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Potential for nitrogen fertilizer variable rate management: a case study

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Abstract

Nearly anyone who has spent at least a little time planting, nursing and harvesting a crop of corn has witnessed variability of its performance within a field. The existence and magnitude of yield variability has become much more obvious with the advent of precision farming technologies. Naturally, these observations then lead to thoughts such as:

- What factors are creating the varied growth and yield of my corn?
- Are there things I can do differently to increase production in the lower yielding areas?
- Are there areas I can reduce my inputs without reducing yield and increase net profit?

Disciplines

Agricultural Science | Agriculture | Agronomy and Crop Sciences



Potential for nitrogen fertilizer variable rate management: a case study

(This is an expanded version of the article which appeared in the printed edition.)

Nearly anyone who has spent at least a little time planting, nursing and harvesting a crop of corn has witnessed variability of its performance within a field. The existence and magnitude of yield variability has become much more obvious with the advent of precision farming technologies. Naturally, these observations then lead to thoughts such as:

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Similar observations and thoughts have occurred to us while conducting a nitrogen (N) management research project.

The Walnut Creek Nitrogen Initiative is a watershed scale N management and water quality research project near Ames, Iowa. We are using the late-spring soil nitrate test (LSNT) and its guidelines for sidedressing N fertilizer for corn production to evaluate the LSNT program's economic performance and ability to reduce nitrate contamination of surface waters compared to current conventional practices. This effort is being done in cooperation with nine area farmers and the Heartland Co-op of West Des Moines, Iowa, and Iowa State University Extension. To test the economics and plant response of the LSNT program, we are using yield monitors, global positioning systems (GPS) and geographic information systems (GIS), chlorophyll meters, remote sensing (aerial photography) and the end-of-season cornstalk test. We present here a representative sample of preliminary findings from our first year of research, 1997.

Nitrogen fertilization rates were determined independently for each cornfield by the LSNT soil samples and recommendations. Also, every cornfield included an N deficient rate strip and a well-fertilized, nonlimiting N rate strip to enable calibration of several measures of N sufficiency and to evaluate the performance of the LSNT program. Although each of the eight cornfields in the 1100 acres study area displayed similar trends, we will limit this discussion to a single field that is a representative sample of all the cornfields in our study. For this field the LSNT recommended rate was 157 lb. N/ac, the N deficient rate was 50 lb. N/ac and nonlimiting rate was 262 lb. N/ac.

A yield map of the three N rate areas (Figure 1) displays several interesting trends. The 50 lb. N/ac rate shows lower yields in some areas, but is similar to the higher N rates in others, and

these trends appear to follow soil type. Another trend is that the LSNT rate seems to have performed as well as the nonlimiting rate across all soil types. Statistical analyses of yield by soil type and N rate support these observations. Means of these data are shown in Table 1.

When assessing yield responses by N rate, the 50 lb. N/ac rate had significantly lower yields on the hilltop (Clarion 138B and 138C) and sideslope (Canisteo 507) soils than the other N rates, but had mixed results in the lowland soils. The 50 lb. N/ac rate yields were not statistically different than the higher N rates on the lowland Okobojo soil (90), but were somewhat less on the Harps soil (95) when compared to the nonlimiting rate. The LSNT rate yields were similar to the nonlimiting rate on the Okobojo, Harps and Canisteo soils, but actually greater on the hilltop Clarion soils. When looking at results by soil type across the three N rates, the steeper sloping Clarion soil (138C) produced significantly lower yields than the other four soil types. The Clarion 138B, Canisteo, Harps and Okobojo soils had statistically similar yield responses across all three N rates.

Explanations for these mixed results become much easier if we make the assumption that the LSNT rate and nonlimiting rate yields can be categorized together. This seems reasonable since the LSNT rate yields were not significantly less than the nonlimiting rate on any of the soil types within the field. Therefore, we can accept that the LSNT rate probably optimized corn yield. Also, it appears that the 50 lb. N/ac rate may have been a sufficient N rate to optimize yields on the lowland Harps and Okobojo soils for 1997. Therefore, an N fertilization rate of less than 50 lb. N/ac would have been required to limit yield due to N deficiency on these soils. This situation is probably the result of an interaction between soil characteristics and the climatic conditions experienced in 1997. These lowland soils have high soil organic matter contents and retain greater amounts of moisture throughout the year than higher elevation soils. The drier than normal conditions of 1997 likely resulted in minimal leaching and an elevated degree of N mineralization in the high organic matter soils. Such conditions resulted in a low N fertilization requirement to optimize yield on the lowland soils and indicates that we overapplied the N fertilizer by at least 107 lbs. N/ac on these soils.

Drs. Alfred Blackmer and Susan White of Iowa State University have observed similar results in their studies at different locations in Iowa, as have other researchers in Illinois. They have also found areas of reduced--and no--corn yield response to recommended N fertilizer rates. Such findings, particularly at a regional scale, suggests that with some refinements in sampling methods considerable opportunities may exist for site-specific variable rate N application. Recent revisions in N fertilization recommendations by Iowa State University Extension were made to deal with such occurrences. It is recommended to carefully consider which areas are to be sampled independently of others within a field and those samples should consist of a composite of 16-24 cores. The trick in all of this is how to determine what those areas should be. One method would be to carefully analyze yield responses to varied N rates across all soil types in each field over a period of several years and climatic conditions. After the data has been gathered, then look for areas that have relatively consistent results. Once those areas are identified, then LSNT samples can be taken and matched to major areas of variability. This might result in a plan to variably apply N across a field with confidence of optimum net returns.

If we had based our method of LSNT sampling on the results of this first year of data we would have grouped sample sites by topographic location. The lowland soils (Harps and Okobojo) would have been sampled independently of the sideslope/hilltop soils (Canisteo and Clarion). Assuming we applied 50 lb. N/ac for the lowland soils and 157 lb. N/ac for the sideslope/hilltop soils, what kind of production cost savings would have been realized? With

the lowland soils comprising 16 acres of this field and sideslope/hilltop soils 61 acres, 1712 less lbs. N would have been applied to the field. At 12 cents per lb. N, this would have saved \$205.44 in production costs for the field, or \$3.06/ac, for 1997. Whether these savings would adequately compensate for the costs of sampling and the required technology to do variable rate application could be looked at several ways. One year of fertilizer savings might not pay for all of the sample processing and precision farming technology, but it should be compared by amortizing the technology costs. In addition, the costs to the environment may have been greatly reduced by not over applying 1712 lb. N on 16 acres of this field.

It must be remembered that what we presented here is simply a case study of data from one field and one year. Decisions on identifying areas within a field, or fields, to sample independently from others for N fertilizer needs must come from data collected over several years and climatic conditions. The end-of-season cornstalk tests, which are being processed at this time for our project, should also be used to verify the yield results. As we continue with this project over the next few years it will be interesting to see if the trends presented here remain consistent for all of the 1100 acres in the study each year.



Figure 1. A geo-referenced map of corn grain yield for limiting (50 lb. N/ac), nonlimiting (262 lb. N/ac) and late-spring soil nitrate test recommended N fertilizer rate (157 lb. N/ac) strips.

Table 1. Corn grain yield averages by soil type and N rate.

N Rate (lb. N/ac)	Soil Type:	Average Corn Grain Yield (Bu/ac)			
		90 ¹	95 ²	507 ³	138B ⁴ 138C ⁵

Limiting, 50	167	165	164	153	146
LSNT, 157	173	170	174	180	174
Nonlimiting, 262	170	175	176	171	170

¹ Okoboji, lowland soil

² Harps, lowland soil

³ Canisteo, sideslope soil

⁴ Clarion, hilltop soil

⁵ Clarion, hilltop soil

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