OFRF Final Report – August 16, 2018

Title:	Evaluating Soil Protein as a New Soil Health Indicator
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Background

Predicting the capacity of soil to supply nitrogen is an ongoing challenge in organic farming. Simple and affordable soil tests that can predict organic nutrient release are of particular interest for organic farmers, because organic farming exclusively relies on this microbially-driven process for crop nutrition. Emerging soil health measurements can shed insight into organic nutrient mineralization, offering organic farmers a better nutrient management tool.

Of the compounds that constitute soil organic matter, proteins represent the largest pool of organic N in soil. Depolymerization (rate of amino acid supply), rather than the breakdown of amino acids to ammonium N, is considered to be the rate-limiting step in soil N cycling. Therefore, soil proteins measure the size of the soil N reservoir that is subsequently released through mineralization processes.

This project evaluated soil protein, a quick and emerging soil health indicator method.

The objectives of this research were to:

i. Establish the range of soil protein across a diverse set of organic farms in the Midwest and determine how management practices influence soil protein values
ii. Evaluate the relationship among the three soil health measures (soil protein, mineralizable carbon, and active carbon) and evaluate how each of these tests relate to crop productivity.

Activities and Findings

Objective 1. For this objective, we leveraged our on-going work of running free soil health tests for organic farmers in Ohio and surrounding states. We had initially run soil health tests which included active carbon (POXC, permanganate oxidizable carbon), respiration and a routine soil test (pH, organic matter, Mehlich-3 extractable P, K, Ca, Mg, S and micronutrients). We since took these archived soils and ran soil protein on all available soils. We ran a total of 780 soil samples, from approximately 200 different farmers. These farmers ranged from large scale

producers (>1,000 acres) to small scale producers (<5 acres) growing crops ranging from field crops, vegetables, fruits and livestock and dairy. The majority of farmers were located in Ohio (>80%) and most of these growers were either certified organic or non-certified but implementing many organic practices.

We have compiled all of this information and now have good distributions of soil protein (and active C and respiration) across Ohio and eastern Midwest farms. This is an important first step in interpreting the results of soil health analyses. It enables us to make inferences about if a soil we analyze has a soil protein value that is "low", "medium", "high" or "very high". We classified soils into the above categories based on the <25th, 25-50th, 50-75th, >75th percentiles, respectively. Across all soils, soil protein averaged 5.38 g per kg of soil, with a range of 0.75 – 20.87 g kg^{-1} (Table 1).

Table 1. Summary statistics for soil health indicators evaluated.

	Soil Protein (g kg^{-1})	POXC (Active C, mg kg^{-1})	Respiration (mg kg^{-1})	LOI (Total Organic Matter, %)
Low	< 4.2	< 385.9	<28.0	< 1.4
Medium	4.2 – 4.8	385.9 – 479.9	28.0 – 39.4	1.4 – 1.8
Good	4.8 – 5.8	479.9 – 593.9	39.4 – 53.1	1.8 – 2.3
Very good	> 5.8	> 593.9	>53.1	> 2.3

We are now able to not only provide a number to farmers, but actually provide context to how their soils might stack up to soils on other farms. We have heard feedback that this is very helpful and appreciated information.

For all soil samples, we collected detailed management information from growers on how these soils have been managed over the past several years. This survey asked questions about crop rotation, tillage practices, manure and amendment applications, other soil fertility amendments, etc. The management survey is supplied as an attachment here for more information. We are currently in the process of analyzing these relationships to determine which management practices influence soil health indicators across these farms. This information should provide insight into how management impacts measured soil C and N pools and microbial activity.

Objective 2. We evaluated the relationships of soil protein with the other soil health indicators in this study (POXC, Respiration and Total Organic Matter). Graphed relationships show these indicators are related, but have a large amount of unexplained variation between them (Figure 1). Soil protein correlation coefficients were as follows: POXC = 0.50; Respiration = 0.34; LOI = 0.35. This suggests these indicators reflect unique processes and do not simply provide redundant information.

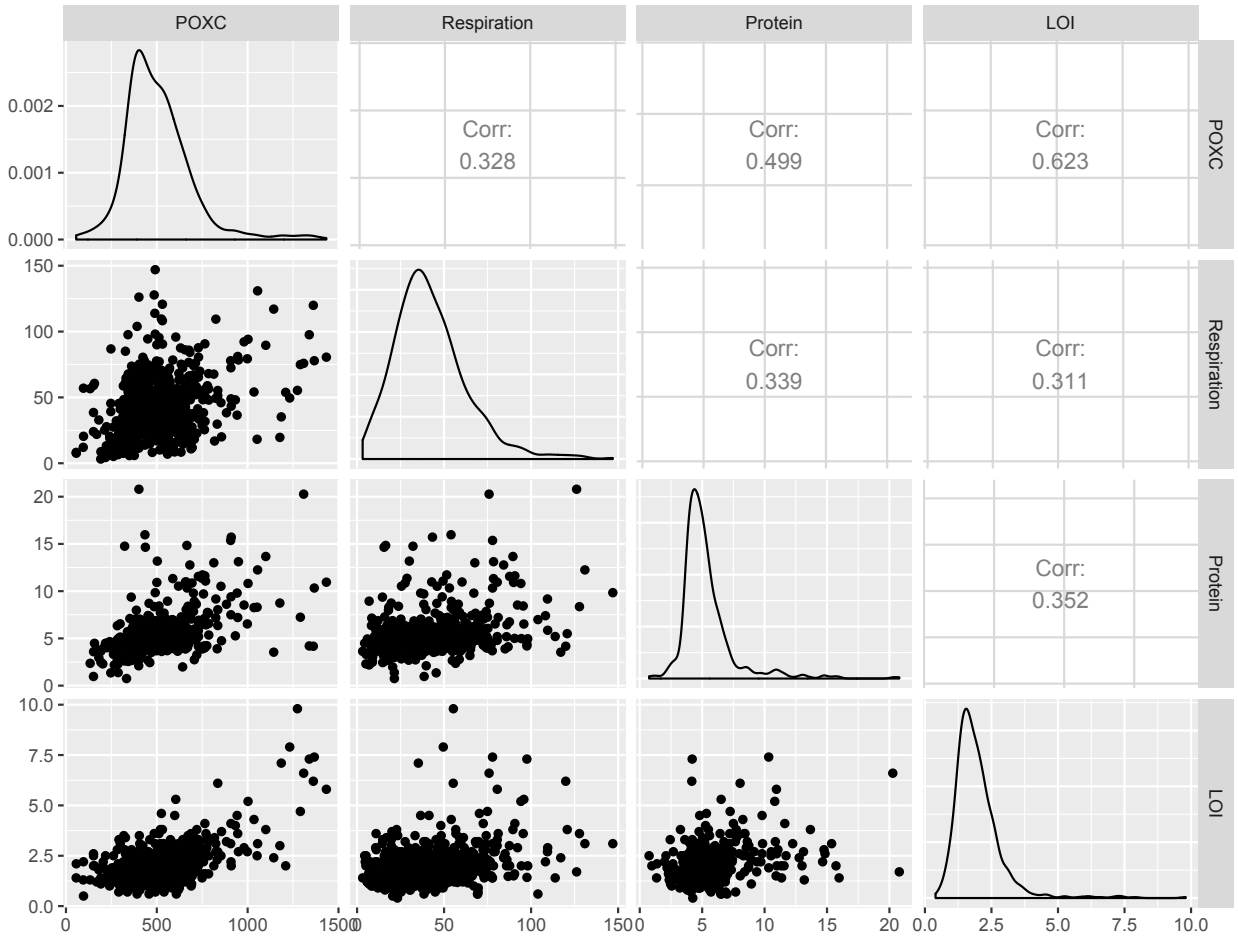

Figure 1. Relationships between Active C (POXC), Respiration, Soil Protein and Total Organic Matter (LOI). Lower left of matrix shows relationship between two corresponding indicators. Upper right of matrix shows correlation coefficient of corresponding indicators. Diagonal shows frequency distribution of each corresponding indicator.

Generated Outputs

We generated several outputs from this work with more in progress. One of the main outputs has been the soil health test reports to our farmer cooperators. An example report is attached below.

A second output has been the publication of a concept paper introducing soil protein as a soil health indicator. This manuscript, "Soil Protein as a Rapid Soil Health Indicator of Potentially Available Organic Nitrogen", was published in *Agricultural and Environmental Letters*, an open-access widely read paper among agricultural scientists. The article was featured in several news stories, including CSA News, Science Daily, a feature story on the Soil Science, Crop Science and Agronomy websites (https://www.soils.org/discover-soils/story/quick-soil-test-nitrogen-need).

In light of the generated interest and findings, we will continue this momentum with soil protein and work toward developing this test as a rapid and useful indicator of soil N for organic farmers. We sincerely appreciate the investment and support from the Organic Farming Research Foundation toward this shared common goal.