*Fact Sheet Series* **20-1**

# The Biological Component of Soil Health: *Measuring it and Harnessing it*

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## The Important Role of Microbes in Agricultural Systems

Biological soil health largely focuses on the important roles that microbes (bacteria and fungi) play. Soil microbes are manipulators of their environment, and so the crop's environment. They regulate organic matter and plant-available nutrient levels in the soil. They can either release nitrogen (N) stored in organic matter or compete with plants for plant-available forms of N, such as ammonium ($NH_4^+$) and nitrate ($NO_3^-$).[1] They improve soil structure and water-infiltration by increasing soil aggregation through their production of "sticky" substances.[2,3,4]

They are small but mighty!

For these reasons (and many more), there has been a huge push to understand the role of soil organisms in soil health and how to quantify it.

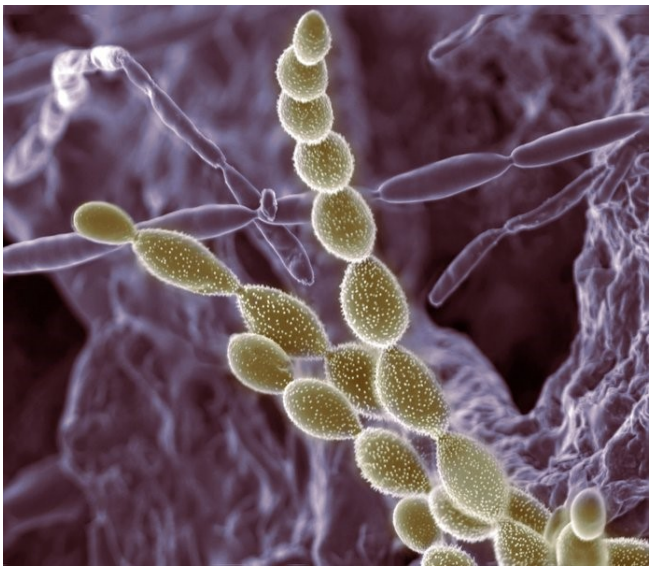

*Photo: Soil microbes in ponderosa pine ecosystem - scanning electron microscopy. Credit: Alice Dohnalkova (distributed via imaggeo.egu.eu)*

## What is Soil Health?

According to the United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), soil health is "the capacity of the soil to function as a vital living ecosystem that supports plants, animals, and humans."[5] In general, soil health is broken down into three components: the physical, chemical, and biological. Measurements are well developed for the physical and chemical components of soil health. However, researchers are currently evaluating the best measurements for assessing the dynamic, biological component.

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| Indicator Name | Purpose of Measurement |
|---|---|
| Soil Respiration (mineralizable carbon) | General microbial activity |
| Active carbon (permanganate-oxidizable carbon (POXC)) | Microbial carbon food source |
| Soil Protein (autoclaved citrate extractable protein (ACE)) | Bioavailable N |
| Potentially mineralizable N (PMN) | Bioavailable N |

Table 1. Examples of biological soil health indicators recommended for further development by USDA-NRCS.[5]

## Indicators as a Proxy for Microbial Processes

The latest focus has been to use indicators to measure a soil's capacity for biological processes. The greatest effort has been put towards the indicators important for soil health that relate to crop productivity (Table 1). An indicator is a measurement that can indirectly quantify a process due to its strong relationship with that process. For example, soil protein is used to measure bioavailable N (N available to living organisms such as microbes and plants). Even though soil protein is not a measure of all of the bioavailable N in the soil, it is the largest pool of N in soil organic matter. This pool can be decomposed by soil microbes into plant-available forms making it highly related to bioavailable N and a good indicator of bioavailable N.[6]

The benefit to indicators is that they are more useful for farmers and land managers than solely researchers. Indicators are selected based on their ability to inform management such that they are cost-effective, can observe management effects and changes on a short time-scale (as short as 1-3 years), and easily fit into sampling routines.[5]

Cornell's Comprehensive Assessment of Soil Health (CASH) is an example of soil health indicators in action. Anyone can submit a soil sample for analysis and receive a report of multiple measures taken to evaluate the complex chemical, biological and physical health of their soil. Each measure is associated with important soil functions. For each measurement, the soil's performance is rated in comparison to the performance of soils with the same texture.[7] Soil texture is known to have a great effect on the capacity of a soil to function, but it

is an unmanageable constraint for a farmer or land manager. For example, soils with a higher proportion of silt and clay are able to form more complexes with organic matter than soils with a higher proportion of sand. This ability to form more complexes leads to better stability of organic matter and overall higher organic matter levels. Since the different textured soils are unable to reach the same soil organic matter levels regardless of management, their soil health is evaluated separately.

## Informing Management for Biological Soil Health

While inherent properties of soils restrict the potential of certain soil functions, soils can still be managed to obtain the best possible levels of soil health and their benefits. For instance, farmers can implement no-till or reduced tillage systems to increase their soil organic matter levels while producing crops, but there are many management options to choose from.

So, what are the most important management practices for biological soil health?

On real farms in Wisconsin's Driftless region, University of Wisconsin-Madison researchers are teaming up with organic grain farmers to answer this question. Together, they are looking at how long a field has been certified organic and how management practices affect biological soil health. Indicators are being used to measure the biological component of soil health on farmer's fields while farm management history is compiled to look at its effect.

In the first year's worth of data, some tentative insights have been made. Increasing the number of tillage passes between the harvest of the previous years' corn crop and the planting of the next crop decreased two biological indicators of soil health: soil respiration and soil protein.[8] During that period between crops, these two indicators also decreased if one of the tillage implements used was a mouldboard plough. More data is necessary before coming to any strong conclusions about which factors are the most important for biological soil health. However, these preliminary results are helpful for demonstrating that on-farm research can be useful for exploring tough questions about soil health.

## Summary

There is major public interest to measure biological soil health in order to better inform management decisions that lead to high-functioning, healthy soils. Recommendations to standardize measurements for key soil functions have been released to coordinate a greater effort for developing soil health assessment on a national scale. On-going research is working to identify soil property and management influences on biological soil health in the Midwest. These findings would be useful in developing a soil health rating system suitable to this region and form management recommendations to address farmer concerns.

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