Australian Cotton Cooperative Research Centre

COTTON information sheet

Soil Biology -

Whats hiding in the ground?

Oliver G.G. Knox[1], Gupta V.S.R Vadakattu[1], Nikki Seymour[2], Kirrily L. Rourke[3], Leonie K. Whiffen[4], David J. Midgley[4] and Peter A. McGee[4]

So many and so different. Where do we start?

Soil contains a huge number and diversity of organisms. The weight of organisms present under 1 hectare of soil (1-2 tonnes / ha) can exceed that of the animals grazing above. Under just 1 m2 of grassland there can be millions of little creatures and fungi, and billions of bacteria (Table 1).

Bacteria are so numerous in soil that in just 1 gram there can be 4000 - 6000 species. Compare this to approximately 4000 species of mammals on the earth. This bacterial diversity represents a huge functional capability. But just what they can do, we are only just starting to understand.

One of the challenges of studying soil organisms is that this huge diversity is not distributed evenly. This is partly due to the soil itself, which varies physically and chemically from row to row, field to field, and from season to season.

Table 1. Number of organisms under one square meter of grassland

Macrofauna	Earthworms	1-10
	Slugs and Snails	100 - 8500
Mesofauna	Ants	600 - 5000
Microfauna	Nematodes	1000 - 10000
	Protozoa	1000 - 1 million

So what do all these soil organisms do?

1. Microbes contribute to soil structure.

Microbes are essential to establish and maintain soil structure. Soil bacteria and fungi break down organic matter to make 'glue' that binds the soil particles into aggregates. Fungi also help aggregate formation and structural stability, by binding the soil together in a net of hyphae (Figure 1 over page).

2. Microbes recycle essential nutrients.

Soil microflora and fauna are the primary players in nutrient recycling. In biogeochemical cyclic pathways bacteria and fungi free up key elements such as carbon, nitrogen, phosphorous and sulphur from cadavers, decaying plant material and faeces. Bacterial involvement in recycling these elements has been recorded for all the ecosystems studied on Earth. Additionally, some bacteria can capture these key nutrients directly from the surrounding environment, as is exemplified by nitrogen fixation.

3. Fungi help plants obtain nutrients.

Mycorrhizal fungi form a symbiosis with plants, so both partners usually benefit. The fungi colonise plant roots and gain carbohydrates from the plant, which it has made during photosynthesis. In return, fungi act like extensions to the root system, vastly increasing its surface area and improving nutrient uptake to the plant, particularly phosphorus and zinc.

Crop species differ in their dependence on mycorrhizal fungi to aid nutrient uptake and plant growth. Some such as cotton, maize and chickpea grow extremely

CSIRO[1] - NSW Department of Primary Industries[3] - Department of Primary Industries & Fisheries Queensland[2] - NT Department of Primary Industry and Fisheries - Agriculture Western Australia - University of New England - University of Sydney[4] - Cotton Research & Development Corporation - Cotton Seed Distributors - Queensland Cotton - Western Agricultural Industries.

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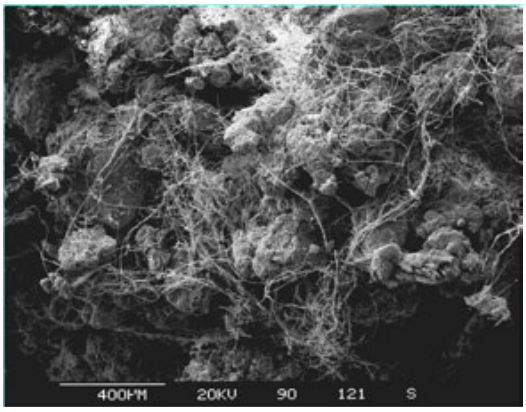

Figure 1. A net of Fungal Hyphae extending through and over soil aggregates.

poorly without these fungi. The good news is that mycorrhizae occur naturally in most soils and so are usually present in our cropping systems.

4. 'Big guys' cycle nutrients too.

The larger microfauna, like protozoa and nematodes, are important for nutrient cycling.

Protozoa have been implicated in the suppression of plant pathogenic fungi by eating them. The most numerous protozoa in clay soils are the naked amoebae. Populations of these can increase dramatically after rainfall events, closely following increases in bacterial numbers. This relationship between protozoa and bacteria can lead to accelerated nutrient mineralization.

Nematodes have been studied for their role as plant parasites, but only a small proportion of a nematode population is plant parasitic. The majority of soil nematodes are bacterial (Figure 3) and fungal feeders. The bacterial and fungal feeding nematodes, like the protozoa, are mostly involved in organic matter decomposition and mineralization when feeding on microflora.

The plant can also have a significant involvement in the soil ecosystem; Root exudates can influence and increase microflora populations which the microfauna and mesofauna eat.

Soil biota feeding on others is critical to maintaining soil quality, but our knowledge about this is limited?

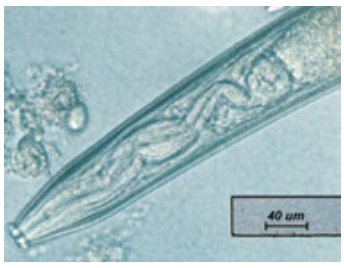

Figure 2. Head of Dipolscapta coronata, a bacterial feeding nematode similar to many found in the soil.

5. Who eats who in the soil?

What is food and what forces do predators exert upon prey, and vice versa? Food webs are often used to depict complex feeding relationships, but food webs don't show the possible effects exerted by predators on prey.

Energy flow webs are used to describe these interactions. Energy flow webs can show the impact of the soil community on decomposition and nutrient cycling processes.

What is predator and prey is not always clear cut in soil systems. Mites may feed on fungi, algae, decaying plant material or other soil animals depending on what is available. Even the diet of earthworms isn't fully understood. Until recently we thought that microorganisms formed a major part of the earthworm diet, but now it seems they are only of minor importance.

We need more information on food preferences of soil animals and what levels or ratios of prey and predators are important for assigning what is feeding on what. Through a better understanding of these biota interactions we might be able to better manage essential soil processes.

Where to now?

We are only just starting to understand what is in the soil, how these organisms interact and what this means for maintaining a productive soil.

Five hundred years ago Leonardo da Vinci supposedly said that 'we know more about the surface of the moon than we do the soil under our feet'. Sadly this is probably still the case.

However, we have started to explore the soil and are making progress. The next time you're out in the paddock pick up a handful of soil and try to imagine the vast diversity of life you are holding. Chances are there will be something in there that isn't even named.

You can make a start:

We know organic matter is vital to maintaining life in the soil. Try to conserve what you have and aim to build it up over time. There may be too many soil organisms to treat like wealthy relations, but if you try to understand them and remember they are there, it might just pay off.

For more information contact Oliver Knox
Oliver.Knox@CSIRO.au,
Phone: 02 67991583
ACRI, Locked Bag 1000, Narrabri, NSW, 2390
He will either deal with your queries or put you in touch with a team member that can help.

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