# Agronomy Guide

Purdue University Cooperative Extension Service

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# Cornstalk Testing to Evaluate the Nitrogen Status of Mature Corn : Nitrogen Management Assurance

Sylvie M. Brouder, Department of Agronomy, Purdue University

Recent studies conducted at several universities, including Purdue, have demonstrated that the nitrogen (N) status of a corn crop can be determined by measuring the nitrate concentrations in the lower portions of cornstalks at the end of the growing season. The objective of this correlation and calibration work was to develop a tool that could be used to identify cases of deficiency and excess in N management for corn production. Evaluation of the test in Indiana has demonstrated that maintaining a database of "end-of-season cornstalk nitrate test" values is a good fine-tuning and quality-assurance tool for better N management practices in corn. When crop yields meet or exceed reasonable yield objectives, the test can be used to determine if soil N supply during the growing season exceeded the needs of the crop.

## Test rationale and sampling procedure

As corn approaches physiological maturity, plants stressed for N export nitrate from the lower cornstalk to the ear, significantly reducing nitrate concentrations in the cornstalk . However, when plants have more N than they need to attain the maximum yield, nitrate can accumulate in the lower portion of the cornstalk. Work conducted at Purdue University in 1930 focused on using this test to identify N deficiency. Recent concerns about nitrate contamination of surface and groundwater have shifted the emphasis of this diagnostic tool to distinguish between sufficiency and excess. Recent experiments in the cornbelt clearly demonstrated the two-phase relationship N availability in the root zone and stalk nitrate concentration at crop maturity. In the first phase, stalk nitrate concentrations remain constant with increasing root zone N supply, where increase in plant available N is translated into increased yield. In the second phase of the relationship, the "zone of luxury uptake," further increases in fertilizer N are not translated into additional yield and, therefore, stalk nitrate concentrations increase. In theory, the test allows the producer to ask at harvest if N management practices were optimized during the growing season.

## Protocol

### Sample Timing

The time to collect samples is between one and three weeks after the blacklayer has formed on 80 percent of the kernels from most ears.

### Sample Area

Divide a field as you would for soil sampling. Separate samples should be collected for different management units, N materials and timing of applications and soil types within management units.

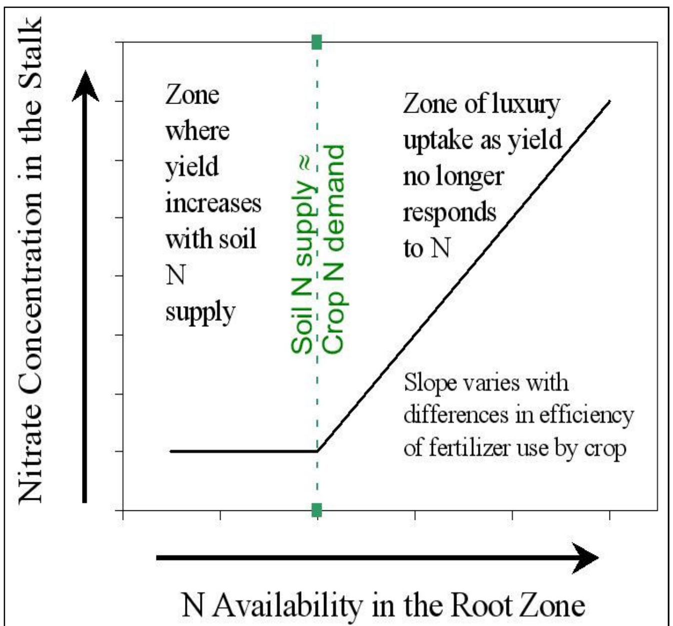



Figure 1. There is a two-phase relationship between N availability in the root zone and stalk nitrate concentration at crop maturity. The dotted line represents a soil N supply that matched the corn crop's season long N demand. (Figure modified from Iowa State Univ. Extension Pub. Pm-1584-Revised 8-96.)

### Plant Material

Select only stalks that are not damaged by insects or disease. Cut the 8-inch segment of stalk from between 6 and 14 inches above the soil surface. Strip the leaf sheaths from the segment. Collect 15 or more 8-inch segments for each sample area. Place samples in a paper bag and mail to a laboratory for analysis. Plastic bags should not be used as they will prevent drying of the sample and will encourage mold growth. Samples can be refrigerated (but not frozen) if they are being stored for more than a day before mailing.

### Laboratory Analysis

The laboratory will dry, grind, and analyze the stalk tissue for the nitrate concentration using standard laboratory procedures. Results are reported in ppm nitrate-N in the dry tissue (parts nitrate-N per million parts of stalk). Most soil testing laboratories will do this test. Contact your soil testing lab for further details on sample preparation and shipping.

## Calibration and Interpretation

The Indiana correlation and calibration work used 13 N fertilizer experiments conducted across the state in 1996 and 1997. Each site-year included 4 replicates of between 3 and 8 N rates with N rates ranging from 0 to 200 lb N per acre. The study used a limited number of hybrids but a variety of tillage management practices for both corn following corn and corn following soybean. Seven of the sites received high rates of poultry, hog manure, or municipal sludge. The rest of the sites were on inorganic soils receiving inorganic fertilizer N. Thus, overall, the calibration studies encompassed a wide range of soil, weather, and management conditions.

The results of all site-year data were combined into a common relationship between the stalk nitrate concentrations and relative yields. Relative yields are yields expressed as a percentage of maximum yield observed within each site. The maximum yield value for a site was the average yield for all fertilizer treatments where the fertilizers did not significantly increase yields. Therefore, deficiencies of N were indicated by relative yields significantly less than 100 percent. Note that some relative yields slightly above or below 100 percent are to be expected in plots with sufficient or excessive N because site or soil specific factors not directly related to N supply may influence yields.

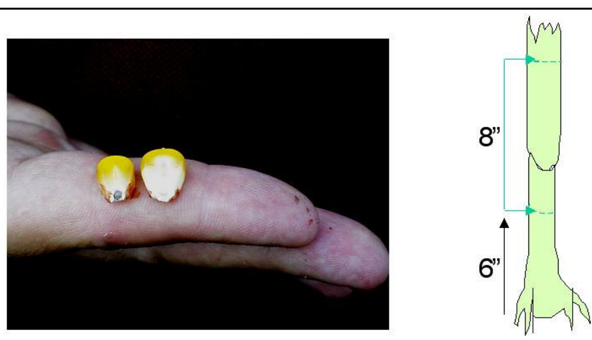
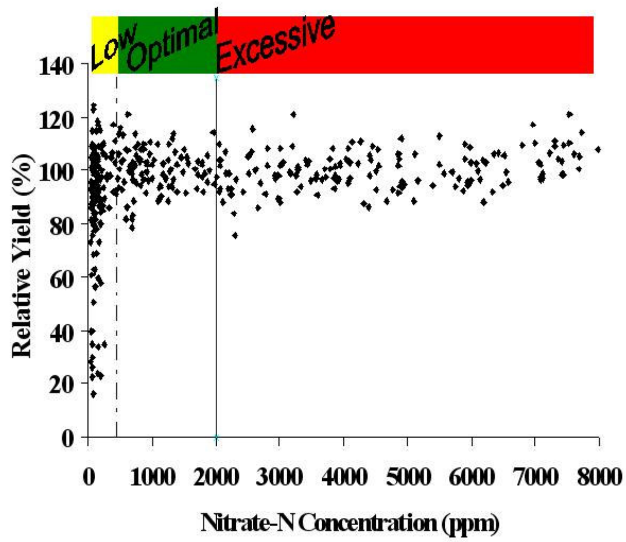



Figure 2. Eight-inch stalk samples should be collected when blacklayers have formed. The formation of the blacklayer (left kernel) signals the end of kernel growth. Kernels near the tip of the ear will mature first. Collect stalks when 80% or more of the kernels have blacklayered.

Figure 3. Diagnosis of in-season N to corn.




Statistical analysis was used to find the critical stalk nitrate concentration that separated N deficient treatment plots from those that did not respond to fertilizer (Figure 2). At stalk nitrate concentrations above 450 ppm, yields were maximized at all experimental sites. At concentrations below 450 ppm, nitrate-N yields in some treatment plots were substantially reduced by N deficiency.

In order to identify stalk nitrate concentrations that corresponded to excessive N levels remaining in the root zone at harvest, we calculated the number of bushels produced in a treatment per pound of N applied. This calculated value is an estimate of the agronomic efficiency of the fertilizer application rate. By plotting the “agronomic efficiency” against the stalk nitrate concentration, we see that when stalk concentrations are above 3000 ppm, the increase in yield per unit of fertilizer applied is zero (Figure 3). Stalk nitrate concentrations below 2000 ppm correspond to a range of efficiencies from 0.1 bushel per pound of N applied to 0.9 bushel per pound of N applied, indicating that the fertilizer N rate that was used was necessary to achieve optimal yields.

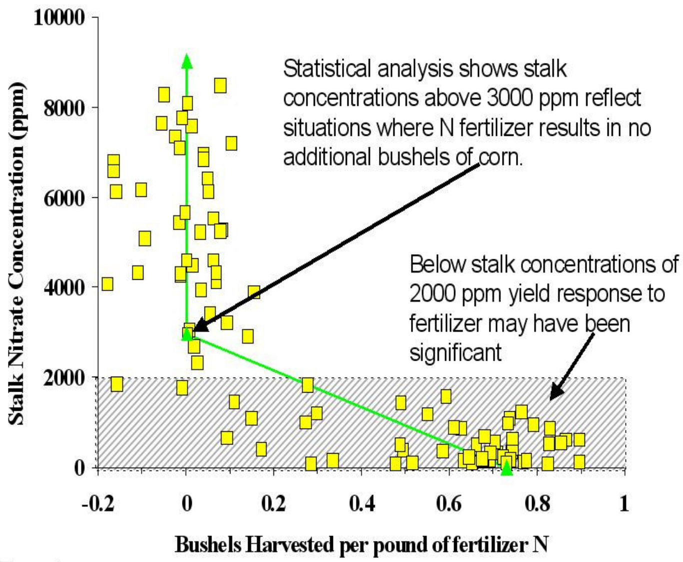



Figure 4.

For application of the stalk nitrate test, we recommend dividing sample results into three ranges with the following associated interpretations:

**Low**: less than 450 ppm nitrate-N.
The low category includes situations where visual symptoms of N deficiency are usually quite clear. Stalk N values in this range indicate a reasonable probability of yield response to greater soil N availability. However, a low test, especially in the range of 250 to 450 ppm, may reflect optimal agronomic efficiency for the fertilizer as yields may have been maximized with virtually no residual remaining in the root zone. In situations were N deficiency is identified, the test does not indicate the magnitude of yield response that could be excepted per additional increment of N supply.

**Optimal**: between 450 and 2000 ppm nitrate-N.
The optimal category identifies the range of N availability where profits are most likely routinely maximized for the producer. Yields will typically not be severely limited by N deficiency. As cost of N fertilizer varies relative to the value of grain, Figure 3 can be used to adjust the threshold concentrations for distinguishing between optimal and excessive N.

**Excessive**: greater than 2000 ppm nitrate-N.
The excessive category identifies the situation where N supply likely exceeds the amounts required to maximize producer profits as well as the amounts required to maximize yields.

## Comparison with Iowa State Calibration/Interpretation

Between 1986 and 1990, Iowa State researchers collected 45 site-years of cornstalk nitrate and yield data. Our critical and threshold concentrations are in general agreement with the values observed in the original calibration and interpretation work. A minor difference in our results concerns stalk nitrate values below 700 ppm. Iowa State recommendations have identified concentrations below 250 ppm as “low” and concentrations between 250 and 700 ppm as “marginal.” While this interpretation is a reasonable general guideline to follow, our results do not support different interpretations for stalk concentrations less than 250 ppm when compared to stalk concentrations that fall between 250 and 450 ppm. In developing a database for a given field or farm, a manager should pay close attention to all areas that consistently have stalk nitrate values less than 700 ppm.

## Weather Considerations

Even when N is optimally managed for a given field, low stalk nitrate concentrations will likely occur when large amounts of in-season rainfall cause significant fertilizer N loss and/or high yields. Conversely, higher than desired (or anticipated) stalk concentrations will likely occur when below-normal rainfall limits N loss and/or reduces final yields. The multiple site-year data from Iowa demonstrated that weather can have this impact on cornstalk nitrate values, but the magnitude of the impact was not enough to substantially alter their conclusions regarding threshold concentrations and the interpretation of the test.

## Sampling Errors

This test has been calibrated for physiologically mature corn, 1 to 3 weeks after blacklayers have formed. Sampling prior to blacklayer formation (e.g. the dent stage) can lead to higher than expected stalk nitrate values.

## Cornstalk Testing Vs. Grain Analysis

At present, there are several tissue testing options that can be used to identify when N has limited corn yield (e.g. testing earleaf N at silking or testing grain N at harvest). None of these tests, however, can be used to identify situations where N supply is excessive. Furthermore, corn plants show no visual symptoms that permit producers to identify over-application of N. Thus, producers may unknowingly over-apply N year after year. Regular use of stalk testing will identify management practices in need of fine-tuning and will also identify situations where in-season soil nitrate testing (the presidedress soil nitrate test) will be beneficial.

End-of-season cornstalk nitrate test levels from a field for a single year will be hard to evaluate. This test will be most useful if it is incorporated into the routine soil testing and plant analysis component of a nutrient management plan. Several years of soil and plant data will permit a producer to customize calibration for each location and soil type.

The concept of this test is sound. In Indiana experiments, the test proved particularly useful for identifying fields that did not require supplemental N applications to achieve maximum yields. The test promises to help fine-tune N management particularly when used with the presidedress soil nitrate test on organic or manured soils (see the case studies below).

## Case Studies

The case studies shown below illustrate how stalk nitrate testing can be used alone or in conjunction with the PSNT to optimize N management for corn.

In cases 1 and 2, regular applications of poultry manure led to a large supply of N in the soil. This is reflected in the PSNT values in soil collected at the four leaf stage that are well above the critical level of 25 ppm. Test strips of 40 lbs. and 80 lbs. N/acre were applied to see if the soil N supply was in fact sufficient, and it was. Stalk nitrate concentrations in samples collected from areas where no additional N was applied were above 450 ppm, also confirming that the plants had sufficient N. In the fertilizer strips, stalk N concentrations exceeded 2,000 ppm, confirming that N was excessive.

In cases 3 and 4, the farmer did not apply any manure and applied fertilizer N as 28% before planting. Following excessive spring rains, the farmer suspected sufficient N loss to cause yield reductions. The PSNT indicated N availability was still sufficient but N test strips identified case 4 as being 40 lbs. N/acre short. The stalk nitrate test identified both sufficient and deficient cases, and in case 4 also identified that 80 lbs. N/acre was excessive. It should be noted that the PSNT test is not well calibrated for assessing N availability of preplant inorganic N fertilizer applied to inorganic soils and its use is not recommended in this situation.

| | Farm History | PSNT Result* (ppm) | Stalk Nitrate Conc. (ppm) | Yield response to N fert. | Stalk Nitrate Conc. w/ N fertilizer | |
|---|---|---|---|---|---|---|
| | | | | | 40 lbs. N/acre | 80 lbs. N/acre |
| Case 1 | Continuous Corn, No-Till, Poultry Manure | 50.0 | 2690 | No | 3194 | 4246 |
| Case 2 | Continuous Corn, Conventional Till, Poultry Manure | 43.6 | 1169 | No | 4057 | 4285 |
| Case 3 | Corn after soybean, No-Till, preplant application of 28% followed by excessive rain | 56.2 | 4078 | No | 6777 | 6144 |
| Case 4 | Corn after soybean, No-Till, preplant application of 28% followed by excessive rain | 47.2 | 360 | Yes, to 40 lbs. | 1195 | 2911 |

**PSNT values in excess of 25 ppm are considered to be sufficient to meet the expected N needs of the crop.*

### *How Helpful Is the Stalk Nitrate Test? It Depends on the Question…*

**Question:** Can it identify corn that produced **less than maximum yields** because of **N stress**?

**Answer: Yes** — 89% of plots that had low yields also had stalk nitrate values below 700 ppm.

**Question:** Does a **low stalk nitrate** value always mean a **low yield**?

**Answer: No** — In some cases, maximum yields were observed even though stalk nitrate concentrations were less than 250 ppm. The use efficiency of N by the plants was optimized in these cases.

***Message:*** *Low stalk N values are likely to be related to N stress only if yields are lower than expected…*

**Question:** Can it identify fields or areas within a field that have **soil N in excess of crop demand**?

**Answer: Yes** — 94% of the plots that had received **more N** than was required to achieve maximum yields had stalk nitrate concentrations **in excess of 2,000 ppm**. In our studies, manured fields that did not respond to N fertilizer had stalk nitrate concentrations in excess of 1000 ppm and sometimes as high as 4500 ppm.

***Message:*** *This test is good for identifying when you don't need to supplement manure with inorganic fertilizer applications...*

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 April 2003).

For related information on the PSNT, see publication AY-314-W, "The Presidedress Soil Nitrate Test for Improving N Management in Corn," at http://www.agry.purdue.edu/ext/pubs/AY-314-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

## Supplemental Sources

Blackmer, A.M. and A.P. Mallarino. 1996. *Cornstalk testing to evaluate nitrogen management*. Pm-1584. Revised. University Extension Bulletin, Iowa State University, Ames, Iowa.

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