Impact of long-term farming practices
ON SOIL HEALTH

Healthy soils are the foundation for growing a good crop of cane. Soil health indicators can be measured to determine the health of soil in terms of chemical, physical and biological characteristics, including root architecture and development which reflects how well your soil is performing as a growing medium. Measurements made over time can identify trends which demonstrate the impact of farm management practices on your soil's root health.

The five year project, *Measuring soil health, setting benchmarks, and driving practice change* (2017-005), currently underway in the Burdekin and Herbert regions, is identifying those indicators that can most accurately be used to define and assess sugarcane soil health. The project has tested over 50 soil health characteristics to date on 11 grower managed "paired sites" (Conventional practice V Long-term IFS practice (10+ years)) and 6 demonstration sites where the project has established IFS treatments in conventionally managed blocks, allowing side-by-side comparisons over the past 1-2 years.

To be useful to industry, these indicators must be:

a) sensitive to practice change;

b) able to identify specific soil constraints;

c) relatively easy to interpret; and

d) simple to use.

DETERMINING INDICATORS OF SUGARCANE SOIL HEALTH

Soil characteristic measurements from year one research demonstrate that there are indicators of soil health which have a close correlation with on-farm management decisions. These indicators show that certain soil characteristics quickly respond to changes in management. Over 2018/2019, further soils will be sampled to determine a final set of soil health indicators for the Herbert and Burdekin regions.

The most promising sub-set of soil health indicators, following analysis of the first year are outlined in Table 1.

	INDICATOR	WHY USEFUL?	CAN BE MANAGED?
Physical	sand/silt/clay %	Provides interpretive power – a measure of inherent soil characteristics	No
	effective rooting depth	Key measure of soil fitness for plant growth	Yes
	water infiltration rate	Indicator of soil structure, compaction and ability of the soil to retain moisture	Yes
Chemical	pH	Important for nutrient solubility, microbial health, and a key factor in break crop establishment	Low pH - yes
	labile carbon	Key driver of biological health, water holding capacity and soil structure	Yes
	% organic carbon	Plays a vital role in soil health – influences soil chemistry, biology and physical properties, and provides interpretive power	Yes, but challenging
	Sodium % of Cations (ESP)	Can be a major constraint to production	Yes
Biological	pachymetra	Can be a major constraint to production	Yes
	root lesion nematodes	Can be a major constraint to production	Yes
	root knot nematodes	Can be a major constraint to production	Yes
	% pathogenic nematodes	General indicator of soil borne disease pressure	Yes
	microbial biomass	Key biological indicator – related to carbon	Yes
	fungal biomass	Key biological indicator – sensitive to tillage practice	Yes
	Fluorescein Diacetate Hydrolysis (Total enzyme activity)	Indicator of soil biological activity – related to organic inputs	Yes

Table 1- Promising Soil Health Indicators from Measuring soil health, setting benchmarks, and driving practice change project (2017-005) year one research.

IMPROVING PHYSICAL AND CHEMICAL SOIL CHARACTERISTICS

Physical and chemical soil constraints can be improved by applying ameliorants (gypsum, lime), reducing compaction, reducing tillage, direct drill planting and promoting soil fungi.

IMPROVING BIOLOGICAL SOIL CHARACTERISTICS

The biological health of your soil is related to abundance and diversity of microbes, fungi and other plants and animals that live in your soil. Biological soil health can be quickly improved by increasing the amount of organic material in the soil through mill mud, cane trash, fallow crop residues or green manure. It can also be improved by reducing the amount of tillage so that soil microbes and organisms, which are beneficial to healthy crop growth, can establish diverse and healthy communities.

IMPROVING ROOT SYSTEM HEALTH

The health of your root system is related to many integrated factors (Figure 1). Depth and length, which provides stability to the stool, reflects the physical freedom, moisture and nutrient provided by the soil medium. Compaction greatly restricts root development but can be addressed by wider row spacing, controlled traffic and permanent bed systems. Longer ratooning is often possible with more stable crops. Root health can be reflected by measuring abundance of fine and secondary root hairs. A range of fungal organisms are associated with sugarcane roots- some are pathogenic but the majority are beneficial, producing antibiotics, helping the crop acquire nutrients, and competing with harmful microorganisms.

Soil disturbance through frequent tillage quickly alters soil structure and soil microbial, fungi and beneficial bacteria communities. By increasing the size and diversity of microbial communities, beneficial organisms are more easily able to thrive and plant pathogens are suppressed. The application of rotations to crops improves the soil biology.

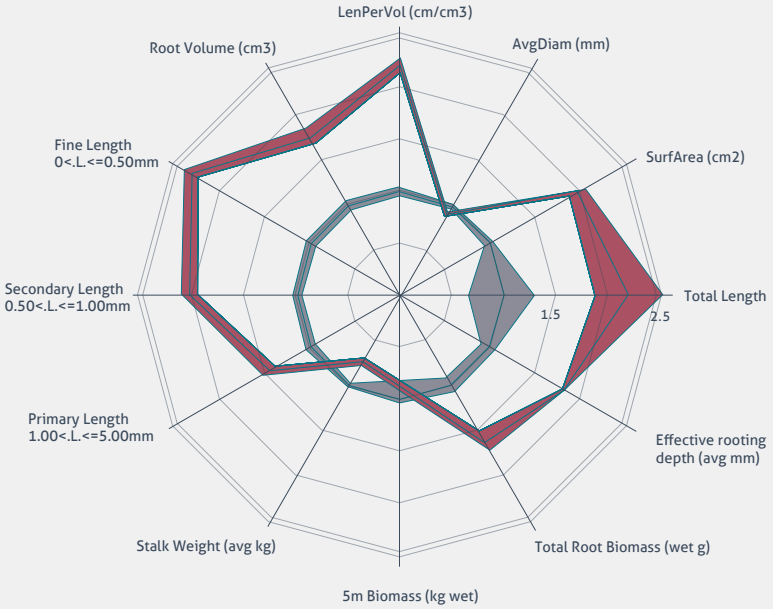

Figure 1- Root system measurement comparison results for a paired site in the Herbert region derived from field samples and analysis using WinRHIZO, an image system designed for root measurement in different forms.

KEY MESSAGES FROM YEAR ONE SOIL HEALTH INDICATOR RESULTS

- **The fallow period matters –** legume fallow crops resulted in increased labile carbon, microbial biomass, fungal biomass, and microbial enzyme activity.
- **Carbon inputs matter –** mill mud, cane trash, green manure all result in huge improvements to the soil biology.
- **Mixed species fallow** seem to provide a longer benefit than a single species break crop. Two sites, after mixed species legume fallows, had greatly increased soil fungi (and fungal: total microbial biomass).
- **One constraint can undo all your good work –** you have to get everything right.
- **The sub-soil is important –** and may be holding you back – this is often where a constraint lies.
- **Healthy soil does not guarantee you good yields.** It is a foundation. You still have to grow sugarcane.
- **Wide row spacing** results in deeper rooting depth and so more roots per plant.
- **How much did it cost to grow?** Yield is not everything. You must understand economics.
- No significant effect of different row spacing on soil biology evident at this stage.

WILL IT BE POSSIBLE TO MEASURE SOIL HEALTH INDICATORS IN THE FIELD?

The project is developing the SRA Soil Health Extension Toolkit to enable productivity services officers and industry advisors to accurately identify soil constraints and measure key soil health parameters in the field along-side growers in all growing regions. Many different tools are being evaluated for inclusion in this kit such as pH, sodium, and EC meters, and a labile carbon instrument (Figure 2).

The SRA Soil Health Extension Toolkit requires in-field validation across a number of farming systems and soil types. When this is completed in 2019, advisors of the Herbert and Burdekin will have access to the Toolkit to work with growers on assessing the impact of farm system decisions on soil properties, understand the soil constraints that are restricting yield potential and changes to soil health over time. Growers will be able to make more informed decisions and manage constraints and risk with greater more confidence.

Figure 2- Soil Health Toolkit content being tested for measuring soil health indicators in the field.

1) Split-core auger;
2) Penetrometer;
3) Sodium Meter;
4) Bulk density rings;
5) Labile carbon colorimeter;
6) Water infiltration rings;
7) pH/EC meter

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