Science Societies

Soil N mineralization potential: What it is and why we should measure it

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Soil organic matter and other soil properties influence the amount of nitrogen that becomes available to crops through mineralization. Measuring or estimating that contribution can help improve fertilizer recommendations. Photo by GEUS/Christian Albers.

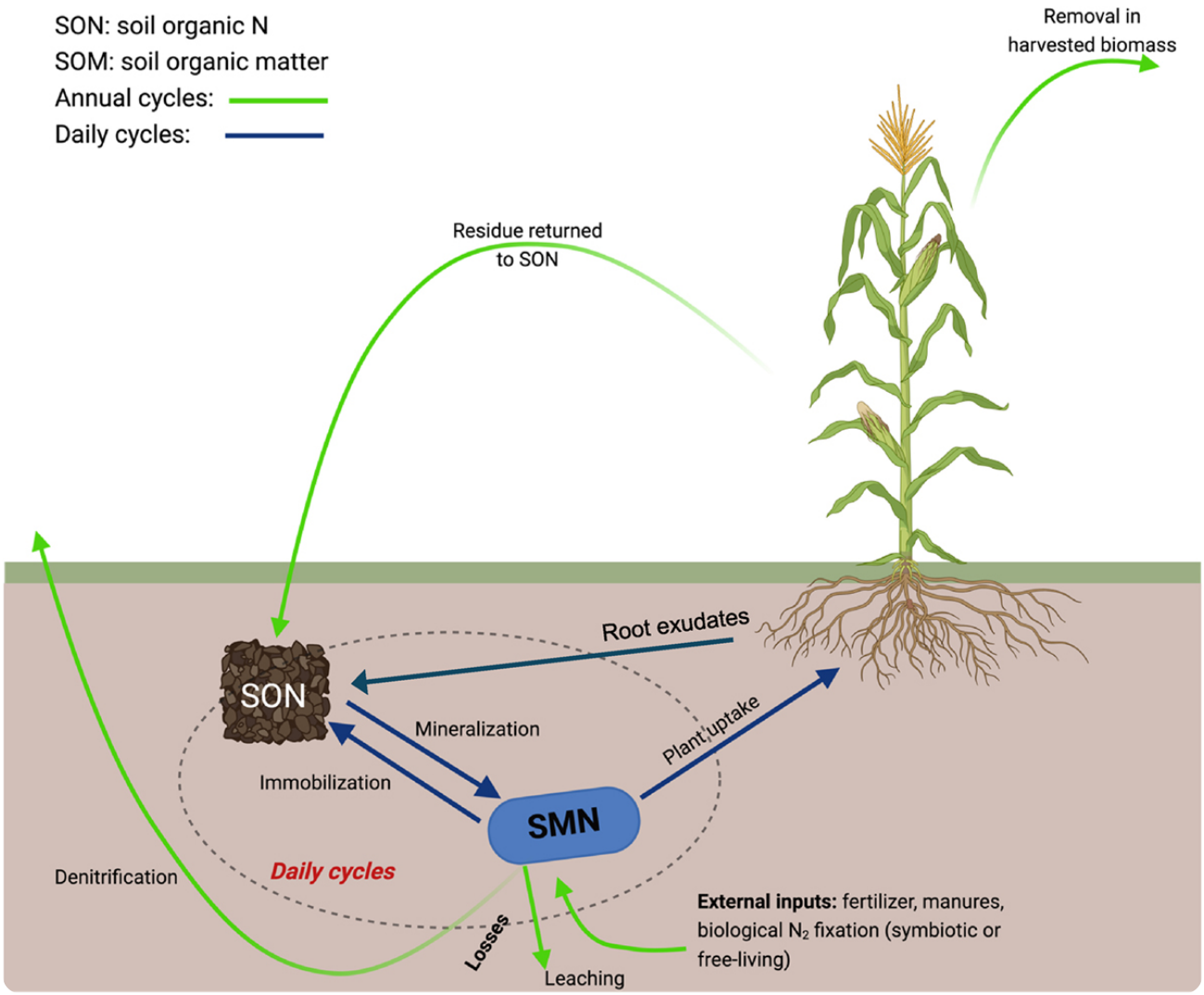
With fertilizer costs and environmental concerns on the rise, accurately accounting for soil-derived nitrogen is more important than ever. Researchers are evaluating practical ways to measure and predict soil N mineralization, helping producers and their CCAs make better-informed N management decisions.

This article focuses on Canadian research and production systems; however, the concepts and tools discussed are relevant to crop advisers throughout North America. Earn 0.5 CEUs in Nutrient Management by reading this article and taking the quiz (coming soon).

With the price of nitrogen (N) fertilizer and crop values fluctuating so dramatically, the efficient use of inputs has never been so important. The determination of the “right rate” of N fertilizer needed to maximize profit requires that we quantify all N sources, including the soil itself. The soil is one of the largest and least quantified sources of N to the crop. The mineralization of soil organic matter supplies approximately half the N the crop takes up. Soil N mineralization potential varies dramatically from field to field

depending on soil type, cropping system, and past management. If we are to improve N management to increase efficiency, control costs, and reduce environmental impacts, it is important that we have a means of routinely quantifying soil N mineralization potential and are able to use this information in the determination of the rate of supplemental N fertilizer.

We have understood the process of N mineralization and its regulation for decades. It occurs as a result of the decomposition of crop residues and soil organic matter. Net N mineralization occurs when N in those substrates is in excess of the microbial community requirements for biosynthesis. We have developed numerous methods for measuring this potential, but unfortunately no one methodology has gained broad acceptance. As a result, few commercial soil test labs in Canada offer a measure of N mineralization potential as part of their routine soil-testing package. This is unfortunate as N is one of the most expensive inputs in agriculture and use in excess of requirement has significant environmental impact.



Nitrogen transformations occur at both short (daily or seasonal) and long (annual or multi-year) scales. Understanding the soil's capacity to mineralize organic nitrogen is key to improving fertilizer recommendations and nitrogen use efficiency. Illustration reproduced from Reid et al. (2025) under license CC BY 4.0.

Measuring soil N mineralization potential

Some approaches to estimating soil N supply rely on the measurement of the nitrate content of the soil. In the Canadian Prairies, fall soil nitrate content is used as an estimate of potential N carryover to the next year's crop. In Eastern Canada, the Pre-sidedress Soil Nitrate Test (PSNT) is often used in corn production to estimate nitrate

carryover (if any), but primarily to assess early-season N mineralization. The challenge with these tests is that nitrate is a highly variable soil parameter, and its content can be altered by soil handling. Laboratory capability to support the rapid turnaround needed for the PSNT is also not present in all regions.

More direct measures of soil N mineralization potential have the advantage of estimating a process that is largely driven by soil organic matter content and therefore is more stable in time and space. This makes the measure more reliable for supplemental N fertilizer recommendations and more practical in terms of the turnaround time required for analysis. Recently, we reviewed the various approaches to measuring N mineralization potential available in Canada (Clément et al., 2025).

Of those laboratories that provide a measure of N mineralization potential, most use biologically based incubation methods, which are reliable but time-consuming and technically demanding. In comparison, chemical extraction methods and emerging techniques like near-infrared reflectance spectroscopy offer faster and simpler alternatives while maintaining meaningful relationships with plant N uptake and incubation-based measures of mineralization.

Laboratory methods for assessing soil nitrogen supply range from biologically based incubations to faster chemical and spectroscopic analyses. USACE photo by Tracy Robillard.

While no single method perfectly quantifies N mineralization, several existing approaches are accurate enough to enhance fertilizer recommendations. Indeed the

“best” measure may be regionally dependent, reflecting the soil characteristics that are regulating N mineralization potential with that region.

Concern has been expressed that reliance on N mineralization to reduce rates of supplementary N fertilizer would result in “mining” the soil and result in a decline in soil organic matter content. This issue is discussed in a second recent paper (Reid et al., 2025), which makes the case that it is carbon management and not the amount of N added to the crop that is the primary determinant of soil organic matter content. The amount of crop residue returned and degree of soil disturbance are more influential factors than the rate of N added in the spring.

Thus, consideration of growing season N mineralization in supplemental N rate decisions is about the efficient use and retention of N that will nonetheless be mineralized and the opportunity to limit the potential for N losses.

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Considering climate

How do we go from a measure of soil N mineralization potential to an estimate of net growing season N mineralization? Obviously, we do not know in advance what next year’s weather will be, and how it will influence N mineralization or crop growth for that matter. Climate normals do tell us the typical range of climatic variables such as temperature and precipitation. These “normal” conditions influence the extent to which N mineralization potential is realized, similar to how they influence crop growth potential. Often the climate conditions that limit N mineralization, such as drought, are similar to those that limit crop N demand. Thus, our

estimate of growing season N mineralization is no more suspect than is our estimate of potential yield. Both should equally influence our decision as to the need for supplemental N fertilizer. In our work, we utilize a biophysical water function (Dessureault-Rompre et al., 2011) to translate N mineralization potential into an estimate of net growing season N mineralization.

Using the data we have to get the data we want

Because so few commercial labs offer a measure of N mineralization potential, there is a need to determine whether we can get a reasonable estimate of N mineralization based on measures that are more commonly available, such as the more typical soil fertility testing suites. Pedo-transfer functions are useful in estimating N mineralization potential and growing season N mineralization from more commonly available soil fertility tests (Laurence et al., 2023). We found that in the soils of Prince Edward Island, 64% of the variation in N mineralization potential and 69% of the variation in growing season N mineralization could be explained by results of routine soil testing such as organic matter content, pH, and soil respiration.

Researchers are developing ways to use routinely collected soil-test data, including measures such as organic matter and pH, to estimate soil N mineralization potential and improve fertilizer recommendations. USDA-ARS photo by Stephen Ausmus.

As we develop these relationships for other regions in Canada, we are finding that the main parameters that govern growing season N mineralization differ, reflecting the soil, climate, and cropping systems typical of the region. In time, we are hoping to publish relationships for each region, adding estimates of growing season N mineralization to be made from the routine soil test results being conducted in the region and describing the cropping systems of that region. Direct measure of N mineralization potential remains the most reliable estimate of growing season N mineralization.

What if you have no soil test data at all?

In the age of "big data," there is a wealth of geospatial data available. Predictions of N mineralization potential and growing season N mineralization were generated for the agricultural soils of Prince Edward Island based on a provincial soil database that contained soil organic matter, pH, and cation exchange capacity (CEC) in concert with available data layers describing climate and multi-year crop cover data generated from satellite imagery (Laurence et al., 2024). Clément et al. (2025) reviews approaches to using kinetic models and pedotransfer functions to translate N mineralization potential, management, and climatic information into estimates of growing season N mineralization.

Geospatial databases, climate records, and satellite-derived crop

data can be combined to estimate soil N mineralization potential when direct soil-test measurements are unavailable. Photo courtesy of Adobe Stock/artiemedvedev.

Using these predictive tools to estimate actual net N mineralization from soil, climatic, and management data makes such estimates more accessible and therefore useful. Obviously, these indirect estimates are not as reliable as a direct measure, but they are more cost effective and thus more accessible. Accessibility has been the major bottleneck in the consideration of N mineralization in N management.

The message in the end is that we have multiple ways of measuring or estimating soil N mineralization, and these should be included in our N budgeting approach to improve the efficiency of N use in agriculture. These efforts will not only result in greater on-farm profitability, but also reduced environmental impacts. As Voltaire has said, "*Le mieux est l'ennemi du bein*"… the best is the enemy of the good. We need to put our good measures of N mineralization into practice. Delaying adoption in hope of a perfect method poses a greater risk to the sustainability of Canadian agriculture than utilizing the good tools that are available now and incorporating improvements as they arise.

Acknowledgements

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Self-study CEU quiz

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1. Approximately what proportion of crop nitrogen uptake is supplied through the mineralization of soil organic matter?

a. About 10%.

b. About 25%.

c. About 50%.

d. About 75%.

2. In the Canadian Prairies, fall soil nitrate content is commonly used to estimate:

a. Soil organic carbon sequestration.

b. Potential N carryover to the next year's crop.

c. Soil pH buffering capacity.

d. Cation exchange capacity.

3. Which test is often used in Eastern Canadian corn production to assess early-season nitrogen availability?

a. Haney Soil Health Test.

b. Mehlich-3 Test.

c. Bray P1 Test.

d. Pre-sidedress Soil Nitrate Test (PSNT).

4. According to the article, which method is most commonly used by laboratories that measure N mineralization potential?

a. Biologically based incubation methods.

b. Drone-based remote sensing.

c. Near-infrared reflectance spectroscopy.

d. Satellite-derived soil mapping.

5. A primary concern about relying on soil N mineralization to reduce fertilizer rates is that it could

a. increase soil salinity.

b. cause soil organic matter "mining."

c. raise soil pH too quickly.

d. reduce water infiltration.

This quiz was drafted with AI assistance and reviewed by the editorial team for accuracy and appropriateness.

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