ONFARM Factsheet:

Measuring Improvements to Soil Health – Nitrogen-Based Indicators

ONFARM

WILTON CONSULTING GROUP

Measuring Improvements to Soil Health – Nitrogen-based Indicators

As industry knowledge of soil health continues to grow, farmers, agronomists, and researchers are studying the connections between soil health and plant-available nitrogen (N). Healthy soils support strong microbial communities that can more effectively convert tightly bound organic N that is unavailable to plants into forms that are plant available. As a result, beneficial management practices (BMPs) which improve soil health could also help to improve nutrient cycling and availability and reduce the amount of N fertilizer applied.

BMPs for improving soil health include:

- Reducing soil disturbance by reducing or modifying tillage
- Increasing field crop and cover crop species diversity
- Keeping soils covered year-round with plants and/or crop residue, while maintaining living roots in the soil for as much of the year as possible
- Amending soil with manure, biosolids and/or compost applications

Minimizing tillage can support soil health.

This corn crop was interseeded with a cover crop.

Leaving crop residue on the soil is beneficial.

This farmer applies a municipal compost on their field.

Nitrogen stored in crop residues, soil organic matter (SOM), manure, biosolids and composts is in a form that plant roots cannot take up directly. This type of N is known as organic nitrogen. Through mineralization, soil microbes convert this N into ammonium (NH_4+) and nitrate (NO_3-) that plants can take up (Figure 1). The supply of plant-available N through mineralization depends on the form and supply of organic N, and a healthy mix of soil biota. Organic N in soils is present in different forms, some of which are more easily mineralizable than others. N-based soil health indicators attempt to quantify these various forms.

Improvements in soil health are part of a longer-term journey. As part of the process, it can be helpful to conduct soil tests to determine the potential of your soil to convert organically bound N into plant-available N. This factsheet will explore three key soil tests being investigated in Ontario:

- Potentially Mineralizable Nitrogen (PMN)
- Solvita® Labile Amino-Nitrogen Test (SLAN)
- Autoclaved Citrate Extractable (ACE) Protein Index

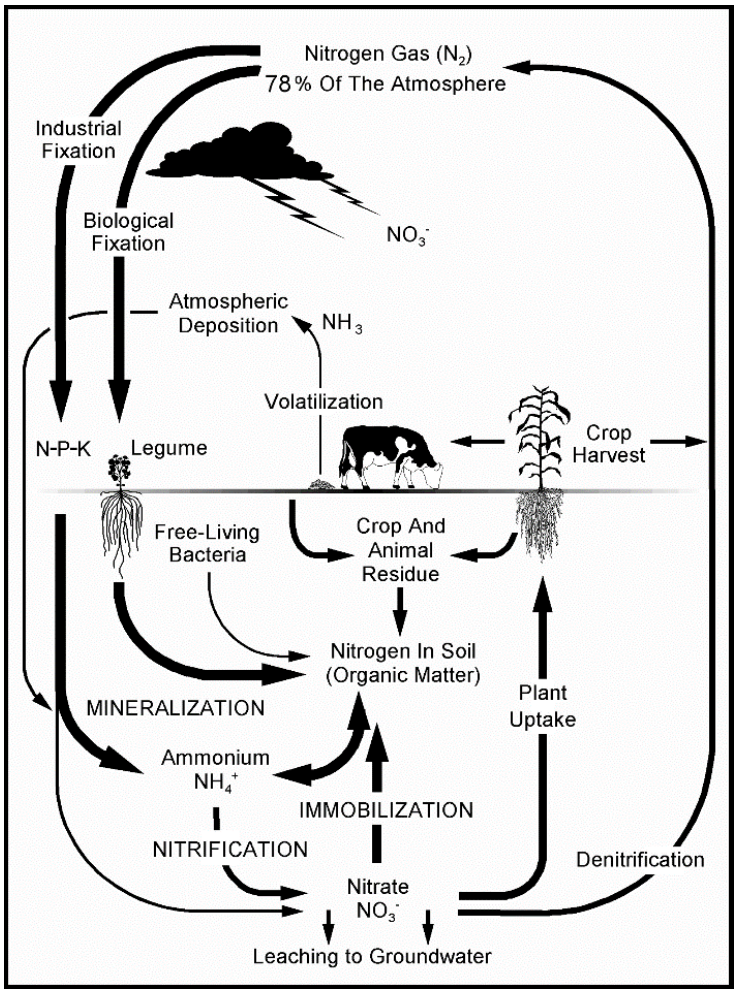

Figure 1. Nitrogen forms and pathways within an agricultural production system. Source: OMAFRA Publication 611. Soil Fertility Handbook, 3rd Edition (2018).

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What is ONFARM?

From 2019 through 2023, the On-Farm Applied Research and Monitoring (ONFARM) program completed extensive soil health and water quality analysis on 33 farm sites on representative soils and landscapes across southern Ontario. This network of sites and newly established cooperator partnerships helped to build a stronger understanding of BMPs and their effect on soil health and water quality on Ontario farmland.

ONFARM Data Collection and Analysis

- Investigations led by the Soil Resource Group (SRG) involved a range of soil health indicator tests, including gathering physical, chemical, and biological measurements
- Other baseline soil data collected included texture, horizons, drainage class, structure characterization, and soil type
- Field landscape and soil degradation assessments, agronomic monitoring, and BMP costing were also undertaken

ONFARM Data Dashboard

The ONFARM Data Dashboard has soil and BMP data from 25 ONFARM sites from 2020-22. The dashboard is interactive, and users can filter data by:

- Year
- ONFARM region
- Landscape sampling position
- BMP type
- Soil type
- ONFARM site number

Users can see the range in soil sample results across various soil health indicators, including organic matter and SLAN.

Check out the interactive ONFARM Data Dashboard to see the range in soil sample results across various soil health indicators.

Potentially Mineralizable Nitrogen

Potentially Mineralizable Nitrogen (PMN) measures the capacity of soil biota to convert N tied up in organic residues into plant-available N. Soils higher in organic matter and good populations of microbes involved in N mineralization tend to have higher rates of PMN.

SLAN

Solvita® Labile Amino-Nitrogen (SLAN) is a commercial soil test which measures the release of ammonia from a portion of organic N that is more readily available for microbial mineralization than other organic N fractions. As soil health improves, and the levels of SOM and microbial activity increases, the level of plant-available N released tends to increase. SLAN measures the N pool that is distinct from ammonium and nitrate that are measured on standard soil nutrient tests. Improvements in SLAN values indicate potential increases in plant-available N.

ACE Protein Index

The Autoclaved Citrate Extractable (ACE) Soil Protein Index measures protein-like substances that are present in soil organic matter. Soil protein content influences the ability of the soil to store N and make it available for crops during the growing season. ACE represents the amount of organically bound N in soil organic matter.

Soil protein content has also been associated with soil aggregation. Higher levels of soil protein may contribute to improved water infiltration and water storage in the soil.

ONFARM Findings

As part of the ONFARM program, PMN, SLAN, and ACE Protein tests were assessed for both the responsiveness and variability in measuring changes to soil health as a result of BMP implementation (Table 1 on page 6). Responsiveness describes how quickly the measurement responds to a change in management; a higher level of responsiveness means fewer years would be necessary to show a change in test results. Variability indicates how variable the results are at sampling locations within a field, and from year to year. An ideal test would have low variability and high responsiveness.

Changes in soil health indicators will not be linear, but “with time, and as practices get established, it is expected to see this trend of increase over time, particularly on more degraded soils,” says Don King, Principal and Research Agronomist at SRG.

Higher levels of soil protein may contribute to improved water infiltration and water storage in the soil.

Initial research shows potential for ACE to be used as a soil health indicator.

Table 1. Preliminary overview of PMN, SLAN, and ACE Protein soil tests.

Soil test	Variability (ranking from least variable [1] to most variable [3])	Time scale estimate (years)[i]	Availability	Relative cost (ranking from most affordable [1] to least affordable [3])
PMN	3	Highly dependent on production system	Limited	3
SLAN	2	5-10	• Available at labs in Ontario • In-field test kits also available	1
ACE Protein Index	1	5-10	Limited	2

While a lot of interest exists in the industry about the PMN test, the level of variability is higher than some of the other tests. The PMN test is also less readily available at Ontario soil labs, says King. From the ONFARM findings, the PMN test may not be practical for widespread use in assessing the impacts of BMPs on soil health, he adds.

Although ONFARM researchers did not conduct ACE Protein testing in the first two years of ONFARM, initial research shows potential for ACE to be used as a soil health indicator. Further research is needed to determine the responsiveness of ACE Protein testing to BMP management changes, King says.

[i] Time scale is an estimation of how long it will take for the soil health indicator to increase and stabilize with continuous BMPs.

Soil Testing Best Practices

To reduce variability and allow for the most accurate comparisons between soil health test results over time, it is recommended to take the samples:

At the same time of year (ideally select a time in early June or late September)

At the same point in the crop rotation (e.g., after wheat harvest)

From the same location in the field

Every three to five years

Ideally, the same lab should conduct the analysis each time too.

For more information on conducting your own on-farm research and the associated data collection, check out the ONFARM Research Guidebook.

If you are interested in using soil health practices to reduce N fertilizer costs, consider how to incorporate BMPs such as manure or biosolid applications and leguminous cover crops into your crop rotations.

Key Takeaways

If you are interested in using soil health practices to reduce N fertilizer costs, consider how to incorporate BMPs such as manure or biosolid applications and leguminous cover crops into your crop rotations. You can work with your Certified Crop Advisor or Professional Agrologist to determine which soil health test you can use to measure the potential of your soils to convert organically bound N to plant-available N and to develop your N fertility programs.

Follow soil testing best practices to measure changes in soil health over time.

Want to Learn More?

If you want to dive further into the world of soil health indicators and plant-available N, you can begin with a visit to the ONFARM Data Dashboard. You can also learn more about ONFARM, read the Technical Reports, and watch previous Forums. Then, consider checking out the following resources:

- Nitrogen Basics – The Nitrogen Cycle
- Long-term effects of crop rotation, tillage, and fertilizer nitrogen on soil health indicators and crop productivity in temperate climate
- Soil for Life
- The Soil Health Institute

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