WWW.MSSOY.ORG ⇒ MSPB WEBSITE WITH UP-TO-DATE SOYBEAN PRODUCTION INFORMATION

SOIL HEALTH

The USDA-NRCS defines soil health, also referred to as soil quality, as "the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans". They further state that "this definition speaks to the importance of managing soils so they are sustainable for future generations".

In a recent publication, the case was made that soil health vs. soil quality emphasizes the biological component of soil because health refers to something that is living; thus, the two are not necessarily synonymous using this criterion.

Understanding soil health involves assessing and managing a soil's inherent properties of fertility, structure, microbial activity, etc. so that it functions to support optimal plant growth, both now and in the future. This means that changes in soil health must be constantly monitored so that soil is not degraded, but rather is managed using a set of practices that are sustainable both agronomically and economically, and that promote soil sustainability for the long term.

Soil is an ecosystem that not only holds and provides nutrients and water for plant growth, but also provides habitat for soil microbes that are an integral part of the soil's interaction with plants that are growing in it. These microbes are key to decomposition of chemical and plant residues and resultant nutrient cycling, as well as integral to soil components that affect soil structure, aeration, porosity, and water holding capacity.

Using the above points, it follows that microbial activity is an integral part of soil health. As stated in the overview of the USDA-NRCS soil biology primer, "The creatures living in the soil are critical to soil health. They affect soil structure and therefore soil erosion and water availability. They can protect crops from pests and diseases. They are central to decomposition and nutrient cycling and therefore affect plant growth and amounts of pollutants in the environment." Other chapters of this primer give additional detail about the living component of soil and how it contributes to agricultural productivity and sustainability, and air and water quality.

A video presentation by soil microbiologist Dr. Sarah Hargreaves titled "The Haney Soil Test and Nutrient Turnover" [go to 20 min. into the video] gives a detailed discussion about the various types of soil microbes and how microbial activity is involved in mineralization and nutrient turnover in the soil. She discusses how the Haney Test [click here for article describing the test and here for results from a study conducted to evaluate this enhanced soil testing method in crop fields] is used to measure microbial respiration, which can then be used as an indicator of soil health by determining the levels of naturally occurring nitrogen and other nutrients.

Dr. Hargreaves also discusses how the C:N [carbon to nitrogen] ratio in the soil can be used to determine the "feed value" of a soil in relation to microbial needs and activity, and how this ratio can be integral to cropping systems and cover crops providing a year-round supply of organic matter to feed microbes.

The Haney Test is touted to better measure the effects of cover crop and no-till practices on soil health. The test results can be used to develop a soil health calculation and suggest a cover crop mix that will give a better C:N ratio. The results can also be used to better understand and measure the contributions made by cover crops.

Dr Anna Cates, an Extension Soil Health Specialist at the Univ. of Minnesota, provides several cautions about interpreting results from a Haney soil test. Click here for her article; highlights from the article follow.

- The Haney test is intended to determine how robust soil biological activity is even if overall organic matter [OM] percentage is low.
- The Haney test measures microbially-available C and N, as well as respiration potential in a lab incubation; these are point-in-time measurements. These soil components will likely be in a constant state of flux because they are being replenished over time by plant and microbial residues in the soil. Thus, look for trends and not absolute values.
- Respiration does not differentiate between food source and microbial activity–i.e., high soil respiration could be due to greater C sources for

microbes, or a large microbial population (both are desirable). Higher values will be seen in higher OM soils and after fertilizer application that stimulates microbial activity.
- The N release value is an average that is based on N release when there is sufficient rainfall.
- A good measure of soil biology can be gained by observing plant health, water infiltration changes, and soil structure. Soil biology can best be assessed by sampling at the same time under the same conditions every few years. Even then, look for trends, not absolute values.

An article titled Should Soil Testing Services Measure Soil Biological Activity by Dr. Alan J. Franzluebbers provides further details about testing to measure microbial activity and how it can be conducted to obtain meaningful results. He also presents strong support for its being incorporated into soil testing procedures. Major points in this article follow.
- A key indicator of healthy soil is potential biological activity, which can be measured rapidly by soil testing services using a test that measures the CO_2 flush following rewetting of dry soil.
- The flush of CO_2 is related to soil microbial biomass carbon, and is strongly related to nitrogen mineralization during standard aerobic incubations.
- Key features of the flush-of-CO_2 test that make it amenable to use are 1) uses dried soil, 2) involves a relatively rapid analysis time, 3) has strong correlation with other important soil health indicators, and 4) uses the inherent biological conditions of the soil.
- Actual soil microbial biomass carbon level needed to achieve a given level of soil health across diverse soils has not been determined.
- Calibration of the CO_2 flush test to determine nitrogen availability in the field is critical in utilizing the test as a predictor of biologically-available nitrogen. This knowledge could fill a critical void since most soil testing laboratories lack a test for biologically-derived nitrogen.
- A test to measure soil biological activity should be based on irrefutable, verifiable calibrations and correlations so that recommendations resulting from such a test are grounded in sound scientific principles.
- Numerous soil testing labs offer the commercialized CO_2 respiration test.
- The Ohio State Univ. provides details about using an in-field respiration test to measure soil health in an article titled "Solvita CO_2 respiration soil health test". Details about The Solvita Soil Field Test and its procedures are presented here.

The value of the above tests for microbial activity in Midsouth soils that are inherently low in OM has not been determined. However, since rotation of soybean with grain crops is now more common in this region, it is probable that it will become valuable as increased residue from grain crops should lead to increased soil OM.

The above points lead to the following tenets for improving soil health.
- Four basic principles govern site management for enhanced soil health. They are 1) minimize soil disturbance by reducing tillage operations, 2) maximize biodiversity by using crop rotations and cover crops, 3) maintain living roots in the soil profile by using cover crops between cash crops, and 4) maintain soil cover with residue management and cover crops.
- Total soil organic matter changes slowly, but active fractions are more dynamic.
- Adopt practices and management systems that will build organic matter in the soil that will in turn enhance microbial activity.
- Adopt minimum till/no-till production systems to maintain cover provided by residue that will prevent or reduce soil loss and rainfall runoff, and that will build or increase soil carbon stocks and organic matter.
- Use cover crops to provide a food source for soil microbes.
- Conduct soil tests at least once every 3 years, and test for more than just standard fertility. Testing for and measuring inorganic nutrient availability alone does not provide a complete assessment of soil fertility or of how soil biological properties affect crops and the environment.
- Evaluation of soil fertility and health can be elevated by testing soil for biological activity.

The USDA-NRCS has a playlist of videos and numerous articles that cover the various aspects of soil health and its maintenance.

Click here for the Soil Health Institute website. The Soil Health Institute is a non-profit organization whose mission is to safeguard and enhance the vitality and productivity of soil through scientific research and advancement. The Institute works with its many stakeholders to identify gaps in research and adoption, develop strategies, networks and funding to address those gaps, and ensure those investments have a beneficial impact on agriculture, the environment, and society.

In an Aug. 12, 2022 press release, the SHI announced its recommended measurements for assessing soil health. These recommendations are based on results from a 3-year project that was conducted across North America where conventional management systems were compared to soil health-improving systems.

Based on the results from this project, the SHI recommends a minimal suite of three measurements that can be widely applied. These measurements were selected based on cost, practicality, availability, redundancy, and other filters. The three measurements and details about each, plus links to SHI's standard operating procedures for their measurement, are listed below.

Soil Organic Carbon Concentration. Soil organic carbon [SOC] is a measureable component of soil organic matter [SOM], and refers to the carbon component of SOM. Since SOM is difficult to measure directly, labs tend to measure and report SOC. Soils with a high SOC are likely to be more productive, will hold more available water, and have better biological, chemical, and physical properties. Sequestering carbon in SOC has been suggested as one way to mitigate climate change by reducing the amount of CO_2 that is released to the atmosphere. SOM can be reasonably estimated from the SOC% that is measured. Changes in stable SOC generally occur very slowly–i.e. generally take more than 10 years–but more rapid changes are most likely to occur in the top 4-6 in. of soil. SHI's standard protocol for measurement of this trait can be found here.

Carbon Mineralization Potential. Carbon mineralization [conversion of carbonaceous material in soil to CO_2] is mainly a function of the soil microbial population. Changes in carbon mineralization are usually determined by measuring the basal respiration of soil. SHI's standard protocol for measurement of the amount of CO_2 that is produced over a 24-hour period after the rewetting of dry soil can be accessed here.

Aggregate Stability. Soil aggregate stability is the ability of a soil to regulate the movement and storage of air and water throughout the soil profile. It is generally accepted that the more stable a soil's aggregates, the more productive the soil. Soils are composed of a matrix of aggregated sand, silt, and clay particles that is held together by mycorrhizae, fine plant roots, earthworm slime, and residues of dead soil microbes; this matrix regulates air and water movement. Soils which have stable aggregates–i.e. aggregates that resist external forces from raindrops and traffic–are usually more productive. Aggregate stability is widely accepted as an indirect indicator of a soil's biological activity, water-holding capacity, and the presence of mycorrhizae. In essence, it is the measured ability of a soil to hold together and maintain structure even when encountering disruptive forces from raindrops, water and/or wind erosion events, and tillage. A protocol for measurement of a soil's wet aggregate stability, or its ability to resist breakdown or degradation, from the OSU Soil Fertility Lab can be found here.

Changes in soil health must be constantly monitored so that soil is not degraded but rather is maintained in or improved to a healthy status. The above three measurements should allow producers to determine just how healthy their soils are so that they can institute and/or continue practices that will maintain soils that are deemed healthy, or adopt practices that will improve the health of a soil that is deemed less than healthy.

In a Delta FarmPress article titled "3 reasons to consider biological soil testing" by Whitney Haigwood [Apr. 7, 2023], the case is made for biological soil testing to provide producers with better information about the health of their soils. Specifically, the

BeCrop Test by Biome Makers is highlighted as just such a test that will provide an indepth look at the microbial activity in soils that are used for crop production. This test provides results that: 1) show the abundance of soil microbial communities in a soil sample in order to identify the biological pathways that are working in the soil; 2) gives producers a precise look at the biodiversity of their soils, which is indicated by the ratios of bacteria and fungi present in the sample; 3) can indicate potential disease risks to a specific crop so that a producer can select resistant varieties or plant a different crop; and 4) can use results from before-planting samples plus additional testing during the growing season to measure and/or monitor the effect(s) of management practices on the soil microbial population so that changes can be made if/when needed.

Sample results from the BeCrop Test are based on DNA sequencing to determine the makeup of the soil microbiome. The company recommends one BeCrop Test for each management zone in a field. Reports offer specific disease risks based on the microbiome population that is related to the indicated crop to be grown on the sampled zone. Also, based on test results, producers can opt to add products that contain the microbials that are deficient and/or will correct an unbalanced microbial ratio that may be hindering important soil processes such as nutrient uptake by a crop.

JUNE 2023 UPDATE

ForGround by Bayer provides resources that can be used as a guide to measuring and assessing soil health. A list of some of those resources follows.

Comparison of Soil Health Tests. Soil health tests measure biological, chemical, and/or physical soil properties. Some of the more popular soil health tests are: 1) Comprehensive Assessment of Soil Health [CASH] Test from Cornell Univ. measures and rates 12 different soil qualities and then combines them to provide an overall quality score for the soil represented by the tested sample; 2) Haney Soil Health Nutrient Tool Test provides different measurements of N, P, and K in the soil so that their availability during the growing season can be estimated–the results of this test are used to provide a soil health score where an increasing number over time indicates improving soil health; 3) Phospholipid Fatty Acid [PLFA] Test measures levels of certain fatty acids in the soil which can then by used to indicate the activity, type, and size of the soil microbial population; 4) Soil Food Web Biology Test uses microscopy to determine the relative abundance of bacterial, fungal, and other types of microbes in the soil; 5) Active Carbon [Permanganate Oxidizable Carbon–POXC] Test was developed by The Ohio State Univ. for farmers to use to measure biologically active OM or active carbon in the soil.

Guide to Visually Assessing Soil Health. This article provides a link to a printable soil health worksheet that can be used to assess variables that contribute to soil health.

Benefits of Mycorrhizae Fungi. This article provides information about how soil-borne mycorrhizae fungi can benefit crop plants by forming a symbiotic relationship with those plants. These fungi may grow either outside or inside the roots of the host plant.

Soil Organic Matter: Its Functions and Value. This article provides an overview of why SOM is an important component of a healthy soil, how it is formed, its value to overall soil health, and how it interacts with other soil properties to create and maintain a healthy soil.

Composed by Larry G. Heatherly, Updated Dec. 2024, larryh91746@gmail.com