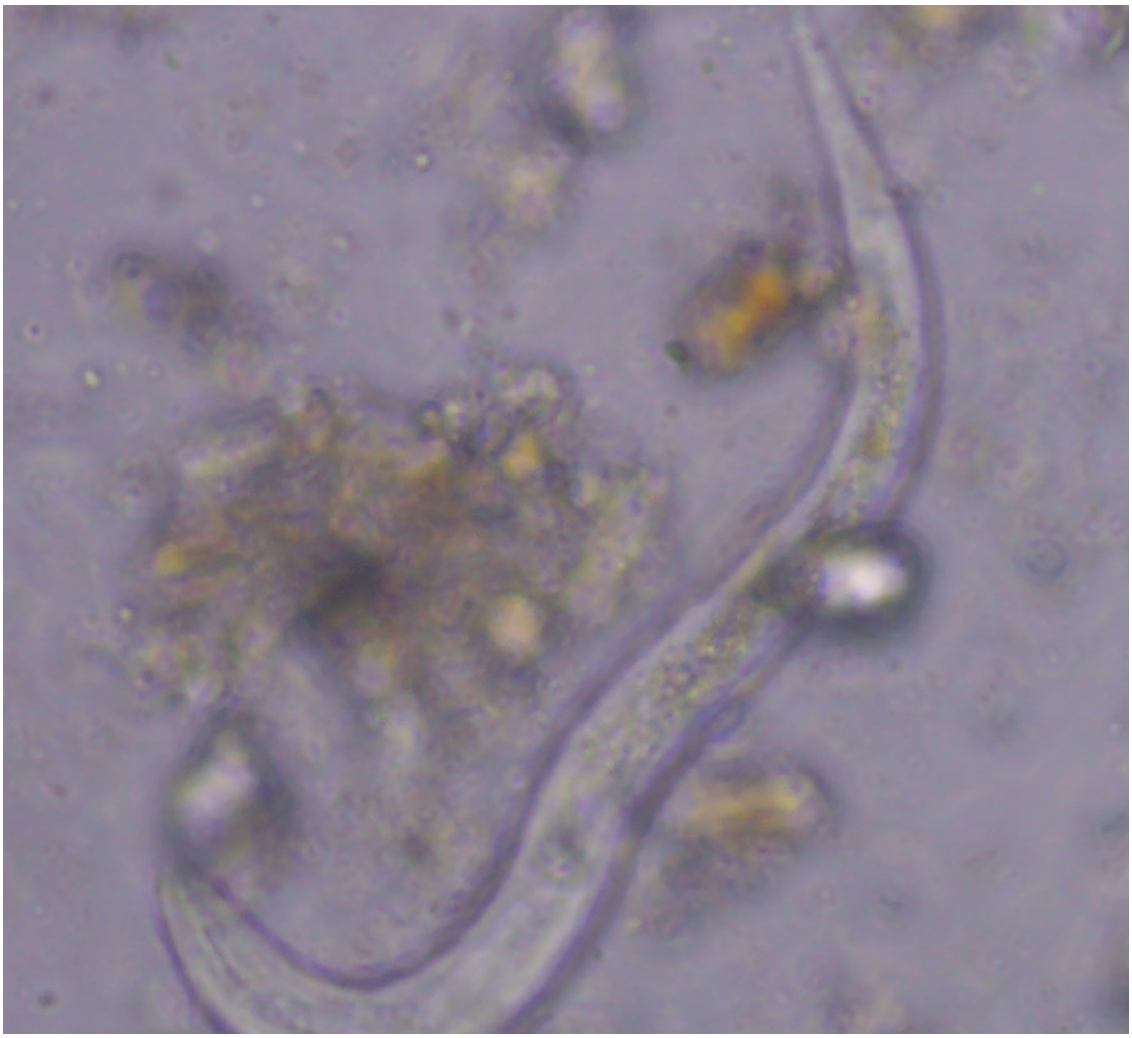
Bacteria are a free living, single-celled organisms that are found everywhere, small only 1-3 micrometre long. They come in many different forms and shapes from rod shaped, round, corkscrew, rounded rods and comma shaped, and comma shaped.

Fungi are either single celled or complex multi-cellular organisms. They are mainly found in the soil and on plants. Fungi help to break down plant matter into nutrients and carbon, but they can also cause plant disease including rot, mildew, canker and rust.



Fungi as seen under the microscope

Nematodes are microscopic round worms that move in the soil like snakes. Nematodes need a relatively damp environment and feed on bacteria, fungi, other nematodes (predatory nematodes) and plant roots. They help to increase nutrients within the soil as by excreting plant available nutrients including nitrogen and potassium. Nematodes can be used as a part of an integrated pest and disease management program as they feed on ground dwelling insects, like slugs, borers, grubs and some snails.



Nematodes exist many different forms, including beneficial and disease causing.

Archaea are similar to bacteria but they have a cell wall and a flagella (a tail), with which they use to swim.

Protozoa are unicellular microorganisms and move by using a flagella or cilia. They consume bacteria and can attack fungi. By feeding on bacteria, protozoa help to release nutrients (including nitrogen and phosphorus) back into the soil.

Ciliates promote nutrient cycling in the soil. Compacted and anaerobic soils tend to contain higher levels of ciliates than healthier soils.

The hairlike structures of ciliates are used for movement and food gathering.

Amoebae are single-celled microbes that move with a finger-like structure

Viruses transfer genes from host to host, and kill other microbes. They are responsible for the turnover and concentration of nutrients in the soil.

What microbes do in the soil?

Microbes undertake a range of different roles in the soil including decomposing plant matter and making nutrients available to plants. Microbes release vitamins and hormones that can trigger a plant's immunity and help to reduce its susceptibility to disease, infection or pests. Nitrogen fixing bacteria pull nitrogen out of the atmosphere and make it available to plants.

Plants supply carbohydrates (simple sugars) to attract microbes in return for nutrients and water and the presence of carbohydrates increases the liable carbon fraction within the soil. If you pull a plant out of the ground and wash the soil off, you'll notice a white foam is formed. This white foam is the carbohydrates or liquid carbon.

Vascular arbuscular mycorrhizal fungi produce a substance called glomalin (a type of glycoprotein) which glues soil aggregates together and helps to stabilise the soil structure. Structures known as hyphae act like an extension of the plant, accessing water beyond the plant's roots reach to supply nutrients and water making plants more resilient to droughts. Mycorrhizal fungi form a connection with mycorrhizae found on other plants, creating a chemical signalling link. When a plant is being attacked by an insect, the signalling chain is used to alert surrounding plants so they can take preventative measures to avoid attack. Mycorrhizae fungi are found on most plants except for Brassica and chenopod families of plants.

A particle of soil organic matter (centre) with a diatom - the microorganisms responsible for removing carbon dioxide from the atmosphere through photosynthesis.

Saprotrophic fungi decompose dead plant and animal matter and make nutrients available for plants. They also make humus - a valuable resource needed by plants and the soil.

Other microbes allow phosphates to be converted from an inorganic form into a more plant available format. Microbes have also been found to initiate and to activate the plants own immune system.

The microbial life cycle

The soil microbiome is always in a different state of flux, with microbes ebbing between different stages of their life cycle - from early development to exponential growth to a lag phase before dying.

As they die, microbes help to release nutrients in a soluble form to the plant. In certain circumstances, the plant actually engulfs the microbe as a source of food, providing the plant with essential nutrients. Dead microbes (known as a necromass) excreted by the plants increase soil carbon and release additional nutrients for plant uptake.

Microbes are the start of the soil food web as they are consumed by one another and then by larger soil fauna like worms and slaters etc.

Bacteria and fungi ratio

The ratio between fungi and bacteria can affect what type of plants grow. To get more fungi in the soil, use a fungal dominated compost, compost tea or spray out fish hydrolysate. For a more

bacterially active soil, use a bacterial dominated compost or compost tea, or spray out a simple sugar like molasses. There are many other different ways to increase either the fungi or bacterial ratio and information about these brews are available online.

Fungi to bacteria ration	Plant type
0.1:1	Weeds
0.75:1	Grasses
3:1	Vegetables
5:1	Shrubs
100:1	Trees

Testing soil microbial activity

Testing your soil to better understand the level of microbial activity and type (bacterial or fungal) is a useful step towards improving soil health.

The Solvita® CO_2 burst test provides a cheap and easy way to assess microbial activity on-farm without the use of laboratory testing. Once sampled, the test takes 24 hours to complete and provides an indication of soil health based on the volume of carbon dioxide produced by soil microbes.

Also available for home testing, the microBIOMETER® test takes just 20 minutes and provides an idea of both microbial biomass and the fungal to bacteria ration of a soil sample. This helps landholders better understand how their soil health is responding to land management practices and adapt management decision to suit.

There are also a number of laboratory scale tests that can be undertaken to assess soil microbiology. A phospholipid fatty acid (PLFA) test measures microbial biomass and identifies missing microbes.

DNA sequencing is also gaining momentum as a way to understand the composition of a microbiome at a genetic level. While the testing itself is relatively cheap, interpreting the results requires the expertise of a soil scientist which makes the process more expensive. Future advances may automate next generation sequencing services and therefore make this a more realistic option for landholders.

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