Rodale Institute
2021 – Final Report for the PA Vegetable Marketing and Research Program

Title Project Title: Impact of Management Practices on Soil Health Indicators in Conventional and Organic Vegetable Cropping Systems (Year 2)

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Introduction:

Tillage as well as cropping systems influence soil health physical, chemical, and biological properties. While total soil organic carbon (SOC) and organic matter are considered long-term soil health indicators, active soil organic carbon fraction (POX-C), macro and micro minerals, and proteins are early and sensitive indicators to management practices. Similarly, biological indicators such as microbial bacterial and fungal biomass are dynamic and change with management practices and environmental factors.

We are reporting here on the second-year results of assessing soil health indicators in samples collected in the long-term Vegetable Systems Trial (VST) at Rodale Institute in fall 2021. The objective of the project is to assess and document the impact of management practices (tillage versus reduced tillage) implemented for vegetable production in organic and conventional systems on soil health indictors at two soil depths. The results from 2021 soil sampling showed that SOC was greatest in reduced tillage plots when managed organically in the top 0-10 cm soil layer and did not differ at deeper depth. The POX-C and soil protein levels were greatest in organically managed reduced tillage plots. Unlike 2020 data, microbial biomass increased two-fold in 2021 and across systems. Bacterial and fungal biomass were slightly greater in the top 0- 10cm than in the 10-20cm. These results provide evidence that while some soil health indicators may not vary as fast as bulk density, dynamic microbial soil health indicators vary with time and crop rotation in the tested management practices.

Materials and Methods

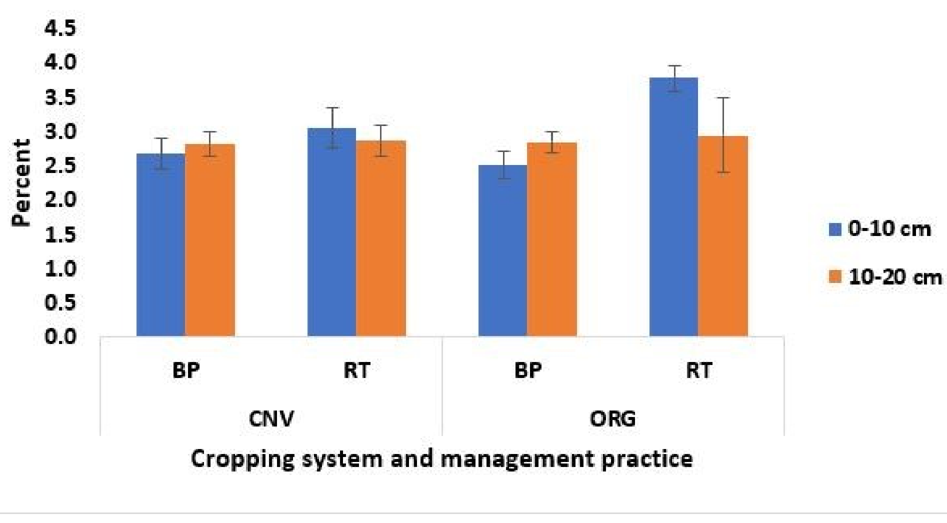
Deep soil sampling in Vegetable Systems Trial (VST) at Rodale Institute occurred on time in the fall of 2021. Soil samples were collected from organic and conventional systems as well as in till with black plastic mulch (BP) and reduced till (RT) plots. Soil samples were collected at two depths (0-10cm and 10-20 cm) as well as at 20-30 cm (deeper depth supported by other grant) using deep soil core equipment. Four tubes of soil cores were collected per plot. Soils were transported to the laboratory at Rodale Institute for immediate processing. Soils from every three cores per depth were composited for determining chemical and biological properties and the fourth core was used to determine bulk density. For chemical properties, soils were laid out on trays and air-dried, sifted through 2.0mm sieve, subsampled and sent to Ohio State University Soils Laboratory in December 2021. For biological properties (bacterial and fungal biomass), soil samples were immediately processed and placed in Ziploc bags and placed in a freezer at -20 C and shipped overnight to Wards Laboratory in January 2022 for analysis. For other biological properties (OM, POXC, and proteins), soil samples were dry sifted and sent to Ohio State University Soils Laboratory in December 2021 for analysis. Soil samples were assessed for chemical properties including %C, %N, P, K, Mg, Ca, S, and micronutrients (Fe, B, Zn, and Cu). Biological indicators were determined by assessing soil samples at each depth for %OM, labile reactive organic carbon (POX-C), proteins, microbial bacterial and fungal biomass. Bulk density was determined by dividing the mass by volume at each depth. The compiled data were analyzed for statistical significance and documented below.

Results

Objectives 1: Assess the physical and chemical properties in soil samples taken in 48 plots at the 0–4-inch (0- 10 cm) depth, and 4–8-inch (10-20cm) depth in VST.

Our 2021 research data showed that soil percent carbon was greatest (averaging 3.77%) under organic reduced tillage practice (RT) at 0-10 cm soil depth in the VST (Figure 1). Percent carbon in organic RT was significantly greater than both of BP and RT levels of the conventional system (averaging 2.74% and 2.95%). There was no significant difference between till with plastic mulch (BP) and RT in conventional system as well as with BP in organic at 0-10 and 10-20 cm. Overall soil percent nitrogen did not differ between organic and conventional system as well as with management practices and soil depth, averaging 0.33%. Similarly for soil phosphorus (averaging 184ppm), potassium (averaging 99ppm), and calcium (averaging 1457ppm) levels. However, soil magnesium and sulfur levels were greater in the organic system (averaging 160ppm, 16.54ppm, respectively) than those in the conventional (averaging 128ppm, 9.50ppm, respectively). Only soil magnesium was significantly greater in the BP plots (averaging 150ppm) than in RT plots (averaging 137ppm). At the 0-20 cm depth these mineral nutrients did not differ. However, these levels were significantly greater than those at deeper depth 20-30cm (matching funds).

Figure 1. Variation in soil percent carbon (%) in till and reduced-till plots under conventional and organic systems in VST, 2021

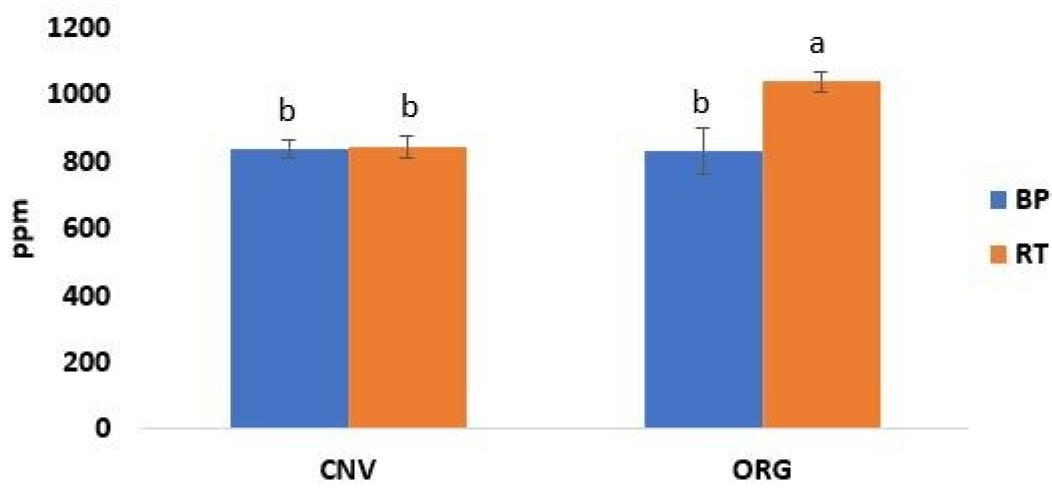


Soil bulk density did not differ with cropping system, management practice and depth, averaging 0.99 g/cm^3 with 0.24% soil moisture content. The 2021 bulk density value was lower than that of 2020 (1.08 g/cm^3).

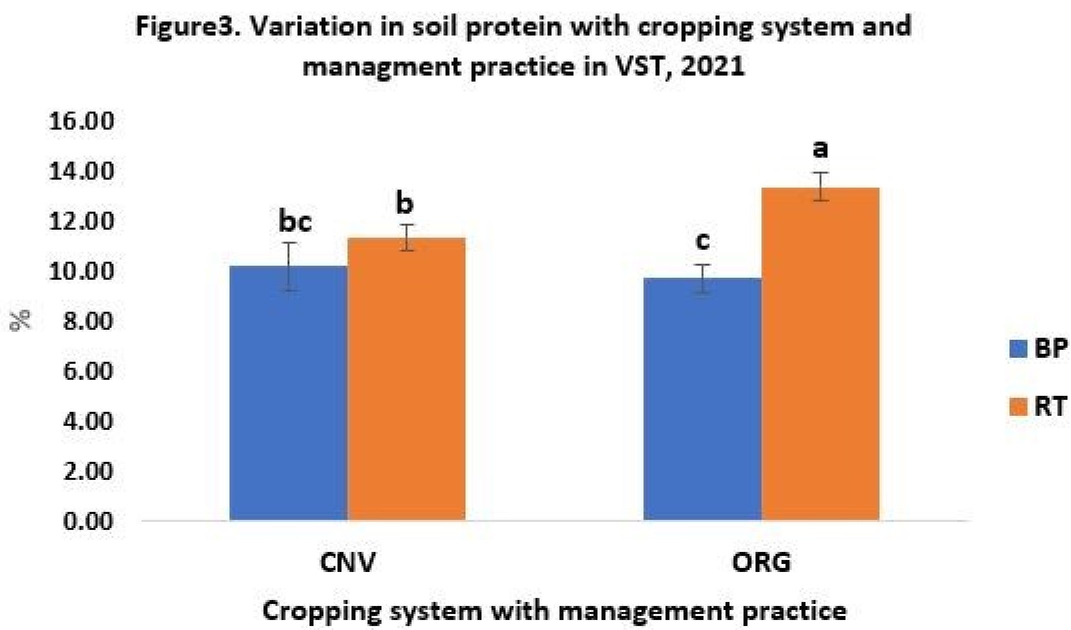
Objective 2: Assess selected biological properties in soil samples taken from 0–4-inch (0-10 cm) depth and 4–8-inch (10-20 cm) depth in VST.

In 2021, we assessed soil biological properties including soil organic matter (%SOM), labile reactive organic carbon (POX-C), protein, and microbial biomass (bacterial and fungal). Soil organic matter is an important soil biological property commonly used by growers to assess their soil health. In this study, the soil organic matter did not differ across cropping systems, management practices and soil depth, averaging 2.53%. The labile (active) organic carbon pool is the pool that feeds the soil microbes and source of rapidly degraded and cycled nutrients. This pool is referred to as POX-C. Oure data shows that levels of POX-C were greater in organic (Averaging 930ppm) but not significantly different conventional (averaging 844ppm). However, these differences were more pronounced with management practices within the organic system (Figure 2) at 0-10 cm soil depth and no difference in the conventional. The active labile organic carbon did not differ in the 0-20cm.

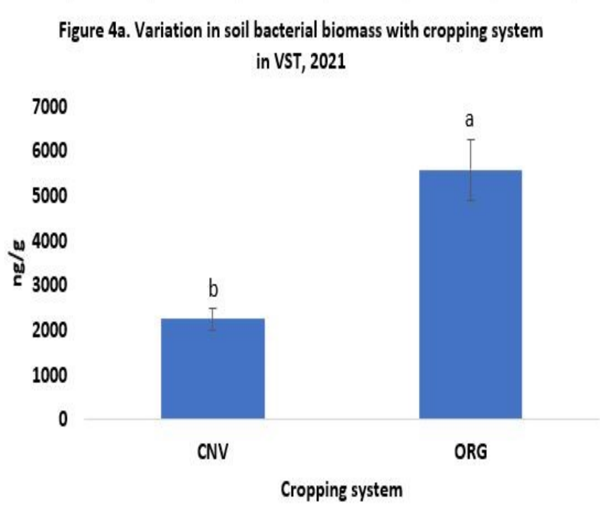
Figure 2. Variation in soil labile organic carbon (POX-C) with cropping system and management practice in VST, 2021

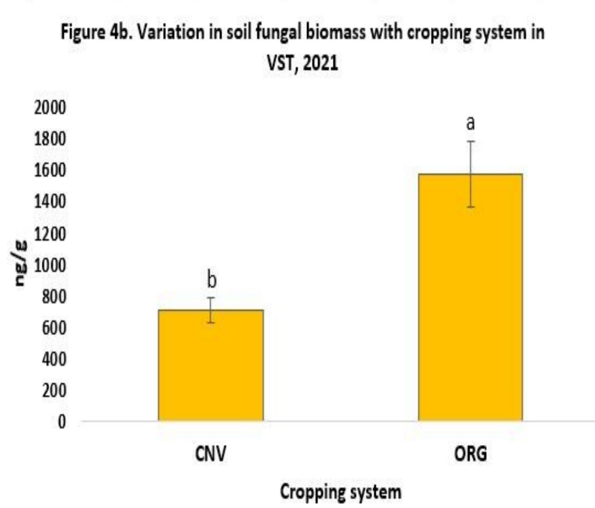


The soil protein, organically bound N did not differ with cropping system, practice, or depth, similarly to N levels as stated above. However, there was a significant interaction of cropping system and management practice effects on soil protein level (Figure 3). The greatest protein level was in soil that was managed with reduced tillage in the organic system followed by the conventional system. A grower could reap the benefit of managing their soil with minimal tillage and can be more pronounced when cropped organically as shown in Figure 3.



Unlike 2020 data, we found that microbial biomass had increased and was more pronounced over time and across cropping systems. Soil bacterial biomass and fungal biomass were 2x greater in the organic system than in the conventional (Figures 4a and 4b). Soil bacterial and fungal biomass were slightly greater in the RT than in the BP and did not differ significantly with the management practice. Both bacterial and fungal biomass were slightly greater in the top 10 cm than in the 10-20 cm. These soil health indicators provide evidence on the system, practice and the depth that favor greater microbial biomass.





Objective 3: Disseminate the results to growers during the annual field day and in a web-article discussing the influence of management practices on selected soil health indicators.

Due to delays in receiving the results, we will share the 2021 VST soil results with growers during the upcoming Rodale Institute's field day on July 22, 2022, as well as in a web article. We would like to include web article in the quarterly PVGA newsletter as we did last year, when invited.

Impacts:

The results from years 1 and 2 will be integral addition to those we will receive in 2023 and the compiled information will expand our scientific knowledge on the impact of management practices on soil health indicators in conventional and organic systems. Such information will be shared and become a guidance for all vegetable growers on practices and systems that conserve soil health and which indicators are important to measure or determine as well as which depth of sampling to reap significant results in managing their lands and production systems.

Challenges:

Due to COVID extended Backlogs at the external laboratories, we were challenged with delays in receipt of sample results and conducting statistical analysis and reporting by April 1st. In this document we are reporting on results received and sent by May 1st, 2022.

Outreach and training/education

Two interns and two technicians were trained on soil sampling in the field, cutting soil cores and processing samples for various laboratory analyses. Outreach is discussed under objective 3.