Soil biological activity testing: is it worth it?

Background

There is growing interest and awareness of the importance of biological soil health. In essence, all the microbial mater (fungi, bacteria, protozoa, mycorrhizea etc) found in our soils play a vital role in driving soil health and productivity. Soil microbes are important for releasing nutrients from organic matter, fixing atmospheric nitrogen (e.g. rhizobia in clover), increasing phosphorus availability (through mycorrizal fungi that attach to plant roots), breaking down pesticides, controlling pathogens and improving soil structure.

Good biological activity in soil requires moisture, appropriate temperatures and oxygen. In unfavourable conditions, many soil organisms will die or shut down activity until conditions are suitable again. Farming systems have their own characteristics which can favour various types of soil organisms and be unfavourable to others.

Soil biological testing is still a relatively new science and further work is required to ascertain which soil biological testing system is the most appropriate for our Kangaroo Island soils & farming systems and how to interpret the results.

Testing for Soil Biology

There are a large number of tests and methods for soil biology available and few standard accredited tests. It is difficult to find information on the exact methods used to do tests, or on useful critical values. Tests are broadly divided into 3 types:

- Population analysis - count the numbers of organisms present or can calculate ratios of various poulations. As farming practices can affect biological populations this needs to be taken into account when interpreting results.
- Biological activity - measures what the soil population is doing. They are sensitive to environmental or management conditions.
- Indirect indicators - generally indicate soil health, such as organic carbon content or ground cover. Generally where organic carbon levels are very low, or ground cover is missing, there is a problem present that will affect soil biology.

What was done

Six different labs Soil Food Web, CSBP, APAL, AgPath, Microbwise and Solvita were used to analyse soil microbiology on six different properties across Kangaroo Island. The samples consisted of three crop sites, three annual pasture sites and one perennial pasture. Each sample was collected and treated in the same way, so that each lab sample was as similar as possible i.e. a representative 0-10 cm soil sample was taken from each paddock (30 cores across the paddock) and a representative sample posted to each lab. The results from each lab were then compared. Note: MicrobeWise was only used at two sample sites. Solvita is an infield test and was only used at 5 sample sites.

The aim was not to determine who was the best "biological farmer", but to gain a better understanding of the range of tests on offer and the results given. All samples were taken in September 2013 (early spring is deemed a good time for taking analysis as the increasing soil temp combined with moist soil will be enhancing biological activity). One site was tested in March 2014 to compare biological activity between an active summer perennial (kikuyu) and annual pastures.

TABLE 1: **What each Lab tested**

Laboratory	Tests performed / what was tested for
Agpath (Victoria)	Measures fungal hyphae diameter, protozoa, nematodes, mycorrhizal colonisation and numbers and ratios of active and total bacteria & fungi and the ratio of fungi to bacteria, also the amount of Nitrogen made available to plants.
CSBP (Perth, WA)	Measures bacterial & fungal biomass (through CO_2 emissions) and mycorrhizal root score.
MicrobeWise Microbiology Laboratories Australia (Adelaide, SA)	Measures total microorganisms, bacteria (categorised) & total fungi, Protozoa and mycorrhizal fungi. Nutrients held in the microbes (K, P, K, S, Ca, Mg & C).
APAL laboratory (Adelaide, SA)	Measures CO_2 emissions over time, which provides indications of soil microbial activity, soil basal respiration and the amount of microbial biomass in the soil.
Soil Food Web (Lismore, NSW)	Offers the same range of tests as Agpath - microscopic examination and score
Solvita	Is a quick in field test whereby a probe is inserted into the soil sample and a reading given for the of soil $C0_2$ respiration. ($C0_2$ respiration is regarded as a measure of soil health)

Results

From comparing the data, there appears to be no clear way to tell which set of results or laboratory is the most accurate. Many samples had very different results for the same type of analysis undertaken by the various labs (Refer to TABLE 2). For example, the labs that ranked bacteria biomass and fungal biomass numbers seemed to show no consistency in results.

The difficulty is that there are currently no standard methods for many of the soil biological tests undertaken by labs. Each lab may use different 'recipes' for their analysis making it almost impossible to compare results. Some labs provided feedback, relating the soil biology test results to paddock conditions such as compaction, waterlogging or dry soil. However, there was no attempt made to relate the overall soil biological health status to soil fertility.

From these results, it appears that general testing for soil biology may not bring any real benefit to farmers at this time. The differences in the results, lab techniques and requirements for soil treatments make it difficult to draw any conclusions from the results.

Landholders may get some value in using these tests if they use the same lab to compare different management systems on their properties (as long as key criteria are consistent i.e. soil type, rainfall etc.), or to compare changes within the one system over time.

Specific testing for aspects of soil biology, such as the presence of pests or diseases, or the presence of beneficial soil microbes such as rhizobium bacteria, has been well documented and may be useful in definite circumstances.

Testing for soil biological activity is a relatively new 'science'. More work is required to develop standard tests and to relate test results to crop yields and plant health. Until this is done it is difficult for landholders to gain the full value of undertaking such tests.

Remember that soil biology is affected by soil chemistry and physical properties. If the chemistry and structure of the soil isn't right, then soil organisms cannot thrive. Adding new soil organisms will achieve nothing if they cannot survive in the soil.

As soil biology is sensitive to many environmental conditions:

- Monitoring soil biology over time gives a more complete picture than just a one-off test.
- Comparing soil biological tests should be done using samples that are as similar as possible i.e. sand v sand or clay v clay from the same paddock.
- Take samples at the same time of year.
- Use a reputable laboratory.

Take home messages

- There is still a lack of scientific research to validate results and their complete interpretation, nor does there appear to be any standardisation of tests.
- Testing may provide a 'guide' and some value as a comparison tool between paddocks.
- Significant differences in results between labs, possibly due to different analysis methods. This highlights the need to be cautious when comparing results from different labs.
- For a copy of the full report contact the PIRSA Office, Kingscote.

Funding/Sponsors

- Agriculture Kangaroo Island (through Caring for Our Country Funding).

For further information contact

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TABLE 2: **Results for 4 samples (for a full listing of all results contact the PIRSA Office Kingscote).** ***Results in italics highlight some inconsistencies between lab results.***

	Agpath Results	CSBP Results	MicroWise Results	Apal Results	Soil Food Web Results	Solvita
(A) Annual Pasture (Summer test to compare to kikuyu)	Bacteria biomass low. *Fungal levels low in both activity & total no's.* All microbes apart from ciliates low. The low ciliate no's suggest compaction. Soil dry, limiting microbial activity. Improve microbial no's by adding compost/teas or humates.	Bacteria total levels in mid-range of all the soil samples tested. Low fungal levels.	Microbial groups - good results. Mycorrhizal fungi levels lower than ideal. Soil may have been waterlogged or compacted. Advise building microbial diversity & monitor.	Shows good respiration rates & microbial activity.	Bacteria -very active but low total bacteria. *Fungal active & high in total no's.* Protozoa no's low except *ciliates high* Nematodes low & mycorrhizae marginal. Nutrient cycling & availability low.	
(B) Perennial Pasture (summer test, kikuyu)	Bacteria low total numbers but activity in 'normal' range. *Fungal biomass low.* Protozoa, nematode and *mycorrhizal no's low.* *Soil fungal dominated*, becoming more bacterial, though overall biomass no's are low. Recommend compost/teas, and fungal foods.	Bacterial biomass low. Fungal biomass low-moderate.	Bacteria levels good to high. *Fungal levels good to high.* High levels of anaerobic bacteria, & bacterial stress may indicate waterlogging or compaction. High levels of nutrients in microbial biomass, nutrient cycling good. Advise building microbial diversity & monitor.	High levels of respiration & microbial biomass higher than that recommended by literature.	Bacterial no's low but active. *Fungal no's high* but inactive. Protozoa & nematode no's low, *Mycorrhizal colonisation good.* Recommend increasing bacterial no's, also *add fungal foods to increase fungal activity.*	
(C) Annual Pasture (Spring test)	*Bacteria biomass low.* *Fungal activity low but high total no's.* Recommend adding compost/teas or humates.	*Bacteria biomass high.* *Fungal biomass very low.*		CO_2 respiration good. Microbial biomass and activity in good range.	*Bacteria – high no's.* Fungal activity low. Protozoa no's low except ciliates high. Nematodes and Mycorrhizal nos. low. Soil bacterially dominated, needs more fungal food.	Microbial biomass - high. Potential Nitrogen mineralization – high.
(F) Crop (Spring test)	*Bacteria no's low for both totals & activity.* *Fungal total no's high total but low activity.* Protozoa, nematodes & *Mycorrhizal no's low* which indicate fungal domination. Low nutrient cycling & availability.	*Bacterial biomass mid-range.* *Fungal biomass mid-range.*		High level CO_2 being emitted from soil as microbes are active and large quantities. These levels are in the good-high range.	*Bacteria high active & total no's.* *Fungal activity & total no's low.* Protozoa no's low, except ciliates, due to compaction or water logging. Nematode no's low *Mycorrhizal no's good.* Soil bacterially dominated, needs more fungal & protozoan no's, for better nutrient cycling.	Microbial biomass - moderate. Potential Nitrogen mineralization – moderate.