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Corn Stalk Nitrate Tests – Research and Recommendation Update

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The corn stalk nitrate test (CSNT) can be used as an end-of-season assessment of a nitrogen (N) management program relative to N source, timing, placement, and rate (Brouder, 2003). For this diagnostic test, 15 or more 8-inch stalk segments (beginning 6 inches above the soil surface) are taken from representative areas of a field from about two weeks prior to or 3 weeks after kernel black layer formation and analyzed for nitrate-nitrogen (NO_3-N). Accumulation of NO_3-N in the lower corn stalk results from N availability exceeding crop N utilization.

Timing of corn stalk sampling

Although stalk samples are typically collected within two to three weeks after black layer formation in accordance with the guidelines initially suggested by Iowa researchers (Binford et al., 1990), there is interest in assessing N management for silage corn which is harvested prior to black layer. Pennsylvania researchers compared results and interpretation of corn stalk NO_3-N samples taken at ¼ milk line (milk line positioned about 25% of the distance from the dented crown to the kernel tip) to those obtained 1 to 3 weeks after black layer (Fox et al., 2001). Stalk NO_3-N levels did not differ among samples taken between ¼ milk line and 1 to 3 weeks after black layer for 176 of 209 comparisons. Where differences occurred, there was no strong trend in the direction of change; 20 increased and 13 decreased from ¼ milk line to black layer. The researchers concluded that the interpretation of the CSNT in Pennsylvania was the same for samples obtained beginning at ¼ milk line through a few weeks after black layer (Beegle and Rotz, 2009).

Interpretation of corn stalk NO_3-N concentrations

Previous research conducted in Indiana in 1996 and 1997 concluded that NO_3-N concentrations less than 450 ppm were low, between 450 and 2,000 ppm were associated with optimal N availability, while concentrations greater than 2,000 ppm NO_3-N indicated

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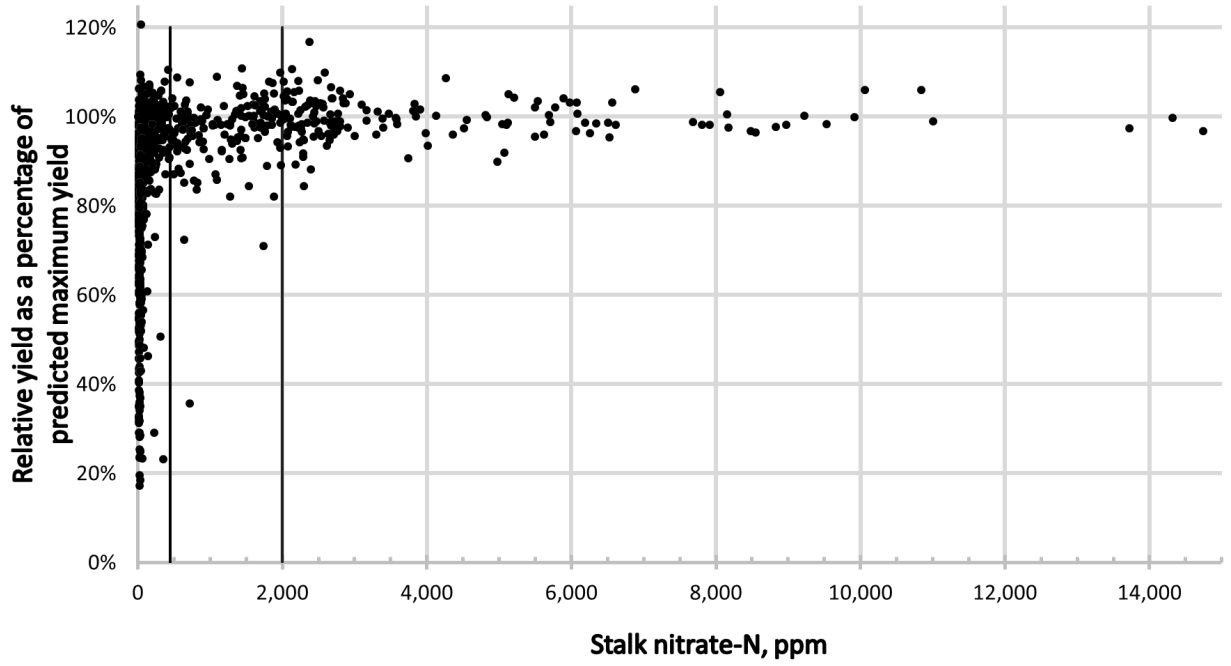
N availability was excessive (Brouder, 2003). The relationship between corn stalk NO_3-N and relative yield from our more recent 35 site-years of N response trials conducted in 2007-2009 and 2011-2013 (Fig. 1) are similar to earlier findings, suggesting similar interpretations are relevant for modern hybrids. Most of our studies were conducted with at-planting or sidedress N application of 28% urea-ammonium nitrate. Although the timing and form of N were not found to alter the relationship between corn stalk NO_3-N in earlier Iowa and Indiana research, recent research conducted in Iowa (Kyveryga and Blackmer, 2013) suggests the fall application of manure may need to be evaluated differently (discussed later).

Figure 1. *Stalk nitrate-N relationship with relative yield for 35 site-years of N trials conducted in Indiana from 2007-2009 and 2011-2013. Within each location and year the yield of an individual N rate treatment was related to the predicted maximum yield at that location in that year. The vertical bars indicate the divisions between low, optimal, and excessive levels as originally defined by Brouder (2003).*



Previous Indiana guidelines did not attempt to quantify the relationship between corn stalk NO_3-N concentrations and deficit or surplus levels of N fertilization. Thus specific recommendations on how much to increase or decrease N fertilization were not made. In attempt to make more specific recommendations on how to alter N fertilization rates based on corn stalk NO_3-N concentrations, the recently collected Indiana data were categorized by corn stalk NO_3-N and and compared to relative yield and the difference in fertilizer N rate relative to the N rate needed to obtain maximum yield.

Low corn stalk NO_3-N: Less than 251 ppm

Sixty-three percent of corn stalk samples had NO_3-N concentrations less than 251 ppm (Table 1). Relative grain yield in this low NO_3-N category ranged from less than 20 to greater than 100% of maximum yield (Figure 1) and averaged 81%. Almost all relative

yields less than 80% of maximum yield were associated with corn stalk NO_3-N concentrations less than 251 ppm (Figure 1). However, 17% of corn stalk NO_3-N concentrations less than 251 ppm were associated with N rate treatments producing 98 to more than 100% of maximum yield. **Therefore, low corn stalk NO_3-N does not always mean the crop was short of N.**

Optimal corn stalk NO_3-N: From 251 to 2,000 ppm

Twenty-one percent of corn stalk samples had NO_3-N concentrations between 251 and 2,000 ppm, which is categorized as optimal. All but 3 of 216 observations in this category had relative yields greater than 80% (Figure 1). At the lower end of this category, between 251 and 500 ppm NO_3-N, average relative yield was 96% and the average N fertilizer deficit was 27 lb N/acre (Table 1). At the upper end of the optimal category, 1,501-2,000 ppm NO_3-N, average relative yield was 99% and an average fertilizer surplus of 5 lb N/acre occurred.

Recommended N fertilizer rates target maximum profit, not maximum yield, thus they are lower than N rates needed to achieve maximum yield. At a commonly occurring corn grain to pound of N price ratio of 10 to 1 [grain at $4/bushel and N at $0.40/lb N ($225/ton 28% UAN)], economic optimum N fertilization rates are approximately 15 to 20 lb N/acre less than those needed to obtain maximum yield (Camberato et al., 2014). Therefore, **corn stalk NO_3-N levels between 1,000 and 2,000 ppm on average represent economically optimum N fertilization rates**.

Excessive corn stalk NO_3-N: Greater than 2,000 ppm

Eleven percent of corn stalk samples had NO_3-N concentrations between 2,001 and 4,000 ppm. Average relative yield was 100% and average excess N was 33 lb N/acre. Although it would be ideal to apply the optimum fertilizer N rate every year, it is not likely to happen. Based on our field-scale research, plus or minus 30 lb N/acre is a normal variation for optimum N rate from year to year for a particular cropping system. **Although one year with corn stalk NO_3-N between 2,001 and 4,000 ppm does not necessarily warrant a change in N management, multiple years at this level indicate the chosen N rate is higher than necessary for achieving maximum yield, as well as profit, and a reduction in N rate is suggested.**

Corn stalk NO_3-N concentrations between 4,000 and 8,000 ppm represented 4% of the samples obtained and were associated with excess N applications averaging 53 pounds per acre greater than that needed to achieve maximum yield (Table 1). Less than 2% of corn stalk samples had NO_3-N greater than 8,000 ppm. The average excess N application was 77 pounds of N per acre for this category.

Corn stalk NO_3-N concentrations in excess of 4,000 ppm represent excessive N application rates substantially beyond what is needed to obtain maximum yield or profit and reductions in N application rate should be strongly considered.

Table 1. *Relative yield (as % of predicted maximum yield within each of 35 location-years) and N rate deficit (-) or excess (+) (relative to the N rate needed to maximize yield in that location-year) for various categories of end-of-season corn stalk NO_3-N. Individual data points are shown in Fig. 1.*

Corn stalk NO_3-N, ppm	Relative % yield	N deficit (-) or excess (+), pounds per acre	Number of observations
≤ 250	81	-92	661
251 - 500	96	-27	61
501 – 1,000	96	-24	65
1,001 – 1,500	98	-9	45
1,501 – 2,000	99	5	45
2,001 – 4,000	100	33	110
4,001 – 8,000	99	53	38
> 8,000	100	77	16

Using the end-of-season corn stalk nitrate test to adjust fertilizer-based N management programs

Multiple seasons of CSNT evaluation are warranted before altering a fertilizer N management program because the optimum N rate for a specific field can easily vary plus or minus 30 lb N/acre from season to season. Many factors affect the optimum N rate; including soil N supply, loss of N from the root zone, hybrid differences for N use, pest and weed impacts on N use, and the interaction of these and other factors. Thus the evaluation of a N management system with the CSNT (or any other N assessment tool) on any given field in a single season is interesting, but not particularly useful in making management decisions for future years. Unfortunately, there is no clear guidance on how many years the CSNT should be conducted, but three or more seasons are probably reasonable.

If end-of-season corn stalk NO_3-N concentrations are consistently less than 250 ppm or more than 2,000 ppm one might consider conducting N response strip trials to identify the optimum N rate, rather than rely solely on the CSNT to alter the current N management program. Guidelines for conducting field-scale N response trials are available online (Nielsen and Camberato, 2011).

Manure-based N management programs and the corn stalk nitrate test

Recent research suggests the current interpretations of optimal and excessive N may be incorrect when fall-applied manure is the N source. Results of 52 trials with fall-applied manure showed that when corn stalk NO_3-N was 3,500 ppm or less there was a greater than 50% probability of having had a profitable response to additional N (Kyveryga and Blackmer, 2013). Conducting strip trials to assess N response in manure-based N management programs would definitely be encouraged in light of these findings.

Interestingly this Iowa research with fall, spring, or sidedress fertilizer applications found a 50% probability of a response to additional N occurred at 500 ppm; well within the current interpretations used in Iowa and Indiana.

Related references

Beegle, D. and J. Rotz. 2009. Late season cornstalk nitrate test. Penn State Univ. Agronomy Facts 70. http://nmplans.net/LateSeasonCornstalkNitrateTest.pdf [URL accessed Sept 2014].

Binford, G.D., A.M. Blackmer, and N.M. El-Hout. 1990. Tissue test for excess nitrogen during corn production. Agronomy Journal 82:124-129

Brouder, Sylvie. 2003. Cornstalk testing to evaluate the nitrogen status of mature corn: Nitrogen management assurance. Purdue University Coop. Ext. publication AY-322-W. http://www.agry.purdue.edu/ext/pubs/AY-322-W.pdf [URL accessed Sept 2014].

Camberato, J., R.L. (Bob) Nielsen, and B. Joern. 2014. Nitrogen management guidelines for corn in Indiana. J. Camberato, R.L. Nielsen, and B. Joern. Applied Crop Research Update, Purdue Univ. Agronomy Dept.. http://www.kingcorn.org/news/timeless/NitrogenMgmt.pdf [URL accessed Sept 2014].

Fox, R.H., W.P. Piekielek, and K.E. Macneal. 2001. Comparison of late-season diagnostic tests for predicting nitrogen status of corn. Agronomy Journal 93:590–597.

Kyveryga, Peter and Tracy M. Blackmer. 2013. 4R management: Differentiating nitrogen management categories on corn in Iowa. Better Crops/Vol. 97 (No. 1) 4-6. http://goo.gl/uYLRgR [URL accessed Sept 2014].

Nielsen, Bob and Jim Camberato. 2011. Purdue On-Farm Nitrogen Rate Trial Protocol. Agronomy Dept, Purdue Univ. http://www.agry.purdue.edu/ext/ofr/protocols/PurdueNTrialProtocol.pdf [URL accessed Sept 2014].