NITROGEN RECOMMENDATIONS BASED ON LOCAL DATABASES

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Abstract

Fertilizer N management practices were developed by an agronomist through a locally-based research program. The objective of the agronomist was to determine if and/or how generalized N recommendations needed to be changed to better fit local conditions. Years of collecting data on local management practices coupled with replicated research trials allowed him to determine economically optimum N rates for the predominant soil types in his trade area. This information provided him with the agronomic basis to use new technologies to vary N rates across the field according to soil type.

Case Study Background

This case study comes from Indiana. The setting is intensive corn and soybean production and increasing regulatory pressure. Discussion centers on approaches taken by an agronomist at a retail fertilizer outlet to tailor N management to local conditions. To examine the effectiveness of these practices, changes in corn grain yield and N use efficiency (bu./lb. N) are presented for several fields from a 2,900 acre family farm serviced by the outlet. In addition to corn and soybeans, this farm also markets about 5200 hogs/year from a 2,600 head confinement operation.

Development of Local Fertilizer N Recommendations

The N management practices developed by the agronomist were part of an overall approach that attempted to manage nutrient variably within fields. Prior to instigating local research efforts on N, the agronomist had already established a site-specific management program in which soil types were used as the basis for creating management zones within fields. These zones were sampled separately to assess soil chemical characteristics. Lime, potassium (K), and phosphorus (P) were variably applied to different zones within fields, based on soil test results. However, N was still managed on a whole-field basis, with a uniform rate of 210 lbs. N/acre being typical for most farmers in the area. As the ability to apply N variably across the field became feasible with new technology, the agronomist began researching what N rates would be economically optimum for the area's two dominant soil types.

A study was established to investigate response of corn to N on two dominant soil types in the area: a Fincastle silt loam (fine-silty, mixed, mesic Aeric Ochraqualfs) and a Cyclone silt loam (fine-silty, mixed, mesic Typic Argiaquoll). A split-plot experiment, replicated four times, was designed with soil type as the whole plot and N rate as the sub-plot. N rates were selected to encompass local farmer management practices. The study was conducted for five years and was configured so that corn always followed soybean. This was done to make the results applicable to the corn-soybean rotations used in the area.

Four-year average responses (a drought year was omitted) were analyzed and economically optimum N rates (EONR) determined using a linear-plateau model (Anderson and Nelson 1975, see Figure 1). The EONRs were 180 lbs. N/acre for the Cyclone soil and 210 lbs. N/acre for the Fincastle soil. These N recommendations represented a different approach to N fertilization than that recommended by Purdue Extension. The university recommendation system increases N rates according to yield goals (Vitosh et al. 1995). The local recommendations used only two rates: one appropriate for the average responses observed for each of the two dominant soil types. In most cases, based on yield goals in the agronomist's geographic area, the locally-developed recommendations resulted in lower N rates than recommended by Purdue Extension. This may be due in part to the choice of a response model that was possibly more conservative in its determination of EONRs (Cerrato and Blackmer, 1990). The local recommendations were also counter to the opinion held by many area farmers that the darker Cyclone soil should get more N because it was more productive. Local research results indicated that the Cyclone soil actually required less N to achieve economically optimum yields. Results from this study were inferred to analogous soil types in the area: a Crosby silt loam (fine-loamy, mixed, mesic Aeric Ochraqualfs) and a Brookston silt loam (fine-loamy, mixed, noncalcarious, mesic Typic Argiudolls). With the completion of this study, the agronomist began varying N rates across farmers' fields using GPS and single-product rate controllers.

At about the same time the N rate study was being conducted, the agronomist initiated another experiment that examined N timing. Prior to the agronomist's employment at the dealership, the retail outlet promoted spring applications of N. This was done, not for agronomic reasons, but because spring was the time when the dealership's N inventory was greatest. Most customers were applying N in the spring before corn was planted. Results from an eight-year study (not shown) showed a consistent (seven of eight years) yield advantage to applying the same rate of N at a later date, closer to the time of crop need (termed, "sidedressing").

Sidedressed N applications used to be more widely used than they are now. This practice involved no additional investment by the farmers and was quickly adopted. By the third year of the study, the agronomist estimates that about 60 percent of the trade area was receiving N at this time in the season. Although farmers were not taking on any additional financial risk with this practice, the dealership was, since it was responsible for timely N application. As the practice began to be accepted, the retail outlet found itself facing high demand for its custom N application business during a narrow time window. The demand for sidedressed N outpaced the dealership's resources to provide the service. Eventually, many of the sales staff no longer promoted the practice and adoption declined.

Open dialogue between the agronomist and farmer customers, combined with the previously established site-specific management program, were critical to implementing new N management practices. Variable N applications based on soil type are used on approximately 25,000 acres (about 25 percent of the dealership's trade area). Variable N applications combined with sidedressed N applications are used on approximately 12,500 acres (13 percent of the dealership's trade area).

Effects of Local Fertilizer N Management at the Farm Scale

The producers from the 2,900 acre case study farm have traditionally worked closely with the agronomist and were one of the first to adopt his new recommendations. Previously, these farmers applied a uniform rate of 200 lbs. N/acre across every field. In Figure 2, Year 1 is an example of how N efficiencies varied across the field when using a uniform N rate. N efficiencies ranged from 0.70-0.93 bu./lb. N, with an area-weighted average N efficiency of 0.84 bu./lb. N. Year 2 shows how N efficiencies improved in many areas of the field when N rates were varied by soil type. Nitrogen efficiencies ranged from 0.64-1.2 bu./lb. N, with an area-weighted average N efficiency of 0.95 bu./lb. N. Since field average yield levels were nearly the same in both years, the 0.11 bu./lb. N average increase in efficiency resulted primarily from the reduced N rate of 180 lbs. N/acre applied to the Brookston soil. The Cyclone and Brookston soils receiving less N comprise about 53 percent of the total land area of the farm not receiving manure applications.

Higher efficiencies were also attained by increasing yields. To examine temporal trends in yields on the case study farm, 37 of 52 fields were selected, based on their longer history of management with variable N and the fact that they had not received manure. Each field was harvested using a yield monitor coupled to a differentially-corrected GPS receiver. Using GIS software, yield monitor data were averaged over contiguous soil type regions in each field. On average, 941 acres from 17 corn fields were analyzed each year.

Figure 3 shows that over the eight years considered, yields have significantly increased (p value < 0.01) on both groups of soils. Two drought years occurred during this period: 1995 and 2002. The 5.5 bu./acre/year average annual yield increase on the Cyclone and Brookston soils was slightly, but significantly, higher than the 4.4 bu./acre/year yield increase on the Fincastle and Crosby soils (p value $= 0.056$). The average yield across all years for the Cyclone and Brookston soils was 172 bu./acre, which was significantly higher than the 167 bu./acre average yield of the Fincastle and Crosby soils (p value < 0.01).

Increasing yields resulted in significantly greater N efficiencies over time (Figure 4). Within each soil group, applied N rates remained constant over the period considered: 180 lbs. N/acre for the Cyclone and Brookston soils and 210 lbs. N/acre for the Fincastle and Crosby soils. The Cyclone group exhibited N efficiencies that increased by about 0.030 bu./lb. N/year, which was slightly but significantly more rapid than the 0.021 bu./lb. N/year observed on the Fincastle and Crosby soils (p value < 0.01).

The differences in N efficiencies between soil groups over time in Figure 4 demonstrate the net effect of increasing yields and simultaneously reducing N rates. Over the eight-year period, N efficiencies on the Cyclone and Brookston soils ranged from 0.015-1.4 bu./lb. N and averaged 0.96 bu./lb. N. Nitrogen efficiencies on the Fincastle and Crosby soils ranged from 0.29-1.4 bu./lb. N and averaged 0.79 bu./lb. N during the eight years. While the average N efficiency on the Cyclone and Brookston soils was significantly higher (p value < 0.01), variability in N efficiency was also significantly higher on these soils (p value < 0.01).

Increasing yields and N efficiencies have resulted not only from improved N management, but also from the entire set of farmer management practices. Specific to nutrient management, variable N applications are part of a broader site-specific management program that includes variable P, K, and lime applications. The nutrient management approach recommended by Purdue Extension and adopted by the agronomist is to build soil test P, K, and pH to levels that do not limit crop yields (Vitosh et al., 1995). Reduced tillage is used on all non-manured fields. Like many in the area, the farmers have adopted new glyphosate-resistant soybean varieties and new corn hybrids. Therefore, the newly adopted N management strategies are part of a much larger management system.

Summary

The case study focuses on an innovative agronomist working at a retail fertilizer outlet and one of his progressive farmer customers. Fertilizer N management practices were developed by the agronomist through a locally-based research program. The objective of the agronomist was to determine how N management practices needed to be changed to better fit local conditions. Years of collecting data on local management practices coupled with replicated research trials allowed him to determine economically optimum N rates appropriate for the soils in his geographic area. The research also produced recommendations for N applied early in the season, during early corn growth stages. The farmers in the case study have adopted both of these improved N management practices.

The effects of these locally-developed practices have been positive. An N rate that is 86 percent of that used previously is being applied to just over half of the crop area. The N management approaches are part of a larger site-specific nutrient management strategy that builds and maintains soil fertility at levels considered non-limiting to crop production.

Major technologies that have been used to improve yields and N efficiencies are:

- computers with improved capabilities
- geographic information system software
- statistics and spreadsheet software
- global positioning system receivers
- yield monitors
- variable rate controllers
- soil testing
- calibrated application equipment
- new soybean varieties, specifically genetically-modified organisms
- new corn hybrids
- field equipment for high residue management

An important theme throughout the case study has been finding local solutions to local problems. Localized N recommendations are an example of taking inventory of what management practices currently exist, then devising ways to improve them. New approaches have been adopted because farmers were involved throughout the discovery process, the agronomist was reputable, and the research was local.

Selected References

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Vitosh, M. L., J. W. Johnson, and D. B. Mengel. 1995. Tri-state fertilizer recommendations for corn, soybeans, wheat, & alfalfa. Michigan State University, The Ohio State University, and Purdue University Extension Bulletin E-2567, http://www.ces.purdue.edu/extmedia/AY/AY-9-32.pdf.

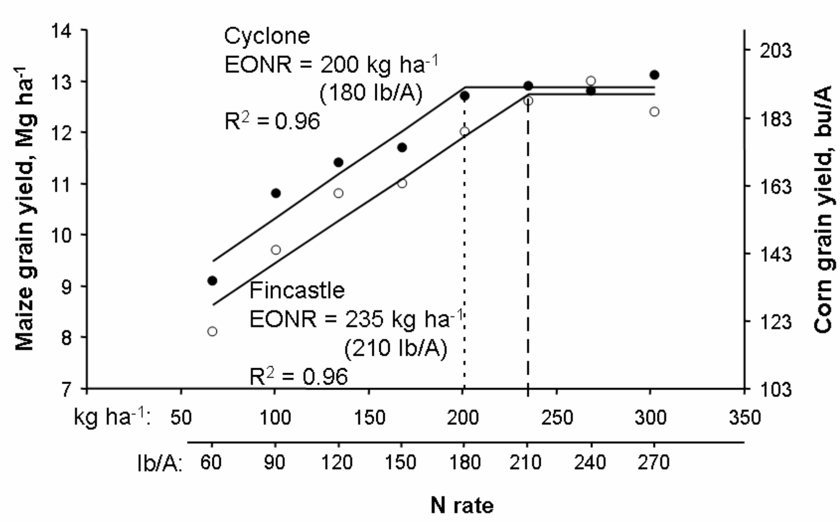

Figure 1. Corn yield response to incremental rates of N for Fincastle and Cyclone soils, with associated economic optimum N rates (EONR). Each data point represents the mean of 16 observations (four replications, four years).

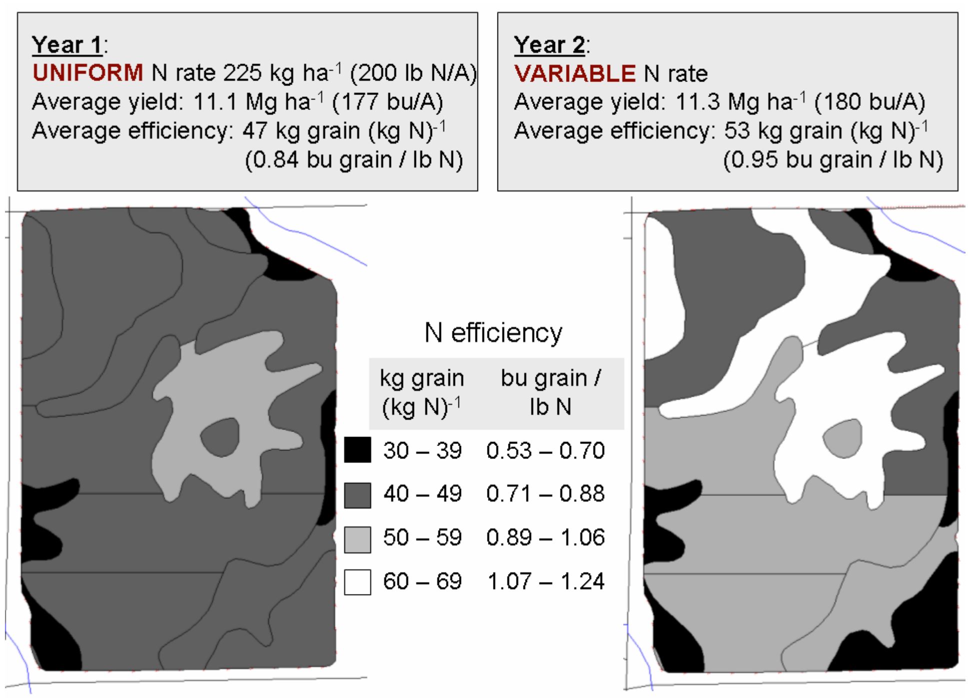

Figure 2. Comparison of N efficiency differences between two different but similar yielding years on the same field. In Year 1, a single rate of 200 lbs. N/acre was applied uniformly across the field. In Year 2, N rate was varied by soil type.

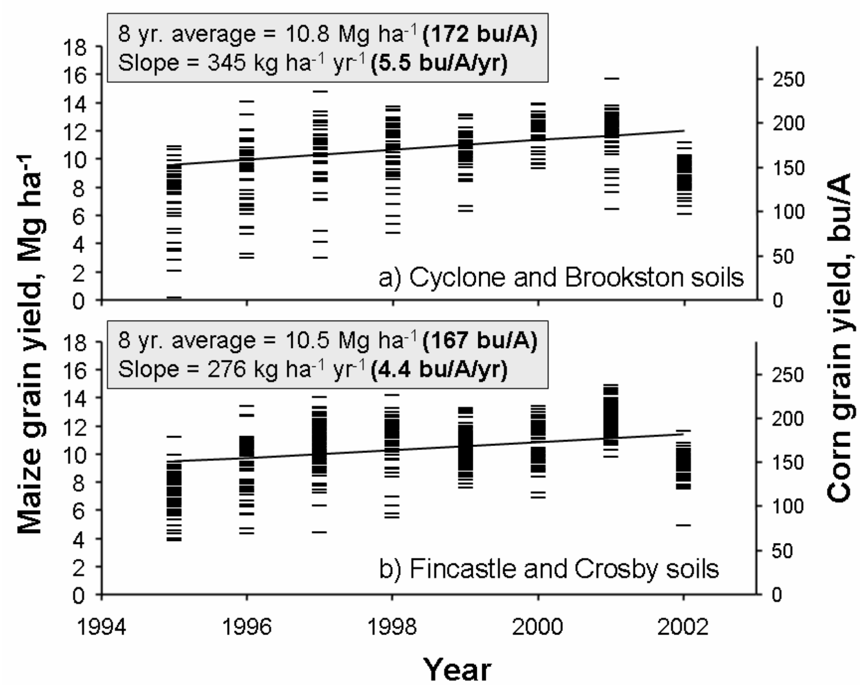

Figure 3. Temporal trends in annual corn yields from (a) the Cyclone and Brookston soils and (b) the Fincastle and Crosby soils.

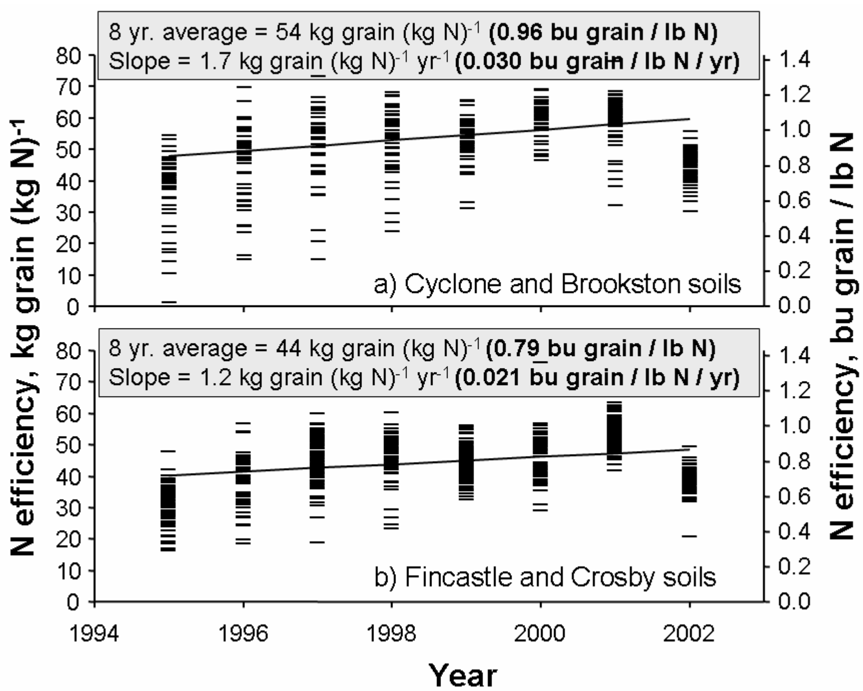

Figure 4. Temporal trends in annual N efficiency from (a) the Cyclone and Brookston soils and (b) the Fincastle and Crosby soils.

