Information Sheet

6.3 Soil biology

Soil is sometimes known as the 'stomach of the earth' as it breaks down plant residues and recycles nutrients and other beneficial compounds. It does this through countless organisms of plant, animal and microbial life which contribute to the functioning of the soil.

This information sheet outlines the role of soil organisms in soil biology and provides guidance on management practices that aim to increase and maintain biological functions of your soils.

What is soil biology?

Soil biology refers to living plant and animal life found in the soil. This includes the root systems of plants, large organisms (such as moles, earthworms and insects) and a very wide range of smaller plant and animal organisms (like insects, nematodes, fungi, bacteria, protozoa and algae).

Soil organisms can be classified into different sizes:

- Macrofauna (> 10 mm i.e earthworms, termites, large insects)
- Mesofuana (range in size from 200 µm to 10 mm i.e. mites and collembola)
- Microfauna (20 – 200 µm i.e protozoa and nematodes)
- Microflora (i.e actinomycetes, fungi and bacteria)

While different organisms often have specific roles in the soil, their functions are closely linked to one another. Often changes in one population will lead to shifts in others and in, some cases may stimulate explosions of unfavourable organisms.

Soil biology is essential in improving and sustaining agricultural production. There is growing evidence that adopting practices that promote the health and diversity of soil biology are critical for sustainable soil functioning.

▲ Figure 1: A diverse range of life forms exist in a healthy soil.

The role of soil organisms

Soil organisms decompose and recycle soil organic matter (SOM), improve availability of nutrients in soil, improve soil structure, reduce the risk of diseases and degrade pollutants. These contribute to processes that include:

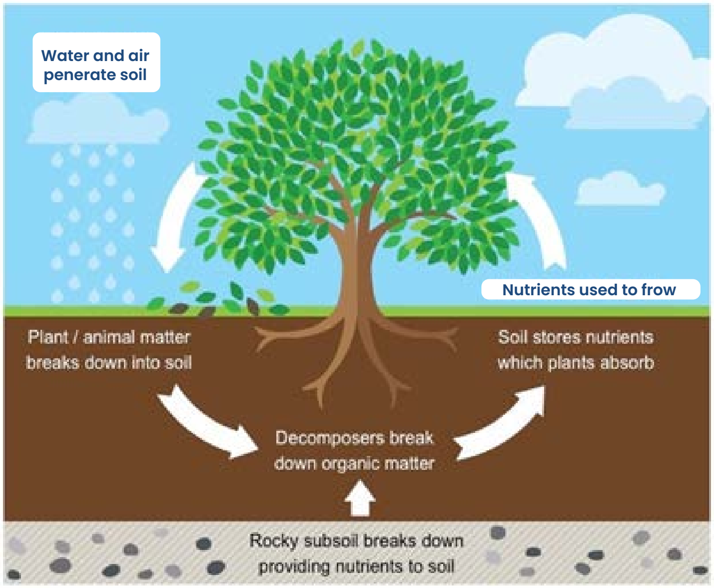
- Nutrient cycling (breakdown and release)
- Nutrient retention (capture and storage)
- Improving soil structure and water retention characteristics
- Disease suppression
- Degradation of pollutants

Nutrient cycling

Many nutrient transformations in soils are biologically mediated thus, for optimum nutrient cycling from both organic and inorganic sources, a diverse biological population is required (see figure 2 below). SOM is responsible for storing and releasing nutrients from the soil which is a big reservoir of carbon (C), nitrogen (N) and other essential nutrients. More nutrients are released from soils that are biologically active and have higher amounts of active C recycled than soils that are biologically inactive and contain less active organic matter.

Soil organisms also influence the two most important cycles (N and C) that occur in soils. In the C cycle, soil biology plays a very important role where soil biota both decompose and also capture and store C. The soil organisms thus act as a large C store and also act as C source for other organisms to feed on. When decomposition exceeds capture and storage, there is a net loss of SOM and this is balanced by inputs from growing plants or amendments added.

Similarly, soil microorganisms can convert unavailable N stored in SOM to available forms, or under some conditions, can capture and store plant available N forms into SOM. The N cycle (Figure 3) gives insights into plant-nutrient relationships and provides the basis of nutrient management decisions on how much and when to apply supplemental nitrogen.



▲ Figure 2: Nutrient cycling.

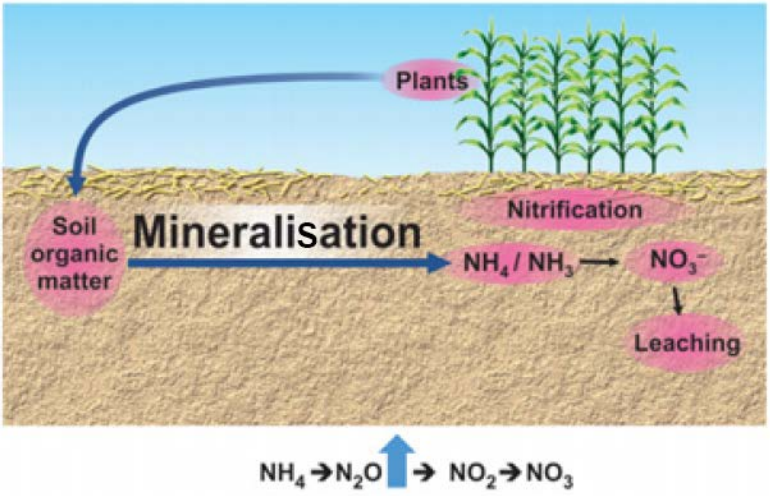


Figure 3: Nitrogen mineralisation and re-cycling.

The breakdown (decomposition), release (mineralisation) and capture and storage (assimilation) are controlled by three main processes:

Decomposition (breakdown)

Decomposition is the process in which plant and animal residue are broken down into different organic and inorganic compounds. This involves the breakdown of large organic molecules into smaller and simpler components. During the initial phases of residue decomposition, nutrients such as nitrogen (N) are captured by soil bacteria and fungi so that all are not leached into ground water, while larger organisms feed on fungi and bacteria with the release of N, P, K and other nutrients that are vital for plant growth. Environmental conditions and the quality of the added plant or animal residue (source of food for soil organisms) are two factors influencing the process of decomposition. Under warm and moist conditions, soil organisms decompose organic matter more quickly than under cold and dry conditions. Soil disturbance also increases the rate of decomposition as this increases the exposure to air available to the organisms to decompose SOM.

Mineralisation (nutrient release)

When soil organisms convert SOM into plant-available forms of nutrients, the mineralisation process occurs. This is usually associated with N, but includes most other nutrients to varying degrees. As the soil organisms consume the organic matter as a source of food, they break down the molecules that hold nutrients, which are released into the soil in forms that can be used by plants. The important role of this process is recognised in sugarcane production, where soils are classified according to their mineralisation potential, where low organic matter soils have low N supply potential while high OM soils can release considerable amounts (see Information Sheet 7.2: Nitrogen Management). This is accounted for in your routine soil sample analysis for fertility recommendations.

Assimilation (capture and storage)

As much as soil organisms are continually decomposing and mineralising SOM, they are also in the process of growing. For this, they need C and nutrients, which they will acquire from the breakdown of SOM. Generally, this process is considered beneficial as it helps to recapture the nutrients released, which slows loss through other processes such as leaching. However, assimilation processes can have a negative impact where the nutrient use by the organism exceeds the available supply in the soil, leading to a shortage. If this coincides with active crop growth, there may be a deficiency for crop needs. This is most often observed when high fibre residues are added to N poor soils. As the residue decomposes and gets assimilated by soil microorganisms, the need for N increases. However, due to insufficient supply from the residue or the soil, this leads to a temporary shortage of N and can negatively affect crop growth.

There are several factors that influence the rate of decomposition, mineralisation and assimilation, including:

- Soil moisture content: excessively dry or wet soils slow the breakdown of SOM.
- Soil texture: Sandy soils tend to have lower SOM than clay soils as clays can bind with OM to help protect and stabilise the structures thus slowing breakdown.
- Amount and type of organic matter and residues: high OM inputs tend to stimulate soil biological activity, where high fibre (or high C:N) residues are broken done more slowly than low fibre residues.
- Soil pH: under acidic soil conditions, the rate of decomposition is slower.
- Soil disturbance: ploughing of fields exposes fresh SOM to the atmosphere which speeds up the rate of breakdown.

Filter function

Soil acts as a filter to protect the quality of water, air and other resources. Soil organisms and SOM are responsible for filtering, buffering and detoxifying of organic and inorganic materials in soils.

Managing soils to improve soil biology

Soil biology can be improved through recommended management practices. Although natural characteristics cannot be changed, they can, to a certain extent, be managed.

To improve microbial biomass and biological functions, good management of soil water, soil temperature, organic matter quality (i.e types of organic materials added), soil disturbance, application of fertiliser, pesticides, lime and other ameliorants are required.

Key management strategies to improve soil biology include:

- Minimise soil disturbance and keep the soil covered to moderate moisture and temperature fluctuations.
- Application of organic material to the soil is still recognised as vital in improving and maintaining good soil biology. Practices include green cane harvesting and mulching, green manure fallowing and applying organic amendments where available.
- Ameliorate constraints such as compaction, acidity, waterlogging and excess salts as these negatively affect root growth and biological functions.
- Avoid over-use of fertilisers, pesticides or herbicides which are likely to impact on different soil organisms. Minimising the use of pesticides and herbicides will have significant improvement on soil biology.
- Avoid over-application of high salt-index fertilisers (e.g. potassium chloride, ammonium nitrate, ammonium sulphate, potassium nitrate).

Special note

Effective management of soil biology requires a long-term view. It is essential that practices that preserve and increase soil organic matter must be continued yearly so that soil biology has regular and continued access to food stocks. For example, a once-off application of animal manure, green manures and use of cover crops to a field will result in a very short-term improvement in soil organic matter level and consequently, good soil biology. However, if application of animal manure is not repeated, then the system will quickly return to the previous state of low soil organic matter with soil biology declining and thus providing no real long-term benefit to soil health.

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July 2022