FarmFLOW
growth through good practice

What do our living soils do and how can we manage them?

Living soil organisms carry out processes needed to maintain soil health and fertility. They improve soil structure and fertility and can be important for disease suppression. Populations of soil organisms can boom or bust daily or seasonally depending on soil conditions and farming practices.

Did you know?

- The earthy smell of newly turned soil is thought to result from chemicals produced by soil organisms.
- Where earthworms are active they can turn over the top 15 cm of soil in 10 to 20 years.
- Of the carbon returned to soil in crop residues, 5 to 15% end up in soil organisms, 60 to 75% is returned to the air as carbon dioxide (CO_2) and 10 to 25% is converted to humus.

Soil contains huge numbers of different living organisms including bacteria, fungi, earthworms, nematodes, protozoa and arthropods (beetles, spiders, ants, centipedes and millipedes).

So what do these organisms do?

Soil organisms have essential roles for soil quality and fertility including:

- breaking down organic matter
- cycling of nutrients
- maintaining soil structure and
- plant health.

Organic matter breakdown, nutrient cycling and availability

All soil organisms need carbon as their main energy source. Breakdown of organic matter releases carbon and nutrients in available forms for plants and soil organisms to use.

The rate of organic matter breakdown depends on soil conditions, the number and type of soil organisms, farming practices and the type of plant residues. Soils with more organic matter will tend to have a greater number and range of organisms.

Soil organisms also cycle and store nutrients. They do this by:

- breaking down organic matter to release available nutrients
- fixing gaseous nitrogen into plant available forms
- transforming nutrients into different forms
- mobilising phosphorus
- forming linkages with plant roots for nutrient exchange (eg mycorrhiza)
- recycling nutrients by feeding on other soil organisms.

Soil structure

Soil organisms are essential for good soil structure.

- Fungi and bacteria produce substances that bind or glue soil particles together, making stable aggregates. Stable aggregates provide a better environment for soil organisms and are important for water infiltration and protecting soil from erosion and compaction.
- Fungi also assist to form stable soil aggregates by physically binding soil together.
- Burrowing organisms such as earthworms, ants, beetles etc mix and aerate the soil and create large pores for the movement of oxygen and water through the soil.


Soil fungi helps to stabilise soil structure

FF10-003

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Plant health

In a natural soil ecosystem disease causing organisms are usually limited through competition, suppression and predation. In agriculture, farming practices and monocultures disrupt this balance. Of all soil organisms only a relative few cause plant disease. These affect plant growth by invading plant cells or producing toxins.

Bioremediation

Soil organisms are increasingly used to buffer, detoxify and break down potential pollutants. Many agrichemicals are degraded by soil organisms. For example, herbicides are degraded more rapidly in soils with high soil organism activity.

Management for living soils

Did you know?

- Increasing organic matter will increase numbers and range of soil organisms.
- Different crop rotations favour a range of soil organisms.
- Reducing tillage can maintain organism habitat.
- Providing soil cover protects the soil environment and provides habitat.
- Sustainable fertiliser and pesticide decisions reduce the impact on soil organisms

Maintaining a living soil

It is very difficult to build populations of soil organisms by physically applying them to the soil. Low numbers of soil organisms are usually the result of unfavourable soil conditions, often due to soil management practices. It is likely that any organisms added to the soil will also find conditions unfavourable unless practices to improve the soil environment are put in place.

Managing the soil environment

Many farming practices can affect the survival of soil organisms by:

- providing or destroying habitat for organisms
- providing or removing food sources
- promoting or killing soil organisms.

A range of other factors are important in the survival of soil organisms including: soil texture and structure, nutrient status, organic matter content, pH, soil moisture and temperature, chemical inputs, soil compaction, salts and soil management practices. Some of these soil factors are inherent to the soil while others can be managed.

What can you do to encourage soil organisms?

Organic matter

Organic matter is essential to soil organisms. Conserve what you have and build on it through crop rotation and residue management.

- High residue crops and cover will increase organic matter levels.
- Reduce the time under bare fallow and provide cover through living plants or plant residues.
- Organic matter amendments can be applied such as manures, composts to increase organic matter.


Compost

Crop rotation

Living plants are important to soil biology as they provide the rhizosphere (the narrow zone surrounding roots) where most soil organisms are found.

Plants release sugars and other substances into the soil to attract and increase soil organisms. They do this as they need soil organisms to obtain nutrients from organic matter and the soil. In return, plant residues provide energy and nutrients for soil organisms.

A greater range of soil organisms are seen with different root types and organic matter sources (i.e. crops).

- Legumes link with N-fixing *Rhizobium* bacteria for nutritional benefits as well as a larger number and range of soil organisms.
- Breakcrops slow the build-up of disease causing organisms.
- Crops with different root structures provide different habitats ie fibrous roots versus tap roots.
- Various crops act as biofumigants as their roots release substances that suppress disease causing organisms. For example, BQ Mulch™ (*Brassica napus*) reportedly reduces lettuce drop incidence by up to 89% when grown in rotation with lettuce. BQ Mulch™ produces high levels of biofumigant compounds (isothiocyanates or ITC s) in the roots which suppresses sclerotinia in the soil.


Lablab green manure crop

Residue management

The location of organic matter will affect the type of soil organisms.

- Incorporating crop residues destroys fungal hyphae, allowing bacterial populations to dominate. Fungi maintain a high C:N ratio, holding carbon in the soil.
- Crop residues on the soil surface are mostly broken down by arthropods (beetles and bugs) and fungi.
- Ground cover at the soil surface maintains soil moisture and temperature, provides food and habitat for fungi, bacteria and arthropods and loss of habitat from cultivation and erosion is reduced.

Compaction and cultivation


Surface residue

Cultivation significantly changes the physical, chemical and biological characteristics of soil.

- Greater depth and more frequent tillage destroy soil organisms and habitats and increases organic matter breakdown.
- Cultivation favours bacteria. Tillage physically breaks up fungi. A single tillage event may also kill up to 25% of the earthworm population in a soil.
- Compaction reduces pore spaces,

limiting the amount of air and water available for soil organisms. The movement of larger organisms to find prey or complete other functions is restricted. Compaction negatively affects arthropods, nematodes and protozoa.

Minimise erosion losses

As most soil organisms live in the top 10 centimetres of the soil, erosion causes physical loss of soil organisms as well as disruption and/or loss of habitat.

- Tillage causes loss of soil structure and increases the erosion risk. Controlled traffic farming and minimising tillage will reduce erosion as well as the effect on soil organisms.
- Cover crops and inter-row cover reduce the risk of erosion and provide organic matter and habitat for soil organisms.

Pest control and fertiliser use

Insecticides, fungicides and herbicides applied to plants and soil effect soil organisms. The effects vary with the type of pesticide, species of organism and the rate of chemical degradation and/or leaching.

- Foliar applied chemicals have less effect on soil organisms than soil applied.
- Stubble applied herbicides tend to persist for longer than soil applied.
- Fungicides have the biggest effect on soil organism populations.
- Herbicides can be toxic to soil organisms or disrupt predator:prey balances.
- Crops with a balanced nutrition program may be less prone to pathogens.
- Fertiliser inputs can cause pH changes with negative effects on soil organisms.
- Fertiliser applications may reduce mutually beneficial soil organism/plant relationships such as mycorrhizae and *Rhizobium*.
- Split application of fertilisers as regular small amounts that match plants needs will be more beneficial for soil organisms and reduce the risk of off-farm losses.

Where to now?

Our current knowledge of soil organisms, how they interact and their role in soil health is only just developing.

The next time you have a handful of soil think about what s living in the soil and the effects your farm practices may be having on the organisms in your hand.

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Acknowledgements

This factsheet was produced as part of the Healthy Country program. The Healthy Country Project is a three-year partnership between SEQ Catchments, Department Employment, Economic Development and Innovation, scientists from Healthy Waterways and indigenous representation through the SEQ Traditional Owners Alliance. The other project partners are coordinating river restoration works and water quality monitoring in three focal case study areas in the Lockyer, Bremer and Logan Albert catchments.

For more information

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