Agronomy Guide

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The Presidedress Soil Nitrate Test for Improving N Management in Corn

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Nitrogen fertilizer is essential for profitable corn yields, but it is also a major production cost and can contribute to environmental degradation. Recent studies have demonstrated that soil nitrate testing could improve the agronomic efficiency of fertilizer N applications and reduce the potential for water quality problems associated with N use on cropland in the Eastern Corn Belt. The presidedress soil nitrate test (PSNT) can predict the amount of organic N that will be mineralized to plant-available forms of N (ammonium and nitrate) during the growing season. Research conducted in humid regions of the U.S. including Indiana, suggests that the PSNT is effective for predicting whether corn will be responsive to N sidedressing.

Background on Developing an Index for Season-long Soil N Supply

Nitrogen fertilizer recommendations in the humid region of the U.S. Corn Belt have traditionally been based on yield potential and field management history (previous crop and manure application). However, numerous studies have shown that this approach to N recommendations frequently overestimates the amount of N needed to optimize yields, especially when manure is applied to a field or when corn follows a legume with high N content such as a vigorous stand of alfalfa. The PSNT was designed by Dr. F. Magdoff at the University of Vermont to estimate the amount of N available in such situations. The test uses the amount of soil nitrate available in the top foot of soil at sidedressing time as an index of the amount of N that will be released during the course of the growing season by organic sources such as soil organic matter, manure, and crop residues.

Regional Performance of Soil Nitrate Tests

To evaluate the potential of soil nitrate tests, extensive research has been conducted in the more humid regions of the North Central Region of the United States by state land-grant universities. Corn yields and soil nitrate data were collected over a five-year period (1988-1992) from 301 sites in Ohio, Michigan, Illinois, Wisconsin, Iowa, Minnesota, Kansas, Nebraska, and North and South Dakota. A single research procedure was used, but sites included a variety of soil and climatic conditions, previous crop and management histories, and manure management practices. The preplant soil nitrate test (PPNT) and the PSNT were both examined for the ability to identify sites responsive to N fertilizer. For both the PPNT and the PSNT, soil sampling depths of 0 – 1 and 0 – 2 feet were evaluated.

Table 1. Critical soil nitrate values and success and failure rates for the PPNT and the PSNT.

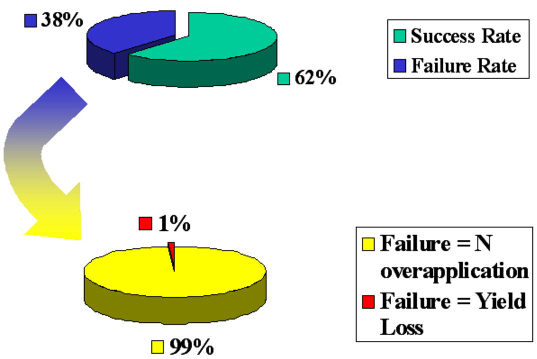
Soil Sampling Time	Soil Depth	Critical Soil Nitrate Level	Test Success Rate	Test Failure Rate		
				Type A	Type B	Total
	ft	ppm N	%	%		
PPNT	0 – 1	22	61	0	39	39
	0 – 2	17	63	1	36	37
PSNT	0 – 1	24	67	1	32	33
	0 – 2	18	71	1	28	29

Type A failure occurs when the test predicts that soil N supply is sufficient but subsequent yields are reduced by N deficiency.

Type B failure occurs when the test predicts that soil N supply is insufficient but the subsequent crop does not respond to a fertilizer N application.

West Lafayette, Indiana 47907

Figure 1. Success and failure rate of the PSNT and a breakdown for when the failure involved over-application of N versus crop yield loss.



It is extremely unlikely that using the PSNT would cause a farmer to lose yield because the test indicated soil N supplies were adequate when, in fact, fertilizer was needed. The test does sometimes indicate that fertilizer N is needed when, in fact, the soil N supply is sufficient.

As shown in Table 1, both soil tests identified the majority of responsive sites (sites where yields without N fertilizer were less than 90% of yields with fertilizer N). The critical PSNT nitrate level for response to sidedress N found by most researchers has been remarkably consistent over a wide geographical area. The critical level is generally between 20 and 25 ppm.

To identify the risks to the producer associated with using either the PPNT or the PSNT, the failure of the test was divided into two categories. The first type of failure, Type A, happened when soil nitrate levels were above the critical soil test level but a response to N fertilizer was still observed. The second type of failure, Type B, occurred when soil test levels were below the critical level but yields did not respond to N fertilizer. As shown in Table 1, Type A failures that lead to yield reductions from insufficient N supply were very rare, occurring on only one percent or less of the test fields. In contrast, type B failures were more common with the PSNT *incorrectly* identifying the need for more N from 30% to 40% of the time. Thus, from the perspective of a producer weighing the option of 1) applying a conservative (high) rate based on yield potential alone or 2) modifying the sidedress rate based on a soil test there is almost no increased risk of economic loss with use of the test.

PSNT Calibration in Indiana

Field research conducted from 1991 to 1995 in Indiana has found the PSNT with a one-foot sample depth to be most useful. For the purpose of making PSNT-based sidedress recommendations, the critical soil nitrate level for Indiana is the same as that found in the earlier studies, 25 ppm. This critical level minimizes the chance of the soil test failing to identify a site that requires a sidedress application of N to attain maximum yields. It should be noted that PSNT levels from continuous or rotational cornfields with *inorganic soils and no manure or biosolid application history* are remarkably predictable. Field research on the PSNT has consistently shown that these fields require the amount of N that would be recommended on the basis of crop rotation and yield potential alone. In other words, the PSNT is not likely to improve nitrogen use efficiency in these situations.

In contrast, fields that particularly benefit from an annual PSNT testing program include those where manure or other organic fertilizers have been applied and those with organic soils, regardless of crop rotations. But, because the PSNT will not be very useful for making sidedress N recommendations when nitrate levels vary greatly across a field, the first step towards using the test on fields where biosolids are applied is to ensure uniform application rates. The type of regular or predictable variability introduced into a field when farmers apply livestock manure via subsurface banding can be accommodated with an appropriate soil sampling pattern. Studies conducted on sampling patterns between rows identified an evenly spaced, three-core composite approach as the most suitable for characterizing N availability to plants in banded situations (described below).

Collecting Samples and Interpreting Results for Indiana

To effectively use this test, soil samples should be collected when corn is in the 4 to 6 leaf stage, or 6 to 12 inches tall (measured from the ground surface to the center of the whorl).

History of Broadcast Materials - Where fertilizer, manure or other biosolids have been broadcast, the sampling procedure is as follows:

- Identify a sampling area that represents a suitable management unit. Soil samples should be collected randomly from several areas that are 1 to 10 acres and relatively uniform with respect to soil characteristics and management histories.
- Collect each core to a depth of 12 inches.
- Make a composite of 15 to 25 cores from each sample area by thoroughly mixing all the soil in a bucket before the subsample for analysis is removed.

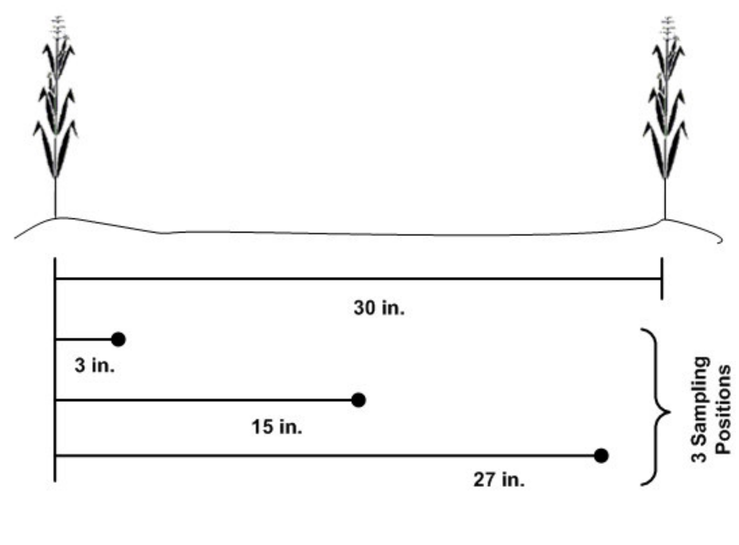


Figure 2. Diagram of recommended sampling pattern in relation to two corn rows. 30 in. sampling transect width.

The large number of cores is important due to the variability in N content of manures and non-uniformity in spreading manures and other fertilizer sources.

History of Banded Materials - If manure or fertilizer has been banded, sets of cores must be collected across the bands as follows:

- Collect one set of cores by sampling in three locations between two corn rows (30 inch rows), with the first core 3 inches to the right of the corn row, the second core 15 inches from the row (row middle for 30 inch corn) and the third core 3 inches to the left of the next corn row (Figure 2).
- Make a composite of 10 to 15 sets of cores from sampling points randomly selected within each sample area.

Air dry the soil samples by spreading them out in a thin layer on paper. A fan can be used to accelerate drying, or samples can be dried in an oven provided the temperature does not exceed 250°F. Send the soils to a certified soil testing lab for nitrate nitrogen analysis. While soil testing kits may be used as a preliminary screening tool, they are not recommended for quantitative determination of soil N availability and fertilizer need.

Results of the laboratory analysis are usually reported in ppm nitrate N. Table 2 presents recommended sidedress rates for a given PSNT level and a specific corn yield potential. ***Note that the amount of N given in Table 2 is for the total amount applied, including any N applied as a starter. To calculate the rate of N to apply as a sidedress, <u>subtract the amount applied at planting</u>.***

Experience has shown that when corn is grown continuously, the soil nitrate levels at the time of sidedressing are typically in the range of 5 to 9 ppm. Therefore, recommendations for N rates when PSNT levels are below 10 ppm are similar to current state preplant recommendations for continuous corn as published in the Tri-State Fertilizer Recommendations Bulletin. (See last paragraph for availability.) However, a sidedress application is typically more efficient than a preplant application, and thus the rate for a given yield goal has been reduced by 10% (row 1 of Table 2).

Soil nitrate levels found at sidedressing time in corn grown in an annual rotation with soybeans are typically in the range of 11-15 ppm. A PSNT value in this range indicates that a soil can supply N at a level comparable to that typically contributed to corn by decomposing residue from a preceding soybean crop. Thus, the recommendations for sidedress N rates when PSNT values range from 11 to 15 ppm are similar to current state recommendations for corn following soybean but again adjusted down by 10% to reflect the increased efficiency of fertilizer applied at sidedressing when compared to a preplant appli-

Table 2. Total N recommendations for corn based on a presidedress soil nitrate test and the field yield potential. To obtain the actual amount of N to apply as a sidedress, subtract the amount of N applied at planting as a "starter".

Soil NO_3-N	Corn Yield Potential in Bu/A					
	80	100	120	140	160	180
ppm	Pounds additional fertilizer N to apply per acre					
0 – 10	75	100	125	145	170	200
11 – 15	45	75	100	125	145	170
16 – 20	30	55	80	110	125	150
21 – 25	0	10	35	55	80	110
> 25	0	0	0	0	0	0

cation (row 2 of Table 2). PSNT levels ranging from 21 to 25 ppm can be viewed as almost sufficient and therefore on a par with the N supplying power of a soil where the previous crop was an average forage legume stand of 3 plants per square foot (row 4 of Table 2). ***PSNT levels greater than 25 ppm indicate that soil N supplies are sufficient to meet the needs of the crop and yields will not be increased by sidedressing N.***

Using the PSNT to Evaluate Fertilizer N Loss after Excessive Early-Season Rainfall

In springs with heavy rainfall there is often a great deal of interest in using the PSNT to estimate the loss of preplant fertilizer N applications. To date, most studies on the PSNT have not tried to use this test to quantify the amount of N lost to denitrification occurring in flooded fields. However, the test does have the potential to provide some insight into the amount of preplant fertilizer N remaining at sidedress time. As with soil testing prior to a planned sidedress application of N, a soil test level of 25 ppm nitrate N or greater following saturated soil conditions indicates sufficient soil N status for plant growth. In this situation the amount of N lost to denitrification was not significant and a supplemental N application would not be needed.

Unfortunately, for soil test values below 25 ppm the interpretation is less straightforward as low soil nitrate values could reflect either a loss of N by denitrification or the movement of N deeper into the profile below the one-foot sample depth. Corn roots can generally access N that has moved deeper in the soil profile. Therefore, low PSNT values need to be assessed in the context of other crop management and field information. Items to consider when deciding whether more N should be applied include:

1. The form and timing of the N application.
2. The soil type and drainage characteristics.
3. The length of time soils were saturated.
4. The negative impact of flooding on the yield potential of the crop.

Summary

The critical value of 20 to 25 ppm nitrate N is relatively uniform over a wide range of soil types, growing conditions, and geographical area. Above this critical level, soil nitrate is judged to be adequate for optimum corn growth and no sidedress N is recommended. Even though nitrate moves readily in the soil profile, increasing the sample depth from one to two feet did not significantly improve the predictive power of the PSNT, and the difficulty of collecting 2-foot cores makes this an impractical protocol. The 1-foot PSNT is most useful for fine-tuning N rates in fields with organic soils or fields where manure or other organic fertilizers have been applied.

For more information on developing N recommendations for corn, see the "Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat and Alfalfa" Extension Bulletin E-2567, Rep. August 1996, on the Web at http://www.agcom.purdue.edu/AgCom/Pubs/AY/AY-9-32.pdf (URL verified March 2003).

For related information on sidedress N, see publication AY-317-W, “Determining Nitrogen Fertilizer Sidedress Application Needs in Corn Using a Chlorophyll Meter,” at http://www.agry.purdue.edu/ext/pubs/AY-317-W.pdf (URL verified April 2003)

For additional agronomic information, please visit the Purdue University Agronomy Extension Web site at http://www.agry.purdue.edu/ext/index.html (URL verified April 2003)

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