Evaluating Soil-Water Retention with Pressure Plate Analysis

2025-2026

Prepared by:

March 31, 2026

Table of Contents

Introduction

One of the key soil characteristics for sustaining crop growth is its ability to retain water and supply it to plants when needed. This function depends on soil texture and pore size distribution. In general, soils with more micropores retain more water, while macropores facilitate infiltration and drainage. A balanced pore system supports optimal plant-available water. However, soil compaction can reduce macroporosity and negatively affect infiltration, aeration, and root growth. Best management practices (BMPs) that improve soil aggregation and organic matter can enhance both water retention and infiltration.

Methodology

In 2023, On-Farm Applied Research and Monitoring (ONFARM) program initiated a new research project to explore the relationship between soil characteristics, soil health, and soil water dynamics. In this work, the water retention properties of seven selected farms were estimated using pressure plate analysis. In 2023, intact soil cores were collected by the Biswas Soil Lab at the University of Guelph and by the Soil Research Group (SRG) from three sites, and the pressure plate analysis was completed by the Biswas Soil Lab at the University of Guelph in 2024 (**Figure 1**). Results were reported in the 2024-2025 annual report. In 2024, SRG collected cores from three farms, and they were analyzed by the Biswas Soil Lab in 2025. This report reports on these results across the three farms sampled in 2024. Farms that were sampled in 2023 will be sampled again in fall 2026 following the completion of a three-year crop rotation. Farms that were sampled in 2024 will be sampled again in fall 2027.

Figure 1. Photograph of soil core collection in 2023 (Photo: SRG).

Sampled Sites in 2024:

- Soil Health BMP Trial – Site 3. This site is situated on a Plainfield loamy sand soil. In 2024, corn was grown, followed by a rye cover crop.
- Soil Health BMP Trial – Site 20. In 2024, this site was cropped with corn, with compost applied preplant and cover crops interseeded for the treatments. The soil type is Otonabee Loam.
- Edge-of-Field (EOF) monitoring site – Site 4 (North Kettle). In 2024, sweet corn was planted at this site following the application and incorporation of chicken manure. The soil type is typically Muriel Clay Loam. A cover crop was planted in the treatment field after the main crop harvest. No cover crops were planted in the control field.

Intact soil cores were collected from benchmark sampling positions established by SRG in 2020, to align with other regular soil sampling and agronomic monitoring. Samples were taken in triplicate from two depths: the top (0-15 cm) and the subsoil (15-30 cm). Each treatment strip included three benchmark locations selected at different landscape positions along a hillslope to represent lower-, mid-, and upper-slope positions.

Figure 2. Photograph of soil cores prepared for analysis in the low pressure system.

To determine each sample's water retention, cores were weighed, saturated with water, and repeatedly subjected to increasing pressure ranging from 33 millibars to 15 bars. Soil cores were weighed at each interval to determine the volume of water extruded, thereby allowing the permanent wilting point, field capacity, and plant-available water content to be calculated (**Figure 2**). Cores were dried after this determination to calculate soil bulk density.

Field capacity represents the amount of water in the soil after excess water has drained away by gravity. In pressure plate analysis, field capacity is measured between 100 millibars (for sandy soil) and 330 millibars, depending on the soil type. Both soil air and water contents are considered optimal for crop growth when the soil reaches its field capacity. Permanent wilting point (PWP) indicates the lower limit of soil water content that a plant needs to prevent wilting caused by water stress. Water is tightly held in soil pores at soil moisture below PWP, restricting water availability to plants. In pressure plate analysis, PWP is measured at 15 bar. The difference between field capacity and the permanent wilting point represents the amount of water available to plants, which is referred to as plant-available water (PAW).

Results and Discussion

Edge-of-Field Site 4

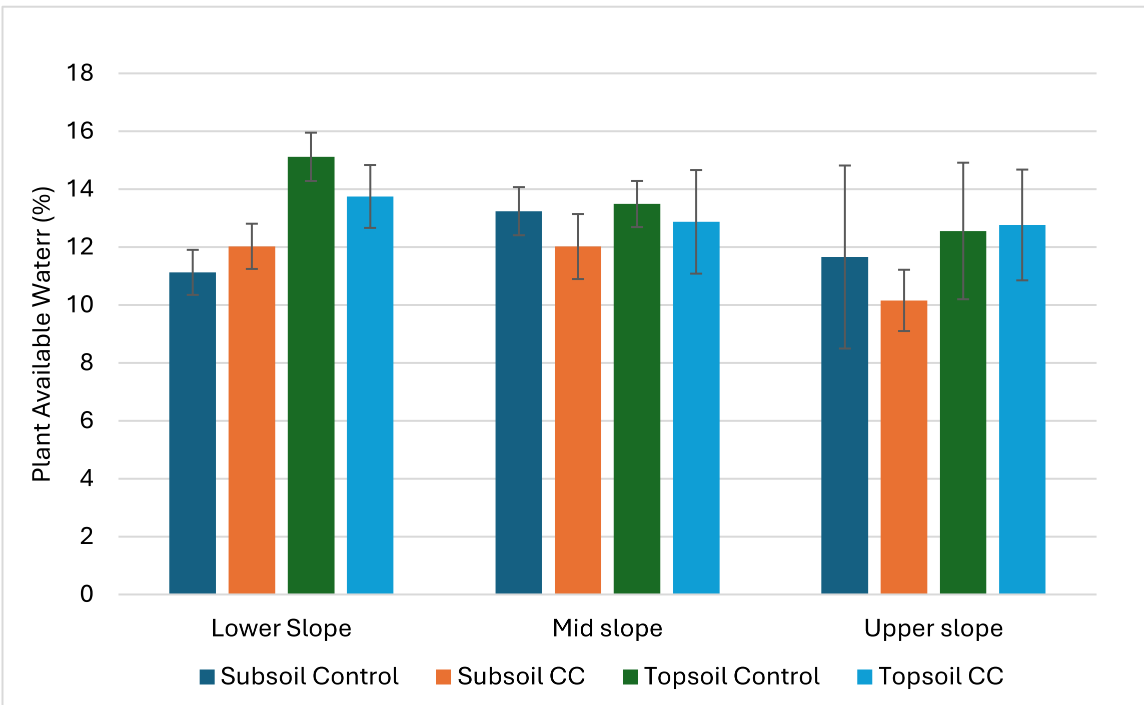

Figure 3. Plant-available water (%) for the cover crop (cc) and the control field at EOF Site 4. Error bars represent ± one standard deviation.

No significant differences in PAW were observed between the cover crop and control fields at EOF Site 4 (**Figure 3**). However, further insights reveal the influence of soil bulk density on PAW and other soil water retention properties at this site (**Figure 4**). Generally, PAW decreased with increasing bulk density at both locations, although the relationship was stronger in the cover crop field ($r^2 = 0.54$). Bulk density also seems to affect other soil properties, such as soil organic matter, with strong negative relationships observed between bulk density and soil organic matter in both fields during spring (ONFARM Soil Health data, not shown).

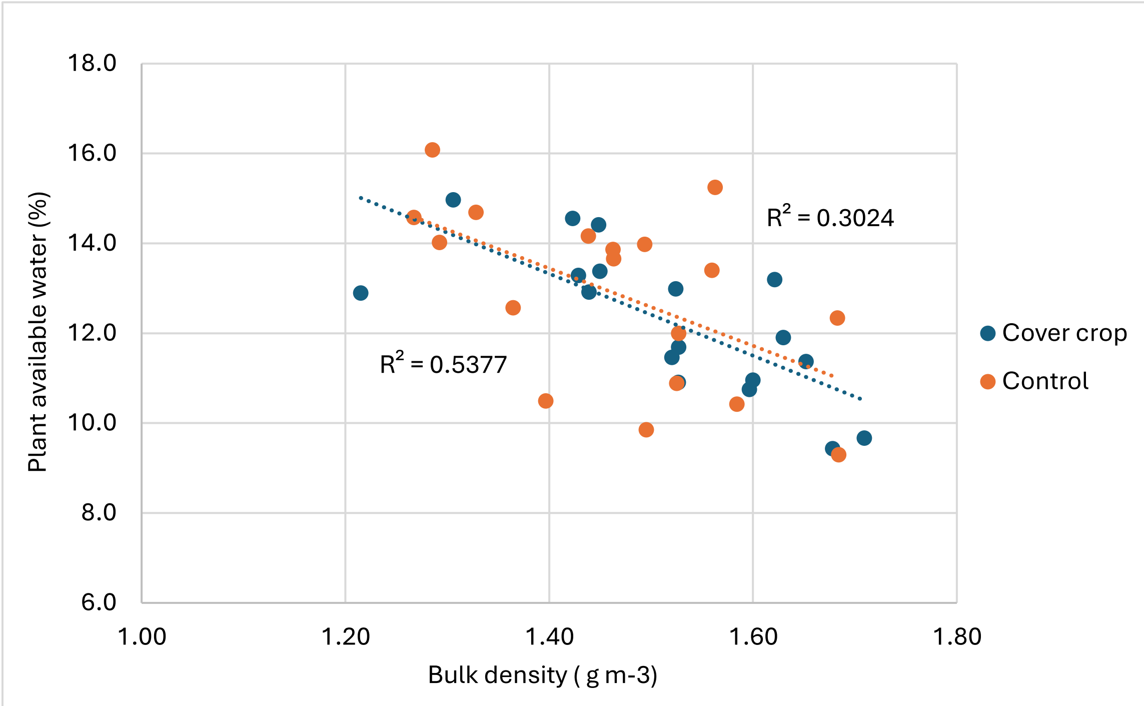

Figure 4. Relationship between plant available water (PAW) and soil bulk density for all collected samples (including both top and subsoil samples) for EOF Site 4 cover crops and control fields.

Soil Health Site 20

The PWP results from Soil Health Site 20 were intriguing. On the lower slope, the cover crop plus organic amendment field showed higher PAW than the control field (**Figure 5**). However, this difference diminished with changes in landscape position, where both site soils exhibited similar PAW . At the upslope, both topsoil and subsoil of the control field had higher PAW than the treatment field. When comparing the bulk densities of the lower slope between the two strips, the topsoil showed no significant difference. However, the bulk density of the subsoil in the control field (1.83 g/cm^3) was higher than in the treatment field (1.68 g/cm^3). Conversely, at the upper slope, both topsoil and subsoil bulk densities of the control field were lower (1.46 and 1.52 g/cm^3, respectively) than those of the treatment field (1.61 and 1.76 g/cm^3).

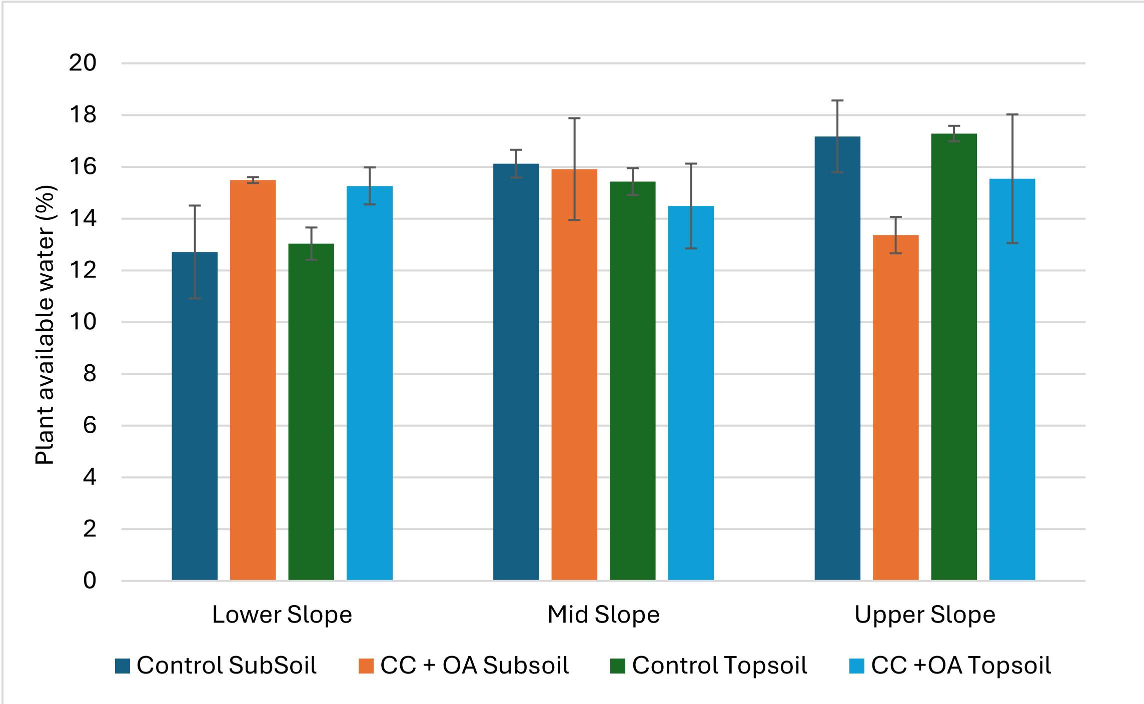

Figure 5. Plant-available water (%) for the cover crop + organic amendment (cc +oa) and the control field at the Soil Health Site 20. Error bars represent ± one standard deviation.

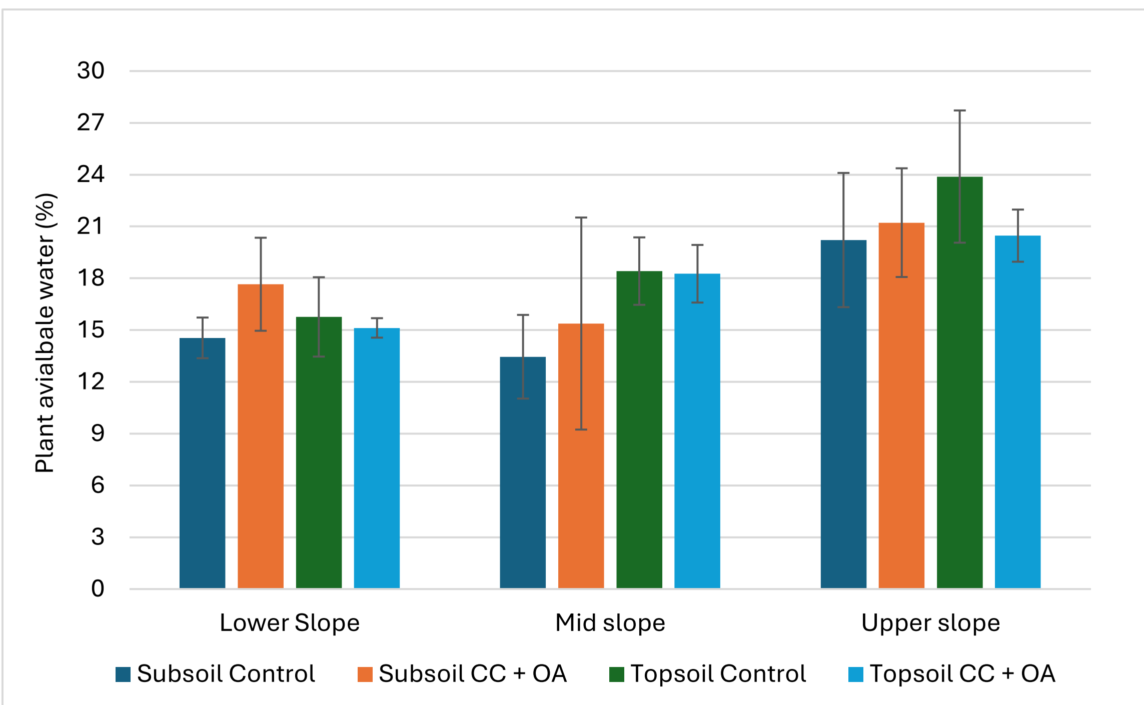

Figure 6. Plant-available water (%) for the cover crop + organic amendment (cc +oa) and the control field at the Soil Health Site 20. Error bars represent ± one standard deviation.

Soil Health Site 3

A gradual rise in PAW was observed in both the treatment and control fields at Soil Health Site 3 (**Figure 6**). However, a closer look uncovered an interesting detail. In fact, the lower slopes of both fields exhibited greater field capacity than the mid and upper slopes. Nonetheless, this does not lead to a higher PAW, as the PWP was also greater on the lower slopes (data not shown).

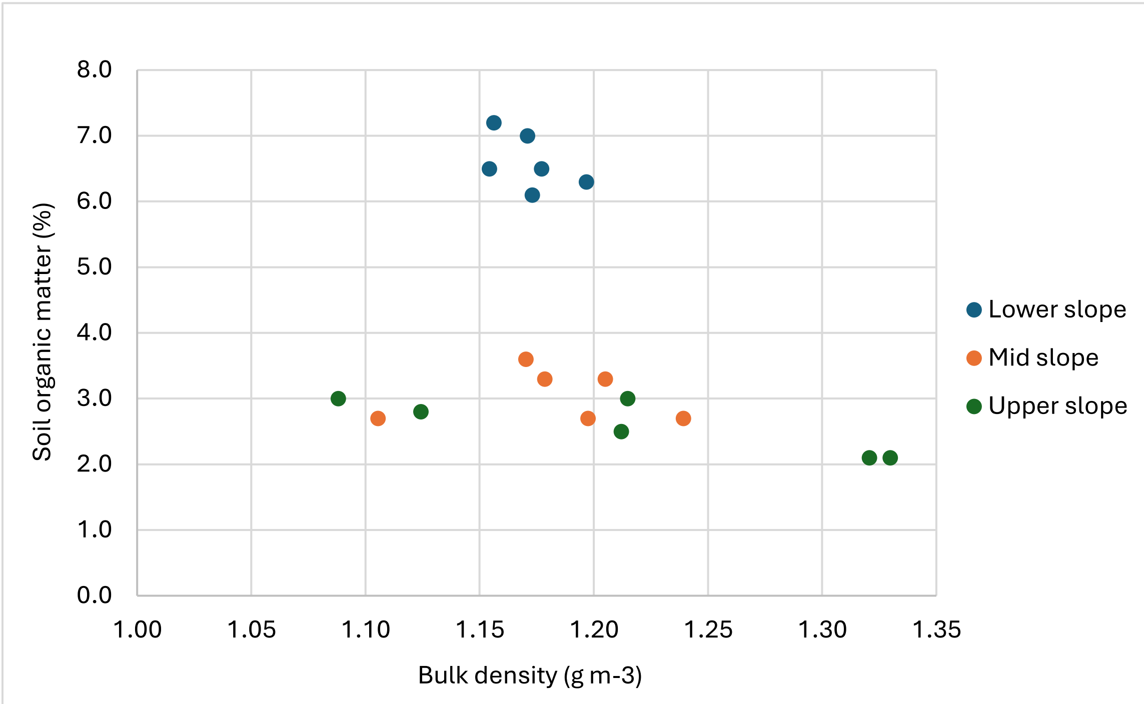

Figure 7. Relationship between bulk density and soil organic matter at Soil Health Site 3.

The ONFARM Soil Health data collected earlier in 2024 revealed a significant accumulation of soil organic matter on the lower slopes of both the treatment and control fields compared with the mid and upper slopes (**Figure 7**). This unusual accumulation of organic matter in a field with sandy soils warrants further investigation. Although this increase in organic matter did not increase PAW, as one might expect, it led to significant increases in other soil health properties, such as aggregate stability.

Conclusions and Future Directions

The results of the 2024 water retention analysis showed no substantial differences in water retention properties between treatment and control plots across the three sampled fields. This first round of sampling was indeed conducted to understand baseline soil water retention properties prior to a three-year crop rotation, and all these locations will be sampled again in the fall of 2027 to assess the impact of BMPs on soil water retention. Regardless, the results from this baseline sampling also underscore the importance of soil physical (e.g., bulk density) and chemical (e.g., soil organic matter) properties, as well as soil type and landscape position, in determining soil water retention.

The Sustainable Canadian Agricultural Partnership (Sustainable CAP) is a 5-year (2023-2028), $3.5-billion investment by federal-provincial and territorial governments to strengthen competitiveness, innovation, and resiliency of Canada's agriculture, agri-food and agri-based products sector. This includes $1 billion in federal programs and activities and a $2.5 billion commitment that is cost-shared 60% federally and 40% provincially/territorially for programs that are designed and delivered by the provinces and territories.