



Soil Health Technical Report 2025-2026

Prepared by:



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Acknowledgements

The On-Farm Applied Research and Monitoring (ONFARM) program is a nine-year applied research initiative managed by the Ontario Soil and Crop Improvement Association (OSCIA) on behalf of the Ontario Ministry of Agriculture, Food and Agribusiness (OMAFRA). It aims to enhance soil health and water quality research on farms across Ontario. Funded by the Sustainable Canadian Agricultural Partnership, a five-year federal-provincial-territorial initiative, OSCIA also recognizes the valuable support from various organizations and agricultural community members that contribute to the program:

- Soil health data is gathered, compiled, and analyzed by the Soil Resource Group (SRG) based in Guelph, Ontario. SRG is crucial in working directly with ONFARM cooperators to coordinate and carry out soil health trials, as well as collecting data at edge-of-field locations.
- Three Conservation Authorities (CAs) collaborate to implement the edge-of-field monitoring aspect of ONFARM. They gather essential data on water quality, water quantity, and land use to meet the program's goals. Additionally, CAs offer technical guidance and collaborate directly with participants to conduct outreach activities associated with ONFARM. The partnering CAs are: Ausable Bayfield Conservation Authority (ABCA), Lower Thames Valley Conservation Authority (LTVCA), and Upper Thames River Conservation Authority (UTRCA).
- Representatives from Agriculture and Agri-Food Canada (AAFC) and OMAFRA, who participate in the ONFARM Technical Working Group (TWG), offer valuable input on various technical aspects of the program, including data management and collection.
- OSCIA would like to highlight the critical role of the participating ONFARM cooperators in supporting the research program's objectives on their respective farms. ONFARM is an applied research program being implemented on working farms across the province. ONFARM would not be possible without the dedication of cooperating farmers and the agricultural community.

Table of Contents

Acknowledgements	1
1.0 Introduction	3
1.1 Organizational Structure and Research Sites	3
2.0 Soil Health Research	5
2.1 Overview	5
2.2 Cooperator Field Sites	5
2.3 Data Collection.....	5
2.5 Soil Health Data Analysis 2025	9
2.5.1 Variability and Correlation of SHI Measurements	9
2.5.2 Range of SHI Measurements by Soil Texture and Landscape Position	10
2.5.3 BMP Impact on Soil Health Indicators.....	14
2.6 BMP Case Study	17
2.6.1 Case Study 1.....	18
2.6.2 Case Study 2.....	21
2.7 Yield Monitoring.....	26
References	31

1.0 Introduction

The On-Farm Applied Research and Monitoring (ONFARM) program is a nine-year applied research initiative that supports soil health and water quality research on farms across Ontario. The program is currently funded by the Sustainable Canadian Agricultural Partnership (SCAP), a five-year (2023 to 2028) federal-provincial-territorial initiative. Developed by the Ontario Ministry of Agriculture, Food and Agribusiness (OMAFRA) and delivered by the Ontario Soil and Crop Improvement Association (OSCIA), ONFARM builds on work accomplished under the Great Lakes Agricultural Stewardship Initiative's (GLASI) Priority Sub-watershed Project with a significantly expanded emphasis on soil health and water quality. The program encompasses a range of activities, including rigorous monitoring of soil health and water quality on working farms across the province and examining the effectiveness of different agricultural best management practices (BMPs) through paired trials and how they impact soil health, water quality, and productivity.

ONFARM has three primary objectives:

1. Evaluate soil health indicators (SHIs) and test BMPs through continued paired plot trials at sites across Ontario.
2. Study impacts of BMPs on in-field soil-water dynamics and water quality.
3. Engage with farmers and stakeholders to transfer knowledge on BMP implementation and impact.

With the success of ONFARM's initial phase from 2019 to 2023, the program has been renewed for continuation through 2028. The program's renewal allows for the continued collection of critical data supporting BMP outcomes from the long-term soil health trial and edge-of-field (EOF) water quality monitoring sites. This will enable a deeper understanding of the impacts of BMPs, such as cover cropping and organic amendment application, and the SHI being tested.

Additionally, the program's extension aims to uncover insights into how these BMPs support good soil-water dynamics for crop resilience and learn more about how profitability and site-specific agronomy can support farmers' management decisions.

Previous technical reports can be found on the [OSCIA ONFARM Website](#).

1.1 Organizational Structure and Research Sites

ONFARM can be divided into three components based on three pillars: Soil Health, Water Quality, and Outreach and Engagement. OSCIA administers all components; however, the Soil Health and Water Quality activities are guided by the ONFARM Technical Working Group. Established in 2019, the Technical Working Group acts as a scientific advisory committee. The Technical Working Group supported the selection of sites and BMPs for the soil health trials completed by The Soil Resource Group (SRG) and provides guidance to ensure best practices for data collection, analysis, and reporting across the program. The Technical Working Group includes members from the following organizations:

- OSCIA
- OMAFRA
- SRG
- Ausable Bayfield Conservation Authority (ABCA)
- Lower Thames Valley Conservation Authority (LTVCA)
- Upper Thames River Conservation Authority (UTRCA)

- Agriculture and Agri-Food Canada (AAFC)

In addition to their roles in the Technical Work Group, SRG and the Conservation Authorities (CAs) play an instrumental role in the collection of ONFARM soil and water data. SRG is responsible for implementing activities in the soil health component and partnering CAs are responsible for implementing the water quality component at the EOF sites.

The ONFARM program is being implemented on working farms across the province in collaboration with partner organizations and cooperating farmers at the 32 research sites. Each site is owned and operated by an agricultural producer who has agreed to work with researchers to manage the field plots where trials are conducted. There are 25 Soil Health BMP trial sites that have predominant soils and landscapes within six representative agricultural regions across the province. The six regions are Lake Erie West (LEW), Lake Erie East (LEE), Western, Central, Eastern and Northeastern Ontario. Of the original 25 sites, 22 are being continued, and three new sites were added in 2024, including two in Northeastern Ontario and one in Eastern Ontario. Currently, there are seven EOF water quality monitoring sites within priority subwatersheds of the CAs. The approximate location of each ONFARM site is shown in **Figure 1**.

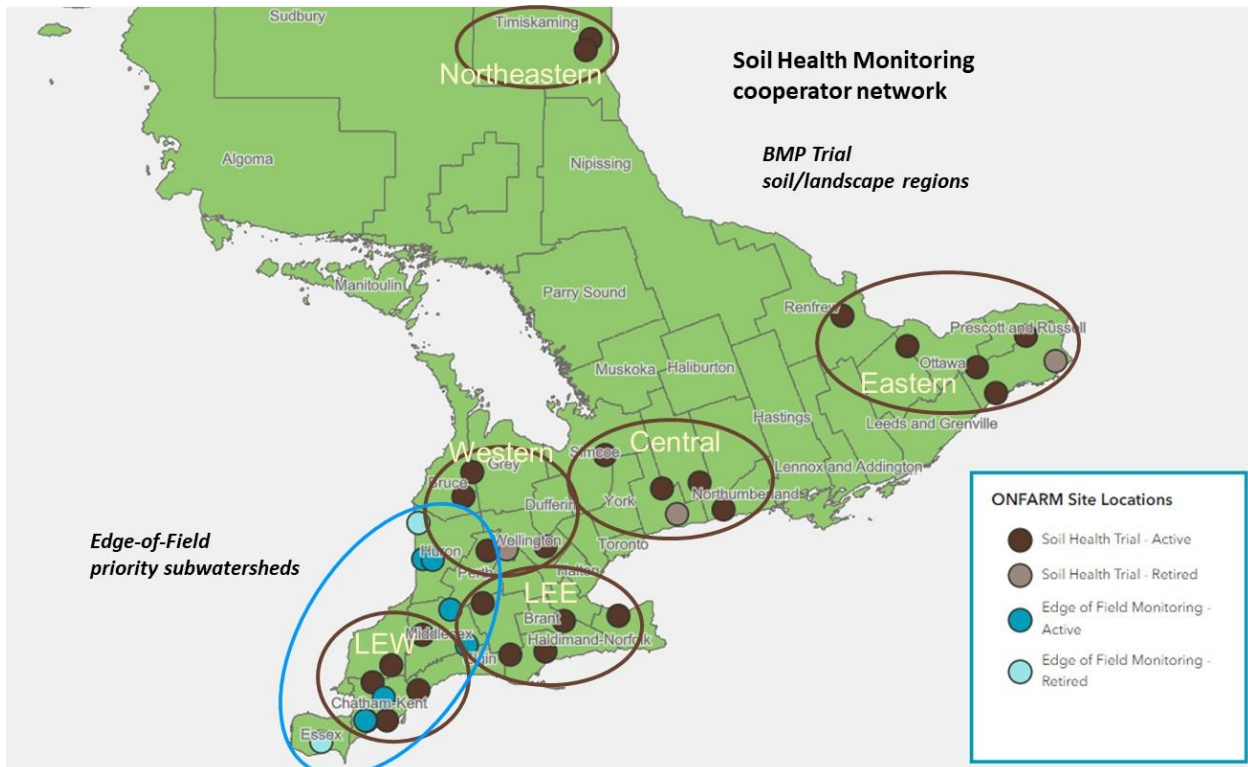


Figure 1. Locations of ONFARM Edge-of-Field (EOF) sites and Soil Health BMP trial sites in 2025. The brown ovals delineate the BMP trial site regions, and the blue oval encircles the EOF sites; Lake Erie West (LEW), Lake Erie East (LEE).

2.0 Soil Health Research

2.1 Overview

In 2025, ONFARM’s soil health research and monitoring component continued investigation at the network of on-farm side-by-side trials across Ontario (**Figure 1**). The purpose of this investigation is to better understand and enhance Ontario’s agriculture sector’s knowledge of:

- The efficacy of soil health related BMPs across the wide variety of Ontario soil types, cropping systems, climatic conditions, etc.
- The potential for using novel indicators as a measure of soil health, and recommendations for their adoption in Ontario.
- BMP impacts on soil health, soil degradation, and water holding capacity, and how these parameters ultimately affect crop performance and quality.
- Soil health-related BMPs’ impact on on-farm profitability and return-on-investment.

These on-farm sites represent the wide range of soil types found across the province and the variability of soils and potential degradation which may be found within a field. The sites capture differences in landscape features at three slope positions of upper, middle and lower that represent predominant soil landscape combinations that may be used for broader regional interpretation.

2.2 Cooperator Field Sites

Soil health investigations continued in 2025 at the seven EOF field sites and 25 BMP trial cooperator field sites. The distribution of grain farms and livestock-based farms in 2025 at the EOF sites is primarily grain farms, though three farms have livestock or source manure from other farms. In the BMP trial, grain farms and livestock farms were distributed and weighted by region across the province, with predominant grain crop mixes and livestock sectors being represented (**Figure 2**).

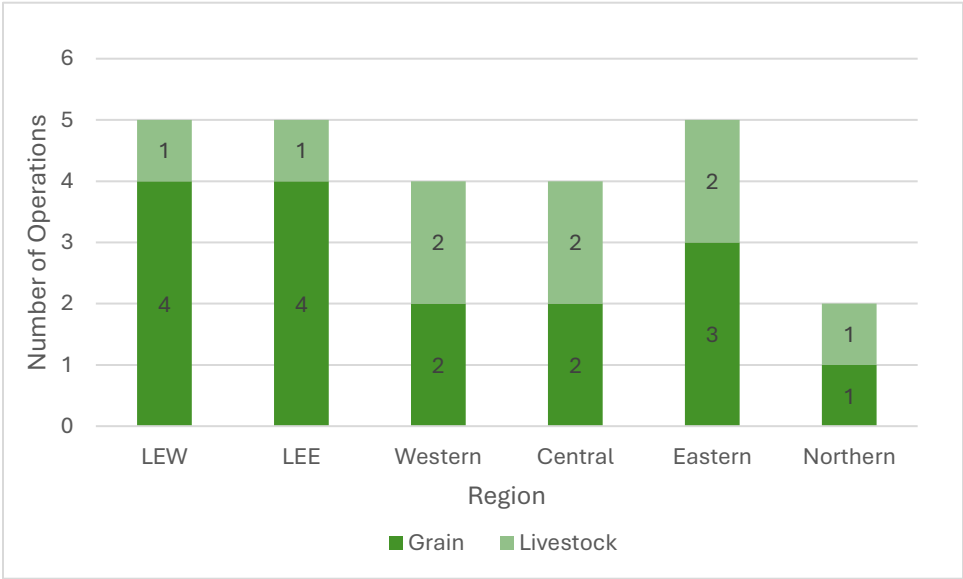


Figure 2. Distribution of operation type by region for the ONFARM BMP trial sites in 2025.

2.3 Data Collection

Annual data collection by SRG at the BMP trial cooperator sites included field crop and BMP management information, agronomic monitoring activities, field and laboratory-based SHI measurements, and field management records. Cropping and management information data were

collected from each cooperator using project record-keeping sheets and from follow-up interviews after the season. Data collected over the 2025 season at each BMP trial site is summarized in **Table 1** with the listed soil health and agronomic data collected at each EOF site.

Table 1. Annual data collection program at the ONFARM locations.

Data Collected	
Treatment data	<ul style="list-style-type: none"> • Baseline/control treatment specifications • Tillage and planting equipment changes – reduced tillage management • Crop/cover crop – species, rates, timing, control • Addition of organic amendments – type, source, characteristics (physical/chemical), calibrated rates, application method, timing
Soil Health data	<ul style="list-style-type: none"> • Soil health indicator (SHI): physical - bulk density (BD), wet aggregate stability (AS); chemical - soil organic matter (SOM), fertility; biological – Solvita® labile amino nitrogen (SLAN), Solvita® CO₂ burst (respiration), active carbon (or permanganate-oxidizable carbon (AC or POxC), potentially mineralizable nitrogen (PMN), autoclave-citrate extractable (ACE) protein
Agronomic data	<ul style="list-style-type: none"> • Emergence and stand population, soil temperature, soil moisture, pest and disease pressure, nutrient deficiencies and toxicities, crop yield, cover crop biomass and/or crop residue
Economic data	<ul style="list-style-type: none"> • BMP implementation costs, other field management costs, and crop yield

The BMP trial sites were selected for their ongoing management under no-till or some form of reduced tillage. Project BMPs include cover crops (CC) or organic amendments (OA), and combinations of both BMPs that were of interest to cooperators to investigate. Management of the BMPs at each site therefore differed across practices, including CC seeding rates and establishment methods, cover crop species and blends, and the timing of planting and termination.

Prior to the 2025 cropping season, CCs were established at 12 sites by the fall of 2024. Organic amendments that included manure (generated both on and off farm) or non-agricultural source materials were applied at eight sites prior to the 2025 crop. The relatively small number of sites able to implement a BMP in the 2025 cropping season was due to many sites having grown corn in 2024 and soybeans in 2025, which left little time in the fall of 2024 to plant a CC and/or apply an OA. Crop and BMP information from the 2025 BMP trial sites is summarized in **Table 2**.

Table 2. ONFARM Soil Health BMP trial site cropping and BMPs implemented in 2024 and 2025.

Site	Crop 2024	BMPs in 2024 (pre 2025 crop)	Crop 2025	BMPs in 2025 (pre 2026 crop)
1	Winter Wheat	Cover crop post	Corn	Cover crop interseed
2	Corn		Soybeans	Organic amendment pre
3	Corn	Cover crop post	Corn	Cover crop interseed, organic amendment post
4	Sorghum- Sudangrass	Cover crop post	Soybeans	
5	Corn	Cover crop post	Soybeans	Cover crop & organic amendment post
6	Winter Wheat	Cover crop & organic amendment post	Corn silage	Cover crop & organic amendment post
7	Corn	Cover crop post	Soybeans	
8	Corn	Cover crop interseed & post	Soybeans	
9	Soybeans		Corn	
10	Corn		Edible beans	Organic amendment post
11	Corn		Soybeans	
12	Winter Wheat	Cover crop & organic amendment post	Soybeans	
14	Corn Silage	Cover crop & organic amendment post	Edible beans	
15	Corn		Soybeans	
17	Corn		Edible beans	
18	Corn		Soybeans	
19	Corn		Soybeans	
20	Corn	Organic amendment pre- & Cover crop interseed	Soybeans	Organic amendment pre
21	Spring Canola	Organic amendment post	Winter wheat	Cover crop interseed, organic amendment post
23	Corn Silage	Organic amendment post	Soybeans	
24	Corn	Cover crop post	Soybeans	
25	Winter Wheat		Corn	
26	Soybeans		Winter wheat	Cover crop & organic amendment post
27	Oats	Organic amendment post	Barley	Cover crop & organic amendment post
28	Dry Peas	Cover crop post	Spring wheat	Cover crop interseed

2.4 Soil Health Sampling

The georeferenced benchmark sampling locations established at each site, based on three distinct soil landscape positions across each of the side-by-side BMP treatment strips, were sampled in June 2025. For the majority of parameters, 24 surface soil cores from 0 to 15 cm depth were composited, hand-homogenized, bagged as a single sample, and stored under refrigeration the same day until laboratory analysis was completed. Composite soil samples were collected in triplicate from three separate areas following a ‘trillium’ design, within a two-meter radius around each benchmark (Figure 3). The field plot design allows for statistical comparison of the benchmark results for the following three groups of analysis:

- Influence of soil landscape position on SHIs
- Impact of different BMPs on SHIs
- Interaction effect of both landscape and BMP on SHIs

The number of soil samples collected in 2025 for SHI analysis, as well as agronomic monitoring, including hand-harvested yield samples, across the ONFARM study sites were:

- Seven EOF cooperator sites represented by 13 treatment field areas with three soil landscape zones with three benchmark location triplicates, totaling 117 samples, and
- 25 BMP Trial cooperator sites of 99 treatments with three soil landscape zones with three benchmark location triplicates, totaling 891 samples.

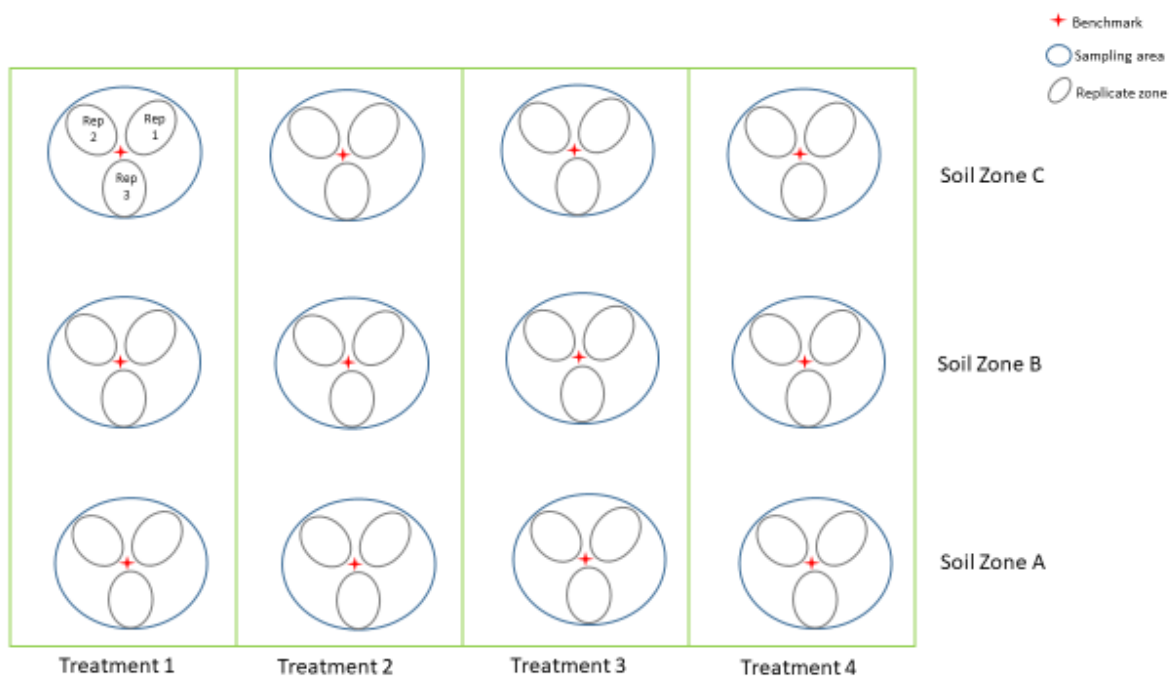


Figure 3. Conceptual soil health sampling design at the benchmark location of field treatment and soil zone/landscape position (upper, mid, lower).

2.5 Soil Health Data Analysis 2025

As in previous years, results of the 2025 laboratory analysis of SHIs at the BMP trial sites continued to demonstrate significant variability within and between sites and reflected the wide range of values for the various tests and range of site conditions. Annual statistical analysis using univariate, bivariate, and multivariate methods, along with graphical relations, was used to compare spatial and temporal differences in the soil health and agronomic monitoring dataset.

2.5.1 Variability and Correlation of SHI Measurements

Tracking the variability of measurement and the correlation between the SHIs is being used to better understand how responsive each SHI is to detect changes in the soil over time. The coefficient of variation (CV) of the SHIs was calculated for the three samples (triplicates) taken immediately surrounding an individual benchmark and rolled up for all sites. The SHIs measured differed in their levels of variability across tests (**Table 3**).

The overall variability of most SHIs in each year and of the project to date was close to or below 10% CV (Table 3). The conventional SHI of SOM remained relatively consistent over time, with close to 7% variability in 2025. Those indicators showing greater than 10% variability between replicates were Solvita® CO₂ burst (microbial respiration) and PMN. The significant shift in variability in the Solvita® CO₂ burst prior to 2023 and in 2023, as well as SLAN from 2023 compared to 2024, is likely due to changes in proprietary laboratory equipment in 2023. However, the variability in Solvita® CO₂ and SLAN was again higher in 2025.

Indicators with values that did not vary as much in measurement around a benchmark of < 6% CV were AC, ACE, AS and BD taken at the soil surface (0 to 5 cm depth). This more consistent measurement of an indicator at a location at any given time provides greater assurance that a change over time can be measured.

Table 3. Variability of soil health indicator test results after six years across BMP trial sites as the coefficient of variation (%).

Year	Soil Organic Matter (SOM)	Active Carbon (AC)	Solvita® CO ₂ Burst	Solvita® Labile Amino Nitrogen (SLAN)	ACE Protein (ACE)	Potentially Mineralizable Nitrogen (PMN)	Aggregate Stability (AS)	Surface Bulk Density (BD)	Surface Soil Moisture
2020	6.9	11.0	5.6	15.8	-	36.6	8.7	6.2	12.7
2021	8.0	8.1	4.3	11.5	-	-	-	6.7	11.4
2022	6.0	6.4	5.3	15.3	6.1	18.0	5.0	5.8	9.0
2023	6.2	9.7	24.1	13.4	6.7	18.4	7.3	5.3	11.3
2024	6.4	6.0	4.1	4.4	6.3	24.3	3.8	5.4	6.2
2025	7.1	5.4	11.2	8.2	5.9	23.8	4.8	5.6	10.6
Average	6.7	7.7	8.9	11.4	6.2	24.3	5.8	5.8	10.2

Relating other SHI measurements to the relatively stable SOM values also provides greater confidence in their ability to show changes in soil health. Correlation analysis conducted again in 2025 across all the BMP trial sites found no strong correlations ($r > 0.7$) between SOM and other SHIs

at the 95% confidence level (**Table 4**). However, AC and ACE levels in 2025 continued to be more positively correlated than other SHIs, with moderately positive correlation coefficients ($r = 0.66$ and 0.65 , respectively) compared to SOM. The next highest correlation coefficient observed was a moderately positive correlation between AC and ACE ($r = 0.53$). SLAN was moderately positively correlated ($r = 0.52$) with AC in 2025, but the variability of SLAN within the triplicate measurements around a benchmark measured in all years lowers its dependability in measuring change over time. Indicators of lower variability may increase the possibility of a greater correlation with SOM; however, in the case of AS with a low sample variability range (4.8%), that also has a relatively smaller range of values, which has likely resulted in a lower positive correlation ($r = 0.37$) with SOM.

Table 4. Correlation analysis for soil health indicators from all BMP trial sites in 2025.

	SOM	AC	Solvita® CO ₂	SLAN	PMN	AS	BD
SOM							
AC	0.658 (n=890)						
Solvita® CO ₂	0.241 (n=889)	0.260 (n=889)					
SLAN	0.457 (n=890)	0.515 (n=890)	0.258 (n=889)				
PMN	0.254 (n=889)	0.099 (n=889)	0.221 (n=888)	0.258 (n=889)			
AS	0.372 (n=890)	0.260 (n=890)	0.222 (n=889)	0.359 (n=890)	0.207 (n=889)		
BD	-0.402 (n=890)	-0.343 (n=890)	-0.095 (n=889)	-0.168 (n=890)	-0.264 (n=889)	-0.055 (n=890)	
ACE	0.648 (n=890)	0.531 (n=890)	0.200 (n=889)	0.412 (n=890)	0.325 (n=889)	0.227 (n=890)	-0.482 (n=890)

Note: Correlation coefficient > 0.5 (highlighted in yellow) is considered a moderately strong positive correlation; soil organic matter (SOM), active carbon (AC), Solvita® labile amino nitrogen (SLAN), potentially mineralizable nitrogen (PMN), aggregate stability (AS), bulk density (BD).

2.5.2 Range of SHI Measurements by Soil Texture and Landscape Position

The range of measured values of SHIs in 2025 across the ONFARM site regions was significantly influenced by soil differences. The regions, having sites chosen for the predominant soil types, were combined by the four soil texture groups and used to compare the range of each of the SHIs. Box and whisker plots were generated in R statistical software to summarize the median and range of values (**Figure 4**). As found in other years of ONFARM monitoring and generally expected, the 2025 SOM levels were lowest for sandy sites (median = 3.7%, CV = 17%) and coarse loamy sites (median = 4.0%, CV = 19%), and higher for more clay-based fine loamy and fine texture soils (median = 4.4%, CV = 22%; median = 4.3%, CV = 17%). The Eastern Ontario, Site 21, was not included due to the presence of organic soils (>30% SOM) in the lower landscape position.

Differences from SOM values were noted in the ranges of values for the carbon-based indicators AC and Solvita® CO₂ burst, which were lowest for the fine loamy soil texture group (median = 460 ppm,

CV = 28%; median = 34%, CV = 41%). This was the group with the highest median value for SOM. Though not statistically different, as well between texture groups, the nitrogen-based indicators differed with values of SLAN similarly distributed to the above, with the fine loamy group having the lowest values (median = 171 ppm, CV = 44%); for ACE, a narrower range of values (median = 6068 to 6762 ppm) were more similar between texture groups; and for PMN, median values decreased consistently with decreasing clay content (median = 11.8 to 5.8 ppm). Physical-based indicators, such as AS, were similar in distribution to SOM, though sandy sites had the potential for much lower values. BD had the highest median and range in coarse loamy soils, but the lowest in sandy soils.

Interpretation of the level of SHIs into rankings of poor to very good, or very low to very high, has been determined on a large scale outside of Ontario (eg: Comprehensive Assessment of Soil Health (Moebius-Clune et al., 2017)). The interpretation of rankings for Ontario-based soils and conditions has not been fully developed or standardized, though recent analysis from OMAFA's Ontario Topsoil Sampling Project (OMAF, 2024) provides scoring curves for SOM, respiration, PMN, AC, AS and BD. The analytical methodology, however, differs from some of the tests used in the ONFARM project, due in part to different laboratories; therefore, ONFARM results cannot always be assigned the ratings proposed in the OMAFA Topsoil Project. SRG, with support from OSCIA, is currently investigating the relationship between the methodologies used in Ontario for SOM (Loss on Ignition, LECO®, Walkley-Black, and Raman Spectroscopy), microbial respiration (Solvita® 24-hour CO₂ burst and Cornell 96-hour basal CO₂ respiration) and AS (Soil Health Institute Slakes image analysis and Eijkelkamp wet sieving).

The other dominant influence on SHI levels measured across the landscape, as previously reported by SRG in OSCIA ONFARM annual technical reports¹ is landscape position. SHI values typically improve as you move down a hillslope from the higher elevation upper landscape position to the mid slope to the lower slope position. Areas of increased moisture, deeper topsoil, and reduced degradation support greater biological activity and improved productivity, as measured throughout the ONFARM project from 2020 through 2025.

The range of values measured in 2025 across the soil texture groups was divided into three contrasting landscape positions, further highlighting the landscape effect across all SHIs (**Figure 5**). SOM levels at the upper position were the lowest in each soil texture group. The lower position most often had the highest average levels of the landscape positions, observed clearly at the fine and sandy soil sites.

¹ ONFARM Soil Health Technical Reports (2023, 2024, 2025). Available at: <https://www.ontariosoilcrop.org/onfarm/>.

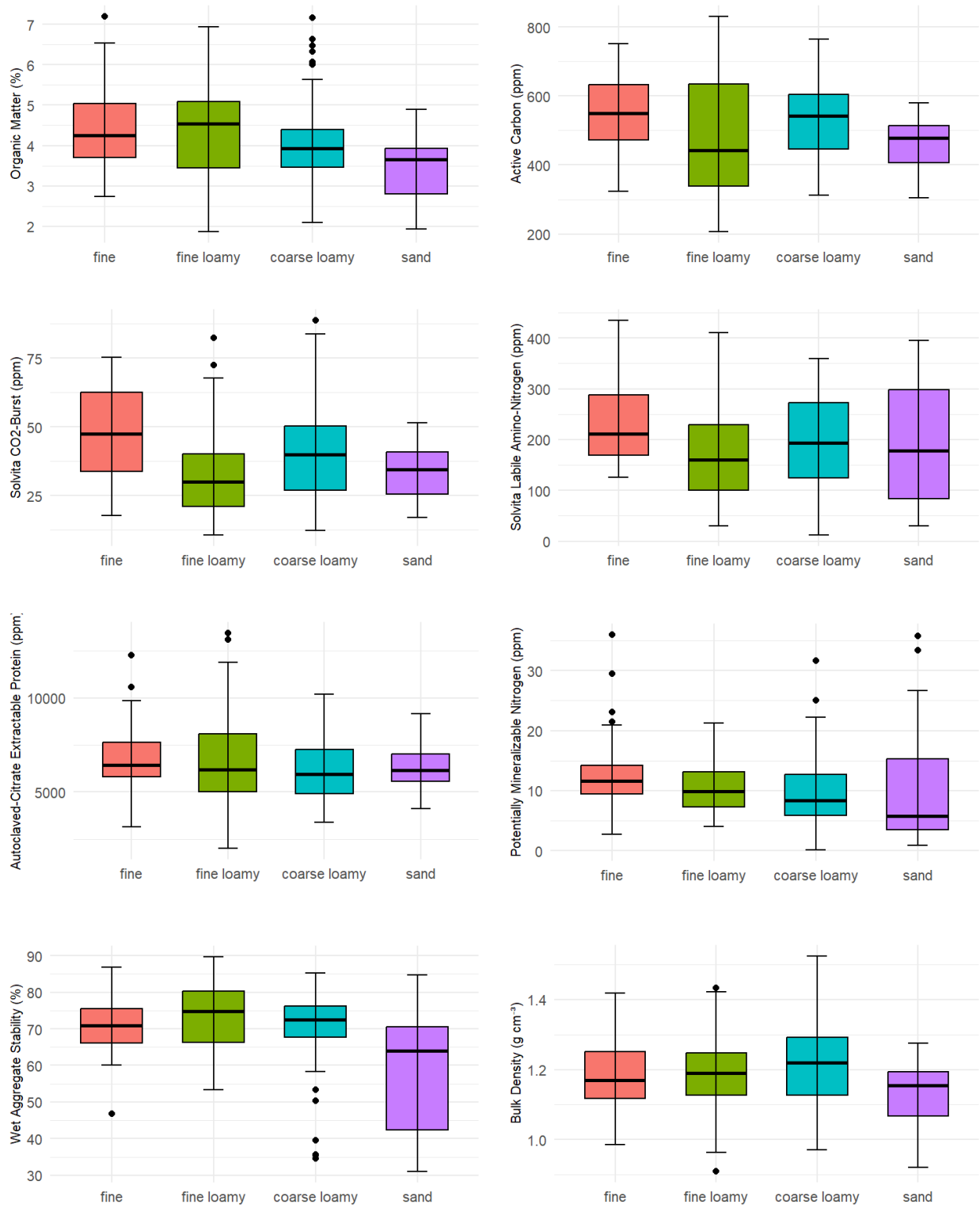


Figure 4. Boxplots of median and range of soil health indicator values by soil texture group across all site benchmarks.

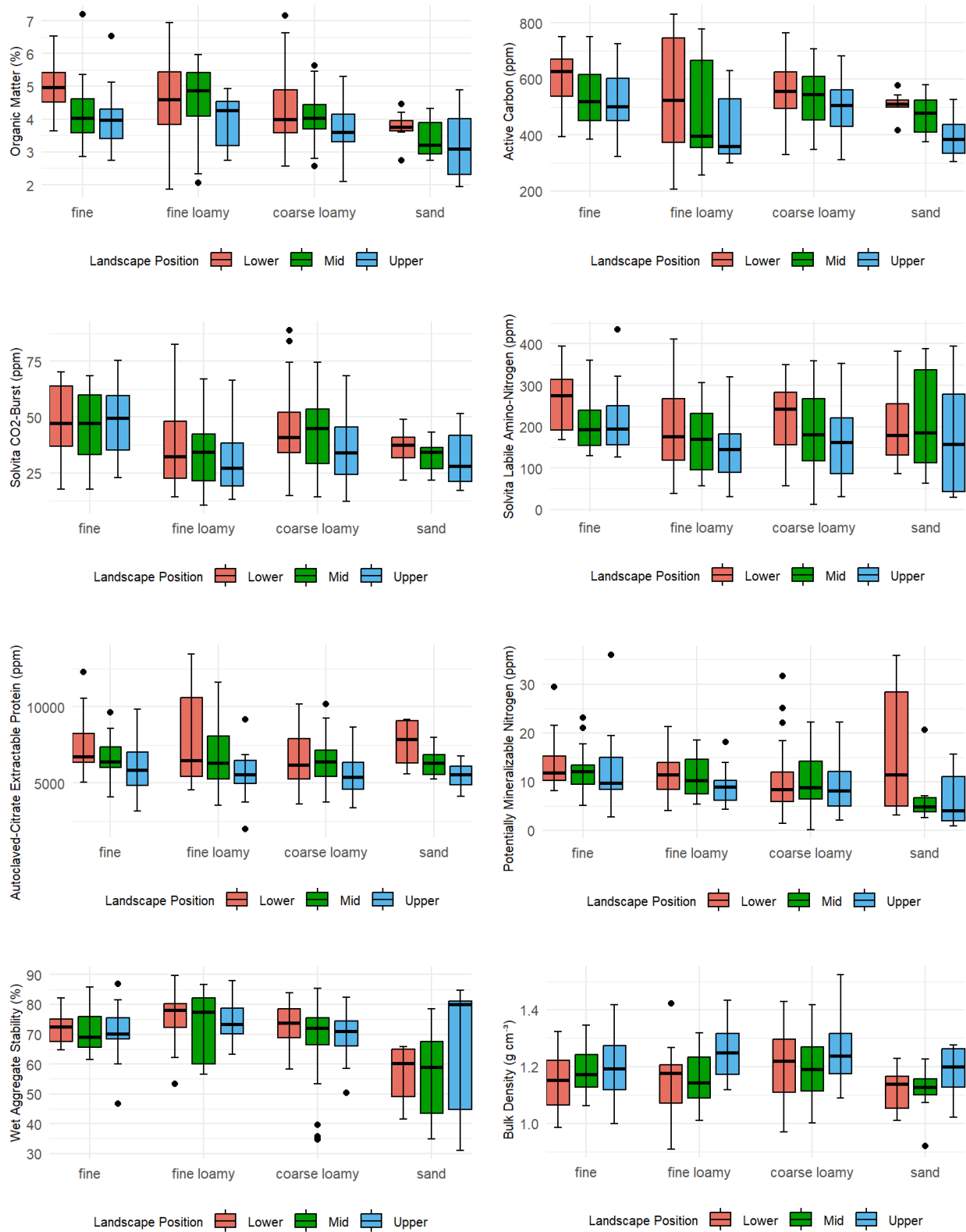


Figure 5. Boxplots of median and range of soil health indicator values by soil texture group, divided by landscape position across all site benchmarks.

Other SHIs showed similar distributions, with the upper position having the lowest value, and the lower position generally having the highest average values. AC was similar to SOM, though it had a greater range of values at the medium-textured sites. The greater range of values was again noticeable across landscape positions for all soil texture groups with the Solvita® CO₂ burst and SLAN tests. For the ACE and PMN values, the widest range occurred in the upper landscape position, possibly reflecting differences in limited-to-severe degradation conditions observed between and within sites. Unlike other SHIs, ACE showed smaller differences in values between texture groups by position, with sandy sites having the highest average value overall at the lower position. Findings from the ACE analysis in 2025 may reflect a test with a greater sensitivity to an improvement in the overall soil condition at the sandy sites, with the adoption of BMPs since the baseline year of 2020.

Aggregate stability, in contrast, was relatively high in rating over the sampling period, with a narrower range for the majority of values across the sites and landscape positions. Levels were noticeably wider in range across the positions of the sandy sites; however, reflecting the physical limitations for aggregate formation and generally lower aggregate strength of coarse textured soils, while still being at risk for compaction at upper positions, resulting in higher levels. In contrast to the other SHIs, the bulk density values were greatest at the upper landscape position, as the risk of compaction increases with decreased topsoil depth and lower SOM. Poor SHI values observed most often at many of the upper landscape site benchmarks are from historic management affected by tillage erosion, topsoil loss, and subsequent soil degradation.

2.5.3 BMP Impact on Soil Health Indicators

In investigating the impact of BMPs on SHIs, the ONFARM BMP trial has completed five cropping years of BMP implementation at 22 of the 25 BMP trial sites. The type and intensity of BMP use have varied as they are implemented specific to a cooperator's goals and management system. The impact on SHIs over this period, as an overall difference across all these sites, was determined when each of the BMP treatment groups was compared to the control treatment at each site. Because of the observed landscape influence, the median benchmark value at each landscape position was compared between the different BMP treatments (CC, OA, or CC and OA) and the control treatment. The % difference measured between a BMP treatment and the control benchmarks was then compiled across all sites.

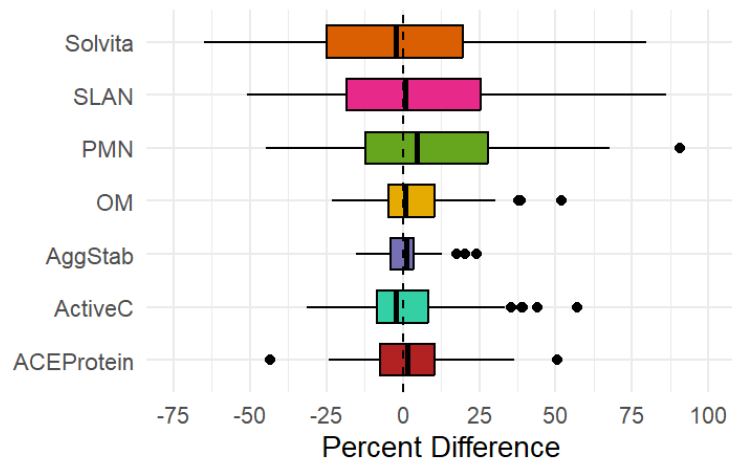
The differences of the three BMP treatments indicated a wide range of values greater than the control treatment and lower than the control treatment (**Figure 6**). For the CC treatment, the median value was a positive difference for five of seven SHIs, up to 5% for PMN, compared to Solvita® CO₂ burst and AC, which were a negative 2% difference from the control. Those SHIs with the greatest range of differences, as indicated by wide boxplots (data quartiles), were Solvita® CO₂ burst, SLAN, and PMN, which also had a large range of values beyond +/-50%. The widespread differences among these three SHIs were observed across all three BMP treatment combinations, indicating significant variability. The PMN values did not appear to change with CC treatment, though SLAN values did appear to increase the number of positive differences with the addition of OA and again with the combination of CC and OA. A much-reduced range of differences was calculated for the remaining SHIs of SOM, AC, ACE, and AS. With the implementation of BMPs, most of these SHI values showed positive changes relative to the control treatment.

Further illustrations of the overall improvement in SHIs with BMP use across the network of BMP trial sites did not consider the three SHIs of greatest variability of Solvita® CO₂ burst, SLAN and PMN, and

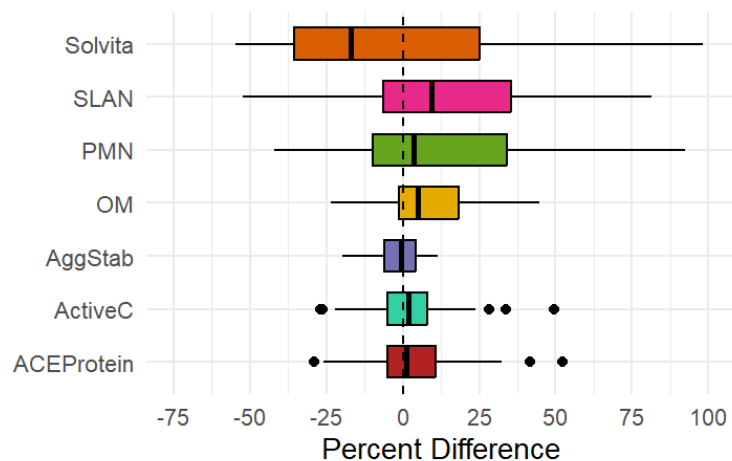
focused on the four more consistent tests of SOM, AC, ACE, and AS. Using the same % difference of a BMP treatment average from a control average at the same position, values across sites were averaged and plotted with 95% confidence intervals using forest plot analysis generated in R statistical software (**Figure 7**). Values determined from baseline levels in 2020 were compared with those measured in 2025. The addition of ACE to the set of SHIs in 2022 is included for the tests and treatments compared in 2025.

The SHI value differences were relatively low, less than $\pm 4\%$ in 2020 for SOM, AC, and AS, and, with 95% confidence intervals (CIs) that cross the 0% (no effect) line, the results are considered not statistically significant or not statistically different. The differences shown in 2025 indicate a trend toward increasing positive change, beginning with the CC BMP, then increasing slightly with OA, and further with the combination of CC and OA. The SHI values for AS and AC, though increasing in the same manner, remain within 5% of each other, have CIs that cross the 0% line, and are not statistically different from the control. The SOM values with CIs above the 0% line are statistically significant, indicating a significant positive increase with the use of BMPs. Average SOM increases measured across all sites after five years were approximately 4%, 8%, and 10% for CC, OA, and their combined BMPs, respectively. ACE analysis behaved very similarly to SOM, showing increases of 2%, 4%, and 8% for the same BMP treatments. The closer response of the ACE protein test to SOM than other tests is likely because the ACE protein test, even though it only measures around 2% of SOM, measures the majority of the soil organic nitrogen component of SOM found in the soil microbial population.

Cover Crop 2025



Organic Amendment 2025



Cover Crop and Organic Amendment 2025

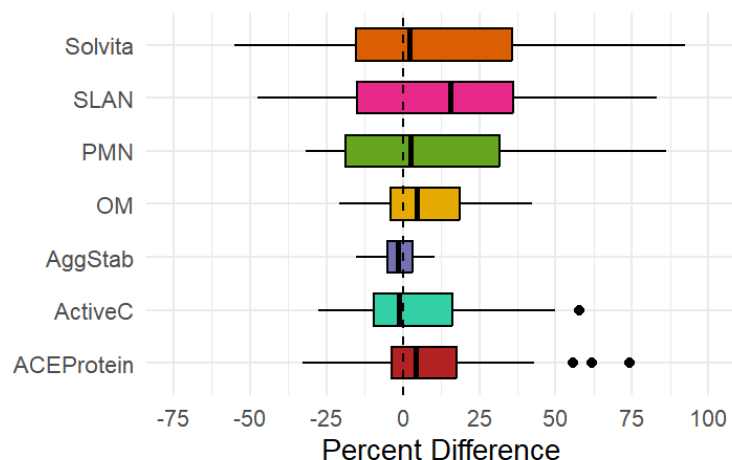


Figure 6. Boxplots showing the distribution of percentage differences between BMP and control treatments for each nutrient across all sites; Solvita® CO₂ (Solvita) Solvita® labile amino nitrogen (SLAN), potentially mineralizable nitrogen (PMN), soil organic matter (OM), aggregate stability (AggStab), active carbon (ActiveC), autoclaved-citrate extractable protein (ACEProtein).

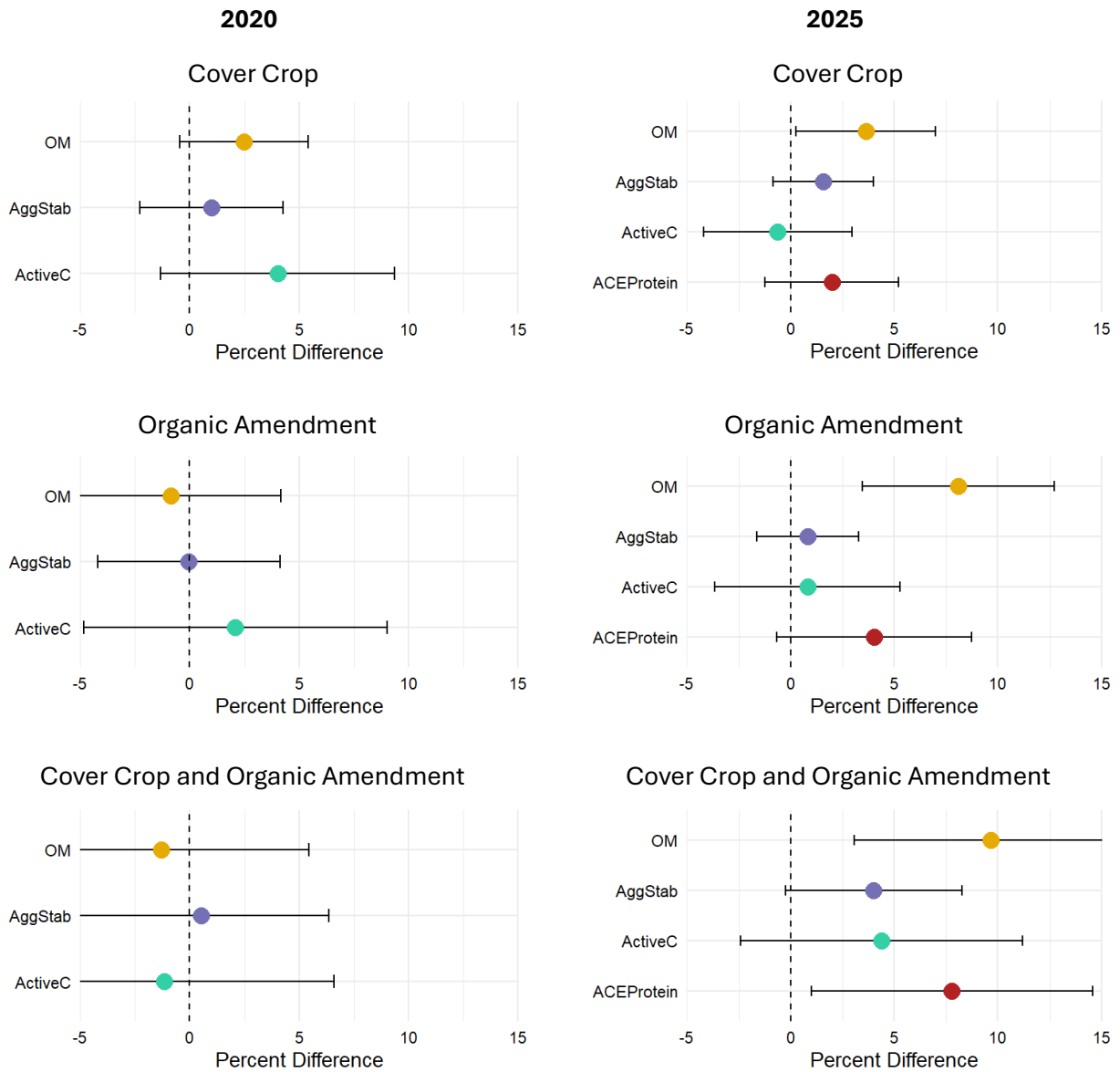


Figure 7. Forest plots of average percentage difference with 95% confidence interval between BMP and control treatments at each site for soil health indicator values across all sites in 2020 and 2025; soil organic matter (OM), aggregate stability (AggStab), active carbon (ActiveC), autoclaved-citrate extractable protein (ACEProtein).

2.6 BMP Case Study

The impact of BMPs on soil health has been shown to be site-specific. In this section, case studies from two BMP trial cooperator sites highlight the effects of BMPs on SHIs over time in fields with contrasting soil types and landscape position differences. The statistical analysis applied a multivariate statistical analysis using an ANOVA analysis for the 2025 SHI data and was computed with SAS®. The 2020 SHI data was used as a covariate to account for the pretreatment variation at each site. The model effects were the 2020 covariate, BMP treatment, landscape position and the interaction of treatment and landscape. A Type III Test of fixed effects was considered significant at $p < 0.10$, and mean differences were computed using the Tukey-Kramer Grouping for Least Square Means. Differences of the BMP treatments from the control treatment, and lower landscape position

from the more degraded middle and upper slopes were reported as BMP treatment effect or landscape position effect, respectively. If the interaction was significant in the model, the individual benchmarks were compared to the control within the same landscape position.

2.6.1 Case Study 1

Site 19 was a newly purchased property, reportedly in poor soil health condition before the start of ONFARM and has maintained consistent BMP implementation during ONFARM from 2021 to 2025. The soil has a sandy loam (coarse loamy) texture, and the site is in ONFARM’s Central region of Ontario, in Oro-Medonte Township, Simcoe County. The SOM level within the plot averaged 3.4%, but signs of poor soil health, such as poor soil aggregation, water and tillage erosion, and lack of visible soil life, were noted. The site has had a crop rotation of barley-soybean-soybean-winter wheat-corn-soybean from 2020 to 2025. BMP treatments applied over the crop years by the cooperator included seeding cover crops and applying a municipal compost to compare with the control treatment (**Table 5**). Site 19 has had frequent BMP implementation, with amendment application rates between 7 and 8 t/ac with light incorporation, and cover crops generating up to 0.5 t/ac of biomass that were winterkilled (**Figure 8**).

Table 5. ONFARM BMP trial and management history of Site 19.

Year and Crop	Treatment 1 Cover Crop (CC)	Treatment 2 Control (no BMP)	Treatment 3 Organic Amendment (OA)	Treatment 4 Organic Amendment + Cover Crop (OA+CC)
2020 Barley	Oat CC (fall)	none	Compost OA (fall)	Compost OA (fall) + Oat CC (fall)
2021 Soybeans		none		
2022 Soybeans		none	Compost OA (spring)	Compost OA (spring)
2023 Winter wheat	Oat CC (fall)	none	Compost OA (fall)	Compost OA (fall) + Oat CC (fall)
2024 Grain corn		none		
2025 Soybeans		none		



Figure 8. Photos of BMP treatments at Site 19 of: a) compost application; b) winter wheat cover crop; and c) cover crop biomass sampling.

The SHI values that have generally shown greater stability from year to year (SOM, AC, and ACE) were compared across the different BMP treatment types implemented over the five-year period from the pretreatment baseline year 2020 to the 2025 data. The addition of multiple CC and OA applications at the site was found to have a significant measurable impact with increased SHI levels of SOM, AC, and ACE at all three landscape positions for the CC and OA treatment. There was no statistical difference for the CC treatment alone (**Figure 9**). Because the OA treatment strip began with statistically higher values than the control, a covariate analysis was conducted and found no additional effect over time from this treatment.

The ACE indicator values showed similar treatment strip differences as SOM in its first year of use in 2022, after two years of BMP implementation. In 2025, however, ACE showed a significant increase in the combined CC and OA treatment compared with the control (**Figure 10**). The use of OAs at different times over the five-year period resulted in significantly greater SHI values than the CC treatment alone, while the combination of CC and OA use tended to have an additional beneficial effect compared to OA use by itself.

Differences determined at the benchmark scale are the level of evaluation most appropriate for assessing treatment effect and is often the level that the statistical analysis requires based on the results of the statistical model. However, tracking changes in the SHI levels within a treatment from year to year also provides insight into whether indicators are increasing steadily over time with BMP implementation at the field scale in spite of differences in crops and weather conditions.

In examining changes in SHIs over the five years of BMP implementation at Site 19, the AC levels measured in the control treatment were subtracted from those measured in the OA+CC treatment, and the resulting differences were plotted for each year (**Figure 11**). In general, the AC measured in the OA+CC treatment shows an upward trend over time, as indicated by the positive trend line on the graph. However, the difference measured between the control and the OA+CC treatment may increase or decrease from year to year, resulting in the undulating annual variation.

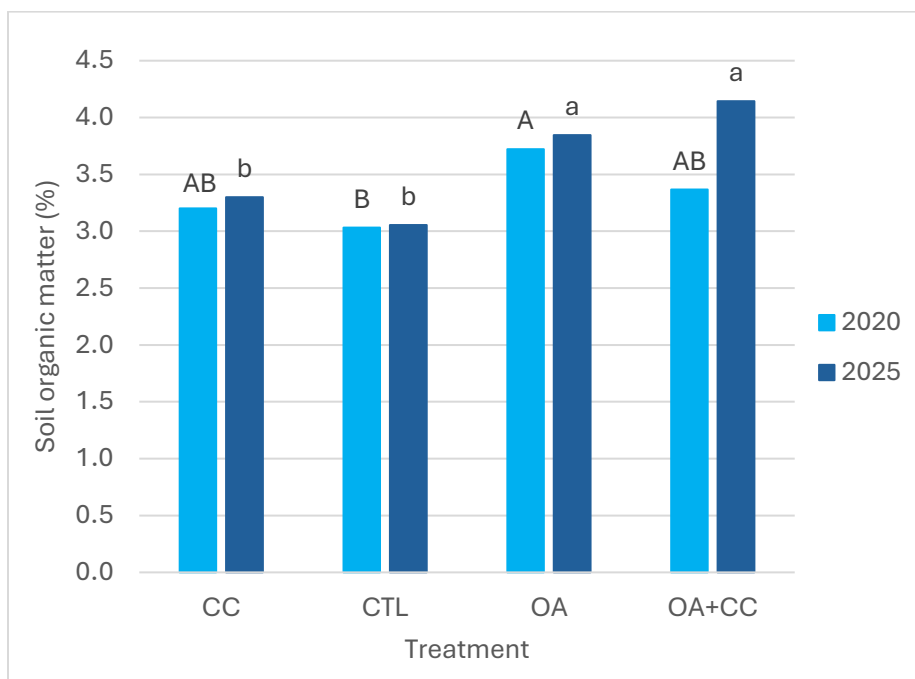


Figure 9. Average values of soil organic matter of treatment strips; cover crop (CC), control (CTL), organic amendment (OA) at Site 19 in 2020 and 2025.

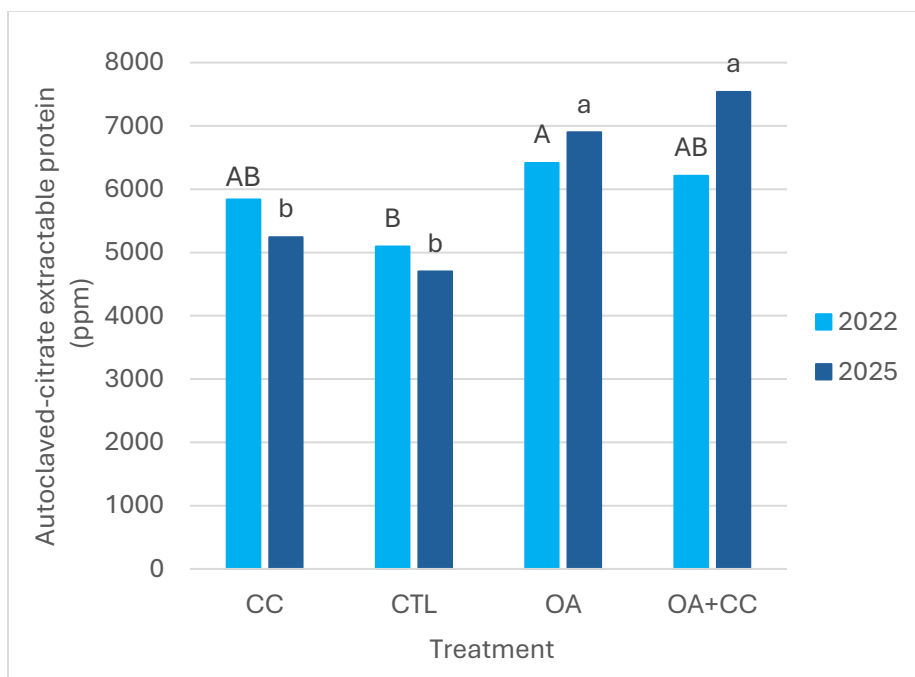


Figure 10. Average values of autoclaved-citrate extractable protein of treatment strips; cover crop (CC), control (CTL), organic amendment (OA) at Site 19 in 2022 and 2025.

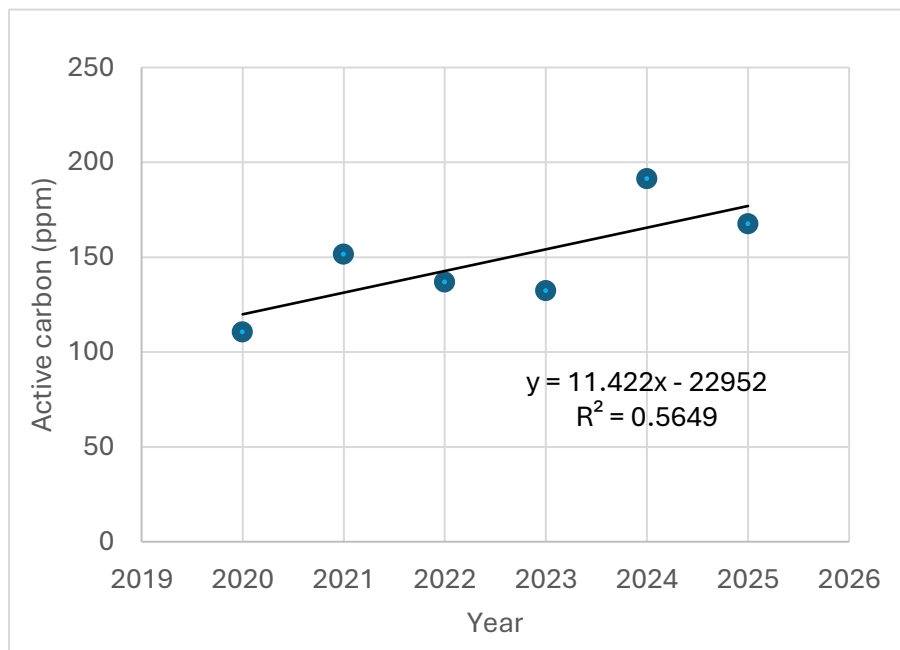


Figure 11. Differences in active carbon values between the organic amendment and cover crop and control treatment from 2020 to 2025 at Site 19.

At Site 19 in 2025, there was a significant BMP treatment effect at all landscape positions with the combined CC and OA application when compared to the control treatment. The OA+CC treatment resulted in significant increases in SOM, AC, and ACE when compared to the control. The OA treatment had increased SHI levels relative to the control in 2025, though not statistically significant because of the baseline year differences. The CC treatment used at the site may require more frequent implementation and greater biomass accumulation in future years to see a measurable change in SHIs.

2.6.2 Case Study 2

Site 8 of the ONFARM BMP trial is located above the Niagara Escarpment in the Lake Erie East region and has been under good soil health management practices for several years. The field is relatively flat with a fine silty clay loam soil type (fine loamy) and an average SOM level of 5.5%. The crop rotation over the ONFARM project has been buckwheat-corn-adzuki beans-sunflowers-corn-soybeans from 2020 to 2025 (Table 6). BMP treatments compared CC management planted as single species or blends in biostrips, solid-seeded, or interseeded. Cover crop treatments generated up to 0.6 t/ac, though in some years, levels were lower before being chemically terminated in the spring (Figure 12).

Table 6. ONFARM BMP trial and management history of Site 8.

Year and Crop	Treatment 1 Cover Crop (CC)	Treatment 2 Control (no BMP)	Treatment 3 Cover Crop (CC)	Treatment 4 Cover Crop (CC)
2020 Buckwheat	CC blend (fall)	none	CC blend (fall)	CC blend (fall biostrip)
2021 Grain Corn	CC blend (interseeded)	none		CC blend (interseeded)
2022 Adzuki Beans		none		
2023 Sunflowers	CC blend (interseeded)	CC blend (interseeded)	CC blend (interseeded)	CC blend (interseeded)
2024 Grain corn	CC blend (interseeded)	none	Winter wheat CC (fall)	CC blend (interseeded)
2025 Soybeans		none		

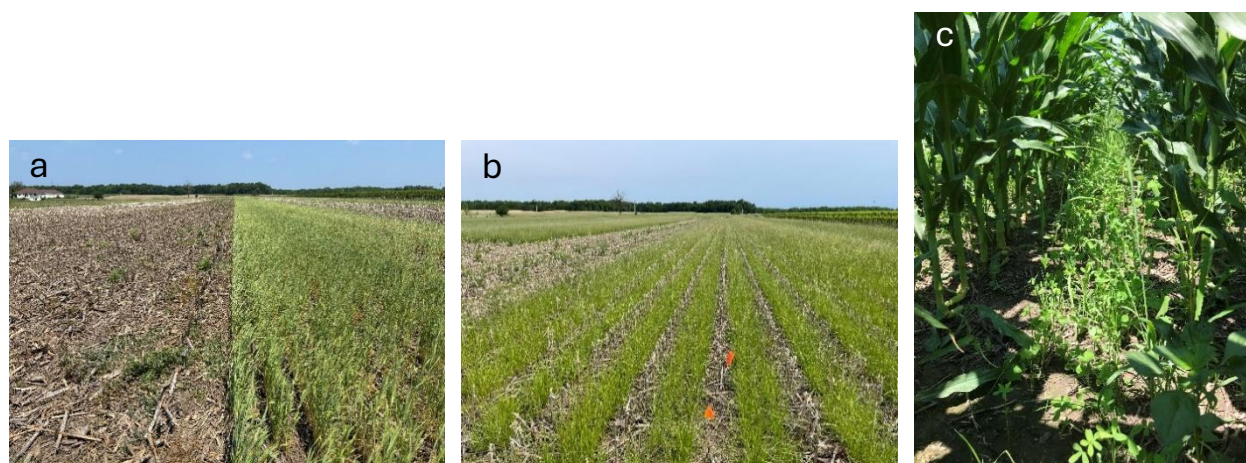


Figure 12. BMP treatment photos at Site 8 of: a) cover crop vs control; b) cover crop biostrips; c) and interseeded cover crop.

As noted in Site 19, differences determined at the benchmark scale are the most appropriate level of evaluation for assessing treatment effect and are often the level that statistical analysis requires based on the results of the statistical model.

In this case study at Site 8, the field is relatively flat and has had years of good soil management, but observations of historical degradation of reduced soil profile depths in the upper landscape position still have an influence on SHIs. SOM measurements in 2025 were found to be significantly different between benchmarks and were influenced by the interaction between the BMP treatment strip and landscape position, but not by the BMP treatment or landscape position, independently.

A closer look at this interaction effect is shown in **Figure 13** by first comparing the 2024 and 2025 SOM levels. The highest SOM levels were predominantly measured in the lower and mid landscape positions from all the treatment strips, highlighted by the red circle. This suggests that landscape position is influencing the measured SOM values more than the cover crop treatment.

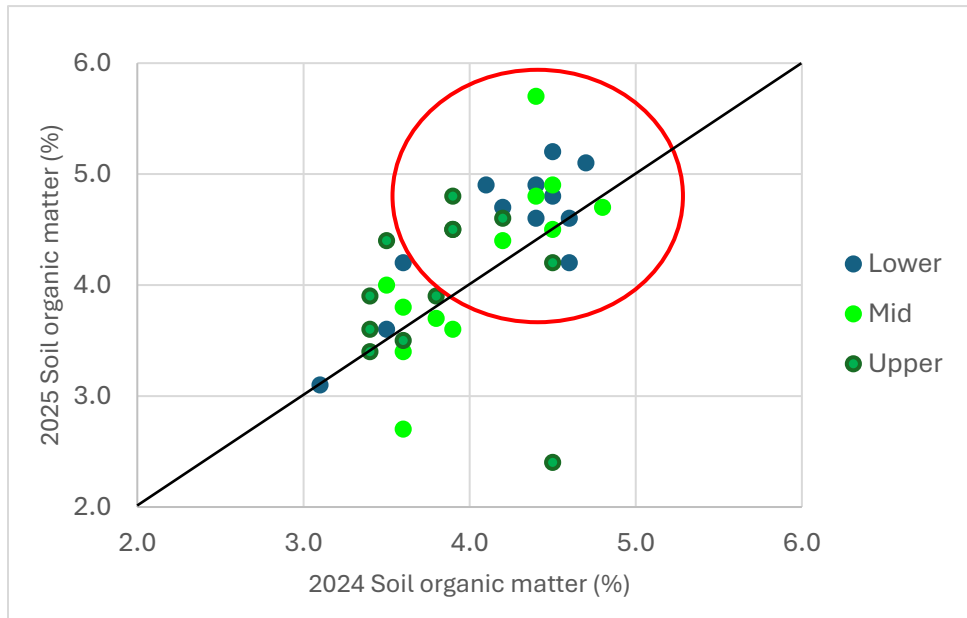


Figure 13. Soil organic matter values from benchmark locations at Site 8 in 2024 and 2025. Points above the 1:1 line indicate increases from 2024 to 2025, while points below indicate decreases.

However, when comparing values of the three landscape positions (**Figure 14**), there is no significant difference even though the upper position has been consistently lower in SOM over the study, indicating the influence of legacy degradation even on this slightly sloping field.

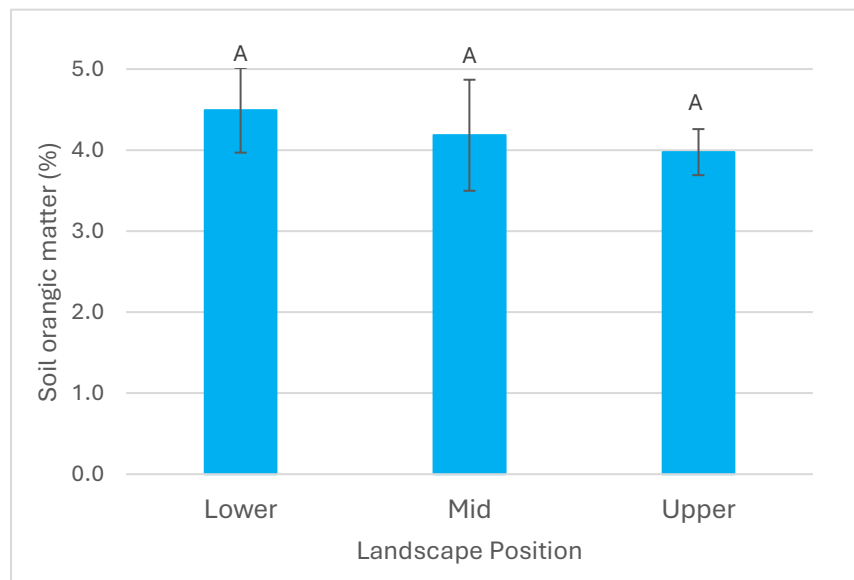


Figure 14. Average soil organic matter across landscape positions at Site 8 in 2025.

In investigating the same analysis with the ACE values, the 2024 and 2025 measurements were similar to SOM (**Figure 15**). The highest SOM values were from the benchmarks in the lower and mid landscape positions across all treatment strips. The ACE measurements in 2025 were, however, statistically different between landscape positions (**Figure 16**). The upper landscape position was significantly lower than the mid and lower positions, which may be an indication that the ACE test could be more sensitive to differences in soil condition than organic matter.

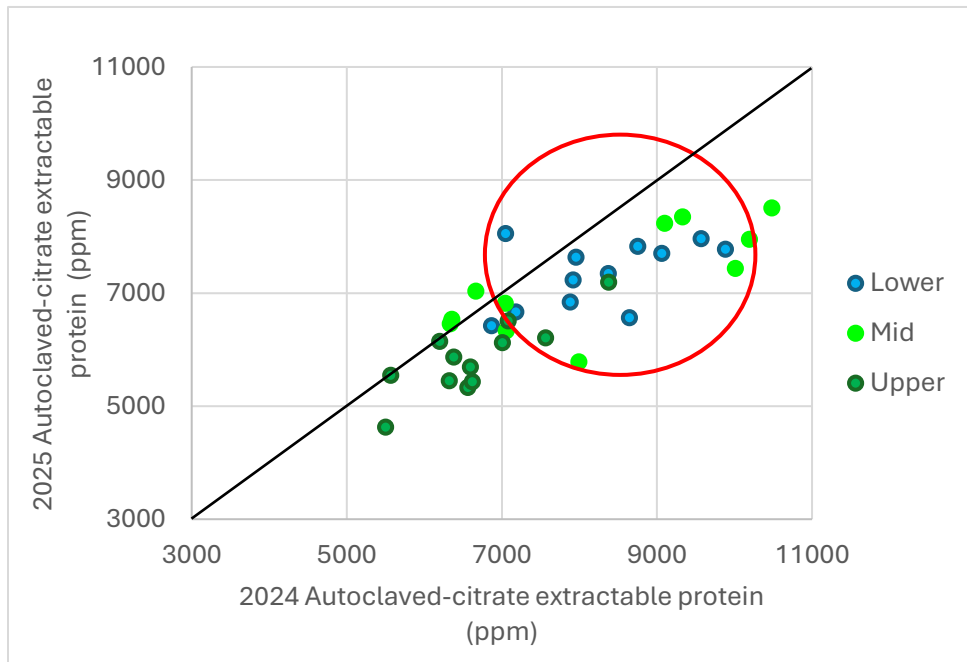


Figure 15. Average autoclaved-citrate extractable protein from benchmark locations at Site 8 in 2024 and 2025. Points above the 1:1 line indicate increases from 2024 to 2025, while points below indicate decreases.

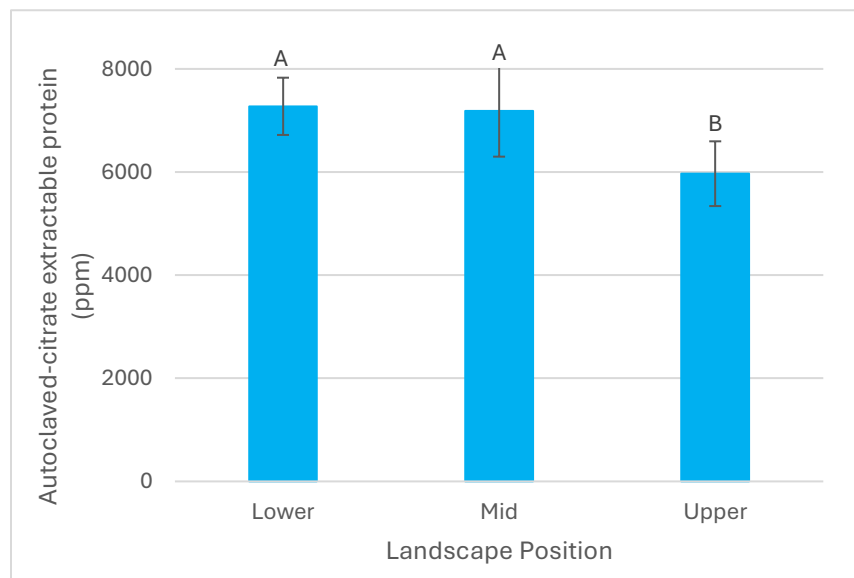


Figure 16. Average autoclaved-citrate extractable protein across landscape positions at Site 8 in 2025.

At Site 8, the landscape differences make determining BMP treatment differences over time a greater challenge to measure, and this difficulty is compounded when SHI values increase or decrease from year to year. The difference between the CC treatment strip with the most biomass accumulation over time at Site 8, and the control treatment was compared for the AC levels measured since 2020 (Figure 17). There was little difference in AC levels up to 2024, which may be due to limited CC biomass growth. In 2024 and 2025, the difference observed between the control and CC treatment was due to a higher level of variability and a reduction in the control AC levels, while the CC treatment maintained similar levels.

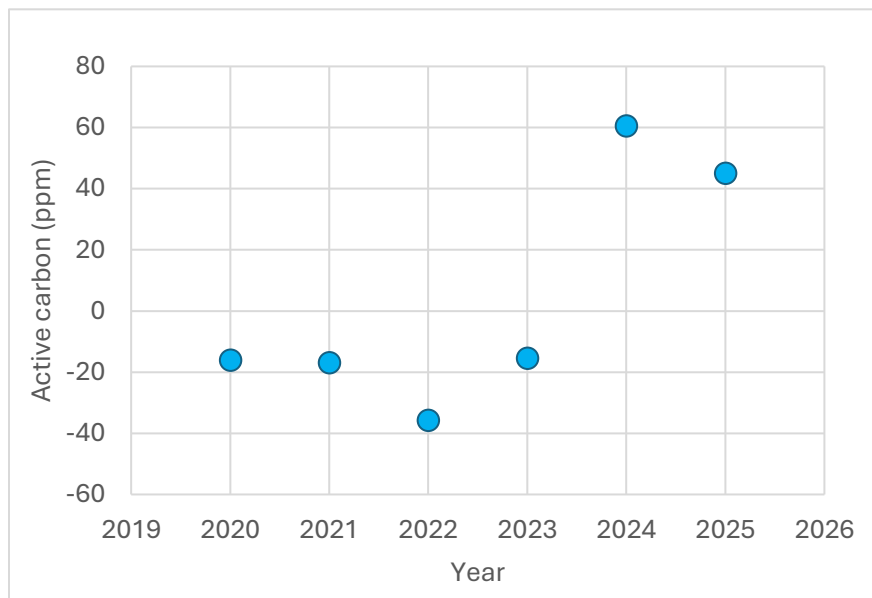


Figure 17 Differences in active carbon between a cover crop and control treatment strip from 2020 to 2025 at Site 8.

Observations at Site 8, as also measured at Site 19, indicate the amount of change with a BMP treatment from the control differs year to year, where in some years the difference is significant, and in others it is not. Findings after five years would indicate that in using SHIs, measurable change of significant and lasting impact from BMP use is not immediate and would require at least five years of regular BMP implementation.

Site factors such as historical soil degradation observed at Site 8 on well-managed, relatively flat clay soil with above-average organic matter content are likely a dominant influence on the SHI levels measured in 2025. The CC BMP treatments may require greater frequency and carbon accumulation, achieved through increased biomass, to result in significant, measurable changes in SHI levels at this site.

2.7 Yield Monitoring

Along with the annual monitoring of SHIs, crop monitoring and yield measurements were conducted at all benchmark locations to examine the impact of BMPs on crop response. Over the six years of the project, yield reductions most often correspond to areas of reduced moisture due to soil degradation, often found at upper landscape positions. Yield, however, has often been an unreliable indicator of soil health year to year across the network of sites. Correlations between yield and any of the SHIs across sites remain weak, with correlation coefficients < 0.4 and often negative (**Table 7**).

Table 7. Correlation analysis for soil health indicators and yield at all sites (n=891) from 2020 to 2025.

Yield	SOM	AC	Solvita® CO ₂	SLAN	ACE	PMN	AS	BD
2020	-0.040	-0.082	-0.107	-0.067	-	-0.030	-0.039	-0.094
2021	-0.118	-0.069	-0.034	0.023	-	-	-	0.112
2022	0.093	0.075	-0.219	0.081	0.134	-0.006	-0.163	-0.205
2023	-0.149	0.003	-0.009	-0.066	-0.114	0.069	-0.154	-0.001
2024	-0.201	-0.008	-0.397	0.036	-0.079	-0.276	-0.052	0.210
2025	0.247	0.148	-0.059	-0.180	0.243	-0.003	-0.032	-0.389

Note: Correlation coefficient of 0 to +/-0.3 is considered a very weak relationship; soil organic matter (SOM), active carbon (AC), Solvita® labile amino nitrogen (SLAN), autoclaved-citrate extractable protein (ACE), potentially mineralizable nitrogen (PMN), aggregate stability (AS), bulk density (BD).

Annual crop productivity potential is significantly influenced by several factors that are not controllable at a farm level (regional differences, climate, annual weather and soil moisture, unknown factors). Only a small portion of yield can be impacted by genetics, crop inputs, field characteristics and management.

The BMP impacts on yield were not evident in 2025. Differences between BMP treatment types with control treatments across sites using Forest plot analysis (**Figure 18**) were low initially (+/- 3%) with no difference in 2020, and again in 2025, where the 95% confidence interval line extended over the 0% line. The impact on productivity from BMP implementation may require more frequent and intense use over a longer period of time to result in a significant change.

Nearly half of the BMP trial sites in 2025 had statistically significant yield differences at the benchmark level, but the differences were mainly due to landscape position. The growing season started wet and cool, but the remainder of the season was typical, often leading to soil moisture deficiency in late summer through to grain fill time. Upper landscape positions, where soil degradation was observed, and less moisture was measured than in lower landscapes, typically had lower yields. Conditions were different in 2024 when adequate moisture conditions throughout the growing season resulted in fewer significant yield differences between landscape positions.

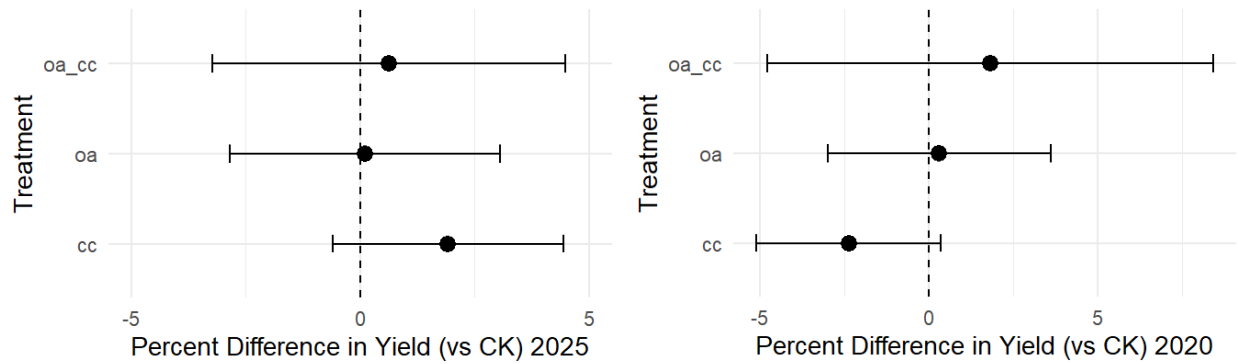


Figure 18. Percentage difference in yield BMP treatments and control/check (CK) across sites in 2020 and 2025.

In 2025 most of the BMP trial sites had soybeans, which is known as an ‘indicator species’ of sensitivity to poor growing conditions. Average soybean yield across sites showed landscape differences, with the upper and mid positions having significantly lower yields than the lower position (Figure 19). Sites in corn, however, did not have statistically significant yield differences between landscape positions (Figure 20).

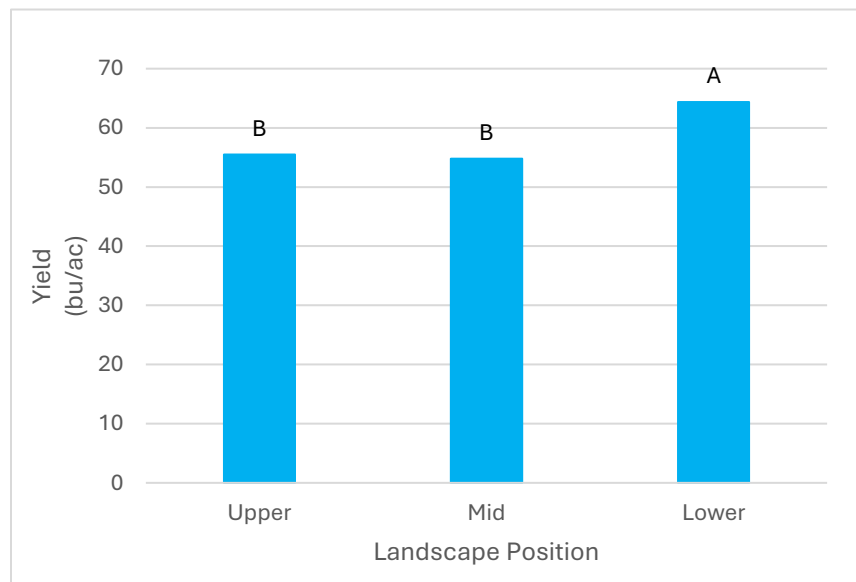


Figure 19. Average soybean yield by landscape position across sites (n=479) in 2025.

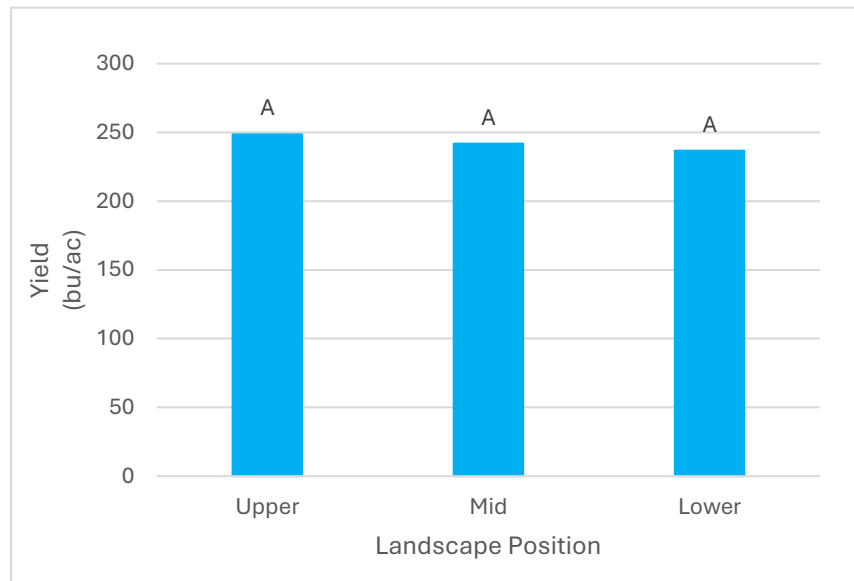


Figure 20. Average corn yield by landscape position across sites (n=105) in 2025.

Given the variability of soil conditions across the sites and other factors that influence yield, such as annual moisture conditions (Figure 21), measuring significant yield differences consistently due to a BMP is challenging, and clear effects are not yet evident. BMP effects on yield will continue to be analyzed at a benchmark level on an annual basis for each site.



Figure 21. Photos of moisture influence on crop growth: a) Site 7 in 2025; b) and c) Site 12 in 2023.

3.0 Summary

The investigation of soil health continued in 2025 at ONFARM sites across the province for the 25 BMP Trial and seven Edge-of-Field sites. Research site farm cooperators implemented BMPs where feasible, alongside business-as-usual practices. Annual monitoring and analysis of the project's SHI package was completed to explore the performance of the different indicators and reveal temporal and spatial differences of the indicators within a site and between sites.

The 2025 laboratory analysis of samples collected from the BMP trial sites was assessed for sampling variability of the SHIs at a benchmark. Findings were similar in 2025 to previous years (2023 and 2024) with consistent values below 8% coefficient of variation for SOM, AC, ACE, AS and BD. The sampling variability in Solvita® CO₂ burst and PMN testing was again greater than 10% CV in 2025, proving less consistent with less assurance of being able to measure a change in soil health over time. SHIs with moderately positive correlations with SOM ($r = 0.65$) are AC and ACE. Only moderately positive correlation was found between these two indicators of ACE and AC. SLAN was moderately positively correlated with AC in 2025; however, the overall variability of SLAN across triplicate measurements around a benchmark reduces its reliability for measuring change over time.

The range of SHI values across the ONFARM regions continues to be influenced significantly by soil variability and different landscape positions. Site results from 2025, grouped by the four soil textures, were used to compare the ranges of each SHI. Although SOM was lowest for sandy sites, then for coarse loamy, and highest for fine loamy and fine-textured soils, the lowest values for AC, Solvita® CO₂ burst, and SLAN were observed at fine loamy sites. ACE had a narrower range of similar values between texture groups, though PMN decreased consistently with decreasing clay content, as expected with SOM. Landscape position typically influenced SHI values, with values improving as you move down a hillslope to areas of increased moisture, deeper topsoil and reduced degradation. Soil degradation was observed to some degree at the upper position across all ONFARM sites, associated with poorer SHI measurements, except for aggregate stability.

Over five years of BMP implementation, the overall impact on SHIs was assessed. The differences in 2025 at a site between a BMP treatment and the control benchmarks as % difference for a SHI were compiled across all sites. Each BMP treatment resulted in a wide range of values greater than the control and lower than the control, with median values within 5 % of the 0 line. Solvita® CO₂ burst, SLAN, and PMN had large ranges of values exceeding ± 50 % across all three BMP treatments, indicating significant variability in these test measurements. The more consistent tests and lower ranging differences of SOM, AC, ACE and AS measured a trend of increasing positive change beginning with the CC BMP, increasing slightly with the use of OA, and increasing further with the combination of a CC and an OA. Statistically significant increases were measured for SOM across all three BMP treatments, and ACE for the combination CC and OA treatment.

Investigation of two cooperator sites of contrasting soil and landscape complexes illustrated the influence of each factor, along with the impact of site specific BMPs. At a sandy site in Central Ontario of reportedly poor condition at the start of ONFARM, the addition of multiple CC and OA applications was found to have a significant measurable impact after five years, with increased SHI levels of SOM, AC, and ACE at all three landscape positions for the CC and OA treatment. SHIs measured in the OA+CC treatment show an increase over time; however, the difference measured between the control and the OA+CC treatment changed from year to year, being significantly higher in some years and not in other years. A second site was evaluated, located in the Niagara region of Ontario and comprised of nearly flat, fine silty clay loam soil, which has been under good soil health

management practices for several years. BMP treatments have compared the impact of CC types and management on SHIs. SOM measurements in 2025 were found to be significantly different between benchmarks and were influenced by the interaction between the BMP treatment strip and landscape position, but not by the BMP treatment or landscape position, independently. The higher SOM levels observed at the lower and mid-slope positions from all the treatment strips suggest that landscape position is influencing the measured SOM values more than a BMP treatment. When comparing values of the three landscape positions, however, there was no significant difference, even though the upper position has been consistently lower in SOM over the study, highlighting the influence of legacy degradation on SHIs even in this slightly sloping field.

Annual agronomic and crop productivity monitoring through ONFARM has shown that yield is significantly influenced by several factors that are not controllable at the farm level (e.g., weather, region). Effects of BMPs on yield have not been clearly evident. Yield measurement is poorly correlated with other SHIs measured. It has been observed to relate to landscape position, particularly at highly degraded benchmark locations. In 2025, soybeans were grown at most sites and due to their sensitivity to soil conditions, they often had reduced yields at upper compared to mid and lower landscape positions. Corn crops this year did not show differences in yield between landscape positions.

The findings suggest that the impact of BMPs on SHIs was significant, with a greater frequency of BMPS. The use of a suite of BMPs increased the likelihood of measuring improvements in SHIs over the five-year implementation period. Further implementation of BMPs will be encouraged across the cooperator sites over the next two cropping seasons as monitoring of soil health will continue. Additional monitoring of improvements with BMPs will consider the influence on soil water availability over the season, which may increase crop resilience and reduce yield variability. Monitoring in 2026 will include additional investigations of available water-holding capacity at a select number of ONFARM sites to improve understanding of the impact of BMPs on in-field water dynamics.

To stay up to date on ONFARM activities and to view past reports, please visit the [OSCIA ONFARM Website](#).

References

B.N. Moebius-Clune, D.J. Moebius-Clune, B.K. Gugino, O.J. Idowu, R.R. Schindelbeck, A.J. Ristow, H.M. van Es, J.E. Thies, H.A. Shayler, M.B. McBride, K.S.M. Kurtz, D.W. Wolfe, and G.S. Abawi. 2017. Comprehensive Assessment of Soil Health: The Cornell Framework. 3rd Edition.

<https://www.css.cornell.edu/extension/soil-health/manual.pdf>

OMAFRA. 2024. Ontario Topsoil Sampling Project Soil Health Baseline Study.

<https://www.ontario.ca/files/2025-06/omafra-ontario-topsoil-sampling-project-2024-en-24-06-2025.pdf>

OSCIA. The Soil Resource Group. 2023. ONFARM Soil Health Technical Report.

<https://www.ontariosoilcrop.org/wp-content/uploads/2024/01/ONFARM-Soil-Health-Technical-Report.pdf>

OSCIA. The Soil Resource Group. 2024. ONFARM Soil Health Technical Report.

<https://www.ontariosoilcrop.org/wp-content/uploads/2024/04/2023-Soil-Health-Technical-Report.pdf>

OSCIA. The Soil Resource Group. 2025. ONFARM Soil Health Technical Report.

<https://www.ontariosoilcrop.org/wp-content/uploads/2025/03/ONFARM-Soil-Health-Technical-Report-2024-2025.pdf>

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