Pre-sidedress Soil Nitrate Test for Corn

The Pre-sidedress Soil Nitrate Test (PSNT) for Corn is an in-season tool to assess the soil nitrogen (N) supply during the growing season and determine sidedress N application rates that optimize crop production.

This version of the PSNT is an update from the original Pennsylvania PSNT that reflects widespread use of cover crops, no-till soil management, and high corn yields in modern crop rotations. This PSNT is only used to calculate sidedress N recommendations on fields with a long-term manure application history (2 or more of the last 5 years with manure applied, not including the current year). In addition, this updated PSNT employs a new formula to calculate an economic optimum nitrogen rate.

Nitrogen and Corn Production

The total nitrogen (N) requirement for a corn crop can be supplied by a combination of organic sources and inorganic N (ammonium N and nitrate N) contained in commercial fertilizers and animal manure. Organic N originates from plant residue inputs such as terminated/harvested cover crops or previous year legumes and from manure additions. Many modern farming systems include regular manure application, cover crops, and reduced tillage which lead to accumulations of organic N. Decomposition of this organic N can release available N in the ammonium and nitrate forms, providing a resilient supply of N to crops during the growing season. However, the contributions of organic N (from manure, cover crops, legumes) are difficult to accurately predict because it is dependent on environmental factors and microbial processes. Ammonium N applied in manure is subject to volatilization losses if not incorporated into the soil with tillage, injection, or a timely rainfall. The actual manure ammonium N content applied to a field can also be uncertain due to variability in nutrient content within a manure storage. These factors lead to a great deal of uncertainty in the actual crop availability of ammonium from manure applied to a field. The in-season Pre-sidedress Soil Nitrate Test (PSNT) can provide a measurement of N supply from organic sources and recovery of manure ammonium N to assist producers in making economic and agronomic N fertilization decisions.

Managers can lower initial costs of manure or fertilizer application in the previous fall or spring by just meeting, or staying below, crop N recommendations. They can then utilize the in-season PSNT to quantify whether soil organic matter will supply enough N to achieve yield associated with optimum N rate or if additional N is required to yield the economic optimum N rate. Precise management of N optimizes nutrient costs, maximizes crop production, and minimizes environmental N loss.

Nitrogen Behavior and Soil Testing

Soil testing has been used effectively for decades to determine the availability of phosphorus (P) and potassium (K) in agricultural soils and fertilizer recommendations for these nutrients. Routine soil testing is commonly conducted outside of the growing season and does not analyze N due to the dynamic behavior of N in the soil.

As is evident in the partial N cycle diagram (Figure 1), N behavior in soil is very complex given its various forms, fates, and multiple pathways for losses. More than 98 percent is relatively unavailable because it is tied up in soil organic matter. The N in organic matter must be decomposed to mineral ammonium (\(\text{NH}_4^+\)) and then nitrate (\(\text{NO}_3^-\)) to become available to the crop. Most soil N changes are carried out by microorganisms in the soil and thus are very sensitive to rainfall, temperature, soil drainage, carbon to nitrogen ratio of an organic amendment (C:N ratio), and soil organic matter levels. Because of this sensitivity to environmental factors, changes in N availability and losses of N are generally greatest during the spring and fall — seasons when the crop is not actively taking up N. During times of low crop N uptake there is greater loss potential for nitrate through leaching and denitrification.
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This behavior has several important implications for managing N for optimum corn production and for determining availability of soil N since corn has the greatest need for N starting about 30 to 45 days after plant emergence, and this timing follows the period of greatest change in soil N availability.

Efficiency of N utilization can be improved if the N is applied after the spring wet season and near to the time of greatest need by the crop. A soil test at that time more accurately reflects the actual availability of soil N for the corn crop. Sidedressing N when the corn is 10 to 20 inches tall has been a common practice for Pennsylvania corn growers for many years.

Nitrogen Soil Test– The PSNT

The Pre-sidedress Soil Nitrate Test (PSNT) for corn is designed to measure nitrate concentration, which can serve as a proxy for the N supply from both manure and other organic N sources in the soil, and to estimate the supply of soil N that will become available to the crop over the growing season. The PSNT is sensitive to the recovery of ammonium N from manure because ammonium N will quickly convert to nitrate in the soil and be measured by the soil test.

The PSNT soil sample is collected during the growing season. The basis for this N soil testing approach is taking soil samples just before sidedressing — after the spring wet period but before the period of major N demand by corn — determining the nitrate-N available in the soil at that time. The results are then used to predict sidedress N requirements to achieve an economically optimum crop response.

PSNT utilization consists of three overarching steps:

1. Collect and prepare soil according to PSNT sampling protocols outlined here.
2. Send the soil sample for laboratory analysis.
3. Use the soil nitrate level provided by the laboratory to calculate sidedress N needs based on the formula provided in this fact sheet.

This version of the PSNT has been updated from the original Pennsylvania PSNT to reflect widespread use of cover crops, no-till soil management, and high corn yields in modern crop rotations. The PSNT is only used to calculate sidedress N recommendations on fields with a long-term manure application history (2 or more of the last 5 years with manure applied, not including the current year).

Nitrogen Management with the PSNT

- Apply only a minimum of fertilizer N in the spring (<50 lbs N/ac as starter fertilizer and/or N used as an herbicide carrier).
- Use a Nutrient Balance Sheet (NBS) or Nutrient Management Plan (NMP) to determine the crop N requirement and calculate manure application rates that do not exceed the N balance based on the manure N content and planned application method. These management plans are available as paper templates or as electronic forms that perform calculations based on your entered cropping information such as expected corn yield (bushels per acre for grain or tons per acre for silage), manure application history, manure application techniques, field crop rotation history, and additional N fertilizers applied. These planning tools can be found on the Pennsylvania Nutrient Management Program website.

Soil Sampling Protocols

- Pay close attention to details to assure accuracy. The largest errors in soil analysis originate from mistakes made during sampling.
- Avoid sampling immediately after a rain event since water infiltration can move nitrate below the PSNT sampling depth.
- Take soil samples for the PSNT when the corn is 12 inches tall or at least a week before planned sidedressing.
- All soil cores should be collected to a depth of 12 inches. If that depth is not possible, sample as deeply as you can (Figure 2).
Collecting soil samples in fields without banded manure or nutrients.

- Sample the fields by taking 10 to 20 cores at random locations (Figure 3) to the 12-inch depth.
- Avoid starter bands and other atypical areas.
- Composite the samples and follow the sample preparation recommendations below.

Collecting soil samples in fields with injected manure or banded nutrients.

- Manure injection and banding of nutrients causes patterned nutrient variation across the soil.
- To sample soil in these fields the exact location of the band does not need to be known but the direction of travel during injection or banded fertilizer application must be known.
- Soil sampling where nutrients are banded is done by collecting a set of 5 soil cores that are equally spaced from each other in an orientation perpendicular to the nutrient band (Figure 3). Collection of the 5-core equispaced sets is repeated at four locations in the field.
- To determine the specific 5-core equispacing for distance between soil cores for the field, take the distance between band locations and divide by 5. For example, if manure injection bands are 30 inches apart then collect 5 soil cores that are 6 inches apart (30 inches / 5 cores = 6 inches between cores).
- The adjacent set of soil cores must be collected perpendicular to the direction in which the manure or fertilizer band was applied, but the exact location of the band does not need to be known because one of the soil samples will be close to the band (one sample would be within 3 inches of the center of the manure band in the 30-inch spacing above), as illustrated in Figure 3.
- The set of five adjacent cores are collected at 4 random locations in the field, for a total of 20 soil cores. The 20 cores are composited and prepared for laboratory analysis as outlined below.

Preparing Soil Samples for Laboratory Analysis

- Composite all the collected soil cores into a single bucket or container.
- Crumble soil cores and break up large aggregates. Discard rocks. Discard visible organic matter such as a piece of a root.
- Thoroughly mix the remaining soil.
- Collect a single subsample from the composited cores for laboratory analysis. Keep careful track of which samples are from which fields.
- Use the volume of soil recommended by the laboratory that the soil will be shipped to. If the volume is not indicated, a cup of soil is a sufficient volume to send.
- To prevent nitrogen mineralization, it’s important to dry samples promptly. Spread the sample thinly and dry it (sun, heat lamp, air dried or under a fan) immediately
after collection and ship to the laboratory as soon as possible. If shipping is delayed refrigerate the samples to impede microbial N transformations and assure test results best reflect field conditions.

- Pack the composited subsample into packaging provided by the laboratory. Be sure to take the time to thoroughly complete all requested information that the laboratory requests on their submission forms. Be sure to carefully label samples and paperwork consistently.

- If soil samples will be delivered to a lab in-person within a day of sampling, the soils can be maintained moist, but under refrigeration, such as in a cooler with icepacks. When dropping off fresh soil samples at a lab for nitrate analysis, make the lab aware the samples are for nitrate analysis so that they immediately dry the soil or keep it under refrigeration until drying is possible.

- Send or deliver the sample to a reputable soil-testing lab for soil nitrate-N analysis.

**Interpretation of Results and Calculation of Sidedress Amounts**

- Use the laboratory test results for nitrate to calculate the N sidedress recommendation using the formula below. Use a realistic corn yield goal for the field in the current year, entered in bushels per acre.

### Economic Optimum N Rate (EONR)

\[
EONR = 0.72 \times \text{Corn Yield Goal in bushels/acre} \\
- (5.1 \times \text{PSNT}) \quad \text{if Long-Term Manure History = Yes} \\
+ 50 \quad \text{if Cover Crop is mixture of plant families}
\]

**Example:** 220 bu/ac corn yield, long-term manure history, grass cover crop, PSNT result = 22 ppm NO\(_3\)-N

\[
EONR = 0.72 \times 220 \text{ bu/ac} - (5.1 \times 22 \text{ ppm}) = 46 \text{ lbs N/ac sidedress recommendation}
\]

Research to calibrate this formula indicated that the PSNT result is only useful to adjust the sidedress recommendation if the field has a long-term manure history, defined as two or more years of manure applied in the last 5 years, not including manure applied in the current year of production. Fields without a long-term manure history should have no adjustments to sidedress N fertilizer rates based on PSNT results.

This formula can account for a wide variety of management practices that affect the N fertilizer requirement, such as greater recovery of manure ammonium through injection, immobilization or mineralization of N from previous cover crop residues, and differences in historical manure application rates. Research to calibrate this formula also identified an adjustment was necessary if the field was planted to a cover crop mixture with different plant families or functional types present (e.g., mix of grasses, brassicas, and/or legumes). In the case of a previous cover crop mixture, add 50 lbs N/ac to the sidedress recommendation as indicated in the formula. However, there were relatively few observations in the calibration dataset following cover crop mixtures, so there is a greater degree of uncertainty in this adjustment factor, and producers should proceed cautiously using the PSNT recommendation following a cover crop mixture.

Furthermore, the sites used in the calibration data were all managed using no-till practices during the year of corn production, so it may not be appropriate to use this calibration of PSNT recommendations in soils that have been tilled in the current year.

Unlike some other calibrations of the PSNT recommendations, our research did not detect a fixed critical soil nitrate threshold above which no sidedress N fertilizer is recommended. Rather, if the results of the equation above return a negative number, it indicates no N fertilizer should be sidedressed, as there will be sufficient N available to meet the needs of the crop. If the equation results in a small sidedress N recommendation, such as less than 30 lbs N/ac, producers and their advisors should carefully weigh the costs and benefits of making an application. As the recommended sidedress N approaches zero, the expected corn yield response will decline and may not be worth the fertilizer, equipment, and labor cost of making a sidedress pass.
Soil Test Submission

There are many reputable soil testing laboratories that can provide soil nitrate testing for samples provided to them with the protocol described here. The Penn State Analytical Services Laboratory provides these services with information available at this PSNT webpage.

Summary

The PSNT is a valuable tool that can be used to adjust sidedress N recommendations in fields with a long-term manure history. The test is sensitive to a wide range of management practices that affect N fertilizer requirements for corn and can help resolve uncertainty about whether sidedress N applications are necessary, and if so, how much N should be applied. To obtain accurate recommendations from the PSNT, it is important to carefully follow all soil sampling and handling guidelines described in this factsheet.

Key references:


extension.psu.edu

Penn State College of Agricultural Sciences research and extension programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

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Code: ART-1146