Impact of fallow management
ON SOIL BIOLOGY

The five year project, *Measuring soil health, setting benchmarks, and driving practice change* (2017-005), currently underway in the Burdekin and Herbert regions, has delivered some key outcomes on the relationship between good soil biology and legume fallow cropping from year one results. The six demonstration sites, comprised of side-by-side conventionally managed v Improved Farming System (IFS) practice fields, have undergone a regime of soil and plant testing. Soil biology measurements have potential to act as indicators of overall soil health for the sugarcane industry and in these examples demonstrate a strong correlation between the way in which the fallow period is managed and the abundance and diversity of beneficial biological communities.

WHY IS GOOD SOIL BIOLOGY BENEFICIAL?

Soil biology is key to developing a healthier soil. It ranges from invisible bacteria to earthworms you can see (Figure 1) . Soil microbes are responsible for converting organic material such as mill mud, cane trash and fallow crop residues or green manure into nutrients that are available to the crop. They also aerate the soil through their activities providing better soil structure for crop root development and an aerobic living environment for beneficial fungi that process carbon that is retained in the soil longer-term. Having readily available nutrients in the soil reduces fertiliser input and better aligns nutrient availability with crop demand.

But we need to be careful to manage soils to promote soil biology. Soil disturbance through frequent tillage quickly alters soil structure and soil microbial, fungi and beneficial bacteria communities. Plant pathogens can more easily dominate in anaerobic environments effecting crop development and yield. By increasing the size and diversity of microbial communities, plant pathogens are suppressed and beneficial organisms are more easily able to thrive. The application of rotations to crops improves the soil biology and reduces reliance upon pesticides.

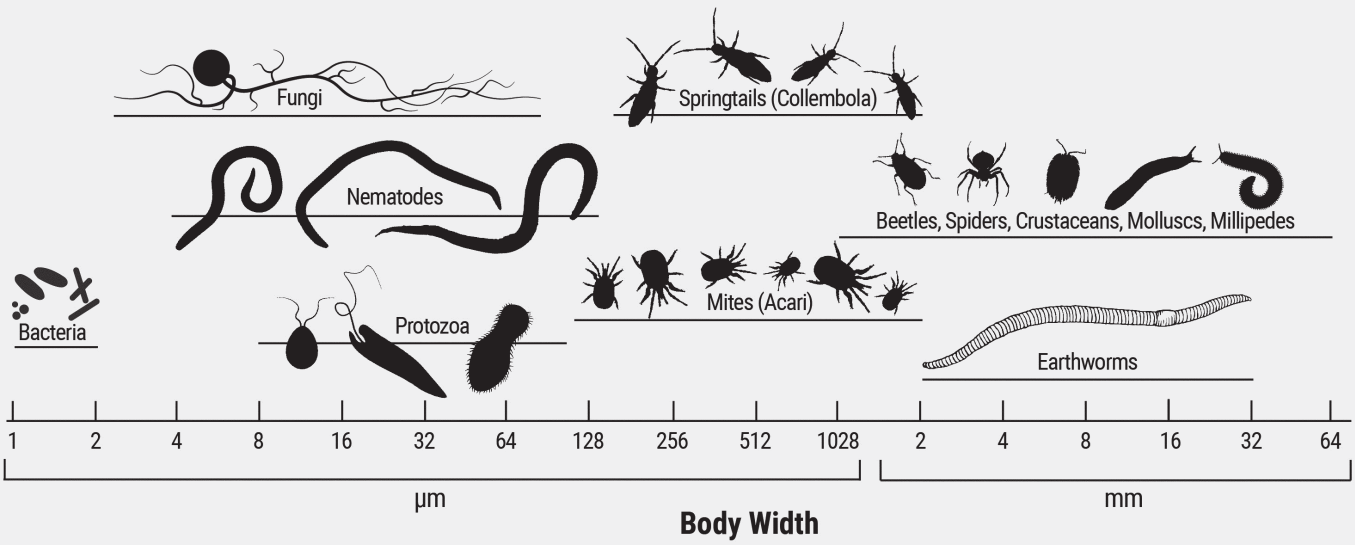

Figure 1- Biology in your soil, from invisible bacteria to visible earthworms (Source: Brackin et al., 2017 "Soil biological health - what is it and how can we improve it?. ASSCT vol. 39, pp. 141-154.)

SOIL HEALTH PROJECT DEMONSTRATION SITES

There are three Soil Health Program demonstration sites in the Herbert region comparing two farm management practices; conventional and an Improved Farming System (IFS) of, primarily, 1.83m row spacing, legume fallows, and minimum or no tillage. There are also three demonstration sites established in the Burdekin region comparing conventional practices with IFS of 1.83m dual row spacing, mixed species legume fallow and minimum or no tillage with precision irrigation monitoring and scheduling.

Additionally, there were five "paired sites" in each of the Herbert and Burdekin regions, comparing conventional and long-term IFS practices (10+ years), contributing to increased understanding of trends associated with IFS and soil biology. A second year of "paired site" comparison analysis is underway.

Measurements of many different soil health indicators are collected for both farm management practices (Figure 2) on both demonstration and paired sites. Four key soil biology indicators are discussed (Table 1 & 2).

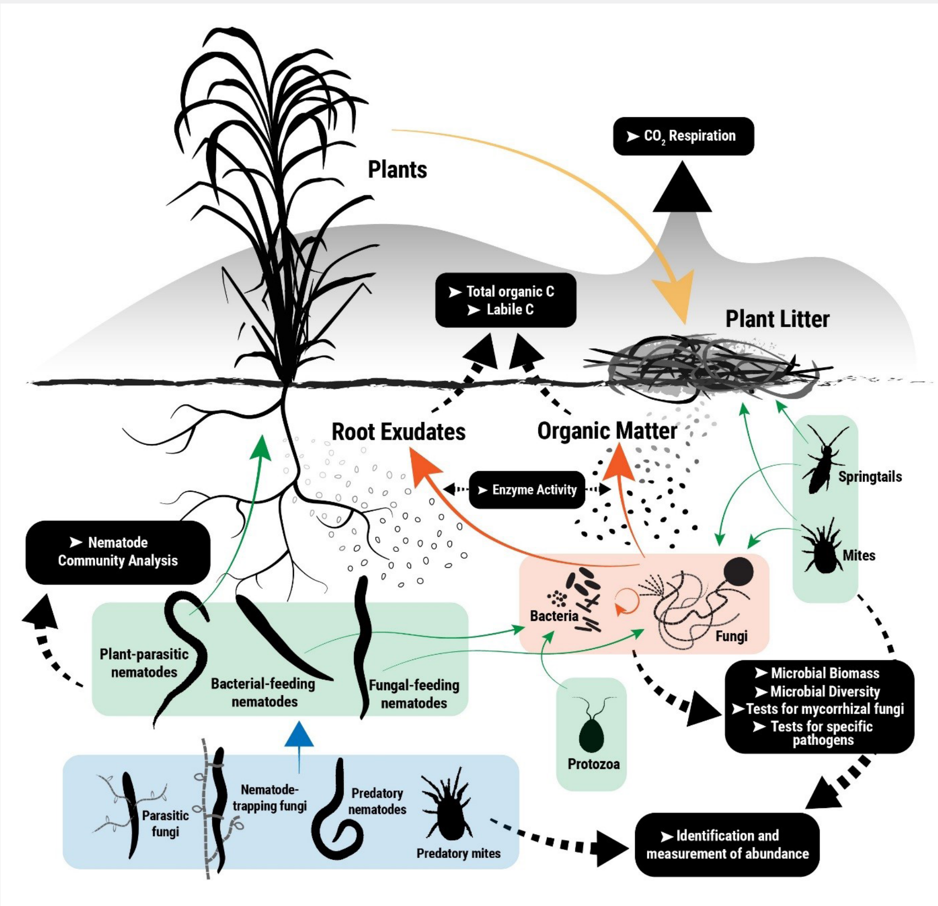

Figure 2- Soil biology measurement in sugarcane soils that have potential as overall soil health indicators (Source: Brackin et al., 2017 "Soil biological health - what is it and how can we improve it?. ASSCT vol. 39, pp. 141-154.).

THE KEY OUTCOMES OF YEAR ONE RESULTS

Labile Carbon - Labile carbon was higher where the Improved Farming System was used. While total soil organic carbon levels can be difficult to increase by farm management practice changes, labile carbon is relatively responsive to management.

Soil Microbes - Labile carbon is an easy-to-digest, crucial food and energy source for soil microbes. In general, soil microbes are limited by energy (not nutrients) and most of their activities are centred around obtaining energy.

Microbes produce enzymes to decompose organic material and these enzymes can be measured in the soil to indicate total microbial activity. Soil microbial biomass and total microbial activity were significantly increased with the Improved Farming System at all of the demonstration sites.

Table 1- Results from one Herbert demonstration site; pre-treatment and after plant cane established.

SOIL HEALTH INDICATOR	2017	2018	
	PRE-TREATMENT BASELINE	CONVENTIONAL	IMPROVED FARMING SYSTEM
Labile Carbon (mg C / kg)	362	308	504
Microbial Biomass (mg N / kg)	0.92	1.0	3.3
Total microbial activity (µg FDA / g / h)	469	462	833
Total fungal biomass (µg ergosterol / kg)	91.8	142.2	978.8

Table 2- Results from one Burdekin demonstration site; pre-treatment and after plant cane established.

SOIL HEALTH INDICATOR	2017	2018	
	PRE-TREATMENT BASELINE	CONVENTIONAL	IMPROVED FARMING SYSTEM
Labile Carbon (mg C / kg)	310	340	430
Microbial Biomass (mg N / kg)	0.86	0.78	2.62
Total microbial activity (µg FDA / g / h)	19.5	39.0	88.0
Total fungal biomass (µg ergosterol / kg)	242	128	480

Soil Fungi - Total soil fungal biomass also increased significantly with the Improved Farming System at all sites. Fungi form complex hyphal networks through the soil, spanning large distances to access different resources throughout the soil.

Fungi are a very important component of soil biology and are mostly beneficial to crop health. Higher soil fungal populations are associated with healthier and more efficient soils. Fungi are particularly sensitive to disturbance such as tillage because the hyphal networks are slow growing and can only regenerate slowly after any disturbance.

SUMMARY

- Legume fallows resulted in increased labile carbon, microbial biomass, fungal biomass, and microbial enzyme activity which are all important for soil health.
- This boost in soil biology after a legume rotation is likely to be short lived (3-5 months) but it occurs during the crucial window of initial cane establishment and will reduce pathogen populations in the soil.
- Legume rotations have a much greater impact on soil biology indicators than row spacing.
- Carbon inputs matter-long-term IFS fields with a history of crop residue retention and use of mill mud demonstrated significant biology improvements.
- Two demonstration sites significantly increased soil fungi and their fungal: total microbial biomass ratio. These sites both had mixed species legume fallows, but also started with a relatively high soil carbon percentage (%).

This technical sheet has been prepared with the assistance of Dr. Richard Brackin, The University of Queensland.