Soil Health Applied Research Alliance

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ARECA Soil Health Initiative

This article is part of a series to promote better understanding of our agricultural soil resources along with practices that can influence soil health.

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Soil Health Assessment: An introduction to farmers

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The more you know about your soil, the better you can care for it. Standard soil tests have primarily focused on the soil chemical composition. Recommendations generated from these analyses have been for applying soil amendments (fertilizers, gypsum, lime, etc.) for increasing crop yields, but not for improving intrinsic soil conditions. The biological and physical conditions of the soil are often overlooked. Soil is a living biological ecosystem (habitat for microbes) and the impacts of some soil management activities negatively affect its physical and chemical conditions. Soil biological functions are related to nutrient cycling, soil aggregation and soil water fate, among other soil properties.

Soil health assessments (SHA) provide us with information about soil constraints beyond nutrient deficiency or excess. They measure soil degradation or improvement from targeted management practices. SHA will create awareness as farmers get answers to several important questions: What is their soil condition? Are the soil properties functioning properly? What can be done for improvement? These questions not only take into consideration the most important soil health “indicator” constraints, but also their interactions for understanding the actual soil conditions. SHA does not only give soil amendment recommendations, it also allows farmers to select the best available soil management practices to significantly boost productivity and quality of their cropping systems while improving their soil health. As a consequence, their farmlands will then be monitored for farming system risks and their farms will be more valuable.

Soil management practice contributions to improve soil health were learned in the ‘30s through the ‘60s but were then forgotten with the use of soil chemical amendments. SHA is a relative new approach when compared with the standard soil analytical evaluations. Indicators measured by soil health protocols should be those soil properties which are representative of key soil processes necessary for the proper functioning of the soil. They should provide information about the status of a specific important soil process that can be managed to improve crop quality and yields, reduce risk to the environment as well as to secure agroecosystem long term sustainability.

Soil Health Assessments and Tests

Many Laboratories are now moving beyond standard soil nutrient testing. Recently, there have been several different soil health assessments and tests developed. Many have not been standardized but have still shown improvement of the soil health in many farmlands. The most well-known soil health approaches are: soil respiration tests (such as the Solvita Test), the Cornell Soil Health Assessment and the Haney Test. They report information that has been used to suggest and/or recommend soil health managements to improve soil overall condition.

Soil Respiration

Soil respiration is considered an indicator of soil health and is measured as carbon dioxide (CO_2) emissions from the soil. It is directly correlated to soil biological activities: microbial biomass, carbon sequestration and nitrogen (N) mineralization rates. As soil organic matter (SOM) residues are incorporated into the soil, microbial activity will increase. Microbes then break down SOM, building up humus and emission of CO_2. On the contrary, when the incorporation of organic residue declines in the soil, microbes will starve for food and respiration declines, SOM turnover decreases and the soil's ability to sustain humus content is inhibited. Declining CO_2 respiration rates are also associated with soil compaction as well as intensive tillage, which compromise soil humus accumulation. The overall soil health might be improved or jeopardized depending on microbial activity. The relationship between these processes is an important indicator of soil health.

> **The Solvita® Test**, (Solvita is Latin for "soil life"), was developed for measuring soil's natural biological functioning as soil respiration (CO_2). It is reported that with this test, CO_2 respiration can be easily measured and be used to quantify soil microbial activity and potential mineralized N. The rate of CO_2 measured is generally regarded as an indicator of soil health. This method needs to be standardized, taking into consideration cropping systems, environmental conditions, soil sampling and laboratory analysis protocols. Information generated as CO_2 emissions per surface area have been used for developing soil management strategies for improving soil health conditions with practices such as cover crops. It has also been reported that this test gives results which are typical of actual field conditions but tend to be inherently more variable than lab results. Consequently, further field based evaluation is required. The Solvita Test has been gaining momentum; it has been offered in more than 30 commercial labs around the world (US, South Africa, Australia and the UK).

Cornell Soil Health Assessment

The Cornell Soil Health Assessment evaluates soil health indicators for biological constraints: soil respiration, soil protein, organic matter, and active carbon; physical constraints: available water capacity, sub and surface hardness, and aggregate stability; chemical constraints (Modified Morgan or Melich III extractant): pH, P, K, and minor elements; and other soil constraints for site specific condition not included in their standard assessment. Data generated are reported on a "color-coded scale" (red, yellow and green in a 0-100 scale). Low values are in red and/or values with yellow

colours providing very important information about soil processes that are not functioning optimally. The reports generated on targeted soil constraints include mineral recommendations based on standard soil test. For addressing physical and biological constraints and/or for maintaining soil functionality, suggestions for short and long term management are given.

The Haney Test

The Haney Test considers the measurement of biological and chemical indicators of soil properties as follows: chemical (weak acid (H3A) extractant): N, P, K, Ca, Fe, Al; and biological: soil respiration (Solvita Test), soil water extractable organic C and N and Carbon to Nitrogen (C to N) ratio. The information generated from these tests report a "Soil Health Calculation Number" which varies from 1 to over 50. This score indicates where the soil health condition is now. It is used as soil health baseline data that over time, and with different management might quantify improved soil health of a given cropping system over the years.

The Haney Test uses a different approach but still considers many of the same soil nutrients as the standard soil test, but incorporates soil microbial activities. This test brings in and considers a very important concept of biological activity as something influencing nutrient availability and therefore what should be fertilized for. What the Haney test does, is to consider the C to N ratio. This information is considered for providing NPK fertilizer recommendations and suggesting cover crop ratios of legumes to grasses.

What should be known about C to N ratio?

Soil Health raises a lot of N management related issues. The C to N ratio is very important, especially for N fertility managements. If it is very high, the soil is unlikely to mineralize N from soil residue because the microbes will utilize all N to decompose that SOM. The carbon will be used for respiration and the N will be tied up in their cellular structure, unavailable for mineralization. If the C to N ratio is low, the microbes will use all C and not the N so the N will be mineralized into plant available forms. This interaction is also affected by the rate of respiration. If respiration rate is high, this interaction will happen faster. But if there is low respiration, it will be a slow process.

How does the Cornell Health Assessment compare with the Haney Test?

The Cornell assessment includes chemical, physical and biological constraints while the Haney test does not test for the physical constraints.

They have different biological constraints identified: Cornell identifies the active carbon fraction and soil protein while the Haney Test measures water-extractable organic C. They have similar respiration assays, but the Haney test (Solvita) measures the CO_2 burst in a 24 hours period while Cornell's test measures it in a 4 day period. The Haney nutrient recommendations are based on biological and chemical protocols, but Cornell's mineral recommendations are generated using standard soil testing protocols.

Cornell suggests management strategies to address constraints identified in physical/biological/chemical measurements and in connection to the USAD Natural

Resources Conservation Service (NRCS) practices. Haney recommends soil management for nutrient applications and cover crops (%legume / % grass) generated by biological processes and C to N ratios, respectively.

The Haney approach of considering indicators of SOM quality (C to N ratios) and biological activities is a very important component to include in any soil health evaluation to provide better nutrient recommendation for the cropping system.

Chinook Applied Research Association (CARA) Initiative for Soil Health Testing in Alberta

At CARA, we will be exploring which soil health indicators will provide vital information on how soil components are interacting for farmers to have a better understanding of their soils to improve them now and for future generations.

Soil health testing could be a challenge for us considering that we currently don't have all the necessary instruments to evaluate all of the soil health biological, physical and chemical indicators. However, a cost-effective soil health testing package will be developed to bridge the gap between standard soil testing and biological and physical soil constraints.

The approach will be to use currently available soil health assessments taking into consideration the need to adjust and to integrate key soil aspects. Emphasis will be given to manage the soil in a way to improve its biological properties. Some researchers have suggested that by simply knowing a soil indicator value such as soil organic matter (SOM) or respiration rate for example, they can predict other soil health process such a microbial respiration, aggregate stability and nitrogen mineralization. Other researchers have found that when SOM data is combined with soil respiration and soil protein there is a better estimate of potential N mineralization. These findings will provide good baseline information for our soil health lab initiative, but once local farmers get their soil tested, the values generated will be used for engaging in a long term adaptive management strategy for measuring, managing, monitoring and calibrating (correlating) our soil health protocols and management tools to improve soil health in the province.

Summary

Although experts have been debating and discussing which soil test provides the best information for fertilizer recommendations, they all agree on one thing: soil health is a priority. Starting to look at interdependent soil interactions such as C to N ratios with the microbial activity influences on nutrient release will not only create awareness among farmers but also within the soil science community to understand and manage soil health properly. Soil health is a long term investment. For this reason, an initiative to assess soil health conditions in Alberta needs to look at different strategies to find the best combination of approaches for the generation of good data for standardization and calibration in soil health testing methodology for Alberta's soil environmental conditions.