Enhancing Biology with Management

FACT SHEET 8

Although soil biology occurs in every environment, the numbers of individuals and populations present at any time will be significantly affected by soil conditions. The soil conditions in managed land will ultimately be determined by the decisions and actions of the land manager.

Soil biota: the plant-soil bridge

The majority of bacteria and fungi reside in the zone of soil adjacent to the plant root known as the rhizosphere. Through the rhizosphere soil biota provide a conduit between plants and soil, enhancing the delivery of nutrients to the plant in a form which may be readily taken up. It's estimated that bacteria and fungi collectively contribute approximately 70% of soil biota biomass.

Management of plants to encourage the optimal amount of root biomass in any situation will enhance biological activity by providing the maximum surface area of roots for bacteria and fungi to reside.

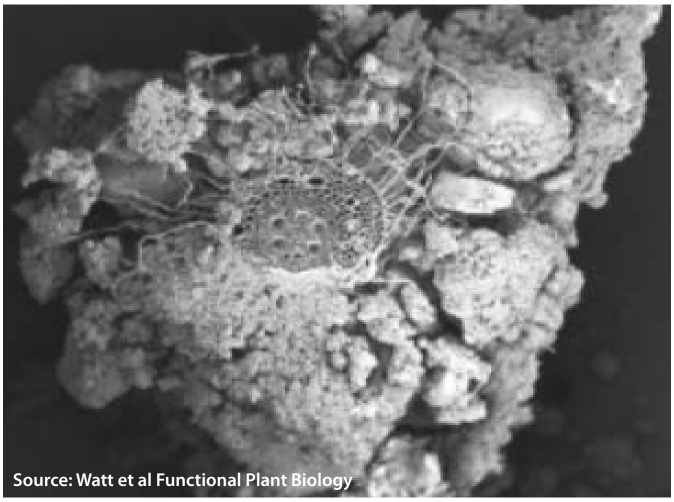

Figure 1: Cross section of wheat root and rhizosphere. The electron micrograph shows root hairs and soil particles at the root surface bound by biology and root exudates

Rhizosphere activity

The rhizosphere is the region of most ecological significance in the soil. It includes the plant root, root hairs, the zone immediately adjacent to the root (the rhizoplane), bacteria, fungi and other organisms associated up to a few millimetres from the plant root.

Roots are affected by the presence of rhizosphere microbes. Microbes can affect root physiology and morphology as well as impacting the pH, soil chemistry (through mineralisation) and plant nutrient availability in the rhizosphere. Symbiotic associations such as occurs in root nodules and with mycorrhizal fungi also influence nutrient uptake.

Microbes influence the flow of carbon from the root through the production of compounds that increase the permeability of root cells. Rhizodeposition of carbon significantly enhances the general soil microbial population density. Microbial growth and activity in the rhizosphere largely depends on the carbon supply from the root.

In addition to sugars and carbohydrates roots also exude enzymes, amino acids, proteins, vitamins, organic acids and mucilaginous materials. These exudates modify the rhizosphere environment, provide signals to microbes and other plants, influence root growth and plant nutrient uptake. In addition to biochemical changes, root exudates also impact the physical and moisture conditions in the rhizosphere which may be very different to those in the bulk soil.

Mycorrhizal associations are primarily initiated in the rhizosphere, at the root surface. The rhizoplane provides a favourable environment for germination of fungal spores. Mycorrhiza require carbon from roots and in return enhance nutrient and water provision to roots for plant uptake.

The rhizosphere is the region of most ecological importance in the soil

NSW GOVERNMENT | Local Land Services

Management to enhance the rhizosphere

Any action which enhances plant and root growth, including enhancing soil structure, porosity, water holding capacity and mineral cycling has the capacity to enhance the rhizosphere area and associated biological activity.

A number of management actions that will achieve this outcome are listed here.

Figure 2: The 'dreadlock' appearance of a wheat plant with a healthy rhizosphere associated. Photo: I & D Haggerty.

Soil moisture content is the factor which has the greatest impact on soil biological activity

Groundcover maintained at 100% year round, easily achievable on the North Coast, reduces soil water loss though evaporation and surface runoff. Standing herbage mass of 2,000 kg DM/ ha also has the effect of buffering daily fluctuations of soil temperature at the surface which is so important in maintaining biological activity in the top layer of soil.

Perennial groundcover provided by a diversity of species with a range of growth patterns maintains actively growing roots for a longer period of the year. A diversity of plants with different root architecture will support a greater diversity of microorganisms.

Organic matter as humus will hold more than 4 times its weight in water. As well as increasing water holding capacity soil organic matter will also improve soil structure, the nutrient status of soil and the cation exchange capacity. As a primary food source for soil biota increasing the carbon and organic matter content of soil will increase biological activity and population density.

More information on the importance of soil carbon and organic matter in soils is provided in Factsheet 6 of this series.

Mulch is defined as a layer of organic matter and may be spread manually on the soil surface, created mechanically by mulching standing herbage mass or using livestock at high density to enhance contact of standing plant material with the soil surface. It is a method to enhance groundcover, reduce evaporation, modify soil temperature and stimulate the creation of soil organic matter.

Pasture cropping is the practice of direct drilling (to minimise soil surface disturbance) an annual crop into a dormant perennial pasture. Most commonly, winter cereals such as oats, barley or rye are direct drilled into pastures dominated by warm season species. In addition to extending the active growing period of plants in a paddock the sugars exuded by the roots of the cereal plants provide longer term benefits to the soil biology associated with the perennial pasture.

Cover cropping is a relatively new extension of pasture cropping where multi species of annual and/or perennial plants are introduced to build soil health. Compatible plants of 4 or more species enhance soil structure, water infiltration, extend the growing season and increase annual herbage mass production.

Figure 3: A cover crop containing multiple grass species, brassicas, legumes and other forbs.

Green manure crops are cover crops planted with the specific purpose of adding nutrients and organic matter to the soil. A crop may be left standing in the field once senesced where the plant material will ideally be broken down biologically or may be incorporated onto the soil surface using a roller-crimper to enhance access by soil microbes. Incorporation of green material enhances the release of nutrients into soil and a flush of microbial activity is associated with the decomposition of the crop.

Figure 4: A green manure crop is rolled and crimped to mulch the soil surface and build organic matter.

Minimal tillage limits the adverse impacts of disrupting fungal hyphae networks so critical to plant and rhizosphere water relations and nutrient transfer. Repeated or aggressive soil disturbance increases soil exposure and susceptibility to erosion, depletes soil carbon and accelerates nutrient mineralisation. Excessive tillage is detrimental to mycorrhizal fungi, earthworms and other soil biota as well as damaging soil structure and aggregate stability.

Limit the use of inorganic fertiliser to allow the soil biology to function to their potential. Soil bacteria and mycorrhizal fungi can provide up to 90% of plants nitrogen and phosphorus requirements. Application of these nutrients in inorganic form makes these organisms redundant in the soil and limits their growth and activity. Plants reduce the production of liquid carbon produced due to the reduced demand from rhizosphere microbes for these elements. In turn soil aggregation is adversely effected and energy available to soil microbes from carbon flow from roots is limited.

Limit chemical use to minimise harm to soil biology. The application of any chemical herbicide must change the chemical and biological conditions of the soil. There is increasing evidence to support the toxic effects of common herbicides on soil bacteria and inhibition of mycorrhizal fungi.

The addition of any chemical product to plants or soil will impact on the chemical and biological conditions and living organisms in the rhizosphere.

Balance soil nutrition through the application of appropriate levels of nutrients, based on soil chemical analyses, in forms which enhance biological activity. For many elements the balance of nutrients (e.g. Ca:Mg) will be more important for biological activity than the absolute amount of particular nutrients. Application of fertilisers or soil amendments which promote soil conditions and biological activity will provide a better long term outcome than products that simply provide plant nutrients.

Compost can be created on either a small or large scale and there are a number of different approaches to effectively recycle organic matter. Well made compost acts as a soil conditioner and can be a source of beneficial bacteria and fungi to otherwise deficient soils. Composted animal manures (e.g. cattle and poultry) are common resources for large-scale application.

Figure 5: The addition of compost as a soil conditioner adds beneficial bacteria, fungi and nutrients to soil.

Working with natural processes and natural products enhances the function of the soil ecosystem. When soils are alive mineral cycling improves significantly.

Enhancing Biology with Management

Grazing management in tune with natural cycles, planning adequate recovery periods for desirable perennial grasses and maintenance of a minimal residual herbage mass (not less than 2,000 kg DM/ha) will optimise root density and rhizosphere activity.

Grazing at high density for short periods promotes more even utilisation of pasture plants. Where plants are fully recovered with a robust root system the 'pulse' grazing initiates a flush of sugars and exudates into the rhizosphere stimulating biological activity. Continuously grazed plants with reduced root systems produce a comparatively much lower volume of exudates into a smaller volume of soil occupied by a smaller volume of plant roots.

Figure 6: Controlling the grazing process and managing to retain minimum residual herbage mass levels enhances soil health and biological activity in pastures.

More information on grazing and pasture management to improve soil health is provided in Factsheet 12 of this series.

Root volume and density - the stimulation of plant root growth through any action or activity will favour biological activity. Plant roots are most effective soil conditioners. The adventitious root system of perennial grasses and the associated root hairs provide a huge potential surface area of rhizoplane.

Soil conditions to enhance biology

Application of tools or actions that result in any of the soil condition outcomes listed here will result in benefits for microbial habitat, soil health and function.

1. Improved soil structure as indicated by increased macro-porosity will increase soil water infiltration and plant available water. Higher levels of soil water will enhance microbial activity. Greater soil porosity increases the ability of plant roots to extend further through the soil profile. More roots provide greater surface area and increase rhizosphere activity.

2. Increasing soil organic matter enhances soil structure and water holding capacity and is a primary source of carbon, which provides energy for soil biota.

3. Increasing diversity of plant species with different growth cycles, form and function enhances plant growth, photosynthesis and root growth throughout the year.

4. Maintenance of maximum groundcover is an essential first step in soil health by enhancing soil moisture retention and buffering changes in daily temperature at the soil surface.

This is the eighth of a series of 12 Factsheets which cover a range of topics regarding soil health and effective function of soil processes.

More Information

This factsheet has been prepared by Judi Earl
Agricultural Information & Monitoring Services
Email: judi@aimsag.com.au Phone: 0409 151 969

Acknowledgments:

This publication is developed as a component of the *Understanding Our Soils – Increasing Adoption and Innovation in Soil Management* project. The project is supported by North Coast Local Land Services through funding from the National Landcare Programme.