Hill Laboratories

SCIENCE VIEWS

NEWS AND VIEWS FROM OUR SCIENCE COMMUNITY

Biological Indicators of Soil Health

Usefulness and limitations

Dr Anwar Ghani for
Hill Laboratories, Hamilton

The concept of soil health dates to ancient times when man started cultivating crops and rearing animals. Soil health is considered a subset of ecosystem health. A healthy ecosystem is characterised by efficient nutrient cycling, stability, and resilience to disturbance. As such, soil health is associated with the soil's physical (structure, porosity, texture etc) and chemical (pH, CEC, substrate availability etc) characteristics, which support plant growth, biological diversity and help in regulating pathogenic microflora and fauna.

A biologically healthy soil has a high degree of tolerance against stress (drought, overgrazing, pugging etc), has high buffering capacity, and the ability to regenerate. A relationship between soil health and biodiversity has been suggested, but has not yet been proven, despite the number of bioremediation studies that demonstrated that a biologically active soil recovers faster, and support better plant growth compared to non-active or less biologically active soil. This underscores the need to develop fast and robust practical methods to measure soil biological health to support the farming sector of our agricultural industry.

Soil biological diversity is a highly promoted concept in the scientific literature as it enables the understanding of the functionality of a soil ecosystem. The organisms living in soils belong to a variety of taxonomic groups including bacteria, fungi, protozoa, nematodes, earthworms, and orthopods. Each of these organisms play an important role in nutrient cycling, aggregation of soils, decomposition of plant residues, animal excreta, and breakdown of toxic substances etc. Some scientists have suggested the food web stability concept, which demonstrates a higher stability in native soils compared to agricultural soils. Soil enzymes such as dehydrogenase or FDA activity or rate of substrate utilisation capacity in soils by microbes have also been suggested for assessing microbial diversity in soils but the interpretation of these biomarkers is difficult. Likewise, other biological measurements mentioned in this article are good for understanding the state of diversity but are faced with similar challenges when interpreting in the context of productivity or environmental health.

Most of the biological organisms in soils are highly influenced by temperature, moisture, pH, availability of substrates, CEC, toxic substances etc (Fig 1). Soil microorganisms which are a subset of soil biodiversity, are highly sensitive to these stress factors and should therefore be good indicators for measuring soil health. Measuring microbial biomass carbon (MBC) in soils by the application of different stress factors with various intensities, provides an indication of the soil's resilience. The level of a response and the time to return to the original state could be a measure of soil biological health.

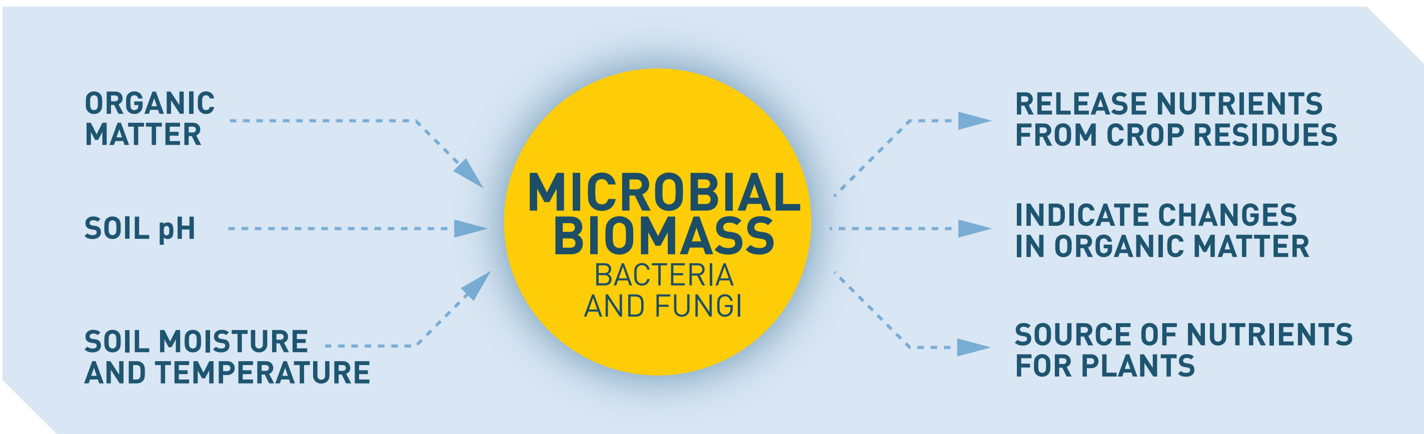


***Fig. 1:** Showing factors affecting microbial biomass and its role in supporting soil functions.*

Biological Indicators of Soil Health

Usefulness and limitations (cont.)

The current methods of measuring soil MBC are time consuming and expensive, and affected by variables as described above coupled with temporal and spatial variability at the paddock or farm level (Ghani et al. 1997). This makes it unsuitable for use as practical indicators of soil biological health for our farming systems.

An indirect measurement of soil MBC can be made by the hot-water extractable C (HWEC) method suggested by Ghani et al. (2003). This method is less time consuming and provides reliable results. The HWEC measurement has strong correlations with other soil biochemical indicators such as mineralizable-N, carbohydrates, and physical indicators e.g., soil aggregation in a range of soils. There are several published studies showing HWEC is sensitive to fertilisation, grazing intensities, cultivation, and soil restoration and provides early indications of loss of soil organic matter and system recovery, such as when soil recovers from slippage etc. Unlike MBC which must be measured in moist field or at a fixed moisture content, HWEC can be measured in air-dried soils with consistency.

Hill Laboratories are offering HWEC measurements to farmers, orchardists, conservation monitoring projects, regional and national environmental monitoring programmes to help in their endeavours to assess their soil biological health. Hot-water extractable C is a labile fraction of soil organic matter which is sensitive to farming practices, and less variable than microbial biomass C (Ghani et al. 2003). This test was developed in New Zealand (Ghani et al. 1997; Sparling et al. 1997) where the soil has greater organic matter in comparison to the global average in agriculture soils. Except for peat soils, HWEC and MBC are strongly correlated across soil types.

A yearly measurement of HWEC in the monitoring paddocks (use guidelines for sampling protocols described in the Hill Labs Technical notes on HWEC) will enable an assessment of the impact of farming practices on labile fraction of soil organic matter as a surrogate measure of MBC and mineralizable-N (Curtin et al. 2006). Generally, HWEC is 5-8 fold higher than MBC (measured by the difference in the concentration of extractable C in fumigated soil with non-fumigated soil samples), with the latter estimated using the following equation reported by Ghani et al. (2003):

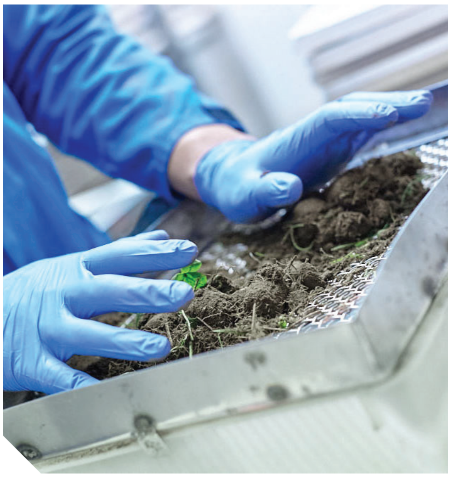
Estimated MBC = HWEC*0.13+26

Article written for Hill Laboratories by
Dr Anwar Ghani - Soil Scientist

Hill Laboratories commissioned Dr Anwar Ghani to write this article, given his in-depth expertise and knowledge of the soil Hot Water Extractable Carbon (HWEC) test and related biochemical processes. Anwar has published research from work carried out on the HWEC test while at AgResearch, Ruakura (Ghani et al, 2003) and this forms the basis of the laboratory method and interpretation offered by Hill Laboratories.

An estimated or derived Microbial Biomass Carbon value will be reported using the above equation whenever a hot water extractable carbon (HWEC) test is requested, to further extend the usefulness of this test. The laboratory recognises that this equation is reliant on correlation with the direct fumigation-extraction method for MBC. It would not be valid where other MBC methods that use a correction factor for the carbon-flush from soil fumigation & extraction (e.g. Sparling et al, 1998 used k=0.41 for this) are being compared. As for all soil tests, comparisons over time must use the same methodology (or at least methods that can show equivalence) to be of value to use for farm management decisions.

Fiona Calvert,
Market Sector Manager (Ag),
Hill Laboratories.



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