The Ohio State University Water Quality Team

Characterizing Soil Health in the Western Lake Erie Basin: A Multi-Year Regional Assessment

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Introduction

Soil health has continued to be an emerging focus of agricultural producers in recent years and is only gaining in popularity as farmers face increasingly variable weather patterns, herbicide resistance, and falling crop prices. A healthy, functioning soil is better able to hold onto water during excessive dry periods, absorb excess water during periods of high rainfall, cycle nutrients from the soil to address crop needs, and improve soil biodiversity. A healthy soil leads to a healthier plant, which may require fewer inputs and better withstand extreme weather events like the droughts that Ohio has seen the previous two summers of 2024 and 2025.

There are many metrics that can measure parameters of soil health, including Permanganate Oxidizable Carbon (POxC), respiration, and wet aggregate stability. All paint a different picture of how a particular soil functions. POxC, a test that measures readily available carbon in the soil, known as active carbon, indicates a food source in the soil for microbiology. [3] Soil respiration, which measures the CO_2 output, or burst, from the soil, indicates how quickly the soil food web can be revived and become active again after being in a simulated resting state.[2] Wet aggregate stability can serve as an early indicator of soil degradation by measuring the ability of a soil to resist breaking apart after being dried and re-wetted. Poor aggregate stability in a soil can indicate a soil is more apt to erode and may have decreased infiltration capability. [1] If producers understand where their soil fits into a wider picture, such as understanding how other soils across the state compare, it can help them work towards healthier soils on their farms and measure progress over time.

Objective

The objective of this study was to understand how past field management practices may influence laboratory soil health values and soil properties. Statewide-collected soil samples from 2020 through 2024 were utilized to determine what soil health looks like across the Western Lake Erie Basin for regional producers to compare their fields to an existing dataset.

Image 1. Soil cores are collected from a corn field after harvest. This sample will be homogenized and submitted to a soil laboratory for analysis.

Methods

Soil Sampling

This data set focused only on the fields sampled for this project by the OSU Water Quality Team and located in the Western Lake Erie Basin of Northwest Ohio. Each field had 15-20 soil cores collected in a whole-field sample at a depth of 8 inches. Soil cores were homogenized in the field, bagged, and analyzed at Spectrum Laboratories in 2020 and 2021 and at Brookside Laboratories in 2022-2024. Routine soil nutrient analyses were performed along with several soil health properties, including POxC, respiration, and wet aggregate stability.

Relationships were identified and further classified based on management history, which was collected from study participants before sample collection. Field management history questionnaires included information about the number of years the field was in no-till, the use of cover crops, the manure application history, as well as average cash crop yields. Cash crop average yields were only collected in 2022 and 2023.

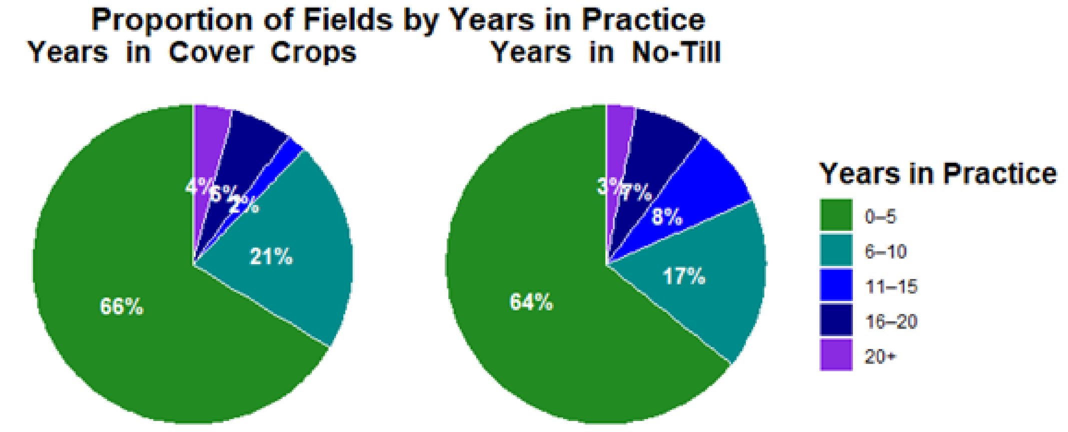
Data Analysis

The lab analysis results were compiled and analyzed using the R software program to determine the relationships between different observed parameters. All visuals were also created in R. The packages tidyverse, dbplyr, readxl, ggmisc, scales, and ggrepel were used in analysis and visual creation.

Results

Years in Cover Crops and No-Till

The management histories of the fields were analyzed and compiled into Figures 1A and 1B, showing 66% of fields sampled had utilized cover crops for 5 years or less. This group also included fields that had never used cover crops. 21% of fields had utilized cover crops for 6-10 years, 2% for 11-15 years, 6% 16-20 years, and 4% for 20 years or longer. The prevalence of no-till in the sampled fields followed a similar distribution, with 64% of fields having used no-till for 5 years or less, 17% for 6-10 years, 8% 11-15 years, 7% 16-20 years, and only 3% for 20 years or longer. Of the sampled fields, only 34% of fields had been cover cropped for longer than 5 years, and 36% had utilized no-till for over 5 years.



Figures 1A and 1B. Proportion of Fields Sampled by Number of Years in Cover Crops and No-Till, respectively.

Results Continued

Field Metrics by Years in No-Till

In Figures 2 and 3, the groups of 16-20 and 20+ years were combined for this analysis, due to small sample size in the two groups. The mean values of each data set are notated by a red dot within the box plot. No clear relationship was observed between any of the measured parameters and years of no-till (Figure 2).

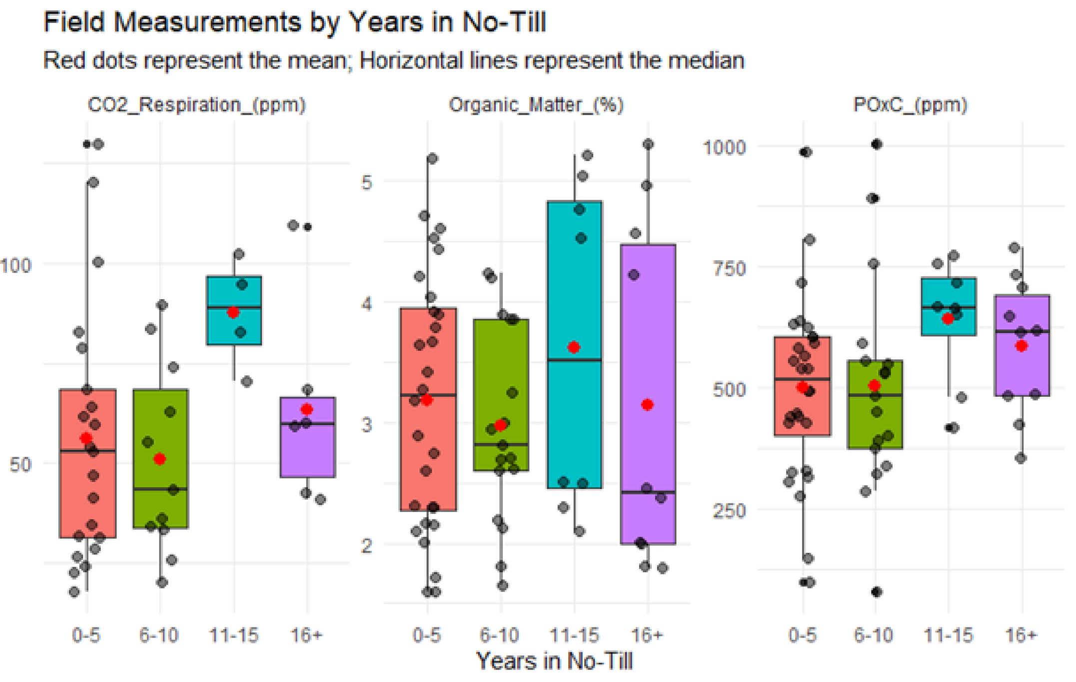


Figure 2. CO_2 Respiration, Organic Matter, and POxC measurements by years of no-till.

Field Metrics by Years in Cover Crops

A positive upward trend can be seen in all soil parameters as years of cover crops increase (Figure 3). Due to small sample size in the 11-15 year range, those groups act as outliers in this trend. A larger sample size of cover crop use above 10 years is needed to further analyze this upward trend in the data.

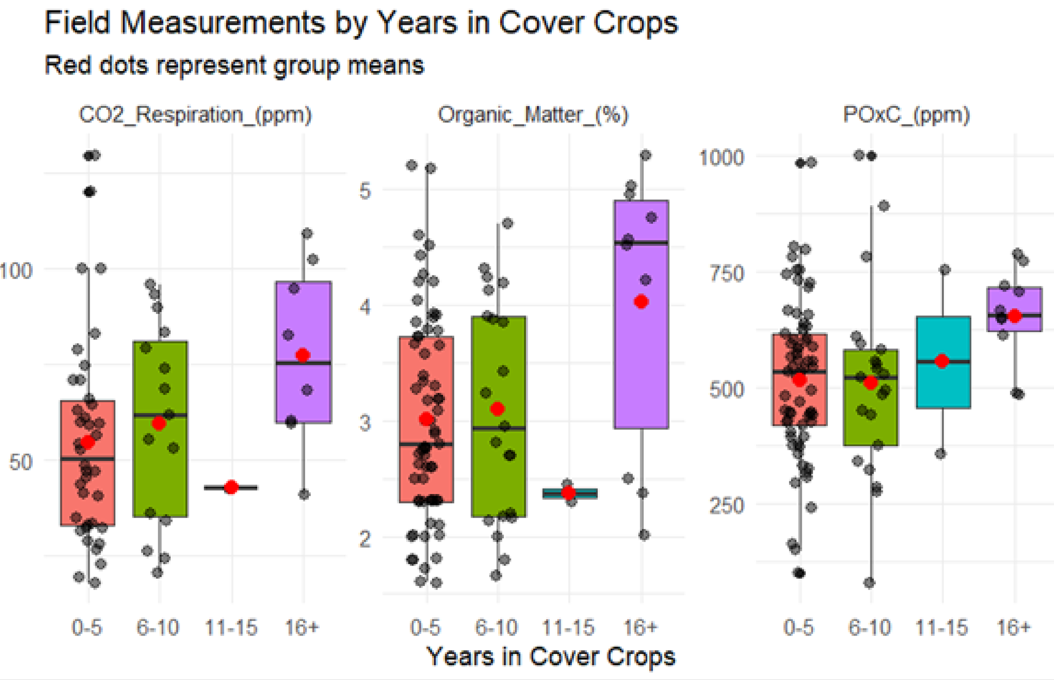


Figure 3. CO_2 Respiration, Organic Matter, and POxC measurements by years of cover crops.

Conclusion

Most fields sampled for this project were either not utilizing cover crops and no-till (66% and 64%, respectively) at all or had been utilizing them for less than 5 years. This could potentially cause a shift in some of the data measured if further research focuses on fields that have been utilizing these two conservation practices for longer than 5 years. More work is needed to identify the relationship between field management history and soil biology, which rely on POxC and are measured by respiration. POxC is a biological indicator, not a storage indicator, as this carbon source is actively changing forms, decomposing, and cycling nutrients in the soil. CO_2 respiration is a measure of biological activity, whereas POxC measures the fraction of soil carbon that feeds that biological activity in the soil.

Scarcity of fields with long-term conservation practice use in this study could be the reason there was no observed relationship between the mean CO_2 respiration, POxC, or % organic matter when field measurements were analyzed by the number of years that field was in no-till. Or perhaps, the use of no-till alone does not improve these three parameters of soil health.

The number of years in cover crops did illustrate a relationship of those same three parameters; CO_2 respiration increased by almost 25% when comparing the 0–5-year and 16+ year datasets, % organic matter increased on average by 100%, and POxC by approximately 25% as well over the same comparison. This data supports the claim from many cover crop growers that most benefits are seen after the building/establishment process, which can last anywhere from 5 to 10 years after starting to incorporate cover crops into an operation.

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