



ONFARM Factsheet:

Measuring Improvements to Soil Health – Carbon-Based Indicators



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Measuring Improvements to Soil Health – Carbon-Based Indicators

Soil health can be improved through the adoption of [beneficial management practices](#) (BMPs). As key soil health indicators such as [soil organic matter](#) (SOM) and soil microbial activity increase, producers may also see improvements to [soil water holding capacity](#) and nutrient availability. Over the long term, improved soil health could lead to improved yields and greater crop resiliency to adverse weather conditions.

If you have adopted or are considering adopting practices that can improve soil health, you can measure the impact of the new practices on your soil. This factsheet will explore three key soil tests being explored in Ontario for measuring changes in soil health over time:

- Soil Organic Matter
- Active Carbon
- Solvita CO₂ Burst

BMPs for [improving soil health](#) include:

- Reducing soil disturbance by reducing or modifying tillage
- Increasing field crop and cover crop species diversity
- Keeping soils covered year-round with plants and/or crop residue, while maintaining living roots in the soil for as much of the year as possible
- Amending soil with manure, biosolids and/or compost applications



Minimizing tillage can support soil health.



This corn crop was interseeded with a cover crop.



Leaving crop residue on the soil is beneficial.



This farmer applies a municipal compost on their field.

What is ONFARM?

From 2019 through 2023, the On-Farm Applied Research and Monitoring (ONFARM) program completed extensive soil health and water quality analysis on 33 farm sites on representative soils and landscapes across southern Ontario. This network of sites and newly established cooperator partnerships helped to build a stronger understanding of BMPs and their effect on soil health and water quality on Ontario farmland.

ONFARM Data Collection and Analysis

- Investigations led by the Soil Resource Group (SRG) involved a range of soil health indicator tests, including gathering physical, chemical, and biological measurements
- Other baseline soil data collected included texture, horizons, drainage class, structure characterization, and soil type
- Field landscape and soil degradation assessments, agronomic monitoring, and BMP costing were also undertaken



ONFARM Data Dashboard

The ONFARM Data Dashboard has soil and BMP data from 25 ONFARM sites from 2020-22. The dashboard shows users the range in soil sample results for a number of soil health indicators, which can be interacted with through filters, including:

- Year
- Region
- Landscape sampling position
- BMP type
- Soil type
- ONFARM site number

Users can see the range in soil sample results for the measured soil health indicators, including:

- Soil Organic Matter
- Active Carbon
- Solvita CO₂ Burst



The ONFARM researchers identified soil types at the participating sites.

Soil Organic Matter

SOM is a standard soil test often used alongside other common fertility tests such as nutrients and pH. [SOM](#) is a complex mix of plant, animal, and microbial matter (biomass) at various stages of decomposition, living cells and exudates. SOM increases soil aggregation, which improves soil's water holding capacity and can help to reduce erosion. SOM also acts as a reservoir for macronutrients like nitrogen. SOM accumulation in soils reflects a balance between biomass inputs and losses through soil microbial activity and factors that affect soil moisture conditions, such as texture and management.

As biomass decomposes, it is mostly converted to carbon dioxide (CO₂) and water. Only a small proportion is converted to SOM. It takes substantial amounts of biomass to result in detectable increases in SOM.

SRG conducted SOM testing at all ONFARM sites, and the average organic matter by soil type can be seen in the below graph.

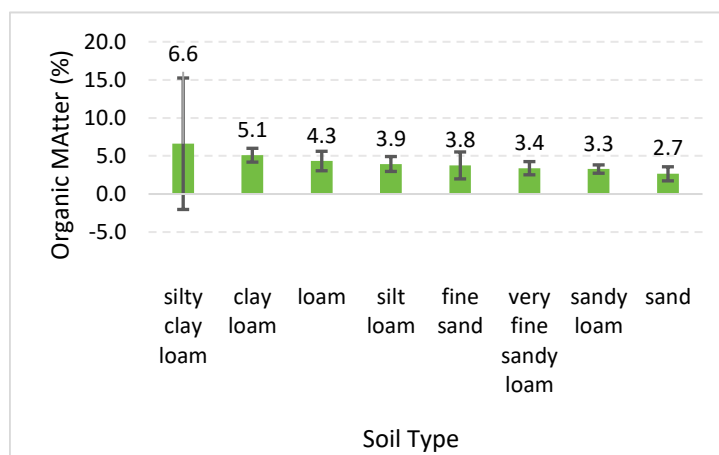


Figure 1. Average organic matter by soil type.

Soil texture is an intrinsic property to your farm. Soil texture will have an impact on your soil's potential SOM values, and can help you set more realistic goals for improving different fields. For example, loam soils often have higher SOM levels as compared to fields with a higher percentage of sand.

SOM levels can be very slow to change, even with the adoption of soil health BMPs. However, the SOM test provides a reliable baseline and "a foundational measurement for soil health," says Don King, Principal and Research Agronomist at SRG.

Active Carbon

[Active carbon](#), also known as permanganate-oxidizable carbon (POxC), is a measure of the portion of SOM that can be used directly as an energy source by soil microorganisms. Thanks to its role as a microbial food source, active carbon can be used as a key indicator of soil health. Active carbon is positively associated with SOM and other measures of soil biological activity.

Solvita CO₂ Burst

Microbial respiration is a measure of metabolic activity in soils. Microbial respiration is related to the process of [nutrient mineralization](#), where important nutrients like nitrogen and phosphorus are made directly available to plants through soil microbial activity. [Solvita CO₂ Burst](#) is a commercial test which measures soil microbial respiration. Soil samples are dried, sieved, and rewetted. The rewetting of soil samples causes a "burst" of soil microbial activity that can be measured as CO₂ emissions resulting from microbial respiration. Unhealthy soils that function poorly tend to have lower CO₂ emissions and lower Solvita CO₂ Burst values than healthy soils.



SOM is a baseline for understanding soil health, says Dr. Ann Huber.

ONFARM Findings

As part of the [ONFARM](#) program, researchers assessed SOM, Active Carbon, and Solvita CO₂ Burst for both responsiveness and variability in measuring changes to soil health as a result of BMP implementation (Table 1). Responsiveness describes how quickly the measurement responds to a change in management; a higher level of responsiveness means fewer years would be necessary to show a change in test results. Variability indicates how variable the results are at sampling locations within a field, and from year to year. An ideal test would have low variability and high responsiveness.

Table 1. Preliminary overview of SOM, Active Carbon and Solvita CO₂ Burst soil tests.

Soil test	Variability (ranking from least variable [1] to most variable [3])	Time scale estimate (years) ⁱ	Availability	Relative Cost (ranking from lowest [1] to highest [3])
SOM	2 ⁱⁱ	10+	Standard test in labs across Ontario	1
Active Carbon	2	5-10	Offered by most labs across Ontario	3
Solvita CO₂ Burst	1	5-10	Offered by many labs across Ontario	2

While no one best measure of soil health has been identified to date, SOM is a baseline for understanding soil health and “underpins all the soil health work,” says Dr. Ann Huber, the environmental microbiologist at SRG. SOM testing is affordable, as it is typically included in a basic soil analysis and is already being done by many farmers.

ⁱ Time scale is an estimation of how long it will take for the soil health indicator to increase and stabilize with continuous BMPs.

ⁱⁱ The variability associated with SOM and active carbon is similar.

Soil Testing Best Practices

To reduce variability and allow for the most accurate comparisons between soil health test results over time, it is recommended to take the soil samples:



At the same time of year (ideally select a time in early June or late September)



At the same point in the crop rotation (e.g., after wheat harvest)



From the same location in the field



Every three to five years

Ideally, the same lab should conduct the analysis each time too.

For more information on conducting your own on-farm research and the associated data collection, check out the ONFARM [Research Guidebook](#).

Key Takeaways

If you are already using soil health BMPs or considering the adoption of new BMPs on your farm, consider how to measure improvements to soil health. Although SOM can be slow to respond to farm practice changes, it provides an important starting point for measuring overall soil health. Active carbon and Solvita CO₂ Burst tests are two carbon-based biological indicators that may be more responsive to practice changes when compared to SOM.





Follow soil testing best practices to measure changes in soil health over time.

Want to learn more?

If you are interested in learning more about soil health indicators and soil microbial activity, you can begin with a visit to the [ONFARM Data Dashboard](#). You can also learn more about [ONFARM](#), read the [Technical Reports](#), and watch previous [Forums](#). Then, consider checking out the following resources:

- [Soil for Life](#)
- The Lower Thames Valley Conservation Authority's [Crops and Conservation Series](#)
- [Farm & Food Care's Soil Health Videos](#)
- [Characterization of Soil Health in New York State](#)
- The [Soil Health webpage](#) of the U.S. Department of Agriculture's Natural Resources Conservation Service
- The [Soil Health Institute](#)